



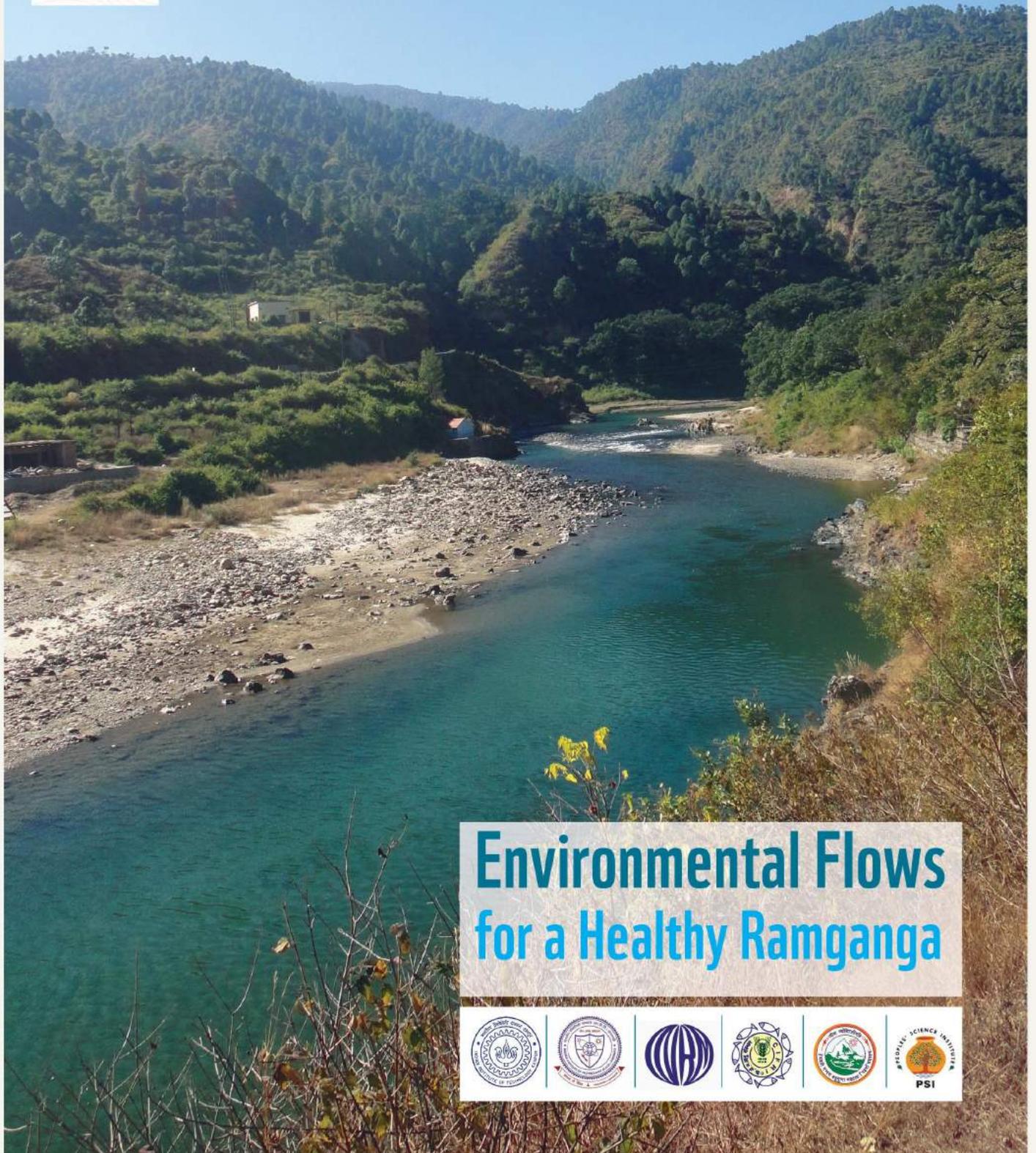
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REPORT

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Environmental Flows for a Healthy Ramganga



ENVIRONMENTAL FLOWS FOR A HEALTHY RAMGANGA

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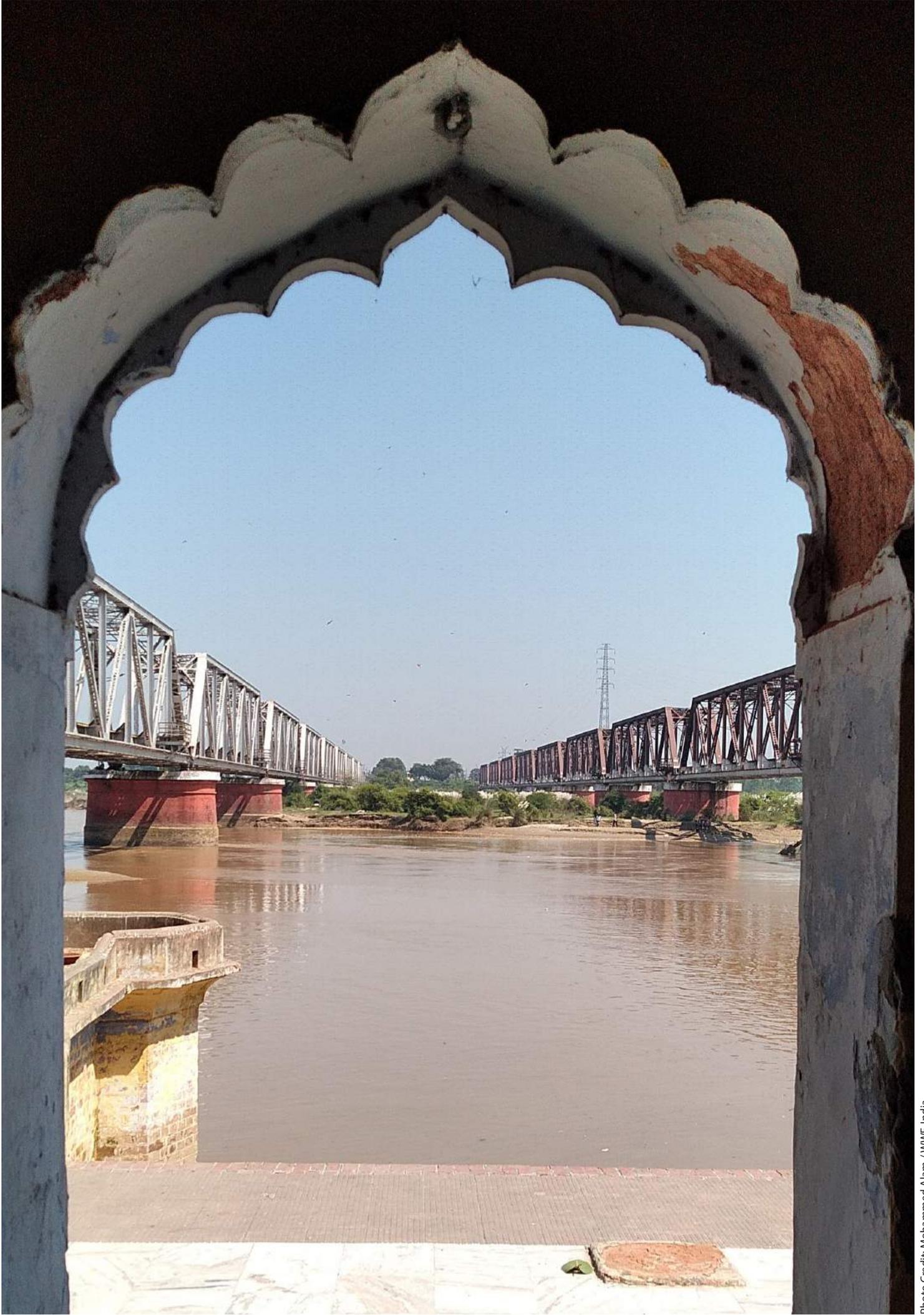
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Environmental Flows for a Healthy Ramganga





धर्मपाल सिंह मंत्री

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प्रस्तावना

नदियां हमारी जीवन रेखाएं हैं, इनका संरक्षण मानव जाति के साथ-साथ जैव विविधता के लिये लाभदायक है। हमारी सरकार नदियों के संरक्षण के लिये गंभीरता के साथ कार्य कर रही है, हाल ही में हमने राज्य के प्रत्येक जिले में एक नदी या सहायक नदी को पुनर्जीवित करने का फैसला किया है। इस सम्बन्ध में कार्य शुरू हो रहा है और हम सभी को (सरकार, शैक्षणिक संस्थाएं, सामाजिक संस्थाएं और समस्त नागरिकों) इस महान कार्य में अपनी भूमिका निभाने की जरूरत है। भारत सरकार का नमामि गंगे कार्यक्रम "अविरल गंगा" और "निर्मल गंगा" पर केन्द्रित है, इसमें पर्यावरणीय प्रवाह "अविरल गंगा" का मुख्य पहलू है। उत्तर प्रदेश राज्य गंगा के संरक्षण में महत्वपूर्ण भूमिका निभा रहा है, क्योंकि गंगा की कुछ मुख्य सहायक नदियां (जिसमें रामगंगा भी आती है) राज्य से गुजर रही हैं।

मुझे यह जानकर प्रसन्नता हो रही है कि डब्ल्यू०डब्ल्यू०एफ० - इण्डिया (वर्ल्ड वाइड फंड फॉर नेचर - इण्डिया) ने अपने साथियों के साथ रामगंगा नदी के लिये पर्यावरणीय प्रवाह (ई-फ्लो) का आंकलन किया है, जिसमें ई-फ्लो को रामगंगा नदी में सुनिश्चित करने के लिये ट्रेड-ऑफ का अध्ययन भी किया है। गंगा समेत राज्य में अन्य नदियों के संरक्षण की दिशा में यह कार्य उत्तर प्रदेश के लिये एक मूल्यवान योगदान है।

उत्तर प्रदेश राज्य जल संसाधन एजेंसी (स्वरा) राज्य के आठ नदी कछार (रामगंगा समेत) क्षेत्रों के लिये नदी प्रबंधन योजनाएं विकसित कर रही है और डब्ल्यू०डब्ल्यू०एफ० का यह अध्ययन स्वरा के काम में भी लाभदायक होगा। राज्य के जल संसाधनों का प्रबंधन, मूल्यांकन और योजना इस विभाग की एक महत्वपूर्ण भूमिका है। नदियों से जल आवंटन की क्षेत्रीय योजना बनाते समय पर्यावरणीय आवश्यकताओं को सम्मिलित करते हुए राज्य में स्वस्थ नदियां सुनिश्चित करेगा। एक बार फिर मैं डब्ल्यू०डब्ल्यू०एफ० इण्डिया टीम और उसके साथियों को इस अग्रणी कार्य करने और इस रिपोर्ट को तैयार करने के लिए बधाई देता हूँ। रामगंगा पर्यावरणीय प्रवाह का अध्ययन कार्य दो वर्षों के दौरान पूरा किया गया है। इस कार्य में आई०आई०टी० कानपुर, सिफरी, आई०आई०टी० बी०एच०यू., पी०एस०आई० देहरादून, आई०एन०आर०एम०, एच०एन०वी० गढ़वाल विश्वविद्यालय, श्रीनगर उत्तराखण्ड आदि संस्थाओं का योगदान रहा है। रामगंगा नदी के किनारे बसे गांव/शहर में से जुड़े रामगंगा मित्रों (किसान, शिक्षक, छात्र, सामाजिक कार्यकर्ता, धर्मगुरु, सरकारी अधिकारी एवं अन्य नागरिक) ने भी इस अध्ययन में सहयोग किया है। इस अध्ययन में रामगंगा नदी में 8 अलग-अलग स्थानों पर पर्यावरणीय प्रवाह का आंकलन किया गया है। इस सभी स्थानों पर सामाजिक, सांस्कृतिक, जैव विविधता, भू-आकृति, जल प्रवाह एवं गुणवत्ता आदि बिन्दुओं का अध्ययन कर पर्यावरणीय प्रवाह का आंकलन किया गया। इस पर्यावरणीय प्रवाह रिपोर्ट में विभिन्न संस्थाओं, संगठनों एवं नागरिकों हेतु उनके द्वारा किये जाने वाले कार्यों के उत्तरदायित्वों का भी उल्लेख किया गया है।

एक बार फिर, मैं डब्ल्यू०डब्ल्यू०एफ० इण्डिया टीम और उसके साथियों को इस अग्रणी कार्य करने और इस रिपोर्ट को तैयार करने के लिए बधाई देता हूँ।


धर्मपाल सिंह,
मंत्री, सिंचाई एवं सिंचाई(यांत्रिक)
उ० प्र० सरकार।



राजीव रंजन मिश्रा, भा प्र से
महानिदेशक

Rajiv Ranjan Mishra, IAS

Director General



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Message

Rivers have been central to the growth and development of human civilization. In India, rivers have had social, cultural, economic and spiritual significance in the life of its people since time immemorial.

The Government of India accords highest priority to the conservation of Ganga. Marking a major shift in the implementation of Ganga rejuvenation programme, the government is focusing on involving people living on the banks of the river to attain sustainable results. Drawing from the lessons learned from the previous phases, the focus of Namami Gange programme goes beyond treatment of sewage & effluent treatment also to include riverfront development, afforestation, biodiversity conservation, peoples' involvement and rural sanitation.

At NMCG, we believe that the wholesomeness of the river is best described in terms of four defining concepts: 'aviral dhara' (uninterrupted flow), 'nirmal dhara' (unpolluted flow), geological entity, and ecological entity.

WWF India, has been contributing to the conservation and rejuvenation efforts in Ganga and its main tributary – River Ramganga for the past several years. They have been engaged in assessment of Environmental Flows (E-Flows) for Upper Ganga and Rāmangā River. WWF India's work provides useful insights and direction to build an informed understanding and further the debate on E Flows based on scientific research and integrating socio-cultural considerations. Their work is truly multi-disciplinary and involves the participation of research institutions, civil society organisations and communities.

I am pleased to note that the organization has also carried out research to ascertain the trade-offs emerging from the proposed releases of E-Flows and has suggested a framework for mainstreaming E-flows in the Ramganga. This initiative will serve as knowledge base to strengthen the planning at basin level to ensure conservation outcomes for our river systems.

I congratulate WWF-India, their team and partners who have been engaged in this initiative. We look forward to engaging with WWF India and other stakeholders to further the cause of E-Flows implementation in Ganga and realizing the vision of *aviral dhara*.

(Rajiv Ranjan Mishra)

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Foreword

The *Namami Gange* programme of the Government of India envisions an *aviral* (having uninterrupted flow) and *nirmal* (clean) Ganga. Concerted efforts are being made by the Government of India, State Governments, technical institutions, academia, individuals and civil society organisations in realizing this long term vision for one of the most revered rivers in the world. This report, “Environmental Flows for a Healthy Ramganga”, contributes to the discourse on the rejuvenation of tributaries of the Ganga, notably for implementing environmental flows in the Ganga.

A decade ago, WWF-India and its partners embarked on a journey to understand the issues around environmental flows and water allocations in the Ganga. Existing global E-Flows methodologies were adapted to develop an appropriate approach for the Ganga system. This approach, based on the Building Block Methodology, integrated various aspects of the river – social and livelihood needs, cultural and spiritual requirements, hydrology and hydraulics, geomorphology, water quality and biodiversity values. Later, the consortium of seven Indian Institute of Technologies responsible for the Ganga River Basin Environment Management Plan further improvised on this approach while framing the E-Flows recommendations for the Ganga.

In a majority of cases, E-flows provisions remain at the stage of policy and debate rather than implementation. Given this background, we felt that it was imperative to demonstrate environmental flows implementation in a manageable river basin or a sub-basin. This work is an attempt to build the base for demonstrating and testing the various mechanisms for the enforcement and monitoring of E-Flows, which would help in refining the strategy for mainstreaming the implementation of E-Flows both at a river basin and a national level. The Ramganga was selected for E-Flows assessment and pilot demonstration jointly with key stakeholders.

This report, an outcome of over four years of work, tries to address these issues. We are pleased that many of the recommendations presented in the report came out of a series of discussions at the local, district and state levels. We are hopeful that the report will build the knowledge base on E-Flows assessment and the trade-off recommendations will provide options for managing our water resources.

We will continue to work with key stakeholders including the Ramganga *mitras* (friends of Ramganga), Government of Uttar Pradesh and National Mission for Clean Ganga, to develop a proof-of-concept demonstration of environmental flows in the Ramganga which could then lead the way for an environmental flows restoration programme for the Ganga and its tributaries.

Assessing, realizing and maintaining Environmental Flows will go a long way in realizing the goal of making our rivers ‘*aviral*’, one of the key components of the *Namami Gange* and other river conservation programmes.

Ravi Singh

Secretary General & CEO, WWF-India



Ramganga Environmental Flows Assessment team



Photo Credit: WWF-India

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List of Abbreviations

AMSL	Above Mean Sea Level
BBM	Building Block Methodology
BCM	Billion Cubic Meter
BOD	Biological Oxygen Demand
BAU	Business As Usual
CCA	Cultivable Command Area
CIFRI	Central Inland Fisheries Research Institute
cm	centimeter
COD	Chemical Oxygen Demand
cumec	cubic meter per second
cusecs	cubic feet per second
CWC	Central Water Commission
DAP	Di-ammonium Phosphate
DEM	Digital Elevation Model
DGC	District Ganga Committee
DO	Dissolved Oxygen
EFA	Environmental Flows Assessment
E-Flows	Environmental Flows
EMC	Environment Management Classes
FDC	Flow Duration Curves
FFG	Functional Feeding Group
FRL	Full Reservoir Level
ft	feet
GDSQ	Gauge, Discharge, Sediment and Water Quality
GPS	Global Positioning System
HFL	Highest Flood Level
HRU	Hydrological Response Unit
IMC	Indian Major Carps
kg	kilogram
km	kilometer
Lat	Latitude
LGC	Lower Ganga Canal
LISS	Linear Imaging Self-Scanning
Long.	Longitude

m	meter
m ³ /s	cubic meter per second
MAR	Mean Annual Runoff
MCM	Million Cubic Meters
mm	millimeter
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoWR, GR & RD	Ministry of Water Resources, Ganga Rejuvenation and River Development
MW	Megawatt
NCIWRD	National Commission on Integrated Water Resources Development
NDMA	National Disaster Management Authority
NEDA	New & Renewable Energy Development Agency
NMCG	National Mission for Clean Ganga
O&M	Operation And Maintenance
RHC	River Health Categories
ROR	Reservoir Operation Rules
SAPCC	State Action Plan for Climate Change
SOP	Standard Operating Procedures
SWaRA	State Water Resource Agency
SWaRDAC	State Water Resources Data And Analysis Centre
SWAT	Soil and Water Assessment Tool
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
U.P.	Uttar Pradesh
UJVNL	Uttarakhand Jal Vidyut Nigam Limited
UPI&WRD	Uttar Pradesh Irrigation and Water Resource Department
UPWSRP	Uttar Pradesh Water Sector Restructuring Project
WALMI	Water And Land Management Institute
WUA	Water Users Associations
WWF-India	World Wide Fund for Nature-India

Executive Summary

BACKGROUND AND CONTEXT

A healthy river is a resource sustaining water security, flood-risk reduction and eco-system services for people and nature, benefiting the economy of the land it flows through. WWF-India's programme *River for Life, Life for Rivers* aims to restore and conserve rivers in its natural state - thus sustaining services to people and nature, and benefiting the country's economy. With the increasing degradation of our river systems across the country, it is imperative to recognize the value of rivers beyond mere water sources for domestic use and development ventures. Policies and practices need to be developed by experts and implemented by decision makers and implementing agencies, recognizing and safeguarding benefits of rivers flowing through communities, cities and states.

The flow in the river is impacted due to decline in aquifer health and over abstractions for irrigation and other sectoral needs. The low base flows on other hand adversely impact aquatic biodiversity, groundwater levels and other riverine characteristics and associated ecosystems. This appeals for maintaining Environmental Flows in the river. Environmental Flows of a river maintains the ecological integrity of the river, their associated ecosystems, and the goods and services provided by them to people, flora and fauna. WWF-India has been working towards the adoption of sustainable water abstraction policies and practices leading to the maintenance of Environmental Flows in the Ganga and its key tributary, the Ramganga.

WWF-India's E-Flows work (since 2008) in the Upper Ganga (from its origin up to Kanpur) focused on developing, improvising and testing an E-Flows Assessment (EFA) methodology. E-Flows work in Prayagraj, Uttar Pradesh during Kumbh in late 2012 and 2013, undertook some additional steps pertaining to actual flows monitoring in the Ganga and comparing it with the recommended E-Flows for the Kumbh. Following this, WWF-India and its partners felt that it was imperative to pilot the EFA and its implementation in a smaller river system to build a base for demonstrating various mechanisms for the realization and monitoring of E-Flows. It would thus effectively strategize on implementation of the mainstreaming of E-Flows, both at river-system scale and at national levels. It was also important to address the concern "where will the water come from and what are the trade-offs?". River Ramganga, a major tributary of River Ganga, was selected for an E-Flows Assessment and pilot demonstration.

This report captures the entire process of the Ramganga E-Flows Assessment, with a trade-offs analysis. The work builds on the lessons learnt from the E-Flows assessment in the Upper Ganga (2008-2010) and in River Ganga during Kumbh (2013) at Prayagraj, with further improvisation in EFA strategy and approach namely:

- Adopted 'River Health Categories' (RHCs) concept with clear-cut qualifiers for each category substituting the 'Environment Management Classes' (EMCs) concept.
- Instead of considering water pollution as a theme, the team developed River Health, a holistic phenomenon as a thematic including water quality assessment, catchment health and biomonitoring.
- Instead of one E-Flows regime recommendation, three scenarios corresponding to various river health categories for each site was suggested for the 'water-managers' and 'decision-makers' to consider, namely:
 - o Improved scenario – a long-term vision.
 - o Target scenario – a minimum immediate need to improve the health of the river.

- o Additional Use scenario – an inevitable scenario, if the trajectory continues in a ‘business-as-usual’ manner.
- The number of sites in this assessment were increased from the previous EFA exercises, for detailed year-long thematic field studies.
- A stakeholder process was built in at various stages of the assessment to record the aspirations of the riparian stakeholders..

The earlier exercise of E-Flows assessment for Upper Ganga was conducted by various international and national experts. However, Ramganga E-Flows Assessment was conducted by local and national experts, under the guidance of an international expert establishing the capacity enhancement at national level in undertaking E-Flows work, which is a valuable outcome of this process.

THE RAMGANGA AND ITS SIGNIFICANCE

The Ramganga river flows for over 650 km (this figure is based on river surveys by the team, though some literature reports figures of 600 km or 596 km), predominately in a southerly direction until it joins the Ganga at Tehra Ghat village, Hardoi district, Uttar Pradesh. The mean annual regulated flow at the basin outlet is around 6.3 billion cubic metres (BCM) which is 2% of the total water resources of the Ganga. The total utilizable groundwater resource in the basin is approximately 5.6 BCM, and around 73% of that resource is presently abstracted, with groundwater taken both for irrigation purposes but also to supplement or replace domestic water supply systems. The Ramganga is a microcosm of the Ganga in many ways, encountering similar challenges as the Ganga; albeit at a smaller scale, but with a potentially similar severity of impact. River Ramganga is an abode of Golden Mahseer in the upper reaches of the Himalayas and supports a diverse fish base of Indian Major Carps in the plains. Besides this, the river supports several species of turtles and the gharial; dolphins have also been sighted in the lower reaches of the Ramganga, in and around Dabri during the monsoon season.

The Ramganga is a ‘near-pristine’ river in the lower Himalayas (100 kilometers from the origin) until it reaches the foothills, where it starts facing fragmentation at Kalagarh Dam, abstractions at the Hareoli Barrage (for the Lower Ganga Canal and other canal systems), sewage and industrial pollution from Kashipur, Moradabad, and Bareilly; encroachment, over-abstraction of groundwater, degradation of wetlands and other unsustainable activities leading to reduced recharge and potentially reduced base flows. Despite this, before the confluence with the Ganga, the Ramganga restores its river health to some extent, which is evident from the fact that Dabri is a reasonable habitat for some of the native aquatic species of the Ramganga. For several decades, the Ramganga’s water resources have been directly supporting or supplementing the irrigation needs of the farms. The water resource has been indirectly extending similar services by recharging groundwater levels and sustaining the wetlands and ponds close to the river and its tributaries.

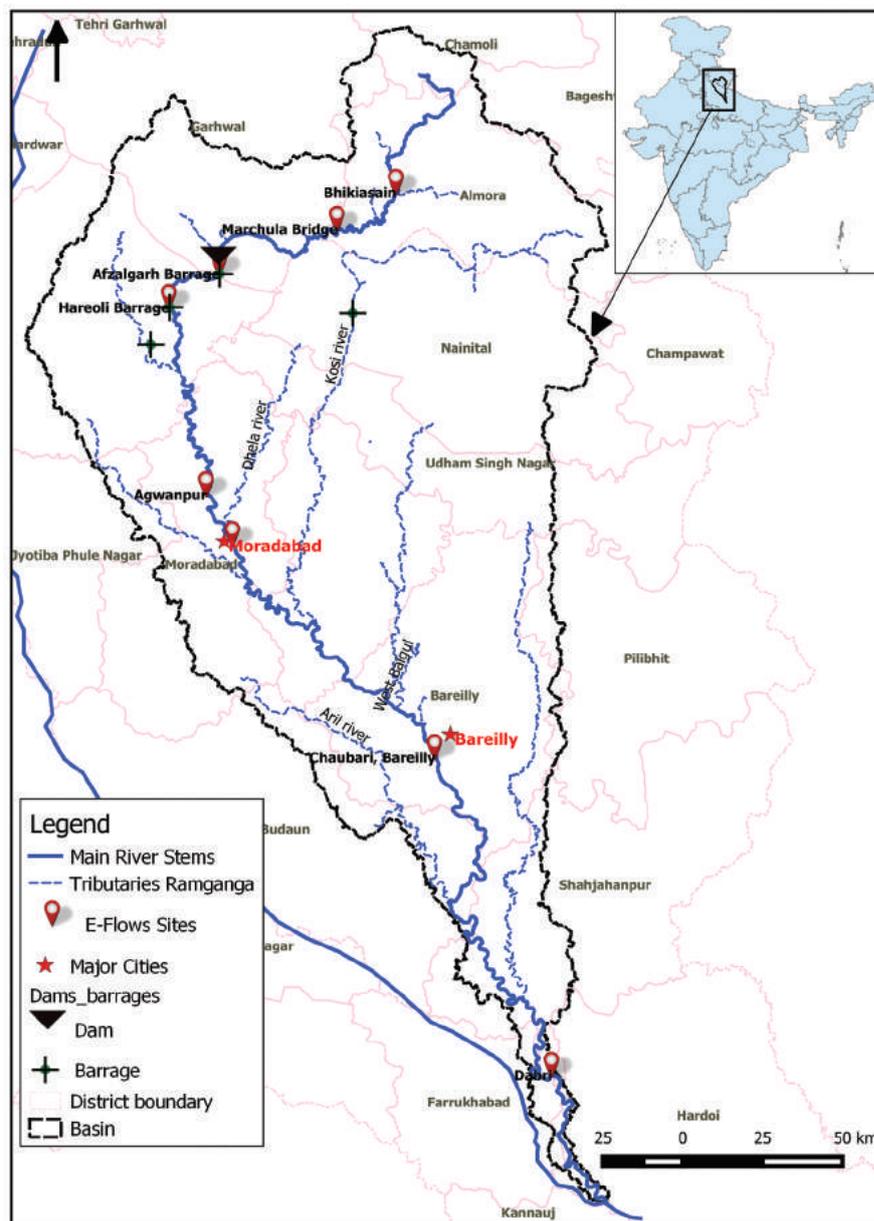
The water released by the Kalagarh dam downstream to the Hareoli barrage is diverted into an 82 km long feeder canal taking the water (1,380 MCM, Million Cubic Meter) to the Ganga. This feeds/supplements the command areas of the Lower Ganga Canal system, which is located outside the Ramganga basin, though in the state of Uttar Pradesh. Diversions to the Lower Ganga Canal represent around 84 percent of water availability at the Kalagarh dam and 22 percent of water available at the outlet of the basin. The Ramganga’s water resources from the Kalagarh Dam, beyond any doubt, contribute to the farm economy in the basin space and beyond. However, there is insufficient amount of water available in the river downstream of the Hareoli barrage from early November to early June, which has led to the deterioration of the river’s health.

RAMGANGA E-FLOWS ASSESSMENT

Eight locations of the Ramganga River were identified for detailed all-season field investigations from the perspective of aquatic biodiversity, fluvial geomorphology, river health, socio-cultural and livelihoods aspects, while hydrology and hydraulic modelling remained the backbone of the study. The sites were:

1. Bhikiasain
2. Marchula
3. Downstream of the Afzalgarh Barrage
4. Downstream of the Hareoli Barrage
5. Agwanpur
6. Katghar at Moradabad
7. Chaubari at Bareilly
8. Dabri

A map depicting locations of detailed field investigations as part of Ramganga EFA are shown in the following figure.

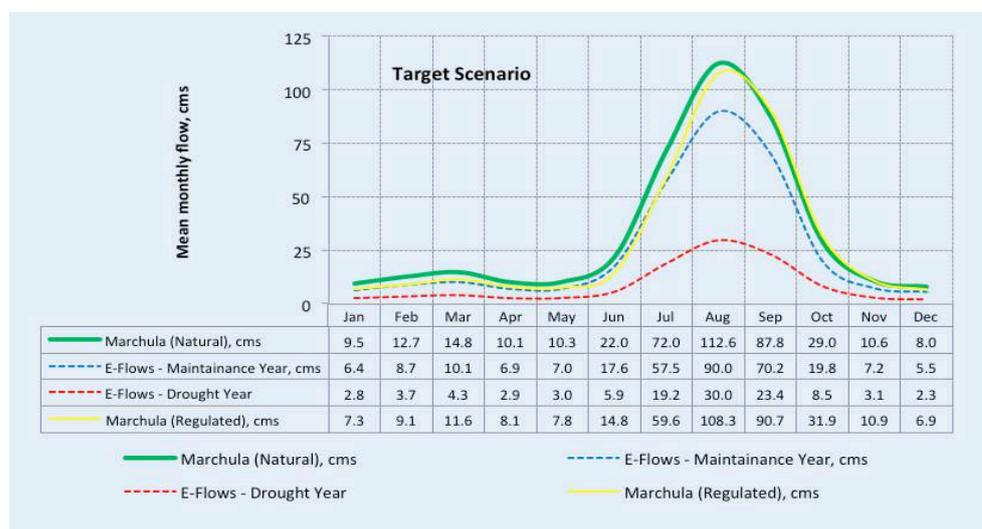
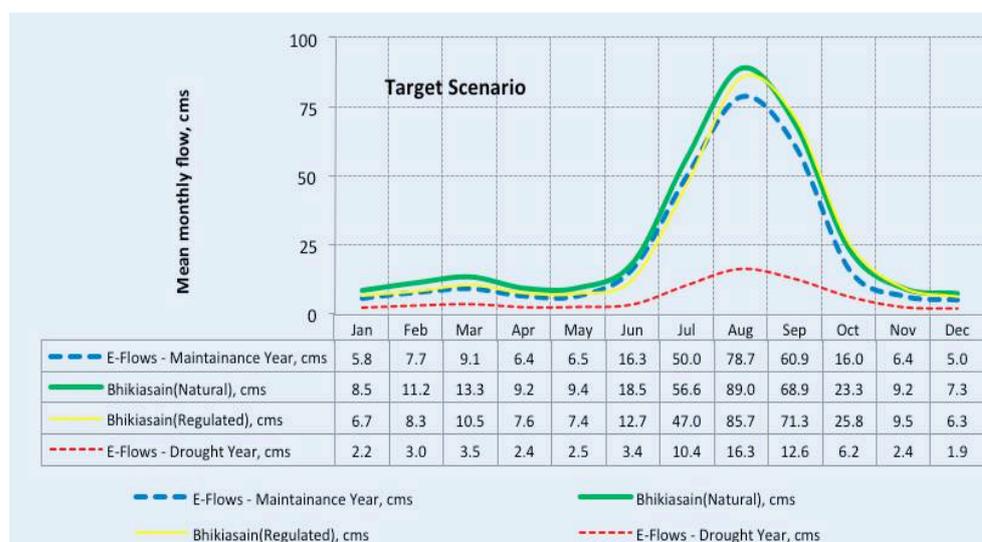


While three scenarios (i.e., Target, Improved and Additional Use) were developed for all the sites (barring a few sites, due to site-specific complexities), and the same are presented in the chapters, here in the executive summary only the ‘Target’ scenario is given for recommending E-Flows at critical sites.

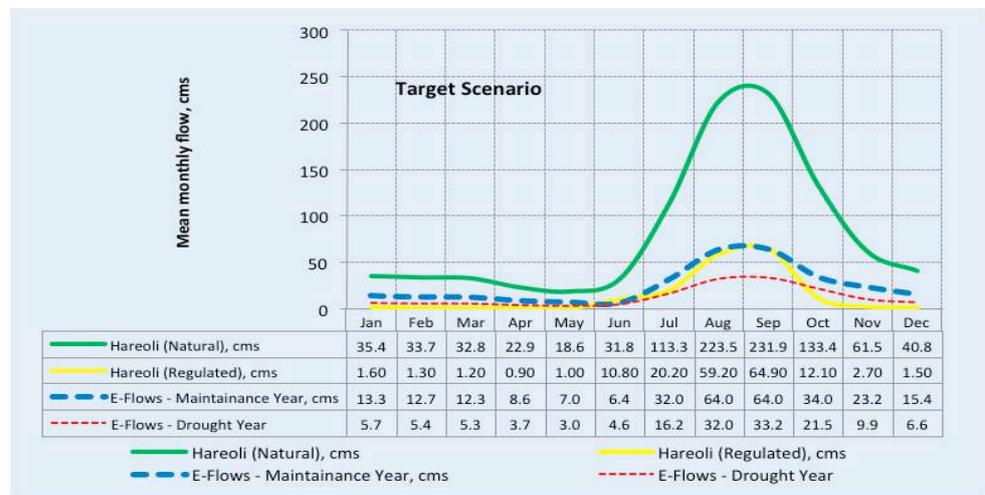
Target Scenario graphs of downstream of Hareoli barrage, Katghar at Moradabad, Chaubari at Bareilly and Dabri.

- Bhikiasain:** At this site, the E-Flows for the maintenance year (a normal year – not very dry and not very wet) for this site is met across all the months in a year.
- Marchula:** Similar to the scenario in Bhikiasain, the present-day flows at Marchula fulfil the E-Flows requirements as the thematic group was satisfied with present-day flows.

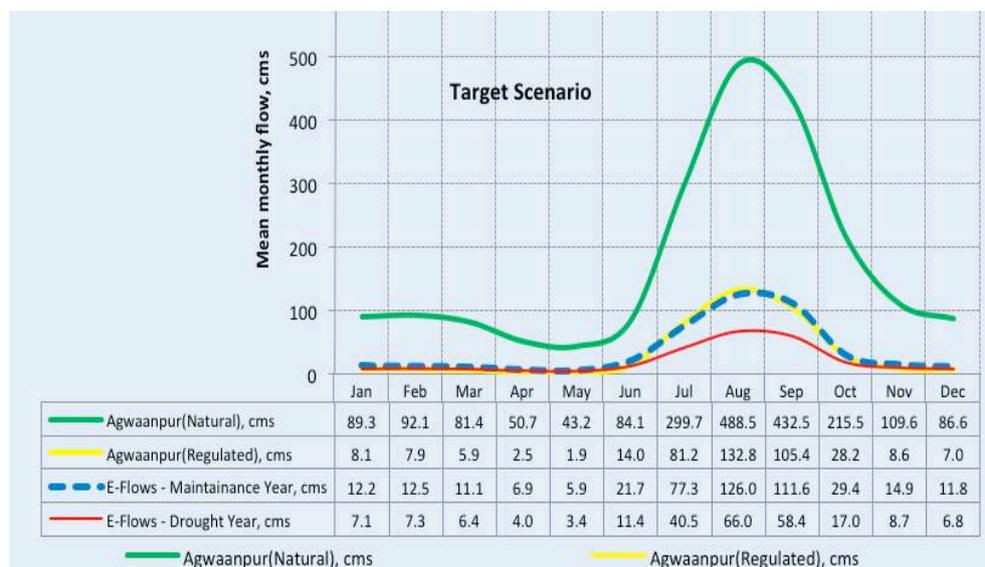
Both Bhikiasain and Marchula are indicative of ‘reference’ conditions and are observed to be relatively intact, sustaining most of the ecosystem functions. The intactness of these sites is going to be critical for the health of Ramganga and it is worth recognizing that the current state of river health should be maintained at these two sites in the future.

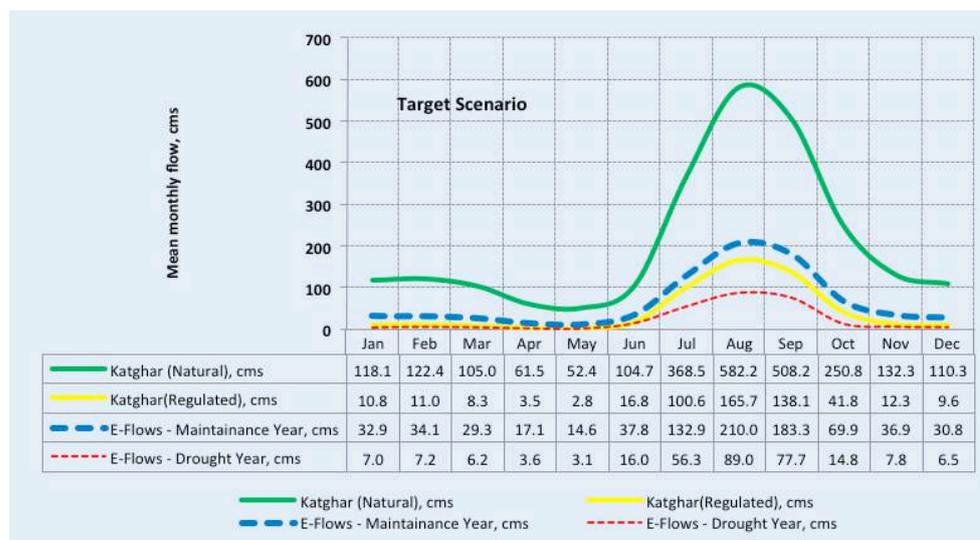


3. **Downstream of the Afzalgarh barrage:** E-Flows assessment for this site was not conducted, as communities living in close vicinity of this site were more concerned about the sudden releases from the dam (given its location, just downstream of Kalagarh dam). Accordingly, the team suggested measures around early warning systems and flood forecasting mechanisms for this site. The current flows regime at this location is practically opposite to the natural flow regime as the released flows are driven by seasonal irrigation demand. During the lean season, there is water in the river at this location to meet the irrigation water needs. However, during wet season, the site has less water due to little release from the dam gate, except when the water level in the dam reaches its desired level.
4. **Downstream of the Hareoli barrage:** This is one of the most critical sites in the Ramganga river, particularly in terms of water quantity. The graph indicates that the E-Flows requirements are not met throughout the year, except for the month of June and September.

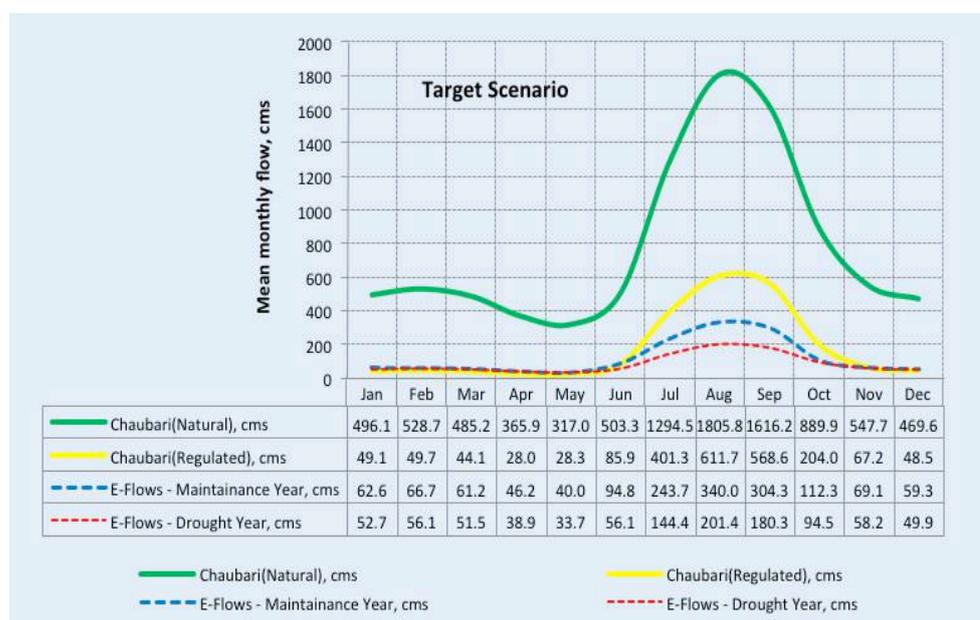


5. **Agwanpur:** This is the most difficult site in terms of hydrology and hydraulics due to local factors. The left side of the river bank is low lying and this is not a gauged site. However, the site is crucial as it is located upstream of Moradabad city, where the river undergoes major change owing to anthropogenic activities. With these complexities, the team recommended E-Flows for this site and the present-day flows are meeting E-Flows requirements only during two months of the wet season, i.e. July and August.

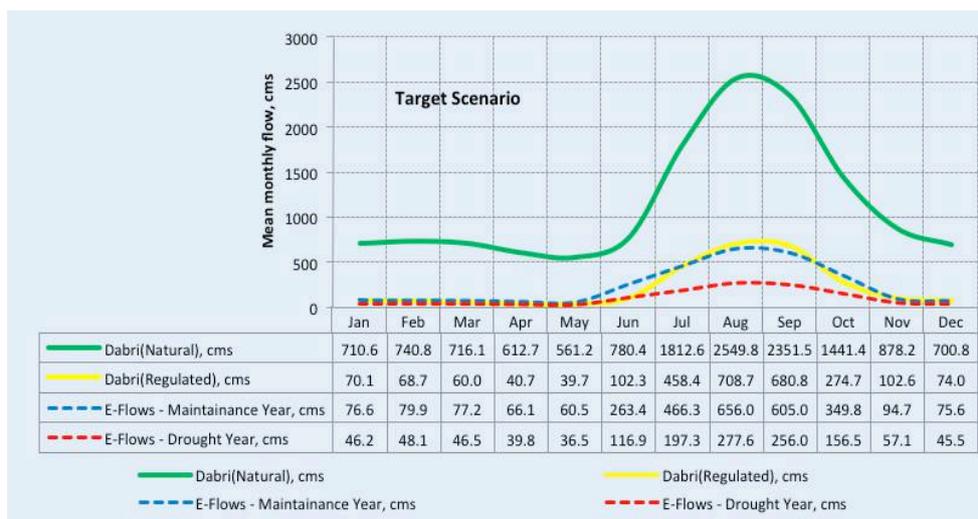




6. **Katghar at Moradabad city:** This is one of the most critical sites in terms of water quality and quantity. It is also the second-most important site from a socio-cultural perspective. The river health at this location is unsatisfactory and as per the above graph, the current flows regime is unable to meet the E-Flows requirements through the year.
7. **Chaubari at Bareilly:** One of the important sites from a socio-cultural perspective. Given that a barrage is being constructed downstream of this site, it becomes a critical site for the study. The present-day flows are able to meet the E-Flows requirements from July to October only.



8. **Dabri:** The last E-Flows site on Ramganga, where the health of the river improves marginally from that of the sites upstream. The national aquatic animal- Ganges River Dolphin has been spotted close to this site during the wet season, so upkeep of this site is crucial. The site is also a good habitat for the Indian soft shell turtle, *Nilssonina gangeticus*; which is recorded only near the confluence of Ramganga and Ganga. As indicated in the adjoining graph, the present-day flows are not meeting E-Flows requirements from October to July. E-Flows requirements are met only for August and September.



The key motivation that prevailed in mountainous sites (Bhikiasain and Marchula – both in Uttarakhand) was largely related to the aquatic biodiversity aspects, i.e. fishes, their prey base, habitat conditions and life-phase requirements. Amongst the fishes, the Golden Mahseer has been one of the key considerations. The thematic group looking at socio-cultural and livelihood aspects concentrated on non-consumptive water uses and cultural rituals like bathing, cremation and worshipping. For the sites in the plains, Indian Major Carps and some native species were the key consideration from the aquatic biodiversity perspective. For the most downstream site, Dabri, the dolphins are also a factor in motivating E-Flows requirement during the wet season. At Chaubari and Katghar, the socio-cultural considerations played an important role in motivating E-Flows requirements.

Various aspects of geomorphology including the longitudinal and lateral connectivity, as well as bar complexities were considered for motivating E-Flows for various sites.

UNDERSTANDING TRADE-OFFS

For drawing up an Environmental Flows one-season site-specific demonstration and long-term implementation strategy, it was important to analyze trade-offs between Environmental Flows and already committed water allocations. The team recognized the pertinence of current committed water allocations; therefore, refrained from considering the allocated water for E-Flows. Rather, the team attempted to estimate the amount of water available in the system, after meeting all the committed water requirements. The trade-off analysis was done keeping in-view one-season site-specific E-Flows demonstrations downstream of Hareoli barrage; however, strategies and approaches for long-term E-Flows realization across all the sites in Ramganga are also given in later chapters.

The choice of downstream of Hareoli barrage is an inevitable one, as this is the site which is immediately downstream of major water abstractions, and in the present-day scenario the river from this site is having lesser water. Therefore, any releases from the Hareoli barrage is expected to bring appreciable and notable change in the river health at this site.

ROAD MAP FOR IMPLEMENTATION

The Government of India and the National Mission for Clean Ganga has recognized 'aviral-dhara' or uninterrupted flows as one of the visions of the flagship *Namami Gange* programme, which aims to rejuvenate the Ganga. This has been one of the most welcomed policy declaration by the government.

Based on the E-Flows assessment and trade-offs analysis, a set of short-, medium- and long-term actions needed for restoring E-Flows, covering social, technical, policy and institutional aspects were developed. It builds on the experiences of Environmental Flows restoration across the globe.

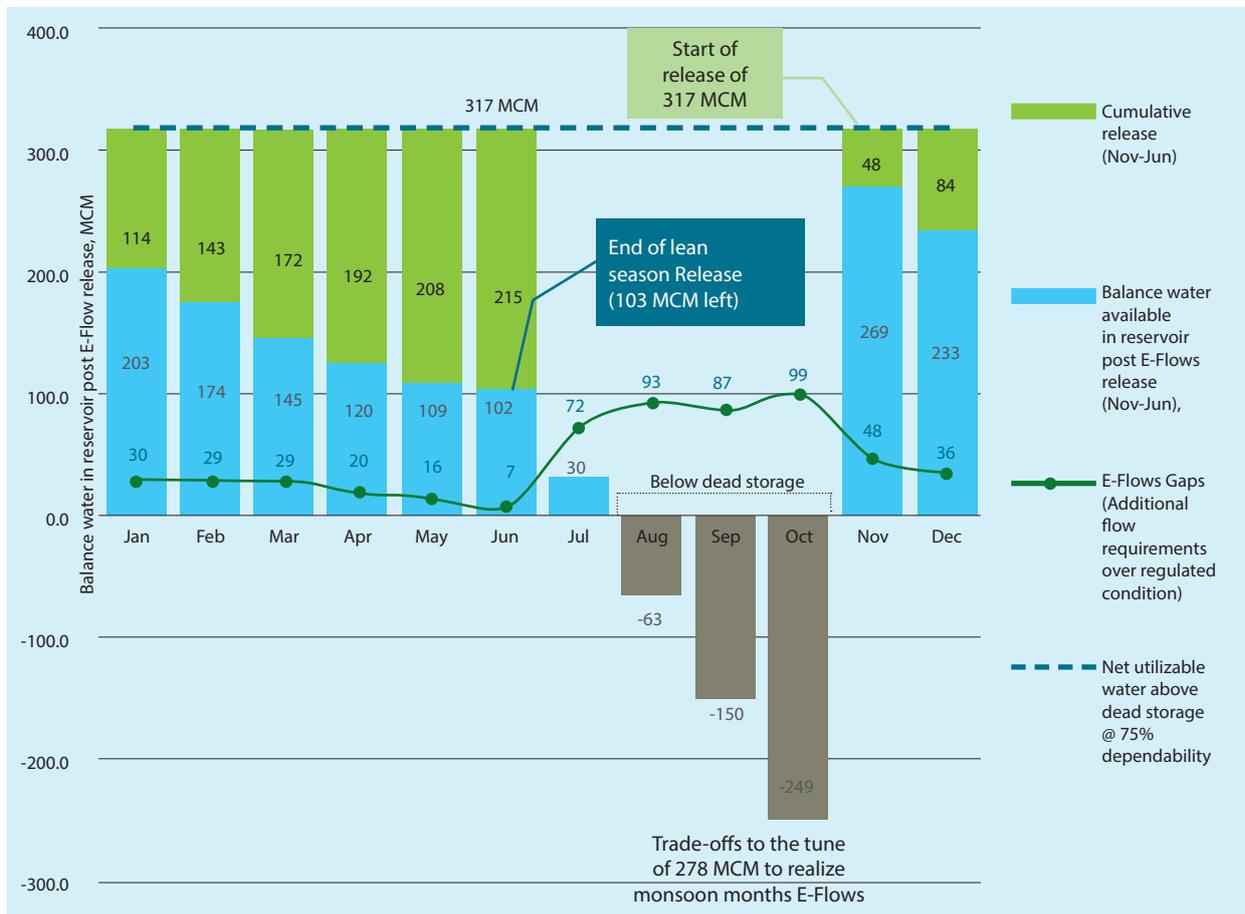
Two strategies are presented below:

1. A proof-of-concept demonstration of lean-season E-Flows downstream of the Hareoli barrage

Downstream of the Hareoli barrage is one of the sites chosen for the trade-offs analysis exercise, particularly since this site is only 20km from the Kalagarh dam and any releases from the dam will show appreciable benefit at this site (i.e. downstream of Hareoli barrage). Such a demonstration will be useful for all the stakeholders to validate the framework suggested and to evaluate the benefits in terms of River Health. This will also help the U.P. Irrigation and Water Resources Department as well as others to review and strengthen a long-term plan for E-Flows restoration in the Ramganga. The trade-offs for the demonstration of E-Flows downstream of the Hareoli barrage takes three aspects into account:

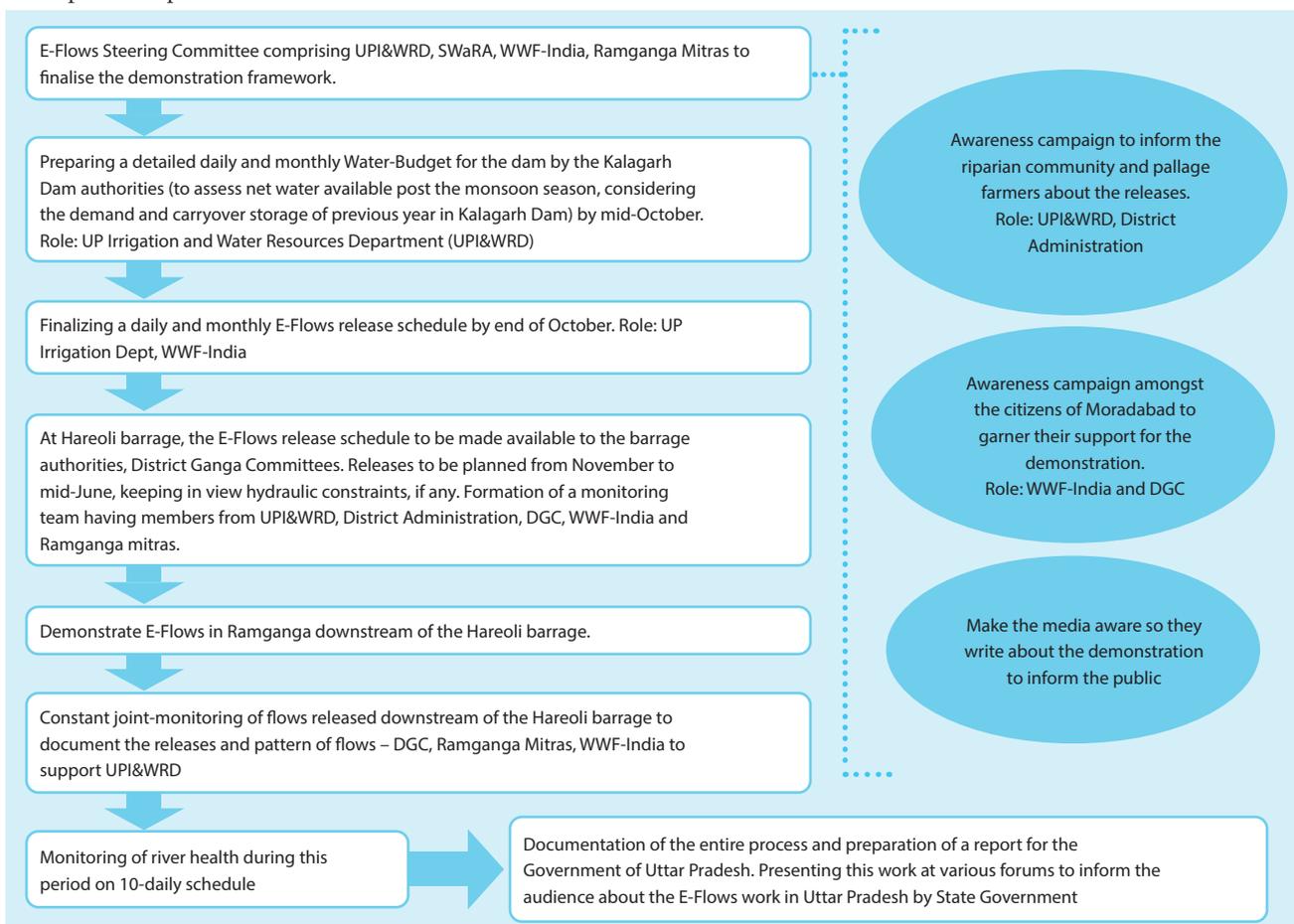
- a. Long-term water availability in the Kalagarh dam,
- b. Water required to meet all the committed uses,
- c. Available water in the dam above the Dead Storage and Normal Depletion levels

Based on this analysis, it was concluded that E-Flows at this site can be demonstrated for the entire lean season, starting from November to mid-June without affecting any current arrangement and commitment. This is depicted in the following graph.



Roadmap for demonstration of E-Flows

A Prospective Implementation Plan



As a first step towards implementation of E-Flows in the Ramganga, a demonstration pilot is proposed.

2. Long term E-Flows strategy

A long-term sustainable E-Flows strategy for a river like Ramganga, where surface-water and ground-water interaction is very strong (and not well understood) will require a combination of social, technical and institutional interventions. The final chapter in this report rather elaborates on each of these aspects:

a. Social

This calls for a strong demand management looking at irrigation water-use efficiency and yield enhancement, soil-health management in the command area of irrigation systems dependent on the Ramganga water resources. This will require large-scale awareness and capacity-building programmes for farmers with assistance from the agriculture extension systems.

b. Technical

Under this aspect, the ‘supply-side management’ needs to be focused, i.e. to consider rehabilitation and modernization of tertiary-level irrigation infrastructures (minors-outlets) that withdraws water from the Ramganga. Additionally, there will be a need to promote conjunctive use (of surface water and ground water for irrigation) along with groundwater regulation to support the base-flow contributions to the Ramganga.

c. Institutional

The implementation of the U.P. Participatory Irrigation Management (PIM) Act and promotion of water-use efficiency through Water Users Associations (WUAs) are going to be critical measures under this sub-head. Besides this, the concerned District Ganga Committees will be able to play a critical role in this initiative.

WAY FORWARD

As discussed, trade-offs for lean season E-Flows demonstration downstream of Hareoli barrage is manageable. Though long-term E-Flows implementation across different sites on the Ramganga will be a complex journey, there is hope that a combination of approaches can actually realise flows in the Ramganga. As a first step, WWF-India and its partners plan to engage and work with the NMCG and the Government of Uttar Pradesh and the UP State Irrigation and Water Resources Department in designing the E-Flows demonstration in Ramganga and making it operational. This will be the first of its kind organized E-Flows demonstration in India, and the state of Uttar Pradesh can lead the national and global discourse on E-Flows.

The E-Flows releases downstream of the Hareoli barrage would be critical to improve the health of river Ramganga, therefore as the first step, an E-Flows demonstration needs to be undertaken for one lean season, starting from November to May. A detailed plan of this is presented in Chapter 5. WWF-India, Ramganga Mitras, District Ganga Committees and the U.P. Irrigation and Water Resources Department will closely monitor and record the changes in the river system at this site, as well as at the Katghar site at Moradabad mainly to ascertain the benefits that will be achieved in terms of the health of the river Ramganga.

The integration of E-Flows requirements into the Ganga River Basin Management Plan (GRBMP) has been a stepping-stone in the recent past. It is envisaged that a long-term win for the E-Flows discourse would be its integration into basin-planning exercises at different river basins. As a long-term strategy, E-Flows needs to be integrated into the planning and policy discourse for water resources management at different levels, including at the national and state levels. One way is to have a comprehensive Ramganga River Basin Management Plan which integrates E-Flows in the water allocation policies.

Both the state and central governments, through their various schemes and programmes, are facilitating water-use efficiency enhancements. Many of these schemes, if implemented, could deliver the vision of rivers with '*aviral jal pravah*'.

We hope that this report will move the discourse on Environmental Flows from assessments to implementation in Ramganga and other rivers. As seen, it is important to understand the trade-offs and work out approaches to manage such trade-offs, if any. WWF-India and its partners remain committed to work with decision-makers and water-managers as well as all stakeholders to move on this path and realize the vision of healthy rivers in the country.

1



श्री मदनसिंह विष्ट
• उदयसिंह विष्ट
• बलवंरसिंह विष्ट
• पदमसिंह विष्ट
• प्रतापसिंह विष्ट
• कृपालसिंह विष्ट

उदघाटन 2005
श्री मदनसिंह विष्ट
तारा
निर्माण किया
ग्राम - मरोडा

The Ramganga Basin: Background and the Need for Environmental Flows (E-Flows)

1.1 The Ramganga Basin - Background

The river Ramganga¹ originates in the Central lower Himalayas (Lat.30.1005'N, Long.79.2834'E, altitude 2158 metres above mean sea level), extends into the alluvial Gangetic plains and drains into the Ganga at 122 metres above mean sea level (AMSL), after traversing over 650km.² The Ramganga, a spring-fed river, is the first major tributary to join the Ganga at its left bank. The Ramganga contributes about 3 per cent (which is about 17.2 BCM/annually)³ of utilisable surface water resources to the Ganga. The Ganga is a mighty river with about 2,525km long main-stem and a basin area of about 25 per cent of the country's land mass, whereas the length of the main-stem of river Ramganga is about one-fourth of the Ganga, i.e., over 650km. The length of River Ramganga, as per Central Water Commission (CWC) Ganga Basin report (see endnote 3) is 596km. However, with such dynamic river systems, the length of the river is always fluctuating, as the course of the river often witnesses channel shifting over the years and natural meandering processes which leads to marginal reduction or enhancement of its length. CWC has estimated the length of the river to be 596km, which is an old figure and thus needs updation. It would not be surprising that later studies down the line may suggest slightly varying length of the river Ramganga, than the one quoted in this study.

Figure 1.1: Ramganga in mountainous reach



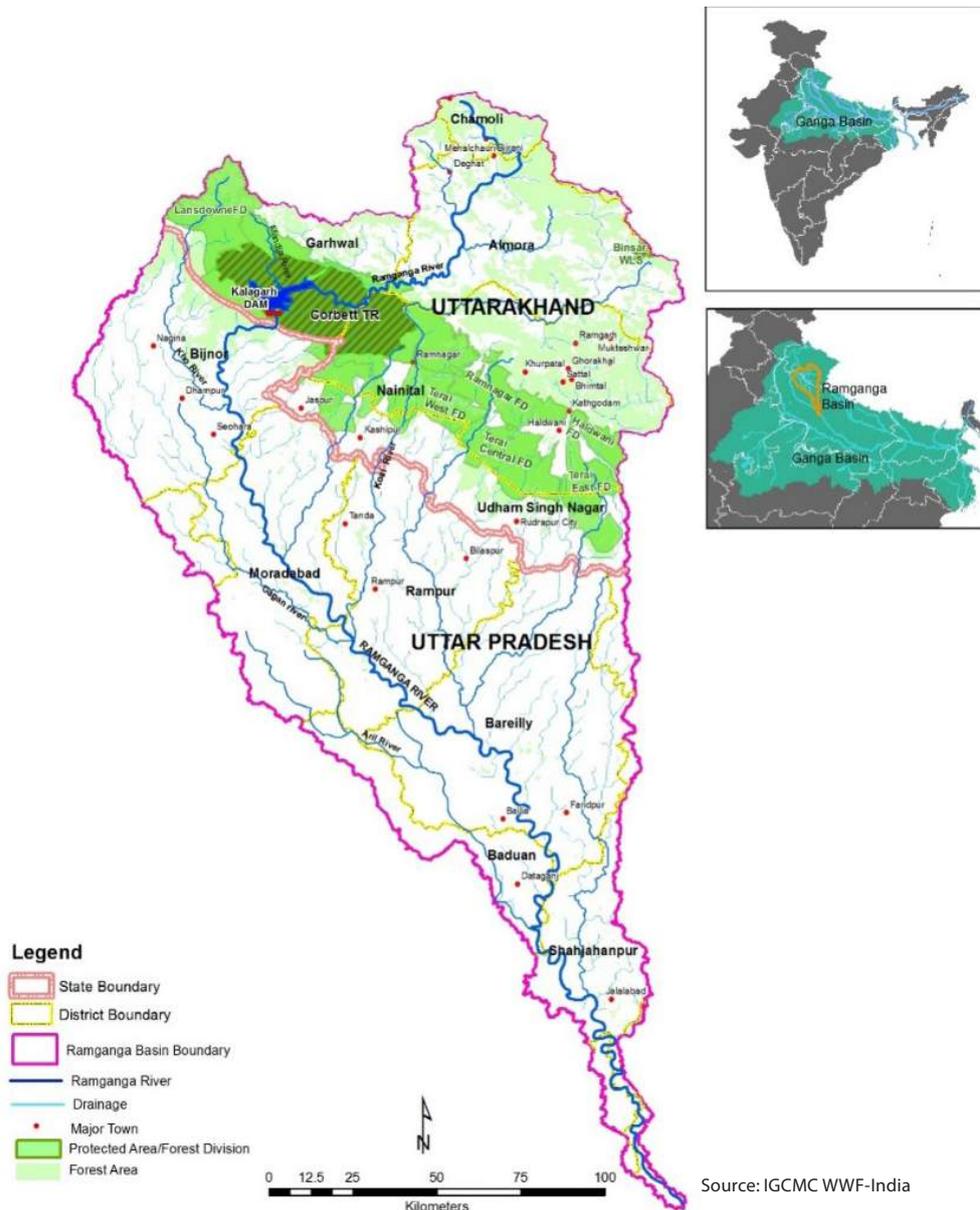
Photo Credit: Nitin Kaushal/WWF-India

In many ways, the river Ramganga is a microcosm of the Ganga, for instance, both the Ganga and the Ramganga face challenges of fragmentation, in its headwaters due to abstraction that affect its flow, and pollution, in the upper to middle stretch. The Ramganga also has socio-cultural dependencies like the Ganga, though these are by no means as massive as that of the Ganga.

The Ramganga basin supports a population of about 18.36 million,⁴ which is heavily dependent on groundwater irrigated agriculture. The main-stem and its tributaries are regulated with dams, barrages/weirs and associated irrigation canal network. Inter-basin water transfer from the Ramganga basin to the Ganga basin and from the Sarada basin to the Ramganga basin has been commissioned, and its management is critical to current and future water resources management in the region. These control structures, on the one hand have moderated the effect of flooding in the region, they, on the other hand, have also created obstructions in the river's flow regime. This has led to reduced flows downstream of these structures, and thus have impacts on the assimilative capacity of the Ramganga.

A map of the Ramganga basin is given as Figure 1.2 below. In the inset there are two smaller maps, one showing the location of the parent basin, i.e., the Ganga basin, on the

Figure 1.2: The Ramganga Basin



Source: IGCWC WWF-India

Figure 1.3: The Ram Darbar Temple underneath of which the 'Ram-Nali' appears roaring; this place is believed to be the origin of the Ramganga source stream



Photo Credit: Nitin Kaushal/WWF India

map of India, and the other giving the location of the Ramganga basin within the Ganga basin.

The location where the river appears on ground joining two streams — one from left and another from right — is in Kali Maati village, in Gairsain tehsil of Chamoli district of Uttarakhand. The exact place of the origin of Ramganga seems to be from Dudhatoli ranges under Bamiala forest in Diwalikhal. Over there 'Ram-Nali' is located in a temple which is believed to be the source of the Ramganga. This local belief also has a scientific logic, as once this tiny stream joins a comparatively bigger spring at the valley, it becomes the Ramganga River, and even before major tributaries joining the river, several seasonal springs join the main course of the river. In reality, during lean season when most of the springs dry out, it's only the 'Ram-Nali' that carry water, and this ensures the perennial nature of the river. Local communities insist that this has been the trend from centuries.

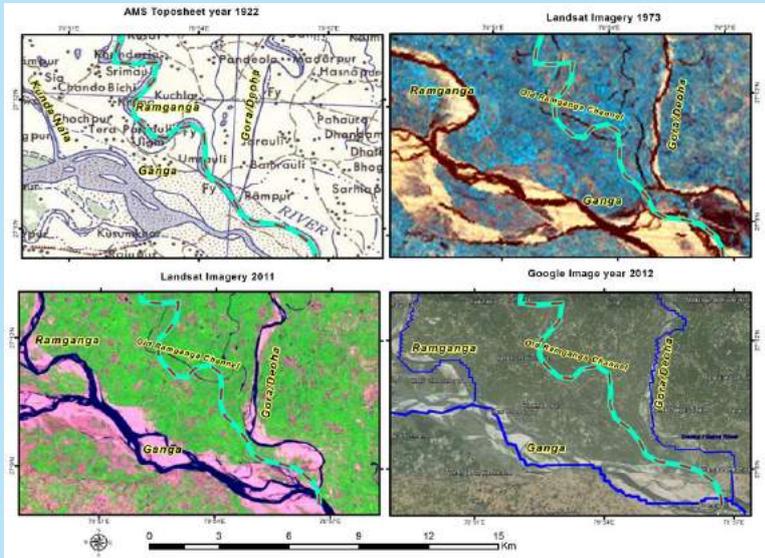
Box 1.1: Ancient Names of Ramganga

According to the Manas Khand,⁵ the Ramganga possesses 'the seventh part of the virtues of the Ganga; its sands are golden and in it are many fish and tortoises'. Alternative names attributed to it are 'Rathabahini', 'Suvarna', and 'Saravati'.

The major tributaries of River Ramganga include Binao, Gagas, Badangad, Mandal, Sona, Playan, Khoh, Gaagan, Dhara, Pili, Phika, Dehla, Kosi, West Baigul, Aril and East Baigul. The Ramganga joins river Ganga, at Tehra Ghat village in Bilgram tehsil of Hardoi district. The Ramganga traverse through two states, i.e., Uttarakhand and Uttar Pradesh, thus becomes an inter-state river system.

As per the *Ganga Basin* report of the Central Water Commission (CWC), the basin area of Ramganga is 30,839km². The report considers the Deoha river as a tributary of Ramganga, whereas in reality, Deoha directly joins river Ganga and thus the entire sub-basin area of river Deoha should be considered out of the Ramganga basin area. This aspect has been verified through satellite imageries at varying timescales and field verifications by the project team. This is discussed in detail in Box 1.2.

Box 1.2: Ramganga and Deoha rivers



It is worth mentioning at this juncture that in many formal documents, it is found that, the confluence of the Ramganga River is reported in Kannauj district and that the Deoha (Garra) River is considered a tributary of the Ramganga, which is factually incorrect. Extensive field surveys and deliberations with local water resource experts of that area and local communities highlight that river Deoha is a direct tributary of the Ganga and joins Ganga much after the confluence of Ramganga with Ganga at the Tehra Ghat village.

The study by Roy and Sinha⁶ has shown that both upstream and downstream movements of two major confluence points in the Ganga plains namely, the

Ganga–Ramganga and the Ganga–Garra confluences have occurred several times over a century-scale period. The net movement of the confluence points is as large as 20km in the case of the Ganga–Ramganga confluence. The Ramganga presently meets the Ganga more than 10km north of Kannauj and the Ganga–Garra confluence is located further 10km downstream.

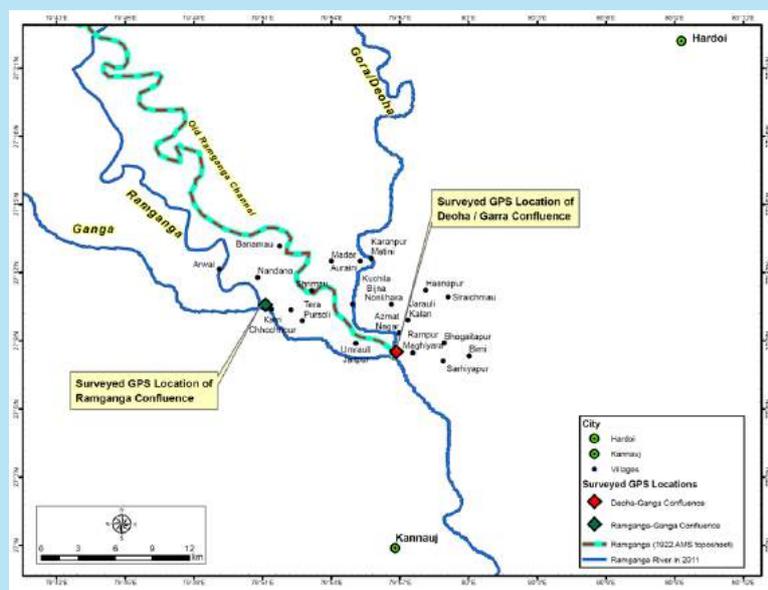
In order to further investigate these two different viewpoints, different editions of the Imperial Gazetteer of India⁷ (Meyer, William Stevenson, Sir, 1860-1922. Burn, Richard, Sir, 1871-1947. Cotton, James Sutherland, 1847-1918, Risley, Sir Herbert Hope, 1851-1911) were studied. The Gazetteer did mention that, Deoha is a tributary of the Ramganga. Along with this, the Survey of India toposheets of 1922, Landsat Images of three time periods, viz., 1973, 1990 and 2010, and 2012 Google images were taken into consideration.

In the 1922 toposheets, it can be seen that, Deoha joins Ramganga, but in all other imageries it directly joins Ganga and is thus no-more a tributary of Ramganga. This was later corroborated through field visits.

The following figure informs present scenario (2014), which was prepared after overlaying (physically taken) GPS coordinates (of Ramganga and Deoha confluences into Ganga) onto the map. The figure clearly establishes that river Deoha is a tributary of the Ganga and not of the Ramganga.

The whole idea of bringing this point in this report is that, if river Deoha is excluded from the Ramganga basin then there is significant reduction in terms of the Ramganga basin area and thus the run-off contribution to the parent channel, i.e., the Ganga. It is hoped that, with the help of this fact-finding exercise, the formal documentation will be revised.

(Source: Ramganga Basin Zonation report, INRM Consultants)



In view of above discussion, the Ramganga basin area is actually 25,028km² and spreads across Uttarakhand (12 per cent) and Uttar Pradesh (88 per cent).

1.2 The Ramganga Basin—Water Resources and their Utilisation

Ramganga water resources are allocated for irrigation and power generation. Most of these allocations are made for areas outside the basin. A major proportion of irrigation and domestic water supply within the basin are supported by groundwater. This sub-section deals with the supportive aspect of the Ramganga.

1.2.1 Irrigation and Hydropower

In the upper stretch of the river there are few minor lift schemes meant for supplementing small-scale irrigation and for domestic water requirement in the hilly areas of Uttarakhand. Under these schemes, water is directly lifted from the river with the help of pump-sets (as shown in Figure 1.4). These lift schemes operate between areas close to the origin of Ramganga till Marchula (upstream of Corbett National Park).

Since the 1970s, starting with the Kalagarh Multipurpose Project, there has been alteration in the flows of river Ramganga.

Figure 1.4: Direct lifting of Ramganga waters from the river for usage. This site is between Chaukhutia and Marchula (upstream of Corbett National Park)

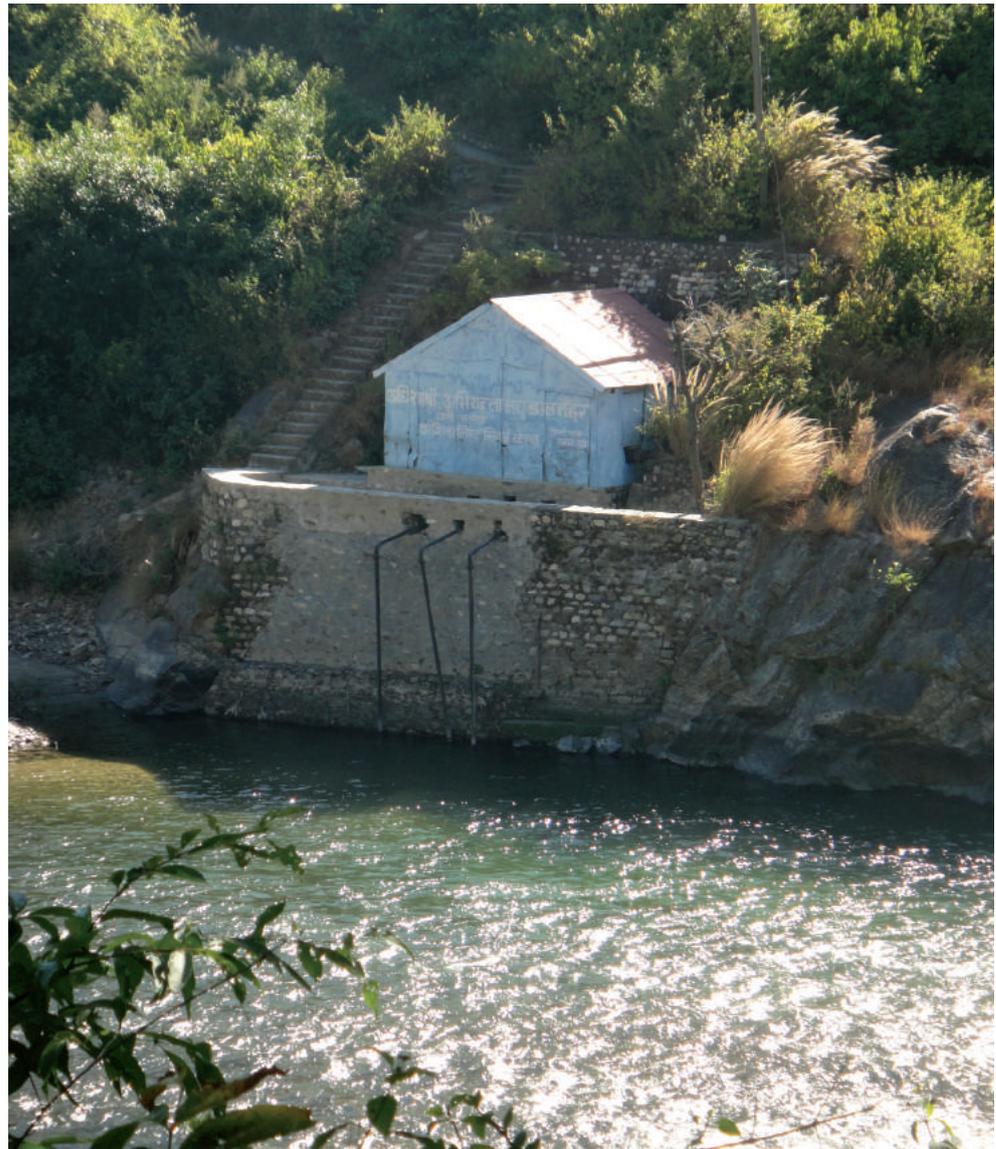
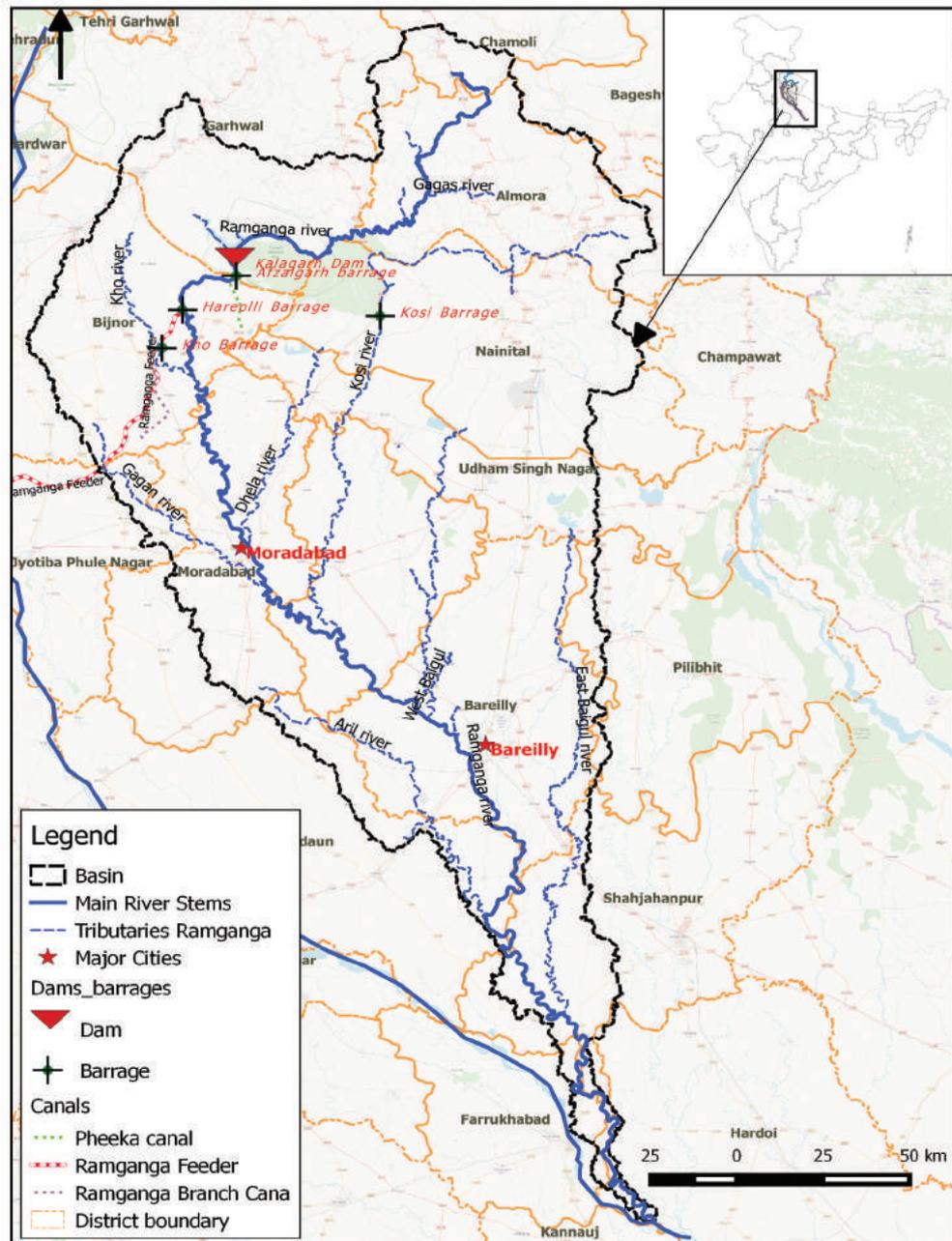


Photo Credit: Nitin Kaushal/WWF India

Table 1.1: Key Features of Kalagarh Multipurpose Project

S. No	Item	Description
1	Purpose	Flood moderation, irrigation, hydropower generation
2	Type	Earth & Rockfill
3	River	Ramganga
4	Height	128 meters
5	Length	630 meters
6	Kalagarh reservoir capacity	2,400 MCM
7	Irrigation diversion	156 cumec (142 cumec to Lower Ganga Canal through feeder and 14 cumec to direct irrigation systems (Pheeka Doab and Ramganga Main Canal) – (see Figure 1.5)
8	Installed Capacity	198 MW (66 MW x 3)

Figure 1.5: Ramganga Basin and its Salient Features



Source: WWF-India

Table 1.1 above lists some of the key features of the Kalagarh Multipurpose Project, along with major interventions in the upper stretch of the Ramganga mainstem. At present, there are three major interventions, i.e., Kalagarh Dam, Hareoli Barrage (on the Ramganga river) and Kho Barrage (on the Kho river). Immediate Downstream of the Kalagarh Dam, there is a structure which is half weir and half barrage, called 'Afzalgarh-Barrage' through which Phika irrigation canal system takes off.

Box 1.3: Transfer of Ramganga Water Resources for supplementing irrigation in Lower Ganga Canal

The inter-basin transfer (Figure 1.5 and 1.6) was a well thought out strategy for supplementing the irrigation deliveries in the Lower Ganga Canal command, with the added advantage of flood moderation to parts of Bijnor and Moradabad districts as a whole. The inter-basin transfer deprives the Ramganga basin of its own water resources, thereby diminishing its flows downstream of the Hareoli Barrage, from where the Feeder Canal takes off.

Whilst the irrigation and flood protection benefits are mainly for the State of Uttar Pradesh, and is managed by the UP Irrigation and Water Resources Department (UPI&WRD), the hydropower generation benefit is meant for the State of Uttarakhand, which is managed by Uttarakhand Jal Vidyut Nigam Limited (UJVNL). This was decided at the time of the formation of Uttarakhand as a separate state from Uttar Pradesh in the year 2000.

The inter-basin transfer deprives the Ramganga basin of its own water resources, thereby diminishing its flows downstream of the Hareoli Barrage, from where the Feeder Canal takes off.

Figure 1.6: Inter-river Water Transfer: Ramganga and Ganga rivers



Graphic Credit: Nitin Kaushal/WWF India

Besides this, there are several earthen dams and barrages on the tributaries of Ramganga meant for irrigation. Prominent among them are the Kosi Barrage at Ramnagar, Dehla Barrage at Uddham Singh Nagar (to divert water into Tumeria reservoir), Gola Barrage at river Gola, Haripura Barrage on Bhakra, minor dams at Dhaura, Baura and Kichha, the East Baigul Barrage etc. Although these structures do not act as direct intervention on the Ramganga mainstem, they still substantially impact the overall water resources of the Ramganga basin. Table 1.2 below lists the barrages with designed storage capacity.

Table 1.2: Minor Dams and Barrages on the Tributaries of Ramganga

Barrages	River	Average annual water abstraction
Afzalgarh wier/barrage (Uttar Pradesh)	Ramganga	73.3 MCM
Hareoli (Uttar Pradesh)	Ramganga	1600 MCM
Kho (Uttar Pradesh)	Kho	91.6 MCM
Kosi (Uttarakhand)	Kosi	180 MCM
Dehla (Uttarakhand)	Dehla	115 MCM
Kichha & Nagla (Uttarakhand)	Kichha	52.82 MCM
Bareilly (Uttar Pradesh)	Ramganga	725 MCM
Phika Barrage (Uttarakhand)	Phika	75 MCM

1.2.2 Hydropower Generation

The Kalagarh Dam is a multipurpose project, and one of its added benefits is hydropower generation. The designed capacity of this project is 198 mega watt (MW) through three turbines each of 66 MW capacity. The discharge required is 226 cumec.⁸ The hydropower generation from the Kalagarh Dam is dependent on irrigation demand, i.e., when irrigation demand exceeds 30 cumec, water is released from the dam through power houses. Hence the power generation is often lesser than the designed capacity.

1.2.3 Socio-cultural Values

There are some places adjoining the river Ramganga, which have sites of historical and cultural significance. The first is a Ram-Darbar Temple at *Ram-Nali* – the place of origin of Ramganga. Mahal Churi and Bhikiasain are the other two such sites, all located in the hills of Uttarakhand.

In the plains of Uttar Pradesh, there are two other important sites on the banks of the Ramganga, which have significant socio-cultural values, viz., Katghar in Moradabad and Chaubari in Bareilly. Auspicious days include – Jyesth Ganga Dashehra and Kartik Purnima, plus other general festivals that are celebrated on the banks of Ganga are also celebrated on the banks of Ramganga in these locations. During these auspicious days, these sites host several thousand visitors.

The associated study to this aspect reveals a rich diversity of livelihoods, rituals, and other ways in which different groups of people relate to the river.

1.2.4 Terrestrial and Aquatic Biodiversity

About 45km stretch of the Ramganga River flows through the Corbett Tiger Reserve. Within Corbett, and even the immediate upstream and downstream, the Ramganga is not only crucial for aquatic species, but it also quenches the thirst of large terrestrial species (tiger, elephant etc.).



Photo Credit: Nitin Kaushal/WWF India

Figure 1.7: Ramganga at immediate upstream of the Corbett Tiger Reserve (at Vanghat)

1.2.5 Other Critical Aspects

The Ramganga River is vital for domestic water requirements of rural communities living in the towns, villages and hamlets on the banks of Ramganga – though water usage is rampant in the stretch throughout Uttarakhand till upstream of the Moradabad city. From Moradabad, the communities refrain from using water from the Ramganga for domestic purposes, mainly due to water quality issues.

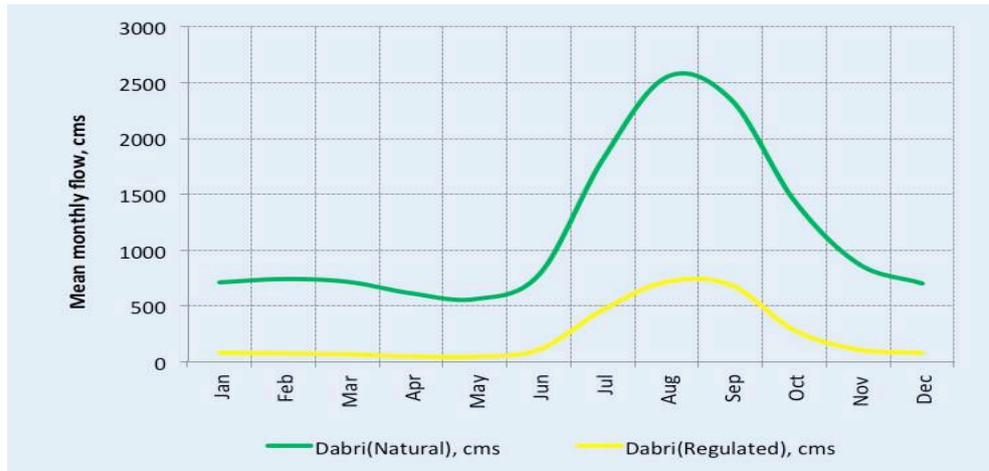
The industries though don't divert the water of the Ramganga, but industrial activities across its stretch from downstream of Moradabad severely impact the health of the river (on water quality parameters) as effluents (untreated or partially treated industrial waste) are dumped into the river and its tributaries (Dehla, Gaagan, Kosi, Aril).

There are around 35,000 industries reported along the banks of the Ramganga River and its key tributaries. These units are largely located in Uttar Pradesh (Moradabad, Rampur, Bareilly) and concentrated in industrial pockets of Uttarakhand (Kashipur and Uddham Singh Nagar). The major polluting industries are paper and pulp, metal ware, sugar and distilleries.

1.3 Rationale for Environmental Flows (E-Flows) for Ramganga

The key benefits provided by the infrastructure on Ramganga, mainly irrigation and flood protection, has altered the natural flow regime of the Ramganga in numerous way. Thus, the flows of the river at downstream of Hareoli Barrage are significantly altered. This phenomenon has a direct bearing on the reduction of flows in the Ramganga. Figure 1.8 shows the natural and current flow regime of the Ramganga, substantiating the above observation. The natural flows are calculated through hydrological modelling exercise (considering no intervention and rain-fed agriculture), which generate simulated natural flows; whereas the present day flows are also the simulated ones with all the interventions and current land-use. The present day flows are validated with the observed flows by the UPI&WRD and the Central Water Commission (CWC).

Figure 1.8: Mean Monthly Flow of the Ramganga River



Source: This information is generated under this project through hydrological modelling and validation has been done through actually observed present day flows by the UPI&WRD and CWC

The deteriorating health of the river, from the perspective of water quantity and quality, calls for securing the Environmental Flows (E-Flows)⁹ for the Ramganga with an ultimate goal to revive the health of the river.

1.4 Lessons Learnt from Previous E-Flows Assessment (EFA) Exercises

Some of the lessons learnt from previous exercises are tabulated below in Table 1.3, where the revised approach is also indicated.

The following modifications in the Ramganga EFA approach have substantially raised the confidence level of the team about the EFA process.

Table 1.3: Learnings from past EFA exercise

Past EFA Exercises	Ramganga EFA
<ul style="list-style-type: none"> • Cross Sections not extended to floodplain • Lesser number of sites (4) • Not adequate presence of thematic groups during cross-section surveys • EMC-based classification • Water quality – a thematic group • Lack of real-time observed long-term hydrological datasets 	<ul style="list-style-type: none"> • Cross-sections extended to HFL • 8 sites selected • Cross-thematic integration and joint field visits
<ul style="list-style-type: none"> • Recommendations are in the form of one recommended flows scenario • Trade-offs not conducted • Implementation framework not suggested 	<ul style="list-style-type: none"> • River health-based classification • River’s health taken into account • Obtained real-time observed hydrological datasets and validation: (i) 30 years observed data for a site & (ii) 3 windows of 5-5 years each for remaining sites; except Agwaanpur site – as this site in not a gauged site. • Different flows scenarios to meet specific river health criteria
	<ul style="list-style-type: none"> • Trade-offs conducted for a critical site • Implementation framework developed

1.5 Scientific Reliability of EFA, the Building Block Methodology process and its Use for Ramganga EFA

When examining the scientific reliability (or acceptability) of any process, the most obvious criterion would be whether the process has been published in peer-reviewed scientific literature. If it has been, then we can assume that it has been examined by impartial assessors of respected professional reputation and has been accepted as a credible scientific process.

In this regard, the EFA process has been widely accepted for publication since the mid-1970's, when Tennant¹⁰ published the well-known Montana method, which has frequently been used in many countries. There were of course, many respected publications prior to this, which connected flow modifications with ecological and environmental consequences. However, a very influential publication, which largely cemented the role of flow as a driver of hydraulic habitat creation, was that of Statzner et al.,¹¹ which demonstrated the variability of habitats, and of the existence of a variety of aquatic organisms in response to flow modifications. There has subsequently been a large volume of scientific literature on this subject. Other influential publications that confirmed the role of flow as a major controller of biodiversity in rivers include Poff et al.¹² and Bunn and Arthington¹³, among many others.

According to Tharme,¹⁴ over 200 methodologies for EFA have been developed since Tennant's pioneering paper, at different levels of details and multi-disciplinarity. Most of these have been published in scientific journals and research papers – some prominent

Figure 1.9: A lean season view of Ramganga river before Bhikiasain village



Photo Credit: Nitin Kaushal/WWF-India

among them include, Hughes and Hannart¹⁵; Smakhtin, Ravenga and Doll¹⁶; Poff et al.¹⁷ and Hughes and Louw¹⁸. One of the earliest developments of the so-called holistic methodologies was the Building Block Methodology (BBM) (King and Louw¹⁹) which uses a participatory multi-disciplinary process to assess and motivate for particular seasonal flows (the building blocks) that are required to provide a pre-defined environmental state for the river. The BBM has been a well-respected method used world-wide for EFA since the 1990s, and results for various rivers have been accepted by management agencies and published in the scientific journals (e.g., most recently intervention is that of McClain et al.²⁰ for the Mara River in East Africa). The BBM is often modified for use in different regions and rivers, e.g., in South Africa, to accommodate a risk-based approach. O’Keeffe et al.²¹ developed the Flow/Stressor Response version of the BBM, which is now used as one of the standard methods for the South African Government’s Department of Water and Sanitation.

In the Indian context, the BBM was first used by WWF-India for assessment of E-Flows in the Upper Ganga (O’Keeffe et al.²²). The methodology was modified to be more suitable for local conditions, in particular, by adding a major assessment of cultural/spiritual issues, as these get affected by the flow regime. Although some attempts to do this have been undertaken elsewhere, this was the first comprehensive trial of such a method (Lokgariwar et al.²³). The Upper Ganga EFA was a preliminary assessment primarily because the specialist teams were being trained in the process, and hydrological data was not adequately available to check the consistency of the recommended E-Flows. These and other uncertainties were captured in the 2012 report of WWF-India as confidence ratings for each discipline for each site, so that these lessons could be addressed in future projects.

In the Indian context, the BBM was first used by WWF-India for assessment of E-Flows in the Upper Ganga. The methodology was modified to be more suitable for local conditions, in particular, by adding a major assessment of cultural/spiritual issues, as these get affected by the flow regime.

Subsequently, this modified BBM has been applied in this project to the Ramganga. Almost the same teams of specialists were used, with additional experts and research associates, and observed hydrological data were available for most of the sites, so that the major shortcomings of the Upper Ganga project could be avoided.

1.5.1 Assessment of the scientific rigour for the Ramganga EFA

Hydrology: Long-term hydrological time-series were generated using the SWAT (Soil and Water Assessment Tool) model, and calibrated using observed data for most sites, through standard scientifically acceptable procedures.

Hydraulics: Three river/floodplain cross-sections points were surveyed at each of the 8 sites, using standard survey procedures for each E-Flows site. In order to generate Longitudinal Profile, the team surveyed the longitudinal section from Point-1 to Point-3 of the selected cross-section sites where the terrain has high slopes (like Bhikiasain and Marchula). The resulting cross-sections were rated and modelled using the HEC RAS model (Hydrologic Engineering Center’s River Analysis System) to derive the water profiles for various flow regimes. The model provides calculations of depth, width, wetted perimeter and average current velocity for a range of water levels. For each site, channel properties (e.g., manning’s coefficient, friction slope etc.) were assigned based on appropriate slope, substrate type, vegetation, water quality etc. The model was then made to run with daily simulated flow values and outputs were compiled. Simulated stage-discharge data were validated using observed values, feedback was assessed, and channel properties were readjusted until fair calibration was achieved. These stage-discharge relationships were used by other specialist groups (biodiversity, geomorphology and socio-cultural) to convert the position of observed habitat characteristics, substrate types and river characteristics and anthropogenic features (such as riverside temples), into required water depth, velocity, or river-bank position. This information was then converted into discharges that would be required to fulfil the desired requirements.



Photo Credit: Nitin Kaushal/WWF-India

Figure 1.10:
Confluence of Binao
with Ramganga

Geomorphology: The LISS IV²⁴ data with 5.8m resolution of pre-monsoon period of 2013 were used to map the different geomorphic features using false colour composite. Each of the E-Flows locations is characterised by certain geomorphic attributes and a common template was generated to describe the geomorphic features at each site. Field investigations involved documentation of various geomorphic attributes and river channel complexities. At each site, three cross sections were measured, and geomorphic attributes were recorded in terms of planform morphology, bed material and riparian vegetation condition.

Biodiversity: River sampling, literature reviews and interviews with local residents (e.g., fishermen) were used to assess invertebrate and vertebrate species diversity, abundance and hydraulic habitat requirements at each site. This data was used to describe present ecological conditions, and to predict the effects of different flows on restoration of habitats and species in the river.

Field surveys were conducted during summer (14–27 May 2014), monsoon (17–26 August 2014), and winter (11–15 December 2014 and 11–16 January 2015). Information on fish fauna was collected through experimental fishing using cast net.

At each site sampling was conducted for one hour. For each catch, species diversity, abundance, size and weight were recorded. A sample of each species was preserved in 10 per cent Formaldehyde Solution. Habitat features such as, river width, river depth, river velocity and substratum were recorded. Sampling for invertebrate fauna was conducted using a kick D-frame net and lifting of stones in the upland stretch of the river while sieving of soft substratum with the help of test sieve (0.05mm mesh size) and Ekmandrage in low land section of the river. Sub-surface velocity was measured using a current velocity metre. Samples were taken from the margin of the river to the maximum approachable depth. The specimens were preserved in 90 per cent Ethanol for laboratory analysis and were identified with the help of standard keys. The identified specimens were categorised under Functional

Feeding Group/s (FFG). For habitat preference by Otters, random plots were laid in survey stretch (centre being the CS point) to record data on riverbank substrate (availability/use), river characteristics (width, depth and flow), escape cover and prey availability.

Inadequate scientific data and a lack of historical information about conditions before the regulation of the river caused some uncertainties in predictions, but professional experience of the senior team members was used to augment the available data.

The river health group opined that reduction of pollutant load at the source allows internalization of pollution in developmental process and is in accordance with the very well accepted “Polluter Pays Principle”. As a policy, this thematic group and WWF believe that ‘provisioning of additional water as E-Flows for dilution should never be seen as solution to pollution’ in river systems.

Social/Cultural and Livelihood: In-depth interviews, focus group discussions and tools from participatory resource appraisal exercise were used to assess the historical, present day and desired flow of the river, based on the uses and activities carried out by riparian dwellers. The resulting data were analysed and cross-referenced to determine how changing flows (and other processes) have changed the use and perception of residents towards the river, and to predict flows that would sustain or restore the desired uses and activities at different river sections.

River Health Assessment (including Water Quality): The team collected three seasonal water samples in a year at each of the eight EFA sites. These were analysed for a range of 15 parameters. There is relatively no historical water quality data (at space and time), so their analysis was confined to these results for a single year. They were therefore only able to provide general conclusions of the likely conditions at each site, with no knowledge of trends over time or likely future predictions. The thematic group opined that rather than recommending freshwater flows for dilution of pollution in the Ramganga it is more appropriate to assess the impact of E-Flows recommended by the other thematic groups on the health of the Ramganga river. As a policy, this thematic group and WWF believe that ‘provisioning of additional water as E-Flows for dilution should never be seen as solution to pollution’ in river systems. The group also opined that reduction of pollutant load at the source allows internalization of pollution in developmental process and is in accordance with the very well accepted “Polluter Pays Principle”. Further the E-Flows recommended by the other thematic groups would help in improving the health of river Ramganga. At the E-Flows Setting Workshop, the job of this team was to respond to the flow recommendations of other specialist groups, by predicting what effect such flow levels will have on water quality, in specific.

1.5.2 Setting Environmental Objectives for E-Flows: A Societal Judgement

One of the critical steps in the EFA process is the setting up of environmental objectives for which the required flows can be predicted by the specialists. The essence of E-Flows is that flows are assessed to maintain or restore some predefined state of the river. For a river in a near pristine condition, which flows through a conservation area, such as a national park, the objectives will likely be to maintain near natural conditions including a near natural flow regime. By contrast, for an urban river, which is likely to be already significantly modified from natural conditions, the objectives might concentrate more on maintaining flows which would provide a reasonably healthy river, and to provide recreational and aesthetic values. In each case, the flows required would be quite different. Without some decision about the state of health in which the river should be maintained, there is no basis for recommending the required flow regime. However, the choice of the target state is not a scientific process, but rather a judgement reflecting the values, priorities and aspirations of the society. Scientific information and prediction can help us to inform that decision and will underpin the actions required to achieve the desired objectives, but the decision itself is a subjective process which is not susceptible to scientific analysis or conclusion.

For the Ramganga, the process of choosing objectives for which flow scenarios could be assessed, was formalised in two ways. The EFA team decided to support the development of a River Health Index, designed to quantify the present environmental state of each of

the river zones, using an integrated index for hydrology, biodiversity, geomorphology, river health, and socio-cultural & livelihood indicators. A draft set of categories, from near pristine, through slightly, moderately and largely modified, to seriously and critically modified, was developed for the workshop, with each of the categories described in qualitative terms for each discipline. Although all five categories could be used to describe the present environmental state for a river section, only the first four categories could be used as target categories, since seriously and critically modified categories are considered unsustainable. At the workshop, the specialists chose a target category for the initial flow assessment of each site, and two alternative scenarios (one better – a long-term objective – and one worse) for which flows were also assessed. This allows decision makers to consider a number of likely future states of the river, and to compare the flows and water quantity required to maintain/restore each such state.

1.5.3 Conclusion for the Ramganga EFA

In the EFA process, where data or analysis is inadequate, it is important to acknowledge and capture such inadequacies, and to make plans to solve them, but not to let these inadequacies derail the whole multi-disciplinary process. EFA is an adaptive process, in which the best available information and expertise are used to set recommended flows, and a monitoring and review process is then applied to update and improve the recommendations. In particular, implementation of the recommended flows will provide the opportunity to test, review, verify and/or modify them.

This account has shown that EFA is a hybrid process, in which all the aspects of assessment of the present environmental state of the river, and predictions of future conditions in

Figure 1.11:
Confluence of Gaagan
with Ramganga
at downstream of
Moradabad city



Photo Credit: Nitin Kaushal/WWF-India

response to modified flow regimes, are all susceptible to scientific methods of data collection and analysis. However, the choice of a desired state for the river is a value judgement. How effectively the scientific aspects are carried out will depend on the available data, the time and resources for the project, the expertise and application of the specialist teams, and the complexity of the river and its uses. The Ramganga is a large river, at least in its middle and lower reaches, with a channel many hundreds of metres wide, wet season flows of hundreds of m³/sec, with floods up to thousands of m³/sec. The hydrology was analysed and modelled adequately for all sites, however observed flow/level data was not available for one of the eight sites. Nevertheless, this was overcome by considering the flows at upstream and downstream sites. Hydraulic cross-section provided adequate rated curves in most cases, but multiple channels (in one or two sites), complex floodplain connections, and a mobile sedimentary river bed, reduced the range of discharges that could be rated, and therefore the confidence in hydraulic modelling at that specific site was average (acknowledged in the concerned section). Geomorphological analysis was of relatively high confidence, with the provision that the consequences of changes in sediment transport and channel forms, consequent on flow modifications, are often very long-term and difficult to predict precisely. The biodiversity recommendations were underpinned by (i) data on the habitat and breeding requirements of some of the sensitive fish species, (ii) general knowledge of habitat requirements, (iii) sensitivities of aquatic invertebrates and (iv) higher vertebrates such as otters and crocodilians, but there is certainly a need for further investigations of these requirements, and of their historical presence and abundance prior to the regulation. The socio-cultural and livelihood components appear to have been extensively investigated, analysed and cross-checked, but the team requested, following the assessment of flows, for a possibility of ‘demonstration flows’²⁵ in the river, that the stakeholders be revisited to assess their responses to the recommended E-Flows regime. Water quality is a major (perhaps the main) issue in the middle reaches of the Ramganga, and this requires extensive further research and monitoring to quantify the present state of the river and look for causes of the present problems. E-Flows should not be used to dilute pollution problems, which should be dealt with at source by treatment and reuse.

E-Flows should not be used to dilute pollution problems, which should be dealt with at source by treatment and reuse.

The overall problem with assessing flows in large rivers – particularly those such as at the middle/lower reaches of the Ramganga, which are wide, flat and alluvial – is that very small increments in average depth, width and velocity, may require very large increments in flow and water quantities. The ability of specialists to discriminate between habitat conditions in terms of centimetres cannot be expected to be precise, and therefore there is always a range of deviation around the flow assessments, that may still provide adequate hydraulic conditions for the target species or components. The way this uncertainty is addressed during the EFA, is through adopting the persona of a water manager, unwilling to allocate environmental water without strong motivation. The facilitator therefore questions the specialists about the recommended flows, and suggests ways, so that these could be reduced.

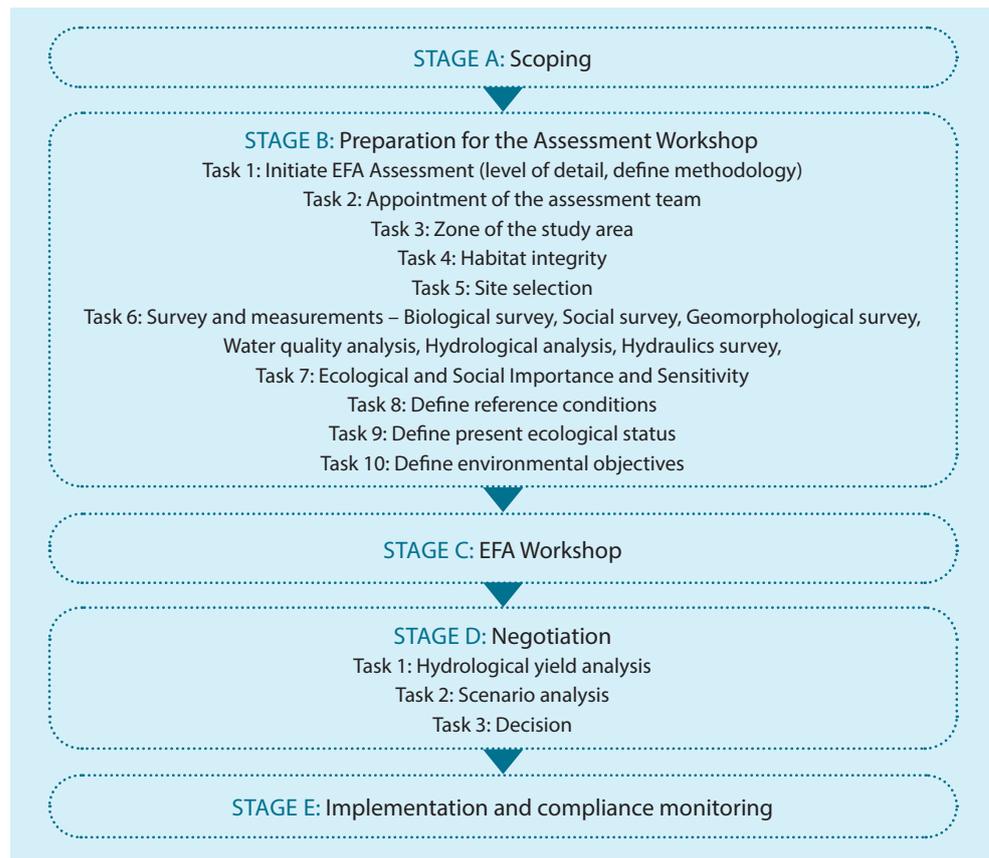
It is important to recognise that an EFA is only a prediction of the flows needed, and these can only be verified by providing the recommended flows and then monitoring the effects in the river.

In view of the above conclusion, the flow recommendations for the Ramganga can be accepted as the best predictions possible, based on present information and knowledge, and on a multi-disciplinary consensus of recognised experts in their fields. The predictions cover a range of modified flow regimes (the scenarios), with the consequences of each being carefully described, so that decision-makers can understand the changes in environmental condition at different flows. These predictions need to be monitored and refined, in terms of the uncertainties captured in the report, and the best way to do this is to implement the flow recommendations and monitor the results.

1.6 Step-by-step Approach Towards Achievement of E-Flows in River Systems

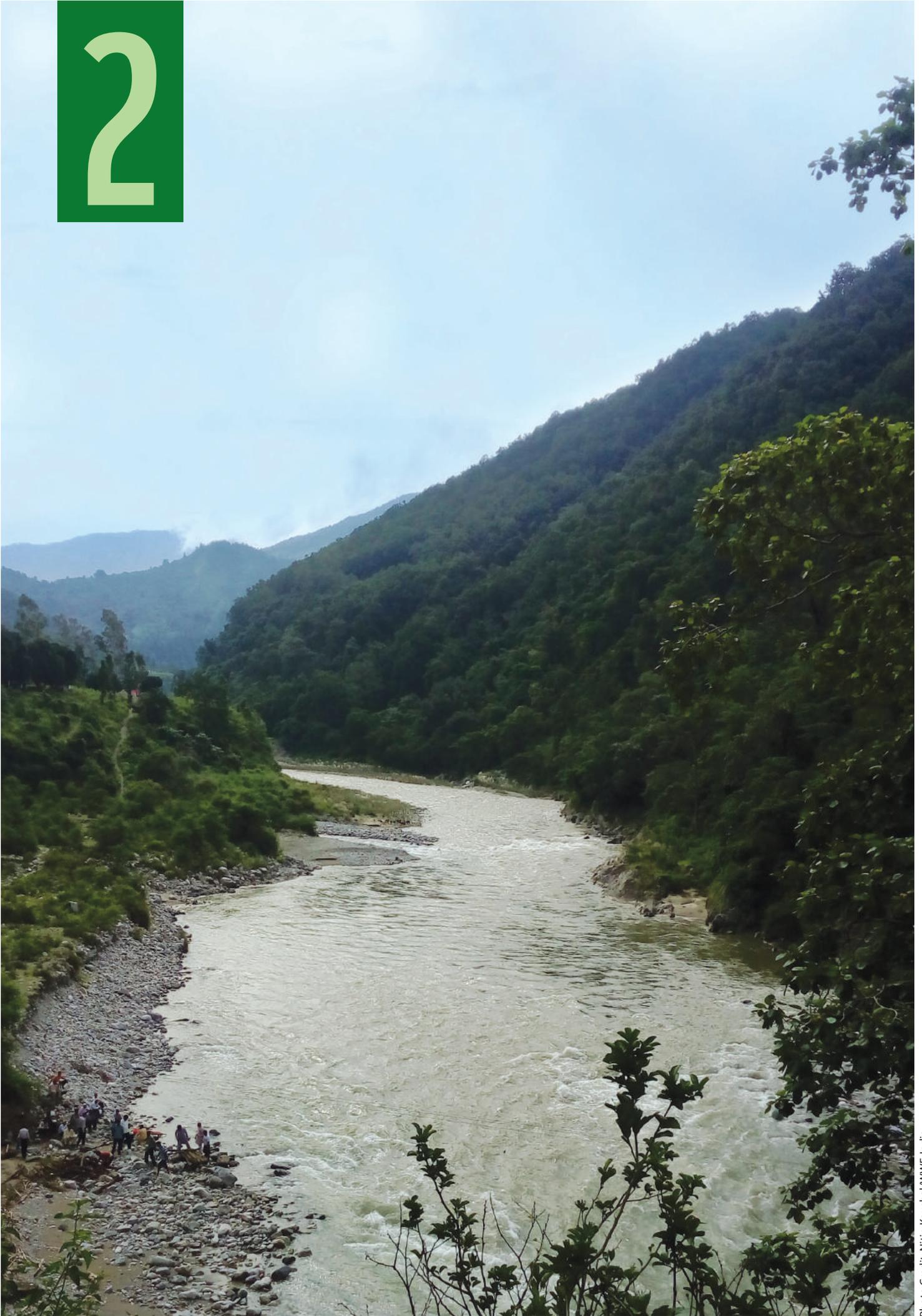
A step-by-step process with the help of a flow chart was exhibited in the earlier report of WWF-India. This report was published in 2012 and was titled *Assessment of Environmental Flows for Upper Ganga Basin*. For the benefit of the reader, the same flowchart from the earlier report is reproduced in Figure 1.12.

Figure 1.12: Stages and Tasks for an E-Flows Initiative



While the earlier study, ended with E-Flows recommendations for Upper Ganga, with some broad suggestions towards furthering the work around E-Flows in India, this report attempts to go a few steps further, by detailing the potential trade-offs for implementation of E-Flows in a critical site. In addition, this initiative also lays out an 'Implementation Framework' for long-term E-Flows maintenance in the Ramganga River.

2



Ramganga E-Flows Assessment Process

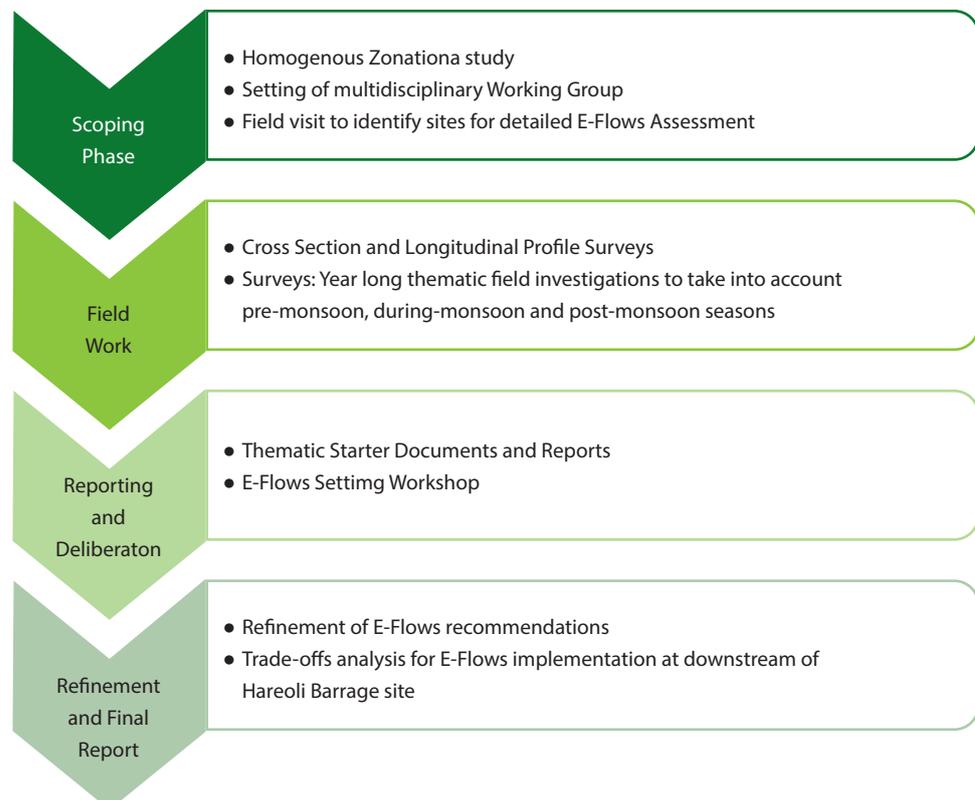
2.1 Background

A holistic methodology for EFA was tried, tested and adapted to suit the local contextual requirements, mainly the socio-cultural aspects attached to Ganga. Later, WWF-India undertook another EFA study for Kumbh, Prayagraj in 2013.

WWF-India initiated the E-Flows work in the Upper Ganga with its partners in 2007–08. There have been several learning from the Upper Ganga E-Flows Assessment (EFA) exercise, which took more than three years (from 2008 to 2011) to complete. During the study a holistic methodology for EFA was tried, tested and adapted to suit the local contextual requirements, mainly the socio-cultural aspects attached to Ganga. Later, WWF-India undertook another EFA study for Kumbh, Prayagraj in 2013. The methodology adopted for the Ramganga EFA is similar to that of the Upper Ganga, which is an improvised version of the Building Block Methodology (BBM).

On similar lines, however with improvisations in approach, the Ramganga E-Flows Assessment (EFA) was taken-up. Figure 2.1 below summarises the step-by-step process of the Ramganga E-Flows Assessment exercise.

Figure 2.1: Process Chart for the Ramganga E-Flows Assessment Exercise

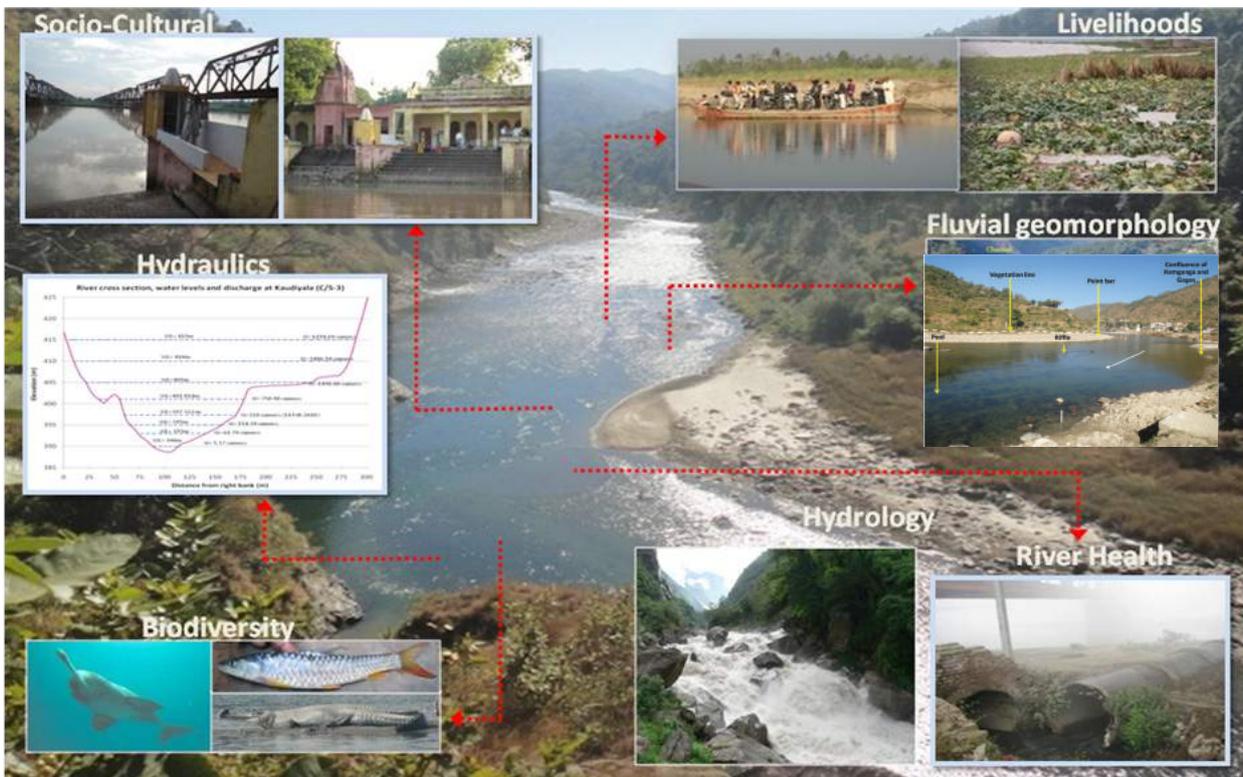


2.2 E-Flows Assessment: Approach and Methodology

The lessons of Upper Ganga and Kumbh, Prayagraj EFAs were fruitful during the E-Flows Assessment for Ramganga.

BBM is a methodology for assessment of E-Flows in river systems, which falls under the holistic set of methodologies for EFA. The team, during the Upper Ganga EFA, improvised the general BBM approach to integrate and account for local socio-cultural aspects while calculating the E-Flows needs. Figure 2.2 illustrates the associated aspects for the Ramganga, which were considered while doing the assessment of its E-Flows.

Figure 2.2: Illustration of the associated aspects for Ramganga E-Flows



2.3 Appointment of Specialist Teams

The BBM calls for a multidisciplinary team of experts for the EFA. Thus, a team of about 25 experts was put together for the Ramganga EFA. The primary emphasis of the EFA was on building institutional partnerships. Since it was felt that such a study aims at strengthening the current national capacity to undertake similar exercises in other river basins, it was imperative to involve national and local institutions as partners in the exercise. One of the authors of the report, Prof. Jay O’Keeffe, who has been engaged as ‘Facilitator’ to the teams during the Upper Ganga EFA, played the role of a ‘Mentor’ during the Ramganga EFA. The names of team members which were part of this study alongwith the thematic areas of their expertise are tabulated at the beginning of this document. This team completed the assessment of E-Flows for Ramganga in 18 months, starting from October 2013 to March 2015. Further refinements to the EFA results and trade-offs analysis for implementation took additional time.

2.4 Homogenous Zonation Exercise

The Ramganga EFA exercise started with a Homogenous Zonation study, which was aimed at dividing the stretch of the Ramganga into homogenous zones, primarily from the perspective of elevation and gradient, using the Digital Elevation Model (DEM) and other high-resolution software. Further, additional criteria were also applied to identify zones of the river, including:

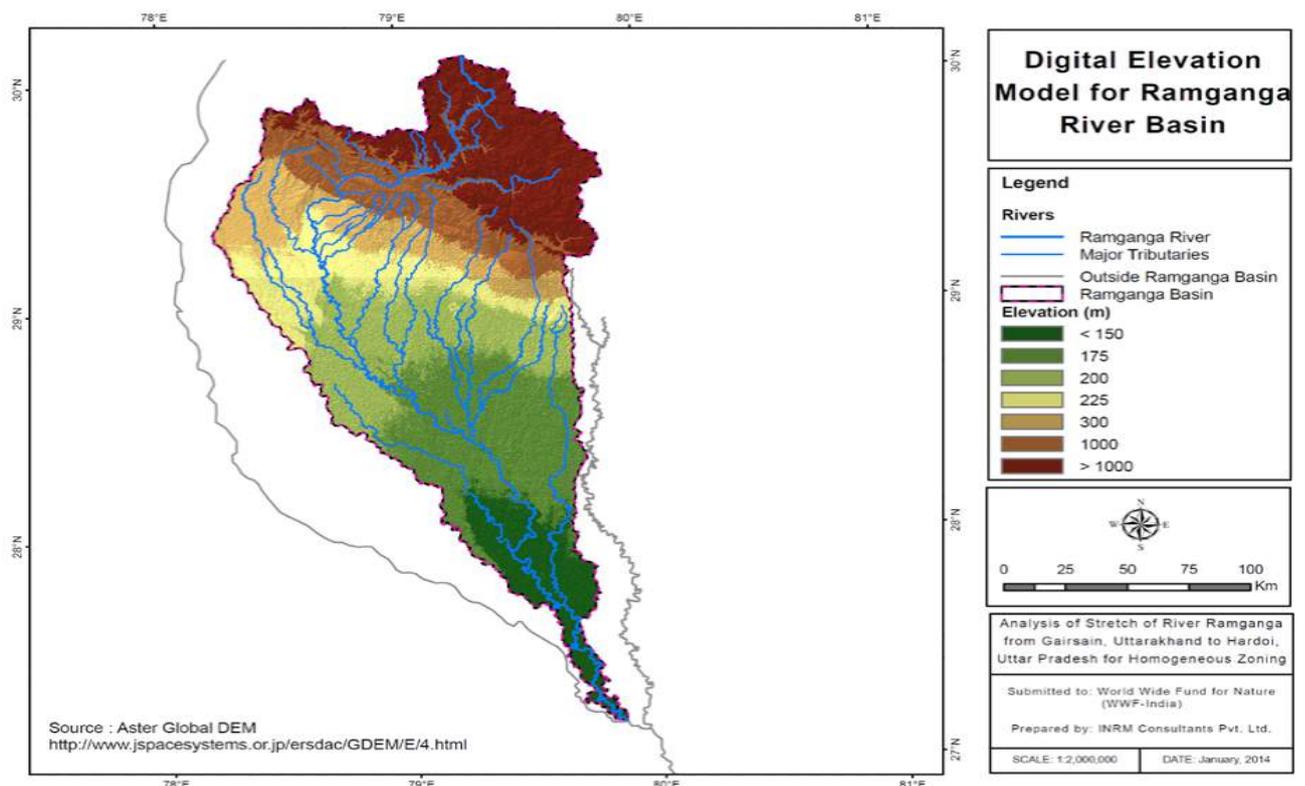
1. tributary confluences
2. major water resources infrastructure (dam, barrage)
3. upstream and downstream of major cities
4. sites important from the cultural perspective
5. established gauging sites (CWC and UPI&WRD)

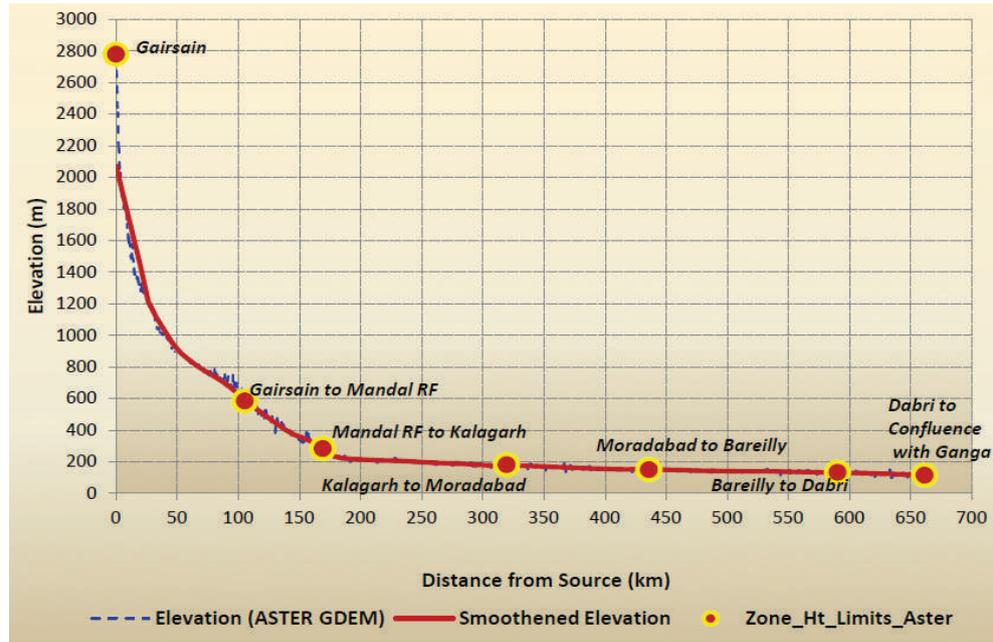
Initially, this was a desktop study, but a lot of field inputs and expert opinions were integrated into the study. The timeframe of the study was four months. The methodology for this exercise included the following items:

1. Analysis of the changes in river morphology and terrain using satellite images.
2. Analysis of the satellite images to assess land-use changes over the floodplain area, even extending the targeted aerial coverage beyond the floodplain, if required.
3. Identification of all the constituent entities such as major tributaries joining the stretch, all the man-made structures, such as barrages and other diversions, the potential point sources of pollution, the meandering and stable sections etc.
4. Secondary data on cities, industries, pollution monitoring sites etc.

An Aster DEM of the Ramganga basin is given in Figure 2.3. The maximum, minimum and mean elevation within the river basin is tabulated in Table 2.1.

Figure 2.3: Various Zones of Ramganga Primarily based on Elevation Levels





Source: Homogeneous Zonation Report from INRM Consultants, New Delhi

Table 2.1: Elevation Range in the Ramganga River Basin

Parameter	Elevation (m)
Minimum Elevation	113
Maximum Elevation	3088
Mean Elevation	500

Source: Ramganga Hydrology Report, INRM Consultants, New Delhi

Based on this exercise, the following six homogeneous zones were identified and in each of the zones EFA sites were accordingly identified. Between two to five sites were initially shortlisted in each of the zones, for the detailed EFA study. All these sites were visited by the larger team and on the basis of expert consultation and field verification, eight EFA sites were finalised. For detailed EFA study, the Ramganga Mitras¹ were also consulted and they actually visited all these sites and contributed to the discussion by sharing their perspective on the Ramganga River, in general and the concerned sites, in particular.

Figure 2.4: The joint team at the Bhikiasain site



Photo Credit: Nitin Kaushal/WWF-India

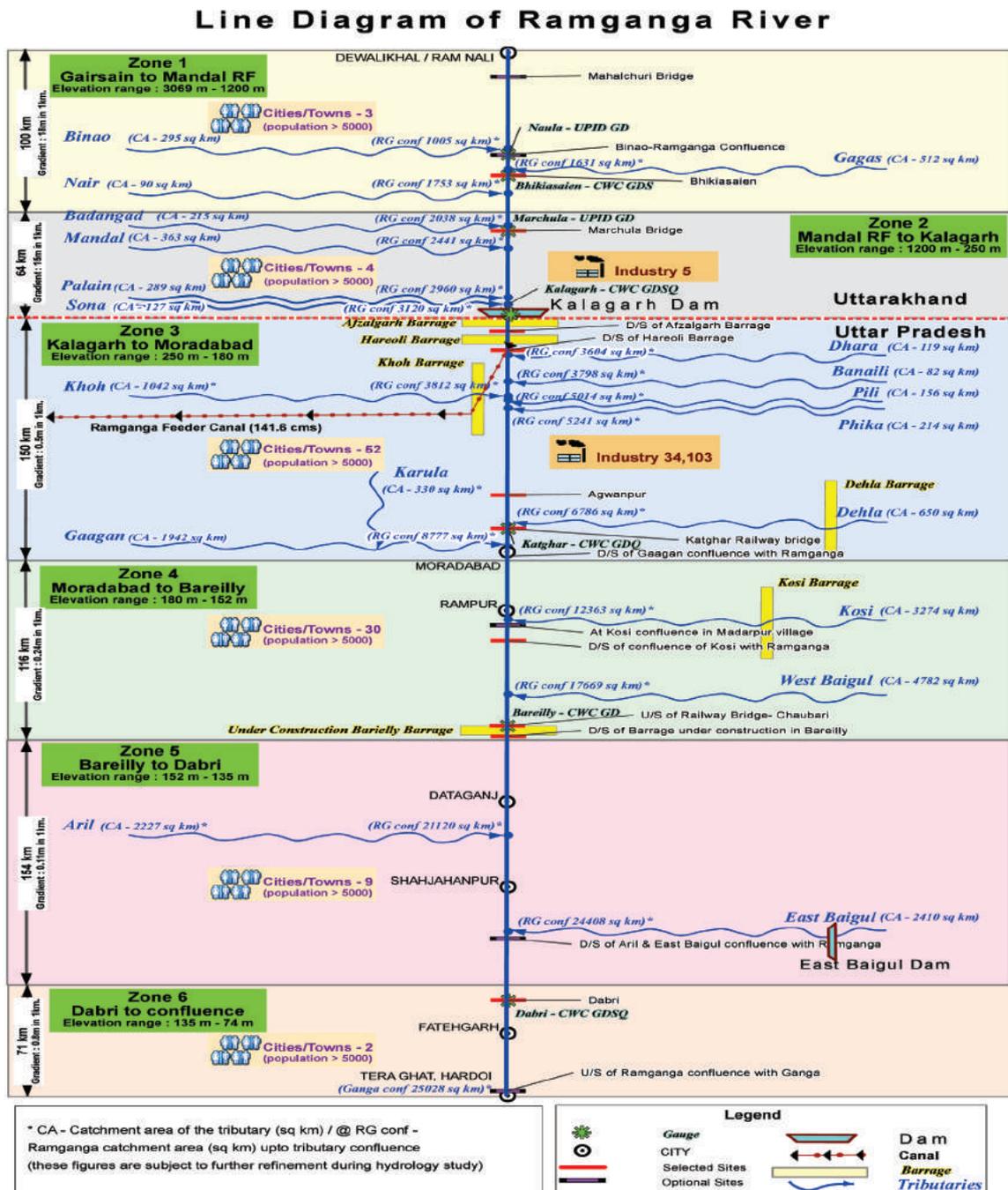
The six homogeneous zones identified for the study are listed below with brief description of each zones.

1. **Zone 1** – Gairsain to Mandal Reserve Forest: Zone 1 has a length of 105km with elevation ranging from 1200 to 3069 metre above mean sea level. Gradient is of the order of 18m in 1km. Three tributaries join the Ramganga in this zone (viz., Binao and Nair rivers from the right and the Gagas river from the left). The Central Water Commission (CWC) has one stream gauge station (Bhikiasain Gauge Station) and UPI&WRD has one gauge station (Naula Gauge Station). There are about 1 Class III, 1 Class IV, 1 Class V cities and 29 villages in this zone. There are no industries and water quality monitoring stations. *Bhikiasain was chosen as the site for the EFA exercise in this zone.*
2. **Zone 2** – Mandal Reserve Forest to Kalagarh: Zone 2 has a length of 64km with elevation ranging from 250 to 1200 metre above mean sea level. Gradient is of the order of 15.0m in 1km. Major streams joining the Ramganga are Badangad, Mandal, Palain, Sona from the right bank. There is one multipurpose project (meant for irrigation flood moderation and hydropower), i.e., the Kalagarh Dam near Kalagarh town. The UPI&WRD has one gauge station (Marchula GD) in this zone. Almora is the only Class III city in this zone. There are about 1 Class III, 3 Class V cities and 55 villages in this zone. *Marchula was chosen as the site for the EFA exercise in this zone.*
3. **Zone 3** – Kalagarh to Moradabad: Zone 3 has a length of 150km with elevation ranging from 180 to 250 metre above mean sea level. Gradient is of the order of 0.5m in 1km. Major streams joining the Ramganga are Dhara, Banaili, Pili, Phika and Dehla from the left bank, and Gaagan and Khoh from the right bank. This zone has few small water resource infrastructure that divert water for irrigation, viz., two Barrages at Afzalgarh and Hareoli on the main Ramganga, Sherkot barrage on Khoh, Ramnagar barrage on Kosi, Dehla barrage on Dehla. The CWC has two stream gauge station (Afzalgarh barrage and Moradabad GDSQ, Katghar) in this zone. There are a large number of metal ware and other industries. Two Class I cities, Kashipur and Moradabad are there and about 2 Class II, 7 Class III, 5 Class IV, 36 Class V cities. There are 1028 villages in this zone. Because of the importance of this stretch four EFA sites were identified. *Upstream of Afzalgarh Barrage and downstream of Hareoli Barrage, Agwaanpur, and Katghar-Moradabad were chosen as sites for the EFA exercise in this zone.*
4. **Zone 4** – Moradabad to Bareilly: Zone 4 has a length of 116km with elevation ranging from 152 to 180 metre above mean sea level. Gradient is of the order of 0.24m in 1km. Major streams joining the Ramganga are West Baigul and Kosi from left bank. There are no existing dams in this zone, however, one under-construction barrage (Badayun Irrigation Scheme) is situated towards the end of this zone. The CWC has one stream gauge station at Chaubari (railway bridge). Bareilly and Rampur are Class I cities in this zone. There are about 2 Class I, 3 Class II, 3 Class III, 1 Class IV, 21 Class V cities and 962 villages in this zone. *Chaubari-Bareilly was chosen as the site for the EFA exercise in this zone.*
5. **Zone 5** – Bareilly to Dabri: Zone 5 has a length of 154km with elevation ranging from 135 to 152 metre above mean sea level. Gradient is of the order of 0.11m in 1km. Major streams joining the Ramganga are Aril from the right and East Baigul from the left bank. This zone has no dams, barrages or hydropower projects. No stream gauging stations are located in this zone. There are no major industries operating in the zone. Aonla and Dataganj are two Class III cities in this zone There are about 2 Class III, 1 Class IV, 6 Class V cities and 349 villages in this zone. *No EFA site was identified within this stretch, as sites immediately upstream and downstream of this stretch were already chosen for the exercise in this zone.*

6. **Zone 6** – Dabri to the confluence with River Ganga: Zone 6 has a length of 71km with elevation ranging from 74 to 135 metre above mean sea level. Gradient is of the order of 0.8m in 1km. In this zone the Ramganga river finally joins with the Ganga at Tehra Ghat in Hardoi district. There are two Class V city and 45 villages in this zone. The CWC has one stream gauging station at Dabri in this zone. *Dabri was the site chosen for the EFA exercise in this zone.*

In Figure 2.5 it can be seen that the elevation levels between zones 4, 5 and 6 are not significant; however there are some other considerations which prevailed in these zones,

Figure 2.5: Depiction of Various Zones with Key Features and Tributaries



Source: Homogenous Zonation Report, INRM Consultants, New Delhi



Photo Credit: Nitin Kaushal/WWF India

Figure 2.6: Ramganga river at upstream of Chokhutia

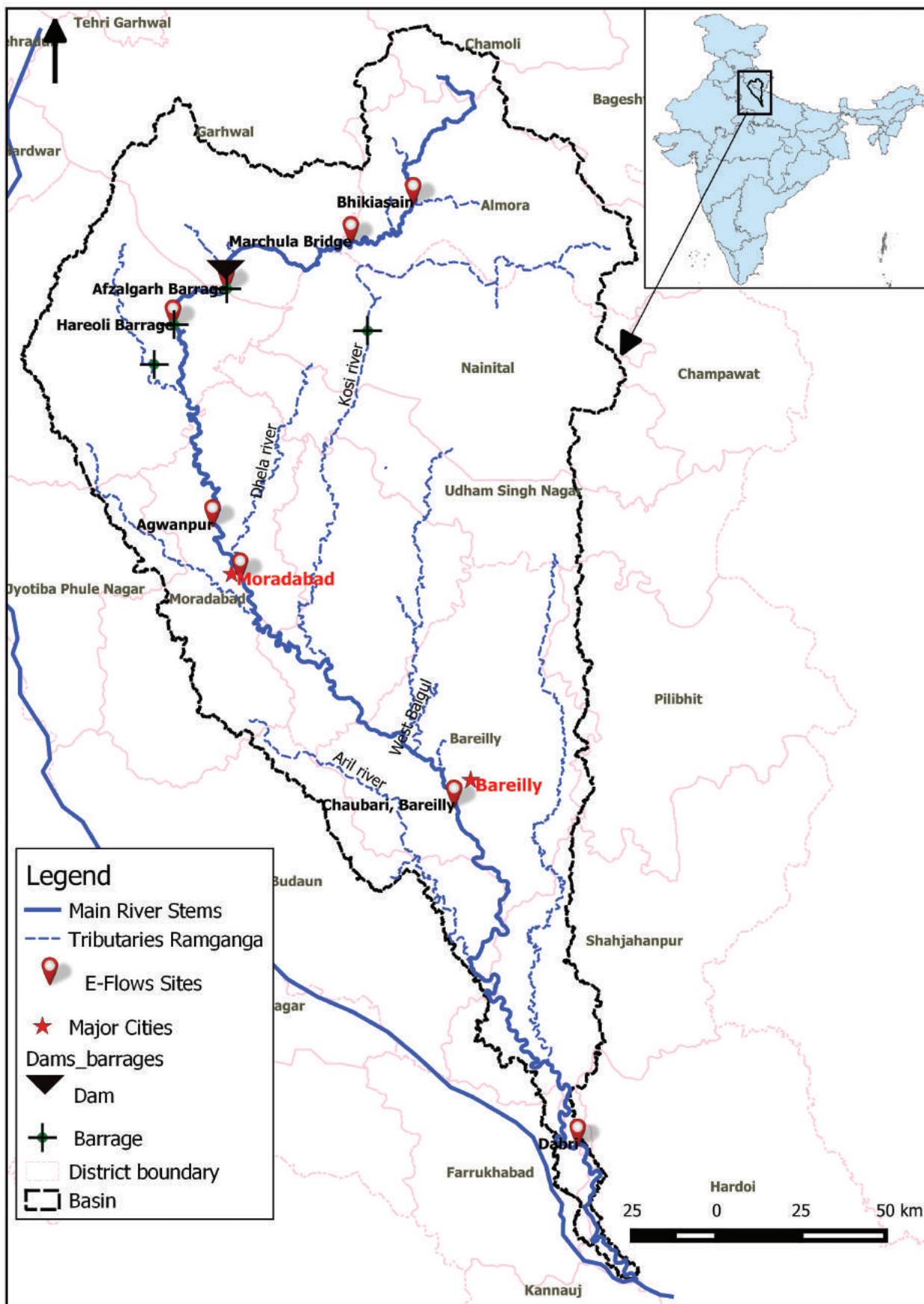
while selecting sites for E-Flows Assessment. For instance, Chaubari-Barielly is the most important site on the banks of the Ramganga from the socio-cultural perspective. Further, there is a barrage immediately downstream of the Chaubari mela site, which is currently under-construction and is expected to be commissioned by 2019-2020. Similarly, downstream of Dabri is a rich biodiversity stretch (turtles and molluscs) with Dolphin also migrating within this zone from the Ganga during wet months (July-Sept).

Figure 2.7 depicts all the E-Flows sites on the Ramganga main-stem, with basin location, area etc. Table 2.2 provides the GPS coordinates of all E-Flows sites.

Table 2.2: Location Coordinates of E-Flows Sites

EF Site Name	Location (GPS Coordinates)
Bhikiasain	79.261018 29.697208
Marchula bridge	79.092723 29.605807
D/s of Afzalgarh barrage	78.760980 29.497251
D/s of Hareoli barrage	78.628074 29.404507
Agwaanpur	78.724339 28.949769
Katghar Moradabad	78.799183 28.825934
Chaubari Bareilly	79.370053 28.296459
Dabri	79.697124 27.497125

Figure 2.7: All the E-Flows sites in the Ramganga main-stem



Source: WWF-India

2.5 Cross Section Surveys and Thematic Field Investigations

This sub-section talks about the field-oriented activities of the teams, which were conducted jointly and thematically.

2.5.1 Cross-Section and Longitudinal Profile Surveys

The river cross-section surveys at all the eight sites were conducted during the month of May 2014. The representatives of all the thematic groups participated in these surveys and other activities. The equipment used included, Total Station, Differential Global Positioning System, Current Meter, and Staff Gauge. During these surveys the following tasks were accomplished:

1. Cross-sectional surveys, across the channel to record Highest Flood Level (HFL) at each of the sites. Three cross sections for each of the site were surveyed:
 - a. one upstream of the identified final site;
 - b. one at the identified final site;
 - c. one downstream of the identified final site.

In general, the distance between the three cross sections for each site was in the range of 1 to 5 kilometre depending upon the accessibility.
2. Velocities were measured at different levels (in accordance with the depth points recorded in the river during the cross-section survey).
3. The socio-cultural, geomorphology and biodiversity groups took advantage of this opportunity and held discussions with local people to understand the aquatic biodiversity, river behaviour and related livelihood activities.
4. In the mountainous reach, i.e., for sites such as Bhikiasain, Marchula and down stream of Afzalgarh barrage, the teams manually mapped the longitudinal profile with the help of a boat and travelled from the first cross-section point to the third cross-section point. In general, the main site for EFA remained the middle one amongst the three cross-section points at each of the sites. For the sites in the plains, the longitudinal profile was developed based on three cross -section points for each of the sites.

Figure 2.8:
Cross Section and
Longitudinal Profile
Surveys undertaken
by the Team of
Experts



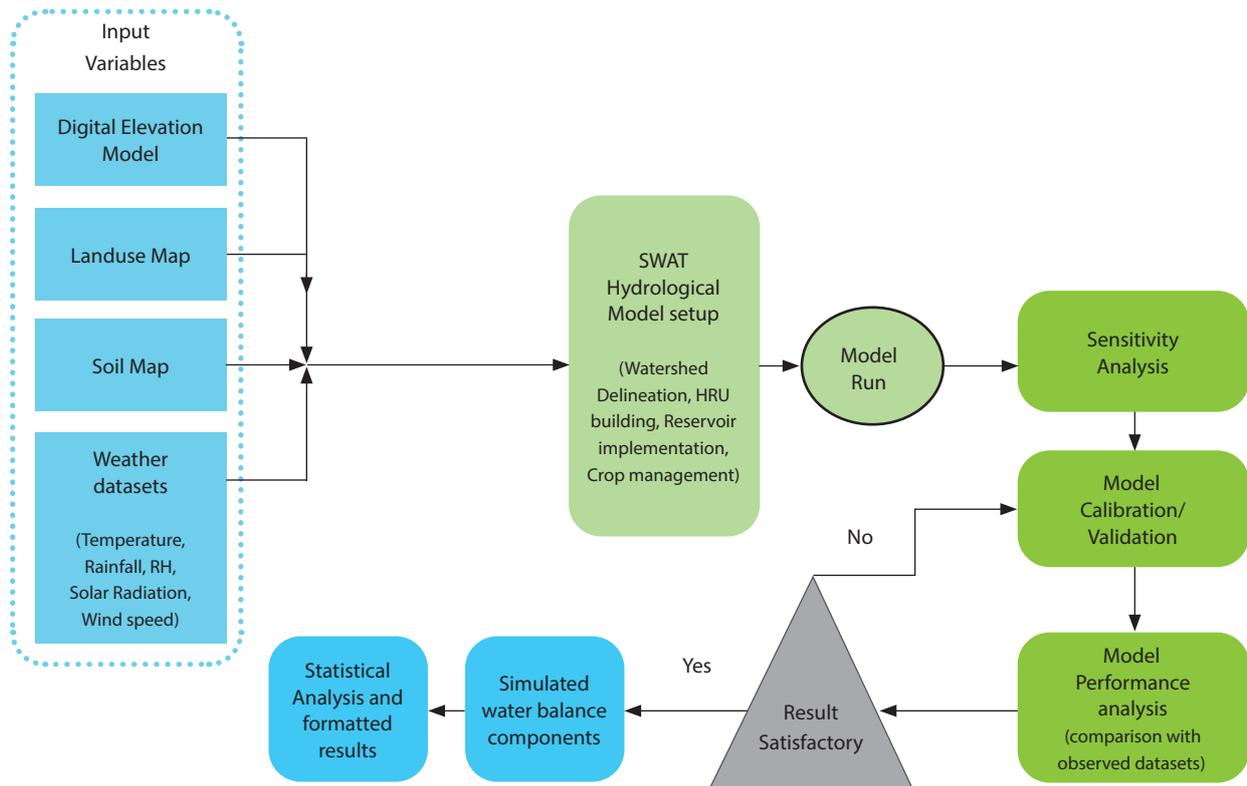
Photo Credit: WWF-India

2.5.2 Hydrological Modelling

Seven of the eight sites (except Agwaanpur) either had established gauge sites or some sort of gauge/flows monitoring was present. This helped the teams to validate the simulated flows with reasonably high confidence. For Agwaanpur, which is neither a CWC nor a UPI&WRD site, the data from upstream and downstream were used for validation.

This sub-section details out the process of hydrological modelling as part of the Ramganga EFA exercise. The steps followed as part of this specific exercise are illustrated with the help of a Flow Chart, as reproduced in Figure 2.9.

Figure 2.9: Step-by-Step Flow Chart of Technical Modelling Exercise under the Ramganga EFA



Source: Prepared by the Hydraulics and Hydrological Modelling Team (INRM Consultants)

2.5.2.1 Validation of Hydrological and Hydraulic Modelling Exercise

The hydrological (gauge, discharge, water quality and sediments) and hydraulic (cross section) data were acquired from the CWC for the sites governed by them, viz., Bhikiasain, Afzalgarh Barrage, Katghar, Chaubari and Dabri. This request was made under the Hydro-Meteorological Data Dissemination Policy, 2013 of the Government of India. The CWC shared monthly data, however, there were some limitations. For instance, Bhikiasain is a gauge site and discharges are not measured at this site (mainly because the main concern at this site is to monitor water levels from the perspective of floods). This also means that the hydraulic cross section for this site was not available. The same also applied to the Afzalgarh barrage site. Nevertheless, the datasets from CWC were adequate for validation of overall hydrological and hydraulic modelling exercise.

There are two sites under the UPI&WRD viz., Marchula and Hareoli Barrage. Required data for validation of hydrological and hydraulic modelling for these two sites were made available by the UPI&WRD.

2.5.3 Field Investigations

Field investigation was undertaken by all the thematic groups from April 2014 to early March 2015. During the field investigation, the teams accomplished the following activities:

1. Detailed surveys of all three seasons i.e., pre-monsoon, monsoon and post-monsoon, in and around the identified sites. The idea was to ascertain the present condition of the river during seasonal variations from different perspectives, i.e., biodiversity, geomorphology, socio-cultural & livelihood and river health.
2. These surveys were documented and presented during the Quarterly Progress Review meetings held at the end of every quarter.

The broad activities undertaken by each of the group are described below:

1. The **Hydrology group** conducted field visits to ascertain the data-sets and information related to Ramganga water resources at various sites of the CWC and UPI&WRD. The visits were also made to all the major water resources projects, including Kalagarh Dam, Afzalgarh Barrage, Hareoli Barrage, Kho Barrage and Badayun Irrigation Project. The aim of visiting all the water resources infrastructure on Ramganga River, was not only to get some technical information, but also to understand the perspective and challenges of the water managers at these establishments. These visits have helped in understanding the practical problems pertaining to regulation of Ramganga water resources.
2. The **Cross-Sections group** was part of the field visits, as they led the surveying of Cross Sections and Longitudinal Profile at all the sites. Inputs from the field were synthesized by this group and final cross-sections and longitudinal profiles were created for all the sites. Thereafter, these inputs were handed-over to the hydraulics team for modelling.
3. The **Biodiversity group** has experts from three institutions, i.e., WWF-India, Central Inland Fisheries Research Institute (CIFRI) and Hemwati Nandan Bahuguna Garhwal University, Srinagar. This joint group did field investigation, primarily of three aspects, i.e., fishes, higher invertebrates (gharial, otter and turtle) and smaller organisms (diatom, plankton etc.). Field surveys were conducted in all three seasons, i.e., pre-monsoon, monsoon and post monsoon. The work distribution amongst the three institutions is as follows –
 - WWF-India: higher vertebrates (crocodile, otter, mugger, turtle, dolphin)
 - HNB Garhwal University: invertebrates and plankton
 - CIFRI: fish species (mahseer, Indian Major Carp and others)

The aim of visiting all the water resources infrastructure on Ramganga River, was not only to get some technical information, but also to understand the perspective and challenges of the water managers at these establishments.

From the perspective of invertebrate specialists, the suggested desired condition of Ramganga in different seasons and at different stations is based on the functional feeding group of the taxa. Ramganga is a third order stream in the upper stretch, and because it is relatively shallow and has clear-water, it is functionally heterotrophic. The lower stretch is of fourth to fifth order, deeper and more turbid, and therefore functionally autotrophic. The type and diversity of taxa will depend on the type of substratum and habitat available at a particular station. For the development of the heterotrophic condition of the river in the upper stretch, the taxa should be functionally shredder/predator/collector type. For autotrophic conditions in the lower stretch of the river, the desired taxa should be grazer/collector types. Both heterotrophic and autotrophic macro-invertebrates form a prey base for fish fauna. On the other hand, this team was also concerned with rare taxa and aimed to have the rare taxa surviving in the future scenario.

4. The **Fluvial Geomorphology** group, in addition to field investigations, the group made use of high end satellite images, i.e., LISS IV (Linear Imaging Self Scanner IV), which provides 5.8m spatial resolution and has been really helpful in understanding geomorphic complexities of the river at various stretches. The field investigations were aimed to zoom into the geomorphic characteristics at various sites representing the stretches/zones.
5. The **Socio-Cultural and Livelihood** team helped in understanding and documenting the people's perspective and aspirations when it comes to their cultural requirements and relevant flow levels. In addition, this group also looked at all the subsistence livelihood activities which are non-consumptive in nature, i.e., those activities in which river water resources are neither abstracted nor diverted. These livelihood activities over the decades, have evolved in tandem with healthy rivers and are consequently dependent on adequate flows.
6. The **River Health** group was tasked to ascertain the health of the river at the sites, which represent their respective zones, from the perspective of water quality and bio-indicators. The River Health group concluded that, since extensive data-sets on Ramganga river quality are not available for the reference conditions, the reference condition for water quality at all stations/stretchers can be taken as the water quality required by the characteristic aquatic species to survive and flourish.

The River Health group did water sampling (for analysis) during all the three seasons at 8 E-Flows sites, plus additional 15 sites (purely from the river health perspective). The key parameters assessed were: turbidity, total suspended solids (TSS), total dissolved solids (TDS), alkalinity, pH, temperature, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), chloride, sulphate, nitrate and total coliform.

The group refrained from drawing very detailed conclusions, because of the one-time sampling datasets. For a conclusive statement, a long-term data-set is required for all the sites. Nevertheless, the group came to some broad conclusions. This group predicted the impacts of recommended flow scenarios with respect to the health of river Ramganga.

The River Health Categories (RHC) are discussed in detail in Section 2.6.2 River Health Class.

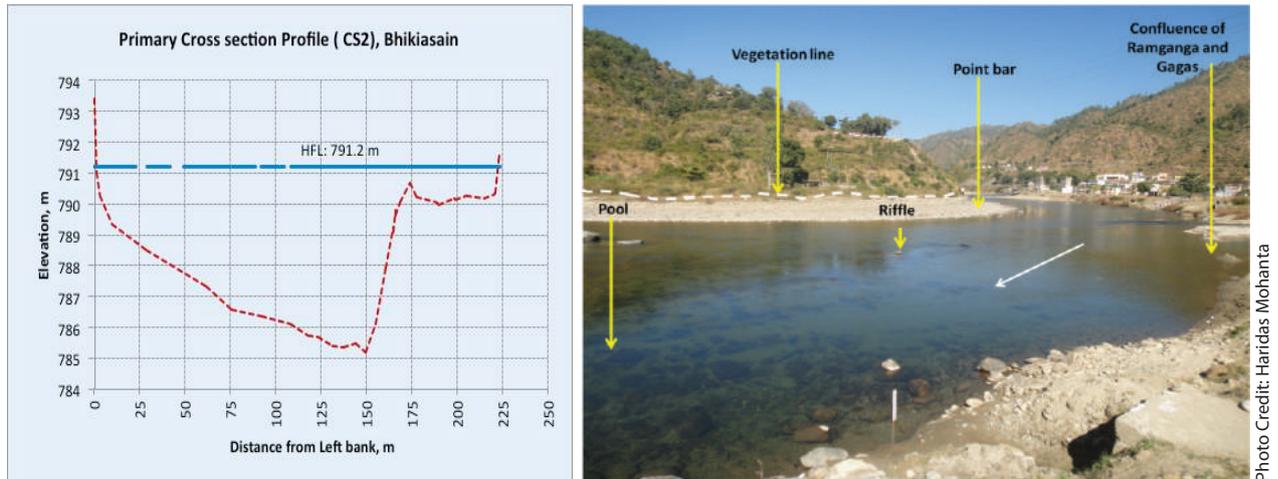
The remaining part of this sub-section discusses the thematic findings of field investigations and examines critical issues and related aspects. The present state of the river at each of the sites is also discussed in detail.

The hydrology aspects of each of the sites are detailed in the Ramganga Hydrology Report, available as Annexure-1 Similarly, all the thematic groups submitted Starter Documents, which are available as Annexure-2, for detailed reference. Sitewise short summaries are provided below.

2.5.3.1 Bhikiasain – Present State

The cross section of Bhikiasain site is given along with the photograph in Figure 2.10. At Bhikiasain, the river is generally fast flowing with riffles, runs and pools. Over the seasons and across the year, the river width ranges between 10-50m and the average depth ranged between 0.50-1.80m. In the stream, the substrate particle size varies with varying depths.

Figure 2.10: Bhikiasain Cross Section and a View of the Bhikiasain Site



Boulders with occasional sandy patches dominate deep waters (>60 cm), while cobbles and pebbles dominate shallow water (≤ 10 cm). The river bank is composed of boulders, rocks and sand with no or occasional marginal vegetation.

From the fluvial geomorphology perspective, the landscape setting of Bhikiasain is Himalayan bedrock and the entire stretch of the river falls in high mountainous area. The river valley is narrow and is confined on both sides by valley walls. The river channel is generally a single thread with low sinuosity and the channel belt is characterised by vegetated sidebars with boulders, pebbles and cobbles. Riffle-pool sequence is observed at several places in this stretch. No large floodplains are present, but there are small pockets of floodplains in a few reaches. Patches of riparian vegetation are observed on both sides. Bank material consists of boulders and coarse sand. Settlements are observed in some places above the HFL on both sides. Some areas are covered by trees on both sides above the HFL.

The Sangam (confluence of Gagas, Naurad and Ramganga) is considered sacred. Close to this confluence, there is an old temple with substantial cultural significance for the local communities.

In terms of aquatic biodiversity, this site is rich in fish fauna. The key species include, golden mahseer *Tor putitora*, stone roller *Crossocheilus latius*, boalla *Labeo dyocheilus*, tor barb *tor tor*, sucker fish *Garra mullya*, minnows *Barilius gatensis*, sucker head *Garra gotyla*, snow trout *Schizothorax richardsonii*, trout barb *Raiamas bola*, dudhnea/khoksa *Barilius vagra/Barilius barna*, balitora minnows *Psilorhynchus balitora*, reticulate loach *Botia lohachata*, mottled loach *Acanthocobitis botia*. During the winter survey an abandoned holt (den site) of smooth-coated otter *Lutra perspicillata* was found in the tree roots at Naulla, about 5km upstream of Bhikiasain. Rare invertebrate taxa recorded are blephariceridae, brachycentridae, chaobonidae, chironomidae, choloroperlidae, corixidae, ephemerillidae, glossomatidae, hemiptera, heptageniidae, hydropsihiidae, leptoceridae, leptophlebiidae, limnephilidae, perlidae, psychomyiidae, psephenidae, pyralidae, rhyacophilidae, siphonuridae, siphonuridae and tipulidae.

In terms of **socio-cultural and livelihoods** aspects, Bhikiasain town is the hub for several local activities, and this place is frequented by many people, living in the nearby but remote villages for their weekly or monthly needs. The Sangam (confluence of Gagas, Naurad and Ramganga) is considered sacred. Close to this confluence, there is an old temple with substantial cultural significance for the local communities. This temple is frequented by thousands of visitors each year, and the river is used for ritual purposes as well. Close to this place is a cremation ghat. Fishing is another activity practiced by people of the area, but it is not that significant. Recently, sand-mining has also started and if not checked properly, could be a problem for the river as well as for the villagers in future.

The state of Uttarakhand plans to develop this area as a tourist spot and this is one of the reasons that the Kumaon Vikas Nigam Limited has constructed a resort in Bhikiasain to cater to the needs of tourists. The discussions with the community led to the understanding that people are feeling that historical flows are reducing. According to them, one of the reasons could be the number of water pumping stations along the river stretch. These pumps are meant to provide domestic supply to the villages in this hilly region.



Photo Credit: Nitin Kaushal/WWF-India

Figure 2.11: A pumping system meant for domestic supplies

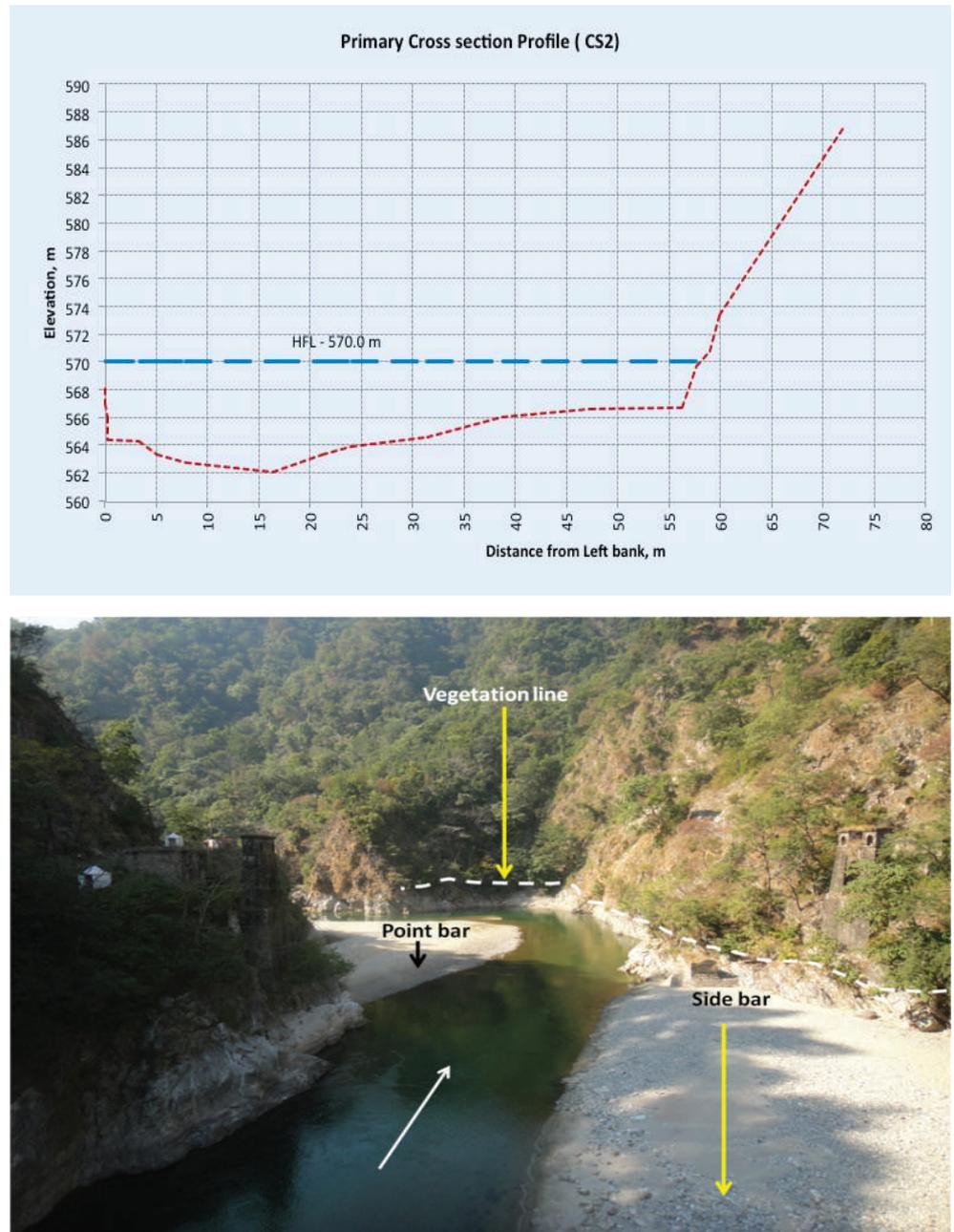
The community members aspire to have reasonable water levels during dry season to sustain their socio-cultural & recreational activities (swimming/bathing) and livelihood (fishing). In terms of the depth, they wish to have about two feet close to the banks and maximum depth of about five to six feet. During monsoon, respondents cited historic flows which fills up the river bed up to the retaining wall. In case of floods, they remember the river reaching up to its floodplains.

2.5.3.2 Marchula – Present State

Marchula is a small village on the banks of the Ramganga, this E-Flows site is a UPI&WRD Gauge (G), Discharge (D) and Rainfall (Rf) site. This mountainous reach falls in the outskirts of the Corbett National Park and there are some formal restrictions in terms of fishing and construction activities. There are few tourist resorts on the banks of the Ramganga in Marchula. Tigers and elephants are sometimes sighted here. The main site is confined between two steep mountains that also make the channel narrower.

At Marchula, the river generally flows fast with riffles, runs and deep pools. Over the seasons and across the year, the river width ranges between 10 to 40 metres; average depth ranges from 0.60 to 2.50 metres. In-stream substrate particle size varies with varying depth. Boulders with occasional sandy patches dominate deep water (>40cm), while a combination of cobbles, pebbles and sand, and boulders dominates shallow waters (≤ 30 cm). The right bank is composed of boulders and slanting sand rock ridge with no or occasional marginal vegetation, while the left bank is largely sandy and flat.

Figure 2.12: Cross Section of Marchula and a Photograph of the Marchula Site



From the Fluvial Geomorphology perspective, the landscape setting of the Marchula site is Himalayan bedrock; the distinctive characteristics are very narrow valley and highly sinuous channel. The channel belt is characterised by large point bars and vegetated sidebars with boulders, pebbles and cobbles. The downstream reaches show mid-channel bars despite high sinuosity. Riffle-pool sequence is observed at some locations in this stretch. This site is otherwise quite similar to Bhikiasain. No major floodplain development is observed. Riparian vegetation is patchy on both sides. Bank material consists of boulders and coarse sand. The river, in this stretch, is single channelled. The channel belt is characterised by boulders, pebbles and cobbles. Figure 2.12 shows the Marchula site with key geomorphic features.

The biodiversity team concluded that the existence of sand banks indicates basking sites for both otters and crocodilians. The fish species include golder mahseer *Tor putitora*,

stone roller *Crossocheilus latius*, boalla *Labeo dyocheilus*, sucker fish *Garra mullya*, sucker head *Garra gotyla*, snow trout *schizothorax richardsonii*, dudhnea/khoksa *Barilius vagra/Barilius barna*, mottled loach *acanthocobitis botia*. Among invertebrates caenidae, chironomidae, chloroperlidae, dytiscidae, elmidae, empidae, ephemeridae, gomphidae, hemiptera, heptageniidae, hydrophilidae, leptophlebidae, limnephilidae, notonectidae, perlidae, psephenidae, psychomyiidae, sialidae, simulidae, siphonuridae and tabanidae were recorded as critical/rare taxa.

The socio-cultural and livelihoods team pointed out that, just like the Bhikiasain site, there is a confluence of three rivers at Marchula, i.e., Ramganga, Devta Gadera and Badan Gadera. Both Devta Gadera and Badan Gadera are seasonal streams. This site is called as 'triveni sangam' and thus is a spiritually important site. The Narsingh Temple at Balluli village is considered auspicious. River Ramganga is an east flowing river and as tradition in the region holds that the east flowing rivers are generally considered auspicious and hence traditionally worshipped. The local people also feel that this river is the lifeline for the Corbett National Park. In addition to the temple, this site also has a cremation ghat, hence bathing becomes a regular cultural activity. Fishing is a historical livelihood activity of the area. Tourism based livelihood activities also exist. A couple of residents of the village are employed in the tourist lodges near the river. Lately, farmers have departed from historical agricultural practices and moved towards growing ginger, chilies and mangoes. The local youth is involved in other tourism-based livelihood activities, like home-stays³ and guides. There are few resorts which have come up in this area that also provide some employment to the local population.

River Ramganga is an east flowing river and as tradition in the region holds that the east flowing rivers are generally considered auspicious and hence traditionally worshipped.

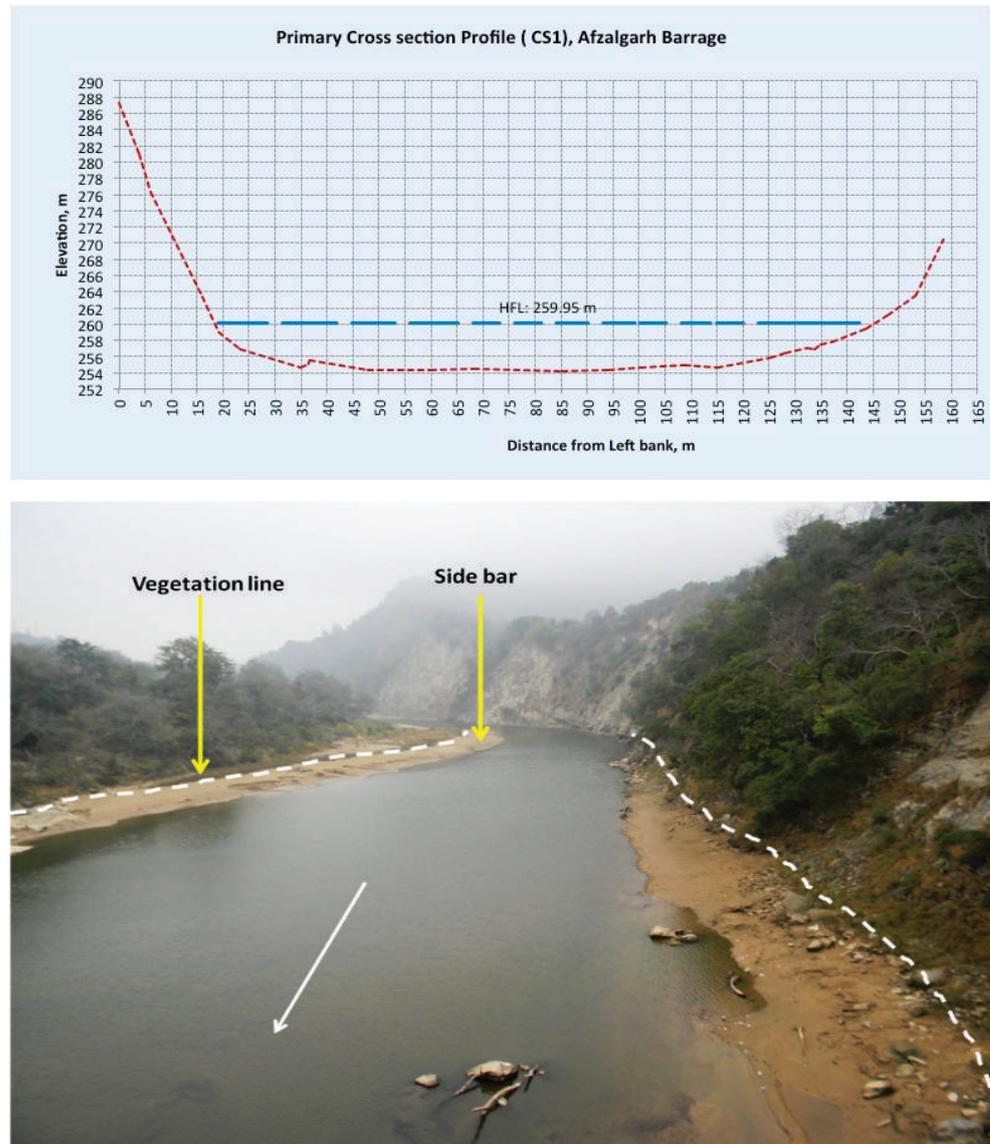
The respondents mentioned a visible decrease in the flow of the river since historical times. They said that earlier it was difficult to cross the river during summers. Some of them attributed the reduction in the flows to the pumping activities upstream. Several respondents also mentioned that the springs in the catchment have dried up, and this has reduced the flow of the river. However, they were satisfied with current water levels and aspired to have depths varying between three to five feet, with some pools during the lean season. During winters, the historical flows were slightly more than summer flows. The respondents commented that, current lean season flows are satisfactory, i.e., about 3 feet deep with some pools with a depth over 6 feet. The present day flows during the monsoon are also satisfactory. In the monsoon, the river fills the bed. Nearly all respondents wanted the flows to be the same as the present flows. It was a widespread feeling that, lower flows are not perceived as being natural or near-natural.

2.5.3.3 Afzalgarh Barrage – Present State

Immediate upstream of the Afzalgarh Barrage site (about 100 meters) is a CWC Gauge (G) site. The Afzalgarh Barrage is half-weir and half-barrage. A small irrigation system called the Phika Canal system takes off from the left bank at the barrage site, which diverts about 11 cumecs of water for irrigation. As noted earlier, this is a first site after the Kalagarh dam and hence is important from a flood-forecasting perspective. The stretch from the dam to the Hareoli Barrage, which is about 25km, generally has adequate flows throughout the lean season, because this water is diverted from the Hareoli Barrage to the Lower Ganga Canal through a feeder canal.

Based on the analysis of past flows data, it has been observed that there is a complete reversal of flow regime in this site, i.e., more flows during lean season and low flows during monsoon, as the water is being stored in the reservoir upstream (from 15 June to 15 September every year). The team had to take this aspect into consideration, while contemplating E-Flows recommendations for this site.

Figure 2.13 Cross Section of the Afzalgarh Barrage Site at view of actual location



The fluvial geomorphology team concluded that the site falls under the transition zone between the hilly and the plain areas, and the landscape setting is classified as valley interfluvies⁴. The channel belt is characterised by large and vegetated sidebars with boulders, pebbles and cobbles near the barrage (see Figure 2.13). The downstream reaches show mid-channel bars with silty and clayey bed materials. There is little sinuosity in the entire stretch with an average sinuosity of 1.07. Riffle-pool sequence is absent in this stretch. No active floodplains on the upper reaches, but continuous floodplain starts on both sides from the middle reaches. Riparian vegetation is patchy on both sides. Bank material consists of boulders and coarse sand in the upstream, and silt with clay downstream of the site. Settlements are above HFL on both sides of the river.

From a biodiversity perspective, the Afzalgarh barrage stretch has been recorded as a high water level fluctuation zone and the landscape is dominated by agriculture. Initially the river is generally shallow and fast flowing, while the river downstream is deep. Over the seasons and across the year, the width of the river ranges from 30 to 70 metres, with an average depth of 0.50 to 2.25 metres. Riffles are found along with fine sand substratum. The river bank substrate composition is largely cobble and pebble, but the composition changes

abruptly from cobble and boulder to sand within a 5km stretch from downstream of the barrage. Otters and crocodilians often disperse into this zone, as it forms a suitable refuge. The site lies abutting to the buffer areas of the Jim Corbett Tiger Reserve and is disturbed with anthropogenic pressure.

With cobble and pebble as bed materials, this site is suitable for fish species like golden mahseer *Tor putitora*. The other important species reported in the stretch are great snakehead *Channa marulius*, freshwater garfish *Xenentodon cancila* and day's mystus *Mystus bleekeri*. The substrate of the river bed changes abruptly from cobble-boulder to sand from upstream to downstream of the barrage. Sand mining is one of the critical anthropogenic activity in this reach, which disrupts habitat of several species. Over 40 varieties of fish species are found in and around this site, including, Angra Labeo *Labeo angra*, Kalabans *Bangana dero*, Reba Carp *Cirrhinus reba*, Silver Hatchet Chela *Chela cachius*, Indian Glass Barb *Laubuca laubuca*, Pool Barb *Puntius sophore*, Padin *Wallago attu*.

Among invertebrates, Tipulidae and Anthericidae were recorded as critical/rare taxa. The socio-cultural and livelihoods team spoke to people from Kalagarh town and nearby villages on Ramganga's left flank, that were settled after World War II. People said that the forest was cut down and the government allotted land to people with one room and land for agriculture. On the right bank are some villages that were originally inhabited by the Buksa tribes and settled by Sikhs after the partition in 1947.

The younger generations were born after the dam was commissioned, and equate the river with sudden release of water. The socio-cultural dependencies on the river are still very much there, especially – bathing during festivals like, *Shraavan*, *Kartik Dusshera*, *Ganga Dushehra*, *Durga Puja* and *Gurunanak Jayanti*. Some of the key perceived statements from the respondents conclude that, there is:

- Great fear of floods due to memories of unprecedented flooding in 2010
- Decline in agriculture has led to a surge in sand-mining activities
- Fear of sudden flow releases has led to a decline in the traditions observed along the river

This disruption in the flows has drastically affected resource-dependent livelihoods. As one respondent described it, “Earlier due to good flows, our livelihoods could be sustained. Before the dam, fishing was one of the main livelihood activities, but this has significantly declined.” The respondent's main concern has been sudden releases and that, according to them, is a critical issue which needs to be addressed.

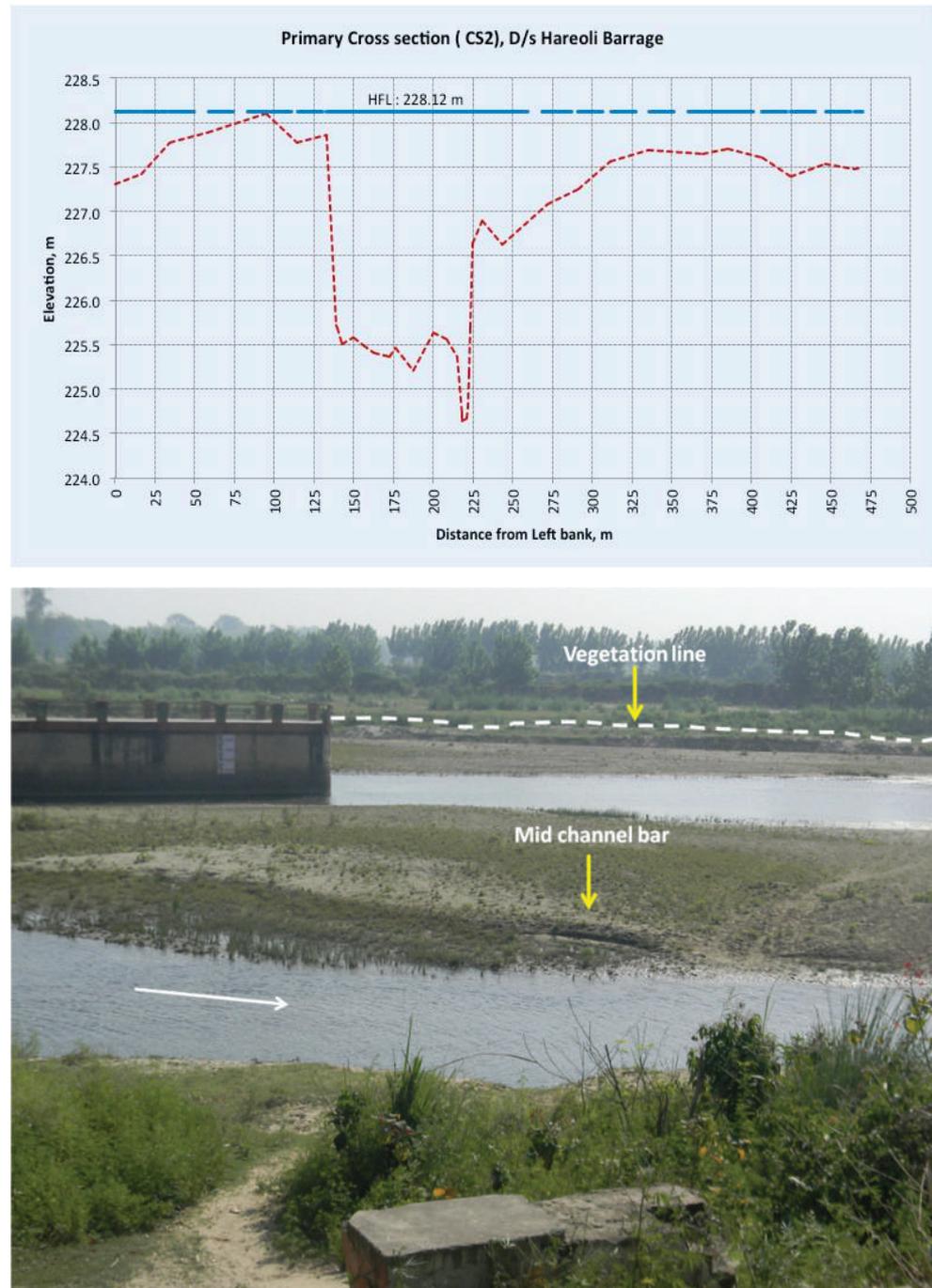
2.5.3.4 Downstream Hareoli Barrage – Present State

Downstream of the Hareoli Barrage, the river is deprived of flows as water is diverted to Lower Ganga Canal (LGC) through the Ramganga feeder that off-takes from the right side of this barrage. The river in this location is in an unhealthy state from the perspective of flows. Whatever one can see downstream of Hareoli Barrage in the river is either seepage from the barrage or irrigation return flow. At times there are occasional releases, mainly due to socio-cultural festivities in Chaubari and Katghar or to flush the sediments down the barrage.

Box 2.1

The negative implication of having a lean and thin Ramganga stretch downstream of this barrage for a long time is that the nearby villagers have started using the 'moist-to-dry' river bed for cultivation. The idea of flow releases down the barrage will have to take into account this challenge.

Figure 2.14: Cross-section Profile and Geomorphic Attributes of the Downstream Hareoli Barrage (UPI&WRD) Site



The fluvial geomorphology team felt that the landscape setting of the Hareoli Barrage site is valley interflaves. The distinctive characteristics are very wide floodplain and high bar density. Channel belt is characterised by sidebars, mid-channel bars and point bars. Fine sand and clay are observed in the channel belt. The downstream reaches show high sinuosity. Significant floodplain features like ox-bow lakes and meander cut-offs are mapped. Riparian vegetation is available on both sides. Bank materials consist of fine sand and clay. Figure 2.14 shows the geomorphic characteristics downstream of the Hareoli Barrage site.

From the biodiversity perspective, the wetted channel is often reduced due to negligible flows. Over the seasons and across the year, river width ranged between 10 to 25 metres, with an

average depth of between 0.50 to 1.50 metres. Riverbanks are largely sandy and both banks remain exposed. The dominant in-stream substrate particle recorded are sand and silt. Land-use is primarily for agriculture. The wetland (upstream of barrage pondage area) and the river stretch are given on lease to fishermen.

Within the bed materials present in the stretch, the Orange fin Labeo *Labeo calbasu* and Sind Danio *Devario devario* are the characteristic fish species. There are over 40 species of fishes found in this stretch. Notable examples are Mrigal Carp *Cirrhinus mrigala*, Giant River-Catfish *Sperata seenghala*, Day's Mystus *Mystus bleekeri*, Freshwater Garfish *Xenentodon cancila*, Great Snakehead *Channa marulius*, Tank Goby *Glossogobius giuris*, Philippine Catfish *Clarias batrachus* and Stinging Catfish *Heteropneustes fossilis*. Amongst invertebrates, Leptoceridae, Lestidae and Palaemonidae are recorded as rare taxa. The barrage on the river diverts the flow for irrigation. The floodplain of the river stretch is extensively used for agriculture. The pondage area is leased to fishermen.

The entire area upstream of the barrage is impounded for a significant stretch of the river, with practically no release of water downstream. The only time water is released from the barrage is during the Rabi season when the canal requires maintenance. In such cases, lack of warning mechanisms is a key issue for the villagers living downstream of the Hareoli Barrage, seriously endangering their lives.

The current perceived status of the river at this site is:

- Extremely low and stagnant flow downstream of the barrage,
- Sudden release of water is often a concern.

The current perceived status of the river at this site (downstream of Hareoli Barrage) is: Extremely low and stagnant flow downstream of the barrage, Sudden release of water is often a concern.

The dominant feature of life along the Ramganga at Hareoli is the barrage. The flood of 2010 was damaging, however there are floods every year that are much less in magnitude. When there is no flood, there is stagnation.

The main cultural fair, locally called as the Nahan (ritual bathing) fair, takes place in the month of November. It is a much-awaited event and communities from 10-20 surrounding villages participate in the festivities. In addition to this, rituals such as *mundan* and cremations are carried out regularly at the banks. The rituals, traditions and festivals associated with the river serve to link the people to the river.

Several of the respondents remembered the period before the construction of the barrage. In their words, "the barrage holds back water. Earlier the Ramganga would flow '*khull*' (open and full)". This was also a time when the river would provide clean water for livestock, with fish for consumption and the '*sarkanda*' for thatching roof of dwelling houses. During the summer season, the Ramganga used to be a perennial river. The depth varied between two to seven feet across the channel; whereas, during monsoon, the width of the river extended up to the fields, which is approximately a kilometre wide.

The people desire that flows during the lean season should be little above the knee. During the monsoon, proper warning systems are desired for sudden release of water from the barrage.

2.5.3.5 Agwaanpur – Present State

This site is in Agwaanpur village and is situated 10km upstream of the city of Moradabad. At this site, one can easily distinguish between the reasonably satisfactory physical appearance of Ramganga water in comparison to all the downstream sites. Another striking fact about this site is that, the water levels at this site are far better than the water levels in the next

site, i.e., Katghar-Moradabad (and this is despite the contribution from river Dehla, which confluences into Ramganga at Moradabad much before the Katghar site). This indicates the 'losing' nature of the river stream, as it seems to feed the groundwater aquifer.

From the fluvial geomorphological perspective, the landscape setting at Agwaanpur is defined as valley interfluves. This stretch falls in the alluvial part and the channel is characterised by multiple-thread, but still with high sinuosity in certain stretches. Large mid-channel bars and extensive sidebars composed of sand characterise the stretch which is generally vegetated. Banks are muddy. In contrast to the mountainous reaches, wide floodplains are observed in this area on both sides with significant floodplain features (ox-bow lakes, meander cut-offs etc.). Large patches of riparian vegetation are observed on both sides. There are seasonal croplands on both sides of the river, as well as on the mid-channel bars. However, settlements are located far away from the river. Figure 2.15 shows key geomorphic features of the Agwaanpur site.

Another striking fact about this site is that, the River Health at this site is far better than the next site, i.e., Katghar-Moradabad. This indicates the 'losing' nature of the river stream, as it feeds the groundwater aquifer.

The biodiversity team observed that the substrate is predominantly silt and sand. Floodplains are wide with patches of riparian vegetation. The banks are utilised for agriculture and extensive cultivation of *Saccharum officinalis* and seasonal *Cucurbitaceaeous* crops (pumpkin, water-melon, cucumber etc.). At Agwaanpur the

Figure 2.15: Cross Section Profile and Geomorphic Attributes at the Agwaanpur Site

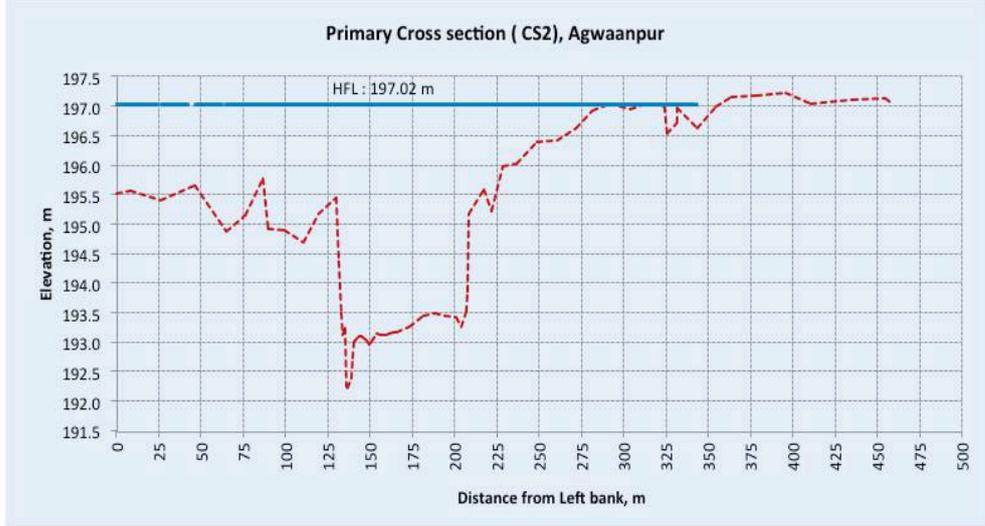


Photo Credit: Haridas Mohanta

water current is faster than that of the Hareoli site. Over the seasons and across the year, river width ranges between 30 to 40 metres, with an average recorded depth of 1.5m. The substratum composition is mainly clay and silt, but is unstable due to retreating flood waters. Land-use is predominantly for agricultural purposes. The team observed about 38 species of fishes in the river at this site. Some of them are exotic, e.g. Common Carp, while others fish species include, Orange Fin Labeo *Labeo calbasu*, Koriya Labeo *Labeo gonius*, Sind Danio *Devario devario*, Catla *Catla catla*, Padin Wallago *attu*, Pabdah Catfish *Ompok pabda* etc. Among invertebrates, Bulminidae, Corbiculidae, Culicidae, Gerridae, Lymnaeidae and Nepidae are recorded as critical/rare taxa.

The socio-cultural and livelihoods team held discussions with farmers, shopkeepers, timber merchants, fishermen and other village folks. The river banks on both sides are characterised by vast flood plains with deposition of silt and sand, patches of riparian vegetation and seasonal crops. Agwaanpur village is located about a kilometre and a half from the river bank with farms on both sides of the village road.

According to one such belief, Lord Ram, during his exile, was rowed across this river by a boatman. The river since then started to be called as Ramganga.

Like other sites, people living in Agwaanpur also shared stories and beliefs passed through generations as oral history. According to one such belief, Lord Ram, during his exile, was rowed across this river by a boatman. The river since then started to be called as Ramganga. Rituals like *Aachaman* are performed, along with holy bathing. A fair is also organised on its banks.

People from Muslim community have been living here for generations. They share a cultural association with the river. One of the respondents stated that, “God created river for our benefit”. He further added that, “people from all religions put up stalls at the cultural fairs organised on the river bank”. Since time immemorial the cultural fairs along the rivers have provided opportunities for livelihood for many across communities.

The present day perceived status of the river at Agwaanpur includes:

- Bed scouring and sand deposition by the river on the farms,
- Low lying bank on left side

People at Agwaanpur have a particular understanding of the river and its floodplains. This is evident from a statement made by one of the respondent that “Ramganga’s house is large”. Villagers take livestock to the river for bathing and drinking, and one of them pointed out that, “Had Ramganga not been here where would our animals drink water from?” *Pallage* (river-bed farming) farmers do not drink water directly from the river, but access it by digging small burrows near the river bank.

In winter, the quantity of water in the river is more than in the summer season. During the monsoon, the river reaches the tree-line, situated a few kilometres from the main course, mainly due to the low-lying bank on the left side of the river. The channel is unstable and keeps shifting, which results in relocation of settlements around the banks. Due to the barrage upstream, “the river does not bring the same quality of nutrient rich silt from the mountains, that it used to bring earlier”. Further, according to the villagers, the presence of one industrial unit deteriorates the quality of water by dumping industrial waste into the river.

The main livelihood of the area is *pallage* farming with some fishing as well. However fishing is subsistence in nature. In *pallage*, the villagers grow cucurbit fruits and vegetables. The team interviewed people from a fishing community to understand their practices, perception about the river and its flows, and the impact that the changes in river movement

have brought to their livelihood. There have been changes in the number and variety of fish found in the river. Earlier several fish species were found in the river, like Rohu, Keral, Lachi, Sol and Mahseer, which one can now hardly find in this part of the river. One fisherman confirmed the existence of large size Mugger and tortoise (local name *pattal*, soft shelled turtle, which are big in size). He further added that earlier one could find a large number of fish including various varieties, like Mahseer and Gonch, during monsoon as compared to other seasons. People do fishing almost daily and sell the catch at the local market in Moradabad. However, fishing as a livelihood is on the decline as the younger generation is not much interested in fishing. During the summer season, when the water is stopped by the dam upstream, fishes are not found in great abundance in the river. The *Dhimars* are the traditional fishing community of this region. The respondents did mention that the dam officials inform them of the release of water from the dam.

Some cultural fairs are organized at the site, with visitors mainly from the Agwaanpur village. Ritual bathing and Dusshera fair is organised on the river banks. Under natural conditions, the Ramganga would flow continuously throughout the summer season, with the depth varying from waist and chest levels near the banks. Due to the continuous decline in the flow of water and thereby depth of the river, along with deteriorating water quality, the number of people visiting the fair is on the decline.

The respondents commented that during the lean season, water is present up to the waist level near the banks and to above the chest level at the deepest parts of the channel. The residents desire historic flow of water during the lean season. However, during monsoon there is often flood damage, as the left side of the bank of the river is low lying.

2.5.3.6 Katghar, Moradabad – Present State

Katghar is the second most important site from a socio-cultural perspective, and a historical temple is located on the right bank of the river. It is also a CWC site for GDSQ. On the other hand, Katghar is a site where one can find several detrimental activities that negatively affect the river, such as, dumping of solid and liquid wastes, sand-mining, burning and washing of electronic-waste etc.

The fluvial geomorphology team felt that the landscape setting of Katghar is interfluvial, but this stretch is characteristically straight and the channel hugs the left bank (embankment) all along. There is a very wide floodplain and a large meander cut-off is conspicuous. Elongated bars, both mid-channel bars as well as side bars, are dominant in the entire stretch. Both bed and bank materials consist of fine-grained sediments. The channel beds are composed of fine to very fine sand and banks have silt and clay. Figure 2.16 exhibits, both the cross-section and the key geomorphic features, through a site picture.

The biodiversity group felt that Katghar was heavily polluted due to sewage and other anthropogenic activities, particularly washing and dyeing of clothes. The wetted channel is generally reduced due to low flow. Over the seasons and across the year, river width ranged between 10 to 80 metres, with an average depth ranging between 0.50 to 1.50 metres. Micro-habitats recorded included runs and pools where the riverbanks are steep. The dominant substrate particle composition recorded is sand and silt. About 47 fish species are recorded from this site, including Common Carp *Cyprinus carpio*, Rohu *Labeo rohita*, Boggut *Labeo boggut*, Silver Carp *Hypophthalmichthys molitrix*, Grass Carp *Ctenopharyngodonidella* etc. Among invertebrates, Tubificidae and Glossoscolecidae are recorded as critical/rare taxa.

Katghar is a site where one can find several detrimental activities that negatively affect the river, such as, dumping of solid and liquid wastes, sand-mining, burning and washing of electronic-waste etc.

Figure 2.16: Cross Section Profile and Geomorphic Attributes at the Katghar (CWC) Site



Photo Credit: Haridas Mohanta

One respondent commented that “The Ramganga is mother for us. We go for bathing there. This is mother’s abode. This is an old tradition and holds importance. We worship the river for attaining salvation.” There are many stories that associate the river with Lord Ram.

The socio-cultural and livelihoods team observed that today a temple marks the spot where high flows once reached. Now the Ramganga flows on the left bank upstream of the bridge. From just upstream of the bridge, it forms two channels which flow on both banks of the river. On the left bank of the river are several villages that still maintain their rural lifestyle and are primarily dependent on agriculture.

Despite the decline in quality, people along the river continue to venerate it even today. This proves the faith and cultural connect of communities with the river. One respondent commented that “this is mother for us. We go for bathing there. This is mother’s abode. This is an old tradition and holds importance. We worship the river for attaining salvation.” There are many stories that associate the river with Lord Ram.

The present day perceived status of Ramganga at this site includes,

- Pollution is a key concern,
- Decline in the flows of the river,

- Decline in domestic and ritual use due to pollution, though the livelihood use still continues.

This current state of the river has its impact on livelihoods. One of the respondents highlighted that “due to increasing pollution and dirt in the river, and reduced water flow and levels, all associated livelihood activities have been negatively affected.” The pollution is reflected in the number of visitors coming to the river; as one respondent explained, “the number of people coming in all seasons has come down and people’s participation in religious rituals and ceremonies has also reduced.”

For the local communities, the river acts as a barrier and provides them with a sense of security, i.e., the people from other side find it difficult to venture into the river to reach to the other side.

Earlier the Ramganga was clean, had abundant natural flows, was full of fish and deposited silt on its flood plains, dutifully, every monsoon. This combination made it ideal for several resource-based livelihoods. Primary among these was pottage farming. Fishing was also carried out on a large scale. Bamboo would be floated down the river from upstream for sale in Moradabad. Hosting festivals and providing services to tourists also added to the residents’ income. Washing clothes and watering cattle are another activities of the residents of Moradabad. With the reduction in flows and increase in pollution, all these livelihood activities are declining.

In place of these activities, which depend on a healthy river, other livelihoods have come up. These activities use the existing water and sand in the river. Several of these activities such as metal washing, washing of brass etc., tend to pollute the river. The communities living alongside the river use the water for domestic purposes such as washing and bathing. This has changed since the last three to four decades. Water for domestic use and bathing are the basic needs of the communities. The residents’ vision of a healthy Ramganga involves being able to use the water for domestic purposes and bathing.

Agriculture has been traditionally practiced along the river banks. It was almost entirely organic. One farmer described the “use of biodegradable waste as compost. The watermelons grown were so big they didn’t fit in the hands.” Even today, people understand some basic principles of organic agriculture. This leads them to value the floods, “Ramganga comes into farm lands and leaves adequate amounts of fertile silt.”

Proximity to the city of Moradabad means that the price of land is more than the other sites. ‘Pottage farming has reduced, since agricultural land is sold off for urban use’, informed a villager. Another farmer seconded this statement by saying that “we left agriculture some 40 years back and we now carry on business. The agricultural land is being acquired for construction of houses.”

In addition to diminishing flows in the river, the most critical issue is increase in pollution, which has led to decline in fishing activities. A villager remembered that “fishes weighing 20-30kg were found [at earlier times].” Today, said another respondent, the catch is only 5-6kg. This was reiterated by another respondent, “Earlier there were more fishes. Varieties like Lachi, Singhara, Chaal could be found. And one could get a good fish catch and income by spending 1 to 1.5 hours on river banks and get a catch of 50kg. Now drain water and water from industrial units kill the fishes. The fish catch is only 3kg at one time and 10kg after spending a day.’

A respondent asserted that “some 20-25 years back, numerous turtles could be found in river.” Fish species are dependent on adequate and clean flows. The viability of fishing as an occupation is directly related to fish health and to in-stream flows.

Major cultural activities associated with the river are “holy bathing in the river during festivals and fairs. The fair during *Ganda Dusshera* goes on for 15 days.” A respondent spoke about the changes in the nature of fairs, “My grandmother tells me that during her time, water use to be blue in colour. Now there is little water. We refrain from taking bath but people coming from outside of the city do take bath during the fair. People put up stalls of eateries and entertainment during the fairs.”

The people working at the temple in Katghar earn income from the rituals associated with the river. In addition, the fair provides a welcome additional income to the residents. These rituals and events has been greatly affected by the decrease in flows as well as increase in pollution level in the river. One respondent described the flows in summer as, “the river water use to be clear and clean in the past. The flow, velocity and vigour, used to be so great that the river banks had chains for facilitating holy bathing in the river. One could see the fishes and turtles in the river, standing from the bridge.” The depth of water at the ghats used to be “up to the third stair from the bottom of the ghat, or about 4-5ft deep.” During monsoon the flows used to completely fill the river bed. It used to reach “till the upper most step of the temple, i.e., 10-12ft.

“The river water use to be clear and clean in the past. The flow, velocity and vigour, used to be so great that the river banks had chains for facilitating holy bathing in the river. One could see the fishes and turtles in the river, standing from the bridge.”

2.5.3.7 Chaubari Bareilly – Present State

Chaubari is the most important socio-cultural site on river Ramganga and there is an under-construction irrigation barrage (Badaun Irrigation Scheme) immediate downstream of the site. This site is a CWC site as well.

From the fluvial geomorphological perspective, the landscape of this site could be regarded as valley interfluves. There is a wide floodplain on both sides of the river. Elongated side bars, mid-channel bars and point bars are dominant in the entire stretch. In the active floodplain, a number of dry channels and flood channels are present. Bed as well as bank materials are composed of fine sand and clay. Riparian vegetation occurs in patches on both sides. Key geomorphic features are presented in Figure 2.17

The matter of concern is going to be the site or stretch immediate downstream of the under-constructed barrage. Therefore, the team recommended flows for this site, which not only meets the requirement of the Chaubari site (upstream of barrage), but also sustain the requirements downstream of the barrage. This should mean that, there is no substantial flows alteration. This project is meant for irrigation during the *kharif* (wet) season, so ideally the lean season flows should not be hampered. Therefore, it was prudent for the team to come out with recommended E-Flows which are required to be maintained downstream of the barrage.

The under-constructed Badaun Irrigation Scheme

The UPI&WRD is developing the Badaun Irrigation Scheme, with irrigation benefit for Badaun district and groundwater recharge benefit for the district of Bareilly. This is supposed to be an irrigation scheme meant to provide irrigation only during the *kharif* (wet) season. The designed diverted discharge into the canal system would be 56 cumec. Under this scheme the department is also developing the Chaubari site with bathing ghats, plus some river-front development activities.

Figure 2.17: Cross section profile and Geomorphic Attributes at Chaubari – Bareilly site

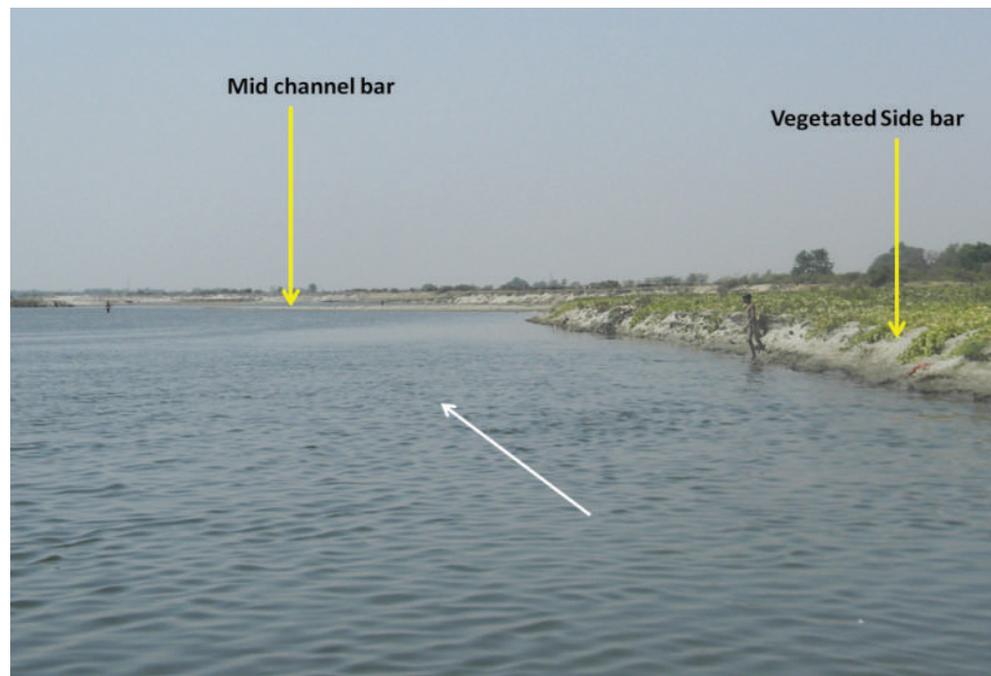
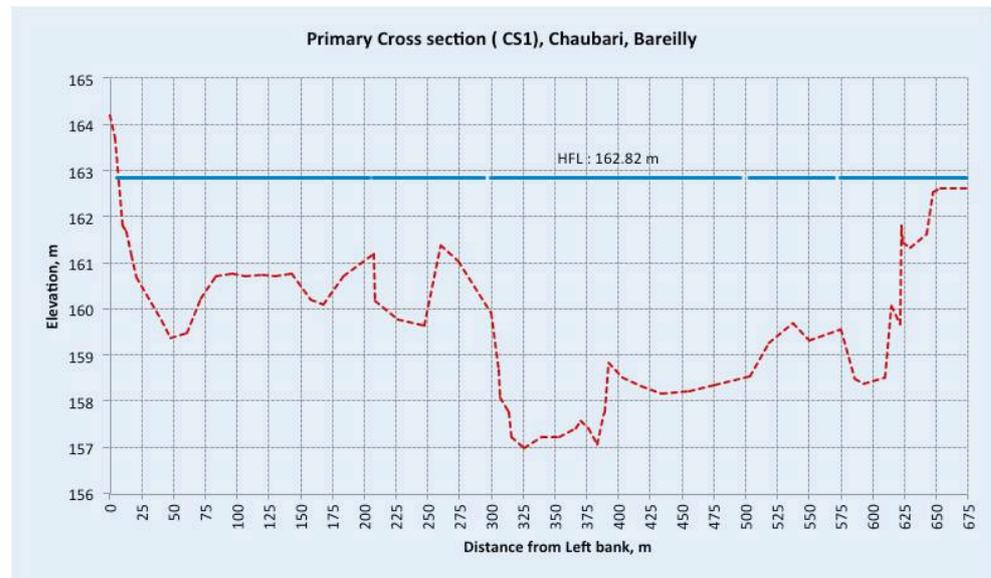


Photo Credit: Haridas Mohanta

From the biodiversity perspective, at Chaubari the main channel of the river is fragmented due to generation of sand bars in the mid-channel. Clay and silt composition are the dominant substratum. River width ranges between 15 to 60 metres, with an average depth of 0.50 to 1.10 metres. Extensive palling (river-bed) farming is recorded. About 33 varieties of fish species are found at this site. Some of them are, Common Carp *Cyprinus carpio*, Indian Glass Barb *Laubuca laubuca*, Rosy Barb *Pethia conchoniuis*, Padin *Wallago attu*, Giant River Catfish *Sperata seenghala*, Long-Whiskered Catfish *Sperata aor* and Goonch *Bagarius bagarius*. Among invertebrates Culiciade, Corbiculidae, Dytiscidae, Naucoridae, Notonectidae and Syrphidae are recorded as rare taxa.

The socio-cultural and livelihoods group observed that the main site from the socio-cultural perspective is just below a railway bridge. In addition to being an important socio-cultural relevant site, the Ramganga in and around Chaubari is a means of livelihood for fishermen

and pottage farmers. Some of the stories narrate the origin of the river itself. The present day perceived status of the river at this site includes:

- Pollution is a major concern for all groups associated with the river,
- Catering to visitors/pilgrims during the Chaubari mela and other auspicious days,
- Fishing and pottage farming are key river-associated livelihood activities,
- Sand-mining also takes place at the site,
- Reduced flows are definitely a concern with the local people.

Certain livelihood opportunities are also attached to cultural rituals, like selling worshipping materials, including – *prasad* and sweets, and toys and vegetables grown in the nearby fields. The residents of the villages around Chaubari earn considerable income from rituals associated with the river. In addition, the river provides a welcome space for residents of Bareilly, from a recreational perspective.

The respondents desire to have 3-4ft deep water during the summer season, primarily for ritual bathing. During monsoon they wish to get water in the entire flood plain up to the embankments for saturating the fields and depositing nutrient rich soil.

2.5.3.8 Dabri – Present State

Dabri is the most downstream CWC site on the Ramganga and is about 20km upstream of Ramganga's confluence with river Ganga.

During monsoon, Dolphins can be seen in and around Dabri site, however these would be migratory from Ganga, as the confluence is near to this site.

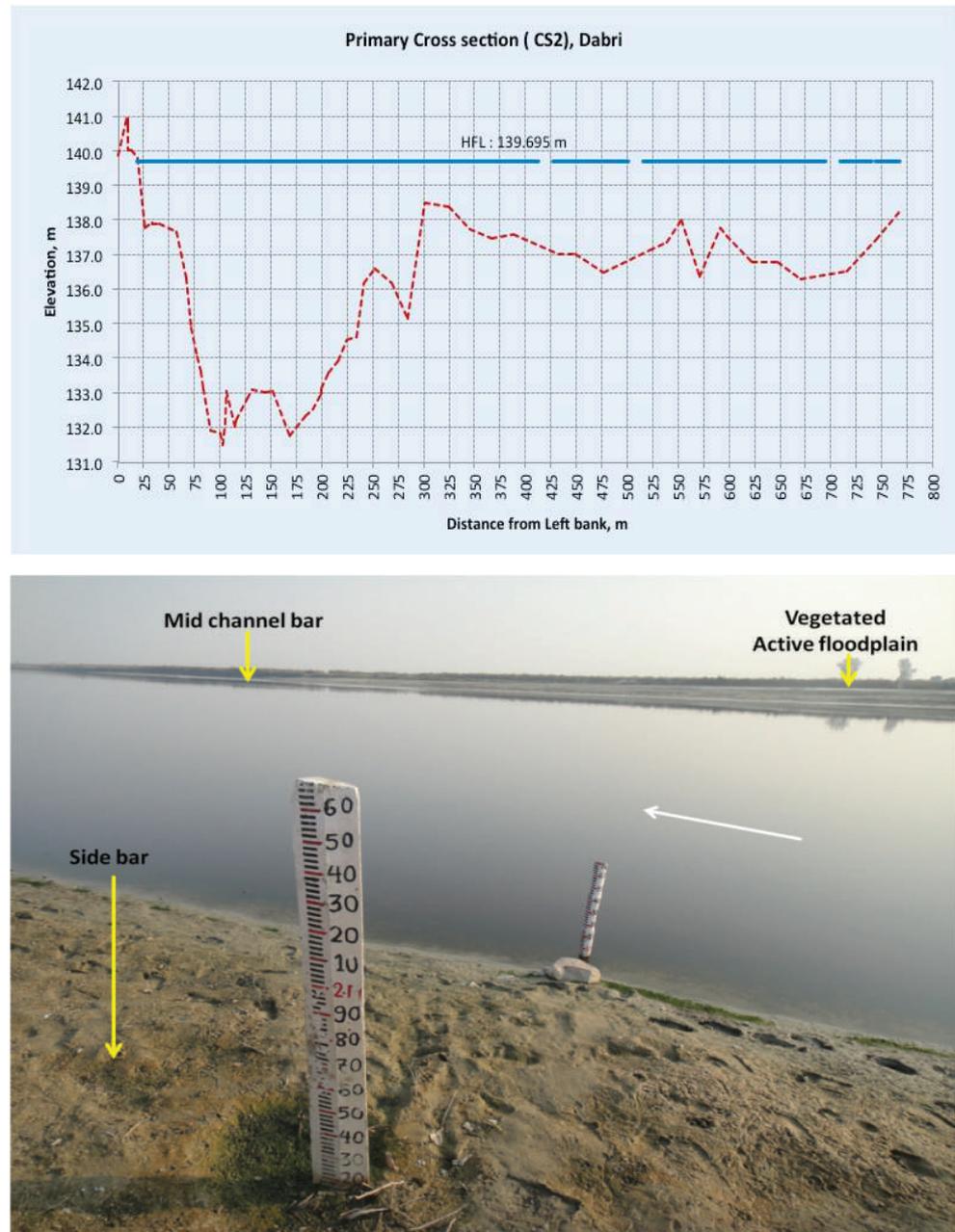
From the fluvial geomorphological perspective, the landscape setting at Dabri is defined as valley interfluvies. This stretch falls in the alluvial part and the channel is characterised by multi-thread system, but still have high sinuosity in some reaches. Large mid-channel bars and extensive side bars composed of sand characterise the stretch which is generally vegetated. Banks are muddy. In contrast to the mountainous reaches, wide floodplains are observed in this area on both sides of the river with significant floodplain features (ox-bow lakes, meander cut-offs etc.). Riparian vegetation is identified on both sides. Some of the key geomorphic features can be seen in Figure 2.18.

This site surprised the biodiversity group as the site was found to be the best habitats for turtles and mollusks. Even dolphins are sighted during the monsoon season. Water current at Dabri is relatively fast. Over the seasons and across the year, river width ranges between 80 to 150 metres, with an average depth of four metres. The dominant substrate particle composition recorded was clay and silt. The landscape is agriculturally dominated and anthropogenic activities like fishing, coin collection, cattle bathing and washing of clothes are recorded. Key fish species include, Carp *Cyprinus carpio*, Orange Fin Labeo *Labeo calbasu*, Boga *Labeo boga*, Indian River Shad *Gudusia chapra*, Giant River Catfish *Sperata seenghala*, Gangetic Ailia *Ailia colia*, Padin *Wallago attu*, Goonch *Bagarius bagarius*. The team also found some species of mollusks. It was also reported by nearby villagers that, during monsoon, Dolphins can be seen in and around this site, however these would be migratory ones from the Ganga, as the confluence is nearby. At Dabri, Chaoboridae, Gerridae and Lymnaeidae are recorded as rare invertebrate taxa. Filter feeders like Unionidae are exclusively found at this site.

From the socio-cultural and livelihoods perspective, fishing and pottage farming are carried out. The villages around the section are accustomed to living with floods.

Residents perceive a decline in the water quality, as well as quantity. In addition, flood velocities have increased. One respondent summed up the status of the river as, “the river does not have depth now and it keeps on changing its course.” Before a ban was imposed on

Figure 2.18: Cross Section Profile and Geomorphic attributes at the Dabri Site



sand mining, sand would be taken from river for all months except during the flood period. Traditional ways of using sand by villagers was for raising the ground level of houses to prevent flood water from entering the houses.

The present day perceived status at this site include:

- Pollution is a key concern,
- Decline in flows is also a major worry, and
- Decline in domestic and ritual use due to pollution.

Fishing in the river is done during all the seasons except monsoon (June, July, August). According to some respondents, “earlier there were more fishes which were sold at a rate of Rs. 20/kg. Now there are fewer fish and they are sold at a rate of Rs 200/kg. Sighting of Crocodiles has also reduced”.

Pallage farming still remains traditional and an important part of people's livelihoods. Sowing of pallage crop starts in the month of November and harvest is done during May-June depending on arrival of monsoon and floods. Farmers invest between December and February, and earn income by June.

Cremation is also carried out on the banks of this site. The river is the main source for carrying out rituals during cremation.

Historically, the flows during the summer months were about 5-6ft deep close to the banks and varying between 10-15ft at the centre. During monsoon, the width of the river expands to about a kilometre (20-25ft deep). During winters, the depth ranges between 4-10ft along the cross-section.

The role of Ramganga Mitras has been central to the entire exercise of E-Flows assessment. The team held interactions with them to ascertain their perspective on the present and desired state of the river.

The residents would like the river to have about 5-6ft depth during the summer season. This, according to them, would maintain the groundwater levels, allow animals to drink water and provide habitat for fish. Boat navigation (across the banks) is also provided for. During monsoon, the expected flows, according to the residents, should be filling the river bed, within its confines. During winter, the depth should be ranging between 4-10ft.

2.6 Flow Motivations

This section details out the process for motivating flows for different sites and for different seasons. There are few improvisations in the Ramganga EFA, as compared to the previous exercises, which are also discussed.

The role of Ramganga Mitras has been central to the entire exercise of E-Flows assessment. The team held interactions with them to ascertain their perspective on the present and desired state of the river. In fact, during the E-Flows setting workshop, some of the Ramganga Mitras participated in the deliberations.

2.6.1 Different Flow Scenarios for E-Flows Recommendations

One of the lessons of the Upper Ganga EFA exercise was, not to look at one recommended flow value for policy and decision makers. Therefore, Ramganga EFA aims to present different flow scenarios and their resultant river health status in order to facilitate informed decisions by policymakers around E-Flows implementation. This report also presents a scenario, 'Additional-Use', to show what would happen if the water levels go below the present levels following the current trajectory, for instance—from slightly to moderately modified (see Section 2.6.2 below).

In accordance with this idea, three different scenarios were identified, discussed and finalised during the initial phase of the E-Flows setting workshop. There scenarios are:

- **Target Scenario:** In this scenario the teams set immediate goals. This scenario should achieve all the objectives set by the specialists. In other words, this scenario seeks answers to questions like – “what category, according to you, should be the objective to ensure sustainable biodiversity, biophysical processes, and provision of adequate ecological goods and services?”
- **Improved Scenario:** Under this scenario a long-term goal is set which is a class above the Target Category. The teams envisage the set goal in the coming years. Though this may be considered an ‘ambitious’ scenario, due care was taken that the recommendations under this scenario are practical and implementable.
- **Additional-Use Scenario:** under this a scenario is predicted by specialists in which the river degrades to a level one class lower than its present state following the current

trajectory. In other words, this scenario cautions the stakeholders that, if the water resources of the river are further exploited or continued to be exploited at the present trajectory, then the river will degrade. Another dimension to this category is that “if the site is presently in a sustainable River health Classes (RHC), what alternative category should be considered, if the water resources in the reach are to be further exploited in the future?”

It was not considered necessary to have all three scenarios for all the sites, sometimes only two scenarios were considered based on the site-specific situation and requirements. Nevertheless for all the critical sites (Hareoli, Katghar, Chaubari, Dabri), the E-Flows setting was done for all three scenarios.

One of the modifications in the Ramganga EFA approach was to re-think about the Environment Management Classes (EMC) method for E-Flows recommendations. Instead, the River Health Classes (RHCs) were draft.

2.6.2 River Health Class

One of the modifications in the Ramganga EFA approach was to re-think the Environment Management Classes (EMC) method for E-Flows recommendations. Instead, the River Health Classes (RHCs) were drafted and it was very much ‘an experiment’ which the team undertook. Before the setting of E-Flows for the sites during the seven-days long E-Flows Setting Workshop (held in March 2015), the draft of the River Health Classes (RHCs) was presented, discussed and finalised. The agreed version of various RHCs are as follows –

1. Near-Pristine

Minimal human interference

- The most sensitive species are present in abundance.
- All biophysical processes are operational,
 - Minimal erosion and sedimentation, river well connected longitudinally
 - Largely unmodified channel morphology with natural riparian vegetation cover
 - Floodplains, if present, natural, with no intensive agriculture, largely unmodified wetlands and flooding regime
- Natural water quality with no or insignificant anthropogenic contamination
- Almost all river-based sustainable livelihood needs and recreational activities are met
- People’s expectations of what a holy river looks like are met
- All religious rituals and cultural activities can be carried out without reservation

2. Slightly Modified

Some evidence of human interference, but still functionally intact

- There may be some reduction in the abundance of sensitive species, but they are not at risk of disappearance, even during extreme events
- Slight or negligible effects on biophysical processes
 - Some erosion and sedimentation may be evident, but with slight or negligible effects on biodiversity.
 - Slight or insignificant modifications to channel morphology, good longitudinal connectivity.
 - There may be some introduced or exotic riparian plant species, but natural species are still dominant.
 - Floodplains, if present, connected to the main channel at regular intervals, with no intensive agriculture, but most wetlands largely unmodified and natural flooding regime.
- Water quality natural or only slightly modified, with zero industrial waste, possibly insignificant agricultural runoff and domestic waste.
- Most sustainable river-based livelihood needs are met.
- People’s expectations of what a holy river looks like are met.
- Cultural activities are carried out.



Only the first three categories may be applied as environmental objectives. For sites/stretches presently in a Degraded or Critically Degraded category, the minimum objective will be to improve them to at least a 'Moderately Modified' category over the long term.

3. Moderately Modified

Clear evidence of human interference, but still largely, functionally intact

- Reduction in the abundance of sensitive species, and possible risk of disappearance for the most sensitive, during extreme periods (e.g., drought, flood, pollution etc.)
- Observable effects on biodiversity and biophysical processes:
 - Significant erosion and sedimentation may be evident.
 - Significant modifications to channel morphology may be present, possibly with introduced or exotic riparian plant species, which may be common.
 - Longitudinal connectivity disturbed particularly during lean flow.
 - Floodplains often used for agriculture, but with some wetlands, which may be modified; flooding regime mostly natural but doesn't inundate the entire floodplain thereby reducing lateral connectivity.
- Water quality may be moderately modified, with the possibility of industrial waste, agricultural runoff, and/or domestic waste. A shift from sustainable river-based livelihood to other livelihoods is clearly observed.
- People's expectations of what a holy river looks like is met during certain seasons.
- All cultural activities and rituals are carried out, but with hesitation.

Only the above three categories may be applied as environmental objectives. For sites/stretches presently in a Degraded or Critically Degraded category (see below), the minimum objective will be to improve them to at least a 'Moderately Modified' category over the long term.

4. Degraded

Evidence of considerable human interference and functionally disturbed

- Sensitive species absent (except during rare improved flow and/or water quality conditions).
- Increased abundance of hardy species
- Serious erosion and sedimentation may be evident, with significant effects on biodiversity and biophysical processes, which will only be partially intact.
- Serious modifications to channel morphology may be present, with significant reduction in longitudinal connectivity.

- Dominance of introduced or exotic riparian plant species, which may be invasive.
- Floodplains usually completely modified for agriculture, possibly occasional surviving modified wetlands, flooding regime may have been significantly reduced and lateral connectivity is lost.
- Water quality may be seriously affected, with one or more of industrial waste, agricultural runoff, and/or domestic waste.
- A shift from sustainable river-based livelihood to other livelihoods are observed; migration is observed, people's shift to other livelihoods that may harm the river.
- People's expectations of what a holy river looks like is met during certain seasons.
- Religious rituals, other than cremation, are not carried out.

5. Critically Degraded

Dominated by human interference

- Sensitive species will be permanently absent, and species communities will be dominated by hardy species, some of which may be pests or disease vectors.
- Very little natural biodiversity will be apparent (except for hardy species).
- Serious erosion and sedimentation may be evident, to the extent that channel morphology will be permanently altered (possibly channelised), longitudinal connectivity is completely lost, and river is reduced to isolated pools.
- Riparian vegetation, if present, will be dominated by introduced or exotic invasive species.
- Floodplains may have been drained and disconnected from the river but will anyway be completely modified for agriculture or industrial uses, no surviving wetlands, flooding regime may have been significantly reduced, diverted or intercepted.
- Water quality will probably be completely modified, with flow usually dominated by industrial, agricultural and/or domestic effluents.
- Sustainable river-based livelihoods are non-existent.
- No river-based recreation activities are carried out.
- No religious or cultural activities are carried out.
- Cremation is not practised if alternative sites are available.

A process chart is given in Figure 2.19 for understanding the procedure adopted by the teams to arrive at consensus River Health Classes for respective Ramganga E-Flows sites.

The consensus RHCs (which were finally arrived at after discussions) for all the sites is tabulated in Table 2.3.

Figure 2.19: Process to Arrive at Consensus regarding River Health Classes / Categories for the E-Flows Sites

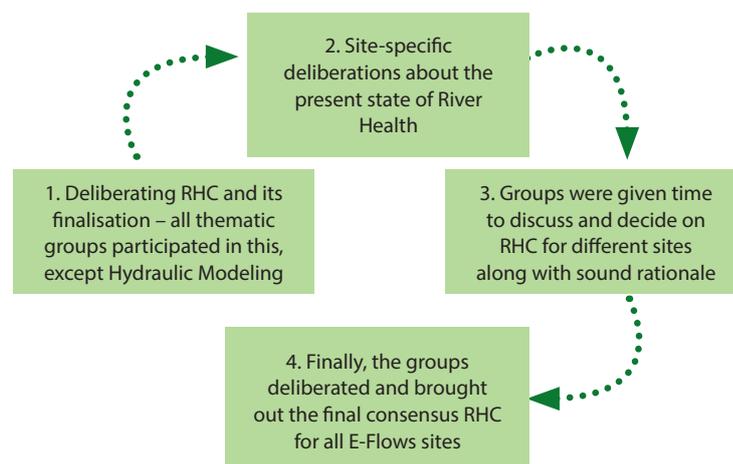


Table 2.3: RHC for All the Sites

Site	Present Category (Lean Season)	Present Category (Monsoon)	Trajectory of change	Target Category	Improved Scenario	Additional use Scenario	Remark (brief of present state)
1. Bhikiasain	Near Pristine	Near Pristine	Negative	Near Pristine	Nil	Slightly Modified	Natural water quality with insignificant anthropogenic contamination
2. Marchula	Near Pristine	Near Pristine	Negative	Near Pristine	Nil	Slightly Modified	Natural water quality with insignificant anthropogenic contamination
3. Afzalgarh	Slightly Modified	Slightly Modified	Negative	Near Pristine	Nil	Nil	No industrial pollution but very low input from agricultural and domestic influence as indicated by nutrient, coliform, TDS/ chloride
4. Hareoli	Moderately Modified to Degraded	Moderately Modified to Degraded	Negative	Slightly to Moderately Modified	Near Pristine to Slightly Modified	Moderately Modified to Degraded	No industrial pollution but very low input from agricultural and domestic influence as indicated by nutrient, coliform, TDS/ chloride
5. Agwaanpur	Moderately Modified	Moderately Modified	Negative	Slightly Modified	Nil	Nil	Agricultural and rural waste as indicated by nutrient, coliform, TDS, and pesticides
6. Katghar – Moradabad	Degraded	Degraded	Negative	Slightly to Moderately Modified	Slightly Modified	Degraded	Industrial, domestic and agricultural pollution as indicated by nutrient, coliform, TDS, heavy metals and pesticides.
7. Chaubari – Bareilly	Degraded	Degraded	Negative	Slightly to Moderately Modified	Slightly Modified	Moderately Modified to Degraded	Fragmentation by under construction barrage, industrial, domestic and agricultural pollution as indicated by nutrient, coliform, TDS, and pesticides
8. Dabri	Degraded	Degraded	Negative	Slightly to Moderately Modified	Near Pristine to Slightly Modified	Moderately Modified to Degraded	Industrial, domestic and agricultural pollution as indicated by nutrient, coliform, TDS, and pesticides.

2.6.3 The E-Flows Setting Exercise

Before the beginning of the E-Flows Setting Exercise, the objective-setting was done by the biodiversity, socio-cultural & livelihoods, fluvial geomorphology and river health teams, so that they could concentrate on the integration of specific objectives into a final set of objectives for E-Flows requirements at each of the study sites. The hydrologist and hydraulics teams did not have any direct input at the objective setting exercise, but they commented on the objectives of other groups, and provide advice in terms of likely flows and habitat conditions. The groups (other than hydrology and hydraulics) while looking at the present scenario at each of the site, classified them into RHC (detailed classification given in section 2.6.2). While doing so, these groups also filled up information to capture the trajectory of the present scenario. After these processes, deliberations were held among the larger team for the final consensus on RHC. This process is illustrated in Figure 2.20.

Once there was consensus on both the RHC and scenarios, the teams initiated the E-Flows Setting Exercise. During this process, a number of steps were taken for each of the sites, as illustrated in the process-chart in Figure 2.21.

The Ramganga Mitras contributed to this activity of E-Flows setting, by participating in the deliberations and specifying the motivations and aspirations for different sites.

Figure 2.20: RHC Process Attained to Categorise Each of the Selected Sites

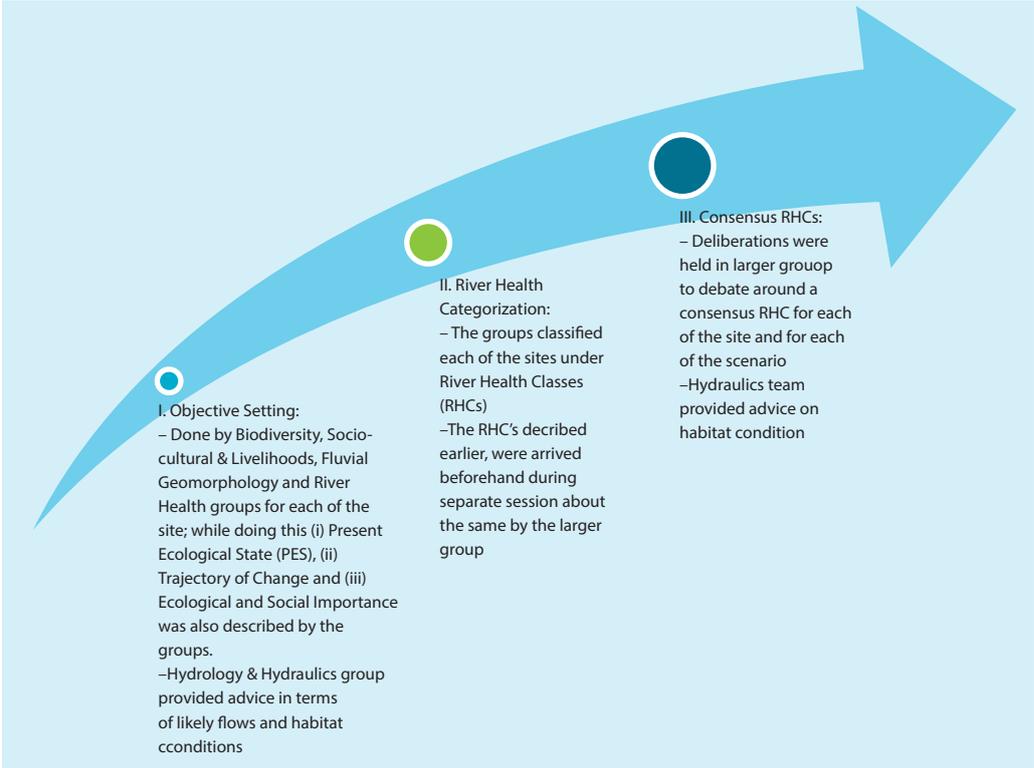
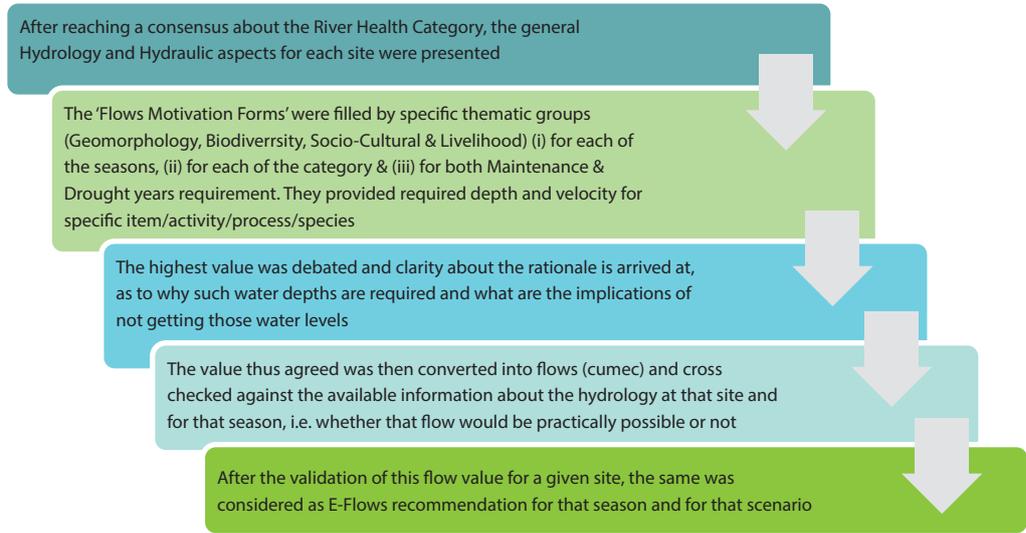


Figure 2.21: Process of E-Flows Setting for Ramganga



The flow values thus derived for driest (May) and wettest (August) months from the depth level and flow velocities etc., recommended by the thematic groups, were extrapolated for the remaining months, and accordingly the graphs were prepared. The flow motivations, as can be seen in subsequent sub-sections, are often the same for different sites as the purpose is to capture the motivation for each of the sites (for both dry and wet seasons) and from each of the perspectives. For instance, in the case of fluvial geomorphology, the main motivation in dry season is the maintenance of longitudinal connectivity and in wet season for maintenance of lateral connectivity.

It is important to note that the motivations for each of the sites in the next chapter are for Maintenance Year⁹ – Target Scenario. For detailed motivations and for the motivations for rest of the scenarios, please refer Annexure-4.

3



Ramganga

E-Flows Recommendations and Confidence Level

This chapter talks about the Ramganga E-Flows recommendations for all assessed scenarios, and for both dry and wet seasons. In addition, calculations pertaining to the drought year and return flood requirements are also discussed in detail. The chapter ends with a discussion about the 'level-of-confidence' of the team in the Ramganga EFA process, along with their confidence in the E-Flows recommendations.

3.1 E-Flows Recommendations

3.1.1 Bhikiasain

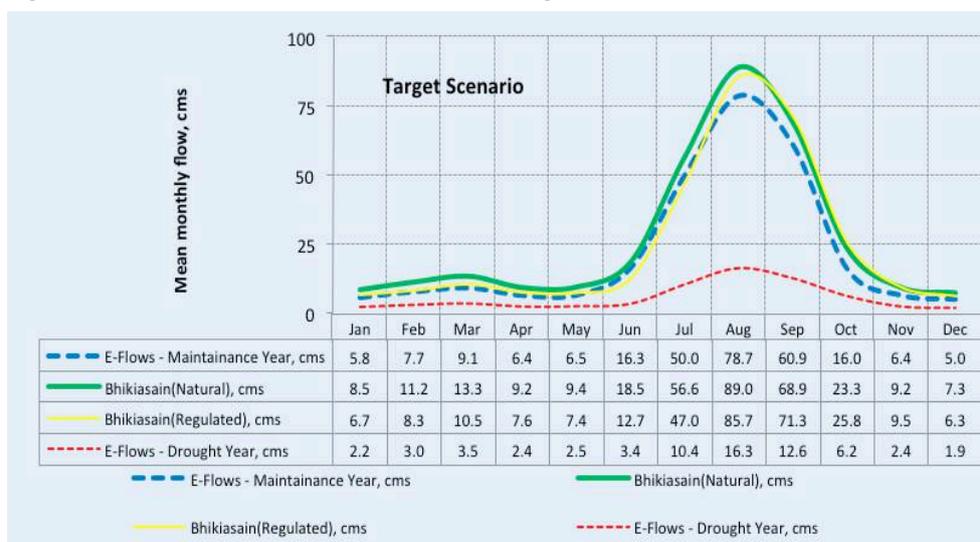
For the Bhikiasain site, which is judged in 'Near Pristine' condition at the moment, two scenarios are recommended, i.e., Target scenario and Additional Use Scenario. The Improved Scenario was not done for this site, as the Target Scenario itself was Near Pristine, which is the top-most category in the River Health hierarchy. Further, the Additional Use Scenario was slightly modified.

Key motivations for the required flows under the Target Scenario:

1. Fluvial Geomorphology –
 - Dry Season: For maintaining longitudinal connectivity.
 - Wet Season: For inundation of main channel and for lateral connectivity.
2. Biodiversity –
 - Dry Season: For emergence of breeding period and for fish species, such as *Tor putitora*, *Labeo dyocheilius*, *Garra sp.* and *Barilius sp.*
 - Wet Season: For inundation of floodplains (side pools) which provides a variety of habitats for spawning for both fish (*Cyprinids*), common invertebrates (*Baetidae*) and sensitive species (*Ephemeralidae*, *Perlodidae*, *Siphonuridae*, *Limnephilidae*). Another motivation is for providing deep mid-stream pools for Mahseer and other fish species.
3. Socio-cultural & Livelihood –
 - Dry Season: For sustenance of cultural and recreational activities, including ritual bathing.
 - Wet Season: Excessive rise in water level during this season is an issue from this perspective, so the team wanted to have water levels within the recommended limits, as this will fill the river channel without causing damage.

The river health group concluded that, from the ecological perspective, water quality is not significantly modified and is therefore satisfactory.

Figure 3.1: Bhikiasain E-Flows Recommendations – Target Scenario

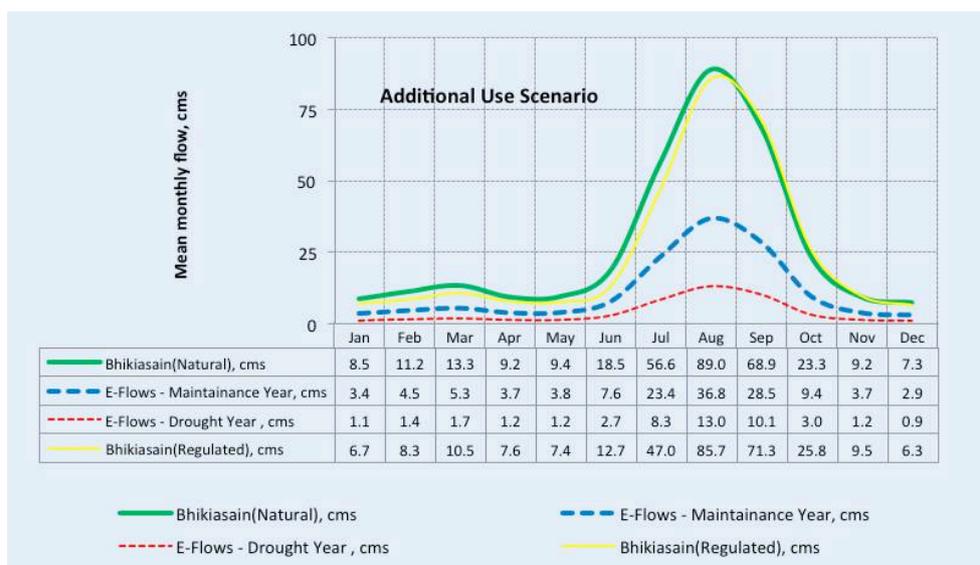


The seasonal E-Flows requirements for Target Scenario were also calculated and are tabulated in Table 3.1. It is to be noted that, mid-June to mid-September is considered as monsoon season and the rest of the months are considered as non-monsoon months.

Table 3.1: Seasonal and Annual E-Flows Requirements for Bhikiasain

Site Name & scenario	Year	Natural Flows (in %)			Regulated Flows (in %)		
		Monsoon	Non-Monsoon	Annual	Monsoon	Non-Monsoon	Annual
Bhikiasain – Target	Maintenance Year	88.4	68.8	82.8	95.0	76.6	89.9
	Drought Year	18.3	26.5	20.6	19.7	29.5	22.4

Figure 3.2: Bhikiasain E-Flows Recommendations – Additional Use Scenario



3.1.2 Marchula

The Marchula site is in Near Pristine condition at present and two scenarios were recommended as in the case of Bhikiasain. Near Pristine as Target Scenario and Slightly Modified as the Additional Use Scenario were assessed for Marchula.

Key motivations for the required flows:

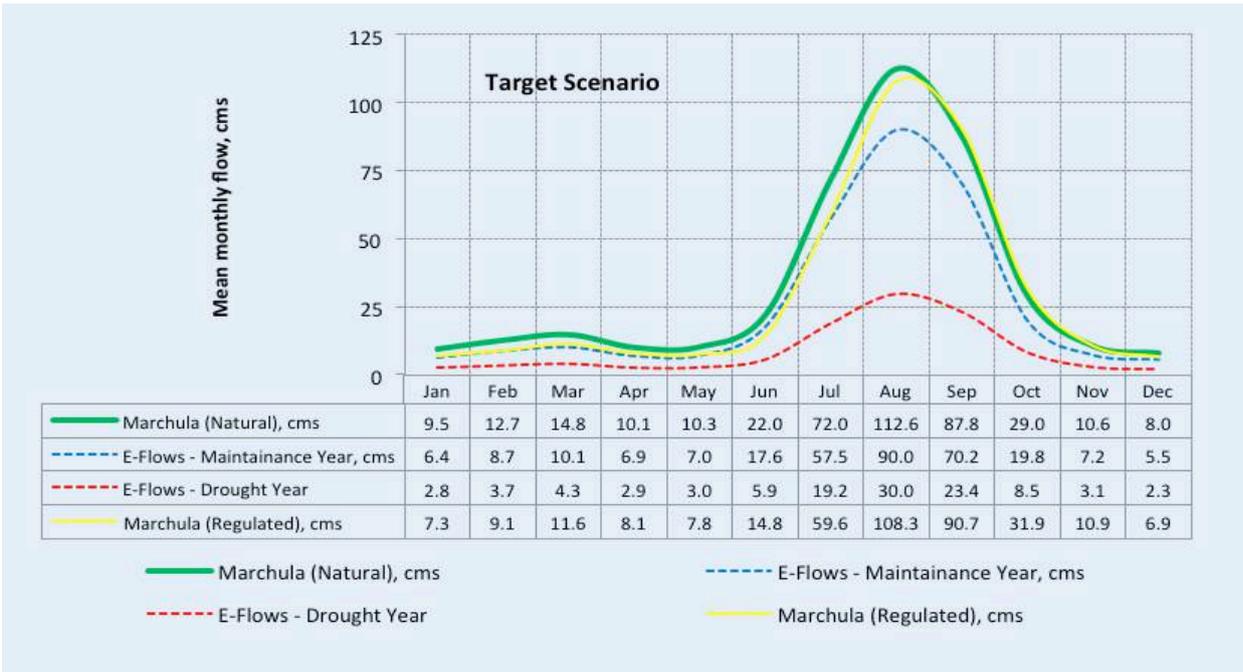
1. Fluvial Geomorphology –
 - Dry Season: For maintaining longitudinal connectivity.
 - Wet Season: For maintaining lateral connectivity.

2. Biodiversity –
 - Dry Season: As this period is the emergence and breeding period, which starts around June. The process of laying eggs would occur in the inundated banks. Sensitive species found in the area are *Siphonuridae*, *Psephenidae* and *Limnephilidae*. Naturally abundant species are *Hydropsychidae* and *Perlodidae*.
 - Wet Season: For inundation of floodplains, which is necessary to provide habitat to a variety of fish for spawning, and habitat for invertebrates. Examples include *Hydropsychidae*, *Baetidae*, *Siphonuridae* and *Limnephilidae*. The deeper mid-stream may be used by Mahseer, if it is migrating upstream.

3. Socio-cultural & Livelihood –
 - Dry Season: For sustenance of domestic use, eco-tourism, ritual bathing and other cultural activities.
 - Wet Season: For ensuring visible impression of a healthy river from the community perspective.

In terms of water quality, the river health group concluded that though this site is categorised as near pristine, there have been reports of health issues, possibly due to domestic waste. This problem should be tackled at source.

Figure 3.3: Marchula E-Flows Recommendations – Target Scenario

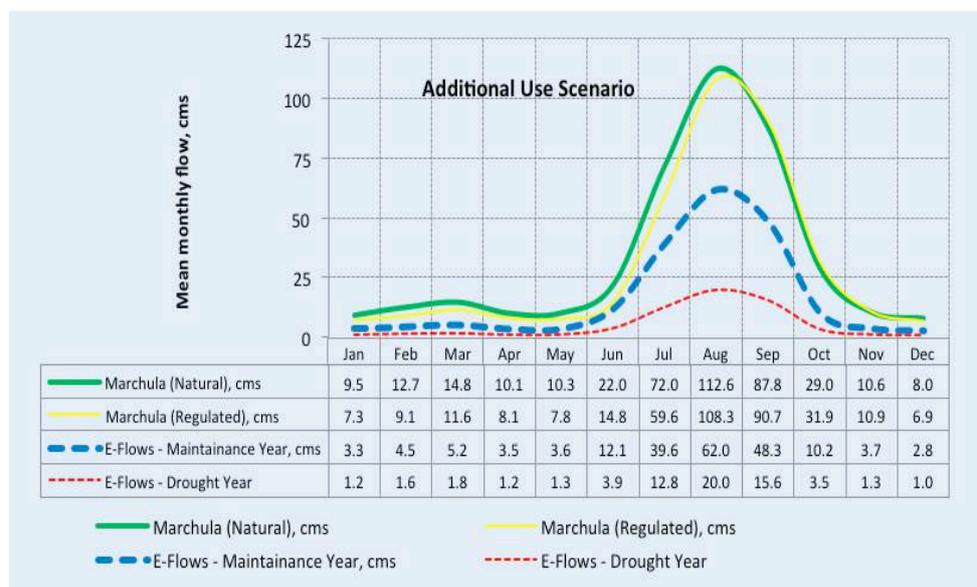


The seasonal E-Flows requirements for the Target Scenario are also calculated in Table 3.2.

Table 3.2: Seasonal and Annual E-Flows Requirements for Marchula

Site & Scenario	Year	Natural Flows (in %)			Regulated Flows (in %)		
		Monsoon	Non-Monsoon	Annual	Monsoon	Non-Monsoon	Annual
Marchula – Target	Maintenance Year	79.9	68.2	76.9	86.1	76.5	83.6
	Drought Year	26.6	29.2	27.3	28.7	32.8	29.7

Figure 3.4: Marchula E-Flows Recommendations – Additional Use Scenario



3.1.3 Afzalgarh Barrage

The site downstream of the Afzalgarh Barrage has adequate flows and the real issue for this site lies in sudden release of water from the Kalagarh Dam that passes through this barrage. This often creates havoc (in terms of sudden rise in water level causing inundation of farms) among the communities and sometimes causes devastation in the region (as water reaches the habitations, although this happens rarely; last time it happened in 2010).

In view of the following reasons, the team engaged in Ramganga EFA decided NOT to recommend a regime of flows as E-Flows for this site –

- The community members often get frightened, the moment they are reminded of the 2010 floods, which caused massive destruction in the area. Therefore, for them, it's the warning mechanism that is more in need than aspiring for near natural flow regime.
- The flow regime, at this site has been reversed from the natural one for the last 35-40 years and during this time period the aquatic biodiversity might have largely disappeared and new communities may have moved in.
- Re-reversal of current flow regime is unlikely because of dedicated use, including supplementing the command of Lower Ganga Canal (LGC), and irrigation to direct canal systems off river Ramganga.

Nevertheless, the RHC was discussed for this site and the groups concluded that the river at Afzalgarh Barrage is in 'Moderately Modified' condition and the Target Scenario is 'Slightly Modified, which is only achievable if re-reversal of flow regime can be ensured.

As per current operation guidelines and policy of the Kalagarh Dam, the timing of flows at Afzalgarh is mainly influenced and governed by irrigation demands from the LGC system and some part is governed by power generation and additional releases are also made for religious events, like 'Maagh mela'. In current scenario, the flows at Afzalgarh are highly managed and follow a reverse pattern as compared to a natural flow regime. The sudden downstream release of water from the dam is also controlled by dam safety management guidelines and practices followed by the administration of the dam.

3.1.3.1 Disaster Management: Standard Operating Procedures of Dams

The Central Water Commission (CWC) in its report¹ on dam safety lays down state-wise status of dam safety and operational procedures. In the report, CWC lays formal recommendations to create flood inundation maps and identify disaster prone areas in case of any extreme event and places for relocation. This is required to be considered by the Kalagarh dam authorities to avoid implications onto the riparian communities from sudden releases from the dam in the wake of unprecedented rainfall in the upper catchment.

Although the guidelines are in place, but enforcement has always been a challenge. Local hooters should be installed in riparian villages within 10kms downstream and village heads should be informed through mobile phones, so that the response mechanism can be more effective.

When it comes to dam safety issues, there is a need to set-up rules for release of water and Standard Operating Procedures (SOP) in case sudden release of water is required during certain situations. One of such notification² was made by the Dam Safety Monitoring Directorate, CWC to the Government of Madhya Pradesh for strengthening the alarm and warning system for safety of people from sudden release of water from dams. It clearly states that, "A robust warning system to alert downstream habitants before release of water should be put in place. The warning for release of water shall be given through speakers, sirens or hooters and mobile vans equipped with a public address (PA) system adequately in advance of the release of water from dams. All such instruments shall be directly connected to the control room eliminating dependence on watch-staff stationed at vulnerable area."

Although the guidelines are in place, but enforcement has always been a challenge. Local hooters should be installed in riparian villages within a 10km downstream radius and village heads should be informed through mobile phones, so that the response mechanism can be more effective.

The measure proposed by NDMA (National Disaster Management Authority) flood guidelines states that "flood forecasts and warnings will be formulated, preferably, in the local language, in a format which is simple and easily understandable by the administrators and common people as well. CWC will also improve the usefulness of the forecasts and warnings by marking the area likely to be inundated, location of flood shelters etc., on the map of the area."³

This fear of sudden release of water from the Kalagarh Dam was echoed by riparian communities living alongside the Ramganga River. This calls for setting up of a similar alarm and warning system at Kalagarh Dam to ensure no loss of life and property.

3.1.3.2 Kalagarh Dam Operations

The Kalagarh Dam was constructed to reduce flood damages around the Ramganga basin and this target has largely been achieved since 1974 – after the commissioning of the dam, except in 2010. The dam authorities, learning a lesson from the flood in 2010, have updated the dam operation policy. During the pre-2010 era, the dam was never filled to Full Reservoir Level (FRL) in a hydrological year. The only year that it touched the FRL limit of 366.20m was in 2010. Before this the maximum level that the dam was filled was in 1990 up to 365.99m. Now the authorities have revised FRL as 365.30m.

In addition to this, in 2011 (post the 2010 disaster) the authorities issued an 'Office Order', which revised the SOP for release of water from the Kalagarh Dam. As per the order, a

threshold level for monsoon months was setup, and the excess water was to be released in a controlled manner (maximum 11.3 cumec) to keep a cushion in the dam for the next wet spell. Prior to 2010, there was no such SOPs for flood release in various months, and sudden release of excess water downstream occasionally, used to create loss of life and property as happened during the flood in 2010.

The threshold level set for the month of August is 355m; by 15 September the release level is set to 358m and if the reservoir level reaches at 360m by 30 September, water will be released in a phased manner (maximum 11.3 cumec) to keep a cushion.

The sustainable solution lies in development of a Real Time Flood Forecasting Capability and amending accordingly the Reservoir Operation Rules (ROR), this will help in disaster preparedness for communities by moving them to safer places.

3.1.4 Hareoli Barrage

From the perspective of Rivers for Life - Life for Rivers programme, the Hareoli Barrage site is critical one, since during lean season, the river is deprived of water, which seriously impairs its flows downstream. The scenario improves once the Kho River, one of the tributaries of the Ramganga, brings some water into the Ramganga river.

The team assessed all three scenarios for this site and concluded that the present state of the river is in 'Moderately Modified to Degraded' condition. Whereas the Target Scenario would be 'Slightly to Moderately Modified'; the Improved Scenario is 'Near Pristine to Slightly Modified' and Additional Use Scenario is Moderately Modified to Degraded.

Key motivations for the required flows:

1. Fluvial Geomorphology –
 - Dry Season: For partial inundation of bars for longitudinal connectivity.
 - Wet Season: For connectivity of all secondary channels, to maintain lateral connectivity.
2. Biodiversity –
 - Dry Season: To increase the abundances of sensitive fish species, such as Cyprinids, and prevent proliferation of hardy and exotic species, such as *Cyprinus carpio*. Also, to increase the abundances of sensitive invertebrate species, such as *Leptoceridae*, *Palaemonidae* and increase richness in species in general.
 - Wet Season: For successful recruitment processes in fish species (for example, Cyprinids) and invertebrate species (such as *Corixidae*, *Lestidae*, *Leptoceridae* etc.) inundation of the floodplains is necessary which provides a variety of habitats.
3. Socio-cultural & Livelihood –
 - Dry Season: For having waist deep flowing water to have cremation-related activities and ritual bathing at desired conditions.
 - Wet Season: desired farm fields inundation.

The river health group concluded that from the water quality perspective the recommended flows will benefit overall river health at this site.

As evident from the Figure 3.5, the present-day flows are not meeting E-Flows requirements for any of the months in a year.

The seasonal E-Flows requirements for the Target Scenario were also calculated and are tabulated in Table 3.3.

Figure 3.5: Hareoli Barrage E-Flows Recommendations – Target Scenario

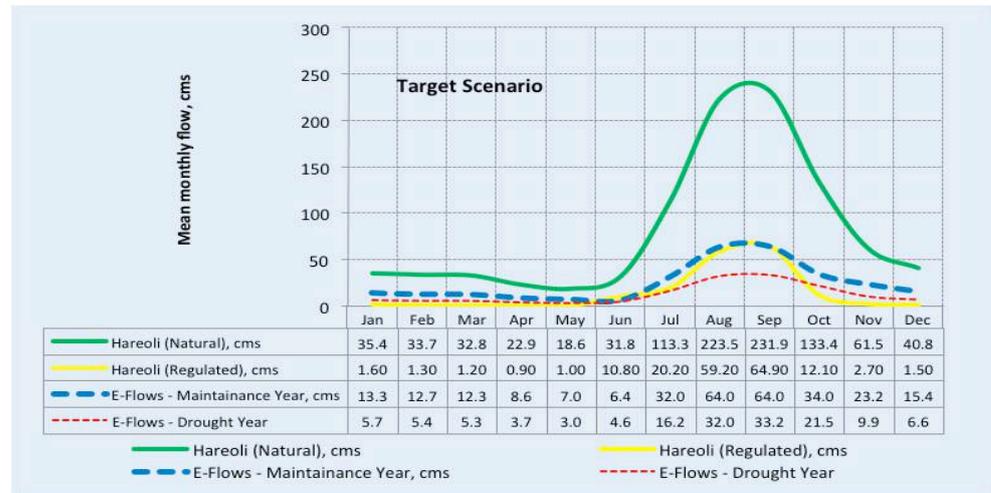


Table 3.3: Seasonal and Annual E-Flows Requirements for D/S Hareoli Barrage

Site Name & Scenario	Year	Natural flows (in %)			Regulated flows (in %)		
		Monsoon	Non-Monsoon	Annual	Monsoon	Non-Monsoon	Annual
D/S Hareoli Barrage – Target	Maintenance Year	42.5	37.7	40.6	241.0	640.7	310.4
	Drought Year	14.3	16.1	15.0	81.2	274.6	114.8

Figure 3.6: Hareoli Barrage E-Flows Recommendations – Improved Scenario

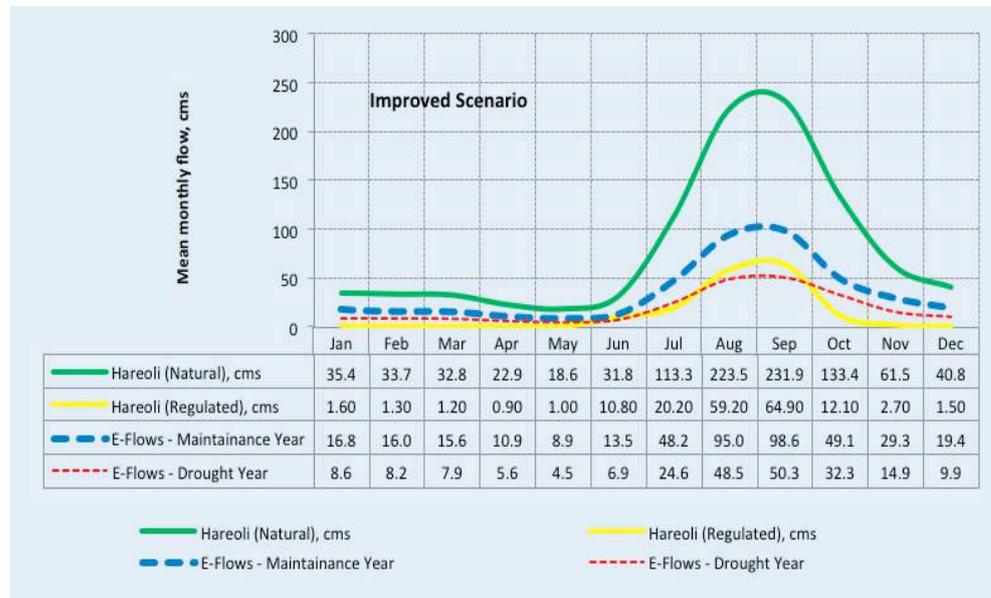
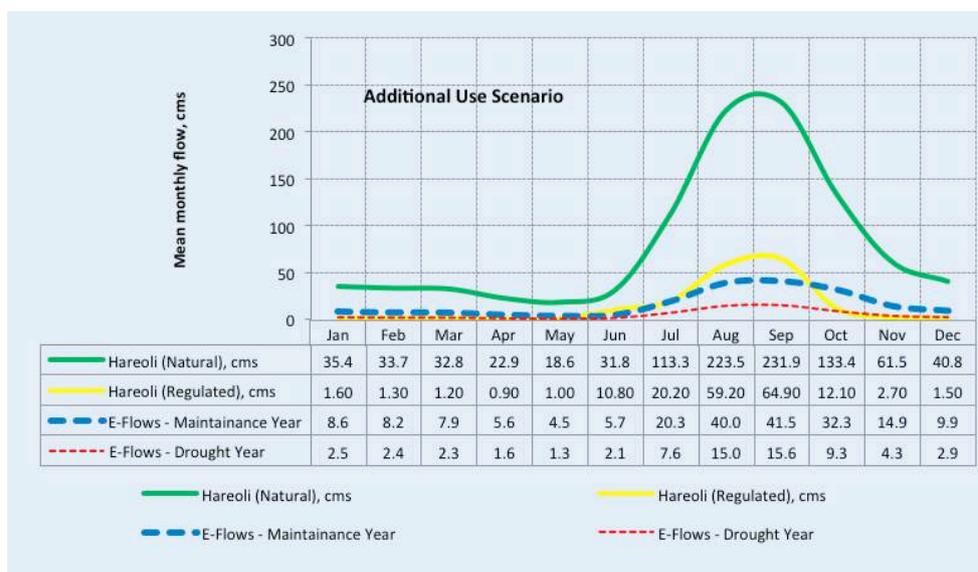


Figure 3.7: Hareoli Barrage E-Flows Recommendations – Additional Use Scenario



3.1.5 Agwaanpur

As noted earlier, the Agwaanpur site remained a challenging one for the hydraulic modelling group, as the left bank is low lying and there was a bit of struggle to ascertain the HFL (since this site is not a gauged site). The thematic groups engaged in recommending E-Flows (fluvial geomorphology, biodiversity and socio-culture & livelihood) were given some limitations, under which the teams were asked to keep their recommendations.

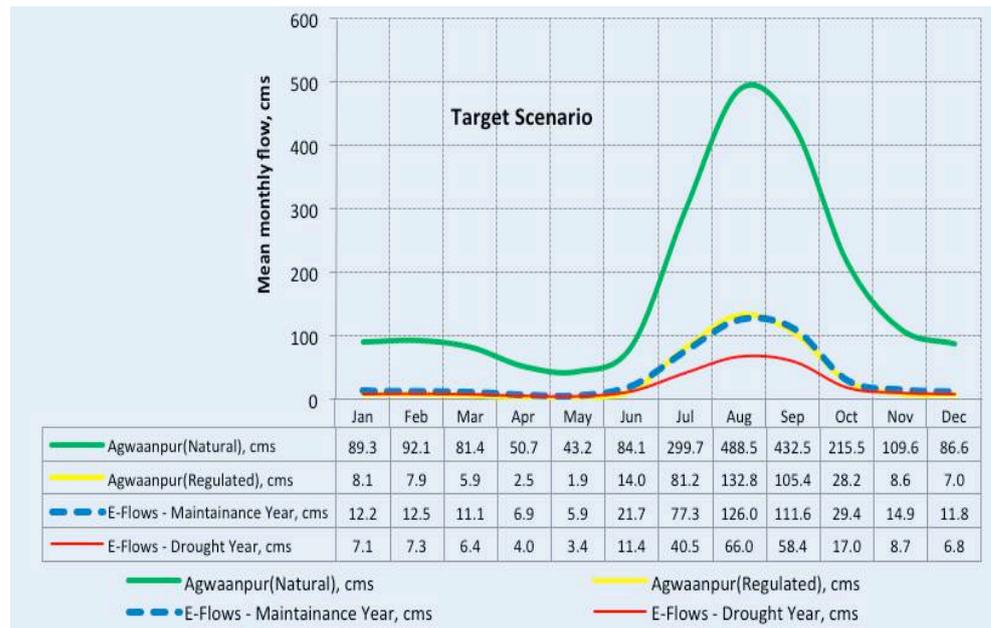
The group only recommended Target scenarios for this site. It was concluded that the river at this site is presently in a 'Moderately Modified' state and the aspiration is to take it to the 'Slightly Modified' state. However, there was difference of opinion, where the fluvial geomorphology thematic team asserted that the river at this site is in 'Degraded' state from their perspective, so for them a 'Moderately Modified' state could be the Target scenario.

Key motivations for the required flows:

1. Fluvial Geomorphology –
 - Dry Season: For filling the present channel belt and for longitudinal connectivity.
 - Wet Season: For maintaining lateral connectivity and for inundating the base of riparian vegetation.
2. Biodiversity –
 - Dry Season: To maintain sensitive species such as Cyprinids among fish and Gerridae, Bulmidae among invertebrate species.
 - Wet Season: To inundate the floodplain which will essentially provide few spawning areas/habitat for fish and accumulation of nutrients, i.e., increase in plankton as food base. For Cyprinids such as *Labeo calbasu* (fish), this condition will fulfil the recruitment requirements of sensitive invertebrate taxa, viz., *Gerridae*, *Bulmidae* etc.
3. Socio-cultural & Livelihood –
 - Dry Season: For having chest deep water on right bank for rituals and for fishermen.
 - Wet Season: For pottage field inundation.

The river health group from the water quality perspective concluded that, the recommended flows will further improve physical appearance of water (the water in the river will look cleaner) in the river.

Figure 3.8: Agwaanpur E-Flows Recommendations – Target Scenario



As evident from the Figure 3.8, the present-day flows are only meeting E-Flows requirements for two wet months in a year, i.e., July and August.

The seasonal E-Flows requirements for the Target Scenario were also calculated and is tabulated in Table 3.4.

Table 3.4: Seasonal and Annual E-Flows Requirements for Agwaanpur

Site Name & Scenario	Year	Natural flows (in %)			Regulated flows (in %)		
		Monsoon	Non-Monsoon	Annual	Monsoon	Non-Monsoon	Annual
Agwaanpur – Target	Maintenance Year	25.8	13.6	21.3	101.0	149.6	109.4
	Drought Year	13.5	7.9	11.4	52.9	86.8	58.8

3.1.6 Katghar – Moradabad

Moradabad has been the centre of all activities being taken up under the Rivers for Life, Life for Rivers programme. Thus, Katghar naturally becomes a vital site for E-Flows assessment. This is also a critical site for CWC there is a GDSQ (Gauge, Discharge, Sediments and Quality) site at Katghar and a sub-division office in Moradabad.

While it is true that water quality has been the critical challenge at Katghar, the local people relate this issue with inadequate flows. In general, WWF-India and its partners are against the proposition that “dilution can be the solution to the pollution”. The water quality should not be addressed by allocating dilution flows and should be tackled at source.

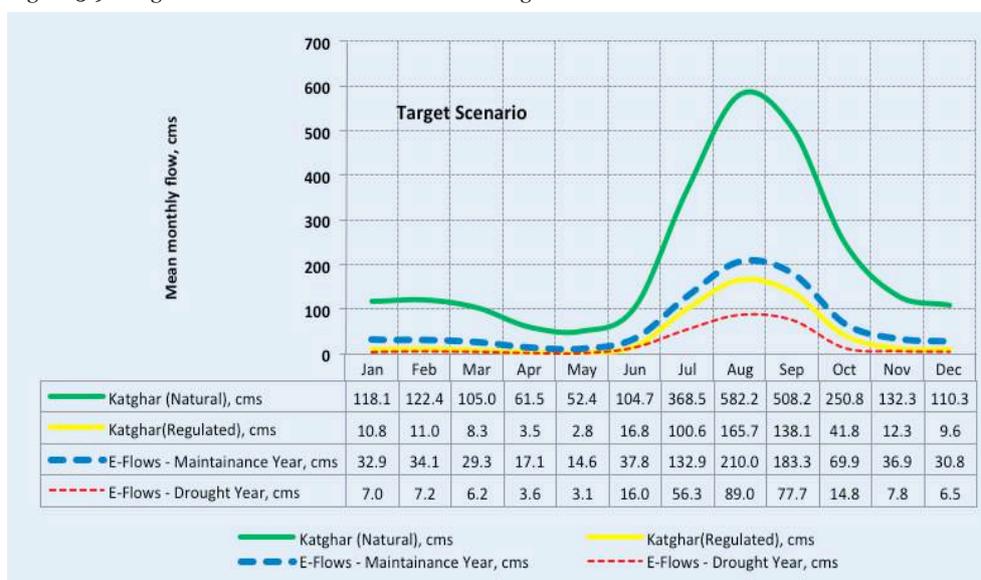
The group recommended all the three scenarios for this site. It was concluded that presently the river is in a ‘Degraded’ state and thus the Target Scenario should be ‘Slightly to Moderately Modified’, whereas the Improved Scenario should be ‘Slightly Modified’. The Additional Use Scenario could be ‘Degraded’.

Key motivations for the required flows:

1. Fluvial Geomorphology –
 - Dry Season: For filling the present channel and for longitudinal connectivity.
 - Wet Season: For inundation of the main channel and the right-side channels to ensure lateral connectivity.
2. Biodiversity –
 - Dry Season: To increase the abundances of sensitive fish species, such as Cyprinids (*Labeo sps.*) and sensitive invertebrate species, such as *Pelecypods* and *Lymnaeidae*. This would help increase richness of the fish species in general.
 - Wet Season: Inundation of the floodplains is essential to provide a variety of habitats for spawning and successful recruitment processes, among fishes (e.g., IMC (Indian Major Carps) and Cyprinids) and among invertebrates (e.g., *Naididae*, *Dixidae* and *Glossoscolecidae*). Further, inundation of floodplains will help in accumulation of nutrients as food.
3. Socio-cultural & Livelihood –
 - Dry Season: For enabling cultural activities and ritual bathing
 - Wet Season: For carrying away debris and for submergence of pottage fields.

The river health group from the water quality perspective concluded that, because of the Dehla tributary (joining Ramganga about 1-2km upstream of this site) and Moradabad waste water draining into river Ramganga, the water quality may not improve substantially.

Figure 3.9: Katghar E-Flows Recommendations – Target Scenario



As evident from the Figure 3.9, the present-day flows are not meeting the E-Flows requirements for any of the months in a year.

The seasonal E-Flows requirements for Target Category were also calculated and are tabulated in Table 3.5.

Table 3.5: Seasonal and Annual E-Flows Requirements for Katghar

Site Name & Scenario	Year	Natural Flows (in %)			Regulated Flows (in %)		
		Monsoon	Non-Monsoon	Annual	Monsoon	Non-Monsoon	Annual
Katghar – Target	Maintenance Year	36.1	27.9	33.0	133.9	265.4	159.2
	Drought Year	15.3	5.9	11.7	56.8	56.2	56.6

Figure 3.10: Katghar E-Flows Recommendations – Improved Scenario

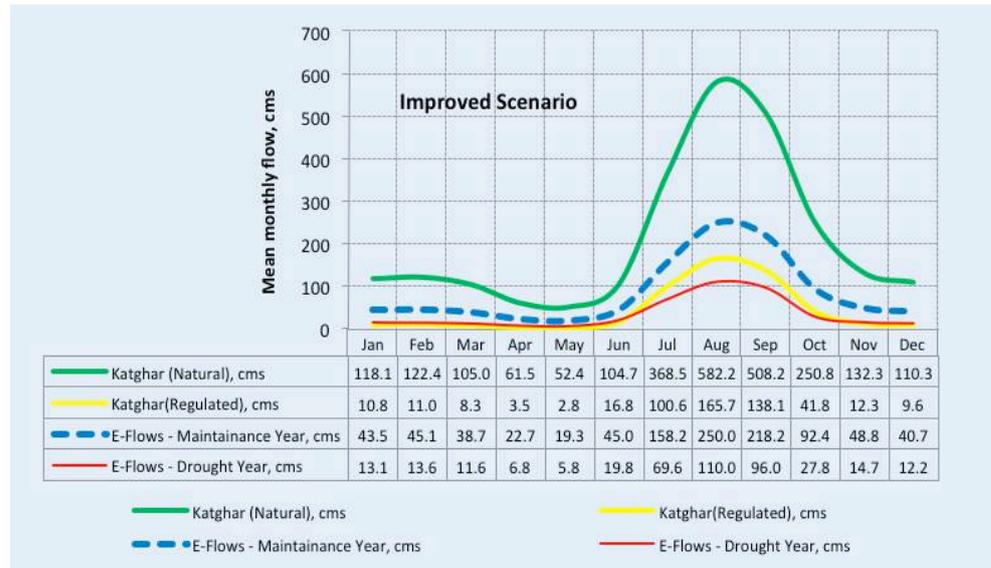
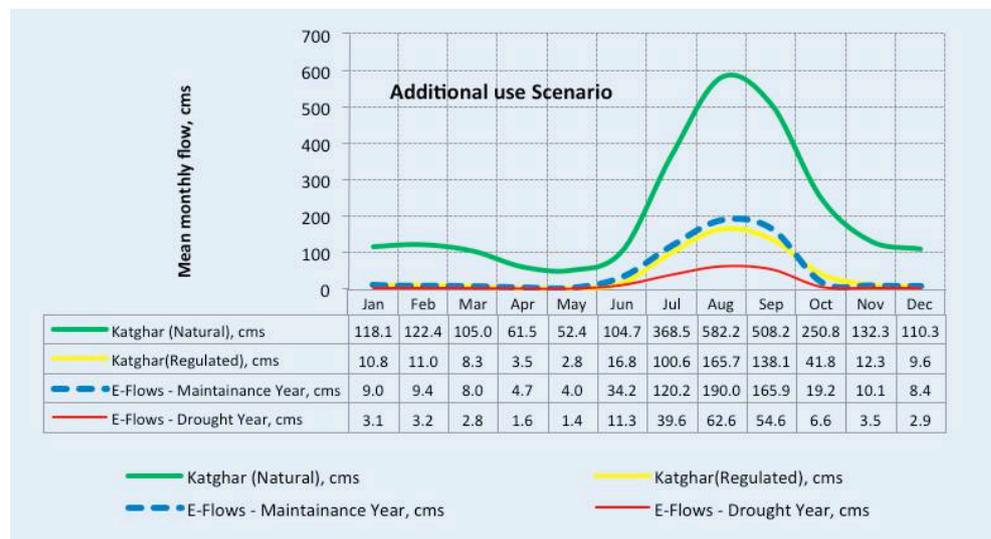


Figure 3.11: Katghar E-Flows Recommendations – Additional Use Scenario



3.1.7 Chaubari – Bareilly

The Chaubari site has the merit of being the most important socio-cultural site on Ramganga. An under-construction barrage for irrigation adds to the criticality of this site from the E-Flows perspective. The team wished to ensure recommended E-Flows for this site, with an aspiration that same recommended flows for this site are also released downstream of the under-construction barrage (Badayun Irrigation Scheme) at immediate downstream of this site.

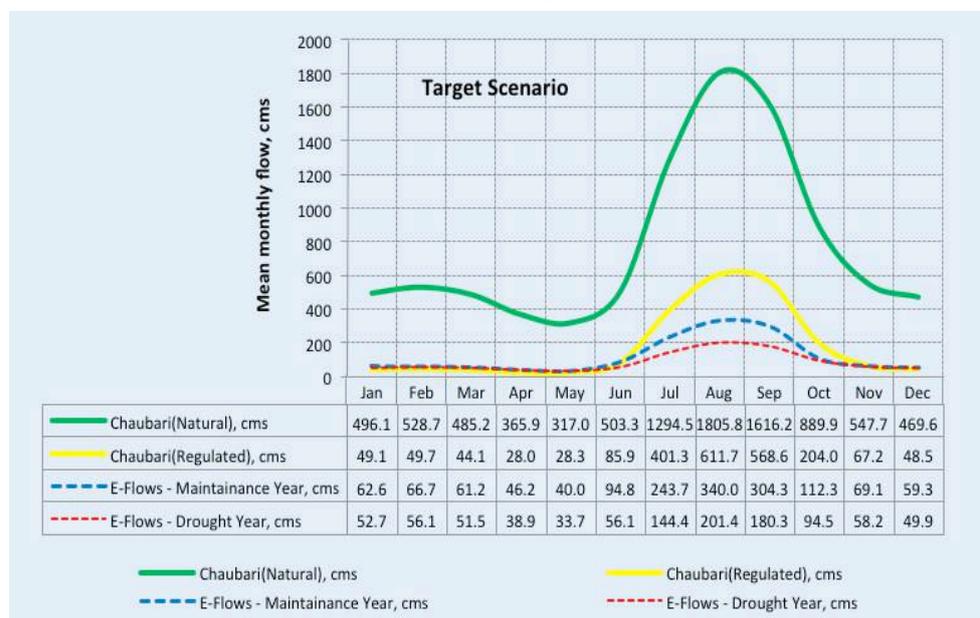
The group recommended all the three scenarios for Chaubari. The team concluded that presently the river is in a 'Degraded' state and the Target scenario could be 'Slightly to Moderately Modified', whereas the Improved scenario could be 'Near Pristine to Slightly Modified'. The Additional Use scenario should be 'Moderately Modified to Degraded'.

Key motivations for the required flows:

1. Fluvial Geomorphology –
 - Dry Season: For longitudinal connectivity.
 - Wet Season: To inundate the main channel and right-side channels for lateral connectivity.
2. Biodiversity –
 - Dry Season: Moderate habitat is available for occurrence of sensitive fauna (fish species such as Cyprinids, and invertebrate species like Naucoridae and Pelecypoda).
 - Wet Season: Inundation of most of the habitat is essential for providing spawning grounds resulting in successful recruitment processes in Cyprinids (fish) and invertebrates (e.g., *Naucoridae*, *Pelecypoda* and *Leptoceridae*). In addition, inundation helps in accumulation of nutrients as food.
3. Socio-cultural & Livelihood –
 - Dry Season: For enabling cultural activities and ritual bathing.
 - Wet Season: For submergence of pottage fields.

The river health group concluded that from the water quality perspective the pollution issue would largely remain the same even in an event of increased flows.

Figure 3.12: Chaubari E-Flows Recommendations – Target Scenario



As evident from Figure 3.12, the present-day flows are meeting E-Flows requirements for four wet months, i.e., July, August, September and October of the year.

The seasonal E-Flows requirements for the Target Scenario were also calculated and are tabulated in Table 3.6.

Table 3.6: Seasonal and Annual E-Flows Requirements for Chaubari

Site Name & Scenario	Year	Natural Flows (in %)			Regulated Flows (in %)		
		Monsoon	Non-Monsoon	Annual	Monsoon	Non-Monsoon	Annual
Chaubari – Target	Maintenance Year	18.8	12.6	16.1	58.9	99.7	68.6
	Drought Year	11.2	10.6	10.9	34.9	83.9	46.5

NOTE: The percentage of non-monsoon E-Flows to regulated flows at Bareilly is 99.7% which is the result of lesser E-Flows requirement in the month of October with respect to regulated flows. If lean season flows are considered from November onwards then the ratio of E-Flows requirement will be 128% of regulated flows (between November and May).

Figure 3.13: Chaubari E-Flows Recommendations – Improved Scenario

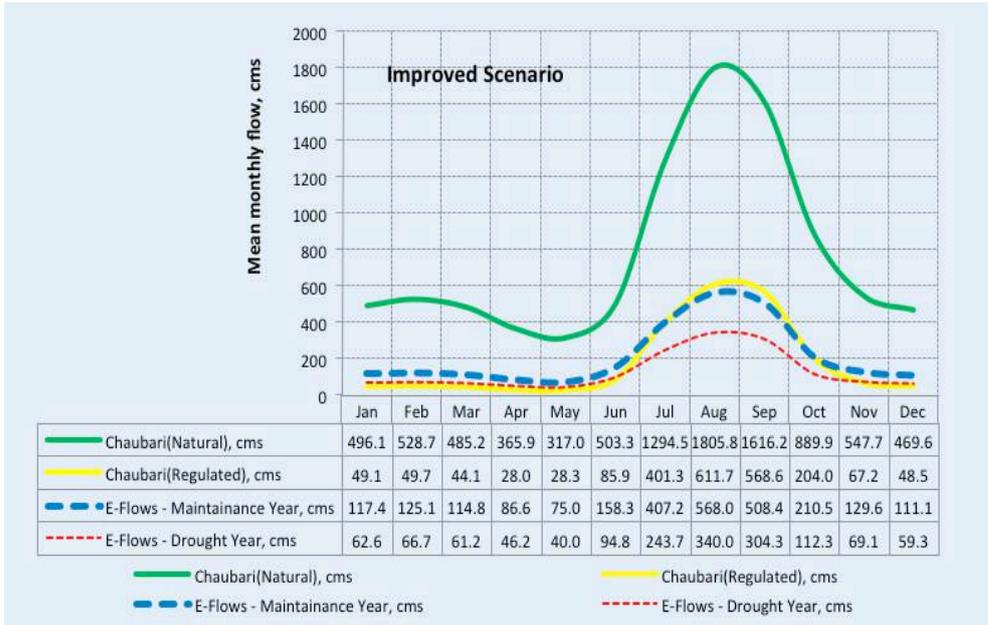
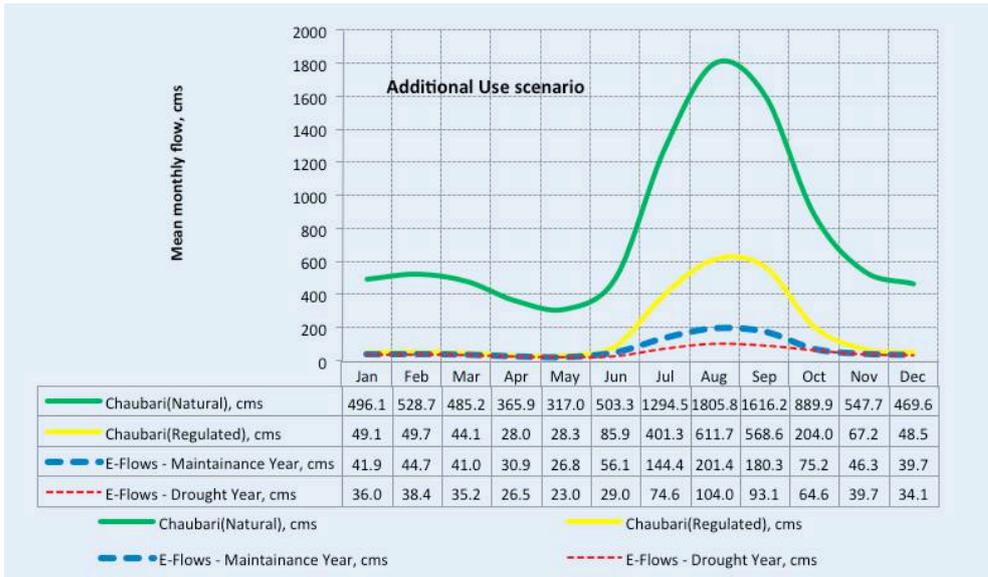


Figure 3.14: Chaubari E-Flows Recommendations – Additional Use Scenario



3.1.8 Dabri

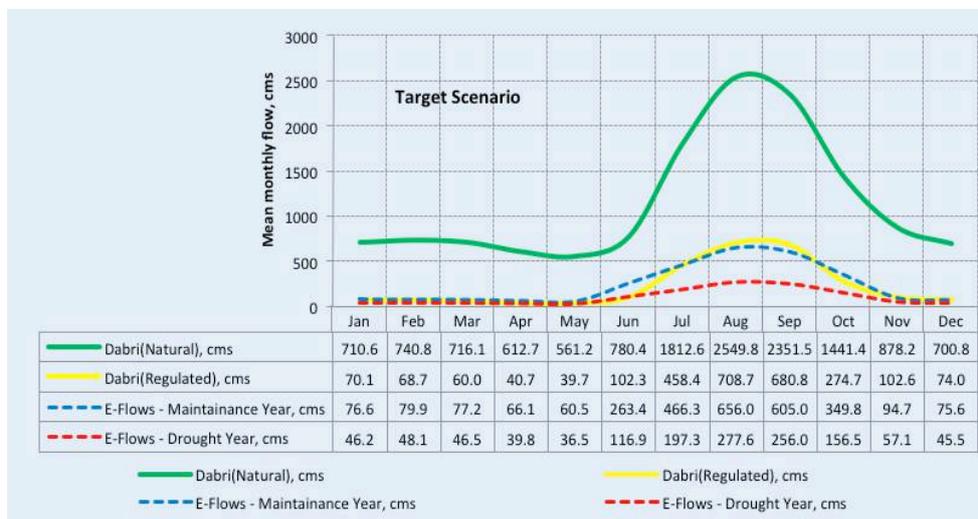
Dabri is the last site on Ramganga, both for the E-Flows assessment exercise and also for CWC. This well-maintained site is close to a road-bridge which joins Shahjehanpur to Farrukhabad. The group recommended all the three scenarios for this site. It was concluded that presently the river is in a 'Degraded' state and the Target Scenario could be 'Slightly to Moderately Modified', whereas the Improved Scenario could be 'Near Pristine to Slightly Modified'. The Additional Use Scenario should be 'Moderately Modified to Degraded'.

Key motivations for the required flows:

1. Fluvial Geomorphology –
 - Dry Season: For longitudinal connectivity.
 - Wet Season: For inundation of the main channel to ensure lateral connectivity.
2. Biodiversity –
 - Dry Season: Moderate habitat is available for occurrence of sensitive fish species, such as Cyprinids (*Labeo spp*) and sensitive invertebrates like *Gerridae* and *Unionidae*. No exotic fish species were recorded. Occurrence of turtles is also recorded in good numbers.
 - Wet Season: Inundation of most of the habitat is essential for providing spawning grounds resulting in successful recruitment process in fish (e.g., Cyprinids) and invertebrates (e.g., *Gerridae* and *Unionidae*).
 - Since dolphins (*platisnesta gangetica*) have been sited at Dabri during monsoon by the local inhabitants, this suggests that the hydrological parameters (flows and depth) are favourable at this site for dolphins to come in during monsoon, which helps them disperse from river Ganga into Ramganga. Therefore, wet season flows for this site are also motivated by hydraulics and hydrological requirements for dolphins.
 - Further, desired inundation helps in accumulation of nutrients as food.
3. Socio-cultural & Livelihood –
 - Dry Season: For sufficient livestock watering and for having cremation related activities at desired conditions.
 - Wet Season: For submergence of pottage fields.

The river health group concluded that from the water quality perspective the pollution issue will remain largely the same even in an event of increased flows.

Figure 3.15: Dabri E-Flows Recommendations – Target Scenario



As evident from the Figure 3.15, the present-day flows are meeting E-Flows requirements for two wet months in a year, i.e., August and September.

The seasonal E-Flows requirements for the Target Scenarios were also calculated and are tabulated in Table 3.7.

Table 3.7: Seasonal and Annual E-Flows Requirements for Dabri

Site Name & Scenario	Year	Natural Flows (in %)			Regulated Flows (in %)		
		Monsoon	Non-Monsoon	Annual	Monsoon	Non-Monsoon	Annual
Dabri – Target	Maintenance Year	26.6	13.8	20.7	102.1	120.5	107.1
	Drought Year	11.3	7.5	9.6	43.5	65.2	49.4

Figure 3.16: Dabri E-Flows Recommendations – Improved Scenario

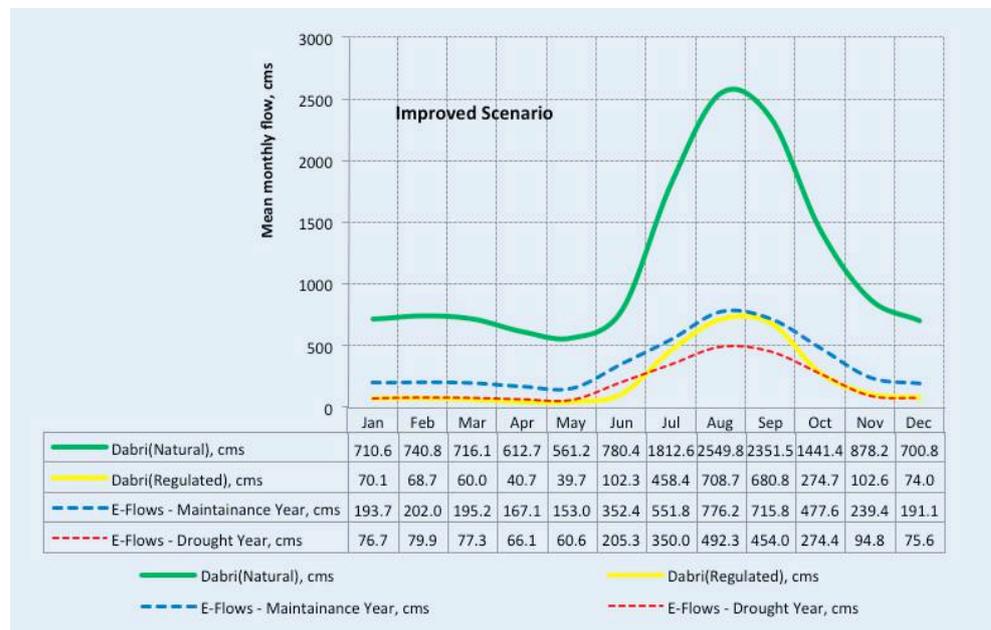
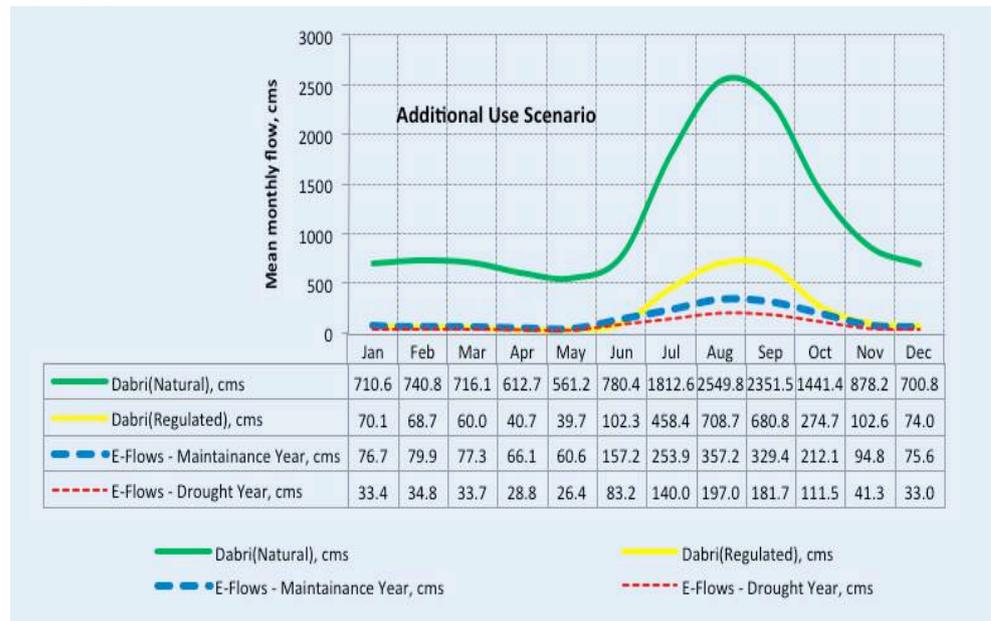


Figure 3.17: Dabri E-Flows Recommendations – Additional Use Scenario



For a ready reference, Table 3.8 informs about various thematic motivations for E-Flows recommendations at different sites during the driest (May) and wettest (August) months. It is worth mentioning here that, based on the recommendations for driest and wettest months, the extrapolations are done to develop a month-wise annual flows regime, as depicted in the graphs, exhibited earlier in this chapter. The Table 3.8 only talks about the Target Category.

In Table 3.8 the critical flows are derived parameter from depth and an average velocity recommended by the respective thematic teams.

Table 3.8: Ready Reckoner on E-Flows motivations for all Sites for Both Driest and Wettest Months for the Target Category.

Bhikiasain EFA Site

Motivations for May Month

Specialty	Critical Flows, m ³ /s	Depth (m)	Average Velocity (m/s)
Biodiversity	6.5	0.65	0.56

For emergence of breeding period and for fish species, such as *Tor putitora*, *Labeo dyocheilius*, *Garra sp.* and *Barilius sp.*

Fluvial Geomorphology	6.5	0.65	0.56
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At low flow, maintenance of longitudinal connectivity will be critical. Historically, average depths in lean season varied from 0.2 to 0.8 metres (past five years), therefore the recommendations are kept close to the historical flows.

Socio-Cultural and Livelihoods	6.5	0.65	0.56
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For sustenance of cultural and recreational activities, including ritual bathing.

Recommended Flows: Discharge of 6.5cumec with 0.65m depth (Geomorphology, Biodiversity and Socio-Cultural)

Motivations for August Month

Specialty	Critical Flows, m ³ /s	Depth (m)	Average Velocity (m/s)
Biodiversity	39.00	1.30	0.82

For inundation of floodplains (side pools) which provides a variety of habitats for spawning for both fish (Cyprinids), common invertebrates (Baetidae) and sensitive species (Ephemeralidae, Perlodidae, Siphonuridae, Limnephilidae). Another motivation is for providing deep mid-stream pools for Mahseer and other fish species.

Fluvial Geomorphology	59.00	1.50	0.93
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For inundation of main channel and for lateral connectivity

Socio-Cultural and Livelihoods	98.00	1.80 (upper limit)	1.10
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Excessive rise in water level during this season is an issue from this perspective, so the team wanted to have water levels within the recommended limits, as this will fill the river channel without causing damage.

Recommended Flows: Discharge of 78.7cumec with 1.67m depth (Socio-Cultural, Fluvial Geomorphology)

Bhikiasain being in near pristine condition, the flows are recommended considering the fact that recommendations should fall within current conditions.

Marchula EFA Site

Motivations for May Month

Specialty	Critical Flows, m ³ /s	Depth (m)	Average Velocity (m/s)
Biodiversity	4.5	1.0	0.88

As this period is the emergence and breeding period. The process of laying eggs would occur in the inundated banks. Sensitive species found in the area are Siphonuridae, Psephenidae and Limnephilidae. Naturally abundant species are Hydropsychidae and Perlodidae.

Fluvial Geomorphology	7.0	1.2	0.86
For maintaining longitudinal connectivity to assist migration of aquatic species.			
Socio-Cultural and Livelihoods	4.5	1.0	0.88
For sustenance of domestic use, eco-tourism, ritual bathing and other cultural activities.			
Recommended Flows: 1.2m Depth and 7cumec flows for maintenance year flows (Geomorphology)			

Motivations for August Month

Specialty	Critical Flows, m ³ /s	Maximum Depth (m)	Average Velocity (m/s)
Biodiversity	79.80	3.3	1.2
For inundation of the floodplain, which is necessary to provide habitat to a variety of fish species for spawning, and habitat for invertebrates. Examples include Hydropsychidae, Baetidae, Siphonuridae and Limnephilidae. The deeper mid-stream may probably be used by Mahseer, if it is migrating upstream.			
Fluvial Geomorphology	157.80	4.4	1.50
Maximum depth of 4.4m for maintaining lateral connectivity in the channel. Peak pulse flows of 210cumec (4.9m depth) for once in two years during wet season.			
Socio-Cultural and Livelihoods	92.00	3.5	1.22
For ensuring visible impression of a healthy and mighty river from the community perspective.			
Recommended Flows : Avg. discharge of between 80-90cumec with maximum depth of 3.3-3.5m. High flows of 158 cumec for 10-15 days during the wet season (Biodiversity and Geomorphology)			

Hareoli Barrage EFA Site

Motivations for May Month

Specialty	Critical Flows, m ³ /s	Depth (m)	Average Velocity (m/s)
Biodiversity	7.0	1.17	0.19
To increase the abundances of sensitive fish species, such as Cyprinids, and prevent proliferation of hardy and exotic species, such as Cyprinus carpio. Also, to increase the abundances of sensitive invertebrate species, such as Leptoceridae, Palaemonidae and increase richness in species in general.			
Fluvial Geomorphology	7.0	1.17	0.19
For partial inundation of bars for longitudinal connectivity.			
Socio-Cultural and Livelihoods	7.0	1.17	0.19
For having knee to waiste deep flowing water to have ritual bathing and cremation-related activities at desired conditions.			
Recommended Flows: 7.0cumec and 1.17m Depth discharge for maintenance year (Biodiversity, Geomorphology and Socio-Cultural)			

Motivations for August Month

Specialty	Critical Flows, m ³ /s	Depth (m)	Average Velocity (m/s)
Biodiversity	64.00-90.00	2.56	0.33
For successful recruitment process in fish (for example, Cyprinids) and invertebrate species (such as Corixidae, Lestidae, Leptoceridae etc.) inundation of the floodplain is necessary which provides a variety of spawning habitats.			
Fluvial Geomorphology	48.50	2.36	0.33

For connectivity of all secondary channels and to maintain lateral connectivity

Socio-Cultural and Livelihoods	64.00-90.00	2.56	0.33
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For palling field inundation which will enrich the floodplain with nutrients.

Recommended Flows: 64 cumec discharge and 2.56m depth flows for maintenance year (Biodiversity and Socio-Cultural)

Flood Frequency: Peak flood (74 cumec) for about 15 days each for 3 month (June-August) with maximum depth of 2.6m and (fish to breed and attain spawning)

Agwaanpur EFA Site

Motivations for May Month

Specialty	Critical Flows, m ³ /s	Depth (m)	Average Velocity (m/s)
Biodiversity	1.28	2.70	0.01

To maintain sensitive species such as Cyprinids among fish and Gerridae, Bulmidae among the invertebrate species

Fluvial Geomorphology	1.28	2.70	0.01
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For filling the present channel belt and for longitudinal connectivity.

Socio-Cultural and Livelihoods	5.88	2.90	0.04
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For having chest deep water on right bank for rituals and for fishermen (recommended depth is from lowest channel elevation which will amount to chest deep water near bank).

Recommended Flows: 5.88 cumec discharge and 2.90m depth for maintenance year (Socio-Cultural)

Motivations for August Month

Specialty	Critical Flows, m ³ /s	Depth (m)	Average Velocity (m/s)
Biodiversity	126.00	Due to constraint in Hydraulics Depth and Velocity could not be presented. Long term mean August regulated flows are considered recommendations.	

To inundate the floodplain which will essentially provide few spawning areas/habitat for fish and accumulation of nutrients, i.e., increase in plankton as food base. For Cyprinids such as Labeo calbasu (fish), this condition will fulfil the recruitment requirements of sensitive invertebrate taxa, viz., Gerridae, Bulmidae etc.

Fortnightly peak pulse required by fishes to breed and attain spawning. Hydraulics could not quantify the flood in volumetric terms

Fluvial Geomorphology	126.00	Due to constraint in hydraulics the depth and velocity could not be presented. Long term mean August regulated flows are recommended.	
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For maintaining lateral connectivity and for inundating base of riparian vegetation.

Peak pulse for 10-15 days once in 2 years for filling up the entire channel was recommended.

Socio-Cultural and Livelihoods	126.00	Due to constraint in hydraulics depth and velocity could not be presented. Long term mean August regulated flows are recommended.	
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For palling field inundation which will enrich the floodplain with nutrients.

Peak pulse flows extends upto the cemetery on the right bank (once/twice a year), occasional floods do overtop, but that's not desired.

Recommended Flows: 126 cumec flows for maintenance year (Biodiversity, Socio-Cultural, Geomorphology)

Katghar Moradabad EFA Site

Motivations for May Month

Specialty	Critical Flows, m ³ /s	Depth (m)	Average Velocity (m/s)
Biodiversity	9.36	1.27	0.1

To increase the abundances of sensitive fish species, such as Cyprinids (Labeo sps.) and sensitive invertebrate species, such as Pelecypods and Lymnaeidae. This would help increase richness of the fish species in general.

Fluvial Geomorphology	9.36	1.27	0.1
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For filling the present channel belt and for longitudinal connectivity.

Socio-Cultural and Livelihoods	14.60	1.37	0.14
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For enabling cultural activities and ritual bathing

Recommended Flows: 14.60 cumec discharge and 1.37m depth for maintenance year (Socio-Cultural)

Motivations for August Month

Specialty	Critical Flows, m ³ /s	Depth (m)	Average Velocity (m/s)
Biodiversity	210.00	2.77	0.45

Inundation of the floodplain is essential to provide a variety of habitats for spawning and successful recruitment processes, among fishes (e.g., IMC and Cyprinids) and among invertebrates (e.g., Naididae, Dixidae and Glossoscolecidae). Further, inundation of the floodplain will help in accumulation of nutrients as food.

Peak pulse with depth of 3.17m and discharge: 312.8 cumec is recommended. Some areas inundate providing spawning grounds and nursery rearing.

Fluvial Geomorphology	210.00	2.77	0.45
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For inundation of the main channel and the right-side channels to ensure lateral connectivity.

Peak pulse for 10-15 days once in two years for filling up the entire channel work.

Peak flows with depth of 3.57m (to submerge all channel belt) for frequency of 10-15 days, once in two years (during wet season) with discharge of 415 cumec.

Socio-Cultural and Livelihoods	210.00	2.77	0.45
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For pottage field inundation which will enrich the floodplain with nutrients.

Peak pulse flows extend upto the cemetery on the right bank, occasional floods do overtop, but that's not desired.

Peak flows with depth of 3.47m (washing away of debris, inundation of fields on the left bank) once/twice in a season with discharge of 400 cumec.

Recommended Flows: 210 cumec flows and 2.77m depth for maintenance year (Geomorphology, Biodiversity and Socio-Cultural)

Flood Frequency: Peak flood (415 cumec) for about 15 days each for 10-15 days in wet season (June-September) with maximum depth of 3.57m.

For Katghar site the dry season flows were motivated by socio-cultural and livelihood aspects whereas in wet season the requirements were motivated by all three aspects.

Chaubari, Bareilly EFA Site

Motivations for May Month

Specialty	Critical Flows, m ³ /s	Depth (m)	Average Velocity (m/s)
Biodiversity	40.00	1.03	0.70

Inundation of most of the habitat is essential for providing spawning grounds resulting in successful recruitment processes in Cyprinids (fish) and invertebrates (e.g., Naucoridae, Pelecypoda and Leptoceridae). In addition, inundation helps in accumulation of nutrients as food.

Fluvial Geomorphology	40.00	1.03	0.70
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For filling the present channel belt and for longitudinal connectivity.

Socio-Cultural and Livelihoods	40.00	1.03	0.70
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For enabling cultural activities and ritual bathing.

Recommended Flows: 40 cumec discharge and 1.03 m depth for maintenance year (Geomorphology and Biodiversity, Socio-Cultural)

For Chaubari site the recommendations of thematic group were matching in both seasons; whereas in case of the Dabri site the flows were motivated by Biodiversity aspects for both seasons.

Motivations for August Month

Specialty	Critical Flows, m ³ /s	Depth (m)	Average Velocity (m/s)
Biodiversity	340.00	2.53	0.95

Inundation of the floodplain is essential to provide a variety of habitats for spawning and successful recruitment process, among fishes (e.g., IMC and Cyprinids) and among invertebrates (e.g., Naididae, Dixidae and Glossoscolecidae). Further, inundation of the floodplain will help in accumulation of nutrients as food.

Peak pulse for about 15 days each for 3 month (from mid-June to mid-August), with 4.03m depth (water level 161m) for inundation for fish to breed and attain spawning.

Fluvial Geomorphology	340.00	2.53	0.95
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To inundate the main channel and right-side channels for lateral connectivity.

Peak pulse (2,146 cumec) with frequency of 10-15 days, maintaining a depth of 4.33m ,once in two years (during wet season)

Socio-Cultural and Livelihoods	340.00	2.53	0.95
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For palling field inundation which will enrich the floodplain with nutrients.

Recommended Flows: 340 cumec discharge and 2.53m depth for maintenance year (Geomorphology, Biodiversity and Socio-Cultural) and Peak pulse (2,146 cumec) with frequency of 10-15 days, maintaining a depth of 4.33m ,once in two years (during wet season)

Flood Frequency: Peak flood (415 cumec) for about 15 days each for 10-15 days in wet season (June-September) with maximum depth of 3.57m.

Dabri EFA Site

Motivations for May Month

Specialty	Critical Flows, m ³ /s	Depth (m)	Average Velocity (m/s)
Biodiversity	153.00	3.02	0.60

Moderate habitat is available for occurrence of sensitive fish species, such as Cyprinids (Labeo spp) and sensitive invertebrates like Gerridae and Unionidae. No exotic fish species were recorded. Occurrence of turtles was recorded in good numbers.

Fluvial Geomorphology	60.00	2.52	0.33
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For filling the present channel belt and for longitudinal connectivity.

Socio-Cultural and Livelihoods	60.00	2.52	0.33
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For sufficient livestock watering and for cremation related activities at desired conditions

Recommended Flows : 153 cumec discharge and 3.02m depth for maintenance year (Biodiversity)

Motivations for August Month

Specialty	Critical Flows, m ³ /s	Depth (m)	Average Velocity (m/s)
Biodiversity	656.00	4.32	1.38

Inundation of the floodplain is essential to provide a variety of habitats for spawning and successful recruitment processes, among fishes (e.g., IMC (Indian Major Carps) and Cyprinids) and among invertebrates (e.g. Naididae, Dixidae and Glossoscolecidae). Further, inundation of the floodplain will help in accumulation of nutrients as food.

Peak flows of 1,050 cumec for about 15 days for each of three months (June-August) at water level 136.5m (5.02m) are desired for fish to breed and attain spawning, also facilitates dolphin dispersal from downstream to upstream.

Inundation of most of the habitat is essential for providing spawning grounds resulting in successful recruitment processes in fish (e.g., Cyprinids) and invertebrates (e.g. Gerridae and Unionidae).

Since dolphins (*Platisnesta gangetica*) have been sited at Dabri during monsoon by the local inhabitants, this suggests that the hydrological parameters (flows and depth) are favourable at this site for dolphins during monsoon, which helps them disperse from river Ganga into Ramganga. Therefore, wet season flows for this site are also motivated by hydraulics and hydrological requirements for dolphins.

Fluvial Geomorphology	492.30	4.02	1.17
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To inundate the main channel and for lateral connectivity.

Peak flows of 1,000 cumec for about 15 days, once in two years during wet season (June-August) maintaining a water level 136.4m (4.92m) to submerge channel belt.

Socio-Cultural and Livelihoods	492.30	4.02	1.17
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For pottage field inundation which will enrich the floodplain with nutrients.

Peak pulse flows extend upto the cemetery on the right bank, occasional floods do overtop, but that is not desired.

Peak pulse flows of 950 cumec (4.8m depth) to inundate agriculture fields (for wheat and fodder) upto one foot for 4-8 days to replenish soil moisture.

Recommended Flows : 656 cumec discharge and 4.32m depth for maintenance year (Biodiversity) and peak pulse of 1,050cumec for about 15 days for each of three months (June-August) at water levels of 136.5m (5.02m depth)

Flood Frequency: Peak pulse of 1,050 cumec in one year return flood.

SOURCE: information extracted from Flow Motivations Forms (Annexure – 3)

The E-Flow recommendations in terms of annual volumes for each of the sites of Ramganga are summarised in Table 3.9 as a ready reference. This table also show the percentage of 'Naturalised-Flows' (Virgin Flows) and Present-Day Flows, in terms of MAR (Mean Annual Runoff), that will be needed to meet E-Flow requirements at various sites.

Table 3.9: Annual E-Flows Requirements for Each Site as Quantities (MCM) and Percentage (of Natural and Present Flows) in MAR Terms

Site Name	Natural Flows Volume (in %)						Present-day Flows Volume (in %)					
	Target Scenario - Maint. Year	Target Scenario - Drought Year	Improved Scenario - Maint. Year	Improved Scenario - Drought Year	Additional Use Scenario - Maint. Year	Additional Use - Drought Year	Target Scenario - Maint. Year	Target Scenario - Drought Year	Improved Scenario - Main. Year	Improved Scenario - Drought Year	Additional Use Scenario - Maint. Year	Additional Use - Drought Year
Bhikiasain	82.9	20.6	EFR not assessed for these scenario		41.1	14.1	89.9	22.4	EFR not assessed for these scenario		44.6	15.3
Marchula	76.9	27.3			49.8	16.3	83.6	29.7			54.2	17.7
Afzalgarh	Volumetric E-Flows Requirements (EFR) not assessed for this site											
Hareoli	40.6	15.0	43.0	22.7	20.3	6.8	310.4	114.8	328.6	173.2	155.4	52.1
Agwaanpur	21.3	11.4	EFR not assessed for these scenario				107.7	57.9	EFR not assessed for these scenario			
Katghar, MBD	33.0	11.7	40.6	15.9	23.2	7.7	155.6	55.4	191.8	75.2	109.4	36.3
Chaubari, BLY	16.1	10.9	28.0	16.1	10.0	6.4	67.2	45.6	116.9	67.2	41.6	26.8
Dabri	20.7	9.6	30.4	16.6	13.3	6.8	104.8	48.3	153.9	84.2	67.2	34.5

3.2 Confidence in the Ramganga E-Flows Process

The assessment of confidence level for the entire Ramganga EFA exercise and for flows recommendations at specific sites is an important input for this initiative, and it also has the potential to strengthen the case for E-Flows in Ramganga, as the flows are recommended through sound scientific and technical rigour that can stand up to scrutiny.

The team was extra-cautious about the inputs and thus conducted two sub-activities as part of the E-Flows Setting Workshop. The thematic groups were requested to inform the gathering about their confidence level for a given site, once the E-Flows setting for that specific site had been completed. The marking in terms of confidence level has been backed with justification. This was done on a scale of 5, where 1 indicates very poor (very little confidence in the flows recommended, very much additional research and monitoring required) and 5 for excellent (absolute confidence, no further information required) (2-Poor; 3-Good, 4-Very Good). Towards the end of the event, a detailed feedback form was filled by each of the participants. This form also captured inputs from the participants on several aspects, including –

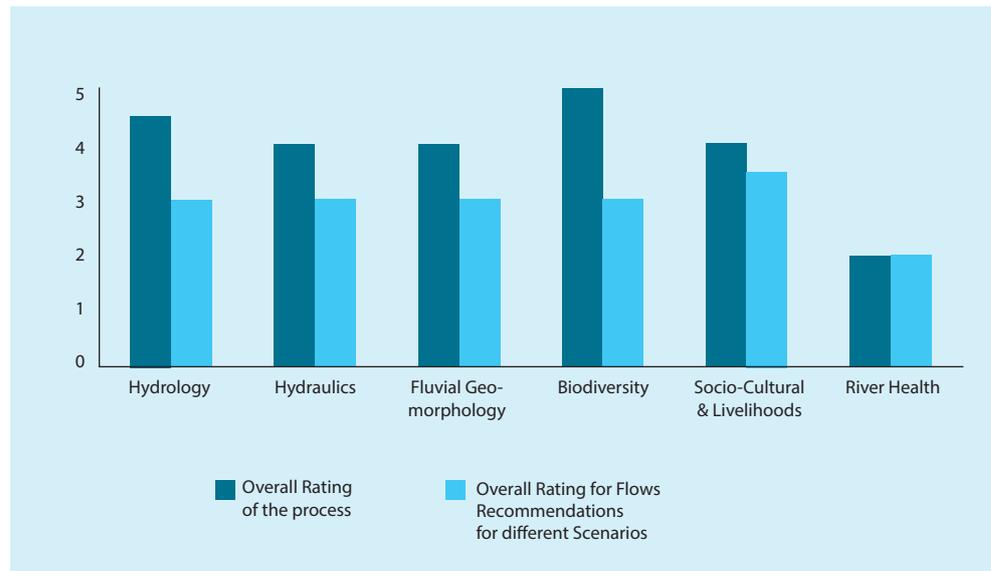
- Overall rating of the Ramganga EFA process
- Overall confidence level for flow recommendations for specific sites and for different scenarios

3.2.1 Overall Ramganga EFA Process Feedback

The groups appreciated the multi-disciplinarity of the entire exercise, where various thematic groups were formed to look at each associated aspect or function of the river in detail. The groups were satisfied with the coordination aspect within the thematic groups.

Overall, there was an appreciation for the BBM and its applicability to local conditions. However, there have not been many studies of aquatic biodiversity and water quality for this river, so the baseline and reference information was a challenge for the concerned groups and for the entire team.

Figure 3.18: Confidence Level of the Overall Process for the Ramganga EFA



The analysis of overall confidence level about the Ramganga EFA process is illustrated in Figure 3.18. In this graph, the X axis refers to the marking and Y axis represents the thematic groups. The marking is on a scale of 1 to 5.

The overall average of the responses with respect to the Ramganga EFA process and flow recommendations for all sites is 3.5 on a scale of 5.

3.2.2 Confidence Level for Sites

The lessons learnt by the team as part of Upper Ganga E-Flows Assessment exercise conducted during 2008-2010, were useful and have allowed the team to do a much more refined job this time. It is a matter of progression, continuous learning and thereby gradual improvement in the approach and methodology towards a concept. Hence, the Ramganga EFA was much more refined and accurate when it comes to various processes, aspects (Ramganga EFA approach – the improvisations, with respect to RHCs, scenarios) and recommended E-Flows. It also provided further lessons, which the team thought should be part of future exercises, and these are discussed in this sub-section. The team concluded that the Ramganga EFA has strengthened their confidence level in conducting holistic E-Flows assessment exercises, and they are much more confident in terms of recommendations for a majority of the sites.

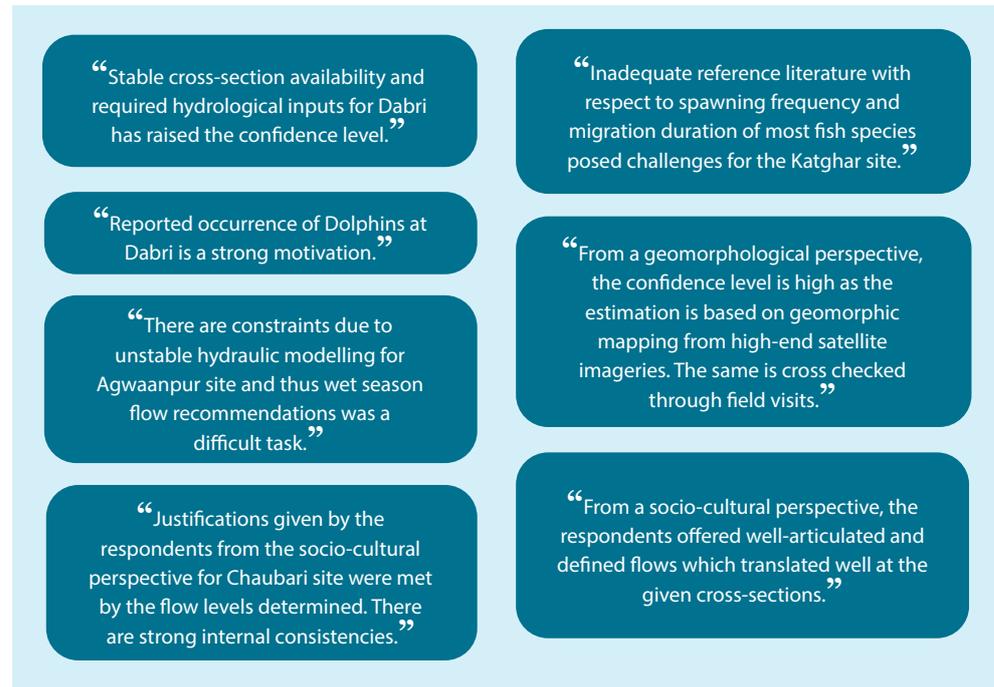
As mentioned earlier, there is inadequate research on the Ramganga river system with regard to habitat requirements for flow-dependent species. This was one reason why the biodiversity group faced challenges in recommending the flows. The group went ahead on the basis of whatever little secondary literature the team could get and their experience gained as part of the all-season surveys at the sites. Additionally, the biodiversity group has experienced domain experts, thus this exercise could be accomplished with reasonable confidence.

Table 3.10: Confidence Level for Sites – Lessons for Future Exercises

S. No.	Name of Site	Scoring	Rationale
1	Bhikiasain	3.25	<ul style="list-style-type: none"> A well-maintained gauge site of the CWC, with a stable section. Since the flows are not monitored at this site, it was challenging to validate the present-day flows. The recommendations made by the respective groups are based on sound rationale, so the confidence about the motivations and the required aspects (depth, width & velocity) was reasonably high.
2	Marchula	3.25	<ul style="list-style-type: none"> The hydrological information for this site was possible as this is a well-maintained UPI&WRD gauge site (an upstream one for the Kalagarh Dam – mainly to understand inflow for reservoir filling) and this enhanced the confidence of the team in recommending E-Flows for this site. There was some groundwater contribution, which the hydrology team was unable to comprehend, and this has marginally lowered their confidence.
3	Afzalgarh Barrage	Not Applicable	<ul style="list-style-type: none"> The E-Flows were not recommended for this site. The stretch of Ramganga around this site is witnessing reversal of flows regime due to the fact, that the Kalagarh Dam reservoir fills the water during monsoon and water is released as per the need, during rest of the year. On the other hand, the local people at downstream of this site were more interested in having a better information system in place to inform them about releases from the dam. Flooding due to releases from the dam is a bigger issue for them.
4	Downstream of the Hareoli Barrage	3.25	<ul style="list-style-type: none"> It was a difficult site, as the river flows through 2-3 small streams and the flows are heavily regulated. There were also issues in defining the floodplain, which impacted the stability of the cross section. However, since the Hareoli Barrage is being regulated by the UPI&WRD, with the help of hydrological inputs from the authorities, the team could increase their confidence during the preliminary exercises.
5	Agwaanpur	2.58	<ul style="list-style-type: none"> This was the most difficult site in terms of hydrology, hydraulic modelling and cross-section surveys. From the hydrology perspective, this site is not a gauged one and hence no reference of flow patterns is available. From the hydraulics viewpoint, the difficulty is that the left bank of the river at this site is very low and one cannot distinguish between floodplain and adjoining fields. This scenario continues for few kilometres on the left side of the bank. This site has been found to be critical as it is upstream of the Moradabad city, the main industrial hub on the right bank of Ramganga. Hence, getting a sense of flows required upstream of this city was paramount and that is why this site was chosen. Resident community members and farmers informed that, during excessive flows in the rainy season, they often face huge flooding in the field on the left bank and this extends for kilometres. Therefore, for them flooding is a threat. The E-Flows recommendations for this site thus focused on required flows during the lean season and the flows required to inundate immediate floodplain on both sides of the river and not really heavy flooding extending up to kilometres.
6	Katghar – Moradabad	3.5	<ul style="list-style-type: none"> The site of Katghar in Moradabad city is one of the most important sites, especially in terms of the city's footprint on river health in this zone. It's a well maintained CWC site, since early 1970s, where discharges are also monitored and hence the team has high confidence for this site. It is the hub for various activities, clothes washing, electronic waste washing, cattle bathing and sand mining. It is also the second most important site from the cultural perspective.
7	Chaubari	3.7	<ul style="list-style-type: none"> The site of Chaubari at the outskirts of Bareilly city is a CWC site as well and that means historical reference of hydrological information was possible. This certainly enhanced the confidence amongst all the thematic groups. In fact, since there is an irrigation barrage under-construction immediately downstream of this site, the E-Flows recommendations for this site becomes all the more critical. Additionally, this site is the most important socio-cultural space on the banks of the Ramganga.
8	Dabri	3.8	<ul style="list-style-type: none"> Dabri, the last site on the Ramganga river, is a CWC site, with well-defined river section. The thematic groups were satisfied in terms of background research and with the hydrological and hydraulic inputs.

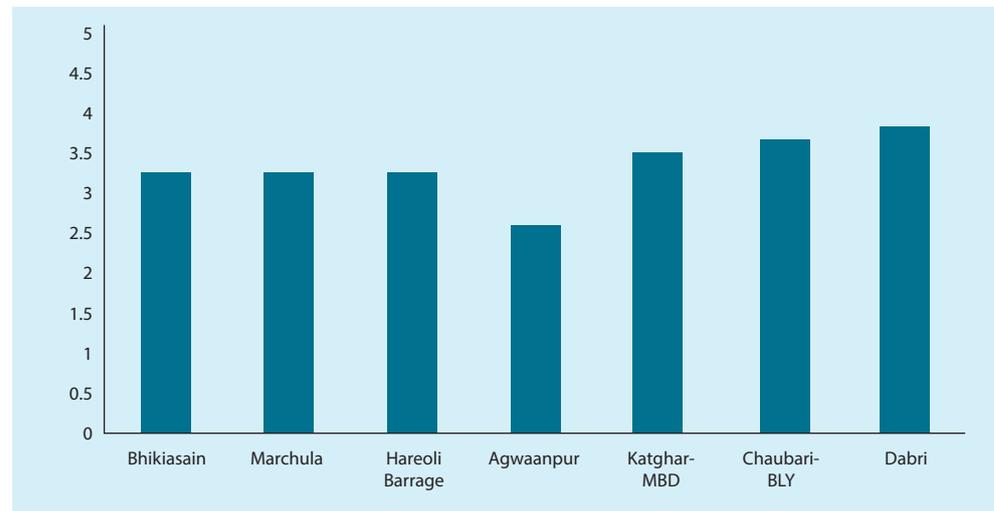
Some of the thoughts which the thematic groups shared while adjudging the confidence level for different sites can be seen in Figure 3.19.

Figure 3.19: Some of the Statements made by the Thematic Teams during the Session on Confidence Level



A site-specific graphic representation of the confidence level for E-Flows recommendations is given in Figure 3.20, where on the X axis is the marking (on a 5-point scale) and on the Y axis are the names of sites.

Figure 3.20: Confidence Level in the Site-wise Manner



The team made some observations, which can be considered as ‘lessons learnt’ from the exercise, and the team would like to take that into account while undertaking such exercise in future. These points are –

1. Information about flow and water-level dependencies of the aquatic species in different river reaches and during different seasons for their varying life-phases is an area which requires long-term primary surveys and investigations; the secondary data at present is inadequate to draw robust conclusive inferences. In the absence of this, available literature and expert’s judgement becomes the only best option.



Photo Credit: Arijit Mishra/WWF-India

2. The socio-cultural and livelihood surveys could be of great help, if the representatives from other thematic groups should also be made part of such surveys; mainly to hear the aspirations and perspective of the people who are directly and indirectly dependent on the river system, functions and processes. This would help other groups to better visualise a desired state of the river.
3. The integration of 'River Health' as a thematic area (replacing the 'Water Quality') within the framework of Ramganga EFA was an innovation, learnt by the team from past experiences when Environment Management Class (EMC) based classification was adopted. The RHCs are well defined and clear. However, since it was a pioneering attempt, the work and final outputs under this thematic component needs to be strengthened and streamlined for future studies of similar nature.
4. The team needs to reach out to similar sections of the society (which were interviewed earlier as part of the socio-cultural and livelihood surveys) in a scenario under which the E-Flows releases are made, then they should be made part of such an event to make them feel that they are part of the change in-making.
5. In an event, E-Flows are released, even if for one site and for a given season, the team should carefully monitor the flows downstream of that site and record the changes in the river system in the wake of additional flows in the river at that site. This is required to be done to strengthen the case for long-term E-Flows implementation.



Photo Credit: Ajjit Mishra/WWF-India

4



Trade-offs for E-Flows implementation

4.1 Introduction - the concept of trade offs

The maintenance of E-Flows in a committed river system would require answering a critical question, i.e., what would be the implication on other committed uses. This chapter attempts to understand the trade-offs (if any) and related aspects, from the perspective of water management. The chapter examines the demand (sectoral allocations) & supply of surface water at key locations and assesses the trade-offs (if any) for releasing E-Flows in the Ramganga. The teams also tried to create plausible scenarios for releasing water downstream of key diversions during critical months with minimal impact on existing water release policies. It is to be noted that, the trade-offs presented in this chapter are pertaining to only one site, out of the total eight sites studied in the report, i.e., downstream of the Hareoli Barrage. This is done keeping in view the vision and goal of the Rivers for Life programme (2012-17 and 2017-20), i.e., ‘demonstration of E-Flows in Ramganga at a critical location’, from where visible positive changes onto the river health can be ascertained in a short time-span. The purpose with this is to demonstrate to the authorities that E-Flows maintenance leads to improved river health.

4.1.1 The Situation ‘as is’

The trade-offs exercise for E-Flows implementation, looks into the following aspects:

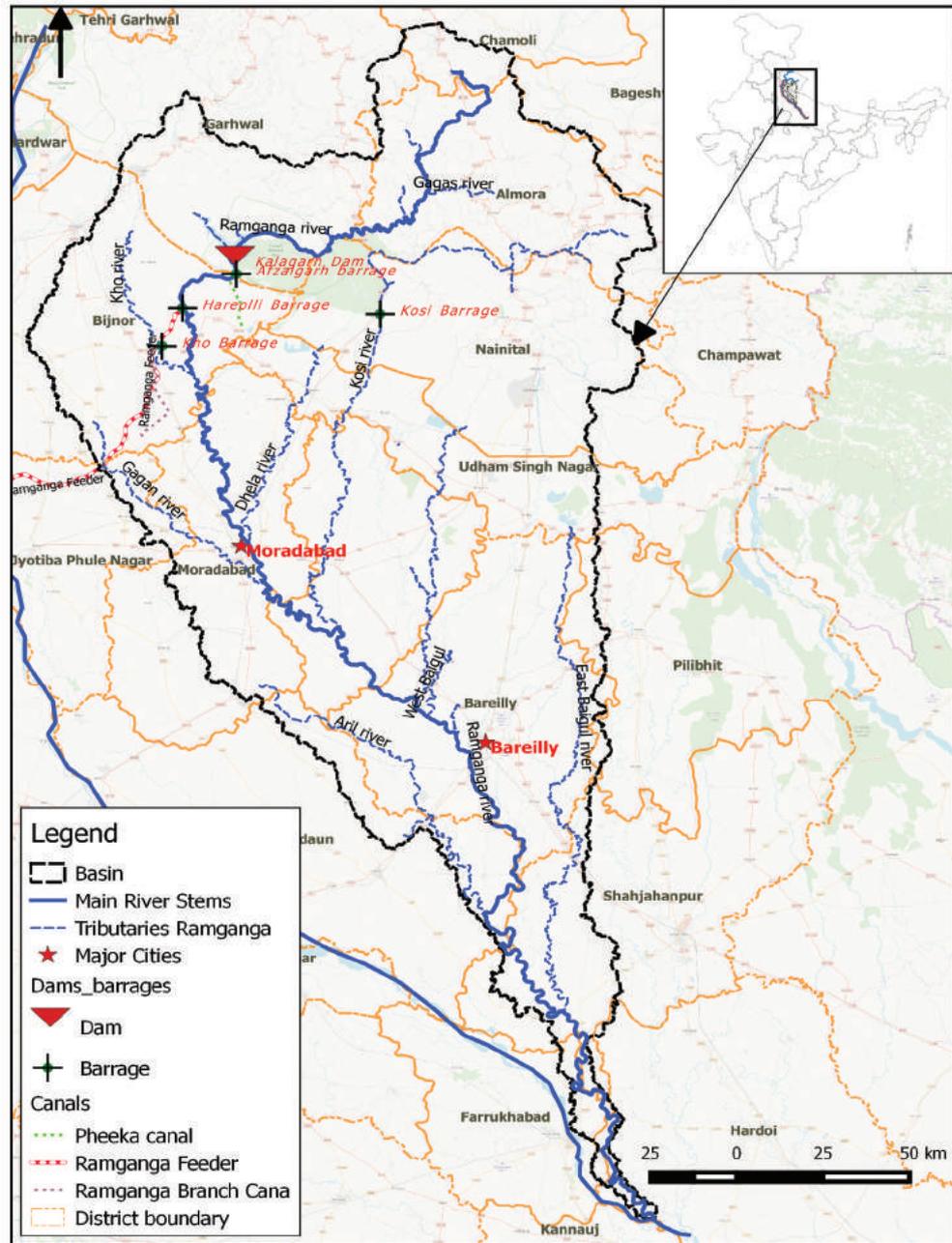
1. Water availability at the Kalagarh Reservoir
2. Committed allocations & uses (Figure 4.3):
 - a. Lower Ganga Canal share,
 - b. Share of direct irrigation systems (Ramganga Main Canal and Phika Irrigation System) taking off from Ramganga (as shown in Figure 4.2);
3. Reservoir operations –reservoir levels (monthly), operation rules & revised regulation (2010);
4. E-Flows implementation: Presents various release pattern scenarios (from the Kalagarh Reservoir) along with alternate avenues to cater to the E-Flows requirements.

Figure 4.1: Villagers often used boats for transportation from one bank to the other



Photo Credit: Nitin Kaushal/WWF-India

Figure 4.2: Ramganga River Basin map showing Salient Features



Source: WWF-India

In order to demonstrate the immediate results of E-Flows in Ramganga, the site downstream of Hareoli Barrage is an ideal one, as any enhancement of flows downstream of this barrage would show visible improvement in the health of the river. Plus, this intervention should ideally have some positive impact on the downstream sites, i.e., Agwaanpur, Katghar-Moradabad, Chaubari-Bareilly and Dabri – although there is substantial surface-water and ground-water interaction in these downstream sites. The situation worsens, as there has been massive groundwater pumping for irrigation all along the basin from downstream of the Hareoli Barrage. This would call for a comprehensive strategy to realise E-Flows in entire stretch of the Ramganga. Keeping this in view, the team has done trade-off analysis focusing on one site, i.e., the Hareoli Barrage. In other words, the implications of E-Flow releases onto the current scenario at this site was investigated.

4.1.2 Committed Allocations and Uses

The water resources of the Ramganga River have several committed uses. These primarily include supplementing irrigation to Lower Ganga Canal command and irrigation to direct canal systems from the Ramganga River. These systems are managed by the UP Irrigation and Water Resources Department and Uttarakhand Irrigation Department, based on jurisdictional limits.

Figure 4.3: Allocation of Ramganga Water Resources at the Kalagarh Dam



Key highlights –

- Mean annual withdrawal from the Kalagarh reservoir was 1,600 MCM (before commissioning of Tehri reservoir) and 1,400 MCM (post-commissioning).
- Out of the total amount of water allocated for irrigation, 85 per cent is reserved to supplement irrigation for the Lower Ganga Canal (LGC) system, 5 per cent for irrigating local Pheeka doab (take off from Afzalgarh Barrage) and the remaining 10 per cent for the direct canal systems (from the Kho Barrage).
- Entire water is reserved for irrigation, and there is no provision of separate reserve/ allocation for power generation.
- Power is generated in parallel with the irrigation release.

4.1.3 Reservoir Operation

Some of the key highlights of the Kalagarh reservoir operation policy are:

- Of the total, 10 per cent of water in the reservoir can be used anytime of the year for power generation as per demand and the same will be allocated for irrigation in command (no carry forward to next year).
- Post-2010 flood disaster, UPI&WRD has changed the policy pertaining to water release from the reservoir. Presently, they have set a threshold levels for each month (during the wet season) over which water will be released downstream (in a phased manner) to maintain a cushion for further inflow.

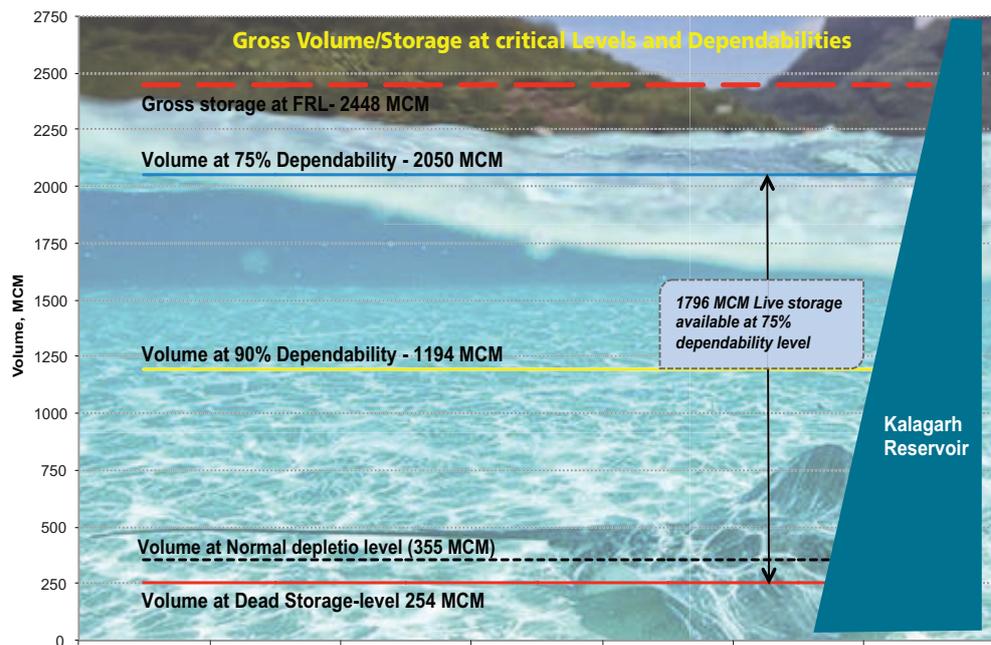
4.1.4 Water Availability

Outcomes of water availability at various hydrological scenarios (at the Kalagarh reservoir) is presented in terms of dependability or probability of exceedance function. Figure 4.4 illustrates the volume of water available at various reservoir levels and flow dependabilities (probability of exceedance).

Box 4.1: Approach for Analysing Water Availability in the Kalagarh Reservoir

- The proportion of time any given flow is exceeded can be determined by generating a Flow Duration Curve (FDC).
- The team considered four main dependability levels (this is based on long-term hydrological information) for our analysis
- 25 per cent dependability: Volume at this level is available 2-3 times in a decade and reflects extreme events
- 50 per cent dependability: Volume at this level is available 5 times in a decade and reflects long-term mean values
- 75% dependability: Volume at this level is 7-8 times in a decade. This reflects normal Maintenance Year Scenario.
- 90% dependability (almost every year): low-flow regime, characterises the ability of the basin to sustain low flows during dry seasons. This is the level at which drinking water & hydropower schemes are designed.

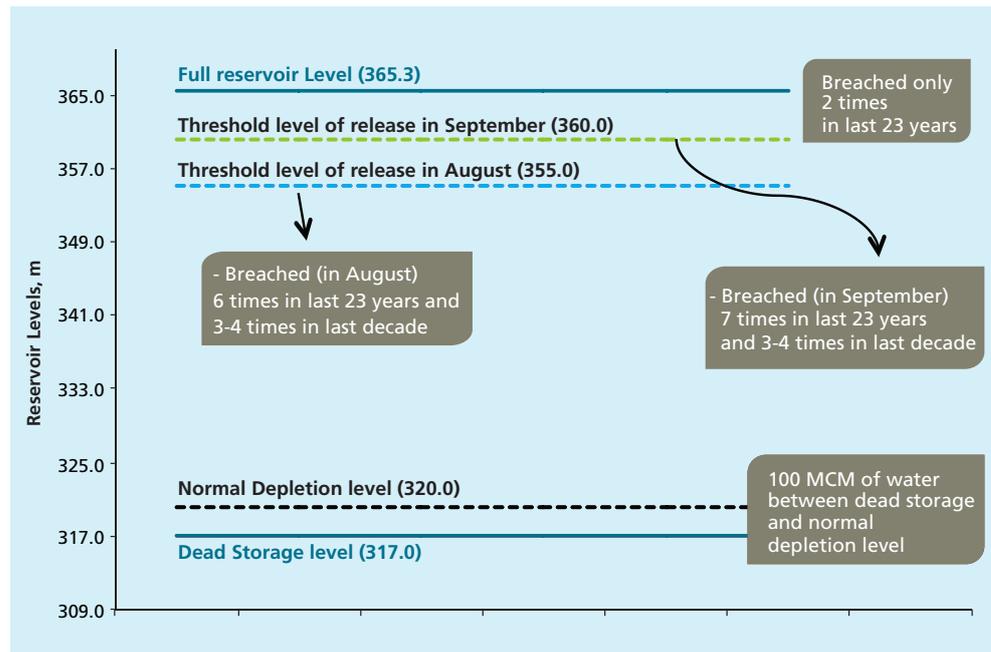
Figure 4.4: Water Availability at Different Dependabilities



Post-2010 flood in Ramganga, UPI&WRD has formulated a flood management plan for the Kalagarh Dam. A threshold was setup for wet months (mainly August to September) so that water could be released in a controlled manner as soon as the water-level in the reservoir reaches the designated threshold during the wet months, to minimise flooding downstream. Annual water storages in Kalagarh was analysed to assess the scenarios and to collect data on the number of times the threshold level was breached in the past (Figure 4.5).

Figure 4.5: Water-Level Analysis for Various Flood Return Periods

**7-8 times
in a decade
(75 per cent
dependability),
volume stored
in reservoir
is 2050 MCM
with net water
available above
dead storage of
317 MCM (after
all dedicated
releases)**



Box 4.2: Water-Level Analysis for Various Flood Return Periods

- Total volume stored in Kalagarh reservoir, 7-8 times in a decade (75 per cent dependability), is 2,050 MCM with net water available above dead storage of 317 MCM (after all dedicated releases).
- Volume available five times in a decade (50 per cent dependability) is 2,657 MCM
- Every three out of four years' reservoir is depleted up to the level of 320m which is termed as 'Normal Depletion Level' which accounts for storage of 355 MCM.
- Twice every three years (66 per cent dependability) the total volume of water available in the reservoir is 2,284 MCM with net water available above dead storage of 461 MCM (after dedicated releases).
- Threshold level set for August and September month release (355m and 360m) had been breached 6-7 times in last 23 years and 3-4 times during last decade

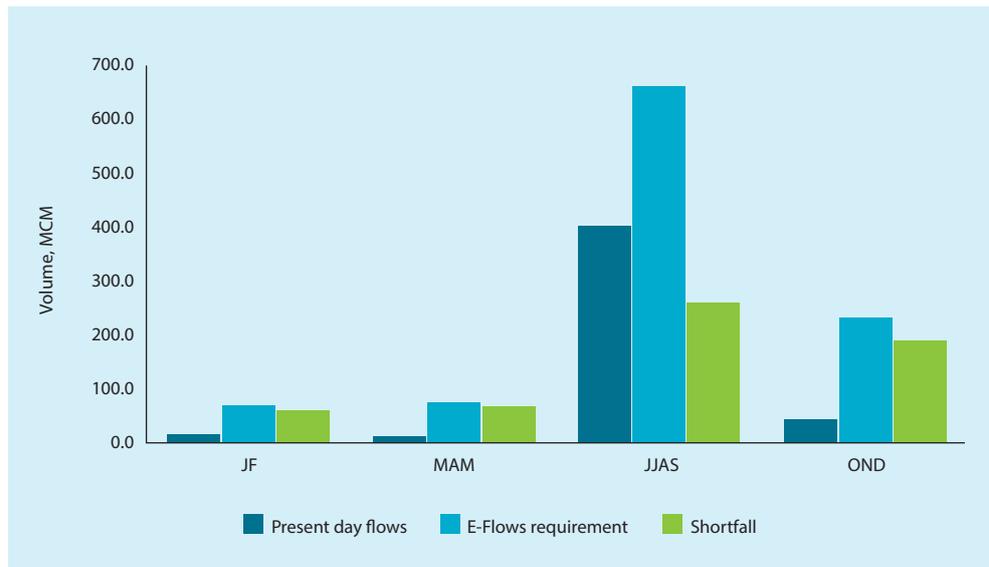
4.2 E-Flows Implementation and Trade-offs (Downstream of the Hareoli Barrage)

The E-Flows implementation and possible scenarios of trade-offs is presented in this subsection for E-Flows site, i.e., downstream of the Hareoli Barrage.

Figure 4.6 presents the seasonal variation in present day flows v/s E-Flows required and shortfall to fulfil the same. The shortfall volume is compared with net volume available above normal depletion level (NDL) of the Kalagarh Ddam (post all dedicated withdrawals).

- During the months of January - February, and March-April-May, nearly 20 per cent of water is required to maintain E-Flows at downstream of Hareoli Barrage
- During October-November-December nearly 59 per cent of water is required to maintain E-Flows at downstream of Hareoli Barrage

Figure 4.6: Present-day Flows vis-a-vis Required E-Flows for Different Seasons and Months



**JF: January-February, MAM: March-April-May, JJAS: June-July-Aug-Sept, OND: October-November-December

4.2.1 Water Availability vis-à-vis Quarterly E-Flows Requirement

The team evaluated gross water availability, annual withdrawals, and net water availability post-withdrawals (over critical operational levels) at various dependable flow conditions to assess the present water availability scenario which may be used to cater for E-Flows requirements (see Figure 4.7).

Figure 4.6 and Table 4.1 presents a quick overview of the hydrological scenarios under which E-Flows requirements can be met, which has provided some valuable information (for the trade-offs exercise). It is evident that there is a considerable amount of water left in the Kalagarh reservoir above the dead storage and normal depletion levels (in business as usual (BAU) case), which can be used to cater to the flows requirements downstream of the Hareoli barrage site. This implies that E-Flows could be provided without any trade-offs for the BAU case, at least during the lean season.

From the perspective of a water manager, the irrigation and hydropower schemes are made at 75 per cent dependability. Therefore, Figure 4.6 illustrates 75 per cent dependability scenario, in addition to the 50 per cent dependability (which shows the mean) and 90 per cent dependability (which exhibits the extreme hydrological drought conditions).

The Kalagarh multi-purpose project on Ramganga is designed at 75 per cent dependability. Although the Dead Storage Level of the Kalagarh Dam is 317meters, but the water managers tend to keep water up to the 'Normal Depletion Level', (i.e., 320m) with a consideration of keeping some cushion for them, which can be used for urgencies.

Figure 4.7 – Water Availability vis-à-vis Seasonal E-Flows Requirement

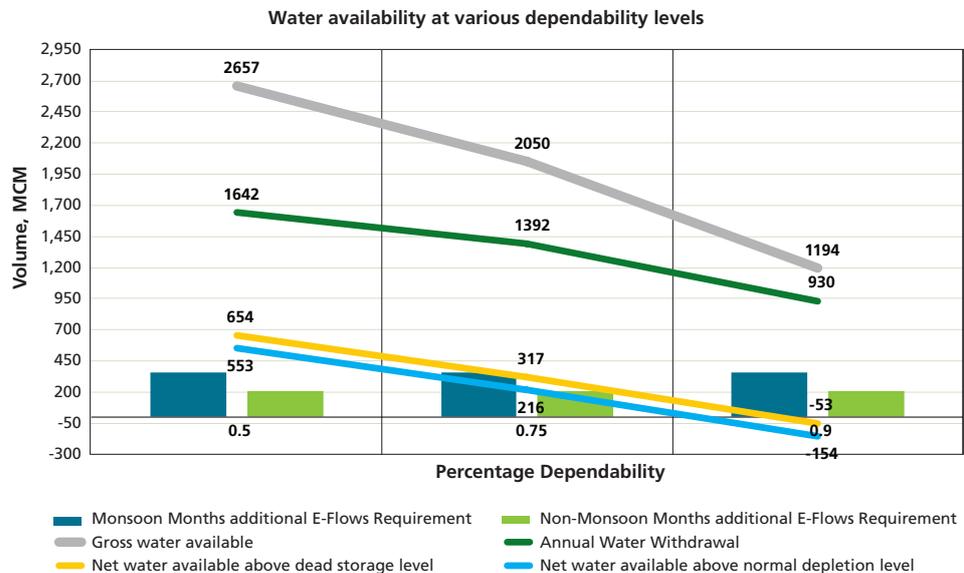


Table 4.1: Overview of Hydrological Scenarios which can Cater to the E-Flows Requirement

	Net water available above dead storage level (in MCM)	Monsoon Months	Non-Monsoon Months	Annual	Net water available above normal depletion level (in MCM)	Monsoon Months	Non-Monsoon Months	Annual
2-3 times in a decade (25%)	1180				1,079			
5 times in a decade (50%)	654				553			
6 times in a decade (66%)	461				360			
7-8 times in a decade (75%)	317				216			
Almost every year (90%)	-53				-154			
Annual, Monsoon and Non-Monsoon months additional flow requirement: 517 MCM, 358 MCM, 213 MCM respectively								
Completely realised		Partially realised			No realisation			

Box 4.3: Reflections from Figure 4.6

- Additional flows required to realise recommended E-Flows cannot be fulfilled at 90 per cent dependability flow condition (hydrological drought condition) and trade-offs will be maximum in this scenario.
- Seven to eight times in a decade (75 per cent dependability) the net water available above dead storage is 317 MCM. Therefore, in the 10 years, seven to eight times non-monsoon months' flows can be fulfilled, while monsoon months E-Flows fulfilment will have considerable trade-offs on other allocations.
- E-Flows requirements during the monsoon and non-monsoon seasons can be fulfilled under 25 and 50 per cent respectively.
- Non-monsoon season E-Flows gaps can be fulfilled under all hydrological scenarios, except for 90 per cent dependable flows (hydrological drought condition) where the trade-offs are maximum (if E-Flows are implemented).
- Under normal year (75 per cent dependable condition) only non-monsoon months' E-Flows requirement can be realized.
- It is evident from the historical flows analysis, that the annual E-Flows requirement can be fulfilled five times in a decade when gross water availability is 2,650 MCM and net utilizable water above dead storage is 654 MCM.

The above illustrations present the hydrological scenarios when the E-Flows requirements (Seasonal-Annual) can be met. The subsequent sub-section will highlight the avenues through which E-Flows requirements can be realised and implemented downstream of the Hareoli Barrage site by releasing water from the Kalagarh reservoir.

4.2.2 How to Realise E-Flows

It was recognised after analysing the hydrogeological scenario of the catchment downstream of the Hareoli Barrage, that there is substantial interaction of surface-water and ground-water, in addition to the excessive ground-water pumping for irrigation and domestic purposes, which is making the stream an effluent and influent nature in different stretches. This phenomenon can have a significant impact on the health of the river, as far as flows are concerned, especially during the lean season. There could be appreciable improvement in the river health downstream of the Hareoli Barrage due to E-Flows releases from the Kalagarh reservoir.

However, for long-term E-Flows in Ramganga throughout the river, the following measures are required:

- Regulation of ground-water extraction,
- Exploring the releases from other surface-water storages (on tributaries of Ramganga) in addition to release from the Kalagarh reservoir,
- Release from Kalagarh Dam

4.3 E-Flows Implementation Scenarios

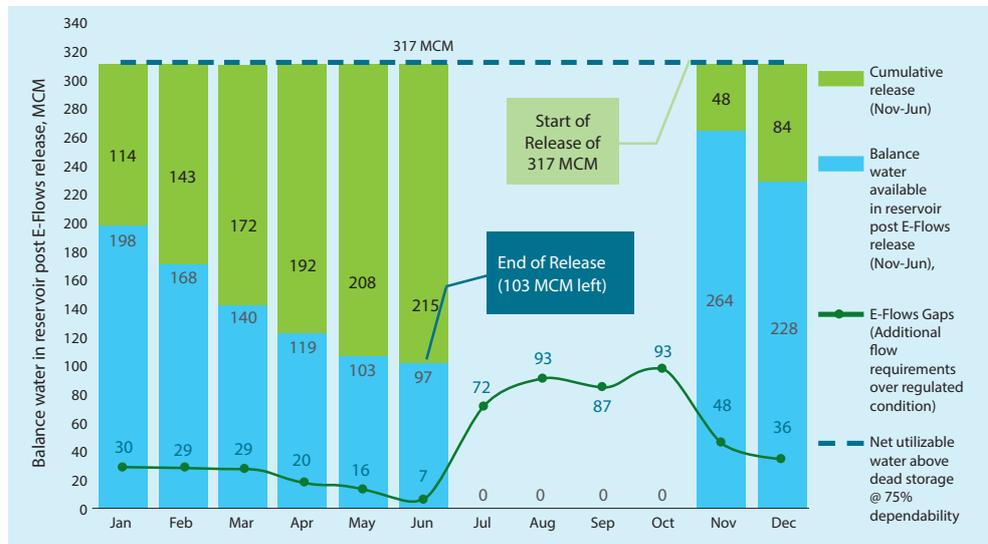
This sub-section talks about two scenarios, i.e., how E-Flows at downstream of the Hareoli Barrage can be maintained under the BAU scenario, and how E-Flows can be maintained through other alternate scenarios.

4.3.1 The Business As Usual (BAU) Scenario

For year round E-Flows implementation, the trade-off analysis for the Hareoli site is required. In the BAU scenario, net water available (leftover in Kalagarh reservoir above the normal depletion level post dedicated withdrawals) should be used to cater to the E-Flows requirements. This would require changes in reservoir operation policies (to be proposed to the state administration), which can allow water to be released downstream of the Hareoli Barrage during the lean season

The release pattern of net water available at 75 per cent dependable flow condition (for Maintenance Year Target Scenario) is presented in Figure 4.8.

Figure 4.8: Release Pattern for Water Availability at 75 per cent Dependability



Key takeaways:

- Here, net water available (317 MCM) is released from November onwards of the current year up to June of the next year.
- After fulfilling E-Flows requirements of lean season (November – June), almost 32 per cent of water would still be left in the reservoir (103 MCM) above the Dead Storage Level at the start of the filling season (from 15 June), which can be either kept in reserve or released downstream to cater to the flows required at critical times during the monsoon months.
- If we consider water availability at Normal Depletion Level (after accounting all uses) we are left with 216 MCM and we can still meet entire lean season E-Flows requirements.



Photo Credit: Nitin Kaushal/WWF-India

4.3.2 Alternate Scenario

This part of the chapter discusses the alternate scenario for downstream Hareoli Barrage site only; whereas Chapter - 5 delves deeper into the long term E-Flows implementation in Ramganga.

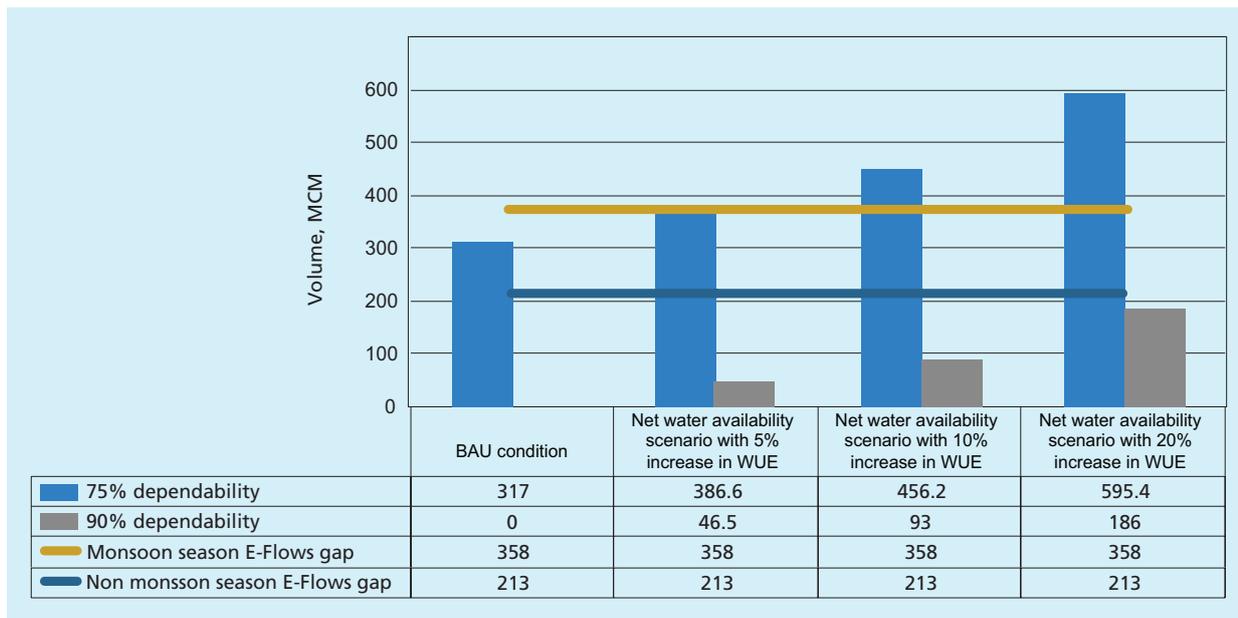
As per a report by CWC (*Guidelines for Improving Water Use Efficiency in Irrigation, Domestic & Industrial Sectors-2014*, by the Performance Overview & Management Improvement Organization – Irrigation Performance Overview Directorate) on Water Use Efficiency (WUE) of existing irrigation systems

- Current WUE status of major irrigation systems is low (35–38 per cent)
- National Water Mission aims for further increase in Irrigation WUE by 20 per cent from baseline, as one of its goal by end of the 12th Five Year Plan

The para 5.5 of the 12th Five Year Plan recommended that the irrigation departments should move their focus towards a more multi-disciplinary, participatory management approach for Medium and Major Irrigation schemes, with a focus on command area development and a sustained effort at improving water use efficiency.

Irrigation being the biggest consumer of water (over 80 per cent), this sector calls for bigger attention as far as water savings is concerned. This can be achieved through enhancing WUE, adopting organic farming, conjunctive use and climate smart agriculture techniques that can be implemented through institutional mechanisms.

An attempt has been made to generate potential irrigation WUE scenarios vis-à-vis net water availability to cater to the E-Flows requirement at downstream of the Hareoli Barrage. Three main irrigation WUE scenarios with 5 per cent, 10 per cent and 20 per cent increase in water use efficiency from baseline (to assess the potential water savings and implications on E-Flows requirement), have been created.



Box 4.4: Benefits of Irrigation Water Use Efficiency leading to Adequate Water for Releases in Ramganga to Meet the E-Flows Targets at Downstream of Hareoli Barrage

For downstream of the Hareoli Barrage site:

- In the BAU condition (baseline) non-monsoon season E-Flows gap can be easily fulfilled under 75 per cent dependable flow condition.
- If we increase WUE by 5 per cent, we may be able to fulfil both monsoon and non-monsoon season E-Flows gaps at 75 per cent dependable flow condition.
- If we could achieve enhancement of WUE by 20 per cent, net water available even in drought condition (90 per cent dependability) reaches close to fulfilment of non-monsoon season E-Flows requirements for a maintenance year.

Box 4.5: Proof of Concept – Piloting Demonstration of Irrigation Water Use Efficiency in a Canal System fed by Ramganga Waters

The team has worked on a WUE pilot project in 2015-16, in one of the local canal command (Jairampur minor) within the Ramganga basin in Bijnor district of Uttar Pradesh. Jairampur minor canal serves an area of about 600ha (design discharge of 6.45 cusecs)

- Number of farmers engaged: 284
- Total pilot area: 35ha
- Seeds distributed: Flood tolerant + Drought tolerant

Under this pilot the team has trained farmers on using organic fertilizer called “Amrit Paani and Amrit Khaad”. Farmers were provided training on best management practices with respect to irrigation and improved crop variety which provided good results

Since July 2017, a pilot project on Khanpur minor canal command (falls in Seohara, Bijnor) is underway to implement irrigation WUE approaches with an aim to bring water to a nearby tributary that feeds the Ramganga. Under this pilot initiative, farmers in Khanpur minor command are engaged to take up improved irrigation practices and better variety of crops. This is aimed to reduce the surface water consumption during irrigation. It has been envisioned that, the saved water would be directed through an escape channel to the nearby Karula river (tributary of Ramganga system) thereby improving its health.

Whilst the first pilot was focussed on the awareness and training aspect; the second pilot is much more focussed and oriented towards field-level activities.

Whilst both the BAU and alternate scenarios are given, the BAU scenario is what can be looked into at the earliest and the alternate scenario should be taken as long-term goals for efficient and sustainable management of the water resource of the Ramganga River.

5



Roadmap for Restoring E-Flows in the Ramganga

This report, thus far, captures the approach and results of the Ramganga E-Flows assessment. In addition, trade-offs emerging from the future release of E-Flows at Hareoli barrage – a critical site in Ramganga – has also been discussed in the previous chapters. This chapter will discuss in detail the short, medium and long-term actions needed for restoring E-Flows covering social, technical, policy and institutional aspects. The Government of India and the National Mission for Clean Ganga has recognised ‘*aviral dhara*’ or uninterrupted flows as one of the visions of the flagship Namami Gange programme which aims at rejuvenation of the Ganga. In this regard, the Ganga Notification of 2016 is a positive step, which calls for maintaining E-Flows in Ganga and its tributaries. Later on the ‘Ganga Vision’ document of December 2017 (a joint policy document of the National Mission for Clean Ganga – implementing agency of Namami Gange programme of the Government of India and cGanga – Centre for Ganga River Basin Management Studies), categorically stressed on the implementation of E-Flows regime in the Ganga and its tributaries. On the other hand, the State of Uttar Pradesh also aspires to rejuvenate one river in each of its districts. This has been a welcome policy declaration by the government. This chapter attempts to build on the experiences of E-Flows restoration across the globe.

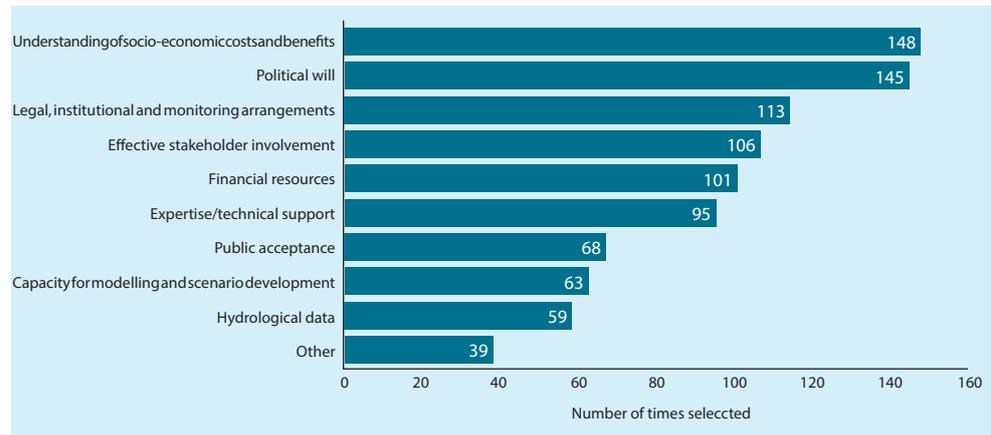
5.1 E-Flows Restoration

Through the Brisbane Declaration, the delegates to the 10th International River Symposium and Environmental Flows Conference in 2007 called upon “all governments, development banks, donors, river basin organisations, water and energy associations, multilateral and bilateral institutions, community-based organisations, research institutions, and the private sector across the globe” to commit to a set of actions for restoring and maintaining E-Flows.¹



Despite the fact that many countries now have some form of policy or legal recognition of E-Flows, the implementation has been limited across geographies.² A number of international reviews (Moore, Hirji and Davis, and Le Quesne et al.)³ have assessed E-Flows implementation challenges and identified three principal obstacles (see Figure 5.1): (a) lack of political will and stakeholder support; (b) insufficient resources and capacity; and (c) institutional barriers and conflicts of interest.⁴

Figure 5.1: E-Flows Implementation Challenges: Principal Obstacles



Note: Reproduced from The Implementation Challenge. Le Quesne, et. al. 2010.

A number of international reviews have assessed E-Flows implementation challenges and identified three principal obstacles: (a) lack of political will and stakeholder support; (b) insufficient resources and capacity; and (c) institutional barriers and conflicts of interest

On the 10th anniversary of the Brisbane Declaration in 2017, WWF released a report titled *Listen to the River*⁵ which showcased success stories, since 2007, of governments and water management authorities across the globe in developing policies and regulations, and undertaking activities to protect and restore E-Flows. These successes were not without obstacles and challenges, which ranged from a lack of political will and stakeholder support, to insufficient resources and capacity, to competition for water use among sectors, institutional barriers and conflicts of interest.⁶ These stories also illustrate that there are numerous ways for achieving success in E-Flows restoration, which are both dependent on system-specific and jurisdiction-specific concerns and relate to legal, political, institutional, social, economic and ecological contexts. Further, these examples testify Le Quesne's⁷ conclusion that there cannot be a single approach towards E-Flows implementation, and that any attempt at E-Flows restoration must be carefully tailored to the context. However, one cannot also ignore some common truths that came out with every success story.

- Enact clear and effective legislation and regulation, and maintain the political will to implement and enforce those legislations and regulations;
- Engage meaningfully with stakeholders to properly understand the issue and to garner support for E-Flows implementation;
- Secure sufficient resources and capacity for E-Flows design (including stakeholder engagement), implementation and monitoring;
- Consider how E-Flows implementation will affect not just the ecology, but also economic and social conditions of different groups of people;
- Implement some level of protection as early as possible, since it is easier to restrict allocation than attempting to re-allocate water;
- Keep E-Flows prescriptions as scientific as possible, according to the level of risk and intensity of water use, and within the available financial and human resource constraints. However, there is a need to balance this to keep science targeted and only as complex as the context allows, and with the need for clear non-technical communication of the issues with stakeholders; and

- Monitor ecological, social and economic outcomes of E-Flows implementation and manage adaptively. These lessons reinforce and complement the conclusions of earlier case study reviews of E-Flows implementation.⁸

The Brisbane Declaration of 2017 on Environmental Flows⁹ went a step further and called upon all governments, development banks, donors, water and energy associations, multilateral and bilateral institutions, community-based organisations, research institutions, indigenous groups and the private sector across the globe to commit for protecting and restoring E-Flows as a central element of water resources management, and as a foundation for achievement of the water-related Sustainable Development Goals (SDGs). There is a larger recognition of the fact that E-Flows are required to protect not only aquatic ecosystems, but also the social, economic and cultural benefits that humans draw from rivers and interconnected lakes, wetlands and aquifers, and to enhance water security.¹⁰

5.2. Restoration of E-Flows in Ramganga

In the case of the Ganga and the Ramganga – both are over-allocated basins – there is an opportunity to look at a comprehensive roadmap, integrating actions, institutions, and social and economic measures as a part of the basin management plan. Based on global experiences, it is evident that E-Flows restoration is a step by step and long-drawn process, which will require collective and collaborative efforts from different stakeholders. A roadmap for E-Flows restoration in the Ramganga, can be divided into two parts:

1. A proof-of-concept demonstration of lean season E-Flows downstream of Hareoli Barrage, and
2. Roadmap for restoration of E-Flows highlighting short-, medium- and long-term measures

The first section focuses on modalities and aspects of one-time E-Flows releases during lean season at downstream of the Hareoli Barrage and the second presents a basket of measures that could be adopted for long-term restoration of E-Flows in the Ramganga.

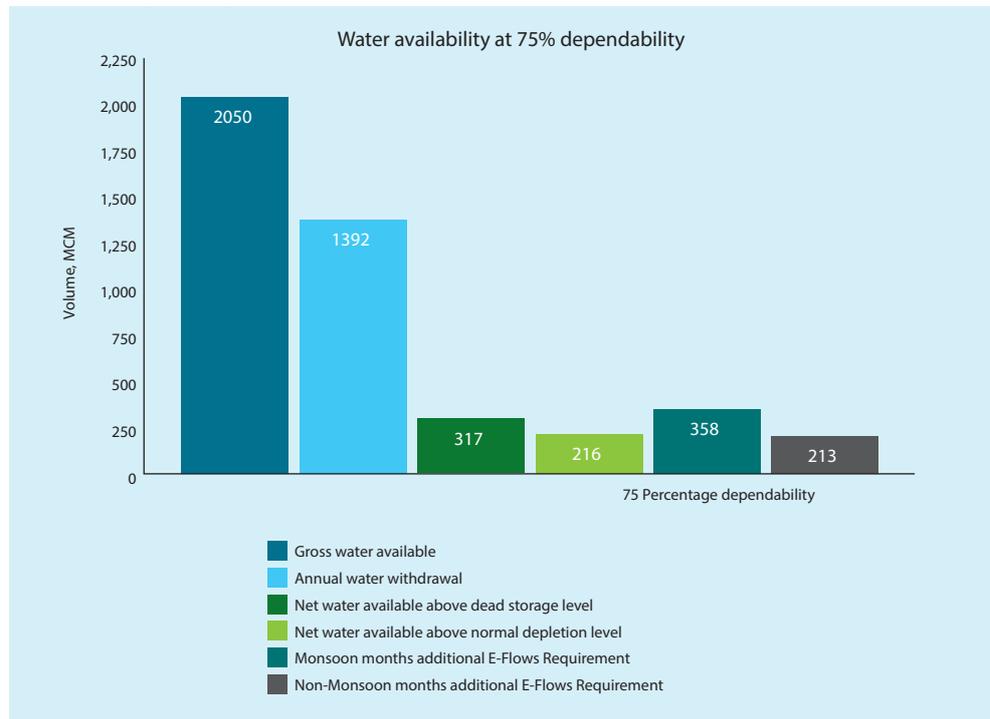
5.2.1 A Proof-of-Concept Demonstration of Lean Season E-Flows Downstream of Hareoli Barrage

While the overall vision is to restore E-Flows (in a regular and sustainable manner) in the Ramganga, the stakeholder consultations point to the need to demonstrate the costs and benefits of E-Flows releases on health of the river, and the associated services and functions. Therefore, as a short-term objective, the lean season E-Flows demonstration at downstream of Hareoli Barrage is envisaged and this section details out the steps needed to roll out this demonstration.

As discussed in the previous chapter, net water available (after fulfilling committed requirements) above dead storage at 75 per cent dependability is 317 MCM whereas lean season E-Flows requirement above the present day regulated flows is 213 MCM. It is also clear that in 7-8 years out of every 10 years, flows for ‘non-monsoon months’ (November to mid-June) can be fulfilled, while monsoon months E-Flows fulfilment will have trade-offs on other existing dedicated allocations. This means that there is adequate water available to ‘cater’ to the lean season E-Flows requirements at downstream of the Hareoli Barrage site (see Figure 5.2).

An attempt has been made here to answer the technical side of ‘how’ E-Flows demonstrations at downstream of the Hareoli Barrage during lean season can be

Figure 5.2: Water Availability at Kalagarh Dam vis-à-vis E-Flows Requirements at downstream of Hareoli Barrage during the Lean Season



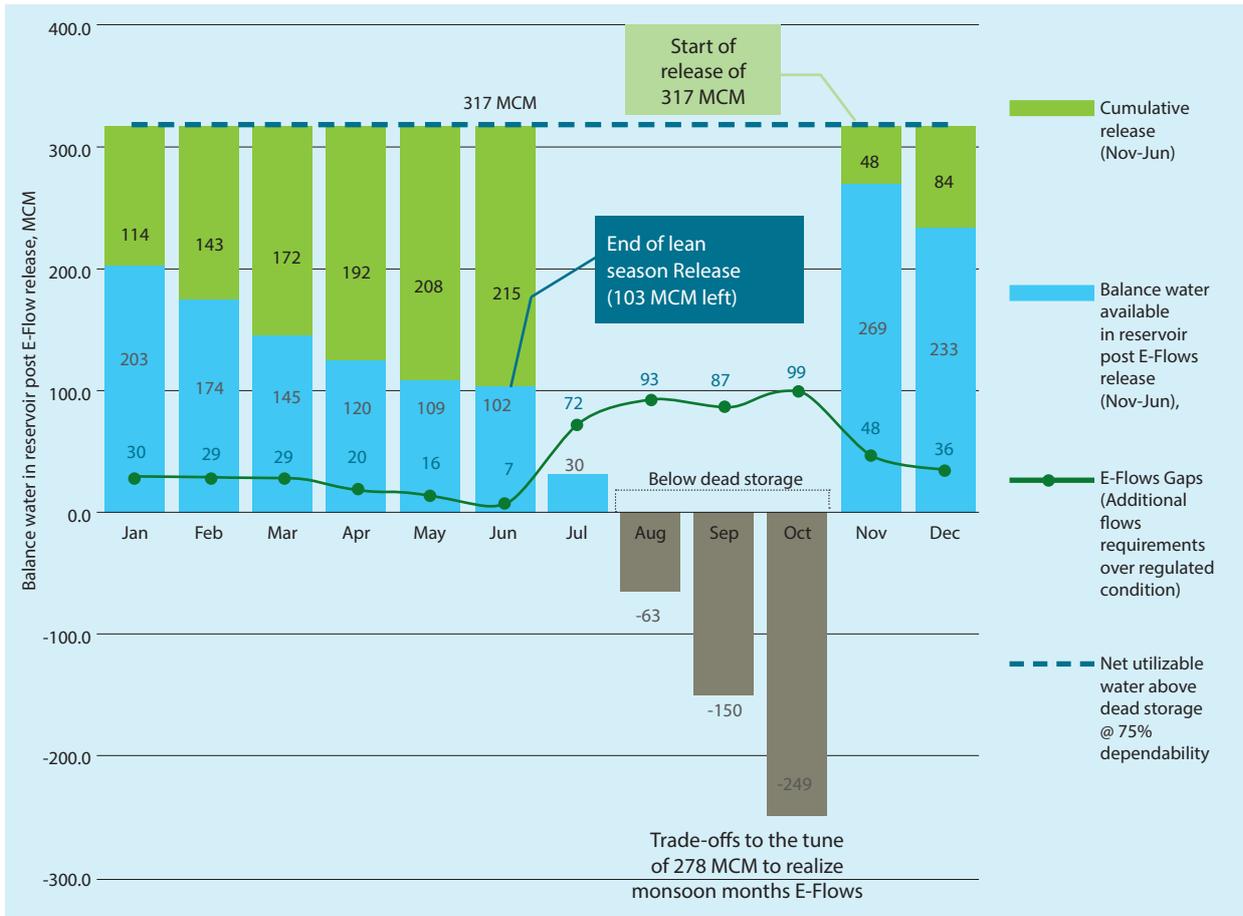
achieved. Following are the broad conclusions that has been drawn based on the available information:

- After meeting all the committed requirements, the net water available (317 MCM) can be released from November onwards of the current year up to the middle of June of the next year to cater to the lean season E-Flows requirements.
- After fulfilling E-Flows requirements of lean season (November-June), almost 32 per cent of water (103 MCM) would still be left in the reservoir above the Dead Storage Level at the start of the filling season (from 15 June), which can be either kept in reserve or released downstream to cater to the flows required at critical times during the monsoon months.

Thus, there seems to be no significant technical challenge to demonstrate E-Flows at this site for lean season. Figure 5.3 depicts the proposed release pattern from the Kalagarh Dam to ensure the E-Flows during lean season at downstream of Hareoli Barrage.

From a technical perspective, such a situation is both promising and doable, with some difficulties, as there are no trade-offs with the existing demand scenario if E-Flows is released during the lean season. Parallel to this, the benefits and other impacts of E-Flows demonstrations need to be properly documented for future reference. This is a critical question and a month-wise release plan needs to be developed and agreed upon by all the stakeholders, mainly the Uttar Pradesh Irrigation & Water Resources Department, concerned District Authorities, river-bank communities, and local citizens.

Figure 5.3: Proposed Flows release pattern from the Kalagarh Dam to cater to the E-Flows requirements during the lean season



5.2.2. The Implementation and Monitoring of Demonstration of E-Flows at Downstream of Hareoli Barrage during the Lean Season

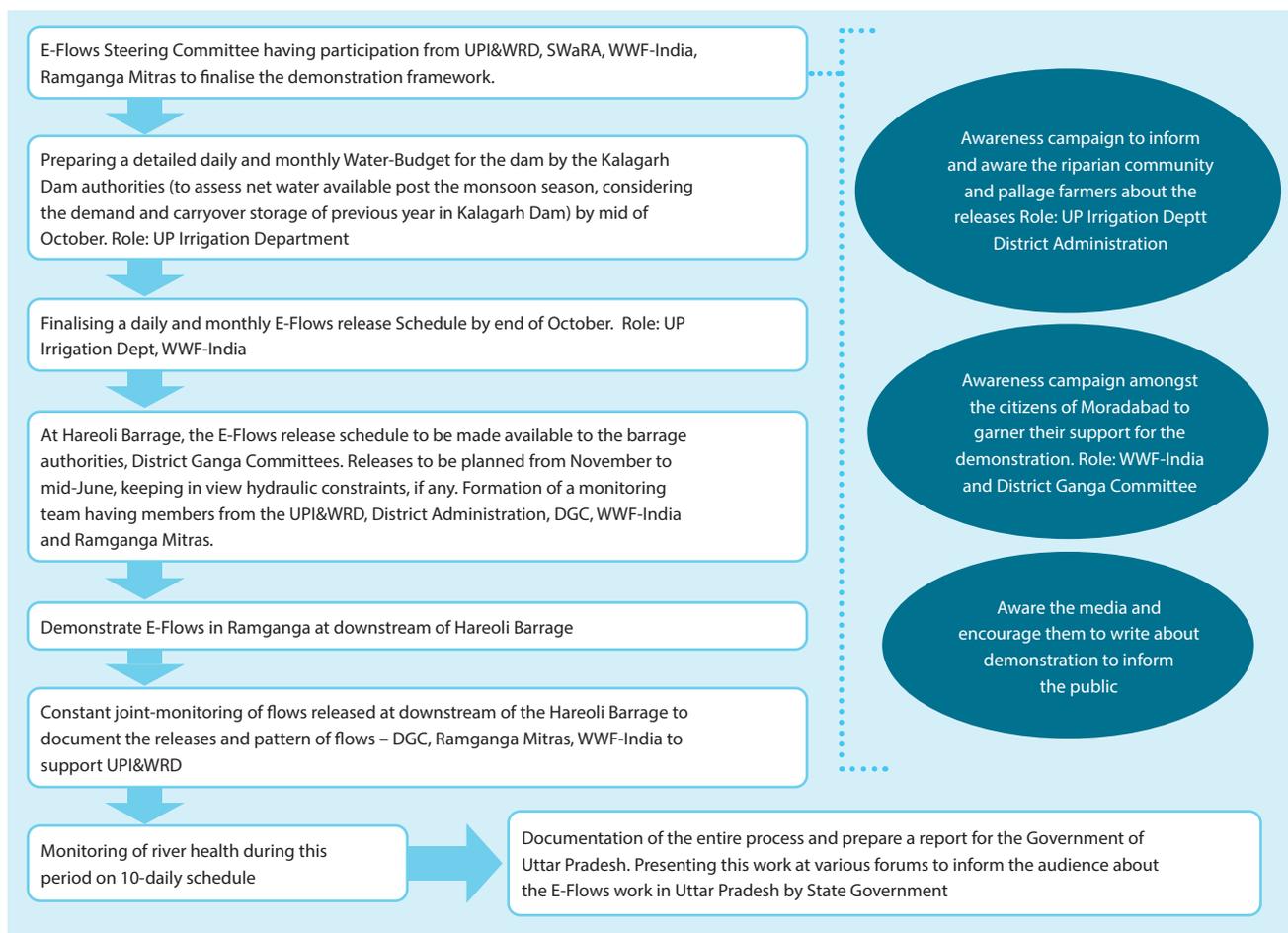
The demonstration of E-Flows during the lean season at downstream of Hareoli Barrage site is going to be a joint effort of the Uttar Pradesh Irrigation and Water Resources Department, the District Administration, District Ganga Committees, river-bank communities and pottage farmers, Ramganga Mitras, local citizens and WWF-India.

The monitoring aspect is critical for the success of the demonstration. Besides the technical monitoring pertaining to flows at downstream of the Hareoli Barrage, the monitoring around river health, impact on the aquatic biodiversity and overall community perception (especially the water users in Ramganga command to assess any unforeseen trade-offs), also needs to be taken up. The monitoring is to be done at four main locations, i.e.,

1. Downstream of Hareoli Barrage
2. Agwaanpur village
3. Katghar – Moradabad
4. Selected areas in the Ramganga irrigation command (covering head, middle and tail) sections

The key aspects to be monitored under each of these heads is listed in Figure 5.4.

Figure 5.4: A Prospective Implementation Plan



A broad month-by-month roadmap for E-Flows demonstration is given in Table 5.1.

Table 5.1: Roadmap with the tentative timeline for E-Flows demonstration at downstream of Hareoli Barrage during the lean season

October	November	Dec	Jan	Feb	March	April	May	June
Preparing a detailed daily/10-daily and monthly Water-Budget for the dam	Agreeing to the Water-Budget Perception survey of citizens, river bank communities and pottage farmers	Monitoring of E-Flows releases from the Hareoli Barrage	Monitoring of E-Flows releases from the Hareoli Barrage	Monitoring of E-Flows releases from the Hareoli Barrage	Monitoring of E-Flows releases from the Hareoli Barrage	Monitoring of E-Flows releases from the Hareoli Barrage	Monitoring of E-Flows releases from the Hareoli Barrage Perception survey of citizens, river bank communities and pottage farmers	Compilation of all monitoring results, perception surveys and benefits of awareness campaigns
Awareness campaign for pottage farmers, citizens	Start of Releases through Hareoli Barrage	Assessment of changes in the river health up to Moradabad	Assessment of changes in the river health up to Moradabad	Assessment of changes in the river health up to Moradabad	Assessment of changes in the river health up to Moradabad	Assessment of changes in the river health up to Moradabad	Assessment of changes in the river health up to Moradabad	Reporting

The role of all the stakeholders is going to be critical for a successful demonstration of E-Flows downstream of the Hareoli Barrage. As an immediate need in the wake of E-Flows demonstrations, the role of key stakeholders is listed in Figure 5.5.

Figure 5.5: Role of Key Stakeholders in implementation and monitoring of E-Flows demonstration at downstream of Hareoli Barrage

River Health	Biodiversity	Community Perception
<ul style="list-style-type: none"> River discharge /level data at Afzalgarh Barrage, D/s Hareoli Barrage and Moradabad pre & post release (with UPI&WRD support) Water Quality parameters at Afzalgarh Barrage, Hareoli Barrage, Agwaanpur, Moradabad River Health report cards Groundwater levels in wells in riparian villages 	<ul style="list-style-type: none"> Monitoring of aquatic species especially fishes both pre and post release at Afzalgarh Barrage, D/s Hareoli Barrage, Agwaanpur and Moradabad 	<ul style="list-style-type: none"> Monitoring community perception about released/enhanced flows in the river Perception of riparian community, especially pottage and command farmers Perception of riparian community
UPI&WRD	CWC	WWF and Ramganga Mitras
<ul style="list-style-type: none"> Modification in Dam operations Water Budgeting of Kalagarh dam and assessment of net water available above dead storage or normal depletion levels Release of E-Flows as per recommendations Monitoring of flows downstream of Afzalgarh Barrage and Hareoli Barrage (both lean and monsoon seasons) 	<ul style="list-style-type: none"> Monitoring of flows/ levels and water quality parameters at Moradabad, Bareilly and Dabri EF sites pre and post E-Flows release 	<ul style="list-style-type: none"> Monitoring abundance and population of key fish species Generating River Health report cards Water quality testing Gauging the community perception Spreading awareness about benefits of E-Flows

5.2.2.1 Monitoring

A joint monitoring team comprising people from UPI&WRD, DGC, Ramganga Mitras, SWaRA and WWF-India to be constituted. WWF-India will be responsible for training the members of the joint monitoring teams.

5.2.2.2 Reporting and Feedback

The entire process of demonstration of E-Flows, right from water-budgeting, to releases, to monitoring of the impacts should be reported against certain targets and objectives. This process would strengthen the case for long-term E-Flows implementation in Ramganga. The reporting needs to have technical, socio-cultural and biodiversity targets, which include–

- **Technical**
 - The enhancement of flows in the river
 - Improvement in water levels (water column depth)
- **Aquatic biodiversity**
 - Increase or decrease in aquatic life (fish and other organisms) or recording of new set of species
 - Qualitative and quantitative improvement in habitat of the aquatic species
- **Socio-cultural aspect**
 - Community perception of river at Katghar temple in Moradabad and at other locations between Hareoli Barrage and Moradabad
 - Perception of pottage farmers/river-bank community
- **Fluvial geomorphologic**
 - Channel processes
 - Channel complexity
- **Groundwater**
 - Change in groundwater levels at space and time along the stretch of the Ramganga from the Hareoli Barrage to Moradabad
- **Farmer perceptions on trade-offs**
 - Farmer perspective about enhanced flows in river and implications onto their activities, if any

5.2.2.3. Post-demonstration Review

Once the demonstration is over, a thorough feedback and lesson-learning session should be organised. This joint session should ascertain various levels of impacts and then strategise for–

- **Changes in release plan from the Kalagarh Dam** – release patterns may be changed to continue achieving what has been achieved after one-time demonstration
- **Reservoir Operations Plan** – this needs to be adjusted as per the flows requirement and can be embedded in general Standard Operating Procedures (SOP) of Reservoir Operations
- **E-Flows policy for Ramganga** – as the Ramganga pilot E-Flows demonstration releases achieve desired results, efforts should be made to standardise this practice through a policy intervention from the Uttar Pradesh State Government. In a long-run such a policy should be devised for all the major river systems in Uttar Pradesh.

As part of the review process and pursuant to that, various stakeholders will have a role to support E-Flows implementation on a long-term basis for the downstream of the Hareoli Barrage. This is informed through Table 5.2

Table 5.2: Role of Stakeholders in E-Flows Implementation

Stakeholder	Short term	Long term
UPI&WRD	<ul style="list-style-type: none"> • Change in reservoir operations • Review results and change release patterns accordingly • Maintain water account in light of E-Flows recommendations • Warning systems to riparian communities and farmers • Insert E-Flows recommendations and values in canal rosters to communicate it to the farmers of command 	<ul style="list-style-type: none"> • Introduce E-Flows policy to revive health of the river in the long run
CWC	<ul style="list-style-type: none"> • Monitor water levels and discharges pre and post-E-Flows releases 	<ul style="list-style-type: none"> • Data sharing on water levels and updated cross-sections
WWF-India	<ul style="list-style-type: none"> • Assist various stakeholders in monitoring and evaluation • Sampling of aquatic biodiversity • Assess and compile river health report cards • Policy advocacy around E-Flows • Technical support to concerned departments 	<ul style="list-style-type: none"> • Coordinating with UPI&WRD on release patterns looking at various components of riverine ecosystem • Policy advocacy
District Administration and DGCs	<ul style="list-style-type: none"> • Leading mass awareness campaign amongst pargana farmers about E-Flows releases 	<ul style="list-style-type: none"> • On-ground support to connect with various communities and tackle roadblocks in successful implementation of E-Flows
Ramganga Mitras	<ul style="list-style-type: none"> • Generating river health report cards • Awareness drives, training and education on benefits of E-Flows • Water quality testing 	<ul style="list-style-type: none"> • Play a proactive role in delivering the message to various communities on water savings and their responsibilities & contributions in keeping the river healthy
Command Farmers	<ul style="list-style-type: none"> • Open to irrigation Water Use Efficiency (WUE) techniques, and ways and means to reduce their irrigation water consumption for the purpose of realising the flows in the river • Consider less-water consuming varieties of crops 	<ul style="list-style-type: none"> • Adopt WUE approaches and also convince fellow farmers to achieve the objective of river rejuvenation through their contribution in terms of using lesser water for irrigation • In the long run, move towards pressure irrigation techniques, like drip and sprinkler
NMCG	<ul style="list-style-type: none"> • To incentivise the efforts of the State Government 	<ul style="list-style-type: none"> • Long-term financial support to the UPI&WRD for promotion of better irrigation practices and for rehabilitation of tertiary (minors and outlets) level irrigation system to curb water losses.

5.3 Year-round E-Flows Implementation in Ramganga

The ‘as-is’ scenario, with respect to situation-on-ground for implementation of E-Flows in Ramganga, is discussed in this section under two main heads, i.e., technical and social, and institutional.

5.3.1 Current Scenario – Technical and Social

The technical and social aspects of E-Flows in Ramganga in many ways complement each other. For instance, the withdrawals for various irrigation systems are directly linked to the use by farmers in the field, the surface water allocations take into account the irrigation practices adopted by the farmers. Therefore, in a scenario, if the irrigation practices are improvised, it will have a direct bearing on water allocation and therefore the withdrawals from the surface water resources.

5.3.1.1 The Technical Side of Ramganga Water Resources and its Use

The irrigation systems taking off from Ramganga are important for agrarian economy and have been one of the key contributors for food security. This irrigation infrastructure on Ramganga supplements irrigation in the Lower Ganga Canal (LGC) command and local Ramganga catchment area, through Ramganga sub-feeder, besides the Pheeka system which takes off from Afzalgarh Barrage. In the current baseline scenario, there is little room to re-develop the river ecosystem, since almost 70-80 per cent¹¹ of water is withdrawn for irrigation. Thus, some concrete measures are required for river conservation.

In the current scenario, downstream of Hareoli Barrage is one of the ‘Moderately Modified to Degraded’ site on the Ramganga (in terms of flows) is downstream of the Hareoli Barrage. An overview of overall water availability at the Kalagarh Dam and various withdrawals are mentioned in 5.3.

Table 5.3: Average Water Availability in the Kalagarh Dam and Average Annual Withdrawals

Gross Storage capacity of Kalagarh dam	2448 MCM
Gross Water Availability at 75 per cent dependability (carryover storage in June + Withdrawals + Flood Releases + Non-monsoon Flows)	2039MCM
Mean Annual Withdrawals (@ 75 per cent) (LGC, Phika, Ramganga canals ¹²)	1381 MCM
Evaporation Losses	87 MCM
Dead Storage capacity of the Kalagarh Dam	254 MCM
Net Water Available above the dead storage level (and after fulfilling all committed uses) at 75 per cent dependability.	317 MCM

Recommended E-Flows downstream of the Hareoli Barrage can only be realised through release from upstream Kalagarh storage as there is no significant intermediate catchment, which can substantially contribute to baseflows in lean season. This has been discussed in detail in Chapter 4. For rest of the downstream sites, the E-Flows can be realised through (i) releasing water from the Kalagarh Dam in a systematic manner in accordance with the E-Flows requirements, (ii) demand management and (iii) groundwater management in stressed regions.

As mentioned in Chapter 3 and Chapter 4, the key motivations in lean seasons were driven by biodiversity and fluvial geomorphology with socio-cultural aspect in few sites of cultural importance.

At the Hareoli Barrage, the recommended E-Flows in lean season (November-May) is almost 52 per cent of the present day annual regulated flows and 8 per cent of the gross storage capacity of the Kalagarh Dam. The trade-off analysis (discussed in Chapter 4) highlights the implication of required E-Flows in lean season for the Hareoli Barrage on committed uses. The study suggested that, lean season E-Flows requirement can easily be met by release of water from the Kalagarh storage. The gross water availability at 75 per cent dependability is 2,050 MCM, whereas net water available (above dead storage level) and after all dedicated uses (irrigation) is around 317 MCM. These figures are based on long-term data analysis of dam filling over the years. This amount of water can easily cater to the E-Flows requirements of the lean season, which will still leave 103 MCM of water in the reservoir as cushion for exigencies.

5.3.1.2 Social Side of Ramganga Water Resource Usage

The usage of Ramganga water resources is mainly for irrigation and that has been of a great help to farmers in and around the command areas of the irrigation system. The team conducted detailed farmer survey in the command area of Lower Ganga Canal and in the command areas of other irrigations systems directly taking off from the Ramganga river (mainly in the districts of Moradabad and Bijnor). As part of the surveys, interactions with over 1,200 farmers were held at different reaches (head, middle and tail) of these irrigation systems to ensure parity between the sample type and size. The objective of this exercise was to ascertain the existing irrigation practices and explore the potential of irrigation water use efficiency in the irrigation commands of LGC and direct systems taking off from the Ramganga River. The top line conclusion that emerge from the farmer survey include –

- 95 per cent of the farmers adopt ‘flooding’ as the method for irrigating their fields
- About 90 per cent of the farmers feel the need for training and capacity building in use of modern agriculture and irrigation techniques
- Less than 12 per cent of the farmers go for ‘soil-health’ testing of the farms

On the other hand, it is these farmers and other villagers that visit the banks of Ganga and Ramganga Rivers during the socio-cultural festivals to perform their cultural and spiritual rituals. Therefore, as part of these surveys, efforts were also made to understand their perspective towards the Ganga and Ramganga, and their willingness to contribute to the noble cause of rejuvenation of Ganga and Ramganga. The key reflections from these discussions could be noted as:

- Close to 90 per cent of the farmers visit the banks of Ganga and Ramganga to perform socio-cultural and spiritual rituals during various festivities.
- About 73 per cent of the farmers realise that, the aquatic life in the river is on a negative trajectory.
- About 81 per cent of the farmers feel that additional water supplies should be ensured in the river to sustain its aquatic biodiversity.
- About 50 per cent of the farmers are willing to transfer their saved water from irrigation for river rejuvenation

Despite lots of challenges, the field situation offers great opportunity, hope and support for the much-needed Ganga and Ramganga rejuvenation effort.

5.3.2 Current scenario – Institutional

The entire state of Uttar Pradesh is in a transition phase when it comes to Participatory Irrigation Management (PIM). While the PIM Act has been passed, its implementation is underway at the moment. Once the farmer institutions are in charge of (i) operation and management of the irrigation systems at their disposal (ii) and distribution of water resources, they can then look at promotion of water efficient practices. However, the state

The lean season E-Flows requirement at downstream Hareoli Barrage can easily be met by release of water from the Kalagarh storage

and central governments, through various schemes and projects are already promoting efficient irrigation practices.

Further, the water resources planning, allocation and management is done as per the State Water Policy of Uttar Pradesh. While the emphasis has been on irrigation and other uses, the state government, during cultural and religious festivals, makes all efforts to ensure the desired water levels and required flows in selected locations on the Ganga (Triveni Sangam) and Ramganga (Katghar, Chaubari).

5.4 Implementation Framework for Long-term E-Flows in Ramganga

As noted earlier, for implementation of E-Flows we need to look at the existing water use pattern in different sectors. In fact, Goal 4 of the National Water Mission is to “increase water use efficiency by 20 per cent”.¹³ The government is also making efforts for sectoral water use efficiency. The National Commission on Integrated Water Resources Development (NCIWRD) had assessed the water requirement for irrigation as 78 per cent, 72 per cent and 68 per cent of the total water requirement for the years 2010, 2025 and 2050 respectively.¹⁴ In light of these facts, the water use efficiency targets look essential.

Therefore, the government’s ask for improved water use efficiency would have dual benefits; it can lead to securing water resources from irrigation (thereby achieving the target envisaged by the government) and also benefit the movement towards rejuvenation and conservation of the Ganga river system.

While the trade-offs assessment for the Ramganga E-Flows maintenance at downstream of the Hareoli barrage site were discussed earlier, long-term E-Flows implementation across the Ramganga would call for application of multiple measures, including technical, social and institutional. These measures are discussed in detail in the following sub-section.

5.4.1 Technical and Social

With an objective to arrive at plausible management scenarios, the team held consultations with different stakeholders and the following scenarios were developed as part of this exercise.

5.4.1.1. Demand-side Management: Irrigation Systems based on the Ramganga

a. Water-use-efficiency and yield enhancement: At the moment, water use efficiency across the canal systems in this area ranges between 30-40 per cent which indicates a lot of scope of improvements.

b. Maintenance of canal infrastructure: The maintenance of canal infrastructure, especially at minor and outlet levels (as the main, branch and distributary canals often get adequate resources), is a critical step towards water conservation, as a well-maintained canal system can take designed discharge at the head and can then efficiently move the water till the tail-end of the system, provided the water distribution amongst the farmers is disciplined. Therefore, proper desilting drives in canals is essential (as these canals are based on diversion systems from rivers, hence ‘silting-up’ of canals is a usual phenomenon in such systems). Obstruction and bushes clearing is another activity, which is required to be done at regular intervals, usually before every cropping season. Besides this, the upkeep of outlet heads and water-courses is equally vital to ensure efficient water distribution at farm level.

WWF-India's work with 40 villages in six districts of Uttar Pradesh has shown that by adopting Package of Practices (PoPs) for seed selection, sowing practices, bio-fertilizer, bio-pesticides, water application and management, plus nutrient management could yield a 40% water savings in addition to 20-30% increase in productivity.

To build the capacity of farmers in these villages, WWF-India facilitated training sessions, since 2013, with agriculture experts to demonstrate use of Best Management Practices (BMPs). These BMPs include the use of micronutrients to provide a balanced supplement to crops to enhance production, in addition to Bio-Manure (Amrit Khad), Bio-Pesticides (Amrit Pani) and Package of Practices (PoPs) for wheat, paddy and sugarcane. These practices are designed to optimise use of chemical fertilizers like Urea and DAP, without compromising on crop productivity and thereby reducing pollution load and water use.

WWF-India is also working on a pilot project, which aims to enhance flows in Karula tributary (in Bijnor district) of the Ramganga river system by utilizing saved water from irrigation in canal command of Khanpur Minor canal.

The command area of Khanpur Minor is dominated by sugarcane production (70-80%) which is water intensive. The baseline scenario suggests that over 95% of the farmers provide water to the farms through flood irrigation. With demand-side management, the saved water from the command can be utilized for enhancing flows in the nearby Karula river (a tributary of Ramganga river system).

The whole initiative of this Irrigation Water Use Efficiency pilot project in Khanpur Minor is based on following premise – "Can we use spare water from irrigation to enhance the flows in the Karula river, a tributary of Gaagan river, which joins Ramganga at downstream of the Moradabad city."



Better Management Practices in the Ganga and Ramganga basin, vermi compost, line sowing



Trench method of sowing



Canal maintenance underway

Such an initiative would be the contribution from farmers for the noble cause to rejuvenate Ganga-Ramganga and other tributaries. In WWF-India's ongoing work in Khanpur Minor, the focus is on improving system efficiencies (application & conveyance) by carrying out following interventions

- Supply side management, which includes maintenance and repair of canal infrastructure and the passage of water from Khanpur Minor's tail to the Karula River.
- Demand side management, which focuses on efficient irrigation water application and promoting water saving technologies particularly 'trench' method in sugarcane farming and drip irrigation.
- Implementation management which includes training and capacity building of UPI&WRD Field Staff and the farmers in Water User Association (WUA) formation and strengthening.
- Sustainability management through establishment of a local institution like WUA at the minor level which can mobilize the farmers for collective action in maintaining the system

These interventions aims to ensure that the canal runs at design capacity to safeguard equitable distribution of water to the command area farmers and should enable saved water to flow into the Karula river. To assess the change, traditional sown field data was compared with trench based irrigation fields for one season. Initial trends are encouraging and there seems to be approximately 17-20% of water savings in the demonstration farms. These approaches are economically more beneficial for the farmers. The detailed and conclusive findings of this work is underway and would shortly be out through a Practice and Policy Paper, based on this work.

5.4.1.2. Supply Side Management

a. Systematic promotion of conjunctive use: It has been observed that, about 90 per cent of the farmers in the canal command use ground water to supplement canal irrigation. Besides, the use of ground water in comparison to canal water is very high. Our experience and interaction with farmers in Khanpur and other villages indicate heavy reliance on ground water and this may be attributed to (i) designed partial coverage of command area for irrigation by the canal, (ii) changes in cropping pattern, and (iii) unreliable, unequitable canal water supplies. This leads to avoidable extraction of ground water and consumption of fossil fuel and energy. During the discussion with farmers in LGC, they pointed out that due to erratic canal water supply, irrigation through tube wells is more than two times than via canal water.

b. Groundwater management for enhanced baseflows: Here it is important to understand the linkages between ground water and river flows. There is no comprehensive assessment and information on surface-groundwater interaction in the Ramganga basin. It is important to delineate baseflows contribution to surface water flows in the Ramganga and devise a strategy to enhance groundwater recharge and hence the baseflows.

As part of the Ramganga E-Flows assessment exercise, an additional study was carried out to map the Influent and Effluent¹⁵ stretches of Ramganga and its tributaries in Pre- and Post-monsoon seasons through a careful analysis and modelling of groundwater levels data. The objective was to assess the stretches where river is losing its waters to aquifer and vice versa. This would eventually assist in narrowing down to the areas where aquifer management needs to be taken up, so that groundwater levels can be enhanced through demand management and other water conservation measures like rejuvenation of wetlands.

Tributaries of Ramganga like – Dhela, Kosi, Aril and Gaagan are influent (losing stretches) majorly due to over exploitation of groundwater in blocks where the stage of development is greater than 60 per cent. This study was based on macro-level data of groundwater. An

Figure 5.6: Stages of Ground Water Draft

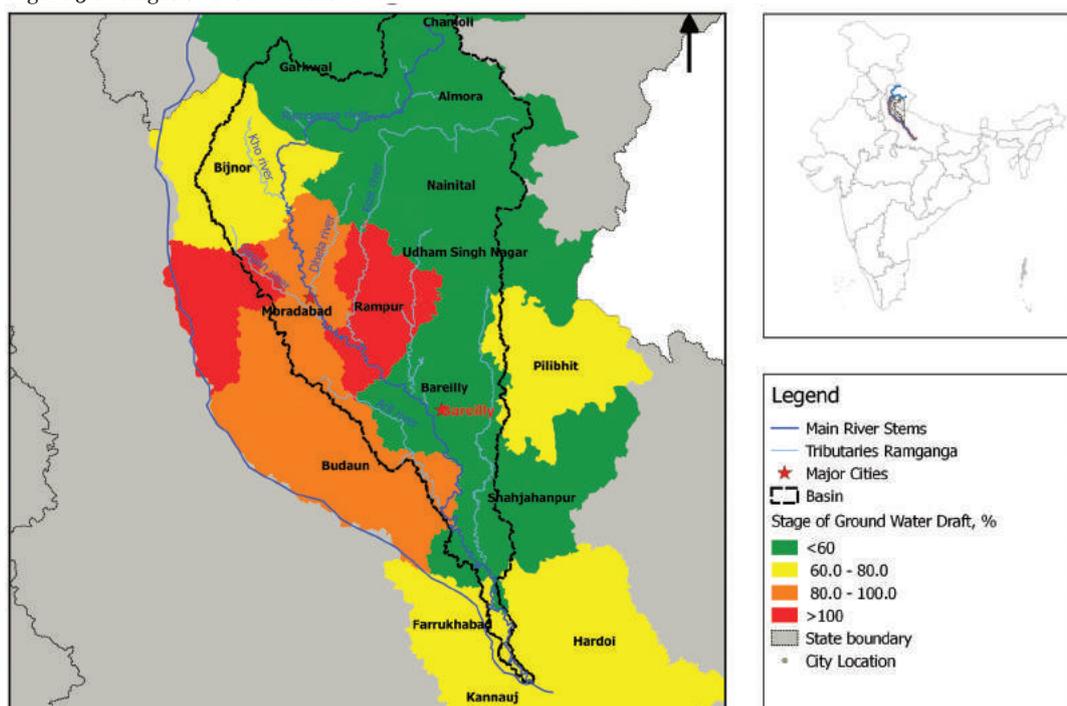
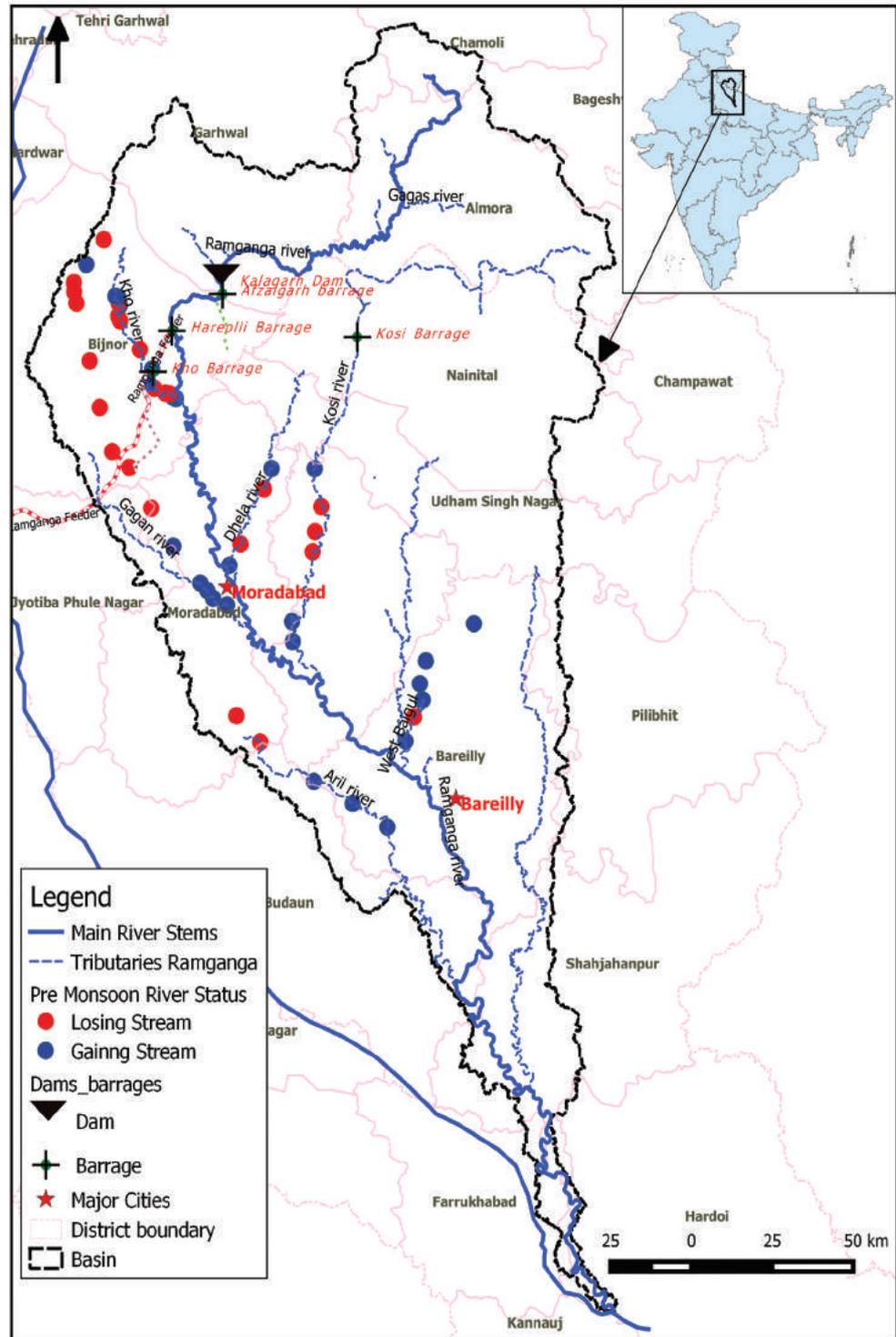


Figure 5.7: Influent & Effluent Stretches of the Ramganga and its Tributaries



The UPI&WRD is developing the Badayun Irrigation Scheme on the Ramganga at the outskirts of Bareilly district. Most of the barrage construction work is nearing completion, which is designed to divert 56 cumes of wet season (June to October) flows, as this is supposed to be a Kharif system (providing irrigation benefits only during the kharif season). As a reformist approach and in many ways, a pioneering step, the State Government is aspiring to bring in about 20,000 hectares of its command area under pressure irrigation techniques out of a total area of 37,000 hectares. This is a welcome step which will be a model project not only for the state, but also for the country.

in-depth hydrogeological study with deeper field investigations will lead to identification of exact influent-effluent stretches. Nevertheless, this will anyway help in identifying potential areas where demand and supply side management needs to be taken up.

c. Assessment of water balance of control structures: All water infrastructure in the river needs a thorough assessment of water availability, demand vis-à-vis E-Flows requirement. In this regard a thorough field-based assessment of all reservoirs in the Ramganga basin should be studied to ascertain the prospects of securing E-Flows in

Ramganga through the ‘tributary’ approach. This work would be a useful input to advocate for E-Flows implementation.

d. Pricing of water: At present, there are no incentives for the farmers to reduce their water consumption as the irrigation water charges are 100 per cent subsidised by the state government. The canal irrigation systems within the state, like in the other parts of the country, are designed for protective irrigation in a defined command area. However, over a period of time, (i) due to the need to grow more food supported by market drivers, (ii) due to the quest to grow cash crops and (iii) in the absence of an effective pricing regime, farmers have diversified into water intensive crops and have also enhanced the area under irrigation. Once the institutional arrangements under the UP PIM Act are implemented, the irrigation water charges should be rationalised by the state government through SWaRA and UPI&WRD.

5.4.2. Institutional Strategies

An assessment of some of the relevant stake-holding departments, ministries and organisations has been undertaken to ascertain the linkages and potential roles of such entities with respect to furthering the cause of E-Flows in Ramganga. The information about some of the critical and key organisations is tabulated in Table 5.4:

Table 5.4: Key Stakeholders their Goals

Stakeholder	Mandate/Goal/Interest	Support desired for the Ramganga E-Flows implementation	what will be achieved and Impact
UTTAR PRADESH			
UP Irrigation and Water Resources Department	<ul style="list-style-type: none"> Custodian of major river abstraction structures on the Ganga and Ramganga, including – Bhimgoda Barrage, Madhya Ganga Barrage, Narora Barrage, Kanpur Barrage, Kalagarh Dam, Hareoli Barrage, Kho Barrage etc. In-charge of irrigation in Uttar Pradesh and also water resources management at the state level. 	<ul style="list-style-type: none"> Revising of the Kalagarh reservoir operations to account for E-Flows releases downstream of the Hareoli barrage. Incentivising irrigation water use efficiency means by farmers. Establishing WUAs and strengthen them. Implementing revised water allocations. 	<ul style="list-style-type: none"> Becomes one of the pioneering irrigation departments in the country to secure E-Flows in the river, while sustaining all other committed uses.
Farmers, and water users associations	<ul style="list-style-type: none"> Major water users; State-wide Water User Associations (WUAs) establishment is under-process. Overall agricultural water use efficiency is low, due to conventional agricultural practices. 	<ul style="list-style-type: none"> Adoption of efficient irrigation practices. Contribute towards formation of WUAs and actively participate in its activities. Contribute towards river's rejuvenation initiatives of the government by using less water for irrigation. 	<ul style="list-style-type: none"> Help the government to achieve its targets of 20 per cent water use efficiency in irrigation.
SWaRA (U.P. State Water Resources Agency)	<ul style="list-style-type: none"> Responsible for planning of surface water resources in the State of Uttar Pradesh. Develops the policy and legal framework for water resources management in an integrated way at a river basin scale. 	<ul style="list-style-type: none"> Drafting, rationalised water allocation principles Draft revised water allocations and publicise it for seeking comments from the stakeholders. Bring in measures to curb the practice of water wastage and over-use across all sectors. Appraise the Government of UP and Irrigation Department to seek their support towards above reforms. 	<ul style="list-style-type: none"> Will become country's leading Water Resources Agency to account for E-Flows in water allocation processes at the state level.

Decision makers	<ul style="list-style-type: none"> Generally, sets the agenda for various activities and plays a vital role as they represent the masses. Their decisions are orders for the executives. 	<ul style="list-style-type: none"> Understand the steps of SWaRA, UP Irrigation Department and other organisations towards rivers rejuvenation and take informed decision in favour of the society, nature and natural resources, including rivers. Support and incentivise water use efficiency across all sectors. Decide for the implementation of E-Flows on pilot basis at downstream of the Hareoli Barrage. 	<ul style="list-style-type: none"> Political support is a must for rivers rejuvenation and implementation of these steps has the potential to get recognised at the national and international levels, as a leader in taking E-Flows initiative as part of the mission for rejuvenation of Ganga and its tributaries, including the Ramganga
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Forest Department	<ul style="list-style-type: none"> The department looks after various forest reserves, national parks and sanctuaries within the state limits. It has interest in maintaining E-Flows in the rivers, wetlands conservation etc. 	<ul style="list-style-type: none"> Can play a crucial role in monitoring of river flows and its benefits vis-à-vis aquatic species like- Dolphins, Indian Major Carps, Gharial, Otters and so on. 	<ul style="list-style-type: none"> Will become one of the pioneering departments in the country for developing the correlation between river flows and habitat viability.
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GOVERNMENT OF INDIA

Ministry of Water Resources, Ganga Rejuvenation and River Development (MoWR, GR & RD) and National Mission for Clean Ganga (MNCG)	<ul style="list-style-type: none"> Responsible for laying down policy guidelines and programmes for the development and regulation of country's water resources. Responsible for Ganga Rejuvenation. The NMCG works under this ministry, hence both these entities are critical for E-Flows work across the entire Ganga river system. 	<ul style="list-style-type: none"> The Ministry can incentivise the efforts and application of water use efficient means in irrigation, through additional financial support and packages. As part of implementation of Ganga Notification 2016 and Ganga Notification 2018, the Ministry can incentivise state's initiatives for rejuvenation of tributaries of the Ganga. The revised water allocation (taking into account the E-Flows requirements) should be provided with additional support (from the Ministry) in terms of share and quota of financial resources for water resources management. 	<ul style="list-style-type: none"> The Ministry becomes one of the rare governmental entity, at the global scale, that supports the cause of E-Flows and river rejuvenation.
Ministry of Environment, Forests and Climate Change (MoEF & CC)	<ul style="list-style-type: none"> It is the nodal agency in the administrative structure of the Central Government for the planning, promotion, co-ordination and for overseeing the implementation of India's environment and forest policies and programmes. 	<ul style="list-style-type: none"> The implementation of E-Flows will improve the health of the river and help in ensuring conducive habitat for aquatic species. Thus, the Ministry should support E-Flows implementation through additional incentives to the state entities or departments who are making all efforts towards E-Flows implementation with an aim for river's rejuvenation 	<ul style="list-style-type: none"> Become one of the leading government entity to support E-Flows in river system
Central Water Commission (CWC)	<ul style="list-style-type: none"> Data repository. Initiates, coordinates and lead project sanctions and consultations between concerned State Governments for control, conservation and utilisation of water resources; mainly for the purpose of flood control, irrigation, navigation, drinking water supply and hydropower development. 	<ul style="list-style-type: none"> CWC's support to access hydro-meteorological data was critical for the Ramganga E-Flows work. Going forward, CWC can play a key role in monitoring of flows regime and sharing the results with the concerned stakeholders. Can develop policies and guidelines for E-Flows implementation in other river systems based on Ramganga E-Flows work. 	<ul style="list-style-type: none"> Becomes the leading state-of-the-art agency to deal with water resources management in a holistic manner, taking into account the environmental and social dimensions.

An effective 'role-play' by these entities would complement the initiatives that could be taken up under earlier components, i.e., technical and social ones. There are certain avenues that have the potential to bind some of these entities and can leverage common objectives, which can lead to long-term E-Flows maintenance in the Ramganga and Ganga rivers. These include:

1. **Alignment with the Ganga Gram Programme:** The Government of India (and the National Mission for Clean Ganga) has for the first time worked out a plan to engage villages along the Ganga and its tributaries (including the Ramganga) in river rejuvenation. This programme is currently looking at waste management (solid and liquid) and to some extent water harvesting and groundwater recharge. This programme can be expanded to incorporate a sub-programme on agricultural water use efficiency, which will be the key to the attainment of *aviral dhara* (one of the missions of NMCG), i.e., continuous flows and E-Flows. Currently the geographical focus of the programme is over 1,600 villages along the main stem of the Ganga. There is a potential to expand the scope to cover UGC and LGC systems. This needs to be aligned with the national soil health card programme. Given the growing urgency to test the approaches for E-Flows demonstration, Ganga Gram offers a potential candidate to pilot and test the technical, social and institutional approaches.

2. **Full-fledged implementation of the Uttar Pradesh Participatory Irrigation Management Act:** The state government, in 2009, enacted the Uttar Pradesh Participatory Irrigation Management Act, 2009 and its rules have been framed in 2010. This Act envisages constituting of Water Users Associations (WUAs) across all the surface irrigation systems within the state. The mandate of these WUAs will be operation and maintenance (O&M) of the minor canals and gradually the vision is to transfer the tertiary level canal systems to the farmers for management. In the long run, this Act provides freedom to the WUAs to frame their regulations for the benefit of the WUA and its command area.

While the WUAs, on pilot basis, were formed within the project area of UPWSRP (Uttar Pradesh Water Sector Restructuring Project) – a World Bank Funded Irrigation Reforms project started in 2001-02. These WUAs were formed in the command of Sharda Sahayak canal system in the parts of central and eastern Uttar Pradesh. Through the Act, WUAs formation is to be further expended to the entire state, covering all the surface irrigation systems. Currently, WUA formation is going on in LGC command area.

Key Provisions of the UP PIM Act

- Water charges collection as per state water rates, 40 per cent of the collection can be kept by WUA at minor/outlet level
- Water distribution as per 'roster'
- Water budgeting at outlet level
- Efficient utilisation of water in farms
- Punitive powers for canal cutting, damage of irrigation structure, other canal offences. This needs to be reviewed to incorporate more incentives for farmers for adoption of sustainable agriculture practices leading to enhanced flows in the river. A strong component on strengthening the agricultural extension system can also be explored.

3. **Expanding the scope of the Uttar Pradesh Water Sector Restructuring Project:** There is great scope to integrate several actions on demand management and institutional strengthening into the UPWSRP.

UPWSRP

The U.P. State Government is implementing the Uttar Pradesh Water Sector Restructuring Project, encompassing the LGC command area and Bundelkhand region of UP. The project objectives are: (i) to strengthen the institutional and policy framework for integrated water resources management for the entire state, and (ii) to increase the agricultural productivity and water productivity by supporting farmers /WUAs in the Lower Ganga Canal, Sarda Sahayak Canal and Systems in Bundelkhand region. The emphasis of the project is to ensure participation of farmers through WUAs in every aspect and at every level of irrigation management. One of the focus areas of the project is to improve water use efficiency without degrading ecology and environment. This will be achieved by improving water availability and better operational control through rehabilitation and modernisation of canals catering to lakhs of hectare of irrigable land. The project has provisions for agricultural demonstrations, through which better agricultural and water management practices shall be demonstrated. The project also aims to provide support to institutions in the state which are responsible for overall water resources management and implementation of the State Water Policy. This includes strengthening the (i) independent water regulatory entity Uttar Pradesh Water Management and Regulatory Commission (ii) SWaRA, and (iii) State Water Resources Data and Analysis Centre (SWaRDAC) and (iv) WALMI.

4. Water Allocation Plans— Regional & Sector wise: The water allocation planning must take care of the right, granted to an administrative region or otherwise available to water users within the particular region. This should take into account the following aspects:

- Existing international water sharing treaties (in case of transboundary river)
- Inter-state water sharing agreements (within the country, between two or more states)
- Regional water allocation pattern
- Sectoral allocation: Current and proposed

Once regional water shares have been defined, those shares are typically allocated amongst sub-regions or users within the region. Regional water shares ultimately need to be converted into individual water abstraction rights, possibly by way of a sub-regional or sectoral allocation processes.¹⁶ The allocation process should follow the following hierarchy level in decision-making:

National State Regional Sectoral

5. Alignment with the U.P. State Action Plan for Climate Change (SAPCC): There is a huge potential to work closely with the U.P. State Environment Department to implement actions around water use efficiency and soil health improvement which would not only enhance adaptive capacity of farmers to climate change, but will also help to restore baseflows and E-Flows. SAPCC, under Jal Mission and Agriculture Mission has identified several activities sustainable water management. Some relevant activities are tabulated in Table 5.5:

Table 5.5: Some of the Key Goals of the Jal Mission and Agriculture Mission

S. No.	Recommendations of Jal Mission	Recommendations of the Mission on Sustainable Agriculture
1	Reducing gap between irrigation potential created and utilized through restoration of old projects	Use of organic manures
2	Integrated Basin Management Plan and impact of climate change	Soil management practices
3	On-farm Water Management (OFWM)	Farming system approach for diversifying incomes and livelihoods
4	Water sector restructuring project	Diversification of cropping systems and promotion of stress tolerant crop varieties
5	Completion of new and ongoing projects	Popularisation of aerobic rice cultivation methods
6	Institutional reform and capacity building	Popularisation of agro-forestry
7	Masonry check dam	Climate responsive research programmes
8	Convergence programme with the Agriculture Department, Fisheries Department, NEDA and Urban Development Department	
9	Increasing water use efficiency through lining of canals	

6. **Demonstrating E-Flows at downstream of the Hareoli Barrage:**

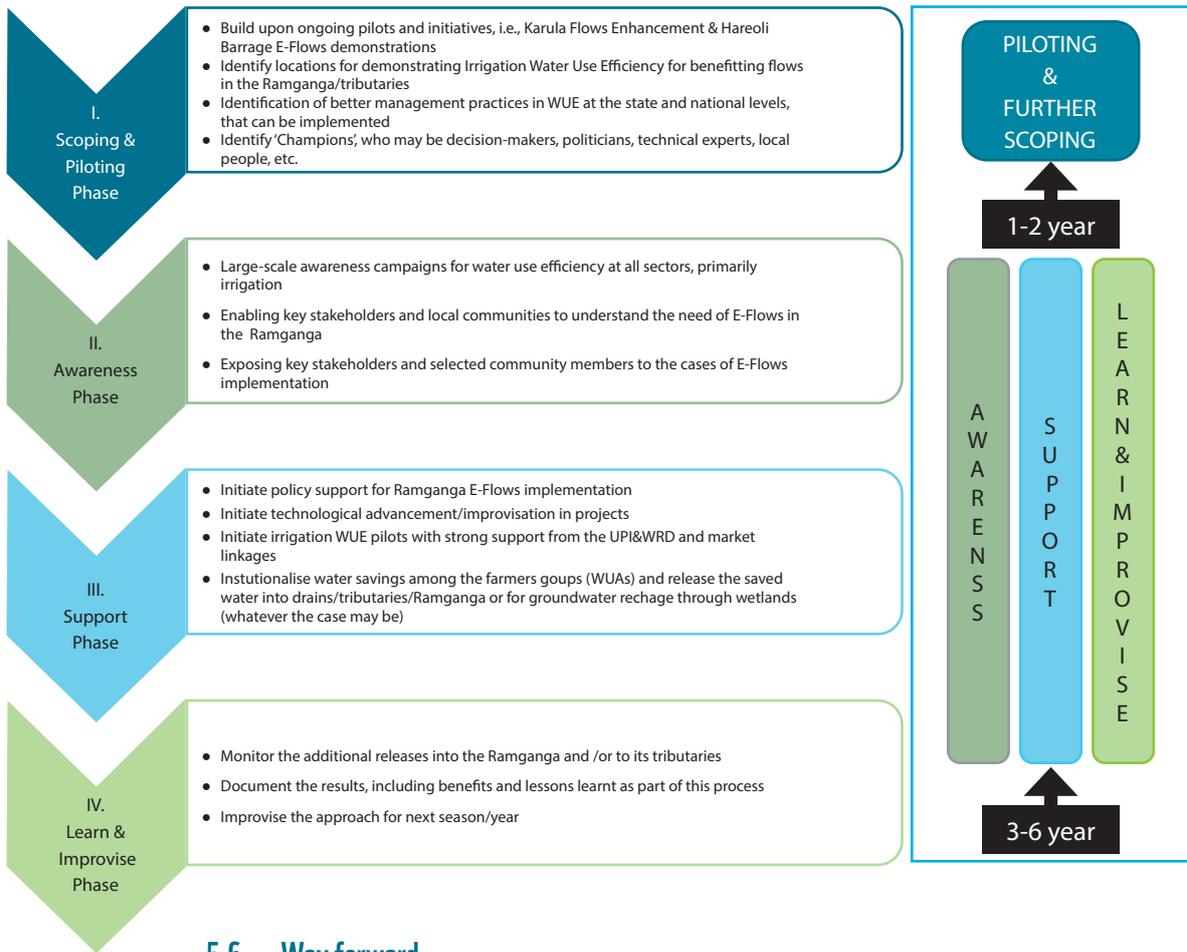
Demonstrating E-Flows at this critical location on the Ramganga would be a ‘quantum-leap’ if properly executed; it would make the State of Uttar Pradesh one of the first in the country where E-Flows are demonstrated to rejuvenate the river system. Such an initiative would invite attention and support from the State Forest Department, besides Central Ministries of Water Resources and Forests. The trade-offs analysis conducted under this work, can be a useful input to the water-managers in taking a call for rejuvenation of Ramganga River, without compromising the existing allocations. On the other hand, WWF-India would be keen to monitor and ascertain the ecosystem benefits of the Ramganga riverine system, in a scenario when the E-Flows are demonstrated in the Ramganga at the location of downstream of Hareoli Barrage.

5.5 Road map for E-Flows implementation

A roadmap for implementation of E-Flows in Ramganga is going to be a long-drawn, persuasive and complex process, however, the time has come, or rather the time is apt, to begin such an ambitious task. It has the potential to mainstream the E-Flows implementation in the public discourse of the country, which has largely been limited to E-Flows assessment, approach & methodology, standardisation of techniques and so on.

Through this work an attempt has been made to fill the existing ‘knowledge-gap’, however a phased and gradual approach is recommended for long-term implementation of E-Flows in the Ramganga. The roadmap, including steps under different stages along with the anticipated timelines is illustrated in Figure 5.8.

Figure 5.8: Roadmap for E-Flows Implementation in the Ramganga



5.6 Way forward

The E-Flows work, initiated by WWF-India in 2007-08 is now over a decade old and there has been a marked progress. The journey which started with an aim to understand the issue of flows led to assessment of E-Flows for the Upper Ganga and later on E-Flows initiative for Ganga during Kumbh 2013 at Triveni Sangam, Prayagraj, which was one step ahead of the previous exercise, as the comparative account of actual versus recommended E-Flows was drawn. This third exercise of Ramganga E-Flows moves one more step further, i.e., envisioning the demonstration of E-Flows in Ramganga, at a selected location (downstream of the Hareoli Barrage). This has been a well thought-out strategy to put on the discussion table, the case for demonstration of E-Flows, which can be a 'turning-point' in the evolution of E-Flows initiatives in the country.

Parallel to this, another activity of demonstrating the irrigation water use efficiency in selected command (of direct system taking off from Ramganga) is under progress and is expected to be accomplished by early 2020. The objective here, as noted earlier, is to strengthen the case for ensuring more water for the river. The objective of this activity is aligned with the overall goal of NCIWRDP (National Commission on Integrated Water Resources Development Plan) and that of the National Water Mission of the Government of India.

This progression of E-Flows work is aimed at mainstreaming the E-Flows in water resources development planning and execution. There has been some momentum towards this aim,

both at Central and State Government levels. The recommendations, guidelines emerging out of scientifically, and technically rigorous exercises are required to be considered by concerned authorities. This should then be implemented with a firm political will.

On the other hand, the surface-water and ground-water interaction is not adequately studied for the Ramganga. As discussed in this report, the team attempted to understand this critical interaction of surface-water and ground-water within the Ramganga basin. While it was a first short-term study, the preliminary conclusion is enlightening, i.e., over 70% of the lean season flows in the Ramganga are fed by ground-water. The other general finding was the fact that the river is 'gaining' and 'losing' at different locations. This means that, for conservation of Ramganga basin and securing long-term E-Flows throughout Ramganga, the regulation of ground-water is a must; otherwise no matter whatever quantum of flows we ensure through various interventions (including Kalagarh Dam, Hareoli Barrage and other small barrages at other tributaries), the flows in river Ramganga won't exhibit appreciable improvement. Thus, conjunctive use of water becomes critical, along with better irrigation practices (including soil health-based water and fertilizer application, so that water can be used for irrigation in a judicious manner). This way, the water usage for irrigation can be rationalised and hence saved water can be used for other purposes, including reviving flows in the river.

It is envisaged that efforts like these ones will go a long way to realize E-Flows in critical river systems, including the Ganga and Ramganga. This has been a clear-cut 'ask' of various campaigns run by the Government of India, including the 'Namami Gange' programme.

In many ways, the alignment with government programmes and schemes, as argued in this report, makes this initiative all the more relevant, hence it not only deserves due attention but also serious thoughts for implementation on ground!

*Ramganga merging
with Ganga...*



Photo Credit: Nitin Kaushal/WWF-India

Ramganga's Lament

*She rushes through gorges - this lady so pure; passing elephant, tiger and mahseer.
While she flows, she is pained, as diversions have drained her precious spirits away.*

*She trips down the ghats - this lady so pure; to reach the dusty, dry plains.
But she ripples and cries as dolphin husbands die, and turtles gasp to keep death away.*

*She is mother to millions – this lady so pure, as she moves through a swerving meander.
But with anger she seethes, and pollution chokes and strangles her lifeblood away.*

*She is covered in mud - this lady so pure; and her sisters struggle for clean water.
And no soul survives in the festering slime, and the tickle of water.....stops dead.*

*Call all the children; check all the pumps;
tell the brass makers to come.
It is now we must act, and shout out the facts,
and bang the Mitra's loud drum:*

My dolphin! My Life! My Ramganga!

DR. GLYN DAVIES

(Former Executive Director, Global Programmes, WWF-UK)

.....

ओं प्यारे भैय्या देखो कितना बदल गया है संसार,
पहले गंगा कितनी अविरल, अमृत जैसा पानी,
आज प्रदूषित जल है इतना, पीवत होवे हानि ।
न जल जीव बचे कोई जीवित, देखो नजर पसार,
ओं प्यारे भैय्या ज़रा मन में करो विचार ।

जब से लगी खाद रासायनिक, भूमि हो गयी खारी,
कीटनाशक प्रयोग करने से बढ़ रही है बिमारी ।
कोई स्वाद न रहा किसी में, हो गयी सब बेकार,
ओं प्यारे भैय्या देखो कितना बदल गया है संसार ।
गंगा माँ की देख दुर्दशा, रहे छेदालाल अकुलाई,
गंगा माँ को स्वच्छ करने की, राह सबको दिखलाई ।
पॉलीथीन पर ब्रेक लगाकर, रखो स्वच्छ जलधार,
ओं प्यारे भैय्या देखो कितना बदल गया है संसार ।

गन्दी चीजों को गंगा में न तुम कही बहाओ,
खुद भी रुको, रोको दुनिया को, और सबको समझाओ ।
स्वच्छ गंगा करो मेरे भैय्या, सफल होय संसार,
ओं प्यारे भैय्या देखो कितना बदल गया है संसार ।

रामगंगा मित्र
छेदा लाल
बरेली

सूख गयी हैं कितनी नदियाँ, सिमट गए कितने सागर,
सूख गयी कितनी बालियाँ, कितने कन न पाए जल,
लाचार वृक्ष भी यही सोचता, मुझसे छूटा मेरा धन,
सूखी डाली टुटा पत्ता विचलित होता मेरा मन ।

तारों के संग होगा चाँद होगी निशा विचरती,
प्रातः के संग होगा भान लेकर संध्या ढलती,
सभी बने ये मिलकर साक्ष्य देखें धुल ही उड़ती,
नीर खोजते होंगे प्राण, बेजान बनेगी धरती ।

खो जायेगा वो कहीं खुशियों का जो आया पल,
रह पूछती ही होंगी अब रह बताती माया धन,
हत्यारे होंगे सभी जर्जर होगा तब भूतल,
तब उठे तलवार युद्ध की जिसका राज रहेगा जल ।

रूठ गए अंधेरोँ से ओठ तब भी मैं उनसे मुस्काऊँ,
दूर हुए जो जग से लोग, उनको अभी दूँद के लाऊँ,
यक्ष करे ये प्रश्न तीसरा जिसका उत्तर न दे पाऊँ,
सूख गए जो जल के स्रोत्र उनको कैसे वापस लाऊँ ।

चमन कुमार शर्मा

References

EXECUTIVE SUMMARY

1. Central Water Commission. 2014. *Ganga Basin*. Ministry of Water Resources, Central Water Commission and National Remote Sensing Centre, New Delhi.

Chapter 1: Ramganga Basin: Background and need for Environmental Flows (E-Flows)

1. In the state of Uttarakhand, there are two rivers with the same name. The only distinction between the two rivers is that, one is called the Western-Ramganga (originating in the Chamoli district, a direct tributary of the Ganga) and other is called the Eastern-Ramganga (originating in the Pithoragarh district, which is a tributary of the Sharda river). The Rivers for Life – Life for Rivers Programme of WWF-India is based on the Western Ramganga, and will henceforth be referred to as Ramganga in the report.
2. Under this study, the length of the river was estimated to about 650 KM. To assess the correct course and length of the river, we have used latest high-resolution satellite images to track the course of the river from the source to its confluence with river Ganga. Plus the team has also done longitudinal survey (by boat) of the entire length of the river Ramganga.
3. Central Water Commission. 2014. *Ganga Basin*. Ministry of Water Resources, Central Water Commission and National Remote Sensing Centre, New Delhi. The CWC Ganga Basin report records the contribution of utilisable water resource of Ramganga to river Ganga to be 17.79BCM annually. The difference in the calculation is mainly due to two factors. First, this study excludes Garra/Deoha river as it is now a direct tributary of the Ganga, whereas the CWC report considered Deoha/Garra as part of Ramganga basin. Second, there is a likely possibility of time-frame difference for calculation of water resources, as the CWC report might have used a different time frame for the calculation, while this report uses 30 years' (1984–2013) simulated flows to calculate the average annual water availability for the Ramganga.
4. Information based on secondary source WorldPop raster based population data. This data is derived from various reliable census information from government sources like Census of India. (World Pop. "India 100m Population". <http://www.worldpop.org.uk/data/summary/?doi=10.5258/SOTON/WP00532>, accessed 31 January 2018).
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23. Lokgariwar, C., Chopra, R., Smakhtin, V., Bharati, L., and O’Keeffe, J. 2014. Including Cultural Water Requirements in Environmental Flow Assessment: An Example from the Upper Ganga River, India. *Water International* 39 (1): 81-96.
24. The LISS-IV (Linear Imaging Self-Scanning System-IV) sensor is a multispectral high-resolution camera which is capable of producing satellite images with a spatial resolution of 5.8m.
25. Demonstration Flows – basically the recommended E-Flows which are aspired to be demonstrated at identified locations.

Chapter 2: Ramganga E-Flows Assessment Process

1. Ramganga Mitras – ‘Friends of Ramganga’ – are multi-stakeholder groups based at different locations on the Ramganga. They are the people from cities and villages. They are common citizens, public representatives, government officials, representatives of industries and civil society organisation. This group is voluntarily contributing to the conservation of Ramganga through the Rivers for Life – Life for Rivers Programme.
2. Monthly data for two windows of 5 years, i.e., from 2001 to 2006 and 2009 to 2013 was shared by the CWC.
3. Home-stays: sometimes the villagers furnish part of their houses for hosting tourists/researchers/ students. These people live in these home-stays and villagers earn some money through this service.
4. A ‘valley’ is defined by the topographical break on both sides of the river. It is generally easy to define in high elevation areas but sometimes tricky in alluvial areas where the topography is subdued. Valley margins are generally much wider than the channel belt, including its active floodplain. While the channel belt and floodplains may change in a historical time scale, valley margins are geological features and they do not change at short time scales. The ‘interfluvial’ area is defined by the area between the two valleys – these are generally older floodplains, but currently not associated with any river.
5. *Aachaman* – A cultural and spiritual activity, in which while worshipping the river, some of the river water is taken onto the palm and the person drinks that water. In this activity, the water is filled in palms three times for intake and fourth time the water filled on the palm is released back into the river.’
6. According to a respondent in Moradabad, “This is Ram’s Ganga. It has come out of the Shankar’s hair locks. This has been flowing since ages. A fair is organised on the banks during the month of

Kartik when during the celebrations, people recreate Ram’s crossing of the river during his exile. The myth goes that, the boatman had stopped the boat at the Katghar temple while carrying Ram. They were coming from the forest of Kashipur. Since then the tradition is followed.”

This incidence is mimicked locally even now during the *Ram-Leela* (a theatrical show based on the life of Lord Ram, performed every year before Diwali (the festival of lights)).

7. The respondents desired the flows to be between 2-5ft at the base of the ghats. This will enable bathing. During monsoon, river water should be touching the temple floor or the top of the ghat steps. During winters, the flows should be between 5-6 feet at the base of the ghats for ritual bathing.
8. “It is Lord Ram’s river”, said a respondent. Another school of thought equates it with Parshuram (reincarnation of Lord Vishnu): “Once Parshuram was on a pilgrimage. He was thirsty and so drank the water from the river. God told him that he destroyed the Kshatriyas (one of the castes within the Hindu community), but is now drinking water brought by them. His name has since then, been associated with the river.” Another respondent stated that, “Ramganga is the younger sister of Ganga and has the same virtues.”
9. Maintenance Year – a normal year, which is neither very wet nor very dry, when all the natural ecological processes will be operational.

Chapter 3: Ramganga E-Flows Recommendations and Confidence Level

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Chapter 4: Trade-offs for E-Flows implementation

1. Probability of exceedance: Probability of exceedance is the number of times a stochastic process can exceed some critical value.
2. Annual dataset on Levels Vs Storages for start and end of filling season is compiled (UPI&WRD-1974-2015)
 - Daily Level-Storage data of Kalagarh reservoir compiled for volume/level analysis (India WRIS, GOI -1992-2015)
 - Observed non-monsoon months flows were unavailable, therefore they were extracted for same time period from SWAT hydrological modelling outputs (1974-2011)
 - Gross water availability is computed by adding carryover storage at start of filling season (15th June), reported annual withdrawal in a water year and non-monsoon month flows (Nov-May from SWAT output)
 - It was assumed that gates of reservoir are closed for filling during 15 Jun to 15 Oct and no release happens downstream.
3. Reservoir water levels and volume data from 1974-75 to 2014-15 (UPID, India WRIS)

Chapter 5: Roadmap for Restoring of E-Flows in the Ramganga

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9. Arthington et. al. 2018. "The Brisbane Declaration and Global Action Agenda on Environmental Flows".
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Annexures

All the annexures of this report can be accessed at:

wwfindia.org/eflows_ramganga

the 1990s, the number of people with a mental health problem has increased in the UK (Mental Health Act 1983, 1990).

There is a growing awareness of the need to improve the lives of people with mental health problems. The Department of Health (1999) has set out a strategy for mental health care, which includes a commitment to improve the lives of people with mental health problems. This strategy is based on the following principles:

- People with mental health problems should be treated as individuals, with their own needs and wishes.
- People with mental health problems should be given the opportunity to participate in decisions about their care and treatment.
- People with mental health problems should be given the opportunity to live in their own homes and communities.

The Department of Health (1999) also states that the following are the key objectives of the strategy:

- To reduce the number of people with mental health problems who are admitted to hospital.
- To improve the quality of care and treatment for people with mental health problems.
- To improve the lives of people with mental health problems.

The Department of Health (1999) also states that the following are the key messages of the strategy:

- People with mental health problems should be given the opportunity to live in their own homes and communities.
- People with mental health problems should be given the opportunity to participate in decisions about their care and treatment.
- People with mental health problems should be treated as individuals, with their own needs and wishes.

The Department of Health (1999) also states that the following are the key actions of the strategy:

- To improve the quality of care and treatment for people with mental health problems.
- To improve the lives of people with mental health problems.
- To reduce the number of people with mental health problems who are admitted to hospital.

The Department of Health (1999) also states that the following are the key outcomes of the strategy:

- A reduction in the number of people with mental health problems who are admitted to hospital.
- An improvement in the quality of care and treatment for people with mental health problems.
- An improvement in the lives of people with mental health problems.

The Department of Health (1999) also states that the following are the key indicators of the strategy:

- The number of people with mental health problems who are admitted to hospital.
- The quality of care and treatment for people with mental health problems.
- The lives of people with mental health problems.

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