Integrated Water Management of the Mahanadi Basin

Water Resources, Water Allocation and Inter-Sectoral Use

Abraham Samuel | K.J. Joy | Sarita Bhagat

Forum for Policy Dialogue on Water Conflicts in India

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Acknowledgement

The integrated report on water management of the Mahanadi basin is a compilation and analysis of the research done in the Mahanadi basin for the last four years, especially in the context of the three identified themes. These are water allocation and water use in the agriculture and industrial sector, environmental flows for river basin management and the rising competition and conflicts around groundwater. The report calls for a holistic integrated approach, based on the principles of Integrated Water Resources Management (IWRM) Framework and gives suggestions as how the waters of the Mahanadi, which is still in better condition, as compared to other river basins in India, can be managed in a sustainable, equitable, participative and democratic manner.

All the thematic groups have contributed their insights and findings based on the four year research on the Mahanadi basin. Special thanks to Neha Bhadbhade from the E-flow group and Siddharth Patil from the groundwater group for the timely inputs and contribution to this report. We would also like to extend our gratitude towards other theme members and key people in the water sector for their inputs, namely, Shripad Dharmadhikary, Himanshu Kulkarni, A. Latha, Sharadchandra Lele, Dinesh Kumar and Craig Dsouza. We would also like to thank Mandar Sathe for his contribution on the institutional and policy analysis in the Mahanadi basin.

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Acronyms

ADB	Asian Development Bank
AIBP	Accelerated Irrigation Benefits Programme
BALCO	Bharat Aluminium Company
BCM	Billion Cubic Meter
CEA	Central Electricity Authority
CEPI	Comprehensive Environmental Pollution Index
CGWB	Central Ground Water Board
CPCB	Central Pollution Control Board
CSE	Centre for Science and Environment
CWC	Central Water Commission
DES	Department of Economics and Statistics
DoWR	Department of Water Resources
DPR	Detailed Project Report
EFA	Environmental Flow Assessment
EFR	Environmental Flow Requirement
EWR	Environmental Water Requirement
GIS	Geographical Information System
GoI	Government of India
IRBM	Integrated River Basin Management
IWRM	Integrated Water Resources Management
LPCD	Litres per capita per day
MAF	Million Acre Feet
MCM	Million Cubic Meter

MoA	Ministry of Agriculture
MoEF	Ministry of Environment and Forests
MoWR	Ministry of Water Resources
NAS	Net Area Sown
NREGS	National Rural Employment Guarantee Scheme
NRSC	National Remote Sensing Centre
NTU	Nephelometric Turbidity Unit
OWRCP	Orissa Water Resource Consolidation Project
OWPO	Orissa Water Planning Organisation
PIM	Participatory Irrigation Management
PPP	Public Private Partnership
RBO	River Basin Organisation
SC	Scheduled Castes
SGWA	State Ground Water Authority
ST	Scheduled Tribes
SWRDP	State Water Resources Development Policy
UIP	Ultimate Irrigation Potential
UNDP	United Nations Development Programme
WAC	Water Allocation Committee
WRB	Water Resource Board
WRIS	Water Resources Information System
WUA	Water User Association

Executive Summary

As the waters of the Mahanadi basin are not yet allocated or abstracted completely, the basin provides ample scope for evolving an integrated approach for equitable, democratic and sustainable management of its resources. However rapid changes in the Mahanadi basin, especially during the last two decades, suggest that not only is the water use increasing, but new problems are emerging in the inter-sectoral allocation and also between the two major riparian states, Odisha and Chhattisgarh. Even though fewer large water infrastructure projects have been built since the 1990s, the number of smaller water resource development projects are seeing an upswing and becoming a major issue of contest as witnessed during the recent dispute between Odisha and Chhattisgarh. While the quantum of water being harvested and used is increasing rapidly, industrialisation, mining, and agricultural practices are also severely impacting the quality of water. It should be highlighted that water allocation to various sectors is not based on any clear guidelines, but determined by administration/line departments on an ad-hoc and case-to-case basis. The absence of policies and institutional mechanism at the state basin level, or the larger basin level, and those on water resource development and water allocation taking into consideration the ecological health of the river is a critical concern, even though Odisha has embarked on this process as part of the sectoral reform supported by multilateral lending agencies.

While the river shows great inter-annual fluctuations in the water flow, independent assessments have estimated reduced flow in the basin, mainly attributed to reduce precipitation in the upper and middle catchments and to land use changes in the basin. While the popular discourse highlights that most of the waters of the Mahanadi flow as waste to the Bay of Bengal, in reality the current surface water impounded is around 30 per cent of the utilisable surface water, and if we add the proposed developments it would be almost half of it. Groundwater use is also accelerating and its development is currently pegged at 37 per cent in the basin area. The water resource development and use is almost of the same extent in both the major riparian states discounting the claims made by both the states during the recent inter-state conflict over Mahanadi waters. However, it is important to note that water resource

development and allocation has not yet reached a critical stage as in the case of Cauvery, Krishna and many other rivers in the country.

There are many hotspots in the basin where the allocation to agriculture and industries is witnessing contestation and conflicts. The issues of increasing allocation of surface water resources for industries, and farmers being pushed towards groundwater use, are also being highlighted by various stakeholders. In Chhattisgarh, all the new developments are mainly to allot water for industries, especially thermal power plants, and in Odisha the farmers' movement has successfully pushed back the agenda of allocating additional water to industries. While the quality of the water is a major issue in the Chhattisgarh part of the basin, the inter-sectoral allocation is seen as a major concern in Odisha. The new barrages and anicuts to meet industrial demands in Chhattisgarh would also bring the inter-sectoral issue to the forefront in the near future. Because of increasing regulation of the flow, the environmental flow is also being altered. The environmental flow assessment of the Hasdeo sub-basin shows decreasing flow during the monsoons, while the non-monsoon flow has witnessed a marginal increase. This is affecting the quality of water as well as the livelihoods of the people. Assessment of the water quality of this basin also shows that both ground and surface water have serious problems in many locations. The analysis estimates the present water use to the tune of 40 per cent of the total utilisable water resource, of which 30 per cent is accounted for irrigation, 7 per cent by domestic and livestock usage, and 3.5 per cent by industrial usage. If we add the water for environmental needs pegged in the range of 24–30 per cent of the annual renewable yield, the overall water use would stand at 60–65 per cent.

There are critical hotspots regarding water resources and the quality and quantity of the availability and utilisation in parts of the basin and sub-basins at present, which might increase and spread across the basin in the near future due to the accelerated thrust on 'development' by both the states. The recent inter-state dispute (2016) needs to be viewed in this context. The river has not reached the state as some of the other peninsular rivers in the country, which provides opportunities for a framework for improved management. The governance needs to be anchored on a normative framework approach, with clearly articulated principles of allocation across sectors and states. It would also require enabling policies, institutional innovations, management frameworks and technological processes. The overall goal of such a governance mechanism is to ensure a democratic approach to manage the waters of the river for life and livelihood needs without compromising on the ecological

integrity of the river system. The new developments at the policy level presents opportunities, and the presence of strong civil society agencies and movements in the basin concerned with various issues around the river and its waters, be it contestation over water allocation, issues of pollution, mining and livelihoods in general opens up opportunities for pursuing a participatory, equitable and sustainable river basin management agenda.

1
Introduction

1.1 The context and background

The Forum for Policy Dialogue on Water Conflicts in India (Forum to be brief) is a network of individuals and organisations who are interested in engaging with issues of water conflicts in India. The Forum has been in existence since 2004, and has completed two phases of its work. While the focus of its engagement during the first phase has been around understanding and documenting various conflicts around water, the second phase focused, besides documentation, on resolving and preventing water conflicts. It saw efforts from the Forum to actively engage with and resolve live water conflicts in western Odisha and Kerala. The Hirakud command at the time witnessed a popular farmers' movement that opposed the increasing allocation of Hirakud water to industries at the cost of irrigation needs. With the help of local organisations and activists, the Forum tried to understand the conflict and document it while providing options on how to resolve the conflict through a participatory, transparent and democratic process of water allocation. This resulted in the publication of the report, 'Floods, fields and factories: Towards resolving conflicts around the Hirakud dam'. Also, the Forum did an extensive documentation of different types of water conflicts in Odisha, especially in the Mahanadi basin, which was published as, 'Water conflicts in Odisha: A compendium of case studies'. Currently, in the third phase, the Forum is working extensively to backstop conflicts. This is realised through a wider and integrated analysis of the linkage between resources and the conflict, and by providing knowledge- and information-based support relevant to future water conflicts. It is carried out through the close engagement and participation of local stakeholders who are part of the conflict.

In the present phase of work, the Forum decided to focus on the Mahanadi basin so that it could take forward the previous phase of work in a more in-depth manner and engage constructively with various stakeholders through the information and knowledge generated as part the excercise. In order to be more focused, three interlinked themes which have a close bearing on the water resource, its use and allocation, and the conflict situation and for which very few studies are available were selected. Thus at the basin level the work over the last four years centered around three thematic areas. These are:

1. Agriculture and industrial water allocation and use
2. Environmental flows in the context of integrated river basin management
3. Competition and conflicts around groundwater

Some of the important reasons why we chose the Mahanadi basin for focused work include: 1) it is not a closed basin and the river flows without any restrictions in many locations. Unlike some of the water stressed basins such as the Cauvery, Krishna and most of the basins in the southern peninsular and western drought prone regions, all the water in the Mahanadi basin is not allocated for different uses; 2) it is assumed that there is sufficient water available in the basin that can cater to the domestic, livelihood, socio-cultural and economic needs of the various communities within the basin as well as the needs of the river system itself (environmental needs); 3) inter-sectoral water allocation and use, especially between agriculture and industry, has been on the rise and will continue to increase because of the 'development' thrust of both the major riparian states and the growth of irrigated agriculture and extractive industries in the form of mining, and also due to a large number of thermal power plants being installed in the basin; 4) there is a vibrant civil society in both Chhattisgarh and Odisha which is alive to the issues of the Mahanadi basin; and 5) it was important to choose a basin where all the themes could work in integration and provide scope for evolving a democratic, equitable and sustainable river basin management framework.

Objectives

There is no detailed study on environmental flows, the increasing use of groundwater, and on water-related conflicts in the Mahanadi basin. The three themes identified in the basin which involved independent thematic assessment are closely linked to one another. The overall hydrology of the river is constituted of an interaction of both the surface and groundwater, as well as sectoral uses of water. Water for environment or environmental flow is influenced by all these factors such as the status of surface and groundwater as well the sectoral extraction and use of both. Water allocation for the industrial and agriculture sector is mainly based on the amount of surface water at present, but increasing use of groundwater is being observed in both these sectors on a large scale at least in certain pockets of the basin. Field observations show that drinking water needs are almost met by groundwater, while very few urban pockets are supplied with surface water from major dams. However, there is very little information in the public domain on the share of groundwater in the overall water use in the basin.

Environmental flows have not been studied adequately in the Mahanadi basin. Environmental flows are not only important from the perspective of maintaining the natural ecosystem of the river and its functionality, but are also important for the livelihood of local communities such as fishermen and river-bed cultivators who are dependent on the river. While planning the allocation of water, environmental flows and thereby the needs of these small communities often take a backseat. Of late inter-state disputes have also emerged between the two major riparian states, namely Odisha and Chhattisgarh, on water resource development and increased use in the upper riparian locations. Even though these are only emerging, they can develop into major conflicts in the future for various reasons, ranging from politics, competitive extraction, the developmental race between states, and poorly informed debates due to the absence of integrated information and data on water resource, extraction, use and so on.

Thus, it is important to conduct an integrated and interdisciplinary analysis of the Mahanadi basin that would bring to the fore the current status of the basin as well as critical issues and hotspots. The main aim of this study is to bring these different aspects together and to come up with an integrated management plan for the basin which is sustainable, equitable and democratic, besides opening up possibilities to address the various conflicts unfolding in the basin. The report presents a river basin framework examining the hydrological, institutional and governance aspects. It also brings in some of the major insights from the three themes that were investigated in detail, and draws upon them for understanding key issues in the basin. The larger objective is in tune with the main objective of the current phase: that is, to generate and provide knowledge-based support to those involved in emerging conflicts. In other words, the study aims to provide scientific public knowledge which will be helpful for various stakeholders and add to the repository of public knowledge for social change.

Methods of investigation

The study was mainly exploratory, with a focus on understanding the hydrology of the river, the issues related to surface and groundwater, its allocations for various sectors, its quantity and quality, the impact of proliferating industries on the availability of water resources and its quality, a broad estimate of water balance from available data sources, and working towards a river basin management strategy for the Mahanadi so that its fate would be better than that of some of the peninsular rivers. This is attempted through the analysis of meta-basin-level data, detailed field visits, and the use of primary and secondary data of selected locations such as the Hasdeo sub-basin, Hirakud and its influential areas, and to some extent the deltaic region.

Throughout the process the local stakeholders were actively informed, consulted and their views were built into the overall research activity as well as the outputs. Since the last phase of the Forum's work in the Mahanadi basin, there were close interactions with various agencies and individuals from both civil society organisations and the people's movement, mainly from the Odisha region, which was extended to Chhattisgarh as well during this phase. Their knowledge and understanding of the issues about the basin and strategies and options to address some of these issues were used in developing not only a preliminary understanding of the study area but also in shaping research questions and the validation of findings. The overall research followed an open-ended strategy rather than any deterministic approach building emerging issues and concerns into it. For example, assessing water quality was not a priority initially, but after realising that the issue is serious as suggested by participants in a stakeholder consultation in Chhattisgarh, this aspect was taken up. Also, during the course of the study as the inter-state disputes emerged, the research could provide factual inputs which the local activists and agencies could use in a progressive manner in comparison to the statist approach which was partisan and not supported by objective facts.

The research method is participatory, bringing both the scientific and local knowledge onto one platform for a critical understanding of the basin, with less focus on using highly sophisticated instrumentations, modelling, etc., which are in vogue for basin studies, but to some extent abstract as far as the local stakeholders are concerned. Using such a participatory method is borne by the belief that people have to own the knowledge and put it to use for change with their own understanding and analysis of possible options that such a study could suggest. In the context of the Mahanadi River, and exploring the ways and means for managing it sustainably, we believe that the local stakeholders and civil society organisations including people's movement have a critical role along with various departments and other agencies, and that the information should be utilisable for their needs.

Data, field investigation and stakeholder interactions

- A large set of secondary data at the basin, sub-basin and administrative scales pertaining to demography, land use, runoff, surface and groundwater, agriculture and cropping, irrigation and so on and also specific project level information on water resources and allocation, the reservoir release, etc. were analysed and used. Various data sources were used for this purpose.
- An exploration of available literature on the basin to understand various issues and changes, which consisted of a review of academic and grey

literature, popular media and government reports. This helped in arriving at an initial understanding of the basin, its characteristics, the changes taking place in the basin, and also issues of water use and conflicts, as well as informing and substantiating some of the arguments in this study.

- Location specific primary data were collected for each theme based on its focus of investigation. The Hasdeo river, one of the main tributaries, was studied in detail, and all thematic groups conducted a number of focused field visits in its catchment and command areas, collected various data and interacted with a number of stakeholders ranging from farmers to fisher folks, government officials, research agencies, and civil society activists. Field visits were conducted in areas impacted by the Hirakud dam, delta regions and various other points as the theme demanded.[1]
- Secondary data both at the basin and administrative scale was cross-verified using data available from different sources and through different methods. For example, there are differences in the basin area and land use details as per different sources such as the Ministry of Water Resources (MoWR), Land Use Statistics of Department of Agriculture and Cooperation, Census Information or when we use the geographical information system (GIS)/ Remote Sensing method which were all employed for analysis. Each source helped us to draw out details according to the requirement of the variable under scrutiny. Even though one can critique the reliability of some of the government data, it is the main source when it comes to macro units of analysis, and provides information on estimates, trends, shifts, etc.
- A major issue in any basin study or for that matter assessment of any hydrological unit is the problem of matching the data/information for which most of the critical variables is available at the administrative boundaries. In order to overcome this limitation, factorisation of the data with the basin area was undertaken, which is found to be the most logical solution even though there can be problems. For example, land use data is available at the district level and its percentage distribution across different land use categories was applied to the percentage area of the district falling in the basin. If a district as a whole is a part of the basin such complications are minimal, but if only a part of the district area falls in the basin, using such a method was the plausible approach.

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1. While the e-flow theme focused its field visits and work in the Hasdeo Basin for both the flow analysis and water quality assessment, the agriculture-industry theme focused on the Hasdeo river (the Minimata Bango project and its command) and the main Mahanadi river (at Hirakud and areas impacted by it). The groundwater theme conducted detailed studies in the upper catchment of the Hasdeo, the middle region near Hirakud, and the deltaic regions.

- Initially two stakeholder consultations — one in Raipur and another in Sambalpur —were conducted to share the scope of the research, receive feedback, and fine tune the objectives and expected outcomes. This was followed by a series of stakeholder consultations, which included three combined larger consultations and a number of smaller consultations by the thematic groups during their field visits. These were the platforms where the findings and progress were shared and feedback was sought. All the consultations had a large number of participants, mostly represented by civil society organisations. However, the drawback was the near absence of participation from any industries even after repeated attempts.
- A number of interns with the Forum have also studied specific issues about the river, and their observations have contributed towards fine tuning some of the findings. For example, the studies included the Kharun riverfront development in Raipur, documentation of conflicts in the Mahanadi basin, which receives only local coverage, study on the barrages in the Chhattisgarh state, water quality analysis, etc.
- There are some limitations one comes across a study such as this, which covers a large geographical and hydrological unit. One of the concerns is the dependence on secondary data for the analysis of scale and matching it with micro-level observations, by both the researchers as well as stakeholders. There was also a lack of data for certain kinds of investigations such as environmental flow at the basin level, as data was required at a much wider temporal scale and without major interventions in the river, which limited the environmental flow analysis to a sub-basin such as Hasdeo. Similarly, the data on groundwater use by the Central Ground Water Board (CGWB), which provides combined figures for the industry as well as domestic consumption, makes it difficult to estimate specific sectoral use.

1.2 Report structure

The report is divided into six sections. The first section provides an introduction to the study including the methodology of research and use of data adopted by all the thematic groups. The second section is an introduction to the Mahanadi basin drawing on secondary literature and data as well as from field observations, which portrays the basic setting of the basin. It is followed by a brief section on the policies and institutional framework that is relevant to the Mahanadi basin. The fourth section is a detailed analysis of the critical hotspots in the basin drawing on secondary literature and data, field work and observations, detailed works of various themes and consultation workshops, and individual discussions with various stakeholders. This provides an integrated understanding of the basin and the major concerns that need to be addressed.

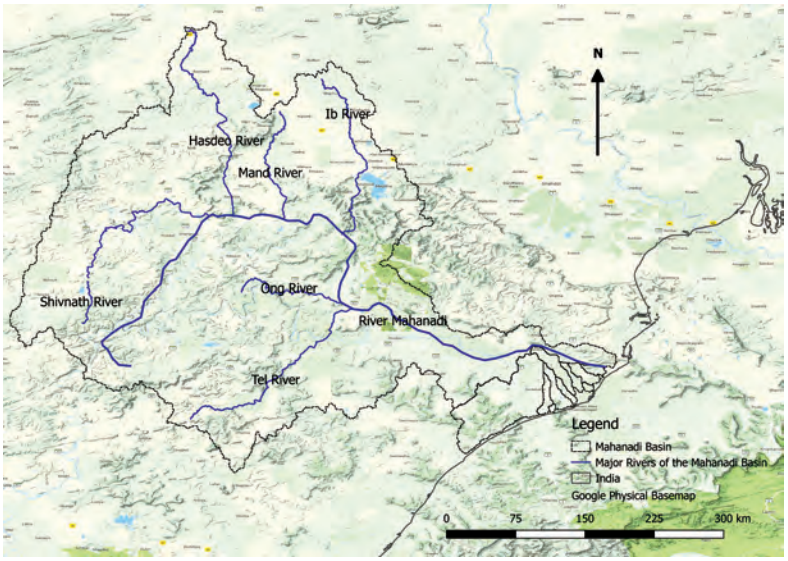
The fifth section estimates the current water use and requirement for various sectors and estimates the use in relation to water resources and availability for further development The sixth section looks into an equitable, democratic and sustainable basin management framework strategy and the options available in policy and practice with reference to Indian context in general and Mahanadi in particular. It also tries to see the possibilities and opportunities available in the Mahanadi basin through a brief subsection in the form of a way forward.

2

Mahanadi Basin - A Brief Overview

The Mahanadi river (Maha: mighty and Nadi: river), is one of the major inter-state, east flowing rivers in peninsular India which originates at 442 m above mean sea level (MSL) near Pharsiya village in the Dhamtari district of Chhattisgarh. The basin lies between the geographical coordinates of 80°30' E to 86°50'E and 19°20'N to 23°35'N. It traverses through the plains of Chhattisgarh and Odisha, and further narrows down to form a large deltaic region in Puri and Cuttack of Odisha before meeting the Bay of Bengal. The total length of the river is 851 km, of which 357 km falls in Chhattisgarh and 494 km in Odisha. On its way, it is joined by major tributaries like the Seonath (Shivnath), Hasdeo, Mand, Ib and Jonk above the Hirakud dam, whereas Ong and Tel join the Mahanadi below the Hirakud dam. Rivers Seonath, Ib and Tel together constitute 46.63 per cent of the total catchment of the Mahanadi. Some of these tributaries are witnessing rapid surface water development during the past few years. The Arpa river, which was once a perennial sub-tributary, is seeing rapid changes in the form of barrage and riverfront development and now has only seasonal flows. Similarly, Seonath was the first case in India where a large stretch of river was privatised.

Figure 1 : Physical features of the basin with major sub basins



Source: Derived from the Digital Elevation Model of the Mahanadi Basin (GTOPO) by analysis in QGIS

Table 2.1 : Basic features of Mahanadi basin

Total area	About 141,589 km^2 (73,214 km^2 in Chhattisgarh and 65,847 km^2 in Odisha, 2,528 km^2 across Jharkhand, Maharashtra and Madhya Pradesh) [1]
Length of river	851 km [1], 357 km in Chhattisgarh and 494 km in Odisha
Major tributaries	Seonath, Hasdeo, Mand, (Chhattisgarh) Ib, Ong, Tel and Jonk (Odisha) [1]
Average annual runoff	66.8 BCM [3]
Utilisable surface water	50 BCM
Potentially utilisable groundwater	13.6 BCM (natural recharge process) and 16.58 cm (including augmentation from canal irrigation) [4]
Major water resource projects	Hirakud reservoir, Minimata Bango project (Minimata Bango reservoir and Hasdeo barrage), Mahanadi reservoir complex (Ravishankar Sagar, Murrum Silli, Dudhawa reservoirs)
Population	38,660,665 [2]
Social composition	16.5% (scheduled castes), 19.2% (scheduled tribes) [2]
Employment	30% cultivators, 27% agricultural labourers, 3% industrial workers
Rainfall	1291 mm [2]
Soil	Red and yellow soils
Major crops	Rice, Gram, Khesari
Irrigation	76 projects (22 major and 54 medium), estimated 1711 Th Ha of culturable command area under major projects[2]
Major cities	Raipur, Bilaspur (Chhattisgarh); Bhubaneshwar, Cuttack (Odisha)
Major industries, Industrial zones	Thermal power, iron and steel, mining (coal and bauxite)

Sources: [1] Central Water Commission, 2011 [2] Ministry of Water Resources, 2014 [3] Central Water Commission, 2012 and [4] Gupta and Deshpande, 2004

2.1 Climate and rainfall

The Mahanadi basin falls under the sub-tropical zone, and the climate is mainly influenced by the geographical location of the catchment with respect to the Bay of Bengal. Also, the patterns of mountains of the Eastern Ghats play a significant role in the rainfall pattern (Jain, Agarwal and Singh, 2007). The average temperature in the basin varies between 24°C to 27°C, with the lowest

2. The culturable command area of Odisha's Mahanadi basin projects is uncertain because of the lack of information in the public domain.

temperature varying between 10°C to 13°C in winter. In the coastal region, the lowest temperature is around 15°C. The highest temperature is recorded in May and varies between 36°C to 43°C.

The basin receives an average annual rainfall of 1291 mm, of which about 90 per cent is received from the south-west monsoon, i.e. from June to October. However, it should be noted that districts in the delta region receive less rainfall (60-70 per cent annual average rainfall), but more rainfall during the north-east monsoon (10-22 per cent annual average rainfall), as compared to the rest of the districts in the basin. Many studies and the Forum's analysis of the 112-year rainfall data shows that except Cuttack and Kandhamal districts, a decreasing trend in the rainfall pattern is observed (Dadhwal, Aggarwal and Mishra, 2010; Ghosh et al., 2016; Forum for Policy Dialogue on Water Conflicts in India, 2017). The Jeyaseelan Committee (the High Level Technical Committee to Study Various Aspects of Water Usage for Hirakud Reservoir) notes a decreasing trend in the rainfall and its potential impact of inflow on the Hirakud (Department of Water Resources, Government of Orissa, 2016b).[3]

2.2 Geography and land use

The Mahanadi basin has a geographical area of around 142,000 km^2, of which a major portion lies in the states of Chhattisgarh (53.07 per cent) and Odisha (46.32 per cent), and a very small area in the states of Jharkhand (0.45 per cent) and Maharashtra (0.07 per cent). There are various estimates for the basin area. The Water Resources Information System (WRIS) web portal of the Central Water Commission (CWC), MoWR, notes the area to be 141,589 km^2, whereas the Mahanadi Basin Report as well as the Integrated Hydrological Data Book (2012) also published by the CWC, MoWR notes the area to be 139,681 km^2.[4]

Agriculture and forest are two main land uses in the basin. The land use statistics by the Ministry of Agriculture (MoA) report that around 37 per cent of land is forested, which has almost remained constant over the last decade and a half. The net area sown (NAS) has more or less remained the same, i.e. 54,066 km^2. However, what one notices is a reduction in the NAS over the

3. As per the report, the average annual rainfall as per the revised project report of 1953 for the Hirakud project (61 years of data based on 66 observation stations in the catchment of the Hirakud above Sambalpur) was 1369 mm while the long-term average for the post project (Hirakud) period is found to be 1142 mm resulting in less monsoon inflow to the system. The spatial variation in rainfall is also found to be significant in the post-project period as per the report.

4. Our analysis of land use data of the MoA for the basin (factorising the district level land use data for percentage area of the basin in the district) shows that the reporting area for the basin is to the tune of 146,950 km^2, of which 53.6 per cent falls in Chhattisgarh and 46.4 per cent falls in Odisha, while using the NRSC spatial data we arrive at total basin area of 143,240 km^2.

years, especially in the Odisha part of the basin. The NAS in Chhattisgarh has more or less remained constant at 41 per cent of the reporting area while showing marginal changes in some years. There is a gradual reduction in the NAS in Odisha from 38 per cent to 31 per cent from 2000-01 to 2013-14. However, data analysis by the National Remote Sensing Centre (NRSC) shows differences in land use if compared with the MoA data. Forest cover (both deciduous and degraded forest) remains more or less the same over the last decade, i.e. about 30 per cent, which could be explained as the difference in the 'administrative' enumeration of forests in the land use enumeration method, while the NRSC bases its analysis on forest cover by different sets of vegetative factors. However, the NRSC assessment of the NAS shows 48 per cent (68,719 km^2) of the total basin under category with a significant 5 per cent increase in the area sown during 2004-2014. The total cultivable area in the NRSC shows some reduction over the years in Odisha while a marginal increase is noticed in Chhattisgarh.

2.3 Water resources

The Mahanadi basin has been studied in detail by the Planning and Investigation Organisation of the CWC which prepared a report on the water balance in the Mahanadi basin in 1980, and later by the Systems Engineering unit of the CWC during 1982-87 in connection with the United Nations Development Programme (UNDP) Assisted Project on Systems Engineering for Integrated Development of Water Resources in India. The assessment study carried out by the Systems Engineering Unit was based on observed flow data available for 10-12 years, and further extended by rainfall-runoff regression analysis. This was followed by various assessments by the CWC in 1993 and 1999. There are varying estimates for the water resources of the basin.[5] The average resource potential (average annual flows) of the Mahanadi is 66.8 billion cubic meters (BCM), of which 50 BCM is the utilisable surface water (Central Water Commission, 2013 and 2016a) and 13.6 BCM is utilisable groundwater which is considered as the most reliable figure if we refer to various sources.

5. Quoting a MoWR source, Gupta and Deshpande (2004) estimate that the available surface water in the Mahanadi basin (km^3/year) as 66.9 BCM, Average Monsoon Runoff as 60.2 BCM, Estimated Utilisable Surface Water as 50 BCM, Replenishable groundwater as 16.5 BCM, and the Static Reserve of Groundwater as 119.7 BCM. The Jeyaseelan Committee Report (Department of Water Resources, Government of Orissa, 2007) estimates the Mahanadi's average resource potential at 59.16 BCM, of which 29.26 BCM is from the catchment of Chhattisgarh and 29.90 BCM from Odisha. Of the annual flows, 32.2 BCM enters as annual flows in the Hirakud reservoir. At 75% dependability, the annual flows in the basin are 43.80 BCM, and the inflow in the Hirakud is 23.5 BCM.

Table 2.2 : Water resource details of Mahanadi Basin

Catchment area (in km^2)	Water resource (in BCM)					
	Average annual runoff	Runoff @75% depend-ability	Potentially utilisable surface water	Replenishable Groundwater potential	Utilisable ground-water resource	Potentially utilisable water resource
141,581	66.88	53.79	50	21.29	13.60	63.60

Source: Central Water Commission, 1999, 2013; Amarsinghe et al., 2004

The available evidence shows that the average annual flow in the Mahanadi basin is reducing. A recent study estimates a 10 per cent reduction in annual flows in the Mahanadi river basin and also significant reduction in rainfall during the time period from 1951 to 2004 (Ghosh et al., 2016). Reducing flows were found to be 4.5 per cent in the time period 1972-2003 in the Mahanadi basin (at Mundali in the delta), which some studies have been attributing to reducing forest cover (Dadhwal, Aggarwal, & Mishra, 2010). This could also partly be explained by reduction in the precipitation in the Mahanadi river basin as a whole. While the estimated yield is based on average figures, the river shows high inter-annual variations in the runoff. The Central Water Commission (2012) notes that the flow is as low as 20 BCM in some years, while it is above 70 BCM in some other years. Thus, the water available would be significantly different on a year-to-year basis and planning and allocation needs to factor in this important variable.

2.4 Water availability

The per capita availability of water based on the 'average annual runoff' is 1826 m^3, which is expected to reduce to 1294 m^3 by 2050 (Central Water Commission, 2013, p. 33). This would be closer to the water stress condition pegged at per capita availability of 1700 m^3. If the potentially usable water resource of 63.6 BCM (50 BCM surface water + 13.6 BCM groundwater) is taken into consideration, the current per capita availability is around 1647 m^3/person. Though this looks comfortable at the moment, with the impact of climatic variations and physiographical changes in the basin the situation may not remain the same in the long run. Like many basins, ecological and environmental functions of the river, including maintaining the necessary environmental flows, would be the casualty.

Table 2.3 : Comparison of per capita availability and projections by some major basins in India

Basin	Average Annual Water Resource Potential (BCM)	Estimated per capita Average Annual Water Availability (m^3)		
		2010	2025	2050
Mahanadi	66.9	1826.37	1522.88	1294.51
Ganga	525	1061.74	885.27	752.48
Cauvery	21.4	530.49	442.24	375.90
Krishna	78.1	932.87	777.81	661.14

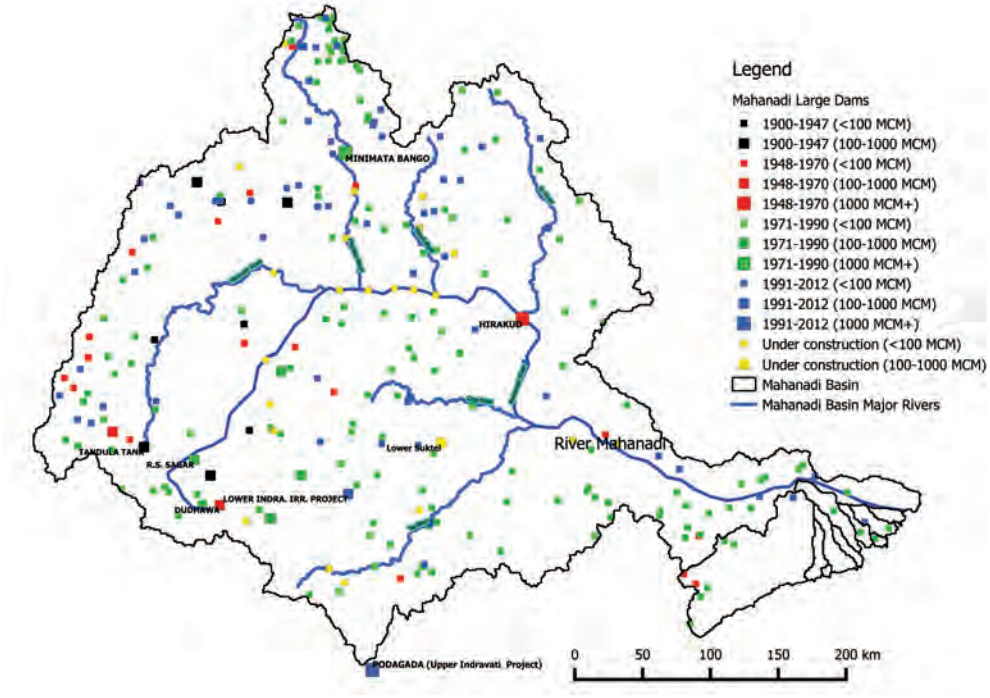
Source: Central Water Commission, 2013

2.5 Water resource development in the Mahanadi basin

The Chhattisgarh portion (or erstwhile Madhya Pradesh half) of the Mahanadi basin witnessed development of its water resources much earlier than Odisha, with several large dams (much smaller in capacity than Hirakud) being constructed in the pre-independence era. They include the Tandula Tank (1920), Murrum Silli (1923) in the hills where the Mahanadi originates, and the Maniyari (1930) and Kharang dams (1931) built on the Seonath, the major tributary of the Mahanadi. The other major projects are Hirakud, Minimata Bango, Mahanadi Reservoir Complex and many other small and medium projects. The most recent large project is the Lower Indravati dam (314 MCM). Inter-basin transfer of water, through the Upper Indravati Project, which consists of a series of dams on the Indravati River (just south of the Mahanadi Basin), supplies water for irrigation to Kalahandi district.

There are 22 major irrigation projects, 54 medium irrigation projects and 5 hydroelectric projects in the basin. The total live storage capacity in the basin is estimated at 14.244 BCM, of which 12.799 BCM is completed and 1.465 BCM is under construction (Central Water Commission, 2016a). This works out to 21.32 per cent of the average annual flow and 28.4 per cent of the 75 per cent dependable utilisable water. There is another 10.094 BCM under consideration that together makes up 36 per cent of the average flow and almost 50 per cent of the dependable flow. Of the completed storage, 52 per cent is in Odisha while the rest is in Chhattisgarh. Thus, in terms of completed storages there does not seem to be much of a variation between the two states.

Figure 2 : Large dams and major irrigation projects in the Mahanadi basin



Source: Central Water Commission, 2014, Department of Water Resources, Government of Chhattisgarh, 2015, Central Water Commission, 2016a

Altogether, the CWC lists 253 dams and 24 barrages/weirs/anicuts in the Mahanadi river basin. Of these structures, 74 are either major or medium irrigation projects, covering a potentially gross irrigable area of 32.8 Lakh Ha (15.4 Lakh Ha in Odisha and 17.4 Lakh Ha in Chhattisgarh). This is 40 per cent of the 82.3 Lakh Ha Gross Cropped Area in the river basin. Apart from reservoirs, about 3839 tanks are identified in the river basin, which help to store surface water. Tanks are an integral system in both Chhattisgarh and Odisha which not only helps in meeting irrigation needs but other non-drinking domestic needs as well.

The recent developments in surface water resources are a major point of contention among the two riparian states. The controversy is around 13 barrages and diversion weirs across the Mahanadi which includes the Arpa-Bhaisajhar Barrage Project and seven pick-up weirs under construction in Chhattisgarh. Besides these, two new projects – the Pairy-Mahanadi Intra State Link Project and the Tandula Reservoir Augmentation Scheme on Mahanadi River Project – under construction are also being questioned by Odisha. These projects are being built to provide water for industries. An assessment by the

Forum on eight new barrages and one anicut shows that the proposed annual allocation for industries is around 1258.16 MCM. These barrages will supply water to more than 45 power plants in three districts of Chhattisgarh. In the post-liberalisation era, we do not witness development of large dams but a large number of small dams, weirs, anicuts and barrages.

2.6 Agriculture and cropping

The basin is predominantly agricultural with a mix of commercial and subsistence farming systems dominated by rice cultivation. While Chhattisgarh is mainly Kharif dominated, we could witness even three seasons of paddy cultivation in the irrigated belt of Odisha. Agriculture in the Mahanadi Basin in Chhattisgarh is concentrated in the western uplands (Kawardha, Rajnandgaon, Bilaspur) and central plains (Durg, Dhamtari, Raipur, Mahasamund, Janjgir-Champa). In Odisha, agriculture is extensive in the western districts (Balangir, Bargarh, Nuapada and Subarnapur) and the coastal parts (Cuttack, Jagatsinghpur and Puri) of the state. In these regions, agriculture is supported by large-scale irrigation infrastructure, through major and medium projects. The northern and southern extremes of Chhattisgarh, as also the central regions of Odisha in the Mahanadi basin are more heavily forested and have smaller-scale rainfed farming systems.

Statistics show a gross cropped area of about 8132 Th Ha for the basin area in Odisha and Chhattisgarh (Ministry of Agriculture, Government of Orissa, 2014). The Kharif area is 6008 Th Ha while the Rabi area is 2089 Th Ha. While there is a marginal increase in the gross cropped area in the Chhattisgarh part of the basin mainly due to the increase in the Kharif area, Odisha shows a reduction in the gross cropped area of 8.5 per cent over the last two decades (Dsouza, Samuel, Bhagat and Joy, 2017). However, the percentage of NAS cultivated during the Rabi season is around 54 per cent in Odisha, while it is only 21 per cent in the Chhattisgarh part of the basin.

In Chhattisgarh, the western districts of Durg, Kawardha and Bilaspur are cropped the most in the Rabi season (about 29 per cent, 19 per cent and 16 per cent respectively of their area). In comparison, the districts in the plains such as Raipur, Mahasamund and Janjgir-Champa, which are highly irrigated in the Kharif season, receive much less irrigation in the Rabi season and hence have less than 5 per cent of their area under Rabi cropping. In Odisha, the small low-lying coastal districts of Cuttack, Jagatsinghpur and Puri have the largest proportion of their geographical area under Rabi cropping. About 60 per cent or more of their NAS is sown in the Rabi season.

2.7 Cropping pattern

Rice dominates the cereals crop group followed by pulses in the basin. Gross area cultivated under cereals in the basin area of both the states is 5257 Th Ha, which is 64.65 per cent of the gross cultivated area, while pulses occupy 1855 Th Ha (22.80 per cent) of the gross cropped area. Rice is the major crop in the Kharif season. 89 per cent (2932 Th Ha) of area sown in Kharif is under rice in Chhattisgarh, while the corresponding area under rice in Odisha is 71 per cent (1738 Th Ha). The area under rice is decreasing in Odisha. The percentage Kharif (Autumn + Winter) area under rice has fallen from 2011 Th Ha to 1833 Th Ha (67 per cent) from 1993-94 to 2013-14 in the Odisha part of the basin.

Since the year 2000, there has been little change in the gross cereals cropped area in Chhattisgarh, while it has come down marginally in Odisha during 2000-2014. However, the area under pulses has seen an upswing in the basin areas of both the states. The rest of the area is occupied by vegetables, oilseeds and few other annual crops. The area under vegetables has also fallen. The Rabi crop is dominated by pulses in both the basin states, followed by oilseeds, vegetables and cereals. While in the Chhattisgarh part of the basin pulses constitute 83 per cent of the Rabi copped area, it is 55 per cent of the Rabi area in Odisha.

2.8 Irrigation

There is no clear estimation of the extent of irrigation in the basin. Disparate and inconsistent data and methods of enumeration add to the complexity. As mentioned earlier, the irrigation data is pegged at an administrative unit in most sources, hence the difficulty in extrapolating it. An assessment on the basin-wise irrigation withdrawal by the Amarsinghe et al. (2004) estimates that the per capita irrigation withdrawal in the Mahanadi basin at 686 m^3, and the net area under irrigation as 1.85 million hectares. This works out to around 30.5 per cent of the NAS in 2001-02 as the base year. The irrigation intensity of the basin as per the study is 112 per cent, while the estimated groundwater share in irrigation is 34 per cent. Cereals consume 76 per cent of the irrigated area, while the irrigation efficiency[6] is pegged at 47 per cent.

6. There is a great deal of debate on the concept of irrigation efficiency. It is in fact true that the water lost in conveyance or application is not actually lost, but that some part of it either replenishes the groundwater or seeps into the drainage which is also used for various purposes. However, a more nuanced understanding would take into consideration various options in terms of what would be the most economical and benefit large numbers of people. The tail ender deprivation and increasing groundwater dependence in command areas would prompt for a more normative position on the issue. This report uses the term water use efficiency of large surface water measures for irrigation with the understanding that water is stored in reservoirs with the objective of being controlled, to serve the design requirements of the project. Since this is the case, knowing where all the water eventually ends up, ensures that it meets the project's design requirements and the extent to which water 'loss' actually exists that can be saved for other uses.

There are 12 major and 29 medium irrigation projects, covering a culturable command area of 1254 Th Ha and an Ultimate Irrigation Potential of 1237 Th Ha, which significantly contribute to irrigation in the Chhattisgarh part of the basin area. If we account for source wise irrigation, canal irrigation has increased to cover about 918 Th Ha (2013-14), a 43 per cent rise since 2000-01. In the same period, well irrigation has almost tripled, from 198 Th Ha to 589 Th Ha. It now makes up 36 per cent of the gross irrigated area in Chhattisgarh, whereas canal irrigation makes up 58 per cent. Thus, there is a very clear push visible towards groundwater-based irrigation on which the dependence was very low previously. Dependence on tanks and other sources is low, at about 2 and 3 per cent respectively.

Table 2.4 : Source-wise irrigation in the Mahanadi basin

	Chhattisgarh			Odisha		
Source-wise irrigated area (in Th Ha)	**2013-14**	**2000-01**	**Project-wise irrigated area (in Th Ha)[7]**	**2013-14[8]**	**2000-01[9]**	**1993-94[10,11]**
Canal Irrigation	918	641	Major Flow	759	635.5	569
Well Irrigation	589	199	Minor Flow	206	191	183
Tank Irrigation	42	45	Minor Lift	353	239.9	179
Other Sources	46	65	Other Sources	373	339.85	322
Total	**1595**	**950**	**Total**	**1691**	**1406.95**	**1253**

7. Source-wise irrigation for Odisha is not available but project-wise irrigation potential is.

8. Project-wise actual irrigated area is about 70 per cent of the irrigable potential for Odisha state, hence a similar proportion is used to estimate the actual irrigated area in the Mahanadi Basin in Odisha.

9. The values given here for 2000-01 are not actual but interpolated values since 2000-01 was an anomaly year.

10. The year 1993-94 is considered here instead of 2000-01 (as it was for Chhattisgarh), because the years from 1999-00 to 2001-02 for Odisha were anomalies where there was low cropping and irrigation.

11. The project-wise irrigable potential for 1993-94 is not available district-wise but as an aggregate figure for Odisha state. The irrigable potential for the Mahanadi Basin in Odisha is estimated as 50 per cent of the irrigable potential of the state as a whole. This proportion is based on available figures for 2013-14. To estimate the actual irrigated area in the Mahanadi Basin part of Odisha, it is calculated as 70 per cent of the irrigable potential.

	Chhattisgarh			Odisha		
Season-wise irrigated area (in Th Ha)	**2013-14**	**2000-01**	**Season-wise irrigated area (in Th Ha)**	**2013-14**	**2000-01**	**1993-94**
Kharif	1163	821	Kharif	1066	898.95	809
Rabi	191	41	Rabi	658	567.65	519
Summer	169	47				
Whole Year	74	41				
Total	1597	950	Total	1724	1466.6	1328

Source: Directorate of Economics and Statistics, Ministry of Agriculture, 2014; Statistics Cell, Ministry of Agriculture, Government of Orissa, 2015 — District-wise, season-wise, source-wise, year-wise irrigated area, Chhattisgarh and Odisha

In Odisha, sources of irrigation are classified as, 1) Major and Medium Flow projects (canal irrigation), 2) Minor Flow projects (canal/tank irrigation), 3) Minor Lift projects (well irrigation), and 4) Other Sources (private lift irrigation, shallow tube wells, WHCs, creeks, dug wells and others). Of these, the first two are equivalent to canal irrigation and the third, we assume, is groundwater irrigation. While the potential created under major and medium projects has almost doubled from 1110 Th Ha (1980-81) to 2014 Th Ha (2013-14), its proportion in the state's total irrigation potential has dropped from 66 per cent to 40 per cent. This means acceleration in other modes of irrigation, which is mainly groundwater based. The potential under minor flow projects has risen from 287 Th Ha to 682 Th Ha in the same period. Minor lift potential has risen the most rapidly from 33 Th Ha to 1059 Th Ha. It now makes up 21 per cent of the state's irrigation potential, and the contribution of Other Sources (which also is mainly groundwater) has increased from 255 Th Ha to 1249 Th Ha. While there are specific concentrated areas of surface water and groundwater use in Chhattisgarh, in case of Odisha the same areas use more groundwater where irrigation is also provided. Districts like Bargarh, Kalahandi, Cuttack, Balangir and Jagatsinghpur show an upswing in the groundwater based irrigation.

2.9 Demography and social characteristics

As per the 2011 census, the population in the basin is 38.6 million, with a decadal growth rate of 19 per cent and a population density of 271 persons/ km^2. The Scheduled Castes (SC) and Scheduled Tribes (ST) population in the basin is 16.50 per cent and 19.23 per cent respectively. In 2011, the sex ratio

in the basin was 978 females per 1000 males and the literacy rate was 65.49 per cent, with the highest literacy rate observed in Raipur, Durg and Cuttack districts. About 77.19 per cent of the population lives in rural areas, where the majority of them are dependent on agriculture for their livelihood. 30.55 per cent are cultivators, 28.53 per cent are agriculture labourers, 3.1 per cent work in industries and 38.52 per cent belong to the 'other workers' category, which includes people working in the informal and unorganised sectors (Forum for Policy Dialogue in Water Conflicts in India, 2017). There is a significant drop in the labour composition in the basin from 2001 to 2011. Cultivators and agriculture labourers have decreased from 68 per cent in 2001 to 58.38 per cent in 2011, which shows that a large section of the basin population is moving to other means of primary livelihood, mainly absorbed by 'other workers' in the informal sectors, who are self-employed and so on. A significant 4 per cent reduction in cultivators/farmers points to the rural marginalisation and decline of the agricultural economy.

3

Policies and institutions in the context of the Mahanadi Basin

Policies and laws related to water fall in the domain of states. While there are national guidelines, policies and the proposed National Water Framework Bill by the Union, the states have to formulate their own policies and institutional arrangements drawing on them. Thus, it is possible to conclude that there are no basin level policies or laws which apply to the management of rivers, but state specific policies which are fragmented as well contradictory at times, and which determine the management of river waters and basins. This often defeats the objectives of equitable, democratic and sustainable management of the rivers as a unit of governance. The Draft National Water Framework Bill (July 2016) points to the importance of the 'establishment of a River Basin Authority for each inter-state river basin, or for a sub-basin of sub inter-state river basin wherever appropriate, for optimum and sustainable development of the inter-state rivers and river valleys, with active participation and cooperation of all basin states to ensure equitable, sustainable and efficient utilisation of the water resources with emphasis on demand management through conjunctive and integrated use of resources' (Ministry of Water Resources, 2016). It also proposes the need for a River Basin Master Plan which shall remain in the public domain, and the decisions and actions on water resources of the River Basin, including implementation of water resources projects, shall progressively conform to the River Basin Master Plan. However, the critical question is the institutional structure of the River Basin Authority and how the federal characteristics are built into it — whether it would be participatory and democratic, or as in case other state initiated institutions, a top-down mechanism centred on bureaucracy and technocracy.

While Entry 17 on the State List enables executive and legislative powers to the state in the matter of water, The River Boards Act, 1956 passed under Entry 56 provides the centre the space for adjudicating 'regulation & development of inter-state rivers and river valleys to the extent to which such regulation and development under the control of the Union is declared by Parliament by law to be expedient in the public interest' (The Gazette of India, 1956). The Inter-State River Water Disputes Act, 1956 has been enacted under Article 262

(Government of India, 1956). Besides, central clearance for various projects under different related Acts also enables the Centre to deal with water resources and its development. These Acts and related laws are important in the context of the Mahanadi Basin as it is an inter-state river.

Given this policy background, an examination of the legal and institutional arrangements for management of the basin under study has to be located in the state's specific policies on the river, its water resources and use. There are state policies and institutional mechanisms to manage the water resources which include an elaborate bureaucracy and historically evolved rules and regulations in both the states, some of which even date back to the colonial period. While Odisha as a state is in existence for many years as compared to Chhattisgarh, it has a more evolved legal and policy framework whereas most of such instruments in the latter are very rudimentary and a part of its parent state, Madhya Pradesh. Recently under the Water Sectoral Reform Projects supported by the World Bank and the Asian Development Bank (ADB), both the states have undertaken reform in their water administration.

3.1 Policies and instruments for water governance in Odisha

The Water Policy of Odisha (Department of Water Resources, Government of Orissa, 2007a) prioritises water allocation in the state in the order of drinking water and domestic use; ecology; irrigation, agriculture and other related activities including fisheries; hydropower; industries including agro- based industries; navigation and other uses such as tourism.

The World Bank funded 'Orissa Water Resources Consolidation Project (OWRCP)' brought in many changes pushed by the agency. Now it has a more elaborate institutional structure under the Department of Water Resources (DoWR), which includes the Odisha Water Planning Organisation (OWPO), Water Resource Board (WRB), Water Allocation Committee (WAC), and River Basin Organisations (RBO) for planning, allocation and management of water resources at higher administrative levels, and the Water Users' Associations (WUAs – also called Pani Panchayats) at the local level entrusted with irrigation management (Department of Water Resources, Government of Orissa, 2002 and 2004).

The overall planning of water resources in the state is done by the OWPO as a nodal agency. The OWPO is responsible for the preparation and updating of macro-level multi-sectoral river basin plans of the state. The RBOs are multi-disciplinary organisations having a two-tier structure formed in the state for the purpose of planning, monitoring and overseeing all water-related activities at the river basin level (The Orissa Gazette, Resolution No. 5788/WR-Irr.-I-WB-4/06, Department of Water Resources, 26 February 2007). The WRB is the

highest authority in the state for formulating policies and principles on water development (The Orissa Gazette, Resolution No. 5788/WR-Irr.-I-WB-4/06, Department of Water Resources, 26 February 2007), and the OWPO functions as its Secretariat. As the highest body in the state for evolving policies and legal instruments for the water sector, it is run under the chairmanship of the Chief Secretary, along with Secretaries of other concerned departments as its members. However, most of the organisations at the planning and management level are techno-bureaucratic in nature and lack genuine representation and participation of various stakeholders. The RBO is formed only in the case of one river basin (Baitarani) as far as information is available.

It also has a detailed State Water Plan (Department of Water Resources, Government of Orissa, 2004) which provides a roadmap for the water resource management in the state in terms of planning, projections, issues of sectoral demand and allocation, institutional mechanisms, legal and policy provisions. A detailed analysis of the industrial water requirement at the scale of basins is one of the salient features of the water plan. However, the estimation and projections for water requirement for various sectors to some extent suffer from a lack of reliable and quality baseline data.

The legal instruments include two important legislations with respect to water resource management in the state — the Orissa Irrigation Act, 1959 (and Amendments to it in later years) and the Orissa Pani Panchayat Act, 2002. There are Rules enacted and amended from time to time for both, such as the Orissa Irrigation Rule (1961 with Amendments in 1993, 2010 and 2015) and Pani Panchayat Rules (2003, and Amendments in 2010 and 2015). Interestingly, the Amendment to the Pani Panchayat Rules brought in fisher folks within the ambit of the Pani Panchayats.

Groundwater is regulated through the Orissa Groundwater (regulation and control of development and management) Bill, 2011. The Act enables the state to constitute an authority to regulate and/or control abstraction of groundwater resources. The authority is also envisioned to become a licensing authority for granting permits for groundwater abstraction in notified areas. The act states that every groundwater user in the state is mandated to register groundwater structures with the authority, within 120 days of the formation of the authority. Similarly, drilling rigs will also have to be registered with the groundwater regulatory authority.

Even though there are many innovations in the legal and institutional mechanisms for water governance and also basin management, they suffer from poor implementation, lack of democratic decision-making, poor participation

of the stakeholders, and the governmental bureaucratic-centred administration of water management. It is also important to note that while there are agencies entrusted with the responsibility for water allocation, in the absence of transparent criteria or guidelines, it suffers from ad-hocism and secrecy.

3.2 Policies and instruments for water governance in Chhattisgarh

In comparison to Odisha, water related policies and various institutional and legal instruments are very rudimentary in Chhattisgarh. As a newly formed state, it is yet to tackle these even though it has an ambitious programme to utilise its water resources in a big way. There are no institutional innovations, while planning and projections are very rudimentary. The Chhattisgarh State Water Resources Development Policy (SWRDP) also referred to as State Water Policy (Department of Water Resources, Government of Chhattisgarh, 2012a) gives drinking water and agricultural utilisation the top priority (Clause 4.1.3). However, there is no clear prescription for the overall prioritisation amongst various competing sectors/uses. The policy suggests that the Master Plan on water resources (medium and large projects) that is yet to be developed would spell out the requirement for industry and power besides the already prioritised needs of drinking water and agriculture.

In the absence of a clear-cut water use priority, the State Water Policy states that priorities and usage of water will be decided through the State Water Resources Utilisation Committee and the district/division-level Water Utilisation Committee (Clause 5.2.2). However, the overall responsibility rests with the Water Resource Department (WRD) and the officers of the WRD such as the Chief Engineer, Superintending Engineer, Executive Engineer, Sub-Divisional Officer, Canal Deputy Collector and Sub-Engineers. Based on the demands at the project level, they make decisions regarding water allocation to the various sectors.

Both the State Water Policy and Industrial Policy emphasise the need and importance of private investments and Public Private Partnership (PPP) models for water resource development. In view of the necessity of huge investment in water resources development, the private sector investment is to be encouraged and that, “in water distribution arrangements in the industrial sector, private investment will be welcomed” (SWRDP – Sec. 4.2.2 & 4.3.3). The Industrial Policy states that “in industrial areas, for industrial projects, water supply arrangement initiatives will be made in PPP model” (Government of Chhattisgarh, 2014 – Sec. 4.1.3). Polices, Acts and Rules which were part of erstwhile Madhya Pradesh (such as the Madhya Pradesh Irrigation Act, 1931, or the Regulation of Waters Act, 1949) are in use in Chhattisgarh, especially

in relation to irrigation management. Unlike Odisha, many of the legal and institutional reforms are still in the nascent stage in the state. However, there are many new initiatives like the Chhattisgarh Participatory Irrigation Management Act and Rules, 2006, the Groundwater Regulation and Control of Development and Management Bill, 2012, etc. The Industrial Investment Promotion Act (2002) and Rules (2004) also have implications for water in the state.

The Irrigation Act and Regulation of Water Act vest entire rights related to water resources and their allocation with the state government and the respective officers as mentioned earlier. In scarcity periods, the collector has the powers to reserve the water for drinking and domestic purposes. However, these Acts remain silent about the details of inter-sectoral water allocation.

There is an attempt to introduce participatory irrigation management through the PIM Act (2002) and PIM Rules (2003). These provide legal provisions for the formation of Water Users Committees (WUAs). The objective of the farmers' organisations 'shall be to promote and secure equitable distribution of water among its users, achieve adequate maintenance of the irrigation system, efficient and economical utilisation of water to optimise agricultural production, to protect the environment, and to ensure ecological balance by involving the farmers, inculcating a sense of ownership of the irrigation system in accordance with the water budget and the operation'. However, it is to be underlined that the WUAs only exists on paper, and neither the are famers keen nor is the WRD genuinely interested in handing over the responsibilities to the farmers' organisations. Overall there are no transparent, participatory institutional mechanisms for water planning, development and allocation. For example, there are attempts to formulate Basin Master Plans through consulting agencies as in the case of Hasdeo or Seonath about which there is a lot of secrecy. It is difficult to find any information about these in the public domain, and there is no consultation with the local stakeholders while such plans are being developed.

Groundwater is regulated through the Chhattisgarh Groundwater (regulation and control of development and management) Bill, 2012. It draws on the state groundwater authority's (SGWA) Model Groundwater Bill.

Thus, we could conclude that at present there are no integrated policies or legal institutional instruments that could be put in use for the sustainable management of the basin, even though the emerging debate in the water sector points towards the need for those. As mentioned in the beginning, this is also acknowledged by the Draft National Water Framework Bill, even though the details of the legal and institutional mechanism for basin management are not

very clear. Fragmented state level policies and the near absence of even such mechanisms, in case of Chhattisgarh, coupled with a lack of a democratic and transparent mechanism would create more difficulties in evolving basin management principles. Increasing suspicion and conflicts between the two states, which is a result of the above, also adds to increasing conflicts and contestation.

4

Critical issues and hotspots in Mahanadi Basin

The Mahanadi River is witnessing fast changes during the last two decades especially after the formation of the new state of Chhattisgarh. The Mahanadi River is considered the lifeline of Chhattisgarh state and constitutes almost 55 per cent of the states' total geographical area. While the region was part of Madhya Pradesh, there were major developments in the river and its pattern has changed recently. As in the case of Chhattisgarh, the other riparian state Odisha also places equal importance on its waters for its own development. Studies also show that the river itself is undergoing changes in the precipitation in its catchment, and the water resources and their utilisation resulting from human interventions and climatic changes.[12]

While developmental aspirations are justifiable as various socio-economic indicators in the basin population are low, the path selected to achieve these puts a lot of stress on natural resources such as water and extractive mineral resources by both the riparian states and hence problematic. The thrust on privatisation, not only of the mineral resources but even of water and rivers, as we see in the case of Chhattisgarh, is going to impact the Mahanadi in a big way in the long run. At present the river looks like it has sufficient water and also has year-round flows in some stretches, but it won't take much time for it to undergo the same fate as many other rivers in the country. Hence it is important that these issues and hotspots are identified and acted upon for ushering in a strategy for its sustainable management and development.

In the present section, we highlight the main issues or hotspots which have a bearing on river management. These are interlinked issues ranging from assessment and planning of the resources to sectoral allocations including the requirement for maintaining the river's health and water quality as well as conflicts around allocation across sectors and states. However, these issues/

12. See Asokan and Dutta (2008) where the authors argue that the Mahanadi River Basin is expected to experience progressively increasing intensities of flood in September and drought in April over the considered years. For a detailed analysis of climate change impact on the Mahanadi Basin, refer Gosain, Aggarwal and Rao, 2011.

hotspots at present are not dispersed across the basin, but in various pockets where one or the other issue is becoming crucial. In the long run, there are chances that the basin as a whole will suffer from most of these problems.

4.1 Water resource estimation and planning of water resource development

There is almost a consensus that the river has around 50 BCM of utilisable surface water and 13 BCM of utilisable groundwater. As stated earlier, some estimates show a reduction in the average annual flow resulting from changing rainfall and land use patterns. However, these changes do not figure in the water planning of the basin, and discussion among the decision makers takes into consideration the static enumeration and hence there might be over assumption of the available water resource. The average availability of water fails to take into consideration the dynamics of the rainfall-land use-hydrology links and also the year-to-year variations. In the absence of a clear estimation, taking into consideration the dynamic nature of the resource leads to problematic planning and water resource development that would heavily impact the basin in the long run. If we add impacts arising from climate variations the difficulties would only amplify.

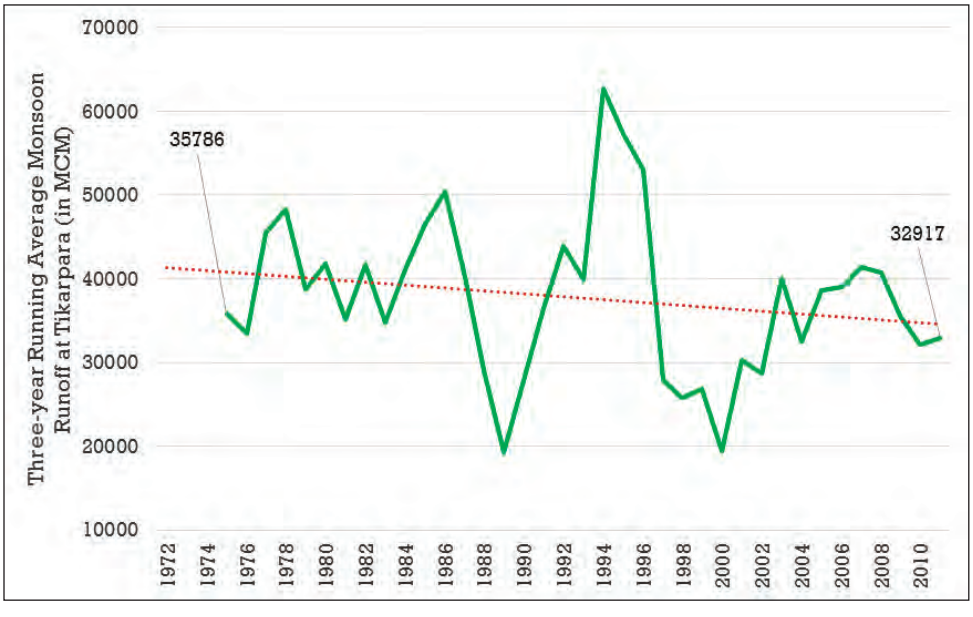
It is striking that there is no clear estimation of the water resource potential of the basin at the level of the major riparian states (Central Water Commission, 2016b). Odisha estimates 59.15 BCM as the average annual flow for the state, of which almost half (29.26 BCM) is contributed from outside the state. The utilisable surface water at 75 per cent dependable flow is pegged at 48.73 BCM, of which 47.66 per cent is estimated from outside. However, this is being contested by Chhattisgarh citing that 87 per cent of the inflow to the state near Hirakud is from its catchments, and that is has the riparian rights to use a certain amount of water for its socio-economic development.[13] The CWC data presented in the above meeting for the period 1957-2014 regarding average annual inflow to the Hirakud shows interesting results. While the average annual flow to the Hirakud has marginally decreased over the years, it shows an increasing non–monsoon inflow till the year 2000 followed by a gradual decline

13. It is interesting to note that the CWC and the respective state governments' presentations shows conflicting conclusions even on inflows into the Hirakud reservoir. While the CWC data shows marginal decrease in the average annual inflow to the Hirakud, it shows an increase in inflow till the year 2000, followed by a sharp decrease in the non-monsoon inflow (annexure to the minutes of the meeting). The reduction could be a result of various developments and changes in the land use, hydrology and water use in the upper catchments. The increase in non-monsoon inflow till the early 2000 even cited by Jeyaseelan Committee as partially an outcome of increasing water harvesting in the upstream areas by Chhattisgarh is now being refuted by Odisha referring to post-2000 data, even though Chhattisgarh is using the same to argue that the inflow has in fact increased.

from then on (Central Water Commission, 2016b, Annexure II). Our own analysis of the data (1959-2008) using the Flood Report shows a gradual decrease in the monsoon inflow, while the non-monsoon flow remains static till the mid-1980s followed by a gradual increase till the end of 1990 and then a decline till 2008 (Dsouza et al., 2017). It is interesting to note that in the same meeting, the state of Chhattisgarh has argued using the same data in a different time frame, that non-monsoon runoff has increased which is more in tune with the observations of the Jeyaseelan Committee (Department of Water Resources, Government of Orissa, 2007b, Table 9).

To examine the cumulative trend in river basin flows due to human uses, land use and climatic factors, we analysed the discharge data from Tikarpara gauging station, the station closest to the Mahanadi delta for which time series data was openly available. The result shows a very marginal decline in the long-term annual runoff. When we disaggregate this trend seasonally, we see a substantial decrease in the monsoon runoff and an increase in the non-monsoon runoff with gradual decline for the last few years.

Figure 3 : Three-year running average monsoon runoff at Tikarpara gauging station

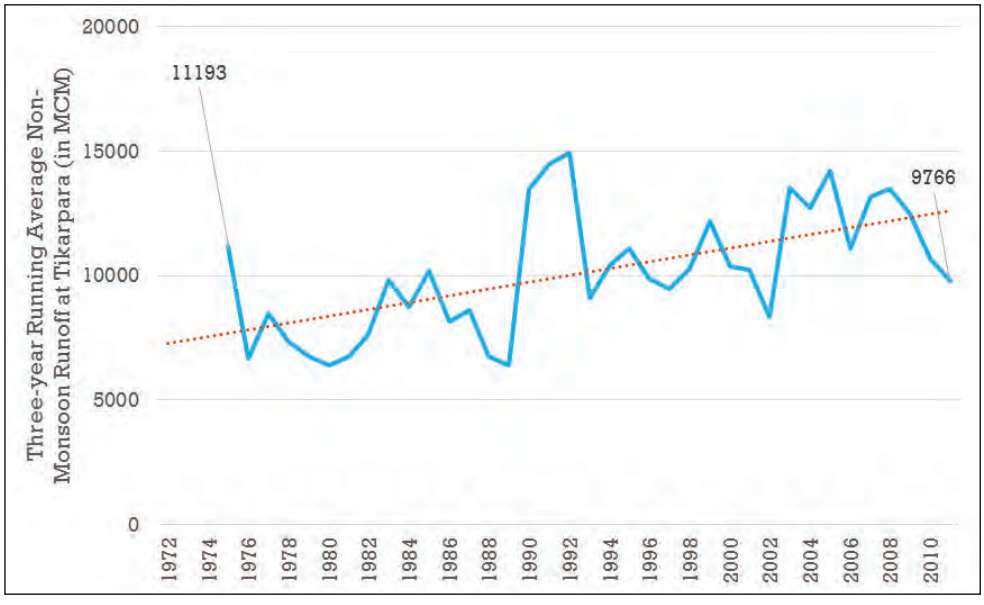


Source: Hydrological Gauge Station Data, CWC, uploaded to Water Resources Information System (Central Water Commission, 2016a)

Decreasing monsoon runoff could also be a result of upstream harvesting and use and in this context the planning of water harvesting not only in the main stem of the Mahanadi but also on its various tributaries. The stakeholder consultation has

brought out the problems most of the tributaries are facing such as Arpa and Kelo and the river front developments proposed on Arpa-Bhaisajar.

Figure 4 : Three-year running average non-monsoon runoff at Tikarpara gauging station



Source: Hydrological Gauge Station Data, CWC, uploaded to Water Resources Information System (Central Water Commission, 2016a)

4.2 New interventions

The recent developments in surface water resources are a point of contention among the two riparian states. There are a number of interventions coming up in the sub-basins in Chhattisgarh. These include several barrages (Samoda, Sheorinarayan, Basantpur, Mironi, Saradih, Kalma, Kudari and Chichpol), minor dams/anicuts/ diversion projects (Amamuda, Salka, Lachhanpur, Khongsara on Arpa and Kudurmal on Hasdeo), two major projects Kelo and Arpa-Bhaisajhar, besides the Pairy-Mahanadi Intra State Link Project and the Tandula Reservoir Augmentation Scheme on Mahanadi River Project. They are mainly to provide water for industries. An assessment by the Forum of eight new barrages and one anicut shows that the proposed annual allocation for industries is around 1258.16 MCM. These barrages will supply water to more than 45 power plants in three districts of Chhattisgarh besides providing Kharif irrigation to a small area (Goyal, 2014).

On the Odisha side, a number of projects are coming up which include the Salki Hydroelectric Project on the Salki river (a minor tributary of the Mahanadi) in

Phulbani/Boudh district, the Barmul Hydroelectric Project in Nayagarh district, the Mahanadi-Brahmani River Link Project and the Tel Integrated Project on the Tel river. The Mahanadi-Brahmani River Link Project is intended to divert the spill waters of the Hirakud reservoir to the Brahmani basin for the optimum utilisation of the available water and to moderate the floods in the Mahanadi basin, and includes the construction of the Garda Nala Dam and Tikira Barrage.

What is new in the present spurt of development in the Mahanadi River is the proliferation of small and medium structures mainly in the sub-basins and its smaller tributaries. The cumulative impact of these on the entire river needs further analysis. For example, the Arpa River, discussed by many of the participants in the stakeholder consultations, which once was a perennial river has now become a dry bed in many stretches during the summer months. Some of these projects have begun even without the statutory clearance required from the CWC, such as the Arpa-Bhaisajhar project, the second Phase of the Rajiv Samoda-Nisda major irrigation project and the Sukhanala medium irrigation project. One of the reasons for taking up smaller projects is that they do not require statutory technical and environmental clearances. Given these large developments, it is important to look into the impacts of these projects on the river flow and environmental and livelihood requirements, especially in the downstream regions.

Another crucial issue in Chhattisgarh is the role of private companies, especially the thermal power plants, in developing and using the water resources. Irrigation in these projects is not canal based, (Central Water Commission, 2016b) and pumping would be allowed in the Kharif season to some extent while the non-monsoon water would be entirely for the industries. The money for the building of barrages has been contributed by the private companies which will take water from the barrage. In case where there are multiple companies drawing water from one barrage, they will invest money in proportion to their respective water usage. The government will not pay any interest on the money given by companies for building the barrage. This money has been paid as advanced water charges by the companies for their future water consumption. The DoWR will adjust this advance money in the annual water bill of the companies. The state government is currently charging Rs. 2 per m^3 for the water withdrawn by companies directly from the river for construction purposes. The water prices will be hiked to three times once the construction of the barrage is complete. These barrages will supply water to companies during the summer, whereas in other seasons companies will withdraw water directly from the river (S. L. Yadav, Executive Engineer, Department of Water Resources, Janjgir-Champa, Personal Communication, June 19th, 2014 as referred in Goyal, 2014). This also points to the new methods of water privatisation aided by

government agencies in the name of industrialisation and development. The new development as we will see later has impacted not only the inter-state disputes on the Mahanadi water sharing but is going to become a catalyst for conflicts of inter-sectoral allocation within the state.

4.3 Environmental flow

The Brisbane Declaration (International Water Centre, 2007) describes Environmental flow (e-flow) as the quantity, quality and timing of water flow required to sustain freshwater, the estuarine ecosystem and human livelihoods that depend on these ecosystems. Currently, in India, e-flow assessment is mandatory for obtaining environmental clearance for only new hydropower projects. Since flow in most of the rivers is altered due to human intervention, the issue of e-flow becomes crucial for the rivers to maintain these functions. As seen above, there are large numbers of water resource development projects being constructed on the Mahanadi River, which can possibly change the natural flow of the river and impact its e-flow. It is obvious that such alterations have impacted the riverine ecosystems and the livelihoods of the people depending on this ecosystem. There are very few studies on the e-flow issues in the Mahanadi basin. The World Bank Environmental Department has introduced the e-flow assessment in the Mahanadi basin in the Chilika Lagoon, downstream of the Naraj Barrage. In 2002 the Environmental Flow Assessment (EFA) project could integrate key water quality concerns, particularly salinity within the lagoon, for the functioning of the lagoon ecosystem while it was not successful in influencing the operation of the barrage at Naraj to regulate the necessary flow (Sahoo, Khare, Behera, Mishra and Krishan, 2016). As part of the Forum's engagement in the basin, we tried to analyse the issues related to e-flow as a key theme and analysed in detail the Hasdeo River which is one of the important tributaries of the Mahanadi located upstream.[14]

The flow analysis of gauging data at Basantpur and Tikarpara referred above shows that there are significant alterations in the flow regime during the monsoon and non-monsoon periods since the 1960s (Figures 5 and 6). However, the absence of data prior to the period when major interventions came up in the river makes it difficult to gauge the changes over a significant period of time. The detailed analysis of the Hasdeo sub-basin shows that there are changes in the flow regime which have impacted the riverine ecosystem as well as the livelihood systems.

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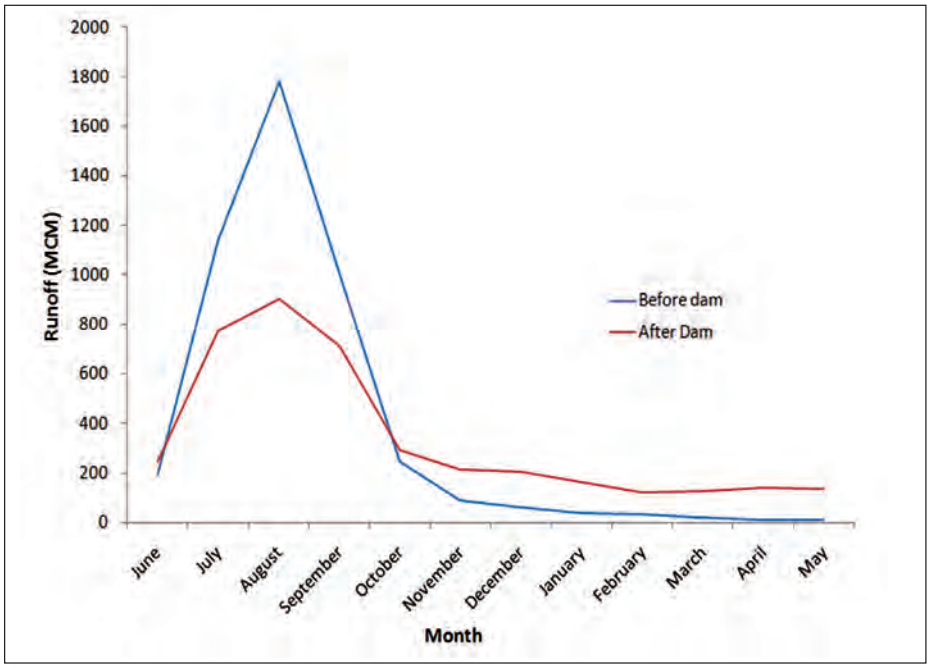
14. The e flow analysis of Hasdeo is drawn from the Forum's thematic study of the Hasdeo sub-basin and for details see Bhadbhade, Anantha and Dharmadhikary, 2017.

The Hasdeo River has a complex water impounding system: a dam-barrage system with the Minimata Bango dam located in the middle of the basin, the Tan sub-watershed, and the Hasdeo Barrage located 42 km downstream near Korba town in the Ahiran sub-watershed, where most of the water supplied from the barrage downstream is regulated flow from the dam upstream. The Tan outlet joins the river after the dam and before the barrage. Apart from the Minimata Bango dam and the Hasdeo barrage, there are four smaller anicuts that are built across the Hasdeo River and another three on the Ahiran River. For the study, two locations where gauging data was available were selected. The first site is located at the immediate downstream of the Hasdeo barrage near the Bhavani Mandir in Korba town, and the second site selected is about 50 km downstream of the Hasdeo barrage near an anicut that connects Hathnewra village (on the left bank) and Pithampur village (on the right bank). In both the villages, besides agriculture, riverbed cultivation, fishing and other livelihoods, a large number of industries are also located.

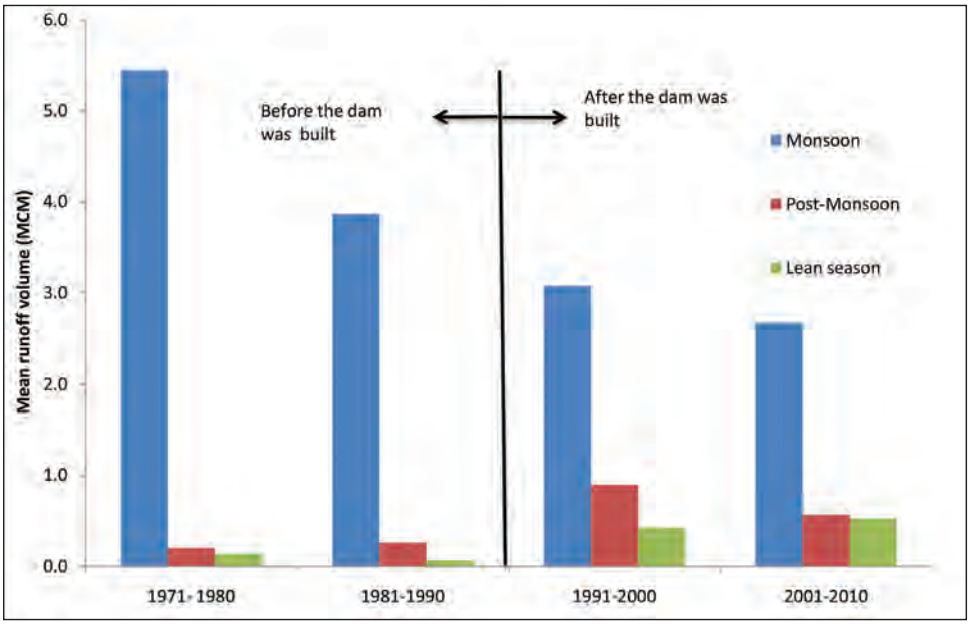
Results shows that the flow regulation from dams, barrages, anicuts and other diversion structures have caused significant changes in the seasonal flow patterns in the natural hydrograph of the streams in the Mahanadi River Basin. There is marginal increase in the flow in the non-monsoon period after the construction of the dam as compared to the pre-dam era, while the monsoon flow shows a decrease.

Figure 5 : Average monthly hydrographs at Bamnidih gauging station before and after the construction of the dam



The analysis of the gauge discharge data at Bamnidih gauging station for the Minimata Bango shows that the mean annual flows after the construction of the dam has reduced substantially. The seasonal runoff analysis shows reduction in the monsoon flows in the river and marginal increase in the non-monsoon and lean season flows as a result of the regulated flow regime.

Figure 6 : Comparison of the mean seasonal runoff before and after the construction of the Minimata Bango dam



It can be seen that the average annual runoff over each decade has decreased. This can be attributed to the increased usage (diversion) of water on the upstream. Post construction, the period of the dam has seen decrease in the monsoon flows. There has been a flattening of the seasonal flow distribution indicating that after the Minimata Bango dam was commissioned, it has been storing the monsoon flows and releasing them in the post-monsoon and lean seasons. A preliminary estimate reveals that over the period from 1971 to 2010, there has been a 38 per cent reduction in the runoff and corresponding discharge rate. However, it may seem that the regulated flow has helped in increasing the non-monsoon flow in the river. It may not have the desired impact on water resources and livelihoods. As our analysis shows, there is a large quantity of water left unreleased/unused in the Bango dam, which could be used for a more systematic release and help the water resource/flow as well as livelihood promotion. However, the overall impact on the flow and especially the need for monsoon flow for aquatic habitat and livelihoods is being compromised in the process of alteration.

The river below the Hasdeo barrage does not flow at all. The biggest impact it has created is on the migration of fish due to which fish population in the Hasdeo River is dwindling, thus impacting the livelihoods of the fishermen. It has also impacted the river bed cultivation which was practiced by landless and marginal farmers since long. Fishermen in and around the two villages, Bhavani Mandir (near the Hasdeo barrage) and Hathnewra (50 km downstream of the barrage), narrate stories of low yield, poor quality of fish as well as the long hours spent in catching fish after the completion of the dam. According to the eldest fisherman in the settlement near Bhavani Mandir, who used to fish in the river even before the Bango dam was built, they used to catch 25-30 kg of fish every day which now even in a good season has fallen to only 1 to 2 kg of fish every day. According to Dilchand Kevat, the head of the fishermen community at Hathnewra, the Government of Chhattisgarh has been promoting aquaculture and trying to curb river fishing. There are a number of fish species that have been introduced from Andhra Pradesh, which are causing the local species to disappear. At both sites that is Bhavani Mandir and Pithampur, one common thing that was observed was the complete disappearance of the Sirangi, Pacheri and Revcha fishes. These fish prefer flowing rivers as their habitat and due to loss of flows are no longer found in the Hasdeo. Besides low flow affecting the fish population, industries are releasing their effluents without treatment further affecting the habitat.

The sediment flows and the frequency of the floods have also reduced in the Hasdeo River. This has impacted the livelihoods of the riverbed/ floodplain farmers. Riverbed/ floodplain farming is an important source of income for the landless people. They use the fertile land on the banks and the beds when the flood waters of the river recede after the monsoons. Cultivation is carried out from October to January. Crops grown are mostly vegetables like cabbage, cauliflower, spring onion, tomato, cucumber, gourd, bitter gourd, brinjal and ladies finger. The farmers said that during the monsoon, the banks and flood plains would remain submerged for some days which help in sediment deposition. The low flows have reduced the cultivation area while increasing the application of groundwater, fertilizers, etc. which they otherwise never used.

4.4 Water quality and pollution

Even though water quality issues were not the focus of the study initially, they became an important concern as pointed out by the stakeholders, which prompted us to understand the issue in some detail, at least for specific locations. Mining, increasing industrialisation and growing urban population is changing the land and water scenario of the basin and adding to the problems of pollution, both water and air, as seen in some of the stretches in Chhattisgarh

and Odisha. Unlike e-flow there are many assessments on the issues of pollution, especially of water pollution in the basin (Department of Water Resources, Government of Orissa, 2004; Jena, 2008; Samantray, Mishra, Panda and Rout, 2009; Chhattisgarh Water Year Book, 2013; Panigrahi and Patra, 2013; Centre for Environmental Studies, 2014). Studies on specific locations as well as on many observation points are conducted by the CWC as well Central Pollution Control Board (CPCB). The CWC assessment shows that the critical absolute values of water quality parameters for the Mahanadi basin exceeded the tolerance limit during the winter season of 2009-10. The prominent parameters which have crossed the tolerance limits frequently are Dissolved oxygen (DO) and Biochemical Oxygen Demand (BOD) (Central Water Commission, 2012; p. 53). While studies on the Chhattisgarh part of the basin are limited, there are many assessments conducted on the Odisha part of the basin. These studies look into various issues such as pollution resulting from domestic waste, urban sewage, industrial and mining related pollution, and so on. The major findings are that the upper reaches are relatively of good quality, while in the lower areas near industries and habitations the water is polluted and needs to be cleaned before human consumption. In the lower parts of Odisha, studies find that the discharge of municipal sewage, industrial effluents and biomedical waste into the Mahanadi has raised concerns about environmental sustainability and also posed a serious threat to the health of people living on the banks. For example, the open sewage system of Sambalpur town consists of seven minor drains and three major naalas or natural water courses, which meander 10 to 22 km each inside the town collecting sewage. The major sewage outfall is through one of these – the Dhobijore. In 1999, it dumped 129.6 kilolitres per day (KLD) of sewage into the river (Jena, 2008). There are 15 large industries in the Mahanadi basin, aluminium and thermal power plants at Hirakud, charged chrome and power plant at Chowdwar, paper industry in Jagatpur and two fertiliser plants at Paradeep which discharge effluent into the Mahanadi directly.

The total industrial effluents released into the Mahanadi at Sambalpur, Cuttack and Paradeep from the larger units are 736 KLD, 2,780 KLD and 5,280 KLD, respectively (Jena, 2008, p. 90). Another study on the water quality (Panigrahi and Patra, 2013) shows increasing Hydrogen Ion Concentration (pH value) and total solids in the Mahanadi water varying from 83.625 mg/L to 309.75 mg/L. The study concludes that BOD 5-days value of the Mahanadi at study stations remains within the range 1.39 mg/L to 3.74 mg/L unaffected by the seasonal trend, and as such the river water might be suitable for domestic use. (Indian standard limit for rivers is 20.0 mg/l. But when its value exceeds 30.0 mg/l, the water becomes polluted and it shows the nature of eutrophication). The OWPO notes that the industrial pollution is mostly due to the presence of large

industries in some locations, like paper mills at Brajrajnagar and Chowdwar, fertiliser plants, i.e., Paradeep Phosphates Limited (PPL) and Oswal at Paradeep, and thermal plants along the Ib River. Besides, there is a ferrochrome factory and other industrial complexes at Chowdwar and some industrial plants in and around Sambalpur. The above industrial units release industrial pollutants into the river and cause pollutions.

4.4.1 Water quality assessment in Hasdeo Basin[15]

Given the background and the paucity of information in the Chhattisgarh part of the basin, besides the concerns raised by the stakeholders from the area, we undertook an analysis of the issues of pollution and water quality check in and around the Hasdeo Basin.[16] A total of 7 surface water samples and 5 groundwater samples were collected from the Korba and Champa regions, respectively. Unfiltered samples were preserved by adding 3 to 5 ml of concentrated 70 per cent HNO_3 (to bring down the pH <2) as preservative for testing heavy metals (Environmental Protection Agency, 2009). The assessments were carried out in the pre-monsoon (June) and post-monsoon (November) season. Of the seven sites, three showed pH values above the permissible limits of 8.5 in both pre-monsoon as well as post-monsoon periods. Fly ash can be seen flowing through the Dhengur naala throughout the year (see Annexure). This clearly reflected in the turbidity measurements of the samples collected at Dhengur naala and downstream where the Dhengur naala joined the Hasdeo. At both these locations the recorded turbidity was higher than 100 Nephelometric Turbidity Unit (NTU), which is much higher than the acceptable range of 1-5 NTU. Except for three pre-monsoon samples, all other samples in both the seasons show iron to be higher than the permissible limit of 0.3 mg/L in all the surface water samples. During the pre-monsoon season, samples collected at Bhavani Mandir had the highest levels of fluoride (in range of 1.5 to 3 mg/L) in comparison to other samples. The high presence of fluoride can be attributed to the effluent from Bharat Aluminium Company (BALCO), as aluminium plants are the major source of fluoride in surface water.

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15. This section mainly draws from the water quality analysis undertaken in few locations of the Hasdeo sub basin of Mahanadi basin.

16. Korba, the thermal power capital of India, is situated on the banks of Hasdeo and near to the barrage. Korba has been identified as the 5th critically polluted industrial cluster in India on the basis of the Comprehensive Environment Pollution Index (CEPI) computed by the Central Pollution Control Board in 2009. Based on 10 years monitoring data (2001-2010) from the Champa monitoring station, the CWC has identified contaminants in the Hasdeo to be Iron (up to 1.8 mg/L), Fluoride (2.72 mg/L), very low levels of DO (0.3 mg/L), and very high BOD (276 mg/L) (Central Water Commission, 2011). Likewise, based on the monitoring stations data from 1995 to 2012, the CPCB also identified the increasing trend of untreated industrial and domestic waste water being discharged into the Hasdeo and its tributaries. This was a major concern raised in the stakeholder interactions in the Chhattisgarh part of the basin.

Except for the sample collected from Dhengur naala, concentration of lead was well within the acceptable limit in the pre-monsoon season. However, all the surface water samples for the post-monsoon season recorded a significantly high concentration of lead as a result of the high amount of effluents being released by the industries due to the availability of water and flow in the river. Similarly, cadmium in all the surface water samples in the post-monsoon season was significantly higher than the permissible limit and was greater by an order of magnitude in comparison with the concentration measured in the pre-monsoon samples. The concentration of manganese in the pre-monsoon season was found to be higher than the acceptable limit of 0.1 mg/L at the two sites.

Groundwater is a major source for drinking in most of these areas. The pH value of groundwater samples was mostly below 6.5, the lowest being at a bore well near the NTPC ash dyke. The hardness component of the samples increased in the post-monsoon season, yet the majority fell within the permissible limit of 600 mg/L. The sample collected at site GW-1 had the highest hardness concentration of 1081 mg/L during the pre-monsoon season, which fell down to 800 mg/L in the post-monsoon season. The chloride concentrations were also above the acceptable limit of 250 mg/L in most of the groundwater samples. During the pre-monsoon season the chloride concentration was 1758 mg/L, and during the post-monsoon the concentration fell to 1152 mg/L, but both were higher than the permissible limit of 1000 mg/L. During the pre-monsoon and the post-monsoon season, the iron concentration recorded in the samples at GW-5 and GW-6 remained the same at 2 mg/L of water. This was higher than the acceptable level of 0.3 mg/L, whereas the highest iron concentration of 3 mg/L was recorded at GW-2 site which was the open well in Udiya basti. This level came down to 0.3 mg/L during the post-monsoon season.

Among the heavy metals manganese, cadmium and arsenic were detected above acceptable limits in many of the groundwater samples. Except for two locations during the pre-monsoon season, cadmium was found to be above the acceptable limit in all the other groundwater samples for both the seasons. The concentration of cadmium at the site closer to the BALCO ash pond was 4 times and 10 times higher than the acceptable limit in the pre-monsoon and post-monsoon seasons respectively. The acceptable limit of arsenic in the drinking water is 0.01 mg/L. In the absence of an alternate source of water, the limit of 0.05 mg/L is allowed. At three sites, the concentration of arsenic measured in both the seasons was much higher than the permissible limit of 0.05 mg/L.

Besides these, the mines and thermal power plants adversely impact the river and its tributaries, water resources and livelihoods. People from Basan village

narrate how the Pathaita naala once used to pass through their village and contained water throughout the year, which has disappeared due to mining activity. In Salhi village which is situated right on the outskirts of the Parsa coal block, the situation is no different. People in Salhi are fearing displacement, the groundwater is falling and coal mines pump water into the local naala. Major thermal power plants are located in Korba. They have been discharging their effluents into the river polluting it. The thermal power plants discharge their fly ash into the ash ponds located close to the plants. However, many of these ash ponds discharge this excess fly ash into the nearby streams.

Apart from discharging effluents into the river, the thermal power plants also release hot water into the river causing 'thermal pollution'. Fishermen near Bhavani Mandir below the Hasdeo barrage in an interview said that they have experienced the impact of thermal pollution where the fish they caught immediately died and began to rot. The Madhya Bharat Paper Mill in Champa used to also release its effluents into the river. According to the field interviews conducted with the local people from Pithampur, the effluents released by the mill used to turn the water completely black making it unfit for consumption, fishing and even other daily activities like bathing, washing clothes and bathing cattle.

The picture emerging is that the basin and its various tributaries are increasingly becoming polluted at many spots depending upon the concentration of mines, industries and habitations. This type of development is the thrust and will continue, and if preventive measures are not put in place the river will be under stress in the near future.

4.5 Contest and conflicts around water allocation

The Forum's engagement in the Mahanadi basin began around the issue of understanding water conflict that emerged in the Hirakud command over allocation of water for industries and agriculture. The conflicts around inter-sectoral allocation in the basin emerged mainly since the late 1990s, before which most of the conflicts in the region were around rehabilitation and issues of compensation for the project affected people, be it Hirakud, Ravishankar Sagar, Ong or the Suktel project.

With the thrust on industrial development in the 1990s and a larger number of water intensive industries emerging in the region, there was an apprehension among the famers' movement in the command that water from the dam is increasingly being diverted to industrial establishments in the areas influenced by Hirakud. The irregularities in the supply of irrigation water to the Sason canal

and its command area, the low storage in the Hirakud reservoir that affected the water supply to agriculture[17] experienced in the later part of the last decade, and also the reallocation as suggested by the Jeyaseelan Committee created the situation for farmers' mobilisation. Various other factors also played a role in the mobilisation, as seen in most of the peasant movements, mainly the issue of Minimum Support Price for paddy, the construction of new intake wells in the dead storage, and the laying of a pipe line to supply water for the industries in Hirakud,[18] as well as developments of water resources in the smaller streams for industrial needs and so on. However, the perceived threat from industries saw the largest mobilisation in the region and still is an issue of concern for famers, as there is a thrust to increase industrial allocation. While there are strong protests and mobilisation around the issue in Odisha, such mobilisation is not seen in the Chhattisgarh part of the basin, even though there are instances of more and more projects being developed for industrial consumption at the cost of domestic and agricultural needs.

In order to understand this issue, we focused on the Hirakud project in Odisha and the Minimata Bango project and other emerging works described earlier in Chhattisgarh. What the data shows with reference to Hirakud is an increase in allocation to both industries and irrigation over the years, while a downward trend is noticed on the releases for power generation, mainly since the early 2000s. The water from power plants is used downstream to irrigate large areas in the delta region (Department of Water Resources Government of Orissa, 2007b; section 5.2.3). The reduction in the water for power plants is attributed to the non-functioning of the unit in Chiplima. Whether it is a deliberate decision to supply water to industries or for technical reasons is not very clear.[19]

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17. It is interesting to note the observations of one of the leading members of the movement as narrated in the stakeholder consultation. In 2007-08 during the mobilisation of the farmers against the diversion of water to industries, when they were arguing that there was not sufficient water in the dam for such diversion, the government kept telling them that Hirakud will not face that problem as there is sufficient water. However, the government did an about-turn on the issue when the inter-state dispute emerged, saying that there is less water in Hirakud to meet the various demands of Hirakud dependent areas of Odisha.

18. The confluence of the Ib and the Mahanadi just behind the Sason canal gate has a large concentration of industries seeking to draw water from the reservoir. Several of them, including, Bhushan Steel and Vedanta, have made attempts to sink intake wells deep into the reservoir's dead storage thereby affecting water availability for irrigation and leading to the protests of 2006-07 (Centre for Science and Environment, 2007; Choudhury, Sandbhor, & Satapathy, 2012)

19. It is also important to understand the operation of the dam and the application of the 'Rule Curve' by which the dam is emptied and filled as it is also a flood control structure. There are some calculated risks as noticed by the Jeyaseelan Committee and one cannot rule out the possibility of the dam not getting filled once the filling starts from 1st September of every year. Before that the dam is brought to the dead storage level to help in its flood management functions. The Rule Curve is being revised periodically.

The data from the Flood Report (Department of Water Resources, Government of Orissa, 2014) shows that the 'Actual Area Irrigated' has achieved the maximum potential since 1967, and since then the Kharif area has maintained its maximum coverage at about 157,000 ha whereas the Rabi season coverage has continued to rise and is now 123,670 ha against the designed irrigation of 153,750 ha and 76,875 ha respectively. Whether the increase in area is a result of groundwater irrigated area getting counted or not (the problem of double counting as mentioned in the stakeholder consultation), the quantum of water released has also seen an increase. The quantum of water now released for Kharif cropping (June to October) is 1383 MCM and Rabi cropping (December to April) is 1478 MCM.[20] At present the allocation to industries (from the data obtained from the Water Services Department) is 423 MCM, which is almost equal to the industrial allocation set by the government in 1990. The current commitment of 825 MCM of water to industries as stated by the state government (Central Water Commission, 2016b) will have its impact on other sectors, if implemented. As the awareness and mobilisation of farmers in the Hirakud command is strong, they may not suffer in the immediate future, but possibly the allocation for power and the dependent delta irrigation will be impacted. The increasing thrust on groundwater irrigation in the delta to a large extent and in pockets of the command of Hirakud should be seen in this context.

In comparison to this the situation in Chhattisgarh is very different. There are many projects coming up to mainly serve water to industries. All the new projects are without any canal system, and 6 barrages (Central Water Commission, 2016b) irrigate a mere 3149 ha of area only in the Kharif season. In case of the Minimata Bango dam, the planned Net Irrigable Area is 255,000 ha (gross area for irrigation 433,500 ha). The planned agricultural water allocation for the project is 2578 MCM (1004 MCM – Kharif, 720 MCM – Rabi, 404 MCM – Summer and 450 MCM – Perennial). However, in comparison to this in the year 2013-14 the Kharif area irrigated was 122,500 ha and Rabi irrigation was provided to only 2061 ha. Data made available for the last 10 years (2004-2014) shows that for none of the years did the irrigated area touch around the 60 per cent of the planned area. While the Kharif area has reached almost 85 per cent of that planned, the Rabi area has never gone above 20 per cent of what is

20. It is important to note the data presented by the Odisha Government in the recent inter-state consultation held at MoWR. The planned utilisation is projected at 5722 MCM for irrigation and 1415 MCM for industries apart from others such as power, domestic requirement, evaporation losses, etc. The present use and commitments from Hirakud are pegged at 6308 MCM and 8179 MCM of which the irrigation commitment is 2804 MCM and the industrial commitment is 825 MCM (Minutes of the meeting annexure III). However, in 1990, the Department of Water Resources, Government of Odisha, had stated that the maximum quantity of water that can be permitted to be allocated from the Hirakud to the industries is 726.16 cusecs (0.35 MAF or 432 MCM).

being planned. This has to be seen in the context that in all these years almost half of the dam was being filled in the month of May. In the post-Rabi season, the reservoir storage level data (1995-2014) shows that in almost every year, the quantity of water left behind in the reservoir is 30 per cent or more at the end of May, while in quite a few years it is almost up to half. *This raises the question of why farmers are denied Rabi irrigation irrespective of water being sufficient*.

There are different explanations on the issue of denying water in the Rabi season when there is sufficient water in the dam. One of the common explanations is that Rabi irrigation is not planned for rice but mainly for pulses, wheat and vegetables, and as farmers are not willing to shift from paddy in Rabi, water is not given as there won't be sufficient water for paddy-based cultivation. The shift in the cropping pattern is determined by various factors, not just water, and not taking these aspects into consideration is just an excuse. Another important aspect is the irrigation practice prevalent among the farmers in the absence of proper infrastructure like field channels and methods of irrigation adopted on the farm. At present, it is field-to-field flood irrigation, and growing paddy is the most suitable for such a method. While we were also told (by the research centre in Bilaspur) that farmers generally go for a long duration rice crop in Kharif which takes an average of above 4 months to harvest (120-140 days crop), following it the land is used for grazing and not many are interested or inclined towards growing crops.

On the issue, a local farmer from Darri, feels that 'the government is not giving water for the Rabi crop and is diverting it to the industries as they offer to pay a higher price for water'. There are quite a few farmers whom we visited who support that Rabi irrigation is done through wells in the absence of Rabi irrigation supply, which shows that assured water will ensure cropping in Rabi in which famers are interested. Facilitating cultivation of less water intensive crops is altogether another issue. Many civil society activists and other actors like the media note that surplus water is released, as and when required, to fill the anicuts in the downstream, mainly serving industrial needs. However, the official data shows that industrial allocation is only 539 MCM (438.7 MCM from the dam/barrage and 99.94 MCM from various anicuts upstream of the Hasdeo dam). As against the total of 2578 MCM of water planned for the gross irrigation, our estimate shows that it would be around 1330 MCM in Kharif and very negligible in Rabi against the planned irrigation need of 720 MCM. No cultivation of summer crop or perennials is undertaken even though 854 MCM water is planned for this purpose as per the Detailed Project Report (DPR). The project officials also confirmed that there was hardly any Rabi irrigation and no summer or perennial crop irrigation in the life cycle of the project.

While there are no apparent visible conflicts around the water use due to various reasons –low agricultural development and traditional single -crop subsistence-based faming, people moving out to non-farming livelihoods through migration, and not having a platform to articulate their concerns as in the case of Odisha — what we can conclude is that farmers are denied their due share for which public money was spent.[21] This itself creates a conflict situation and going by the arguments of farmers and civil society actors, water meant for irrigation is diverted citing many excuses. The proliferation of water intensive industries, especially a large number of thermal power plants (about 37 new power projects have been proposed alone in the Janjgir-Champa district, the downstream district of the Hasdeo River) in Chhattisgarh would accelerate the conflict not only in terms of less water for other uses, but possibly also in terms of the issue of quality of water from the return flow. These kinds of incidences are more likely to emerge in Chhattisgarh in the future, as the government is seen to invest in projects solely for industries.

4.6 Increasing groundwater demand

Traditionally the basin water needs were met mainly through surface water consisting of large and small surface water structures which included a large number of ponds and tanks.[22] Groundwater use was limited to drinking water needs and irrigation in some pockets like Durg and Kendrapara. While the CGWB data available for the years 2004-09 confirms that groundwater development and abstraction is on the rise, it is not evenly spread across the basin. The western part of the basin as well as the areas in the delta and to some extent in the commands in both the states shows increasing use of groundwater. Even though the draft has not reached any critical stage, the push for groundwater based irrigation is going to be a critical issue in the future.

In case of the Chhattisgarh part of the basin, groundwater use is being pushed. Our analysis of the MoA data shows that well irrigation has almost tripled, from 198 Th Ha to 589 Th Ha during 2000-2014, since the year of state formation. It now makes up 36 per cent of the gross irrigated area in Chhattisgarh, whereas canal irrigation makes up 58 per cent, still less if we compare it with the overall share of groundwater irrigation in the country. The concentration of groundwater irrigation is prevalent in districts such as Bilaspur,

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21. The revised detailed project report specifically mentions that increasing the irrigation was one of the reasons for demanding additional funds for the project, whether it is under the support of World Bank assistance or as part of the Accelerated Irrigation Benefits Programme (AIBP).

22. These tanks are still active and in case of the Hasdeo Bango command there are one or two 'Nistar rotations' of irrigation water to fill them in the summer months to meet the non-drinking domestic needs.

Durg and Kawardha, which together constitute about 57 per cent of the gross well irrigation in Chhattisgarh. These pockets would be critical areas for groundwater related issues in the future.

In Odisha as well, the proportion of groundwater irrigation is increasing. Even though there were problems in disaggregating the source-wise data at the district level, the trend in the state is the increasing use of groundwater. The share of canal irrigation potential in the overall irrigation has come down from 66 per cent to 40 per cent (1981-2014), while the groundwater-based irrigation (known as 'minor lift' and 'other sources') has grown several folds.

The CGWB data also shows the same trend even though the data is available for the year 2009. We need to keep in mind that most of the subsidies around well-based irrigation, including well development under the National Rural Employment Guarantee Scheme (NREGS), have emerged in the last 10 years or so in Chhattisgarh and Odisha, and are pushing the groundwater use further. Except for 3 districts showing a decrease in the irrigation draft as seen in the CGWB data, most of the districts show a significant rise in groundwater abstraction for irrigation. The rise ranges between 30 and 130 per cent. The percentage change in industrial draft of groundwater, however, indicates a completely different picture. The draft has actually reduced between 2004 and 2009 in most of the districts while few districts in the emerging industrial areas show an increase in draft of up to 90 per cent.

Field observations in three areas with respect to groundwater use also show differing pictures. The lower reaches of the Hasdeo basin show higher groundwater development indicated by the larger number of dug wells and an ever-increasing proliferation of bore wells. While some of the areas are fully dependent on groundwater, the canal irrigated areas use groundwater as a buffer, as the supply is poor and Rabi water is absent. In the command of Hirakud there are specific pockets such as the tail ends and nearby areas of Sason canal and Attabira, which show an increasing use of canal irrigation. The Jeyaseelan Committee report elaborates on the potential and need for groundwater based irrigation in the command. The report notes that 'for meeting the additional demands of water, a total of 17,526 dug wells are required as assessed by the CGWB. These should be constructed in the identified command area suitably. Conjunctive use of surface and groundwater resources shall be planned to mitigate water logging and optimal use of water resources' (section 3.3.3). In the delta region, groundwater is being tapped using shallow dug wells (~5 m - 10 m depth) and bore wells. Most of the farmers are observed to be using groundwater for irrigation and cultivating paddy during the Kharif season, followed by vegetables in the Rabi season.

Throughout the basin, most of the domestic demands are met by groundwater. The drinking water supply from major projects is negligible, such as 0.004 MAF in Hirakud and 14 MCM in the Minimata Bango project. However, the conflict that could emerge, especially in Chhattisgarh, would be the recent phenomenon of more and more surface water resources catering to the need of industrial water, while farmers are being pushed to use groundwater for their farming and domestic needs. Ideally speaking good quality surface water should be the priority to meet the drinking needs.

4.7 Water use efficiency and conservation

The basin water is largely used for irrigating water intensive crops such as rice, and running water intensive industries like thermal power plants. The overall irrigation efficiency in the basin is pegged at 47 per cent (Amarsinghe et al., 2004), while there are estimates that it would be around 40 per cent (Orissa State Water Plan, 2007). A detailed field-based study of the Hirakud command spread over many years (Rout, Khanda, Panigrahy and Nayak, 2010) shows that the water loss through conveyance and field application (as it is a field-to-field wet-wet irrigation schedule) is very high resulting in considerable rise in the water table in the upper reaches of the canal system, which also leads to high water logging. Data collected over the years shows that water logging conditions in the command during pre-monsoon (May 1994) was prevalent across an area of 174 km^2, while during post-monsoon (November 1994) the corresponding area was 1494 km^2. In the past two decades, it must have increased by several folds as there are no precautionary measures. The study shows that the water table rises rapidly with the unlined canals and intensive irrigation besides the undulating topography of the command. The field results over the years show that grain yield decreased significantly with the increasing depth of the water table.

The link of water use efficiency and the resulting water loss could be debated in the context of a sub-basin/basin, in the sense that there would be less actual 'loss' as it ends up in the system either as groundwater or in the stream which is used again. However, the issue needs to be seen from other technical and normative points of view depending on the context. It can result in water logging as well as less yield in the face of more inputs. If the conveyance and application loss is reduced, more area could be brought under irrigation and the tail-end deprivation could be minimised.

Our field exploration in both the command areas show that field-to-field irrigation is resulting in excess water application as well as large areas in the command becoming water logged, especially in Hirakud where irrigation

intensity is higher. Over the years, the Hirakud irrigation use shows that even though the quantum of water supplied and also the area irrigated is continuously increasing in the command, of late the expected increase in irrigation is not keeping pace with the water released. The local institutions are by and large defunct, even though Pani Panchayats (WUAs) are formed in both the states. The policies also are not very conducive for the irrigation users to get actively involved in planning and managing water. Continuous cultivation of paddy (in seasons and over the years) also needs to be viewed critically even though it is the traditional cropping pattern in the region. In the Hasdeo command, irrigation is less water efficient mainly as a result of problems in the canal linings and application of flood irrigation. Water logging is not found to be a problem as of now but there should be crop diversification which at present is limited due to wet-wet canal scheduling as well as field-to-field flood irrigation.

Water use efficiency in industries is also a concern. Industries use water for cooling, cleaning, processing and removing wastes. Thermal power plants, the pre-dominant industry in the basin, use a large amount of water for cooling. The large percentage of water used for industry is returned to the water cycle, but with altered temperature and chemical properties (Department of Water Resources, Government of Orissa, 2004). By the estimates of the Central Electricity Authority (CEA), coal plants in India consume about 5–7 m^3/MWh in all their processes. Recently, however, plants have been designed that consume much less, up to 3.5–4 m^3/MWh (Central Electricity Authority, 2012). There are also policies that suggest new plants should use recycled wastewater. However, this could also be problematic as there are existing users of such water. As the scenario in the basin is a mix of high water consuming production system and poor efficiency, it is also important that the issue of conservation and efficient use of water becomes important. It is linked to the overall management of the water resources as well as addressing the issues of equity and sustainability of the production system.

4.8 Absence of allocation criteria

Both the states suffer from the lack of an established objective criteria and transparency in water allocation from surface water resources. The decisions are department driven and administrative in nature based on ad-hocism without any clear rule for allocation. This is evident from the fact that while there is sufficient water left in the Hasdeo Minimata Bango system in most of the years in the Rabi and summer periods, water is not allocated for Rabi irrigation. It is also obvious in the case of new exclusive structures built to cater to the needs of the industry ignoring the agriculture sector. The stakeholders hardly have any role in such decisions. Industries gets water through permissions and has many

avenues to complain if water is denied while farmers are left to the irrigation department's whims and fancies without having any avenues but to protest publicly.

4.9 The emerging issue: Inter-state dispute

During the course of the present research, serious contestations over the Mahanadi River's water emerged between the two dominant riparian states – Odisha and Chhattisgarh. In the Inter-state Council meeting held in Delhi on 16th July 2016, the Odisha Chief Minister raised the issue of Chhattisgarh apparently constructing a large number of barrages and pick-up weirs on the Mahanadi in the upstream of Hirakud, which according to the Odisha Government, would seriously affect the inflows into Hirakud. It snowballed into a major point of conflict between the two states as the Chief Minister of Chhattisgarh maintained that they are using only their rightful share and Odisha is making an issue out of political compulsions without paying sufficient attention to facts. The emotional pitching of the issue by the Odisha Chief Minister during his 2016 Independence Day address to the state brought it to the centre stage of the state's politics, with both the ruling party and opposition taking a delegation to the Prime Minister and President, respectively. Odisha also sent two separate delegations to the sites where Chhattisgarh is constructing the dams, barrages and pick-up weirs.

The controversy is around 13 barrages and diversion weirs across the Mahanadi which include the Arpa-Bhaisajhar barrage projects, seven pick-up weirs and also the Kelo Major Irrigation Project which to a large extent is completed. Two new projects – Pairy-Mahanadi Intra State Link Project and Tandula Reservoir Augmentation Scheme on Mahanadi River Project – are also being proposed by the state. Chhattisgarh claims that since most of the projects are minor ones, the Centre has no role and that in the case of all major projects they have shared the DPRs with Odisha and the Centre. Except for Kelo, most of the other projects are minor, but Odisha feels that the combined effect of all these should be considered rather than looking at them in isolation. Odisha also accuses the Chhattisgarh Government of not sharing any information on these new developments which Chhattisgarh denies.

The Centre convened a meeting of both the states on 19th July 2016. Chhattisgarh has given its consent to constitute a Joint Control Board to discuss issues related to Mahanadi and its tributaries; Odisha is yet to give its consent. The Memorandum of Agreement entered between Madhya Pradesh and Odisha on 28th April 1983, by the then Chief Ministers of both the states, envisages the establishment of a Joint Control Board 'to review the progress

from time to time of survey, investigation, planning, execution and operation of joint inter-state irrigation and or power project(s) and to discuss and resolve any issues related to the Mahanadi river'. However, the board was never established.

On a debate on the issue in Parliament on 26th July 2016, the Ministry of Water Resources, Government of India, told the house that the main problem lay in the failure to set up a Joint Control Board as envisaged by the initial agreement of 1983. Promising to initiate the process of a Joint Control Board, the minister said that the Centre would intervene to resolve genuine issues, but Chhattisgarh was free to build minor barrages (less than 2000 MCF).[23] There are also demands for the formation of a River Board to resolve the inter-state issues, and suggestions such as the formation of a National River Basin Organisation to settle such disputes. Critiques also see politics in raking up the issue now as the building of new dams, barrages and diversion weirs are going on for the last 15 years after the formation of the new state. Odisha, even though it was aware of these developments, never raised issues with its counterpart. Chhattisgarh's position is that its catchment is contributing above 80 per cent of the average inflow of the Mahanadi at Hirakud dam (35.3 BCM of 40.8 BCM inflow), while it is using only 9000 MCM of water for its various economic and human uses and is well within its riparian rights to use more water. It also argues that the major use from the newly developing structures is 'non -consumptive industrial use' which goes back into the system. However, the issue of the quality and also the quantity of return flows from the industrial use is not considered in this argument.

In the meeting held by the MoWR on 17th September, 2016, the Odisha Chief Minister desired that work on all ongoing projects should be stopped for three months while an expert committee is formed to look into various issues (Central Water Commission, 2016b). The Chief Minister of Chhattisgarh suggested that the parties should agree to form the Joint Control Board as suggested in the 1983 agreement and that stoppage of work is not feasible as most of the disputed projects are in the completion stage. However, no solutions were found and the MoWR requested both the states to resume talks and share information. The MoWR is also of the opinion that the Joint Control Board may be a first step forward (Central Water Commission, 2016b). The following decisions were taken at the meeting:

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23. Responding to the debate in the House, Minister of State for Water Resources in the centre Sanjeev Balyan said: "In the case of Arpa barrage, it is true that the technical advisory committee's approval had not come and yet the Chhattisgarh government started construction. But, I cannot order it to stop. It is beyond my jurisdiction. Both states should discuss the issues at the July 29 meeting. A tribunal will be set up if no solution is found." Odisha is accusing Chhattisgarh of unilateral decisions on upstream construction even flouting various norms and precedents (The Telegraph, 26th July 2016).

- A special committee would look into various structures that have been constructed without the approval of the Technical Advisory Committee of the MoWR
- Gauge and discharge sites at the border to measure the inflow into Hirakud
- A detailed study of water availability in the Mahanadi basin may be conducted by National Institute of Hydrology (NIH), Roorkee
- An Expert Committee (as suggested by Odisha) to be set up (even though Chhattisgarh was in favour of forming the Joint Control Board as envisaged in the 1983 agreement, they agreed to Odisha's request)

However, the civil society actors from both the states came together to address the issue through various platforms, moving away from the politicisation and sub-national sentiments that were being aroused. They felt that the need of the hour is to create a conducive atmosphere for trust building and dialogue and political processes to settle the issues.[24] Otherwise sub-national sentiments would take centre stage as is often seen in most of the inter-state water disputes and conflicts. There should be transparency in planning and development of water resources by the respective states as seen in the 1980s. This should be followed by basin level strategies with appropriate institutional structures and mechanisms that take into consideration the water resource availability, water resource development, current use and future needs including the environmental needs based on available data and robust and reliable data collected from time to time. The water availability and issues need to be re-calibrated from time to time as long-term averages may not hold true anymore. The political will of the riparian states as well as the objective approach of the Centre also become crucial in this context. We see that establishment of tribunals or the interference of the Centre could not resolve the issues in the cases of the Cauvery, Krishna, Yamuna and Sutlej. A broad-based river basin organisation with active stakeholder participation is the need of the hour. The Mahanadi still has sufficient water to meet the genuine needs of people of both the states who depend on it for their livelihoods and domestic needs.

24. In one of the larger stakeholder consultations where civil society actors and organisations from both the states were present in large numbers, a Joint Press Statement was issued on the emerging concerns and also steps for resolving some of the immediate problems keeping in mind the importance of the river for the people of both the states.

5

Water use trends, estimates and projections

A large number of studies and estimations are available on water use and its projections at various administrative levels such as the national and state level. However, basin level assessments are few and far between. The water uses and water balance assessment of the Mahanadi basin was first carried out by the Planning and Investigation Organisation of the CWC in 1980. The reassessments carried out by the CWC in 1993 and 1999 did not take up five basins of which Mahanadi was one as it felt that the earlier assessments had sufficient reliability. However large changes have happened in the basin in the intervening years and a dynamic and comprehensive assessment is not available on the basin water use and water balance in recent years. A basin level assessment carried out by Amarsinghe et al. (2004) looks into the water resource potential, withdrawals and water accounting at the basin scale and its implication on water scarcity and food production. The analysis categorises Mahanadi basin as a 'non-water-scarce, food-surplus basin'. Three basins — the basin of the easterly flowing rivers between Mahanadi and Pennar, and those of the Brahmani–Baitarani and Mahanadi — are in this group. The assessment suggests that the water-scarcity issues in these basins are not serious, and that the water resources of basins in this group could be further tapped to increase food production (p.16). The study mainly uses data on or before 2002. There are no latest estimations available in the public domain on the basin besides a few assessments in the context of climate change and impacts on water availability and requirements mainly using climate change prediction models mentioned in the earlier section. In this section, we attempt to estimate sectoral water use in the basin based on various available data as well as using the units of estimation available in the literature for certain sectors.

Before getting into this matter, it is important to articulate the potentially utilisable water resource estimation of the basin as it has an impact on the water balance estimation. As we have seen, the accepted utilisable potential of the basin is estimated to be 63.6 BCM (50 BCM of utilisable surface water and 13.6 BCM of utilisable groundwater). The total renewable water resource or

average annual surface runoff is estimated at 66.9 BCM. Thus, the percentage of utilisable water to the renewable water resource is almost 95 per cent, a very high figure. Evapo-transpiration is factored into the calculation of utilisable water and at the all-India level for all the basins together. The evapo-transpiration from the precipitation works out to almost 40 per cent[25] but with high inter-basin regional variations (Gupta and Deshpande, 2004; Planning Commission, 2007). Thus, the high ratio of the utilisable water to renewable water in the basin means that there is very less loss (use) for natural evapo-transpiration and un-utilisable surface runoff. If we factor in the all-India average figure of 40 per cent as the evapo-transpiration rate used in the hydrological process, the water resource in the basin would be much less than from the current figure which would greatly impact the overall assessment. However, it looks like most of the estimations do not take into consideration the return flow.[26] In the absence of the basis of the estimation in the public domain, we could not establish the reasons behind such low levels of evapo-transpiration factored for Mahanadi basin.[27]

5.1 Water for domestic needs and livestock

There are a large number of water use estimations and projections in the country for all major needs, and domestic and livestock needs are not an exception. There are also estimations on the per capita water requirement for domestic and livestock needs.[28] Like many estimations, we do not make any distinction between the urban and rural populace. Based on estimations and the field experience, we assume that the combined current domestic needs are in the range of 80-100 litres per capita per day (LPCD) (we assume them to be 100 LPCD) and 150 LPCD by the year 2050. The livestock requirement is estimated to be 30 litres/day/unit. The projected figure for livestock remains

25. Academics like T N Narasimhan estimates India's evapo-transpiration to be as high as 67.5% (Narasimhan, 2008 as cited in Narasimhan and Gaur, 2009). If this is true then the water available would be much less.

26. Gupta and Deshpande drawing on MoWR reach the figure of 16.5 BCM (as against 13.6 BCM of utilisable groundwater) of replenishable groundwater, including augmentation from canal irrigation.

27. Most of the data that estimates the water resource still depend on the 1993 assessment and its revision in 1999 (Central Water Commission, 1999). Mahanadi along with four other basins was excluded from analysis as the report uses the estimation of water balance done earlier in the basin which fails to give the details on methodology. The details of the previous assessment are not available in the public domain at present.

28. Two instances are cited: the NCIWRD estimates 220 (class I cities), 150 (class II-IV cities), and 55 (rural) LPCD in 2010, which increases to 220 for all urban and 150 for rural by the 2050 projection. Bovine requirement is estimated at 18-30 LPCD (Central Water Commission, 1999). IWMI reviewing many estimations arrives at an average domestic water demand of 85 LPCD in 2000, and 125 and 170 LPCD by 2025 and 2050, respectively. Bovine estimation is 25 LPCD (Amarasinghe, Shah and Anand, 2007).

the same as one does not see much change in the composition of the livestock. The basin population as per the 2011 census works out to be 38.66 million and the livestock population is 17.77 million as per the livestock census (2012). The decadal population growth in the basin (2001-2011) is 19 per cent (24.2 per cent in Chhattisgarh and 14.2 per cent in Odisha), which is likely to remain around that with a marginal decrease by the year 2050. However, the overall livestock population has come down in the basin as compared to the 2007 census, with an increase in Chhattisgarh and decrease in Odisha. In all likelihood, the livestock population would not see any increase as the data over the years suggest, due to various reasons including policy changes.

For the present population at 100 LPCD basis, the total domestic water requirement would be around **3867 MCM (3.87 BCM),** while for the livestock population it would work out to be **533 MCM (0.533 BCM),** together accounting for 4.40 BCM. At present, almost 70 per cent of the needs are met from groundwater, with local tanks and ponds supporting the need partially. If we assume an average decadal population growth of 17 per cent (as compared to the range of 19 per cent during the past couple of decades), by 2051 the population would almost double (72.45 million) and thereby the domestic water requirement would likely be more than double. The requirement would be around 10.87 BCM at 150 LPCD as most projections suggest for 2050. The livestock requirement would remain more or less the same, and the total projection for domestic and livestock needs would be 11.40 BCM by 2050. This would be around 18 per cent of the utilisable water resource estimated at 63.6 BCM.

5.2 Irrigation water

Most of the water in the basin is used for irrigation. The gross irrigated area in the basin as per our estimate and referred earlier is around 3321 Th Ha.[29] Of this, approximately 2134 Th Ha (64 per cent) is irrigated by surface water and the remaining by groundwater sources. Chhattisgarh irrigates about 1596 Th Ha annually. About 983 Th Ha (61 per cent) of its gross irrigated area is irrigated by surface water sources (including canals and tanks and 50 per cent of what is categorised as Other Sources). Odisha on the other hand irrigates about 1724 Th Ha annually. 1151 Th Ha or 66 per cent of its gross irrigated area is irrigated by surface water sources (including major and minor flow projects and 50 per cent of *Other Sources*). The total estimated annual surface water use for irrigation amounts to 5.481 BCM in the Chhattisgarh part of the basin, with the

29. Based on 2002 (MoWR) data, Amarsinghe, Shah and Anand (2007) estimate the net irrigated area in the basin to be 1.85 million ha with an irrigation intensity of 112, where the share of groundwater is pegged at 34 % of the net irrigated area.

bulk of the water being used in the Kharif season. This value has increased from 3.902 BCM in 2000-01.

The total estimated annual surface water uses for irrigation in the Odisha part of the basin amounts to 8.23 BCM, approximately half in the Kharif and half in the Rabi seasons. This value has increased from 7.16 BCM in 2000-01. Thus, the overall surface water used for irrigation in the basin is 13.72 BCM, which is 27.4 per cent of the utilisable surface water of 50 BCM. It has increased from 11.06 BCM in 2000-01, a 24 per cent increase over 13 years.

It is difficult to estimate the volume of the groundwater use in the absence of quantifiable data in volumetric terms. Around 36 per cent of the gross irrigated area is irrigated by groundwater, and the CGWB (2011) estimate is approximately 510,110 Ha-m (hectare-meter) or 5.10 BCM. This has increased from 3.65 BCM in 2004, showing an increase of about 39 per cent. The current use of groundwater is 37 per cent of the 13.6 BCM dynamic groundwater, estimated as usable by the CWC. However, the CGWB estimates that an additional 11.76 BCM is available for additional use in the future, thus estimating the total usable groundwater to be around 16.89 BCM which includes the return flows.

The total irrigation water use is approximately **18.82 BCM**, of which surface water irrigates 64 per cent of area with a share of 73 per cent of surface water, while 27 percent of the groundwater share irrigates 36 per cent of the area. The total water withdrawal for agriculture currently is 30 per cent of the total utilisable water resource. At present 3.32 million Ha (39.4 per cent of the gross cultivated area) is irrigated using 18.82 BCM of water which is equivalent to approximately an average of 5668 m^3/ha of irrigation. If the overall irrigation in the basin area is spread to 50 per cent (just above the national average) of the gross cultivated area in the near future, the approximate water requirement would be 24 BCM. At the current rate of 1.9 per cent yearly increase, the demand for irrigation water in 2050 would be approximately 31 BCM. There would be limitations for such a growth as the states are not prioritising surface irrigation projects. Besides private groundwater development is costly for most farmers unless subsidies are provided. However, the trend shows that it could go into the range of 25 BCM in the coming years. This would be around 40 per cent of the utilisable water resource.

5.3 Industrial water use

Data on industrial water use or allocation at the basin scale does not exist. Surface water allocation for industries is available at each project level while groundwater data from the CGWB is available at the district level, clubbed together with domestic groundwater use. In order to get an idea about the

water allocated to industries, the agriculture-industry team undertook an exercise to find out the information through the environmental clearance process for industries located in the basin. Such a detailed database of industries in the Mahanadi basin that have been given environmental clearances by the Ministry of Environment and Forests (MoEF) (along with the water requirement of each industry) has been prepared and is used for the current water use estimation. This is being validated wherever data was available at the project level. Based on these estimates, the total amount of water in the Mahanadi basin allocated to large industries is about 1.13 BCM in Chhattisgarh and 0.944 BCM in Odisha. This amounts to 2.074 BCM of water for industrial use.

In volumetric terms, even though the industrial water consumption in the basin is less (3.3 per cent of the utilisable water), the increasing thrust on industrialisation, especially the growth of water consuming industries like thermal power plants, iron and steel plants, mining, cement, etc., will have increased the demand of water.[30] The detailed study at two sites (Minimata Bango and Hirakud projects) shows that the allocation from these two projects to industries is 13.6 per cent and 6.7 per cent, respectively. However, it is noticed that most of the new barrages and pickup weirs that are already developed and also under development in Chhattisgarh are to supply water to the industries, to the tune of around 1 BCM. The Odisha State Water Plan estimates the allocation of 0.34 BCM of water for industries from the Mahanadi basin. However, our assessment shows that the current use taking both surface and groundwater together far exceeds the estimate – more than double if we consider that 0.94 BCM is allocated for industries. As of now, projections for what industrial water allocations might look like in the year 2050 hold a great degree of unpredictability since changes in this sector are much more dynamic and less predictable. A lot would depend on the government's policies such as incentives to industries, global economic dynamics and investments, and the progress of policies with respect to thermal power plants, renewable energy and energy efficiency measures. But one can conclude that the industrial water demand is going to increase if the trend continues.

5.4 Water for environment

Another critical but often neglected area is the issue of water for environment and the environmental flow regime. Of late, the demand for environmental flows in rivers is getting more attention as natural river flows are increasingly

30. In the peer group review on Agriculture-Industry Report, one participant (name withheld) who works closely with the Chhattisgarh's Water Resource Department on the Mahanadi basin mentioned that the use in Chhattisgarh alone would have reached 2 BCM.

being modified through dams and weirs, diversions, abstractions for agriculture and urban supply, maintenance of flows for navigation, and structures for flood control. The Mahanadi is not an exception. These interventions have had significant impacts, reducing the total flow that affects the seasonality of flows and also the size and frequency of floods. In many cases, these modifications have adversely affected the ecological and hydrological services provided by water ecosystems, which in turn has increased the vulnerability of people, especially the poor who depend on such services as we saw earlier.

There are various estimates for the environmental water demand of the rivers. The Odisha State Water Plan (Department of Water Resources, Government of Orissa, 2007a) undertakes a detailed exercise on environmental water needs based on various available methodologies and estimates the environmental demand as 30 per cent of the surface water and 40 per cent of the groundwater. On the other hand, Chhattisgarh has a rudimentary estimation for various water uses except that of environmental needs. The State Water Policy (2012) earmarks 50 per cent of the available utilisable water for irrigation, 20 per cent for various domestic purposes, *nistar* and the filling of ponds and livestock needs, and 5 per cent for industrial needs. The remaining 25 per cent is estimated to remain as the balance which may be for environmental needs. In the recent inter-state meeting mentioned above, Odisha makes a strong case for managing the flow in the Mahanadi. Citing the ecological sensitivity of the delta, the Chilika Lake and other ecological hotspots, it argues that environmental flow needs to be maintained in the river, and that controlled flood releases are necessary to keep these ecological hotspots healthy, even though we cannot vouch for their commitment to these issues in times before the dispute.

Amarsinghe, Shah and Anand (2007) provide insights into the environmental flow requirement of the various basins in India (pp. 20-22). The authors estimate the environmental flow requirement for most Indian rivers on the basis of information calculated by Smakhtin, Revenga and Döll (2004).[31] It

31. The environment flow requirement (EFR) estimates of Smakhtin, Revenga and Döll (2004) are assumed to be related to the hydrological variability of river flow. The hypothesis is that river basins with highly variable hydrological regimes may require a smaller proportion of surface runoff to be set aside as EFR, because aquatic life in such rivers is adapted to prolonged periods of little or no flow. On the contrary, river basins with more stable, less variable hydrological regimes require a higher proportion of surface runoff as EFR, because their aquatic life is more sensitive to flow reductions and changes (Amarsinghe, Revenga and Döll, 2004, p.21-22). According to the authors, the EFR estimates built into the assessment are very preliminary. They have been based only on aggregated annual hydrological information, simulated at the coarse spatial scale. Smakhtin and Anputhas (2006) also provides a preliminary estimation of the environmental water requirement (EWR) of various Indian rivers based on the environmental management classes. As per the estimation to maintain Mahanadi at a relatively high environmental management 'class B', 34.8 per cent of the natural mean annual runoff is estimated as long term environmental water requirement (p.22).

ranges from 20 to 27 per cent of the renewable water resources (which are represented by the long-term, mean, annual natural river discharge or volume). The Mahanadi basin's environmental flows requirement necessary to maintain it in fair condition is estimated as 24 per cent of the total renewable water resource of 66.9 BCM, i.e. 16 BCM. If we factor in this quantity as commitment for the environmental need, the total water available for human needs would be drastically less. If we follow the estimate as per the OSWP the environmental needs would be 20.52 BCM reducing even further the quantity available for other needs.

5.5 Total water use estimation

Based on the above estimations for various sectors, the total water requirement/use is 41.30 BCM as shown in the table 5.1. This is above 60 per cent of the total utilisable water resource of the basin.

Table 5.1 : Total Water use estimation in the Mahanadi basin

Water use/ requirement of sectors	Current Estimated Use (BCM)	Per cent of Total Renewable Water Resource (66.9 BCM)	Per cent of Potentially Utilisable Water Resource (63.6 BCM)
Domestic[32]	3.87 (1.16 SW & 2.71 GW)	5.78	6.08
Livestock[33]	0.54 (0.27 SW & 0.27 GW)	0.80	0.84
Irrigation	18.82 (13.72 SW & 5.10 GW)	28.13	29.59
Industry	2.07 (both)	3.10	3.26
Environment[34]	16 (both)	23.92	25.16
Total	**41.30**	**61.73**	**64.93**

SW = surface water
GW = groundwater

32. 70% of the need is assumed to be met from groundwater (GW) and 30% from surface water (SW).
33. 50% of the need is assumed to be met from groundwater, and 50% from surface water.
34. Estimate based on Amarasinghe, Shah and Anand (2007)

At present 23.24 BCM (36.5 per cent of the utilisable water) is consumed by domestic, agriculture and allied sectors, of which 65 per cent is met from surface water while 35 per cent is the contribution of groundwater. The utilisable balance water available, after factoring all the use/requirements, would be 22.30 BCM which is around 40 per cent of the utilisable water in the basin. As we have argued earlier, if the estimation of utilisable water is on the high side (95 per cent of renewable water resource is estimated as utilisable in the basin), what in reality is available would be much less. If evapo-transpiration loss is factored at 40 per cent (the average figure for all basins together in India) of the precipitation, the utilisable water (both surface and ground) would be 40 BCM which is almost equal to the present water use. Even if we consider the original figure of 63.6 BCM as the utilisable water in the basin, it cannot be called a water abundant basin. If the projected growth in demand happens and the trend continues, the situation would be critical by the year 2050 which calls for technical, institutional and legal measures for the sustainable development and management of the basin.

6

Framework for integrated river basin governance in the context of Mahanadi River

The Mahanadi River at present is portrayed as a river which has sufficient water[35] to meet the needs of the various states, especially the dominant riparian states of Chhattisgarh and Odisha. To some extent it is true as its water is not yet fully allocated for various uses, and the inter-state dispute is not as critical or antagonistic as in the case of some of the other rivers in the country. However increasing demand across sectors and states, along with increasing pollution from industries, agriculture and domestic use would impact the river in the near future, as preliminary evidence suggests. The emerging water use pattern in the basin, the political thrust on increasing allocation to industries, the contestation between agricultural and industrial allocation, the inter-state water sharing issues that are emerging and the political economy of development prevailing in the states demands that a framework is evolved in consultation with various stakeholders for the sustainable management of the waters and also the basin. It would call for normative and institutional principles along with technical and administrative/governance mechanisms.

At present the problems are not spread across the basin but there are emerging hotspots. With the institutional and policy vacuum that exists today for democratic and sustainable management of the basin, the inter-sectoral and inter-state issues and constraints could emerge strongly in the near future. This would affect the quantity and quality of water, its availability at a healthy level for domestic and livelihood needs as well as the environmental needs. The present approach to manage the river is not equipped sufficiently to address these concerns due to various reasons such as lack of integration at policy and institutional levels, the top down approach to water resource

35. On the basis of normal rainfall years and estimation of the average availability of water, it may be true to some extent. The inter-annual flow in the river is however highly variable, being as low as 20 BCM in some years to as high as 70 BCM in other years (Central Water Commission, 2012, p. 168). Any discussion and planning needs to factor this in as there would be highly stressed years.

management, problems in conceptual and normative understanding of the river and its functions, lack of democratic decision-making platforms for various stakeholders and so on.[36]

6.1 Integrated river basin governance

The intensive water resources infrastructure development in the 20th century resulted in significant negative social and environmental consequences in many parts of the world (World Commission on Dams, 2000). At the same time, many basins are water stressed resulting from intensive extraction and pollution resulting in water shortage across sectors, especially for life and livelihoods, healthy aquatic life and ecological needs. In this context, integrated water resource management is gaining both acceptance and application during the last couple of decades and is increasingly seen as a strategy to address the major concerns facing the water sector. There is an increasing appreciation among planners and policy makers for integrated basin management systems moving towards an understanding that issues pertaining to both water quality and quantity, and groundwater and surface water, should be treated together. Land use and land-vegetation-water interactions of a particular catchment or hydrological unit are also integral to this process. This comprehensive approach to planning and management came to be known as integrated water resources management (IWRM). However, the thrust is still on surface water or visible flow when a river system is discussed, as that becomes the focus as far as water resource development, water allocation, inter-sectoral and inter-state water disputes are concerned.

Basins and sub-basins are being accepted as a unit of planning and management of resources as well as for institutional frameworks for management under IWRM. As a spinoff of this, Integrated River Basin Management (IRBM) emerged as an approach and strategy concerned with

36. It is not that there are no voices on river basin management in the Indian context. While there are strong voices in the civil society and academics on the need for integrated river basin management, at the policy level the state also has come out with many policy documents highlighting the need of river basin management. The National Water Policy (2012), The Draft National Water Framework Bill (2016), Guidelines for Integrated Water Resources Development and Management (2016), etc. discuss the need for a sub-basin, basin level approach to water resource management. While these policies and propositions elaborate on the need for basin level planning and management and the technical, institutional and policy needs for such an approach, the critical issues of integration (across resources, institutional and management structures and policies) and scale (level of institutional structures such as RBOs, management boundaries determined by administrative scales, etc.). For example, the provision in the Framework Bill on the provision to provide for the establishment of a River Basin Authority for each inter-State river basin looks more like a continuation of the centralised approach to river basin management, than a democratic and participatory way of looking at river basin management.

the decision processes involved in river basin management (Bruce, 2005).[37] Adapting from Mitchel and Hollick (1993), Bruce identifies the following building blocks for evolving an integrated basin management system which has relevance for our concerns.

1. Use of a **Systems Approach** in which attention is directed towards both natural and human systems, their component parts, and the inter-relationships among those parts
2. Use of a **Strategic Approach** in which attention is directed to key, issues and variables identified through consultation with stakeholders and to linkages among the key issues and variables
3. Use of a **Stakeholder Approach** in which it is recognised that citizens and non-government groups should be able to participate in decisions about resource management.
4. Use of a **Partnership Approach** in which state governments, local governments and non-government organisations and individuals each have a role, requiring common objective setting, definition of roles and responsibilities, and conflict resolution mechanisms.
5. Use of a **Balanced Approach** in which concerns for economic development are weighed against ecosystem protection, and satisfying social norms and values.

This would require coordination and integration across resources, sectors, stakeholders and administrative levels based on principles of equity, democratic decision making and platforms for transformative participation and sustainability, and at the same time ensuring the socio-economic and livelihood needs of the basin dwellers.

While the overall objective is to arrive at an IRBM framework for the Mahanadi, here we focus on the architectural details of the framework in the form of a set of options or a combination of mechanisms the stakeholders can deliberate and adapt to, rather than prescriptive solutions. Such a framework needs to move away from the current technical and managerial fixation on water resource

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37. Integrated River Basin Management (IRBM) is defined as an integrated and coordinated approach to the planning and management of natural resources of a river basin, one that encourages stakeholders to consider a wide array of social and environmental interconnections, in a catchment/watershed context. It is different from traditional multi-purpose resource management as it addresses a broader set of issues including social impacts, varying social values and ecosystem functioning. IRBM implies the inclusion of a full array of physical, biological and socioeconomic variables involved in managing a hydrologic region for environmental values and human use (Bruce, 2005, p. 9).

development and management (managing the supply) and incorporate a systems approach, and must include various people and perspectives based on a set of shared concerns and principles.

6.2 Architecture of river basin governance

Earlier sections provide a broad picture of the current status of the basin, key issues the basin is facing as well as some critical data for the stakeholders to deliberate and understand the various issues and dynamics at the basin level. In this section, we elaborate on a set of normative principles, and technical, institutional and policy options for the development of an integrated river basin governance system. Such a vision for integrated water management in the river basin would be imbued with the universal goals or the normative concerns of equitable and sustainable resource use and democratic governance, grounded in a hierarchy of principles, and draw upon a rigorous and nuanced understanding of the prevailing ecological and socio-economic interaction and situation in the basin. In the following section, we elaborate on the various conditions and mechanisms for working towards an integrated river basin management. It is a generic set of options and strategies taking into consideration the existing mechanisms and policies in the basin and at various administrative levels. There is no one single blueprint for river basin governance and the approach needs to be developed based on the specific conditions, challenges and priorities. But a set of issues that impacts the basin governance are highlighted in the following sections.

6.2.1 Conceptual issues in river basin governance

The programmes and policies on basin planning and development in India are centred on water resource development and fail to address basin resources, their interactions and issues in a holistic manner. The first step towards integrated management of the basin is the recognition of the basin as the unit of planning and management, whether it is confined to some specific states or shared between states as in case of Mahanadi. While a basin is a complex unit due to various sectors interacting with each other, the complexity increases as it becomes an inter-state basin.

There is increasing realisation that India's waters should be managed at a basin scale. The CWC issued Guidelines for Integrated Water Resources Development and Management (Government of India, 2016) and acknowledges that 'a fully integrated approach to manage water in a basin may not be immediately possible. However, this does not prevent embarking on IWRM at the basin level.' The Draft National Water Framework Bill (2016) also suggests that a river basin,

including associated aquifers, shall be considered as the basic hydrological unit for planning, development and management of water.

However most of the policies while acknowledging the importance of the basin as a unit of planning emphasize on water resources and not the basin as an integrated system linked across various sectors and actors. Thus, it is important to bring the focus on the basin and its dynamic interaction across climate, rainfall, land use, surface and groundwater and the social and economic system that impacts both the quantity and quality of water resources. A basin needs to be viewed as dynamic system (with variability in time and space) as against the static approaches prevalent now. This means actions in one or sub-system/ sector impacts other sub-systems or the basin as a whole and solutions are to be sought cross- sectorally and in a coordinated way.

Scale is an important issue as hydrological scales need not match the administrative boundaries, the latter being the basis for policies and programmes around water and land. Reconciling these two is a crucial issue when basin governance issues are being discussed. The resource interactions and outcomes also vary with varying scales of a hydrological unit. For example, the interactions and outcomes at a smaller watershed scale (main unit of watershed development interventions in the country) are significantly different from those at the sub-basin or basin scale. The local and non-local nature of water and the dynamics of land-water interactions at various scales impact the unit of planning and management. The critical issue is how micro and macro scales hydrological units as well as those on administrative scales are very crucial while planning and governance agendas are undertaken in the basin. As Mahanadi is an inter-state and large basin, sub-basins and states would also play a crucial role in the governance, in the given policy and management environment.

Studies show that in countries where legal mandates over water management are vested at a state or provincial rather than national level, there can be significant challenges to basin planning because of the lack of legal mandates that can be held by any inter-state organisation or institution. This is the case in both India and the United States, where water is a 'state subject'. In these cases, there may not be a substantive national water strategy, but there are political challenges to the production of comprehensive basin plans, as states are unwilling to hand over any meaningful power or authority to any inter-state (Pegram et al., 2013). However, this needs to be viewed from the point of view of over-centralisation that could happen if all authorities are transferred to a centralised legal and institutional structure. This is where the role of decentralised water governance comes into picture as a normative goal.

6.2.2 Normative concerns in river basin governance

At present the Mahanadi or for that matter other basins in the country are administered by a top down techno-bureaucratic institutional mechanism, which offers very little scope for decentralised and community/stakeholder managed governance systems with decentralised institutional mechanisms. Even though the importance of stakeholder participation is often highlighted in policies and documents related to River Basin Management (see Draft National Water Framework Bill, Guidelines for IWRM in India, etc.), it is often not clear how a genuine decentralised and participatory governance mechanism would be evolved in managing rivers.[38] In cases where river boards were set up as river basin organisations in the country, these were either subject-oriented or project-oriented organisations (South Asia Network on Dams, Rivers and People, 1999) or those working on specific functions, such as flood planning or water resources construction, water allocation, reservoir operation, water pollution mitigation, etc. The adopted approach is demand-oriented and focuses on resolving specific problems in the river basin (Government of India, 2016). Thus, the crucial question is how decentralised and participatory governance mechanisms could be streamlined in river basin management where the community and various stakeholders have a genuine role in managing the river and its resources.

Other important normative concerns in river basin governance are the issues of justice, equity and sustainability. Increasingly these are being recognised and reflect in policies. For example, the Draft National Water Framework Bill highlights that the need for 'equitable and optimal utilisation of waters within a river basin shall be ensured, with due regard to the present and future needs for life and livelihoods, social justice and equity, and ecological sustainability'. These kinds of well-intended pronunciations were seen in even earlier water polices, however, the focus should have been on how to transform them into implementable frameworks, for which there was hardly any roadmap or strategies in place.

Operationalising the concerns such as justice, equity and sustainability is a complex issue given the myriad uses that exist within and across sectors and between states in the basin. For example, at present agriculture is found to

38. For example, the Draft National Water Framework Bill 2016 states that ' The Central Government shall provide for establishment of a River Basin Authority for each inter-state river basin, or for a sub-basin of inter-state river basin wherever appropriate, for optimum and sustainable development of the inter-state rivers and river valleys, with active participation and cooperation by all basin states to ensure equitable, sustainable and efficient utilisation of water resources with emphasis on demand management through conjunctive and integrated use of resources.' (Ministry of Water Resources, 2016)

be the largest user in the basin followed by domestic and industrial sectors in both the states. Agriculture is also the primary livelihood provider. However industrial water allocation is also seeing an upswing, and finding a balance across the sectoral demand which is a crucial concern if one has to talk about the sustainable management of the water in the basin. Thus, the issue which arises is the criteria for sectoral allocation. Should it be the quantum of livelihoods or jobs created by each sector, and should issues such as the impact on water quality and pollution also be considered in such decisions? There are no simple answers to these questions, and in the absence of a decentralised and participatory regulatory framework decisions could be arbitrary and biased.

6.2.3 Inter-sectoral allocation and sharing of inter-state river waters: Hierarchy of principles and broad approaches

Water policies of the centre and the states highlight the importance of water use prioritisation and invariably accord primacy to drinking water followed by allocation to agriculture. While the Odisha State Water Plan prioritises water allocation in the order of drinking and domestic needs followed by ecological needs, irrigation, hydropower, industries and so on, there are no such clear policies in the case of the Chhattisgarh's Draft Water Policy. However, when it comes to river basin units these kinds of principles are conspicuously absent whether in the case of unitary state bound basins or basins shared by federal states.

One of the important gaps in inter-state water sharing in general and the functioning of the inter-state water dispute tribunals in particular is that there is no commonly accepted set of principles and norms for sharing the waters. In the absence of this, even if permanent tribunals are set up (as suggested by the recently introduced bill to amend the Inter-state Water Disputes Act, 1956)[39], inter-state water conflicts would continue to be intractable in the absence of an agreed hierarchy of water sharing principles and norms. In a meeting organised by the Forum in October 2016 at ATREE, Bengaluru to discuss the Cauvery water conflict (especially in the light of the large-scale violence that erupted in

39. The Inter-State River Water Disputes (Amendment) Bill, 2017, a bill to further amend the Inter-State River Water Disputes Act, 1956, mainly argues for a single standing Tribunal with multiple benches and the provision for a Dispute Resolutions Committee. On the receipt of an inter-state water dispute from the Centre, the Chairperson is empowered to assign such a dispute to a Bench of the Tribunal for its adjudication. The Bench of the Tribunal shall, before investigating the water dispute referred to it, take into consideration the report submitted by the Disputes Resolution Committee and forward to the Central Government its detailed report setting out the facts as found by it including on yield, efficiency in the use of water and such other matters as may be prescribed, and giving its decision on such dispute within a period of two years, provided that such a report shall also provide for the distribution of water during distress situations arising from shortage in the availability of water (Amendment to Section 5 of the Principal Act).

the preceding months), the following hierarchy of principles were agreed upon by a large number of participants and we consider it as a starting point for evolving allocation principles across states and sectors.

- First, *water for life*: providing adequate water of acceptable quality for meeting the drinking, cooking and sanitation needs of all the people and animals in the basin,
- Second, *water for the ecosystem*: ensuring adequate water flows and water in the river system for aquatic life and other ecological functions,
- Third, *water for sustaining livelihoods*: enabling productive activities while ensuring equitable use and protecting public health, and
- Fourth, *water for adaptation to change*: keeping reserves and margins for ongoing and future demographic, economic and land use changes and climate change.

While conceptual and normative concerns and hierarchy of principles of allocation would provide the basis for evolving basin governance concerns, its practical and operational milieu would depend on the enabling environment, institutional framework, management instruments and technological processes.

6.2.4 Enabling policy and legal environment

The current policy and legal mechanisms operate at the state level and primary powers of managing water and other resources rest with the state which do not correspond with the river basin boundaries. As seen earlier there are a number of policies, legal instruments and rules pertaining to water, but these are related to specific sectors or water resource development and allocation. While the policy provisions suffer from generalities and lack of implementable road maps, legal mechanisms face inadequate application and implementation hurdles and incomplete monitoring and enforcements. The case of environmental protection legislation in relation to water or the legal provisions for irrigation management by farmers or the implementation of groundwater laws could be examples of such. However, state level policies and legal provisions are fragmented and not in tune with the requirements of basin governance. The policy and legal provisions provided in the Draft National Water Framework Bill states that existing legislations both at the central as well as state level shall be reviewed and amended, wherever appropriate, so as to conform to the principles and provisions of the Act. This opens up opportunities for creating new legal and policy provisions for basin governance.

For inter-state river governance, The River Board Act, 1956 was enacted to provide for the establishment of River Boards for the regulation and development of inter-state rivers and river valleys. However, River Boards in case of other rivers are hardly an institution involved in the governance but only to meet the narrow and specific issues related to the rivers. As mentioned earlier, there was a demand for the establishment of a Joint Control Board for the Mahanadi during the recent inter-state dispute. A MoU to this effect was entered in 1983 between Odisha and Madhya Pradesh, even though its scope was limited to discussion and decisions on inter-state irrigation and power projects, but failed to get established over the years.

The need for policies, legal provisions and regulatory structures for basin governance at the state basin level as well as the inter-state basin level is crucial for evolving the basin governance framework and the recent development, even though it has limited scope, opens up opportunities for such a mechanism at the basin level.

6.2.5 Institutional framework

In recent times, it is realised that the existing institutional structures at the national, state or local level, are not equipped enough to handle the emerging issues of the water sector and are fragmented across departments, sub-sectors and activities. They fail to enable integrated and participatory governance of water resources (World Bank, 1998; Shah, 2016). While water governance itself is highly fragmented, an institutional framework for integrated river basin management is yet to emerge in practice, and a plethora of line departments are involved in managing the water resource of the basin. Integrated management of the basin would require innovative and inclusive institutional mechanisms and a nuanced understanding of the technical and socio-hydrological issues. Integrated river basin management aims to establish a framework for coordination whereby all administration and stakeholders involved in river basin planning and management can come together to develop an agreed set of policies and strategies such that a balanced and acceptable approach to land, water, and natural resource management can be achieved (World Bank, undated).

At present the agencies/institutions that manage the basin water resources are divided across administrative units and boundaries with a specific set of norms, rules and policies and administrative structures. They range from various line departments ranging from the water resource department to public health department. Within this administrative set up, the basin is not the unit of planning and management, and there are no basin management institutions

in both the states with respect to the Mahanadi River. Besides the structure is top down, surface-water centric and involves supply-side management approach. The primary stakeholders hardly have any role in the decisions and lack space for fostering grass root institutions. Other actors such as civil society organisations, farmers' agencies, industrial bodies and other sections linked to various river based livelihoods are conspicuous by their absence in the institutions and decisions. In recent times, there is an emphasis on the formation of RBOs and river basin level integrated planning and management of resources. While some of these initiatives are pushed by multilateral lending agencies, it could be seen as a step forward. As part of such developments, Odisha has undertaken experiments in forming RBOs. However, such initiatives also suffer from the top-down bureaucratic –centred approach, having little space for democratic governance.

Under the present conditions, it may be rather ambitious and difficult to demand a single river basin agency cutting across the two state boundaries. However, effective institutions from the bottom, say at a sub-watershed or sub-basin scale and cascaded at various hydrological scales at the respective states, within a nested and delegated democratic framework, could be the starting point. These institutions should have representation of various stakeholders and should be a platform for democratic decision making. The institutional arrangement could be divided such as a consultative and recommendatory institution drawing on government (both state and central), civil society groups working in the basin, research and knowledge agencies as well as other direct stakeholders and an administrative and regulatory structure involved in implementing the recommendations and related activities in consultation with the former.

The basin agencies for its effective functioning would require integration of various departments that are involved with the basin at some level or other, and the recent Mihir Shah Committee report on institutional restructuring (Shah, 2016) could provide certain pointers. At the basin scale, these state level basin management agencies/organisations could come together and create a platform for coordination and consultative decisions (Inter-State Basin Organisation). At the inter-state level, a Dispute Resolution Committee could be thought of drawing on the inter-state river basin coordination and management organisation stated above. This would be in tune with the recent amendment to the Inter-State River Water Disputes Act, 1956 (see Government of India, 2017 for the Inter-State River Water Disputes (Amendment) Bill, 2017).[40]

40. The Bill proposes to introduce a mechanism to resolve the water dispute amicably by negotiations through a Disputes Resolution Committee, to be established by the Central Government consisting of experts from relevant fields, before such a dispute is referred to the Tribunal. However, an in-built system of coordination and dispute resolution as an ongoing institutional system of basin

Nonetheless it is very important that water governance or basin management should not be left to a centralised political or bureaucratic process alone. Water governance must be democratic, decentralised and participatory and representative organisations and governance mechanisms at various scales are required for the management of the basin. The stakeholders should collectively evolve the governance structure which should not be imposed from above as in the case of RBOs in Odisha.[41] At least the provision for such agencies is a good beginning at the policy level as reorganisation is possible if public pressure is built. The state of Chhattisgarh also should initiate such policy decisions and this is an appropriate time for it.

The institutions at various levels should have the power to evolve and enforce various rules and regulations pertaining to resource planning and allocation. For example, the current water allocation systems are administratively implemented and often the decisions are ad-hoc and arbitrary. This is evident in Chhattisgarh where a large number of new water resources are developed on the Mahanadi, mainly to serve the industrial needs, even ignoring the domestic and livelihood stress it may have. The role of the stakeholders is important in such a context, and basin organisations evolved democratically could be able to address these issues of water allocation.

6.2.6 Management framework

This would critically involve provisions for real-time and ongoing data management, river basin plans and systems for monitoring the resources and the basin ecology at large. At present, there is no systematic and integrated basin level data except for some of the data generated by the CWC. In such data sets too, we could observe variations and inconsistencies. At the state level, it is even rudimentary as compared to the central data repository. The data pertaining to the basin is dispersed across various departments like water resources, irrigation, agriculture, water services, public health, department of environment and forests, mining and industries and so on. To evolve a comprehensive and data supported picture of the basin is quite difficult in the present circumstances. This creates a number of impediments as we could

management would be a better mechanism as compared to an institution established from above. The dispute around water use among the states of a river course does not happen abruptly, even though its expression in the public space may happen swiftly. An inbuilt mechanism to discuss the developments and find solutions within the overarching framework of basin governance would be a more participatory solution. However, it is easier said than done as a lot of emotions are involved in water disputes in the country (Government of India, 2017).

41. For a comprehensive list of Basin Level Organisations from around the world, their characteristics, broad compositions and functions and authority see the World Banks Review of Indian Water Sector (1998).

see in the recent articulations on the basin by respective governments of Chhattisgarh and Odisha during the water dispute.

The recent Inter-State River Water Disputes (Amendment) Bill, 2017 as well as the Draft National Water Framework Bill highlights the importance of data at the level of hydrological units. According to provision 9A (1), "The Central Government shall, for the purposes of maintaining a data bank and information system at the national level for each river basin, appoint or authorise an agency which shall maintain data relating to water resources, land, agriculture and such other matter, containing such particulars and in such manner, as may be prescribed" (Government of India, 2017). It is also important that such data is transparent and accessible to various stakeholders for use and scrutiny.

The importance for a basin level master plan is also underscored by some of the policy documents such as the Draft National Water Framework Bill, Guidelines issued by the CWC on Integrated Water Resource Plan and reviews and studies by various other agencies. The CWC guidelines suggest that The River Basin Master Plan shall, inter-alia, include:

1. all the results of the analysis of the river basin characteristics
2. a comprehensive review of the impact of anthropogenic interventions on the status of surface water and groundwater, including an estimation of pollution, point as well as diffused, in water uses
3. identification of protected areas, social and cultural flow needs and duration
4. environmental needs
5. groundwater and protected aquifers, if any
6. a summary survey of existing pricing policies and an economic analysis
7. a fair assessment of the effects of existing legislations
8. an economic analysis for optimal allocation and the notional cost of deviation from optimal

The Draft National Water Framework Bill not only prescribes the need for an integrated basin plan but suggests that 'the River Basin Master Plan, at all stages shall remain in the public domain and shall be available online'. The suggested two way mechanism is that 'each State Government shall develop, manage and regulate basins of intra-state rivers through a River Basin Master Plan to be implemented by an appropriate institutional mechanism', while at the basin level, the provision is that 'each River Basin Authority shall prepare a Master Plan for the River Basin, under its jurisdiction, comprising such information as may be prescribed and the Master Plan, so prepared, shall be

reviewed and updated after every five years after due consultation with all other planning agencies and stakeholders' (Ministry of Water Resources, 2016; pp. 12-13). Even though the details are not clear as to how integrated planning is possible in the current institutional scenario, this could be a good beginning for embarking on sustainable and democratic planning for the basin.

Under the World Bank assisted sectoral reform, the Odisha state has begun to chalk out basin and sub-basin plans. However, these are top down and non-participatory, and basically put together various data on the basin from different sources and planning for water resources with very little sectoral integration of resources, enabling policies, and institutional reforms. In Chhattisgarh as well sub-basin master plans are prepared with the help of consulting agencies such as WAPCOS to assess the water resource potential for further development. However, none of these plans are available in the public domain nor are they developed in consultation with various stakeholders. It is important to evolve a participatory and multidisciplinary planning tool which takes into consideration the dynamics at various scales of planning units — the micro, the intermediary and the macro levels.

Regular monitoring and dissemination of information on various critical issues such as water resources, the flow regime, allocations, quality and pollution and new developments and its implications is important. Such information should be made accessible to planners, implementers and various stakeholders. It should also be a tool for community awareness and public participation. Monitoring protocols are also clearly articulated in the documents, but the real challenge is to implement and act upon them.

A robust baseline on various indicators needs to be developed and become the basis for consultation and decision making within and across states. The recent meeting to discuss the water sharing issues between the two states has brought forward this issue to the forefront as both the states have contradictory positions on monsoon and non-monsoon runoff and release to the lower riparian state of Odisha. The recent decision to assess various hydrological and related issues in the basin in the face of contending views is an opportunity which civil society could use for their advantage. An objective, transparent, reliable baseline available for public scrutiny should be demanded from the state.

6.2.7 Technical processes

This would involve technical interventions necessary for the integrated sustainable management of land use, surface and groundwater. At present, it is managed in a fragmented way by various departments and through various

policies working at cross purposes at times. Water efficiency also would fall under this process. Land use and integrated water use could be planned and implemented at a lager watershed unit, building above to the sub-basin and basin levels in the states.

Surface and groundwater in the catchments and also command areas need attention and there is a need for integrating the surface and groundwater development, use and management. Even though groundwater use is not at its peak in the basin, it is slowly picking up. While most of the domestic needs are met from groundwater, there is increasing use of this resource by agriculture and industry. Experience also shows that co-management and use of surface and groundwater in the command areas, as in the case of the Waghad Irrigation Project in Nashik district (Maharashtra) leads to better dependability, judicious and efficient use and economic gains (Paranjape and Joy, undated). Institutional innovations are pre-requisites for this purpose as the above cited study shows.

There are provisions for establishing Pani Panchayats in both the states and such institutions are also established in the command. At present, they are mainly on paper and not active in managing the water as well as the infrastructure. They could be revived as well as restructured along the lines of the Waghad WUAs, which would manage the local and exogenous water as well as surface and groundwater together. As all needs are not going to be met from surface water alone, there would be increasing dependence on groundwater. The Jeyaseelan Committee acknowledges this and suggests that groundwater should also receive attention in the scheme of irrigation in the Hirakud command. The farmers' movement in the Hirakud command is also slowly acknowledging the need for groundwater irrigation and they could learn a lot from the Waghad experience of Maharashtra where farmer-centred irrigation management systems are institutionalised.

While all of the above to a large extent would aid and support a basin governance framework, a basin governance system demands much more. For that to happen it is important to move away from water resource centred planning to strategic basin management planning and governance, even though the Mahanadi basin at present does not fall in the category of stressed basins. Moving towards a democratic and sustainable governance should be the larger goal and would be a long journey. It is important to initiate this process, and recent policy developments such as the provisions for a Master Plan and River Basin Authority could be used as the stepping stone. As a beginning, some of the critical issues could be looked into. These would include a fresh estimation of water resource and its link to rainfall patterns over the years, the issue of pollution and the ecological health of the river, evolving a transparent norm for

water allocations to sectors, working towards a participatory basin plan, and putting out all the information in the public domain for analysis and scrutiny. Political commitments of the state and stakeholder awareness and involvement are two crucial components for working towards these objectives. There are many examples available from around the world which could provide some pointers towards evolving institutional and operational mechanisms.

6.3 Way Forward

The water resources situation of the Mahanadi basin as we have seen is not critical in normal rainfall years, and under average annual renewable water resource conditions. But increasing demand from agriculture and industry along with increasing competition for its resources from the dominant riparian states may adversely impact the availability as well as the quality of its water in the coming years. One can see this effect in dispersed areas of the basin and some of the sub-basins are already experiencing it significantly. Thus, it is important to begin a path towards a democratic, equitable and sustainable river basin governance agenda. The governance agenda and mechanism should aim to ensure that the Mahanadi does not suffer the fate of most of the peninsular rivers in the coming years, and continues to flow while meeting the livelihood and development needs of the people living in the basin. In order to begin the process, opportunities exist even though in a limited policy and institutional environment.

The first step in this direction would be to come out with a status paper on the river. It needs to be developed through a transparent and objective consultation processes. The recent consultative meeting of the states organised by the MoWR to resolve the dispute made a decision to study the water resource availability of the basin. This provides an opportunity to begin the process. Somehow narrowing it to only water resource availability would not serve the purpose of understanding the hydrology or the causes of the inter-state dispute. It needs to be broadened to include water resources at different precipitations and in different land use contexts, the extent of water resource development, the water use, the livelihood water link and so on. The status paper should be able to come out with a realistic picture on the current water use and water balance of the basin as well as critical issues the basin is facing. An independent agency could be entrusted with the task as suggested in the coordination. However, it is important that the states as well stakeholders are involved in the process so that better ownership and decisions could be arrived at. Till that time additional water resource developments and allocations especially for water consuming industries such as thermal power plants need to be put on hold.

The state of Odisha as part of its water sector reforms has embarked upon a policy for both river basin plans as well as the formation of RBOs. The civil society organisations and other stakeholders could demand the formation of basin organisations and a basin plan for the Mahanadi in Odisha. They could exert pressure so that the process becomes transparent and democratic, and a realistic and manageable basin plan is prepared and basin organisation becomes a platform to further the basin governance. Such an effort in Odisha could become a starting point to start the same initiative in Chhattisgarh. The Draft National Water Framework Bill, if adopted, also opens up possibilities for the formation of state level basin organisations and master plans as well as an inter-state River Basin Authority. Most often such agencies are thrust from above and driven by techno-bureaucratic agenda. A vibrant civil society could play a critical role in making this organisation more inclusive and democratic. The Inter-State River Water Disputes (Amendment) Bill, 2017 introduced the provision for a Dispute Resolution Committee. Even though its composition and mandate is not elaborated, it could also become an agency with due representation from states and various stakeholders for consultative decisions and resolutions related to inter-state and inter-sectoral issues.

Both the states have a strong presence of civil society organisations and people's movements which are engaged with various issues in the basin, like issues around water allocations, pollution, mining, or livelihoods. They have come together during the recent inter-state dispute and debunked the political agenda and propaganda to put forward the need for a people-centred conflict resolution mechanism. This could be a strong platform for demanding a participative governance agenda through mobilisation and information dissemination. Other stakeholders such as research and educational agencies and industrial bodies in the basin also need to be engaged in the process. The fact that the river still flows in many stretches and all the water is not yet allocated for various inter-sectoral and state specific demands opens up opportunities for embarking on an integrated management of the Mahanadi River.

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Annexure

Picture 1: Release of coal washery effluent into Barra Naala, Hasdeo sub-basin

Picture 2: Flyash pollution at Dhengur Naala

Picture 3: Larger stakeholder meetings at Bhubaneshwar and Raipur in 2015 and 2017, respectively

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- Reform Initiatives in Domestic Water and Sanitation in India
- Right to Water in India: Privileging Water for Basic Needs
- Right to Sanitation in India: Nature, Scope and Voices from the Margins
- Mahanadi River Basin: A Situation Analysis
- Groundwater Resources and Governance in Kerala: Status, Issues and Prospects
- Hasdeo Basin: A Situation Analysis in the Context of Environmental Flows
- Competition and Conflicts around Groundwater Resources in India (Paper)
- E-flows in Indian Rivers-Methodologies, Issues, Indicators and Conditions: Learnings from Hasdeo Basin
- Water Allocations and Use in the Mahanadi River Basin: A Study of the Agricultural and Industrial Sectors

Policy Briefs

- Water Entitlements and Allocations for Basic Needs, Environment, Livelihoods and Socio-cultural Needs: a Framework for Preventing and Managing Water Conflicts
- Towards a New Legal and Institutional Framework around Water: Resolving Water Conflicts in Equitable, Sustainable and Democratic Manner
- Resolving Upstream-Downstream Conflicts in River Basins
- Right to Sanitation: Position Paper of Right to Sanitation Campaign in India
- City Makers and WASH: Towards a Caring city
- Sanitation Rights and Needs of Persons with Disabilities
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Forum Publications

Books, Reports and Paper

- Water Conflicts in India: A Million Revolts in the Making (Routledge Publication)
- Life, Livelihoods, Ecosystems, Culture, Entitlements and Allocations of Water for Competing Uses
- Water Conflicts on India: Towards a New Legal and Institutional Framework
- Linking Lives-Reviving Flows: Towards Resolving Upstream Downstream Conflicts in Chalakudy River Basin.
- Water Conflicts in Odisha: A Compendium of Case Studies
- Floods, Fields and Factories: Towards Resolving Conflicts around Hirakud Dam
- Agony of Floods: Floods Induced water Conflicts in India
- Water Conflicts in Northeast India: A Compendium of Case Studies
- Conflicts around Domestic Water and Sanitation: Cases, Issues and Prospects
- Drinking Water and Sanitation in Kerala: A Situation Analysis
- Reform Initiatives in Domestic Water and Sanitation in India
- Right to Water in India: Privileging Water for Basic Needs
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The Forum and Its Work

The Forum (Forum for Policy Dialogue on Water Conflicts in India) is a dynamic initiative of individuals and institutions that has been in existence since 2004. Initiated by a handful of organisations that had come together to document conflicts and supported by World Wide Fund for Nature (WWF), it has now more than 250 individuals and organisations attached to it. The Forum has completed two phases of its work, the first centring on documentation, which also saw the publication of 'Water Conflicts in India: A Million Revolts in the Making', and a second phase where conflict documentation, conflict resolution and prevention were the core activities. Presently, the Forum is in its third phase where the emphasis is on backstopping conflict resolution. Apart from the core activities like documentation, capacity building, dissemination and outreach, advocacy and policy dialogue, the Forum is intensively involved in right to water and sanitation, agriculture and industrial water allocation and use, environmental flows in the context of river basin management and competition and conflicts around groundwater as part of its thematic work. The right to water and sanitation component is funded by WaterAid India. Arghyam Trust, Bangalore, which also funded the second phase, continues its funding for the Forums work in its third phase.

The Forum's Vision

The Forum believes that it is important to safeguard ecology and environment in general and water resources in particular while ensuring that the poor and the disadvantaged population in our country is assured of the water it needs for its basic living and livelihood needs. The Forum is committed to the core values of equity, environmental sustainability, efficiency, livelihood assurance for the poor and democratisation.

The Forum's Mission

The Forum's mission is to influence policies and actions at all levels and work towards resolving, and preventing water conflicts in an environmentally and socially just manner, and creating awareness for achieving participatory, equitable, and sustainable water use. The Forum aims to carry out these through stakeholder interactions, knowledge creation, policy advocacy, training, networking and outreach.

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