MAHANADI RIVER BASIN

A Situation Analysis

Forum for Policy Dialogue on Water Conflicts in India

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January 2017

Mahanadi River Basin: A Situation Analysis

Contributors: (alphabetically arranged): Craig Dsouza, K. J. Joy, Neha Bhadbhade, Sarita Bhagat, Siddharth Patil and Suchita Jain

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c/o Society for Promoting Participative Ecosystem Management (SOPPECOM)
16, Kale Park, Someshwarwadi Road,
Pashan, Pune 411 008
Maharashtra, INDIA
Tel: +91-20-20251168 / 2588 6542
Fax: +91-020-2588 6542
Email: waterconflictforum@gmail.com
URL: waterconflictforum.org ; conflicts.indiawaterportal.org

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Foreword and Acknowledgement

The Forum for Policy Dialogue on Water Conflicts in India (Forum in brief) in its current third phase of work has taken up specific thematic activities in the Mahanadi basin. This is in addition to its core activities like documenting water conflict case studies, capacity building, advocacy and networking. The three themes chosen for the engagement in the Mahanadi basin are: a) Agriculture and industrial water allocation and use, b) Environmental flows in the context of integrated river basin management, and c) Conflicts and competition around groundwater.

The Mahanadi river basin was chosen for a number of reasons. In the previous phase of the Forum's work, the Odisha Resource Centre was set up to primarily engage with the conflicts over allocation of water from the Hirakud dam. In fact, the civil society groups in this region were very proactive, especially in protesting against the increasing allocation of the Hirakud water to industries. In addition, conflicts were emerging due to the pollution of the reservoir owing to the entry of new thermal and steel plants affecting the downstream villages. The Forum carried out a detailed study to understand the availability of water, its allocation for different uses, various policies, and institutional arrangements with an aim to resolve the emerging conflicts to a certain extent through engagement with different stakeholders. Therefore a knowledge and networking platform was already set up in the Mahanadi basin in the previous phase. In fact, there is a very vibrant civil society in both the states which has been working on critical issues like water privatisation, water diversion from agriculture to industries, pollution, etc.

Second, it was important to choose a basin where all the themes could work in integration. The conflict of allocation of water for industry and agriculture had already emerged around the Hirakud reservoir. Moreover, there is no detailed study on the environmental flows. The increasing number of industries in the basin and development of infrastructures in the upper part of the basin have a direct effect on the flow of water, thereby jeopardising the riverine ecosystem. Similarly, the use of groundwater in the basin is slowly increasing, and it is therefore important to study the emerging competition and conflicts around groundwater for its sustainable management. Also, the two important states of the Mahanadi basin, Odisha and Chhattisgarh, have large marginalised social sections including the Scheduled Castes and Scheduled Tribes. These communities are mostly dependent on forest produce for their livelihood. Many coal and mineral mining industries have emerged in the basin, destroying the forests and thereby affecting the life of these communities.

Unlike some of the other major river systems in the country, for example Krishna, Mahanadi is not a closed basin yet. The water of the Mahanadi is not fully allocated for various human uses. Water still flows in the river and also reaches the sea. With new knowledge and informed civil society action, the water management in the basin can be restructured on sustainable, equitable and democratic lines.

This situation analysis of the Mahanadi river basin is the first in a series of publications planned during the course of this engagement with the basin. The publication is an attempt to briefly profile the basin in terms of key parameters like physiology, geology, hydrogeology, demography, water resource and uses, land use and cropping pattern, mineral resources, fisheries, and the policy and institutional regime. It also discusses some of the emerging critical issues in the basin like environmental flows, water quality, inter-sectoral allocation, inter-state water sharing, and conflicts. We hope the publication would help the readers to develop a baseline understanding of the Mahanadi river basin and its issues.

We have primarily used existing literature and secondary data to prepare this situation analysis of the basin. The insights from the periodic stakeholder meetings have helped in understanding the basin as well as the critical emerging issues. The various government offices from both the states provided us valuable secondary data regarding the basin. We thank all the concerned officers for the support and cooperation. Similarly we also thank all the participants of the various stakeholder meetings, which we organised from time to time, for their critical feedback on the draft version and also for providing valuable information insights about the basin and its issues.

Though the main contributors of this book are, Craig Dsouza, K. J. Joy, Neha Bhadbhade, Sarita Bhagat, Siddharth Patil and Suchita Jain, the thematic team members – A. Latha, Abraham Samuel, Shripad Dharmadhikary and Himanshu Kulkarni -- also helped to finalize the structure of the report and provided inputs from time to time. Similarly Ramya Swayamprakash, Gabriela Quadrado and Nandini Upadhyay – interns with the Forum – also contributed significantly to this publication. Forum thanks each one of them for their efforts.

We would like to acknowledge the financial support and encouragement provided by Arghyam Trust, Bengaluru. We are also thankful to the Steering Committee members of the Forum for the insights and inputs that they provided during the various review meetings.

We are also grateful to other SOPPECOM team members. We thank Neeta Deshpande for the copy-editing, Anuja for the cover and layout and Mudra printers for the production of the report.

Pune
January 2017

Forum for Policy Dialogue on Water Conflicts in India

Acronyms

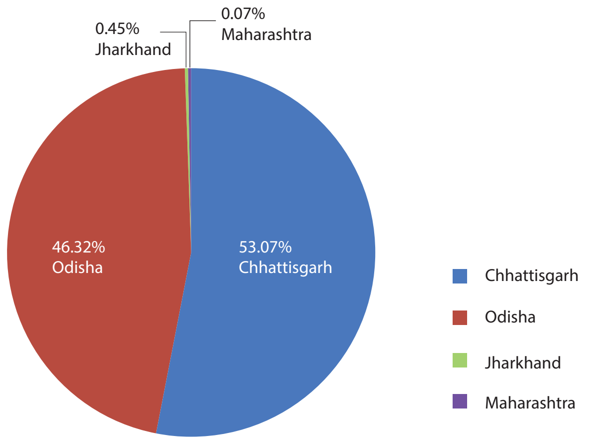
BALCO	Bharat Aluminium Company Ltd.
BCM	Billion Cubic Meters
BOD	Biochemical Oxygen Demand
CAF	Combined Application Form
CCA	Cultivable Command Area
CIPB	Chhattisgarh Irrigation Project Board
CGWB	Central Groundwater Board
CSIDC	Chhattisgarh State Industrial Development Corporation
CWC	Central Water Commission
DEM	Digital Elevation Model
DES	Directorate of Economics and Statistics
DIC	District Industries Centre
DIPC	District-Level Investment Promotion Committee
DLNA	District Level Nodal Agency
DLSWCA	District Level Single Window Clearance Authority
DO	Dissolved Oxygen
DoWR	Department of Water Resources
EC	Environmental Clearance
EIA	Environmental Impact Assessment
FFDA	Fish Farmers Development Agencies
GoC	Government of Chhattisgarh
GoO	Government of Odisha
GIS	Geographical Information System
GSDP	Gross State Domestic Product
HLCA	High Level Clearance Authority
IMD	Indian Meteorological Department
IPICOL	Industrial Promotion and Investment Corporation of Odisha Limited
IWRM	Integrated Water Resources Management
JSPL	Jindal Steel and Power Limited
KBSS	Kelo Bachao Sangharsh Samiti
LULC	Land Use and Land Cover
MAF	Million Acre Feet
MCM	Million Cubic Meters

MoA	Ministry of Agriculture
MoEF	Ministry of Environment and Forests
MTPA	Metric Tonnes Per Annum
MUY	Matsyajibi Unnayana Yojana
NRSC	National Remote Sensing Centre
NTPC	National Thermal Power Corporation
OWRCP	Orissa Water Resources Consolidation Project
OWPO	Odisha Water Planning Organisation
RBO	River Basin Organisation
SAIL	Steel Authority of India Limited
SIPB	State-level Investment Promotion Board
SLNA	State Level Nodal Agency
SLSWCA	State Level Single Window Clearance Authority
UIP	Ultimate Irrigation Potential
WAC	Water Allocation Committee
WRB	Water Resources Board
WRD	Water Resources Department
WUA	Water Users Association

1. Introduction: The Mahanadi Basin

The Mahanadi river originates about 6 km away from Pharsiya village in Dhamtari district of Chhattisgarh, and after traversing a distance of 851 km, meets the Bay of Bengal (India-WRIS, 2016). The Mahanadi, which also means 'mighty and great river', is a lifeline for the people of Chhattisgarh and Odisha. The Mahanadi basin extends over an area of 141,589 km^2, which represents 4.3% of the total geographical area of the country (India-WRIS, 2016). The basin covers a majority of Chhattisgarh and Odisha states, with a meagre portion covering the states of Jharkhand (0.45%) and Maharashtra (0.07%) (Figure 1). The Mahanadi basin caters to 38,606,665 persons who are dependent on it for their domestic needs and livelihoods (Census, 2011). The other important uses of the river include agriculture, industries, fisheries, navigation and tourism. Further details about its physiography, geology and hydrology are described in the next section.

Figure 1: State-wise drainage area of the Mahanadi basin



1.1 Physiographic Features

Physically, the basin is bounded in the north by the Central India Hills, the Eastern Ghats in the south and east, and the Maikala Hill Range in the west, lying within geographical co-ordinates of 80°30′ E to 86°50′ E and 19°20′N to 23°35′N. Thus, physiographically, the Mahanadi basin can be divided into four regions:

a. The northern plateau;

b. The Eastern Ghats;

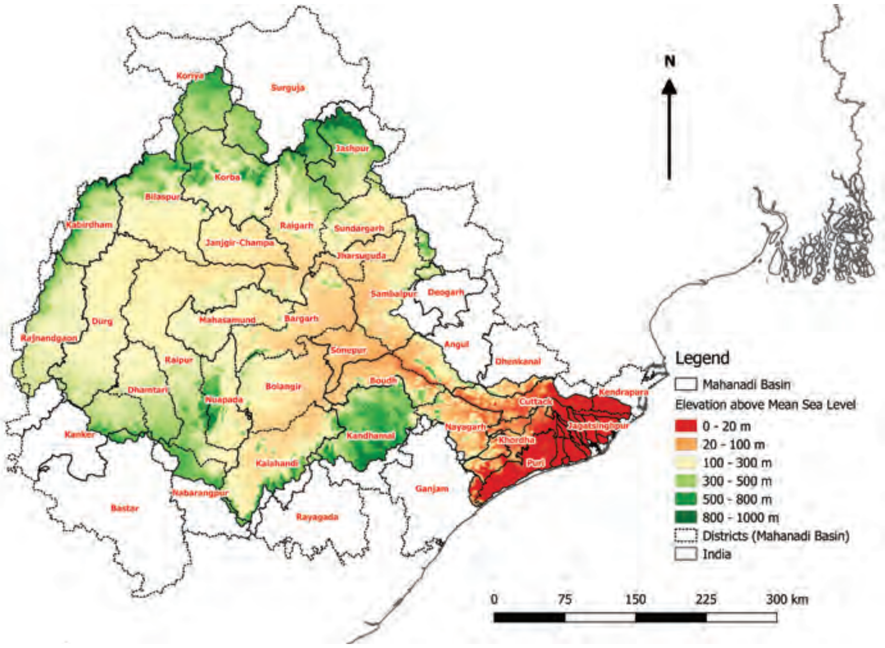
c. The coastal plain; and

d. The erosional plains of the central table land (India-WRIS, 2016)

The first two are hilly regions. The coastal plain is a very fertile delta region while the central table land is the central interior region of the basin, traversed by the river and its tributaries.

A Digital Elevation Model (DEM) of the basin shows an elevation ranging between 800 metres and 20 metres above mean sea level (MSL). Chhattisgarh and some parts of Odisha which are at a high elevation correspond to the forest areas in the basin. The elevation starts decreasing towards the delta region in Odisha.

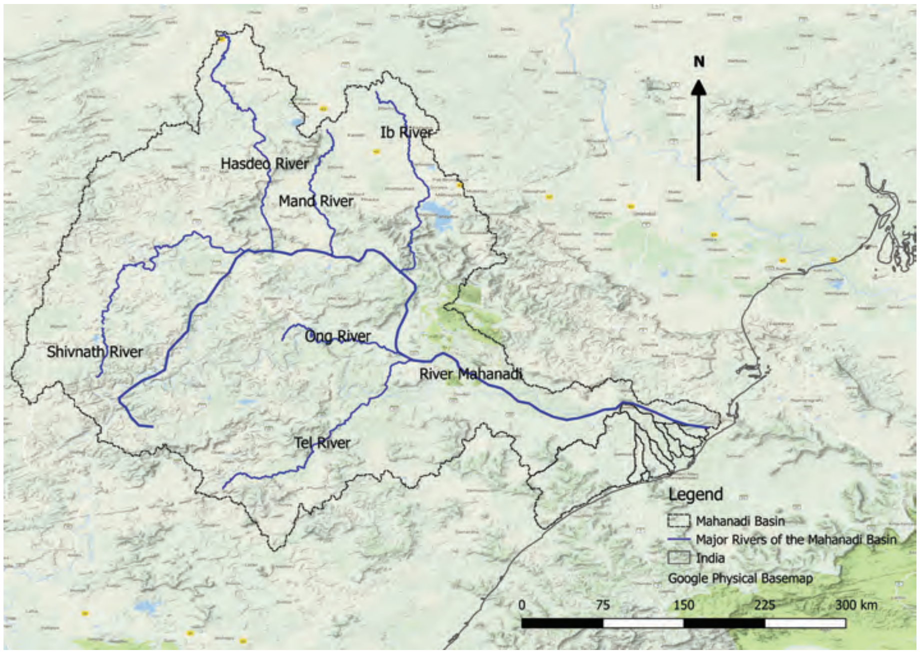
Figure 2: Digital Elevation Model (DEM) showing the lowest and highest points of elevation in the Mahanadi basin



Source: Global 30 Arc-Second Elevation (https://lta.cr.usgs.gov/GTOPO30)

The three major tributaries of the Mahanadi are the Seonath (also known as the Shivnath river), Ib and Tel. Seonath and Ib join the Mahanadi on its left bank upstream of the Hirakud reservoir, whereas the Tel joins the Mahanadi on its right bank downstream of the Hirakud reservoir. The other important tributaries of the Mahanadi are the Hasdeo, Mand, Kelo, Jonk and Ong.

Figure 3: Map showing the tributaries of the Mahanadi river

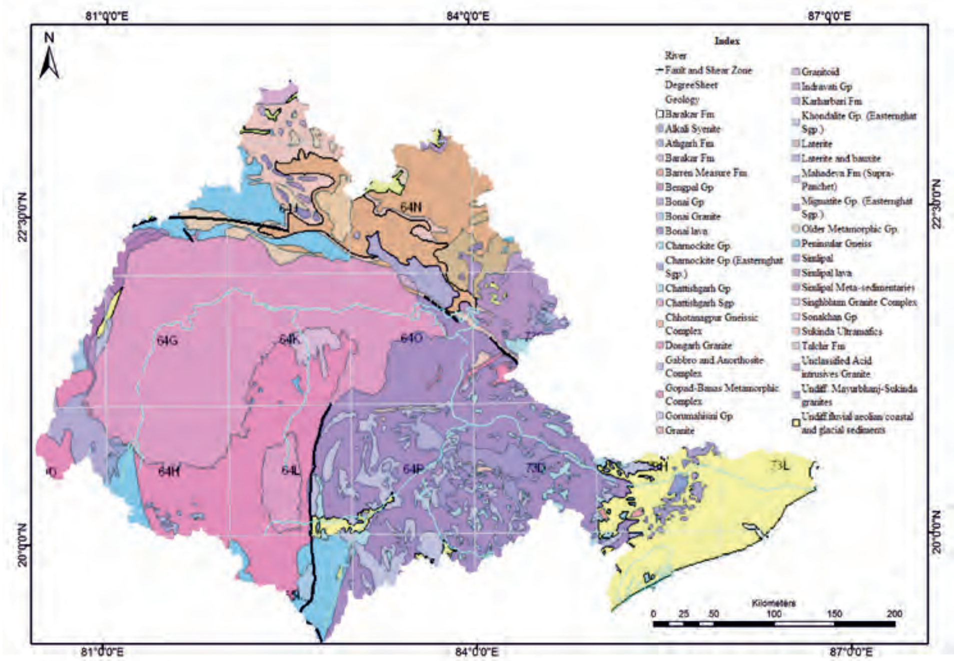


1.2 Geological Features

The Mahanadi basin is characterised by a wide variety of geological formations with a great diversity in rock types. The age of rocks occurring in the basin ranges between Archaean and Recent, which covers the entire geological time scale of the earth. The major rock types observed in the basin include gneisses and sedimentary rocks belonging to the Gondwana Supergroup — mainly sandstones, shales and limestones. Khondalites, charnockites, leptynites, quartzites and minor basic granulites, gneisses, migmatites, anorthosites, granites and minor basic intrusives of the Precambrian age belonging to the Eastern Ghat Supergroup are also observed in the basin. The sedimentary rocks in the drainage basin are chiefly conglomerates, sandstones, quartzites, shales and limestones (Ray, Mohanti and Somayajulu, 1984). The eastern part of the basin is covered by recent alluvium formed in the delta of the Mahanadi river. The delta is arcuate[1] in shape and is traversed by northeast-southwest, east-west and north-south trending lineaments.

Figure 4 shows that the Mahanadi basin is a highly 'lithodiverse' basin comprising of various rock types. This diversity in the geological setting not only defines the geomorphologic and drainage characteristics at the sub-basin scale, but also indicates a large variation in soil types and hydrogeological characteristics, including the geometry of aquifer systems (Kulkarni, 2014).

Figure 4: Geological map of the Mahanadi river basin



1.3 Hydrogeological Features

The diversity in the geological settings of the Mahanadi basin is reflected in the hydrogeological settings of the basin. The hydrogeological formations in this basin are dominated by crystalline and hard sedimentary systems (indicated by pink and dark blue colours in Figure 5). These are followed by the alluvial (yellow) and the soft sedimentary systems (light blue). Each of these systems possesses different characteristics with regards to the aquifer settings. A summary of the aquifer characteristics is given below

1 Arcuate delta is a triangle shaped delta which is formed when the river water is as dense as sea water.

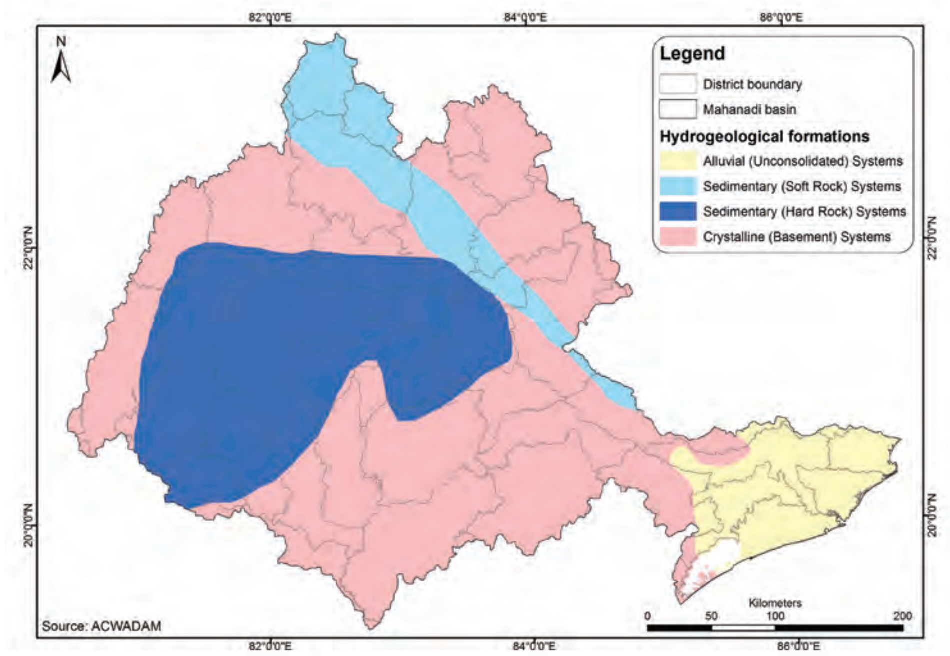
(a) Alluvial systems: These are regional systems with deep multi-layered aquifer systems with generally higher yielding wells.

(b) Soft sedimentary systems: These are local systems with shallow aquifers hosted in the weathered zones with moderate to good yields.

(c) Hard sedimentary systems: These are also local aquifer systems which can be weathered and fractured rocks. Groundwater yields can be low to moderate.

(d) Crystalline basement systems: These are local systems largely dependent on the weathered profile. Water quality issues such as fluoride are common while groundwater yields are generally the lowest amongst all hydrogeological formations.

Figure 5: Regional hydrogeological settings of the Mahanadi river basin

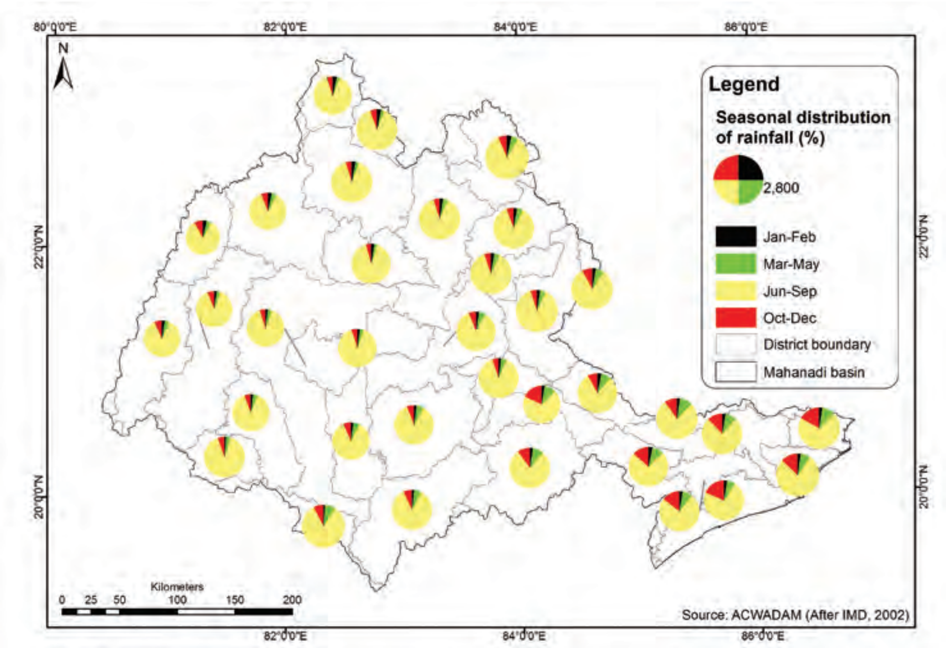


1.3.1 Precipitation

Based on the Indian Meteorological Department's (IMD) annual district rainfall figures from 1901–2000, the calculated average rainfall in the Mahanadi basin is 1406 mm. Overall, the Mahanadi basin is a high rainfall region; the lowest annual average being 1080 mm in the Kawardha district of Chhattisgarh, while the Jashpur district of Odisha has the highest annual average rainfall of 1653 mm. The western portion of the basin bordering Maharashtra receives the lowest rainfall. The central part of the basin receives moderate rainfall, while the northern, southern and the delta regions experience the highest rainfall in the basin.

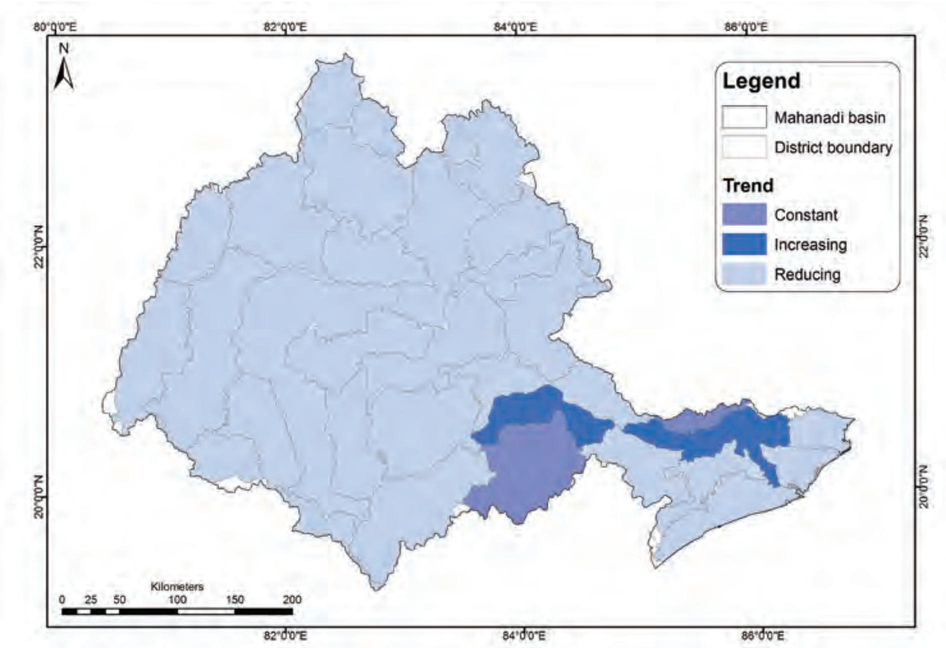
Figure 6 plots the seasonal distribution of rainfall in the basin. Most parts of the basin receives 80–90% of its annual rainfall from the southwest monsoon (i.e. from June to September). However, the amount of rainfall received is dependent on the location in the basin. For example, as compared to the other parts of the basin, the districts located near the delta receive less rainfall (about 60–70% average annual rainfall) between June to September, but receive more rainfall (about 10–22% annual rainfall) from the northeast monsoon (i.e. from October to December). The districts with higher rainfall between October and December also show a marginal increase in the rainfall during March to May as compared to the basin average for this period.

Figure 6: Seasonal distribution of rainfall as a percentage of the annual average



IMD's 100-year district level data was also used to generate trends in the rainfall in the respective districts. Figure 7 is a map of the linear trends observed on plotting the 112 year (1901–2012) IMD district level data set. Majority of the districts in the basin show a reducing trend computed from the long-term average rainfall. Only two districts each show a constant trend and an increasing trend.

Figure 7: Trends in annual rainfall in the Mahanadi basin



Source: District level 100 year IMD data

Note on the dataset used for analysis:

The dataset used for the analysis of rainfall for the Mahanadi basin is IMD's 100-year data between 1901 and 2000. The IMD has released monthly totals for districts for the years 2004 to 2012. This data has also been used in this analysis. Data for the years 2000 to 2003 is not available in the public domain. Certain problems with the data need to be mentioned and these are listed below:

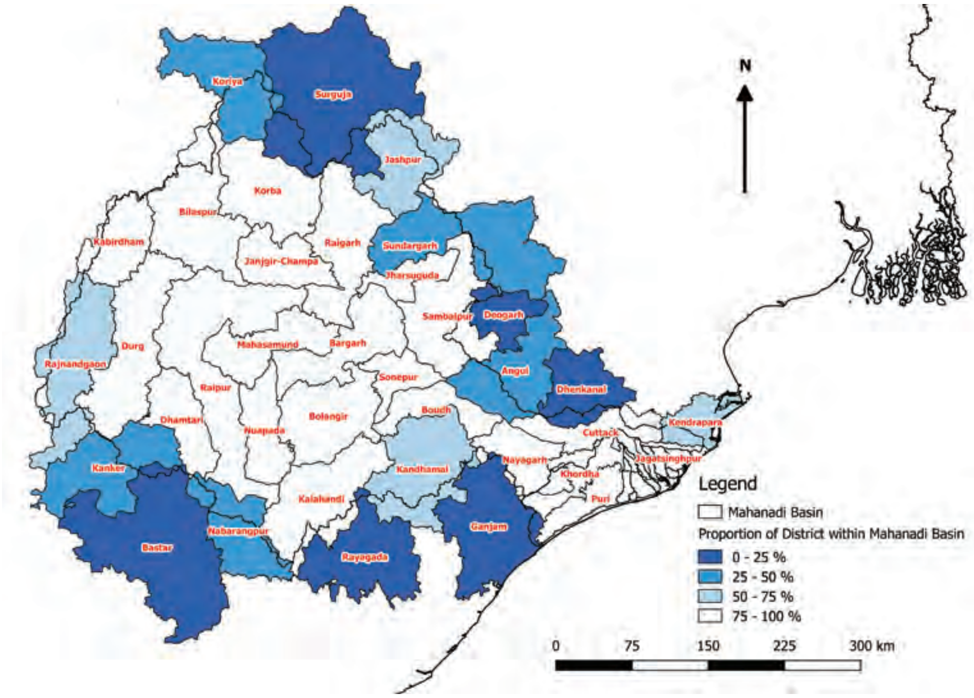
- The data set includes monthly totals for 108 years for districts. The Mahanadi basin boundary is not a perfect fit with the districts' administrative boundaries and some of the districts are partly covered by the river basin. While the rainfall in itself cannot be factorised to fit the actual district areas in the basin, any calculations for quantifying the amount of water in the basin need to consider the district's area falling in the basin.
- There are significant gaps in the data which includes missing values for monthly and annual totals. Entire years' data for multiple years is also missing from the data set in various districts. The trends presented in this report may be affected by these gaps.

2. Demographic Context

The Mahanadi river and its tributaries drains through 37 districts; 15 districts in Chhattisgarh[2] which forms the initial course of the basin and 22 districts in Odisha, forming the middle and lower part of the basin. Most of the districts lie completely within the basin while a few others lie partially within it. An approximate factorisation has been carried out using geographical information system (GIS) and the districts have been classified into four categories as shown in Figure 8.

As per the 2011 census, the approximate population[3] in the basin is 38.6 million (38,660,665), an increase by 1.9% from 2001 (32,491,065). Between 2001 and 2011, the decadal increase in population for the Chhattisgarh region of the basin was 2.42% and for Odisha region, 1.42%. The total number of households (HHs) in the basin is about 8,793,033 and the population density is 273 persons per square km. As per population statistics for 2001 and 2011, Raipur is the most populated district in the basin, followed by Durg and Cuttack (Census, 2011).

Figure 8: Map showing percentage area of the districts falling within the Mahanadi basin



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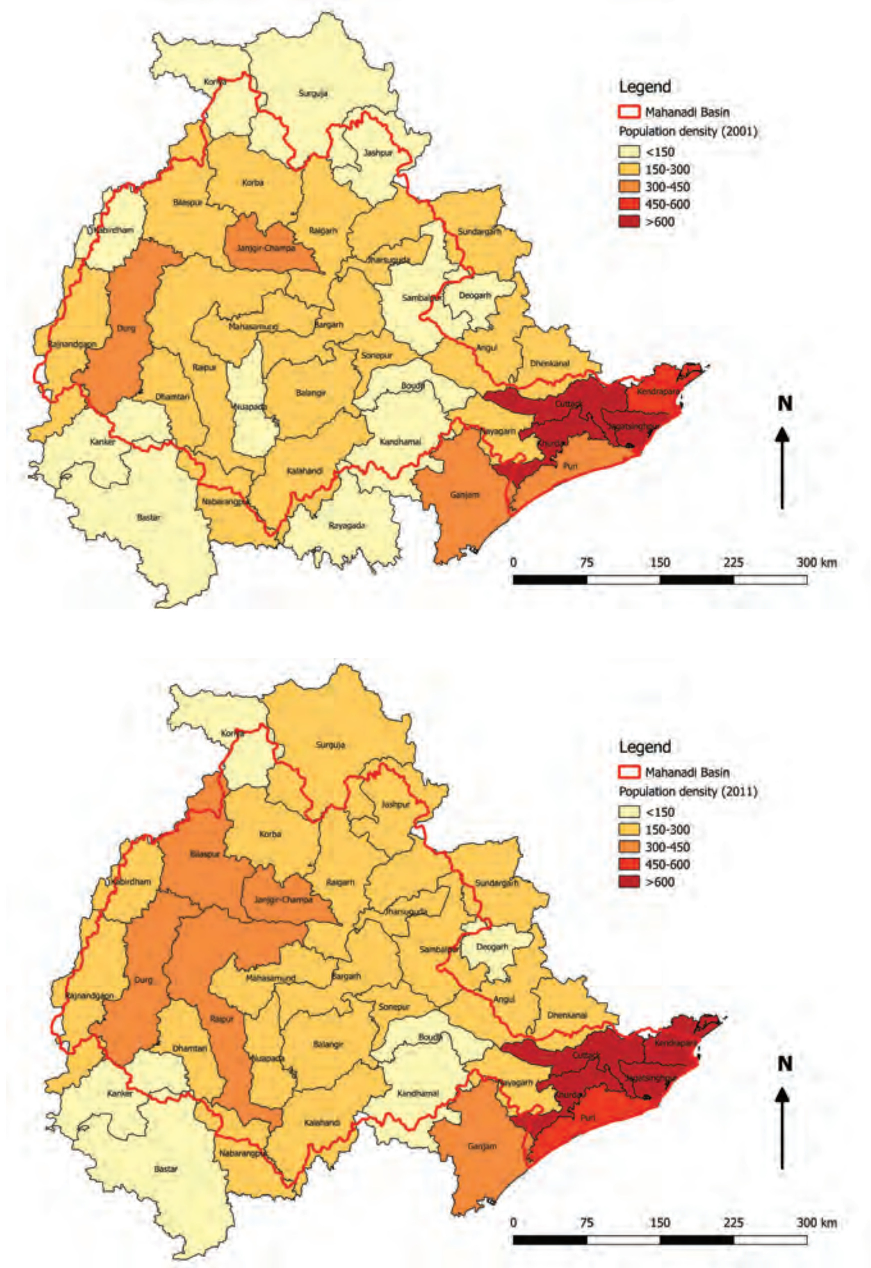
2 After 2005–06 and 2011–12 again, the old districts were split and new districts were formed. Thus, the total districts in Chhattisgarh that come under the Mahanadi basin is 24. However, for the purpose of analysis, all the information of the new districts was consolidated to correspond to the old districts.

3 The 2011 population has been factorised as per the representation of the districts in the basin. See Table A.1 in the appendix section.

Figure 9: Changes in the population density from 2001 to 2011

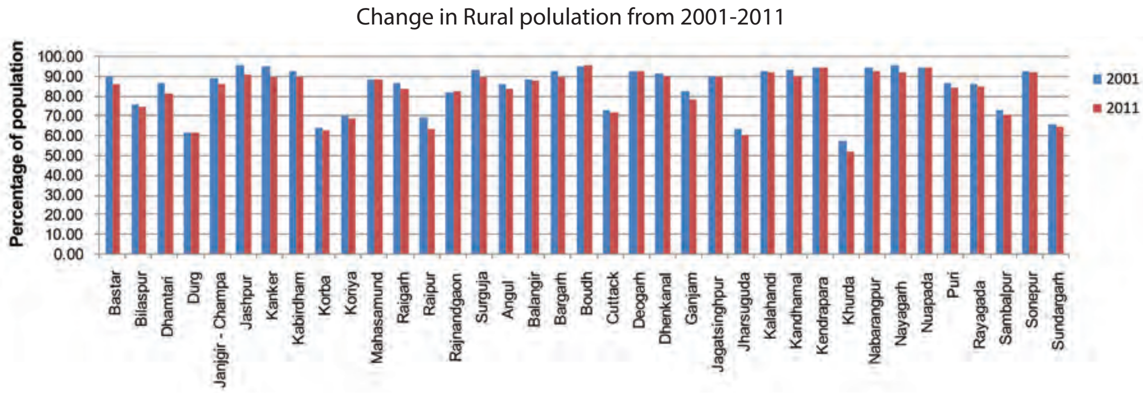


Source: Census data for 2001 and 2011

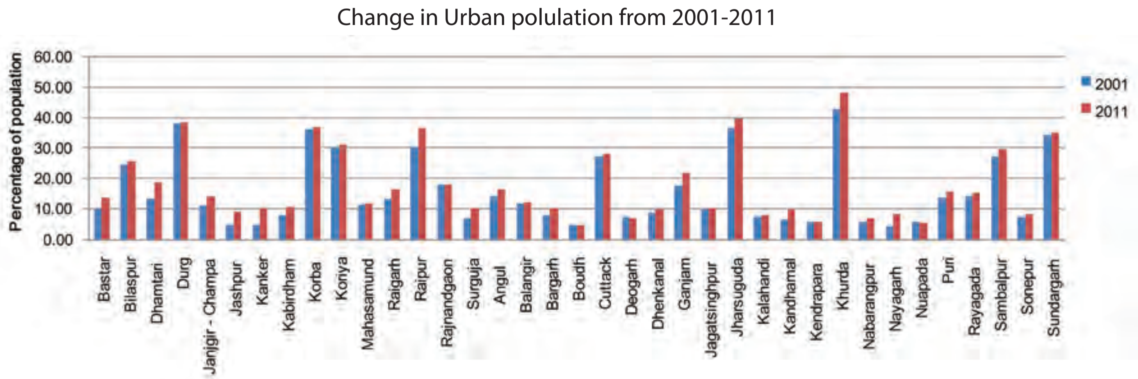
2.1 Rural and Urban Population

In the Mahanadi basin, 77.19% (29,840,819) of the population live in rural areas (Census, 2011). However, there has been a 1.53% increase only in the rural population since 2001 (25,867,736). Between 2001 and 2011, rapid urbanisation has taken place in Jashpur and Kanker districts of Chhattisgarh and Ganjam and Khurda districts of Odisha. The rural-urban population ratio in the Khurda district of Odisha is the highest, which was 57:43 in 2001 while in 2011 it reached 52:48.

Figure 10: Change in the rural (a) and urban (b) population between 2001 and 2011



10(a), Source: Census data, 2001 and 2011

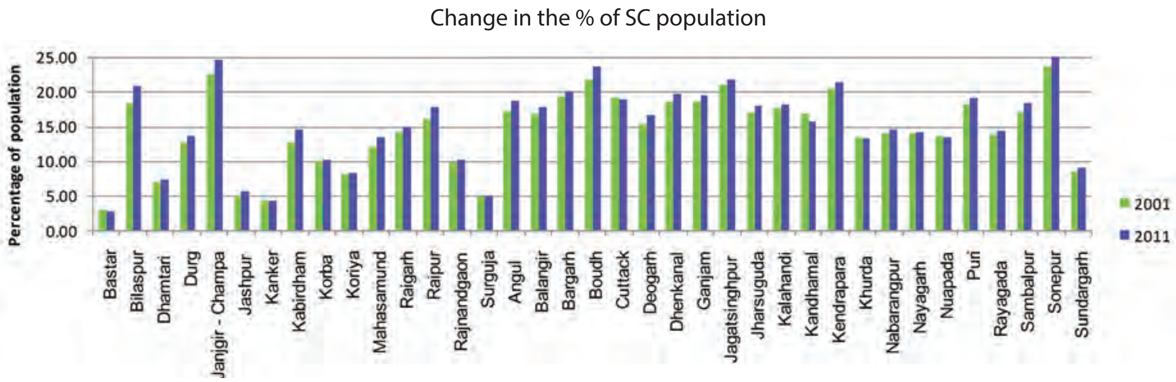


10(b), Source: Census data, 2001 and 2011

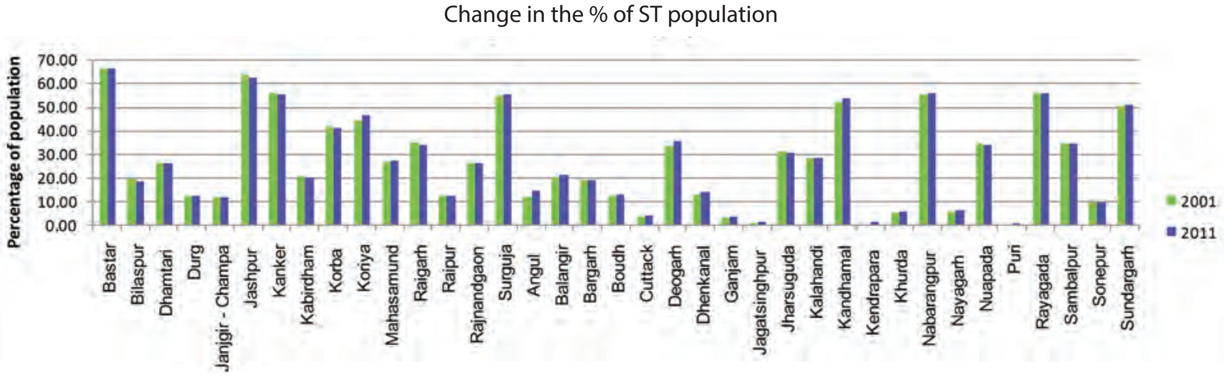
2.2 Scheduled Caste and Scheduled Tribes Population

According to the 2011 census, about 16.50% (6,379,326 persons) of the population in the basin belongs to the Scheduled Castes (SC), while19.23% (7,437,634) belong to the Scheduled Tribes (ST). The Janjgir-Champa district in Chhattisgarh and Subarnapur (now Sonepur) district in Odisha have the highest SC population, whereas Bastar district in Chhattisgarh and Rayagada district in Odisha have the highest ST population.

Figures 11: Changes in the SC (a) and ST (b) population between 2001-2011



11(a), Source: Census data, 2001 and 2011

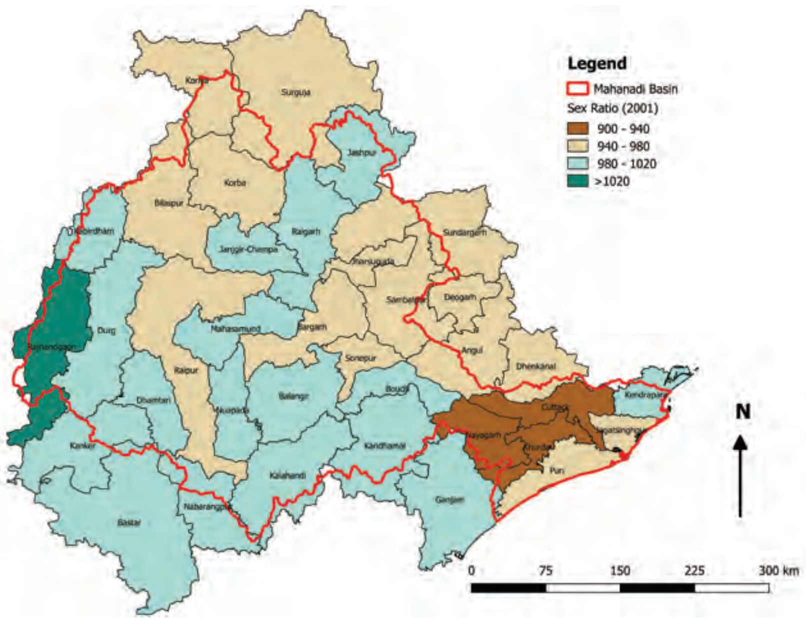


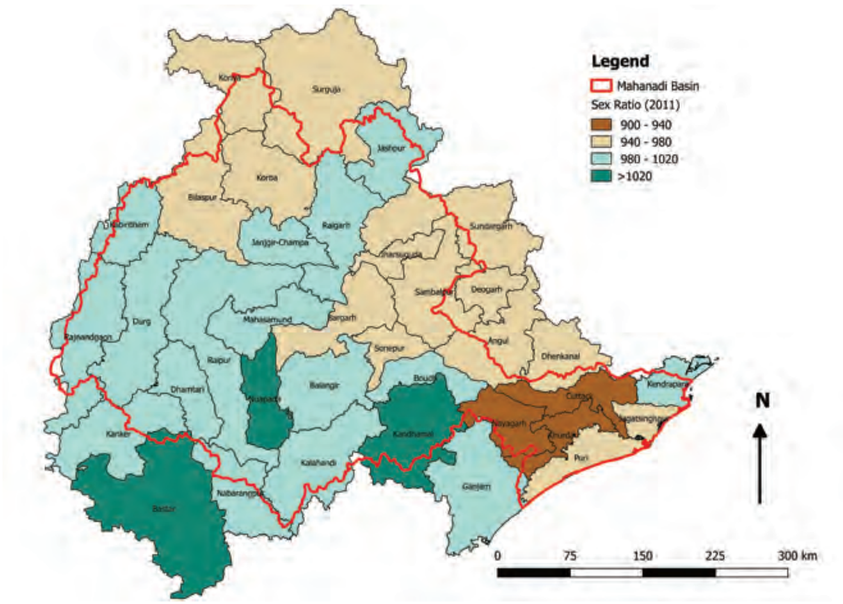
11(b), Source: Census data, 2001 and 2011

2.3 Sex Ratio

The sex ratio in the basin has improved marginally from 975 females per 1000 males in 2001 to 978 females per 1000 males in 2011. In Bastar a large population belongs to the tribal community, and the sex ratio is 1078 females per 1000 males. In Odisha, Rayagada, again a predominantly tribal district, has 1051 females per 1000 males. The lowest sex ratio is observed in the Nayagarh district of Odisha.

Figure 12: Changes in the sex ratio from 2001 to 2011



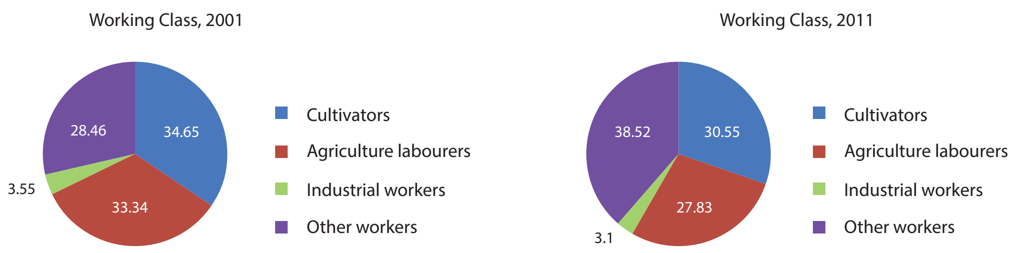


Source: Census data of 2001 and 2011

2.4 Literacy Rate and Working Population

The literacy rate in the basin is 65.49% (25,317,044), with the highest literacy rate observed in Raipur, followed by Durg and Cuttack districts. The lowest literacy rate is seen in Rayagada district of Odisha, which also has the highest ST population. About 44.04% (17,026,642) of the population in the basin are workers and 55.96% (21,634,023) are non-workers[4] (Census, 2011). The number of workers has increased since the last decade by 2.18%. The number of marginal workers[5] has increased from 27.70% (3,712,257) in 2001 to 32.55% (5,541,793) in 2011. The working class can be categorised into cultivators or farmers, agricultural labourers, industrial workers and other workers (which include people working in the government and private sector). Figure 13 provides a comparative picture of the main working class categories. The number of cultivators and agriculture labourers have reduced, whereas the category of 'other workers', which includes people working in the informal and unorganised sector, has increased by 10% in the last decade.

Figure 13: Comparison between the working categories in 2001 and 2011



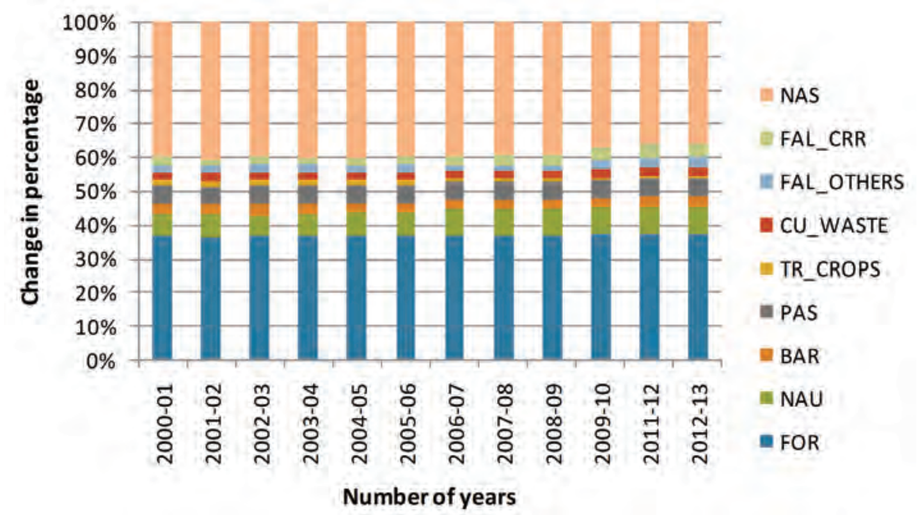
4 Non-workers are people who do not work at all, a majority of whom are students, elderly people, and pensioners who are not included in any economic activity.

5 Marginal workers are those people who have not worked for the major part of the reference point (i.e. less than 6 months). https://data.gov.in/catalog/main-workers-marginal-workers-non-workers-and-those-marginal-workers-non-workers

3. Land Use

The dominant land use in the Mahanadi basin[6] (Directorate of Economics and Statistics, Ministry of Agriculture) is for agriculture, with approximately 37% of the land area (54,066 km^2) of the basin counted as 'Net Area Sown'. This number has fallen from 40% to about 37% largely due to a drop in the net area sown in Odisha from 38% to 31%. The Net Area Sown in Chhattisgarh remains relatively constant at 41%.
The data for the landuse and land cover has been obtained for the years 2000–01 to 2013–14 from two sources, namely, the Directorate of Economics and Statistics (DES)[7], Ministry of Agriculture (MoA), Government of India for both the states, and the Bureau of Economics and Statistics (BES), Government of Odisha. Data for the year 2010–11 for Odisha has some gaps and hence is not included in the analysis. Figure 14 shows the changes in land use from 2000 to 2013 in the Mahanadi basin, while Figure 15 shows land use changes for districts in Chhattisgarh and Odisha that falls under the basin, respectively.

Figure14: Land use change in the Mahanadi basin from 2000 to 2013



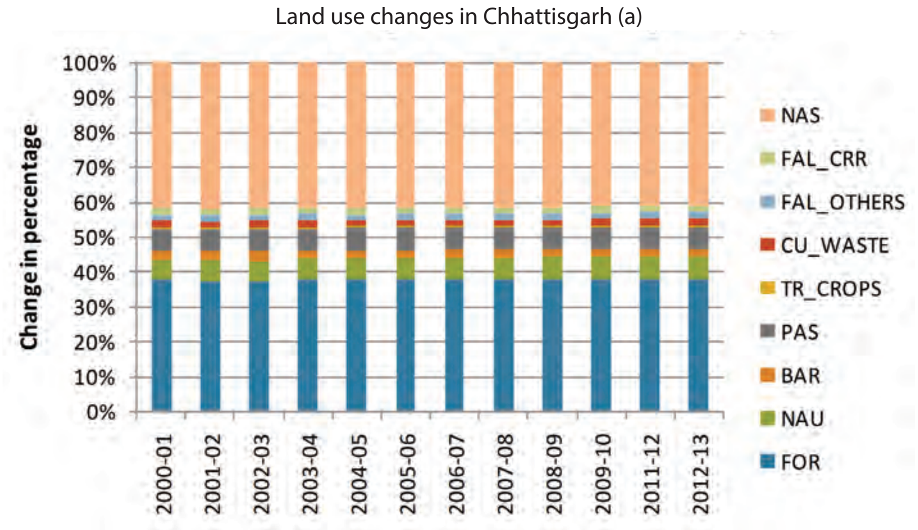
Source: Directorate of Economics and Statistics, Ministry of Agriculture, Govt. of India

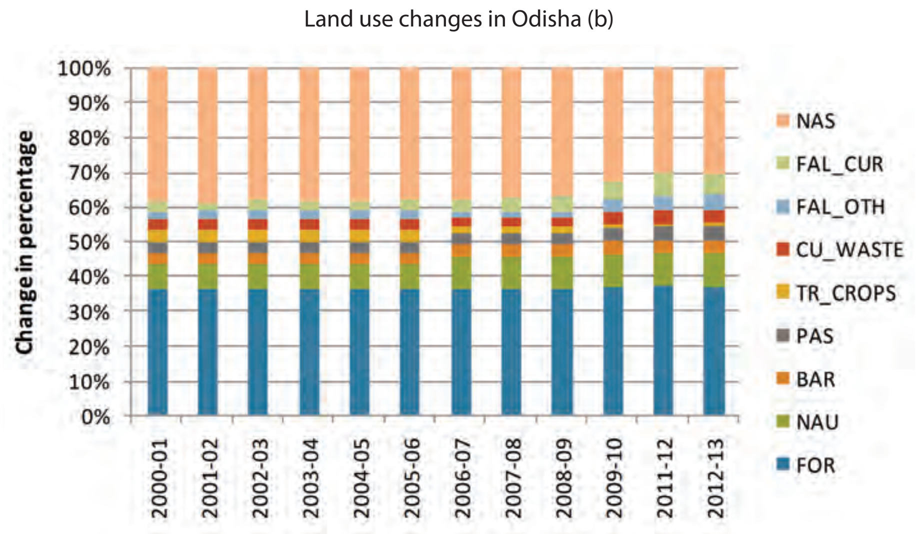
Indicators:
FOR= Forests; NAU= Area under non-agriculture use like built up-area; BAR= Barren and un-culturable land; PAS= Permanent pasture and other grazing land;TR_CROPS= Tress not included under net sown area; CU_WASTE= Culturable waste land; FAL_CRR= Fallow Current; FAL_OTHERS= Fallow Others other than current fallows; NAS= Net sown area

6 The land use statistics of the Mahanadi basin were compiled forthe selected 37 districts of the two states by multiplying the value for each land class by the percentage area of the district that lies within the Mahanadi basin. This method has its shortcomings since the land classes in each district are not distributed uniformly spatially. However, it provides a reasonably approximation for our understanding.

7 Data from the DES for Odisha appears to have large errors, but due to it being the most comparable dataset available, its figures have been used for further analysis. They must be interpreted with caution. The BES dataset for Odisha provides a point of comparison for cropping data.

Figures 15: Land use changes in Chhattisgarh (a)and Odisha (b) from 2000–01 to 2012–13





Source: Directorate of Economics and Statistics, Ministry of Agriculture, Govt. of India

According to Figure 15(a), the forest area has remained more or less the same at about 37% for both the states. The net area sown shows a decreasing trend[8], whereas the non-agricultural area (which includes built-up area) is showing an increasing trend, especially in the Odisha region (Figure 15b). One of the reasons for the decreasing trend in the Net Area Sown maybe that people have shifted to urban areas for better livelihood options. In Chhattisgarh, the stretch between Durg and Raipur city is developing into a larger metropolitan region. Bilaspur and Korba, the other major urban areas of Chhattisgarh, also show

8 It must be noted that in comparison with the National Remote Sensing Centre (NRSC) satellite data, the DES Land Use and Land Cover (LULC) data shows much less agricultural area in the basin —37% vs 48% (NRSC) and also much less forested area — 37% vs 30% (NRSC).

expansion. Bilaspur is developing into a major city, whereas Korba has developed fast as an industrial zone. In Odisha, the major built up areas are limited to the industrial areas in Jharsuguda, north of the Hirakud reservoir, and the cities of Bhubaneshwar and Cuttack near the Bay of Bengal. Pastures account for 6% of the basin area, while barren land is 3%. The cultivable uncultivated land (i.e. culturable wasteland, other fallow land and other current fallow land) make up 9% (14,011 km^2) of the basin area.

Due to the possibility of large errors in this state MoA dataset, arising from the method of data collection, land use classes were also verified using a composite land use map generated by the National Remote Sensing Centre (NRSC) from satellite images of the Mahanadi river basin. The results obtained are below. The thematic land use map of the NRSC shows the Mahanadi basin as largely being under rural land use, with about 48% (68,719 km^2) of its geographical area currently cropped[9]. This is substantially larger than the 37% cropland as per the MoA data. About 30% is land that is cropped in the Kharif season only, whereas about 15% is cropped more than once. The remaining 3% is either land that is cropped in the Rabi only or zaid (summer) only. Another 25% of the river basin is deciduous forest. When evergreen and scrub forests are counted, the total forest area adds up to 30.5% (43,808 km^2). This is substantially lower than the 37% of forests as per the MoA data, however, still higher than the average forest cover in India. This is representative of the comparatively untouched and undeveloped nature of the river basin in some parts. Within Odisha, large parts of the central region are forested and in Chhattisgarh, the northern part of the basin is forested.

Table 1: Land Use Classes as per NRSC

Class	% of Total Geographical Area (in 2004–05)	% of Total Geographical Area (in 2013–14)
Net Area Sown (Kharif only + Rabi only + Zaid only + Double/Triple cropped)	42.9 (61476 km^2)	48 (68719 km^2)
Current fallow	17.3 (24749 km^2)	10.8 (15507 km^2)
Forests (Deciduous forest + Evergreen forest + Scrub/Deg forest)	30.2 (43306 km^2)	30.5 (43808 km^2)
Built up	0.4 (644 km^2)	0.5 (780 km^2)
Plantation/Orchard	0.4 (627 km^2)	0.5 (784 km^2)
Grassland	0.4 (551 km^2)	0.1 (190 km^2)
Scrubland	3.7 (5253 km^2)	3.8 (5460 km^2)
Gullied	0.3 (371 km^2)	0.2 (341 km^2)
Other Wasteland	1.6 (2301 km^2)	2.0 (2880 km^2)
Water Bodies	2.8 (3961 km^2)	3.3 (4771 km^2)

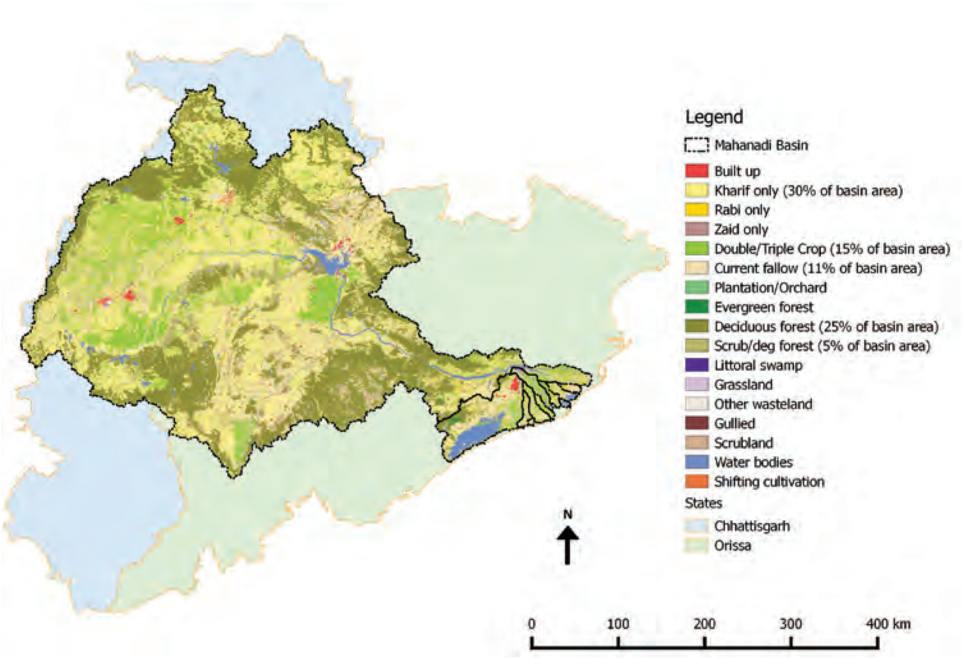
Source: National Remote Sensing Centre

9 Source: LULC Thematic Maps (2004–05 to 2013–14)(1:250k) Bhuvan Thematic Series, National Remote Sensing Centre, Hyderabad. (Analysis done with the QGIS, semi-automatic classification plugin tool.) As per NRSC, the accuracy of these maps varies and is about 79% for cropped lands and 98% for water bodies.

In the last decade since 2004–05, land cropped in the Kharif season only (i.e. largely rainfed land) has decreased marginally to 30% and land cropped twice or thrice (i.e. irrigated land) has increased substantially, from about 8% to 15%. The largest increases in irrigated land are in the plains of Chhattisgarh, with the development of major irrigation projects in the upper reaches of the Mahanadi and Seonath rivers. Fallow lands in the basin have decreased from about 17% to about 11% (15,507 km^2) in the last five years or so. This is in contrast to the MoA data which shows that fallow and culturable wastelands have increased from 7% to about 9% (14,011 km^2).

The comparison of land use classes given by both the NRSC as well as the MoA datasets shows differences, even in the major classes. NRSC shows that the double or triple cropped area (i.e. irrigated area) has gone up, while net area sown has also gone up, indicating that more agricultural land is being brought under cultivation with the assistance of irrigation. The forest land shown by NRSC, 30%, is far lower than the figure shown by DES, 37%. For our understanding of actual land use and land cover in the basin, it would be preferable to use figures produced by NRSC since the method of data generation is automated and less susceptible to human error. Moreover, land use classification data made available by DES does not necessarily correspond to the actual land use, since for any given plot of land, the land use might change while the classification on paper may remain the same.

Figure 16: Land use map of the Mahanadi river basin



Source: LULC (2013-14), Bhuvan Thematic Services, NRSC

3.1 Forests

As indicated above, according to data obtained from the MoA and NRSC, the area under forests is 37% and 30%, respectively. There are many protected areas and reserved areas marked in the basin. The details of floral and faunal species found in the Mahanadi forests are explained in detail in the biodiversity section below.

In Chhattisgarh, two main types of forests are observed, tropical dry and moist deciduous forests. Teak and Sal are the main tree species found in these forests. The total recorded forests in the state are 59,772.39 km^2, of which 37.79% falls in the Mahanadi basin. According to the 2011 assessment by the Government of Chhattisgarh, there has been a net decrease of 192 km^2 from the total reported area (GoC, 2016).

Like Chhattisgarh state, Odisha too reports tropical dry and moist deciduous forests (58,136 km^2). In addition tropical semi-evergreen (Dhenkanal, Puri, Kalahandi districts) and mangrove forests (Mahanadi delta region) are reported in the Odisha state. Teak, sal, bamboo, *kendu*, and *sundari* are some of the important tree species that exist in these forests.

3.1.1 Biodiversity

Both Chhattisgarh and Odisha states are rich in biodiversity, with abundant forests and unique species of flora and fauna and medicinal plants. In Chhattisgarh, the floral biodiversity is complex, with 1,685 species belonging to 785 genera and 147 families identified and preserved. A total of three national parks and 11 wildlife sanctuaries exist in the state. Ten dominant families from the flora exist in Chhattisgarh—Fabaceae, Poaceae, Cyperaceae, Asteraceae, Euphorbiaceae, Acanthanaceae, Convulvulaceae, Malvaceae, Rubiacaeae and Scorphulariaceae. Some of the most important species identified and of high medicinal value are *neem, amla, bel, beheda, ashwagandha, aloe vera, brahmi, shankhapushpi, kali haldi and sarpa gandha*. Fauna includes tigers, panthers, sambhar, *nilgai, chital*, *munias*, ducks, tree pie, hyena, fox, jackals, otter, civets and barlets (CECB, 2004).

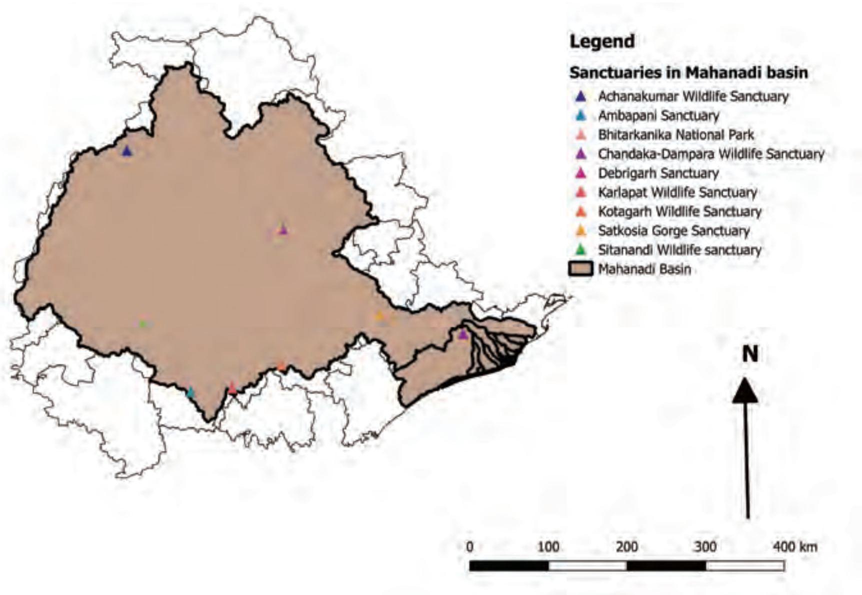
Odisha boasts of several biodiversity hotspots and has varied forests such as semi-evergreen, dry and moist deciduous forests, mangroves and wetlands with endemic, rare and endangered floral and faunal species. The forests in the state are managed by 37 territorial divisions and 13 wildlife divisions. Odisha has two national parks, 18 sanctuaries, and one biosphere reserve. There are three tiger reserves—Similipal, Satkosia and Sunabeda (proposed) and three elephant reserves—Mayurbhanj, Sambalpur and Mahanadi.

Some of the endemic flora that exists in Odisha are, a) **Trees** like *achhu, ambada, char, dhauranja, karada, harida, kendu, kusum, kasi, kumbhi, kangada, mahula, nimbi, phanphana, sal, simili, tentuli, ashoka, chandan, saguan, ritha, arjuna, bela*; b) **Shrubs** like *bana tulasi, bisalya karani, patalgaruda, satabari, sabai grass, kia ketaki*; c) **Herbs** like *apamaranga, bhuinnimba, gheekuanri, palua, kashatandi, salaparni, saptapheni*. In addition, various bamboo species and mangroves like *hental, bani and sundari* exist in the state. Fauna includes, a) **Mammals** including tiger, wolf, leopard, Gangetic dolphin, Irrawady dolphin, porpoise, elephant, antelope, bison and pangolin; b) **Birds** including Dalmatian pelican, giant heron, stork, adjutant, white spoonbill, osprey, falcon, peafowl, skimmer and Malabar pied hornbill; c) **Reptiles** including *ghaggar*, crocodile, Olive Ridley turtle, Green sea turtle, common Indian monitor lizard, Water monitor lizard, Desert monitor lizard and Indian rock python. (Odisha State Forest Department, n.d.(a)).

National Parks and Wildlife Sanctuaries

Using GIS tool, the national parks and wildlife sanctuaries that come under the Mahanadi basin were marked out (Figure 17). The details of the national parks and wildlife sanctuaries are given in Table A.2 in the Appendix section.

Figure 17: National parks and wildlife sanctuaries in the Mahanadi basin



Source: Google Earth

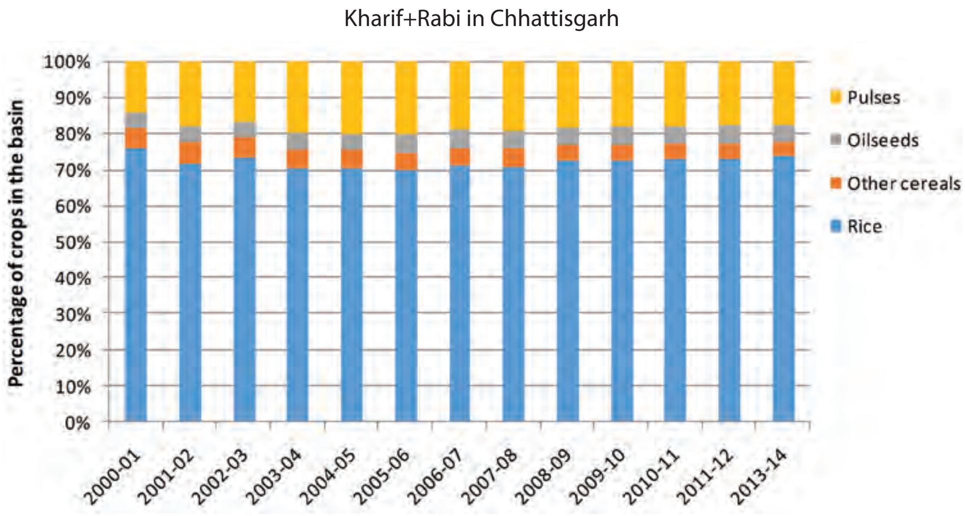
3.2 Agriculture

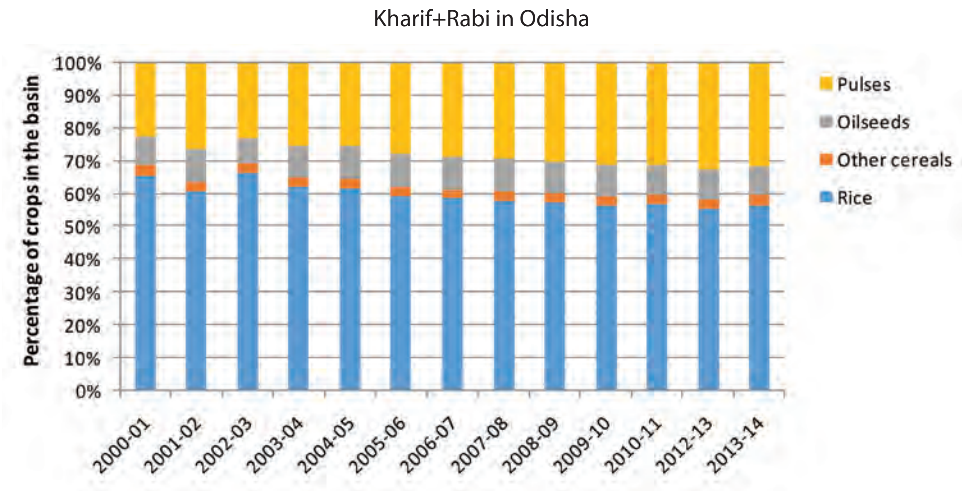
Agriculture is the primary livelihood in the Mahanadi basin. The crops grown in the basin can be categorised as cereals (major crop), pulses, oilseeds, vegetables, fibres and spices and condiments. Among cereals, rice is the major crop in the basin. Other cereals grown in the basin are wheat, small millets and maize. Pulses include moong, biri, khesari, gram and kulthi and oilseeds include groundnuts, soyabean, sesame and mustard.

In the last 10 years, the area under rice cultivation has reduced in the Odisha part of the Mahanadi basin, whereas it has increased in Chhattisgarh[10] (Figure 18). The increase of area under rice cultivation in Chhattisgarh can be attributed to the development of new irrigation projects in the upper parts of the basin. Rice is mainly grown in the Kharif season. As per the data, no rice is reported to be irrigated in the Rabi season in Chhattisgarh, but some summer rice is reported. In Odisha, paddy is grown over three seasons: Autumn (early Kharif), Winter (late Kharif) and Rabi. The area under pulses has increased in both Chhattisgarh and Odisha in the last two decades, while the area under oilseeds has risen in Chhattisgarh and fallen in Odisha.

10 For analysis, data has been sourced from the Directorate of Economics and Statistics (DES), MoA, GoI and Bureau of Economics and Statistics for Chhattisgarh and Odisha. However, due to gaps in the data the years 2011–12 and 2012–13 have not been considered for the states of Odisha and Chhattisgarh respectively.

Figures 18: Major crops grown in the basin[11]





Irrigation plays an important role in ensuring a high yield of crops in addition to other important factors like soil, fertilisers and quality of seeds. The main sources of irrigation in the basin are canals of major and medium irrigation projects, though groundwater has been gaining importance, especially in the western region of Chhattisgarh. The details of these sources for irrigation are explained in Section 4.

In Chhattisgarh, Durg, Dhamtari, Raipur and Janjgir-Champa districts are highly irrigated, whereas Bastar and Jashpur districts are least irrigated. In Chhattisgarh, in the year 2013–14, about 59% of the area is irrigated using canal water and 36% of area is irrigated using groundwater (mainly openwells). The dependency on groundwater for irrigation has increased by 15% since 2000. The Hasdeo-Bango Multipurpose Project is the largest irrigation project in the Chhattisgarh part of the basin, and mainly benefits the Janjgir-Champa district. The Mahanadi Reservoir project is the largest surface irrigation project in Chhattisgarh.

11 In Odisha, the Kharif season is recorded in the data as the Autumn and Winter. This was confirmed from the officials during a field visit.

In Odisha, 33% of the Kharif cropped area and 37% of the Rabi cropped area receive irrigation, largely supported by surface irrigation projects, namely, Hirakud and Mahanadi Delta projects. Puri, Jagatsinghpur and Cuttack are the highly irrigated districts, whereas Balangir, Nabrangpur and Jharsuguda are the least irrigated districts. 10 major irrigation projects help to irrigate the agriculture land in Odisha (given in Table 2). In addition, there are also medium and minor flow projects, minor lift projects and other sources (private lift irrigation, shallow tube wells, creeks, dugwells, and others).

Table 2: Irrigation potential created from the major projects in the Mahanadi basin

CHHATTISGARH	**CCA (Th ha)**	**ODISHA**	**CCA (Th ha)**
Jonk Diversion (2005)	15.5	Hirakud (1957)	157.8
Hasdeo-Bango (2011)	285	Delta Stage I and II*	78
Kelo (ongoing)	24.39	Lower Indra (2012)	29.9
Kharang (1931)	66.4	Lower Suktel (ongoing)	31.8
Kodar (ongoing)	21.7	Mahanadi Birupa Barrage	NA
Mahanadi Reservoir (2011)	301	Mahanadi Chitotpola	19.54
Mand (2000)	11.10	Naraj Barrage (2005)	183.2
Maniyari (1933)	64.77	Salki	19.9
Pairi	33.6	Sunder (1990)	4.6
Rajeev Samwardshan Yojana	28	Upper Indravati (ongoing)	76.27
Sondur Reservoir Project	12.26		
Tandula	246.3		
TOTAL	**1110.02**	**TOTAL**	**601.01**

** The CCA value of Delta stage II project is unknown.*
Source: WRIS, Major projects in the Mahanadi basin

River Bed Cultivation:

During a field visit to the Mahanadi, it was observed that river bed cultivation is a major source of livelihood, especially for the landless farmers. After monsoon, when the water starts retreating, farmers are growing water melons, musk melons, pumpkins and a wide variety of vegetables. In the basin, many barrages or small anicuts are being built which will create small ponds, affecting the farmers who depend on these river beds for their source of livelihood directly. Creating these barrages will also impact the flow of the water which has serious impacts on the river itself and the people dependent on it.

4. Water Use

4.1 Surface Water Availability and Use

The Mahanadi river's surface water has an average resource potential (average anual flows) of 66,880 MCM of which 50,000 MCM is the utilisable water (India-WRIS, 2015; MoWR, 2014). Apart from the rivers, there are other surface water bodies developed in the basin to store surface water. About 3,839 tanks are identified in the basin. Chilika lake in Odisha is the largest freshwater lake in the basin. The basin reports 253 large and small dams, 14 barrages and 13 weirs (MoWR, 2014) which can store ample water to meet various needs like drinking, irrigation, industrial needs, power generation, ecology and tourism. In the basin, there are 22 major irrigation projects, 54 medium irrigation projects and five hydroelectric projects (MoWR, 2014). The total live storage capacity of all the projects in the basin is 14,244 MCM. Of this, the live storage capacity of completed projects is 12,799 MCM, and that of under construction projects is 1,465 MCM (India-WRIS, 2015).

The Jeyaseelan report (2007) estimates the Mahanadi's average annual flows at 59.16 BCM, of which 29.90 BCM is from the catchment in Odisha and 29.26 BCM from that in Chhattisgarh. Of the annual flows, 32.2 BCM (average upto 2013–14) enters as annual inflow into the Hirakud reservoir. At 75% dependability, annual flows in the Mahanadi are 43.80 BCM and the annual inflow into the Hirakud reservoir is 23.5 BCM (Jeyaseelan report, 2007).

In the state water plan of Odisha, at 75% dependability, the average annual flows in the Mahanadi are 48.8 BCM, 25.5 BCM from Odisha and 23.3 BCM from outside (2001 estimate). It is forecasted that in the year 2050, at 75% dependability, the average annual flow will be 50.9 BCM, of which Odisha would contribute 29.9 BCM, whereas the flow from outside the state will reduce to 21 BCM due to upstream withdrawals. The per capita annual dependable water availability in Odisha would decrease from 3007 m^3 to 2017 m^3.

4.1.1 Surface water development in Odisha

Unlike the Gangetic plains, the Cauvery river system, or the Indus valley system, very little was known about the existence of irrigation systems in the Mahanadi delta when the British first came to India. In 1874, J.W. Ottley pointed out that the utility of irrigation was not well known in the Mahanadi basin in general. Wells and canals were non-existent. Irrigation by tanks and lifts from holes in the marshes was practiced till 1866. Irrigation works began in the latter part of the 19th century which encouraged agriculture. Prior to 1850, repair works of old canals and new schemes was started under the Public Works Department (Mahapatra, 2005).

In 1858, Sir Arthur Cotton reported that "control of the Mahanadi is not a question of protection of the town of Cuttack of 35,000 people; it is about the protection of the province, particularly Cuttack and Puri having a population of 1.25 million. The problem of the control of waters in Odisha is similar to that in the Godavari and Krishna deltas". Through his proposal, Sir Cotton called for irrigation and navigation in the Odisha delta, and a main canal to connect the deltas of Calcutta costed about £1,300,000 and could irrigate 2,250,000 acres (Mahapatra, 2005). He suggested the construction of a complete system of irrigation and navigation canals according to the principles then being followed in the deltas of the Godavari and Krishna. The East India Irrigation and Canal Company carried out the construction of the Odisha canal in 1863. However, it was not until the great famine of 1866 that irrigation received attention in Odisha.

Two well-known irrigation systems, i.e Odisha canal and Rushikulya canal systems, were developed during the period 1860 to 1910. While the latter is restricted to the Rushikulya basin[12], the former extends to the deltaic plain. Both systems are almost contemporary, integrated with nature and exclusive of each other. However, the Odisha canal system is much broader in dimension, interlinks three major river systems, has multi-dimensional objectives, and has shaped the history and tradition of Odisha over the years. Between 1893 and 1895, Odisha saw the construction of seven weirs across river channels, primarily in Cuttack. The original three weirs constructed to control the Mahanadi were Naraj, Mahanadi and Birupa, while the other four weirs were built on the Brahmani and Baitarani. The maximum discharge of the canals in 1895 and 1896 was 6,058 cubic feet per second, while the command area was 5,620,000 acres (Mahapatra, 2005).

Hirakud major irrigation project: The Hirakud project involved the construction of one of the largest dams in Odisha state, the Hirakud dam and its canals, the work for which was completed in 1957. The Hirakud dam was mainly constructed for flood moderation and irrigation. The districts which benefit from this project are Sambalpur, Sonepur, Balangir and Bargarh. The CCA created is 157,810 ha and the UIP is 261,260 ha. The work was implemented in three phases which included the construction of three dams —Hirakud, Naraj and Tikarpada. In addition, two power houses, Chiplima (72 MW) and Burla (235.5 MW) were also constructed. Through the Hirakud reservoir about 157,018 ha of land is irrigated in the Kharif season and 109,912 ha in the Rabi.

The construction of the Hirakud reservoir in 1958 assured regular releases of 280 cubic metre per second (cumecs) which were available after power generation for irrigation. Delta irrigation was completed in two stages through the construction of a new weir across the Mahanadi at Mundali upstream of Naraj, and the new Mahanadi and Birupa barrages to replace old weirs (Mahapatra, 2005).

Lower Suktel major irrigation project: This project involves the construction of the Suktel dam and shall benefit Balangir and Sonepur districts in Odisha. From the project, 17.85 MCM will be supplied to Balangir town as drinking water, and a CCA and an UIP of 31,830 ha and 29,840 ha are created, respectively.

4.1.2 Surface water development in Chhattisgarh

Mahanadi Reservoir Complex (1972–2011): This Mahanadi major irrigation project involves the construction of five dams, namely, Ravishankar Sagar, Dudhawa, Murrumsili, Sondur and Pairi. Of these, the construction of the first four dams has been completed and the construction of the Pairi dam is underway. The total culturable command area (CCA) of this project is 301,000 ha and the ultimate irrigation potential (UIP) created is 264,310 ha. The project also involves the construction of the Rudri barrage, replacing the old Rudri weir, and the construction of four canals: Mahanadi main canal, Mahanadi feeder canal, Sondur feeder canal and Pairi Mahanadi feeder canal. The Sondur and Pairi canals have now been scrapped from the scope of the project. Around 10 megawatts (MW) hydropower is generated from the Ravishankar Sagar dam. The districts which benefit from this project are Raipur, Dhamtari and Durg.

Hasdeo Bango major irrigation project (1962–2011): The districts which benefit from this project are Bilaspur, Korba, Raigarh and Janjgir-Champa of Chhattisgarh. The project has created a CCA of 285,000 ha and UIP of 433,500 ha, in addition to generating 120 MW of hydropower. The project was implemented in four phases. During the first phase,the Hasdeo barrage was built to supply water to a 200 MW thermal

12 The Rushikulya basin is located below the Mahanadi basin south of Chilika lake. The basin has a catchment area of 8963 km^2 (India-WRIS).

power plant located at the left bank canal. During the second phase, the right bank canal was constructed to irrigate 42,000 ha land. During the third phase, the Minimata dam upstream of the barrage was constructed, following which the fourth phase concentrated on increasing the irrigation potential through this project.

Jonk diversion project (1973–2005): The project involves the construction of a masonary weir on river Jonk, a tributary of the Mahanadi river, which will benefit Raipur district. The CCA of the main canal is 15,500 ha and its UIP is14,570 ha.

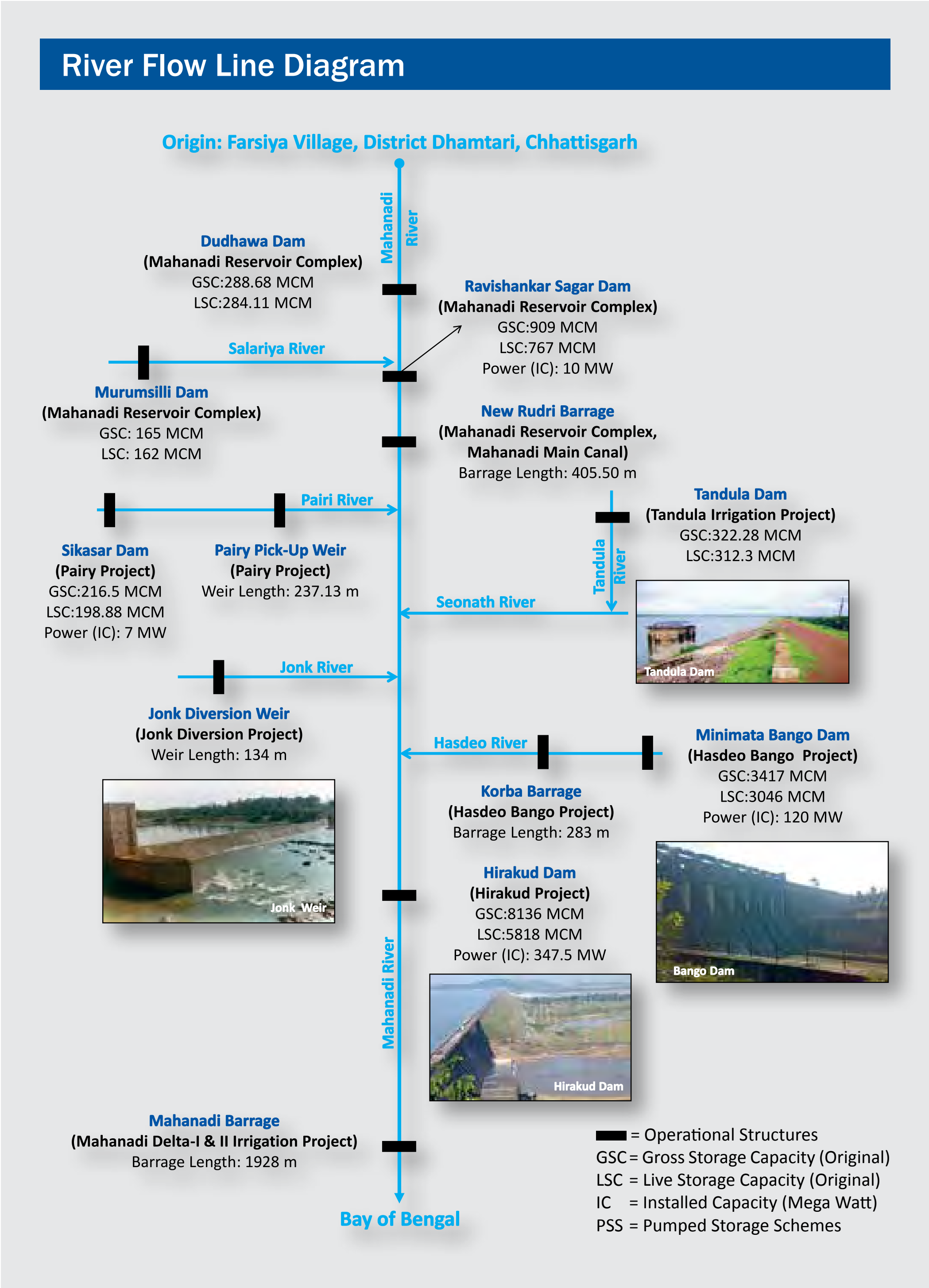
Kelo irrigation project: This is an ongoing project, work for which began in 2005. The project includes the construction of the Kelo dam and canals. After the completion of the project, the CCA of 24,396 ha and UIP of 22,810 ha will be created, which will benefit Raigarh and Janjgir-Champa districts. Around 4.44 MCM will be supplied as drinking water to the cities and 4.44 MCM to the industries.

Tandula irrigation project (1910-1921): This was one of the earlier projects which included the construction of the Tandula dam. CCA of 246,300 ha and an UIP of 84,000 ha were created. The dam was initially constructed for supplying water to the Bhilai steel plant. Currently the steel plant receives water from the Mahanadi reservoir complex.

4.1.3 Dams and reservoirs

The major reservoirs which are larger than 2,500 ha area located in the Mahanadi basin are the Hirakud reservoir, Hasdeo-Bango dam, Ravishankar Sagar, Tandula and Dudhawa dams. Most of these dams were built for the purpose of irrigation. However, due to an increasing presence of industries in the area, especially in Chhattisgarh, there are conflicts over the allocation of water between irrigation and industries. The salient features of these reservoirs are mentioned in Table 3, while Figure 19 explains the course of the river with major irrigation projects.

Figure 19: River flow diagram of the Mahanadi river with major irrigation projects



Source: India-WRIS

Table 3: Salient features of the major reservoirs in the Mahanadi basin

Sr. No.	Name of the reservoir	District	Year of completion	Gross storage capacity (MCM)	Live storage capacity (MCM) (at construction)	Full reservoir level (m)	Catchment area (km2)	Purpose of the project
1.	Hirakud	Sambalpur	1957	8105	5482.88	192.02	83365	Flood control, hydroelectric, irrigation
2.	Minimata (Hasdeo) Bango dam	Korba	1990	3417	3046	359.66	6730	Hydroelectric, irrigation
3.	Ravishankar Sagar	Dhamtari	1979	909	767	348.7	3700	Irrigation
4.	Lower Indravati*	Nuapada	2012	321.6	314.25	NA	NS	Irrigation
5.	Tandula	Durg	1923	322.28	312.3	332.07	8270	Hydroelectric, irrigation
6.	Dudhwaha	Kanker	1965	288.68	284.11	425.12	621	Irrigation

** Upper Indravati is a project which is not situated in the Mahanadi basin, but it provides water for use in the basin.*
Source: India-WRIS, 2015

4.1.4 Canals

Canals are open channels or waterways connected mainly to agriculture lands over large areas. In Chhattisgarh state, the Mahanadi Canal System comprising of the new Rudri weir, Ravishankar Sagar dam and the Tandula canal network irrigates the districts of Dhamtari, Durg and Raipur. The Mand irrigation canal network benefits Raigarh and Janjgir-Champa districts, whereas the canal network formed from the Hasdeo-Bango project benefits nearly the entire Janjgir-Champa district.

From the Hirakud dam, two canals emerge, namely the Bargarh main canal on the right bank and the Sason main canal from the left bank. During normal rainfall, these two canals irrigate 157,018 ha of land in the Kharif and 109,912 ha of land during Rabi which benefits the districts of Sambalpur, Sonepur and Bargarh in Odisha. The Mahanadi Delta stage I project, that comprises the canal network (six main canals and its branching sub-canals), originates from the Mahanadi river and the Birupa barrage and irrigates the districts of Kendrapara, Cuttack, Jagatsinghpur and Jajpur in Odisha. The five main canal system are, i) Taladanda main canal, ii) Macchgaon main canal, iii) Kendrapara main canal, iv) Pattamundai canal, and v) Puri main canal.

4.1.5 Hydropower projects

As per the Central Water Commission (CWC), the hydroelectric potential in the Mahanadi basin is 444.5 MW at 60% load factor. Table 4 describes the four hydropower projects located in the basin.

Table 4: Hydropower locations in the basin

Sr. No.	Name of the Project	Type of Project	Location	Total Installed Capacity (MW)
1.	Gangrel Hydroelectric Project	Small	Gangrel, Chhattisgarh	10 (2.5 per unit)
2.	Hasdeo Bango Hydroelectric Project	Major	Hasdeo river, Chhattisgarh	120 (40 per unit)
3.	Hirakud Hydroelectric Project a. Hirakud I (Burla) b. Hirakud II (Chiplima)	Major	Sambalpur, Odisha	307.5 a. 235.5 b. 72
4.	Sikaser Hydroelectric Project	Small	Pairi river, Chhattisgarh	7 (3.5 per unit)

Source: india-wris.nrsc.gov.in

4.2 Groundwater Use

An assessment of the status of groundwater resources in the Mahanadi basin was carried out based entirely on secondary data. This data consisted of the Central Groundwater Board's (CGWB) national groundwater assessments for the years 2004 and 2009. As only two years' data was available for assessment, the maps and tables presented below may consist of district names and boundaries which might have changed since then. Some of the districts are partly covered in the basin, and their figures have not been corrected to match with the proportional area in the basin as data is available only at the district level.

Direct observations based on the data are presented here. Further work needs to be carried out at two levels:

- Field based verification of the findings from the secondary data and,
- Developing hypotheses based on the field data and secondary data.

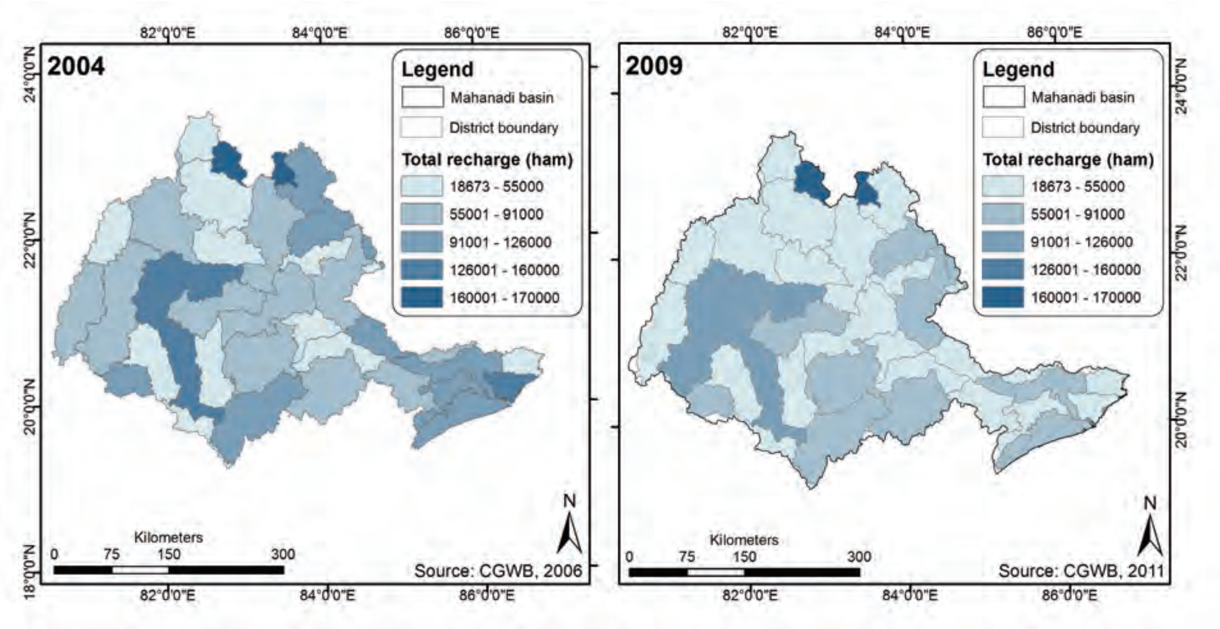
The total annual recharge in the districts in the Mahanadi basin (see Figure 20) shows the following trends;

i) the recharge across the districts does not show any clear relation to the geology of the basin, and

(ii) recharge across the basin shows a decreasing trend between 2004 and 2009.

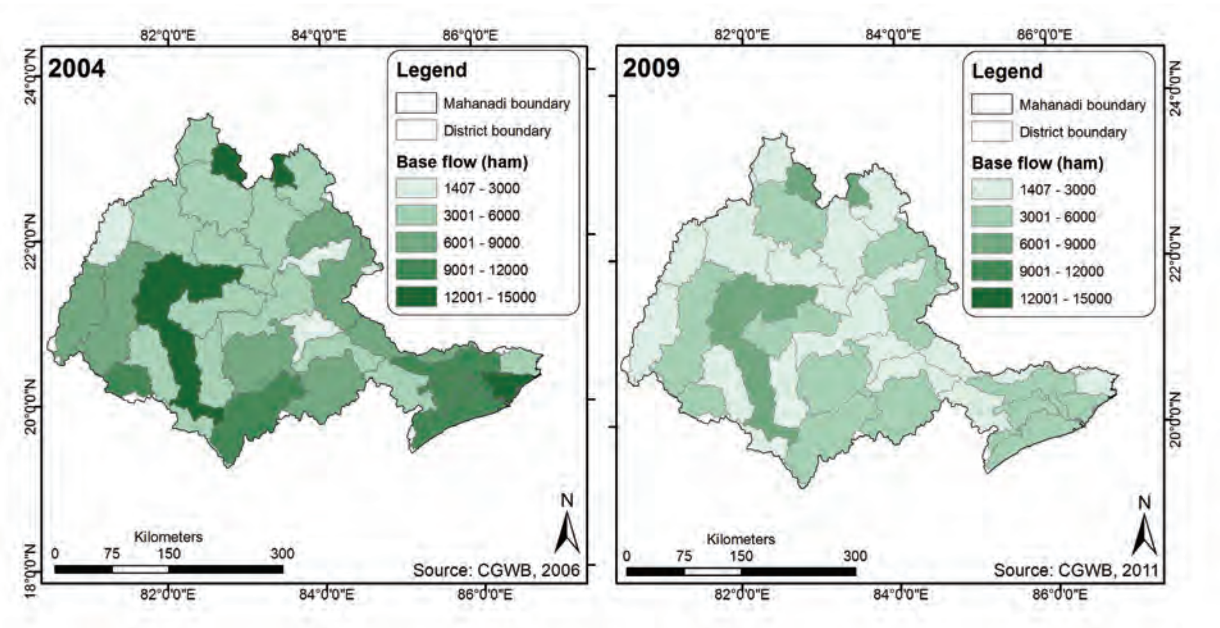
Figure 21 is the comparative plot for the non-monsoon discharge in the Mahanadi basin for the years 2004 and 2009.The comparison reveals the following: (i) base flows do not show any significant trends based on the geology. The only clear picture is that the delta portions of the basin show relatively higher base flows than that for the rest of the basin, (ii) base flow values are also reducing between the years 2004 and 2009 across the entire basin, which raises the basic question of whether this reduction is a consequence of reduced rainfall or increased groundwater abstraction or both.

Figure 20: Comparison of total annual recharge in the Mahanadi basin on 2004 and 2009



Source: Central Groundwater Board

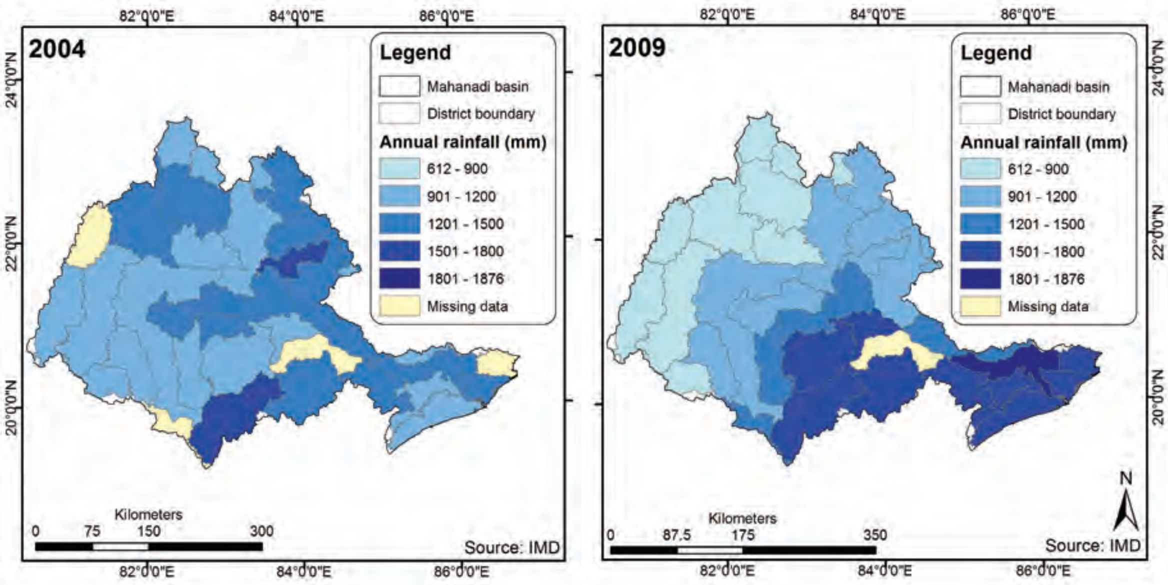
Figure 21: Base flows in the Mahanadi basin



Source: Central Groundwater Board

Figure 22 depicts the district level annual averages of rainfall for the years 2004 and 2009. It is evident that during the year 2009, the majority of the districts in the Mahanadi basin received lower rainfall than in the year 2004. The reduced values of recharge and base flows, adjusted to the annual rainfall, would largely be as an effect of the lower rainfall in the respective districts.

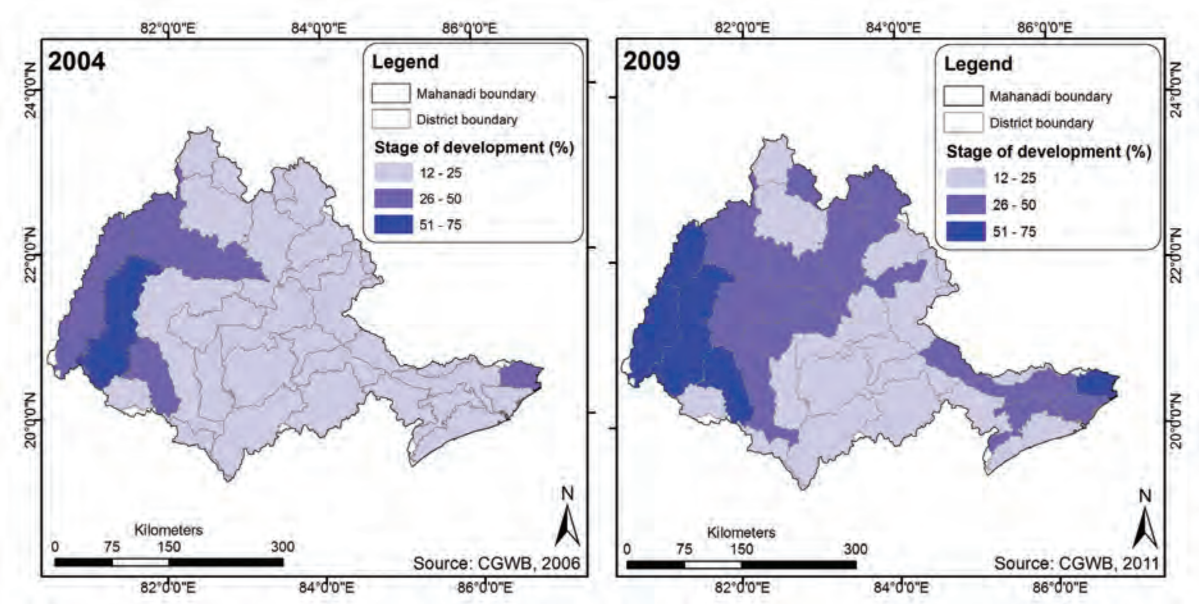
Figure 22: Comparison of annual district level rainfall for 2004 and 2009 in the Mahanadi basin



The stage of groundwater development in the basin for both the 2004 as well as the 2009 assessments shows that all the districts in the basin fall under the 'safe' category. These areas are popularly termed as areas with 'underdeveloped' groundwater resources where the abstraction of groundwater is less than 70% of the total annual groundwater recharge.

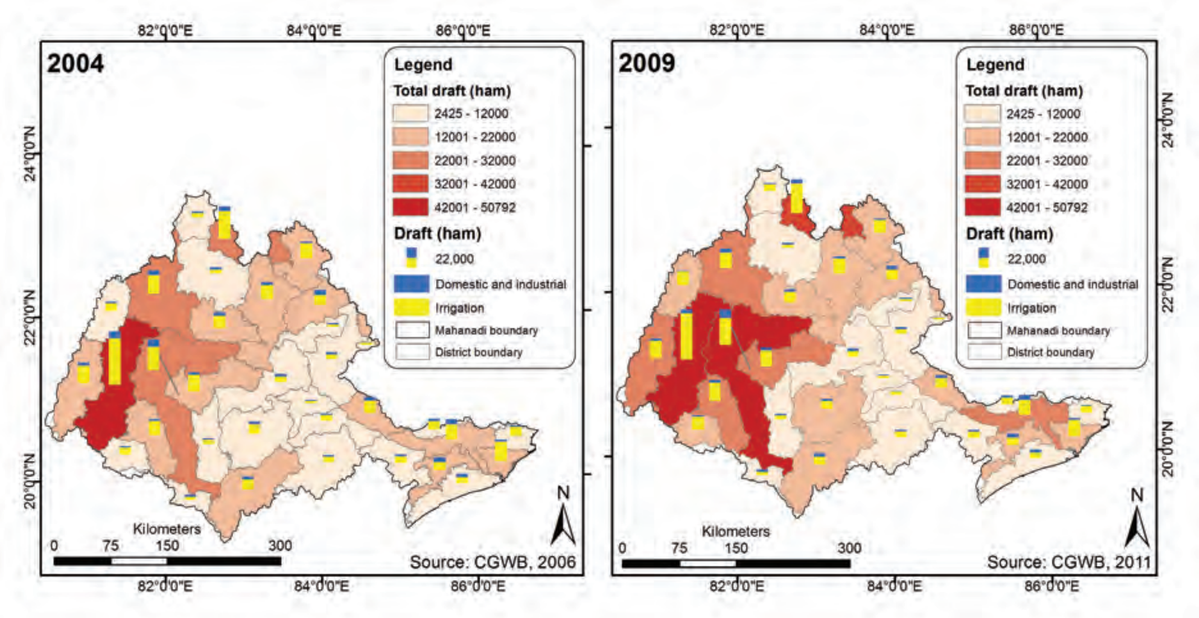
Figure 23 is a comparison of the status of groundwater development between the years 2004 and 2009. Although both the assessments show that the districts are safe, the figure shows the trends of groundwater development through a further disaggregation of the 'safe' category. Although the overall stage of groundwater development is safe, there are clear trends across the basin over these two assessments. In 2004, only the westernmost regions of the basin showed higher degrees of groundwater development. Durg and Kendrapara districts show the highest development while Rajnandgaon, Dhamtari, Kawardha (Kabirdham), Bilaspur and Janjgir-Champa show moderate development. In 2009, the development of groundwater has expanded to a much larger area as compared to 2004. Durg, Rajnandgaon, Dhamtari and Kendrapara show highest development while 12 districts show moderate development (as compared to only 5 in 2004).

Figure 23: Stage of groundwater development in the Mahanadi basin



Source: Central Groundwater Board

Figure 24: Total groundwater draft in the Mahanadi basin



Source: Central Groundwater Board

Groundwater draft in the Mahanadi river basin is not very high as observed since the groundwater development. Nevertheless, clear trends emerge from Figure 24 with regards to the use of groundwater, such as:

- Groundwater usage in the western and delta regions of the basin is the highest. Within these two, the western region shows higher usage.
- Groundwater draft has clearly increased in 2009 as compared to 2004. The increase in draft follows the same pattern as that of usage; the same districts that showed higher drafts in 2004 show an increase in groundwater draft in 2009.
- Koriya, Korba, Jharsuguda, Sambalpur, Sonepur, Nuapada, Balangir, Kandhamal, Boudh and Nayagarh districts have shown relatively low groundwater draft in 2004 and similarly have shown negligible increase in draft in 2009.
- Irrigation forms the dominant share of the total groundwater draft.
- Groundwater irrigation patterns follow almost the exact pattern of total draft. The comparison between 2004 and 2009 also shows almost the same trend as total draft: an increase in most districts that already had higher drafts, while the districts showing lower draft remain almost the same showing negligible increase in draft.
- While three districts are showing a decrease in the irrigation draft, most of the districts show a significant rise in groundwater abstraction for irrigation. The rise ranges between 30% and 130%.
- The percentage change in industrial draft of groundwater, however, shows a completely different picture. The draft has actually reduced between 2004 and 2009 in most of the districts. Some districts show an increase in draft of up to 90%.

Maps in figures 25 and 26 illustrate the groundwater draft for irrigation and industrial use respectively. The maps show that irrigation draft is increasing in some districts of the upper basin and in large parts of the middle basin. The industrial draft has reduced in various districts of the upper and lower basin while showing an increase in the middle basin.

Figure 25: Groundwater draft for irrigation in the Mahanadi basin

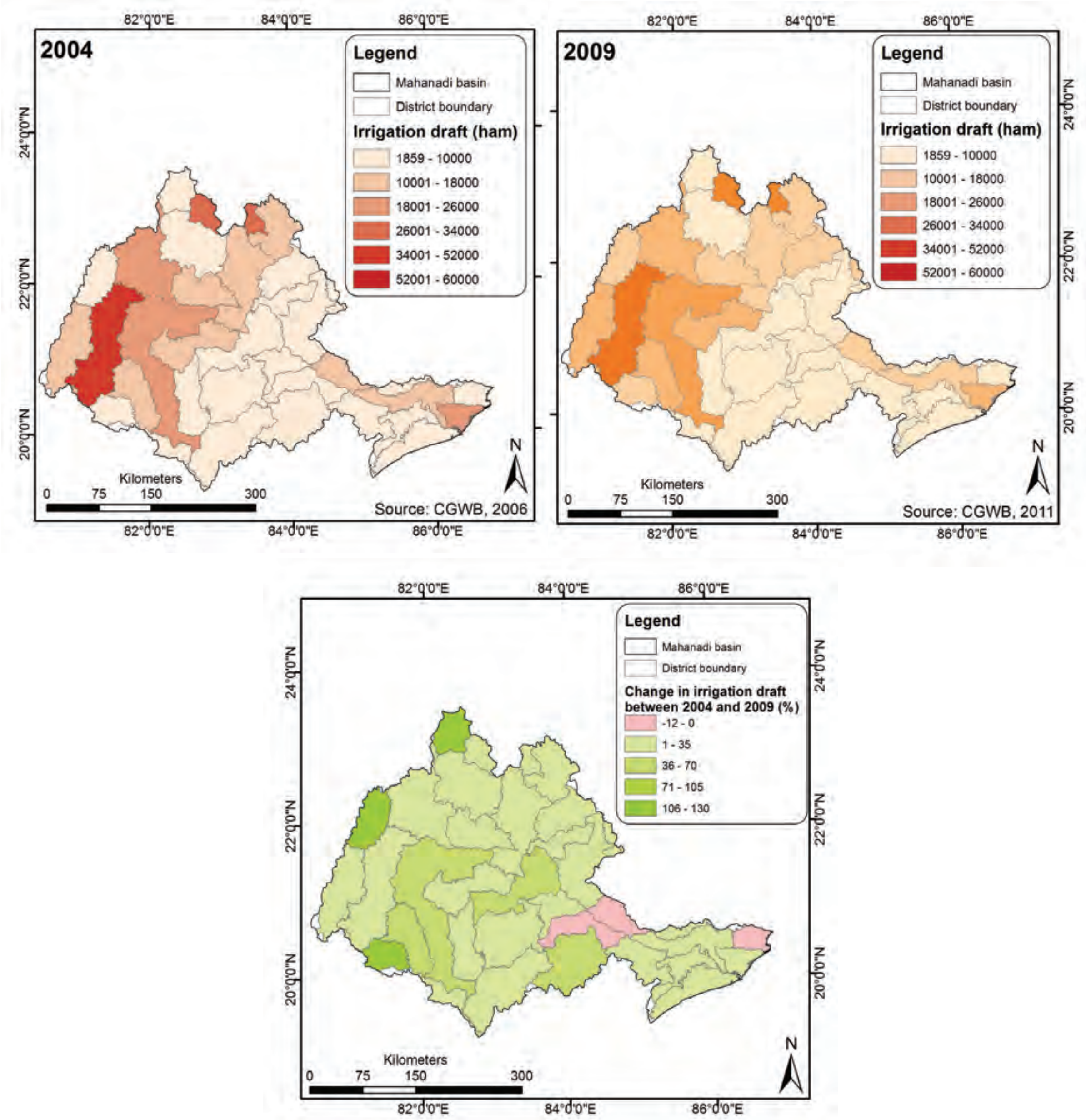


Figure 26: Groundwater draft for industrial purposes in the Mahanadi basin

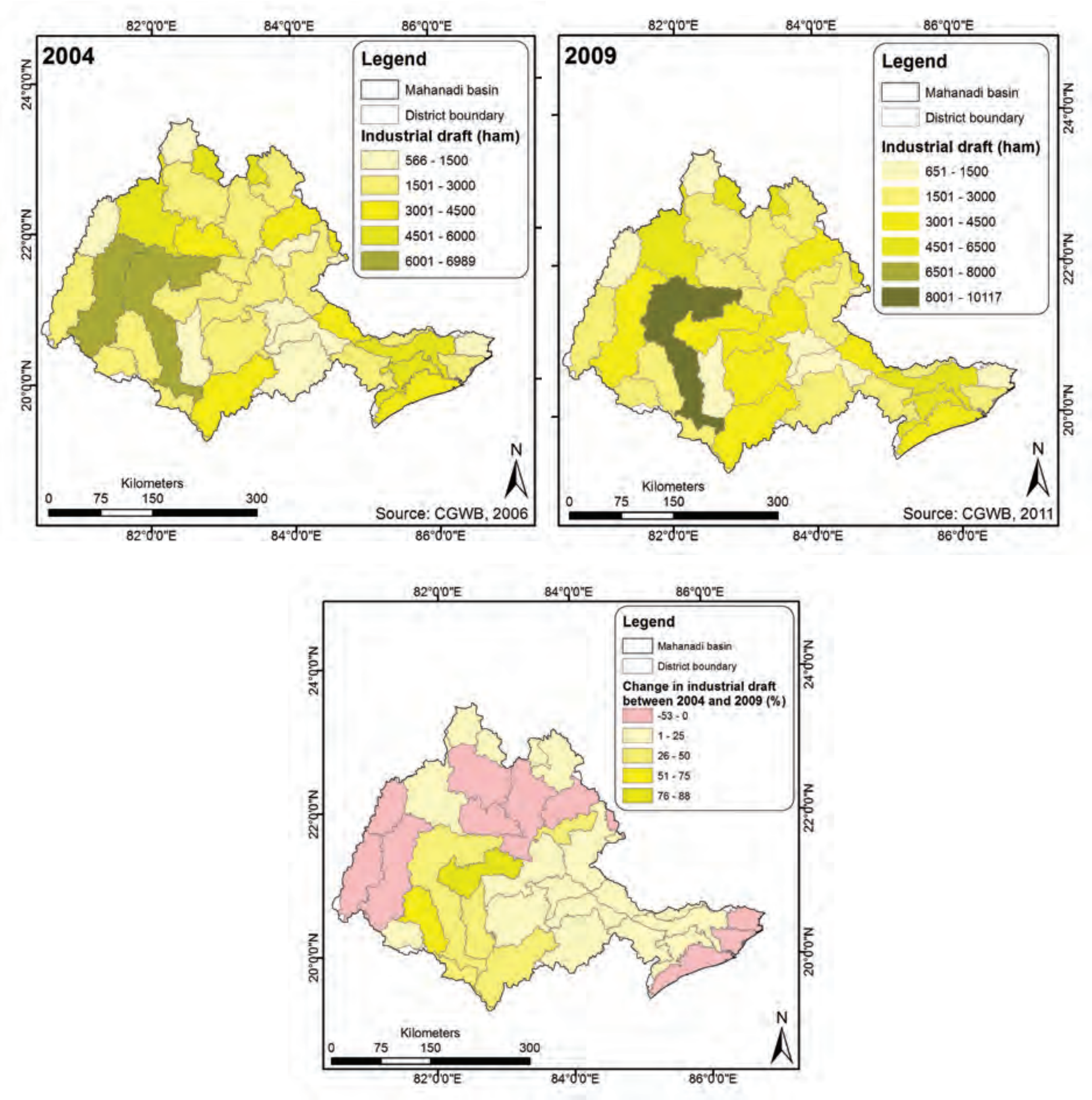


Figure 27: Ratio between non-monsoon discharge (base flow) and annual rainfall for 2004 and 2009

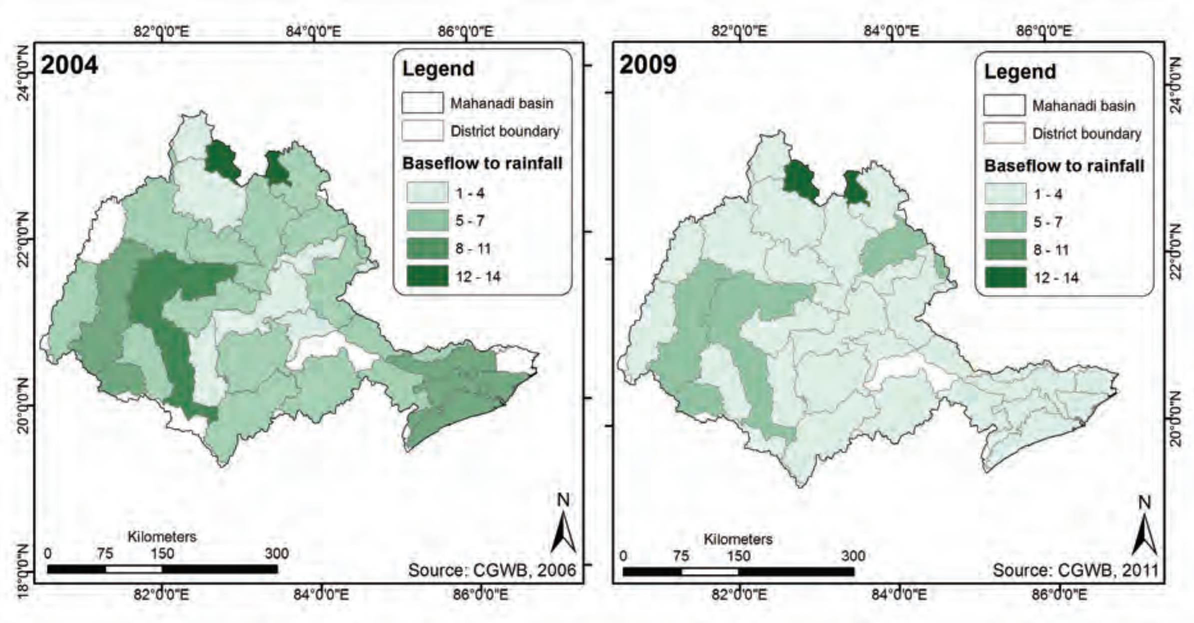


Figure 28: Groundwater draft for irrigation purposes to the total rainfall in the Mahanadi basin

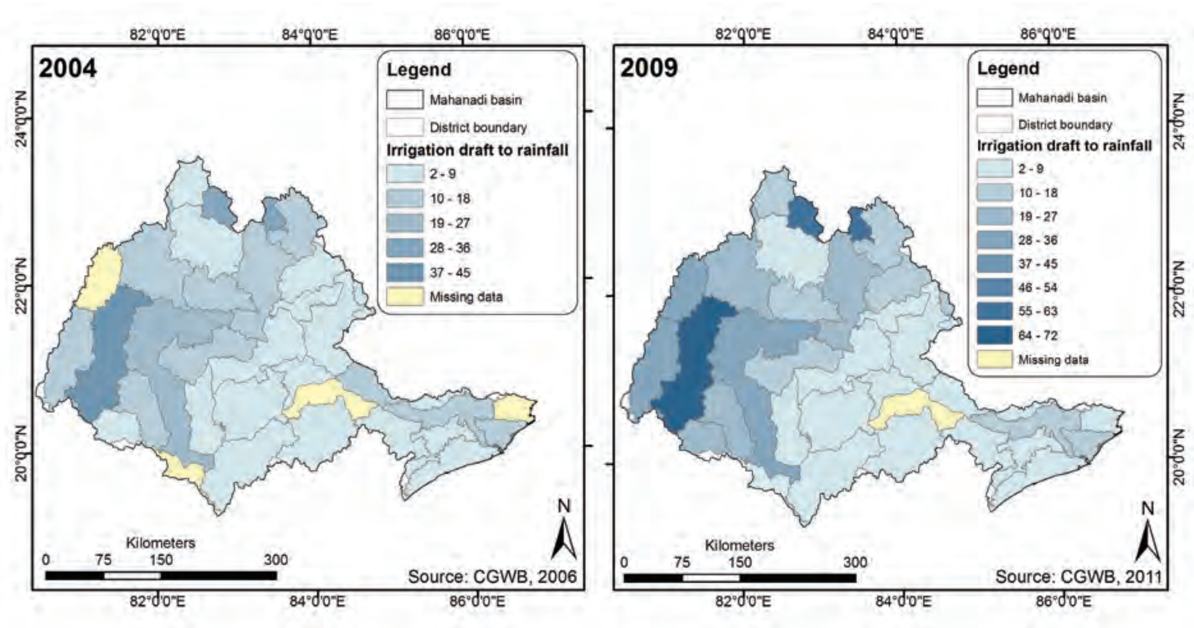


Table 5: List of districts in the Mahanadi basin with the percentage change in different groundwater parameters between 2004 and 2009

		Percentage change between 2004 and 2009						
State	**District**	**Rainfall**	**Recharge**	**Non-monsoon discharge**	**Net availability**	**Draft Industrial**	**Draft Irrigation**	**Stage of groundwater development**
CG	Bastar	-37	-41	-62	-40	1	-0	83
CG	Bilaspur	-33	-28	-55	-25	4	2	38
CG	Durg	-20	7	-43	12	-31	25	6
CG	Kabirdham	DG	1	-48	6	-26	126	94
CG	Dhamtari	22	-5	-48	-47	4	-1	63
CG	Raipur	1	-20	-53	-33	19	21	76
CG	Rajnandgaon	-28	-37	-63	-3	15	15	80
CG	Janjgir–Champa	-17	-24	-58	-20	-4	10	34
CG	Jashpur	-20	-42	-53	-42	2	5	74
CG	Kanker	-16	-13	-53	-8	2	130	133
CG	Koriya	-15	30	-27	36	1	115	35
CG	Surguja	-37	-2	-40	2	5	34	30
CG	Mahasamund	-3	-28	-49	-19	4	1	63
CG	Korba	-39	-10	-26	-18	9	35	7
CG	Raigarh	-7	-28	-56	-25	5	-12	72
Odisha	Jharsuguda	-27	223	147	16	78	58	95
Odisha	Sundargarh	-15	-18	-40	-33	-4	22	40
Odisha	Angul	2	-49	-66	-32	17	4	94
Odisha	Balangir	46	-23	-57	-68	-2	6	24
Odisha	Bargarh	DG	-20	-46	230	83	721	57
Odisha	Boudh	-6	-27	-45	-81	-53	-65	18
Odisha	Cuttack	49	-35	-55	20	186	86	74
Odisha	Deogarh	-3	-4	-21	119	25	-21	27
Odisha	Dhenkanal	39	-35	-63	-65	-70	161	56
Odisha	Jagatsinghpur	20	-68	-72	-2	54	-33	213
Odisha	Kalahandi	-2	-82	-90	-46	-55	5	107
Odisha	Kandhamal	19	15	-27	-21	3	27	64
Odisha	Kendrapara	DG	108	15	-28	7	23	-63
Odisha	Nabarangpur	DG	-66	-76	-16	-3	23	382
Odisha	Nayagarh	19	-7	-51	-1	71	63	-13
Odisha	Nuapda	18	12	-29	-26	88	16	38
Odisha	Rayagada	-3	-48	-66	1	8	17	46
Odisha	Sambalpur	-10	-22	-38	-47	6	18	50
Odisha	Subarnapur	73	-31	-58	-9	-1	1	64
Odisha	Ganjam	28	-1	-15	-26	-7	35	16
Odisha	Khurda	38	-49	-68	-17	45	45	114
Odisha	Puri	48	-36	-57	-34	-15	22	64

DG= Data gap

Colour coding used | **Upper Sub basin** | **Middle Sub basin** | **Lower Sub basin**

Source: Central Water Commission and National Remote Sensing Centre

Table 5 lists the percentage change in different groundwater parameters between the years 2004 and 2009, across the districts in the basin. The table is arranged as per the divisions (marked in different colours) provided in the Mahanadi basin report by the CWC and National Remote Sensing Centre (NRSC) — the upper sub basin, middle sub basin and lower sub-basin. The listing of districts according to the sub-basins is approximate as administrative boundaries do match exactly with the natural watershed boundaries. A summary of the table is as follows;

- Rainfall between 2004 and 2009 shows a clear decrease in the upper and middle sub-basin while it shows an increase in the lower sub-basin;
- Total annual recharge shows a decreasing trend across all sub-basins with some isolated exceptions;
- Non-monsoon discharge or base flows also show a clear reduction between 2004 and 2009 across all sub-basins with isolated exceptions;
  - Industrial draft shows minor increase between the years 2004 and 2009 in all the sub-basins;
  - Irrigation draft shows significant increase across all the sub-basins;
  - Stage of groundwater development also shows a clear increase.

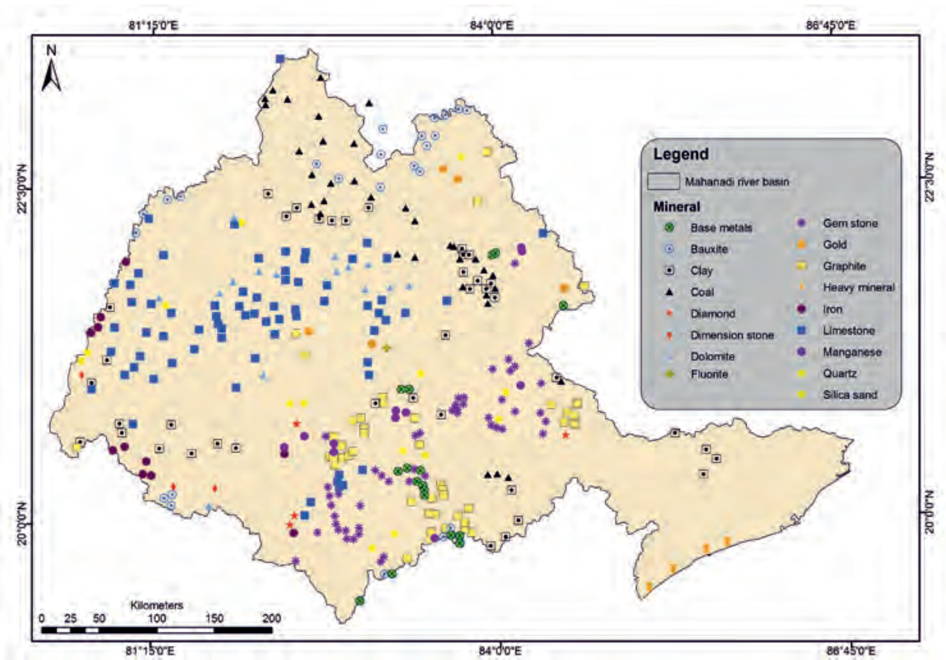
5. Mining and Mineral Resources

The Mahanadi basin is rich in mineral resources owing to its favourable geological setup. It is endowed with large reserves of bauxite, chinaclay, chromite, coal, dolomite, fireclay, graphite, gemstones, iron ore, limestone, manganese ore, mineral sand, quartz, etc.

In the Odisha part of the basin, Precambrian metamorphic rocks (of Archaean and Proterozoic age) host the majority of the minerals, followed by the Gondwanas hosting the coal resources. The Tertiary and Quaternary formations are host to aluminous/nickeliferous laterite and heavy minerals (in beach sand). Proterozoic rocks in western Odisha exhibit platformal sedimentary formations and associated limestone deposits. In central and southern Odisha, the Proterozoics are represented by the Eastern ghats granulite belt comprising of khondalite, charnockite, migmatite, anorthosite and alkaline rocks accounting for the mineralisation of bauxite, manganese, graphite and gemstones. The Mesozoic rocks of the Gondwana Supergroup host the major coal resources of the state. The deltaic fans extending into offshore regions host oil and gas resources.

The Chhattisgarh part of the Mahanadi basin also hosts a wide variety of minerals found associated with igneous, sedimentary and metamorphic rock formation. A few of them form large economic deposits while a number of other minerals are reported as occurrences. Large deposits of coal, iron ore, limestone, dolomite and bauxite are located in different parts of the state.

Figure 29: Mineral resources in the Mahanadi basin



Source: Modified from: a) Mineral map of Chhattisgrah, Directorate of Geology and Mining, Raipur
b) Mineral map of Odisha, Directorate of Geology, Department of Steel and Mines, Government of Odisha

Important deposits in Odisha districts include:

- Bauxite in Balangir, Kalahandi, Kandhamal, Keonjhar, Koraput, Malkangiri, Rayagada and Sundargarh districts;
- Chinaclay in Bargarh, Boudh, Balangir, Keonjhar, Koraput, Mayurbhanj, Sambalpur and Sundargarh districts;
- Chromite in Balasore, Cuttack, Dhenkanal, Jajpur and Keonjhar districts;
- Coal in Ib river valley coal field, Sambalpur district and Talcher coal field, Dhenkanal district;
- Dolomite in Bargarh, Keonjhar, Koraput, Sambalpur and Sundargarh districts;
- Fireclay in Angul, Cuttack, Dhenkanal, Jharsuguda, Khurda, Puri, Sambalpur and Sundargarh districts;
- Graphite in Bargarh, Boudh, Balangir, Kalahandi, Koraput, Nuapada and Rayagada districts;
- Iron ore (hematite) in Dhenkanal, Jajpur, Keonjhar, Koraput, Mayurbhanj, Sambalpur and Sundargarh districts;
- Iron ore (magnetite) in Mayurbhanj district; limestone in Bargarh, Koraput, Malkangiri, Nuapada, Sambalpur and Sundargarh districts;
- Manganese ore in Balangir, Keonjhar, Koraput, Rayagada, Sambalpur and Sundargarh districts;
- Quartz/silica sand in Boudh, Balangir, Kalahandi, Sambalpur and Sundargarh districts;
- Titanium minerals in Dhenkanal, Ganjam, Jajpur and Mayurbhanj districts;
- Zircon in Ganjam district;
- Occurrences of ruby and emerald are reported from Balangir and Kalahandi districts, respectively and;
- Platinum group of metals occur in Keonjhar district.

Important deposits in Chhattisgarh districts include:

- Bauxite in Bastar, Bilaspur, Dantewada, Jashpur, Kanker, Kawardha (Kabirdham), Korba, Raigarh and Surguja districts;
- Chinaclay in Durg and Rajnandgaon districts; coal in Koriya, Korba, Raigarh and Surguja districts;
- Dolomite in Bastar, Bilaspur, Durg, Janjgir-Champa, Raigarh and Raipur districts;
- Iron ore (hematite) in Bastar district, Bailadila deposit in Dantewada district, Chhote Dongar deposit in Kanker district, Rowghat, Chargaon, Metabodeli and Hahaladdi deposits in Rajnandgaon district, Boria, Tibbu deposits in Dalli-Rajhara area, Durg district. Bailadila-Rowghat hill ranges in the state are considered to be one of the biggest iron ore fields in India;
- Limestone in Bastar, Bilaspur, Durg, Janjgir-Champa, Kawardha, Raigarh, Raipur and Rajnandgaon districts;
- Quartzite in Durg, Raipur, Rajnandgaon and Raigarh districts;
- Diamond and other gemstones in Raipur, Mahasamund and Dhamtari districts;
- Fire clay in Bilaspur, Raigarh and Rajnandgaon districts;
- Fluorite in Rajnandgaon district;
- Garnet and marble in Bastar district;
- Emerald and gold in Raipur district;
- Quartz/silica sand in Durg, Jashpur, Raigarh, Raipur and Rajnandgaon districts.

Detailed mineral based industries found in the Mahanadi basin is discussed in the Appendix in Table A.3-A.4

6. Industries

Industrial development has been a key solution put forward by state and central governments for economically poorly developed states such as Chhattisgarh and Odisha. A glance at figures of the Gross Domestic Product (GDP) of the two states shows that the size of the entire economy has grown massively in the last decade. In Chhattisgarh however, the share of industries in this growth has fallen from 37% to 25%, manufacturing having taken the largest hit, whereas in Odisha it has stayed constant at about 24%. While industrial development has contributed to some of the prosperity in the two states, the simultaneous rise of the tertiary services sector must also be acknowledged as a driver of growth. This growth in the tertiary sector however still represents skewed development since it employs relatively fewer people, while the largest part of the population still depends on agriculture. The share of agriculture in the economy has grown by 1.5% in Chhattisgarh and fallen by 3.4% in Odisha. A state wise comparison is provided below. This section puts the spotlight on the secondary industrial sector and more specifically on the power, manufacturing (iron and steel) and mining industries, since these represent a significant share of the demand for water resources and their allocations need further review.

6.1 Chhattisgarh

- Chhattisgarh's Gross State Domestic Product (GSDP) was Rs. 185,682 crore in 2013–14, a rapid increase from Rs. 47,862 crore just a decade ago. This represents an annual growth rate of 14.5% in nominal terms. The largest part of this GSDP (about 40%) is now represented by the tertiary sector, including services such as transport, communication, banking and real estate, while 39% is contributed by the secondary sector composed of power, steel, mining, construction, etc.
- The growth in the agricultural sector has been eclipsed by the growth in the tertiary services sector.

Table 6: Change in the GSDP of the industrial sector in Chhattisgarh

Chhattisgarh	**2004–05 (current prices) (In Rs. crore)**		**2013–14 (current prices) (In Rs. crore)**	
GSDP	47862	100%	185682	100%
Agriculture	7057	14.7%	30150	16.2%
Mining	5367	11.2%	16430	8.8%
Manufacturing	10479	21.8%	22958	12.3%
Construction	3274	6.8%	25427	13.7%
Electricity, Gas, Power	2100	4.3%	7588	4%
Tertiary Sector[13]	16481	34.4%	73663	39.6%

Source: Economic Survey of Chhattisgarh, 2014-15, DES, Government of Chhattisgarh

13 The tertiary sector includes railways, transport, communication, banking, real estate, etc.

- Both Chhattisgarh and Odisha generate more power than they consume. Power sales hence add to the state's revenues. Korba district in Chhattisgarh is the "power capital of India". The entire state of Chhattisgarh itself has about 10683 MW in production capacity as of January 2015, of which 6413 MW is private and 4290 is owned either by the state or centre.
- Mineral resources also play a big part in the development of both states. Chhattisgarh and Odisha's central location and the abundance of mineral resources in both the states have played an important part in attracting resource intensive and exploitative industries to the state. Chhattisgarh produces about 22.6% of the country's coal (127 MT), 19.8% of its iron ore (30 MT), and 7.6% of limestone (21 MT) which are its three biggest minerals.[14] It also produces about 20% of India's cement. (Economic Survey 2014-15, p.2) and is the only tin ore producing state in the country. The number of mines in Chhattisgarh totalled to 202 (in 2013–14). Mining of major minerals contributes to about 9% of the states's GSDP, down from 11% in 2004–05. However its share in the states' revenues is much higher, at 25.5% (Rs. 3028 crore). This has doubled from Rs. 1554 crore just five years ago in 2009–10. The total value of minerals produced in the state was Rs. 19,566 crore (2013–14).
- The state owned South Eastern Coalfields Ltd (SECL) is the largest mining company in operation in Chhattisgarh (as well as Odisha) with its largest mines in Korba district and many others in Surguja and Koriya. Vedanta, ESSAR, LANCO, Jindal, Monet, DB Power, the National Thermal Power Corporation (NTPC), Steel Authority of India Ltd. (SAIL), and Bharat Alumium Company Ltd. (BALCO) are the major companies in Chhattisgarh in the mineral, power, steel and aluminium businesses.
- The state also has many large industrial areas principally around Raipur (Tilda, Urla and Siltara), Bilaspur (Sirgitti, Dagori and Silpahari) and Durg (Borai) cities. Korba is another industrial hub and Raigarh is being further developed as a power and mining hub.

6.2 Odisha

- Odisha's economy had a GSDP of Rs 272,979 crore in 2013–14 (at 2004–05 prices), a jump from Rs. 77,729 crore in 2004–05 i.e. an annual nominal growth rate of 13.4%. The tertiary sector comprises about 47% of the GSDP and the secondary sector which represents industries, construction, etc. comprises 34%. This shows that Odisha's economy is more skewed towards the services as compared to that of Chhattisgarh.

Table 7: Change in the GSDP of the industrial sector in Odisha

Odisha	**2004–05 (current prices) (In Rs. crore)**		**2013–14 (current prices) (In Rs. crore)**	
GSDP	77729	100%	272979	100%
Agriculture (including animal husbandry)	14603	18.8%	42188	15.4%
Mining	5861	7.5%	29828	10.9%
Manufacturing	9369	12%	28742	10.5%
Construction	8092	10.4%	27901	10.2%
Electricity, Gas, Power	3197	4.1%	6726	2.4%
Tertiary Sector	32950	42.4%	128168	47%

Source: Economic Survey of Odisha2014-15, Government of Odisha, 2015a

14 Chattisgarh's coal production is the highest in the country, and its iron ore reserves are the third largest (Economic Survey 2014–15, p. 81).

- Odisha like Chhattisgarh is also rich in minerals. The state has about 52% of the country's bauxite reserves, 44% of its manganese reserves, 33% of its iron ore reserves, and 24% of its coal reserves. In mass terms, 86% of the mineral reserves of Odisha is comprised of coal, of which about 60% is extracted currently from Angul district and the remaining from Jharsuguda, Sundargarh and Sambalpur districts. Coal extraction in 2013–14 amounted to 108 metric tonnes (MT). Iron ore extraction of about 77 MT on the other hand is mostly confined to Keonjhar (71%) and Sundargarh (25%), while bauxite mining is confined to Koraput. Out of 595 signed mining leases in Odisha, 102 are currently in operation, covering an area of 46,788 ha.
- Rourkela is the largest steel plant in the state with a capacity of 4.5 metric tonnes per annum (MTPA). The state government has signed 49 MoUs with steel producers for a total of 83.6 MTPA of production capacity, although current production stands at only 12.6 MTPA. Another 11.4 MTPA of sponge iron production capacity is already operational in the state. Other major companies including Vedanta, Posco, Jindal, Tata, and Essar have set up plants in the state
- Jharsuguda is the state's major hub for sponge iron and thermal power plants. Keonjhar and Sundargarh districts have about 50% of the state's mineral deposits.
- Of the installed thermal power capacity in the state, 5715 MW is from captive power generation plants, 7900 MW is from central power generating plants, and 3170 MW is the state's own installed capacity. Odisha like Chhattisgarh also exports power to other states.

7. Fisheries

The Mahanadi is a perennial river which has abundant species of fish. Studies indicate that the river is healthy as compared to other Indian rivers and the quality of the river is suitable for higher fish production (Pathak, Mahavar and Sarkar, 2001)[15]. Chhattisgarh state is slowly gaining growth in inland fisheries. Odisha state is abundant in fisheries, both inland and marine.

Table 8: Production of inland fish production in Chhattisgarh and Odisha (in '000 tonnes)

State	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
Chhattisgarh	137.75	139.37	158.7	174.24	228.20	250.7	255.61	281.55
Odisha	342.04	349.48	374.82	370.54	3816.18	381.83	410.14	414.64

Source: Adapted from Goswami and Zade, 2015

A lot of fish diversity is observed in the basin and many researchers have reported various species across different areas in the Mahanadi basin. Table A.5 in the Appendix gives an idea of the various fish species in the Mahanadi basin.

Chhattisgarh contributes about 2% to the fish production in the country and the main sources of inland fishery are village ponds or tanks, irrigation reservoirs, and river stretches (HVR, n.d.). The Chhattisgarh government has introduced various schemes to improve the inland fish production, like providing training, introducing new fishing techniques, leasing aquaculture ponds to local fishermen cooperatives, and providing funds for fish seed development. The Department of Fisheries has also introduced welfare schemes like providing housing for fishermen, group accidental insurance scheme and relief schemes.

Different authorities have different leasing rights as per the size of the water bodies: a) Water bodies up to 10 ha area are leased by Gram Panchayats, b) Water bodies from 10 to 100 ha area are leased by the Janpad Panchayat, c) Water bodies from 100 to 200 ha area are leased by the Jila Panchayat, d) Water bodies above 200 ha are allottedby the Department of Fisheries to Fishing Cooperatives (200-1000 ha) and Chhattisgarh Matsya Mahasang (1000-5000 ha).

As per the new amendment, the Department has to lease water bodies in the following order of priority:

- Registered Fishermen Cooperative;
- Fishermen group (above 1 ha is leased);
- Individual fisherman (below 1 ha is only leased);
- Persons displaced on account of submergence caused by irrigation projects;
- Self Help Groups in absence of the above four (HVR, n.d.).

15 Over the years the quality of water, especially in certain stretches, has been deteriorating.

Table 9 provides a compilation of the available water resources in Chhattisgarh for the development of fisheries. The annual fish production in 2013–14 was 2.849 lakh ton as against 1.395 ton in 2007–08. The schemes initiated by the Fisheries Department of Chhattisgarh have improved the inland fish production. This is indicated from the fact that the annual fish yield in 2001–2002 was 2.970 kg/ha and this has increased to 3.439 kg/ha in 2013–14 (Government of Chhattisgarh, 2014).

Table 9: Water resources in Chhattisgarh for the development of fisheries

Type of water area	Area available for fisheries in Lakh ha	Area developed for fish culture (till 2013–14) in Lakh ha	% of area developed
Ponds	0.751	0.683	90.94 %
Reservoirs	0.826	0.800	96.85%
TOTAL	**1.577**	**1.483**	**94.03%**

Source: Department of Fisheries, Government of Chhattisgarh

Interviews and secondary data point out that many varieties of fish species are found in the Chhattisgarh part of the Mahanadi basin. Chauhan earlier reported about 47 species in the Tel river (tributary of Mahanadi), and the HVR report indicates that the government is providing support for mostly commercial fishes like rohu (*Labeo rohita),* catla (*Catla catla*) and mrigal (*Cirrhinus mrigala*) and exotic species like grass carp (*Ctenopharyngodon idellus*), common carp (*Cyprinus carpio*), and silver carp (*Hypothalmitcthys molitrix*). Other important fish species in the Mahanadi are (found in Hasdeo river, tributary of Mahanadi) bata (*Labeo bata*), kotri/swamp barb (*Puntius sophore*), khoksi/ snakehead (*Channa punctatus*), sirangi (*Salmophasis bacalia*), kotia/ bagrid catfish (*Rita rita*), and padhana/ catfish (*Wallago attu*). Besides these, there are also many indigenous species which are called ornamental fishes and have larger demand outside the basin. Jha and Tamboli (2012) have reported 17 species of catfish in the Kelo and Mand tributaries of the Mahanadi river. Some of these species recorded are *Ompok*, *Rita*, *Mystus*, *Bagarius, Ailia, Clupisoma, Eutropiichthys, Pseudotropius, Silonia, Heteropneustus and Clarias*.

The state of Odisha has 6.72 lakh ha of fresh water area, 480 km of coast line and 4.18 lakh ha of brackish water resources (Government of Odisha, 2014), thus forming an important source of livelihood for its people. Inland fishing is carried out in reservoirs, tanks, rivers, canals, swamps, lakes, etc., whereas estuaries and the Chilika lake have brackish water resources. The annual per capita consumption of fish in the state is 9.3 kg. Table 10 gives an idea of the annual fish production from the various sources of water.

Table 10: Fish production in various water resources in Odisha state (in metric tonnes)

Year	Freshwater	Brackish water	Total Inland	Marine	Grand Total
2009-10	215803	25508	241311	129332	370643
2010-11	224956	27750	252706	133479	386185
2011-12	237470	30062	267532	114296	381828
2012-13	261919	29913	291832	118311	410144
2013-14	263862	30006	293868	120020	413889

Source: Department of Fisheries, Government of Odisha

The Hirakud reservoir has about 40 commercial fishes, including catfishes and carps. Since the construction of the dam in 1957, studies show that significant changes have occurred in the fish fauna. A large number of migratory fish and prawn species have been affected like the *Tor mosal, Rhinomugil corsula, Hilsa ilisha* and *Macrobrachium malcolmsonii* (FAO, n.d.; Kumar, Charan and Kumar, 2013). Similarly, due to the Hirakud reservoir, the sedimentation rate has increased in the Chilika lagoon, thereby affecting the fish (Das and Jena, 2008).

Like the state of Chhattisgarh, Odisha state offers many central and state level schemes for fishermen. The Matsyajibi Unnayana Yojana (MUY) is a state scheme started in 2011 to provide social security and livelihood support to the fishing communities in Odisha. A total of 14 proposals exist under this scheme that provides support to the farmers in buying fishing gear, marketing infrastructure and financial assistance on case of accidents to their families. Similarly Fish Farmers Development Agencies (FFDAs) have been formed at the district level to promote freshwater aquaculture in the state, and so far have brought 62.167 ha in 30 districts under scientific fish farming, with an average fish productivity of 2.13 tonnes/ha (Government of Odisha, 2015b). The Mahanadi basin has a high potential to develop fisheries further with proper guidance and knowledge.

8. Institutional and Policy Context

The first National Water Policy in India was formulated in 1987. After its promulgation, the policy has been revised a number of times. The current National Water Policy was formulated in 2012 (Department of Water Resources, 2012). It lays out many of the essential principles under which various water management processes such as planning, coordination, allocation and participation can take place.

8.1 Institutional and Policy Frameworks Encompassing Inter-sectoral Water Allocation in Odisha

In the last couple of decades, sectoral water demand in Odisha has been increasingly shifting from irrigation to industry. With the changing demand pattern, the Government of Odisha has changed the institutional structures managing water resources in the state. In the 1990s, the Irrigation Department was converted into the Department of Water Resources (DoWR). This has resulted in many changes such as Chief Engineers being given the additional responsibility of basin management. Surface water management has also undergone reforms under the World Bank funded Orissa Water Resources Consolidation Project (OWRCP) which aims to:

a. Improve the planning, management and development process for the state's water resources;

b. Increase agricultural productivity through investments to improve existing schemes and complete viable incomplete schemes;

c. Enhance DoWR's institutional capability and;

d. Complete dam safety work during 1994–2005 (Agriculture and Rural Development Unit, 2005)

Under these structural reforms, water management has gone from being project-based management (e.g. in the case of Chhattisgarh) to basin level management which includes planning and development of water resources. The OWRCP also established various offices and processes such as an environmental cell and environmental protection units to look after clearances to safeguard the environment, the formation of the Odisha Water Planning Organisation (OWPO), the preparation of river basin plans and an integrated state water plan based on river basin plans, Rehabilitation and Resettlement (R&R) directorate, and the formation of River Basin Organisations (RBOs) (Agriculture and Rural Development Unit, 2005). Thus, Odisha has become a pioneer state in India practising bottom-up river basin planning which considers the basin as the hydrological unit for resource management.

The first state water policy in Odisha was formulated in 1994 corresponding to the 1987 National Water Policy. After this, the state water policy has been revised to accommodate the updates of the National Water Policy. The current state water policy was formulated in 2007 and broadly follows the 2002 National Water Policy (Department of Water Resources, 2007), the main difference being that the 2007 Odisha state water policy accords second priority to water for the environment.

The main institutions in Odisha dealing with water resources management are, (i) the River Basin Organisations, (ii) the Odisha Water Planning Organisation, and (iii) the Water Resource Board.

8.1.1 The River Basin Organisations

The River Basin Organisations (RBOs) are multi-disciplinary organisations formed in the state with the purpose of planning and monitoring, i.e., overseeing all water related activities in the river basins (The Orissa Gazette, 2007). The RBOs have a two-tiered structure with a planning body, known as the board, consisting of experts and professionals along with a council, to deliberate on action plans put up by the board and accord approval. Councils have members such as elected representatives of the basins' area in the parliament and the legislative assembly, along with district collectors and NGO representatives, whereas the board has members with an engineering background with a rank of Superintendent Engineer/Deputy Director in associated government departments, e.g., Minor Irrigation, Hydrology and Industries.

The two major functions of RBOs are as follows:

- Ensuring Integrated Water Resources Management (IWRM) in the basin along with bringing in coordination of activities of all departments to resolve conflicts.
- Preparation of 10 years perspective action plan for a) conservation, management and optimum utilisation of water resources of rivers and groundwater for all end use sectors, b) prevention of pollution of surface and groundwater, c) drought mitigation and prevention, d) development of crops plans, and e) promotion of afforestation and control of soil erosion and recharge of groundwater.

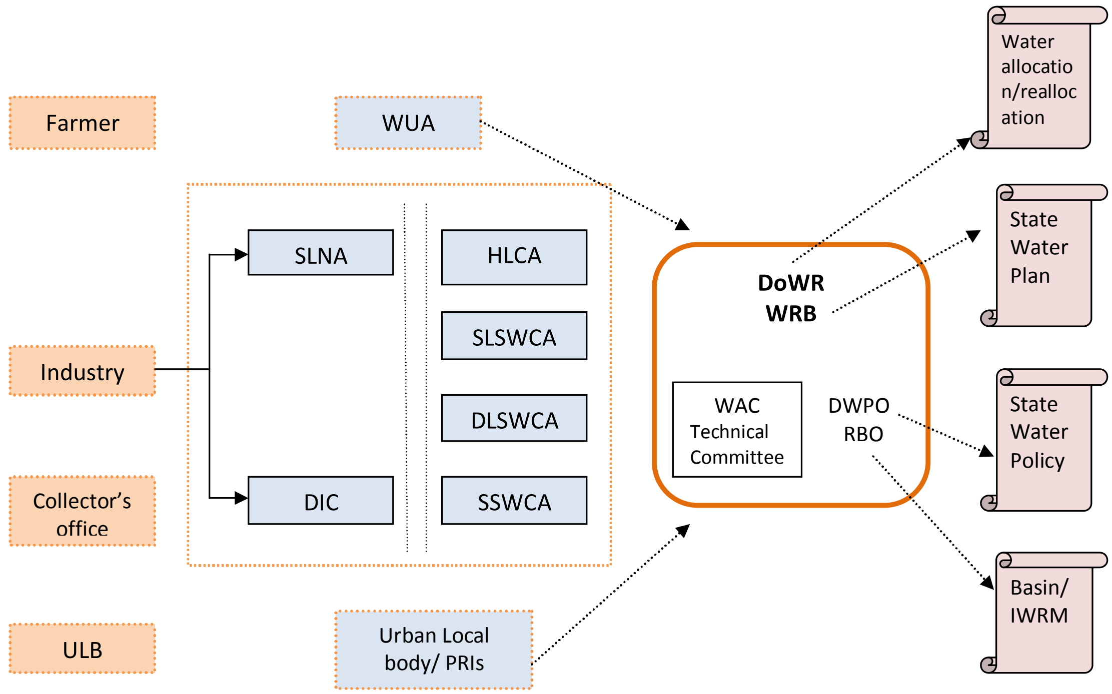
The formation of RBOs, which would plan the basin with elected peoples' representatives and NGOs as its members, has the potential to make the planning process a strongly participatory one as compared to the conventionally technical and bureaucratic processes. However, it is not mandated that the river basin plan be put up in the public domain for either review or comments or for wider public dissemination. In the absence of such dissemination, it is difficult to know if such plans even exist for all of the 11 river basins in the state.

Preparing a 10-year perspective action plan to implement the basin plan, gives RBO the strength not only to coordinate and prepare the respective government departments to manage the water resources but the potential to avoid conflicts due to allocation decisions. Another important function of the RBOs is to finalise allocation of water to various stakeholders in the basin for approval by the Water Resource Board (The Orissa Gazette, 2007).

8.1.2: The Odisha Water Planning Organisation

The Odisha Water Planning Organisation (OWPO) is the nodal agency undertaking the overall planning of water resources in the state. The OWPO is responsible for the preparation and updating of macro-level multi-sectoral river basin plans of the state after interacting with various stakeholders. The OWPO submits the draft basin plans to the RBO for ground truthing and to modify the draft as per comments of the RBO before putting it up for approval. A river basin plan prepared by the OWPO and vetted by the RBOs is then placed before the Water Resources Board (WRB) for approval. The OWPO also comes up with the state water plan based on individual river basin plans of all the river basins. Figure 30 shows various institutions relevant for decision-making, policy and planning, and affecting the inter-sectoral water allocation mapped together.

Figure 30: Various Institutions responsible for decision-making, planning and allocation



8.1.3: The Water Resources Board

The Water Resources Board (WRB) is the highest authority in the state for designing policy and principles on water development (The Orissa Gazette, 2007). The OWPO functions as its secretariat. The Government of Odisha through its DoWR has formulated the WRB in order to facilitate smooth decision-making in the matter of water planning and allocation between various sectors and to provide necessary advice to the government in the matter (The Orissa Gazette, 1993). It is headed by the chief secretary, along with secretaries of other concerned departments as its members. The WRB looks into the following matters of water resources policy and planning:

a. Preparation of Odisha State Water Policy;

b. Integrated Planning of State Water Resources;

c. Allocation of Water Resources among user sectors;

d. Prioritisation of Water Resources Development Schemes;

e. Enforcement of Environmental Management Plans (EMP), acts and rules regarding Water Resources Development.

Water allocation is one of the multi-disciplinary technical as well as normative decision-making problems. In the current set up, the WRB has the responsibility to look into decisions regarding water allocation. The WRB consists of technical and bureaucratic members. The process of water allocation for various sectors takes place through their individual institutional channels, e.g., in case of agriculture the institutional structure of the Pani Panchayats/ Water UsersAssociations (WUA) is used, and in case of industry the institutional structure of industry facilitation services is used. However, the ultimate decisions rest with the WRB as the highest organisation for planning and policy-making.

8.1.4: The Water Allocation Committee

The technical part of allocation decision-making is further looked after by a technical committee formulated under the DoWR known as the Water Allocation Committee (WAC) (The Orissa Gazette, 2010). The members of the WAC are essentially from a technical background. The functions of the WAC are as follows:

- To consider the application of the intending users, assess the requirement of water and recommend for allocation keeping in view the sectoral demands envisaged in the State Water Policy;
- To examine the feasibility of water drawal scheme furnished by the intending users and suggest additional storage, if any;
- To formulate the guidelines for allocation of water for industrial, commercial and any other use;
- To examine the impact of pollution on the environment and suggest remedial measures;
- To suggest additional conditions if any to be imposed over and above the existing terms and conditions;
- To verify overlapping of irrigation command at the time of recommendation for allocation;
- To vet the water management plan for final allocation of water and;
- To perform such other functions relating to allocation of water to the intending users as the government may require from time to time.

Thus, based on the above various procedural criteria, the WAC recommends its decision on allocation of water to the WRB along with additional conditions if any. However, ultimate decision-making rests with the DoWR. The individual channels for water allocation process can be seen in Figure 31. In the case of the Urban Local Body (ULB), the decision to supply water for domestic purposes takes priority as per the current state water policy, and thus the process is relatively simpler. On the other hand, in the case of the industrial sector, there is a complex institutional structure known as the Single Window Clearance System established in order to facilitate the acceleration of industrialisation of Odisha (Industries Department, Government of Orissa, 2005).

8.1.5: Institutional Structure for Water Allocation for the Industrial Sector

The various institutions established under this system are established under the Industries Act, 2005 (The Orissa Gazette, 2004) and its Rules 2005 (The Orissa Gazette, 2005). This gives the whole structure a legal backing to push the line departments for facilitating the clearances in an accelerated manner. Every industrial applicant must fill a combined application form (CAF), reducing the burden on the applicant to apply to multiple agencies for various clearances. The CAF is then submitted to the nodal agency either at the district level (District Industries Center, (DIC)) or at the state level (State Level Nodal Agency (SLNA), which is currently the Industrial Promotion and Investment Corporation of Odisha Limited (IPICOL)) depending upon the amount of investment (The Orissa Gazette, 2005 a).

This nodal agency then looks after all further clearance processes and follows up on activities with the respective departments. There is also a set time limit for various departments to reply in the case of clearance decisions. The nodal agency then depending upon the investment sends the document either to the District Level Single Window Clearance Authority (DLSWCA) (for investments up to Rs. 50 Crore) (The Orissa Gazette, 2005 b) or to the State Level Single Window Clearance Authority (SLSWCA) (for investments more than Rs. 50 crore but less than Rs. 1000 crore) (The Orissa Gazette, 2005 b), or to the High Level Clearance Authority (HLCA) (for investments more than Rs. 1000 crore) (The Orissa Gazette, 2005 c).

The DLSWCA is headed by the district collector and has 10 members from various respective concerned departments. The SLSWCA is headed by the Chief Secretary and has 16 members from secretaries to state heads of various concerned departments. The HLCA is headed by the Chief Minister and has 12 members from either the ministers or secretaries of state. Although technically decision making rests with the concerned line department, in the case of the DoWR, it is unclear what role these 'clearance authorities' play over and above pushing the DoWR for timely clearance. This is especially the case with the HLCA, in which all the members are elected representatives at the top level of the state as against the bureaucratic cum technical composition of the DoWR. Given that the allocation decision making is not just a technical process but also involves normative aspects, the current institutional set up looks highly susceptible to normative decision-making, ruling over the technical criteria, at least at the HLCA level. Here neither is the decision making process participatory nor is the decision made public. Only the applicant is informed about the final decision.

The water allocation process for each of the three sectors takes place through their own institutional channels. However, the allocation process still has many technical, normative and multidisciplinary aspects and concerns from all the stakeholders. Thus the current setup for allocation decision-making does not provide the required multi-stakeholder cross-sectoral platform for participation.

8.2 Institutional and Policy Frameworks Encompassing Inter-sectoral Water Allocation in Chhattisgarh

Prior to the formation of Chhattisgarh, the state water resources were managed by the Irrigation Department of Madhya Pradesh. The Irrigation Department became the Water Resources Department (WRD), which is now responsible for water related decision making in the state. The Chhattisgarh Irrigation Project Board (CIPB) was formed with the prime function of the execution of irrigation and multi-purpose projects. Also the board is in charge of preparing the project report and the river basin master plan. The CIPB is a ministerial board headed by a chief minister and assisted by a secretary who is an ex-officio deputy secretary of the WRD.

The board functions are limited to planning, execution and financial approval of projects. There is no stipulated process and no institutional structure for inter-sectoral water allocation. The WRD makes inter-sectoral water allocation decisions and is the competent authority that grants licenses under the provision of the Act to commercial and other establishments on applications. The individual channel for the water allocation process is shown in Figure 31. As per the state water policy, drinking water has first priority, hence the process of water allocation is relatively simpler.

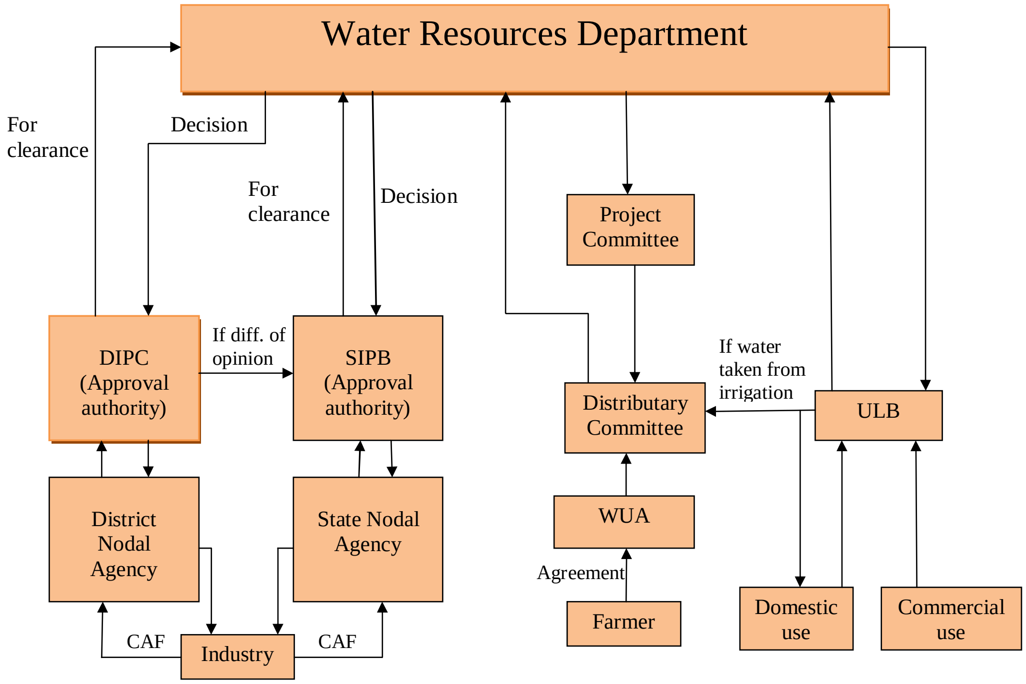
The Chhattisgarh State Industrial Development Corporation (CSIDC) supplies water for industrial purposes if the industries are established under the CSIDC, otherwise industries can apply for individual water allocation to the WRD. The secretary of the WRD holds the discretion to grant or deny permission for water from a prescribed source.

Similar to Odisha, a single window clearance system has been established to facilitate and attract investment in Chhattisgarh. The various institutions established under this system are created by the Investment Promotion Act, 2002 and its rules established in 2004. Similar to Odisha, this is done to facilitate investment in Chhattisgarh. Both states follow a similar procedure, except one major difference. The procedure in

Chhattisgarh does not include a scrutinising agency such as the WAC. Any water requirement proposal is directly sent to the WRD for its approval. The overall process in Chattisgarh is described in the following paragraph.

Every industrial applicant has to fill a CAF, which essentially reduces the burden on the applicant to apply to multiple agencies for various clearances. The CAF is then submitted to a nodal agency either at the district level (District Industries Center, DIC) or at the state level (State Level Nodal Agency, SLNA) depending upon the amount of the investment. The District-level Investment Promotion Committee (DIPC) consists of nominated members from various departments and the State-level Investment Promotion Board (SIPB) is the ministerial board for facilitating the clearances required for industries. The state government also appoints a State Level Nodal Agency (SLNA) and District Level Nodal Agencies (DLNA) as points of contact for the investor. The SLNA shall be a cell under the state's industries department headed by the convener of the state board, and the district industries centre shall be the respective DLNA. The application process for water allocation for various water users is shown in figure 31.

Figure 31: Various Institutions responsible for decision making and allocation



In case of individual connections for domestic or commercial applicants, an application must be made to the appropriate ULB for water supply, and the WRD allocates water for domestic purposes. Although technically decision making rests with the concerned line department, it is unclear what role these clearance authorities play over and above pushing the WRD for timely clearance, especially in the case of the SIPB, which consists of all elected members from concerned ministries as against the bureaucratic cum technical nature of the WRD. With reference to this structure, decision making is not just a technical process but also involves a normative aspect. In case of the SIPB, the current institutional set up is highly susceptible to normative decision making ruling over the technical criteria. Similar to Odisha, neither is the decision making process participatory nor is the decision made public. Only the applicant is informed about the final decision.

9. Critical Issues in the Mahanadi Basin

This section identifies some of the emerging critical issues in the basin. Timely engagement with these issues would go a long way in the sustainable, equitable and democratic management of the Mahanadi basin and its water resources. The emerging issues include environmental flows, water quality, inter-sectoral water allocations, and conflicts and inter-state water sharing.

9.1 Environmental Flows

Rivers are ecosystems in themselves performing vital ecological and evolutionary functions including providing basic needs and livelihoods for millions of people. They cannot be treated as drains or channels which are meant to carry wastes. Most of the tributaries of the Mahanadi, for example, Hasdeo, Seonath, etc., are severely impacted and have lost their natural flows. It is necessary to revive the environmental flows (e-flows) such that the rivers are able to perform the basic eco-hydrological functions and support daily needs of the people and ecosystems dependent on them.

Thus, when using and managing a river, it is important to take into consideration the concept of e-flows. A river is a river only when it flows, and therefore 'flow' is the most important indicator of the health of the river. However, the mainstream viewpoint of the water development sector till now has been that 'any drop of water flowing into the sea is a waste' and this mindset needs to change. Also, despite the importance of flow, it is now that the Ministry of Environment and Forests (MoEF) has started considering environmental flows as a part of the Environmental Impact Assessments (EIA). Recently, the MoEF has made e-flows allocation a mandatory part of the Environmental Clearance (EC) process. Despite this fact, there is still an important debate on how much water should be apportioned for ecological needs of the river (SANDRP, 2012).

In the context of the Mahanadi basin, it is important to define e-flows as flows that need to be released from the various infrastructures such that the river regime will remain environmentally healthy. We also need to understand that e-flows are ultimately a compromise as they cannot transform the river into its original, pristine form. However, to a certain extent, they can help revive the health of the river such that it can perform certain ecological functions. Thus, a key question in the Mahanadi basin is how much water should be released as e-flows? This question should be answered taking into account the needs of all the users of the basin, the views of the stakeholders, and also using the best available scientific information that could guarantee that the basin will continue to be environmentally healthy (MoWR, GoI, 2014).

From the point of view of environmental flow, Mahanadi is not a lost case as yet. Though there is increasing pressure on the waters of the basin from different sectors, it is not a closed basin yet like many other rivers including the Krishna. All the water has not been allocated or committed for different uses. Thus it is an opportune moment to make an informed intervention to make environmental flows a part of the basin management plan. If we do not do it now, then this option will be fore closed forever.

9.2 Water Quality

Water is a fragile resource which can be easily polluted when it gets in contact with exogenous substances. Water quality refers to the chemical, physical and biological characteristics of water. Water quality is a measure of the condition of water relative to the requirements of one or more biotic species and to any human needs or purposes.

The Ministry of Water Resources has reported that the water quality parameters for the Mahanadi basin have been exceeded in tolerance limit during recent years (MoWR, 2014). The parameters that have crossed the tolerance limits are the Dissolved Oxygen (DO) and the Biochemical Oxygen Demand (BOD). There are a number of causes that are affecting water quality in the Mahanadi basin, which include chemicals and hazardous effluents released from industries, raw domestic sewage, and biomedical waste from the growing healthcare facilities (Jena, 2008). This is further compounded by dumping of the untreated city sewage into the river with increasing urbanisation in the basin. Similar is the case with mining activities in the upper part of the basin that would increase the presence of heavy metals in the river. With increasing industrial water use, there will be an increase in generated effluents compared to today's levels.

It is important to pay attention to such causes because they are provoking innumerable health and environmental problems. It is estimated that microbial pollution or contaminated water is the largest single cause of infant mortality and diarrhoea, the single highest cause of work days lost. Moreover, there are diseases such as gastro-enteritis, cholera, typhoid, viral hepatitis and malaria, which are a direct result of stagnant water and polluted environments (Jena, 2008). Heavy metals are toxic to aquatic and other forms of life, and some of the heavy metals like chromium, cadmium, lead, zinc and manganese are carcinogenic. Selenium found in fly ash can be radio-active. With so many thermal power plants already operating in the basin, the possibility of radioactive contamination is high. In the case of the Hirakud reservoir, the fly ash from the nearby thermal power plant is dumped into a portion of the reservoir itself, giving rise to the fear of radioactive contamination of the reservoir water. Thus, there is an urgent need to discuss and find ways to address all these causes that are direct outcomes of not only poor water management but also the type of developmental activities taken up in the basin.

9.3 Inter-sectoral Water Allocations

Over the last couple of decades, serious issues of governance pertaining to inter-sectoral water allocation have been emerging in the basin. Water is getting increasingly (re)allocated from agriculture to industries, giving rise to popular discontent in the basin. The first expression of this discontent about water reallocation took place in the case of the Hirakud dam. Prior to 1991, the industrial allocation from the Hirakud reservoir was very nominal. However, with neo-liberal policies since 1991 and to give a push to industrial development, the Government of Odisha allocated 0.350 MAF (Million Acre Feet) to industries, which comes to about 8% of the total storage capacity of the reservoir. The frequent irregularities of irrigation water supply to the Sason canal command (of Hirakud) from 2005 to 2007 and growing industrialisation and increasing water intake from the reservoir by industries saw massive mobilisations and protests by farmers (Choudhury, Sandbhor and Sahoo, 2012). A similar situation is developing in the upper part of the basin (Chhattisgarh) with more and more water getting allocated to industrial use especially for the thermal power plants.

Increasing allocation and diversion of water for industries has been one of the most controversial issues in the water sector in recent times, which is not limited to the Mahanadi alone. This needs to be seen as part of the wider political economy and the developmental trajectory that is driven by high growth through industrialisation. Hence there are many who argue that what is happening today is basically the expropriation of water from farmers by the industries as part of a wider process of "accumulation through dispossession" (Joy et al., 2011). Given the likelihood that the present developmentalist paradigm, which promotes "growth at all costs" will continue in the country for a long time in the future, the inter-sectoral water allocation issue will get further sharpened in the country. There are enough indications that the Mahanadi basin is going to be at the forefront of this agricultural vs. industry contestation. The report *Life,* *Livelihoods, Ecosystems, Culture: Entitlements and Allocation of Water for Competing Uses* (Joy et al., 2011) offers an initial set of ideas on how to engage with the issue of inter-sectoral allocation. This needs to be further developed in the specific context of the Mahanadi basin.

9.4 Inter-state Water Sharing

The contesting issue of sharing Mahanadi waters between Chhattisgarh and Odisha reached the Rajya Sabha on 26th July, 2016 when Mr. Dilip K. Tirkey of the Biju Janata Dal, through a calling attention motion, raised the issue of alleged construction of barrages in the Mahanadi basin by the Chhattisgarh government. According to him, about 10 barrages are being built by Chhattisgarh, of which two or three are already completed. He also said that the Chhattisgarh government has neither provided any information to the Odisha government on this; nor has it taken the Odisha government into confidence, which should have been done as Mahanadi is an inter-state river and Odisha is the lower riparian state. He also wanted to know the role of the CWC in these developments. Other political members from Odisha also joined Mr. Tirkey on this issue. They also stated that recently the flow into the Hirakud dam has reduced by a third and that they fear that it will reduce even further.

Sushri Uma Bharati, Minister of Water Resources and Ganga Rejuvenation, in her written response, said that the CWC prepares the techno-economic appraisal of major and medium projects, whereas in the case of minor projects the appraisal is prepared by the respective state governments. According to her, at the moment there are three project proposals with the CWC. The Minister of State of the same Ministry claimed that only four of the 'projects' that Odisha is complaining about are major and medium projects and hence under the purview of the centre for clearance. He also said that the CWC had asked Chhattisgarh to provide the details, including the detailed project reports of each of the projects to Odisha which they had done. Moreover, only one of these projects, the Kelo dam, has actually been approved. The others are still awaiting clearance. Ms. Uma Bharati also went on to say that the Memorandum of Agreement reached between undivided Madhya Pradesh and Odisha on 20th April, 1983 did provide for the constitution of a joint Board to look into the inter-state issues. However, till date this Board has not been constituted.

Intervening in the discussion, Mr. D. Raja of the Communist Party of India said that this is not an issue pertaining to only Chhattisgarh and Odisha, but an issue that concerns all riparian states of all inter-state rivers in the country. According to him, an amicable solution needs to be worked out by taking into account the interests of all riparian states. He also said that the river waters should not become an issue of conflict.

Interestingly, nobody from Chhattisgarh seems to have intervened in the discussion. It was left to Mr. Rajaram, a Bahujan Samaj Party (BSP) MLA from Uttar Pradesh, to defend Chhattisgarh. He intervened in the discussion saying that with all the interventions that Chhattisgarh has made in the basin, it gets only 25% of the water whereas Odisha still gets 75%.

What happened in the Rajya Sabha was a reflection of what was happening in Odisha, especially in and around Hirakud, over the last few months, especially in the background of the drought. Experience shows that the inter-state contestations come to the fore in deficit years and hence how we share shortages is an important aspect of inter-state water sharing.

Unlike in the case of many other inter-state rivers like the Narmada, Krishna, Godavari, etc., there was no Tribunal appointed under the Inter-state Water Disputes Act of 1956 to sort out the issues of water sharing between the riparian states of the Mahanadi. However, there have been certain limited agreements between Odisha and undivided Madhya Pradesh which have been arrived at in meetings that were held from time to time both at the bureaucratic and political levels (including the meetings of Chief Ministers) of the states. The Odisha State Water Plan, 2004 (Department of Water Resources, Government of Odisha, 2004) has a 26 page section (Annexure B) on all inter-state agreements it has entered into with its neighboring states on inter-state rivers. In the case of the Mahanadi, these meetings did discuss many of the developments in the basin like the Hirakud Dam Project, Ib Diversion Scheme, Mahanadi Reservoir Project and many other projects on the various tributaries. These meetings have also engaged with issues like flood warning in the Mahanadi basin, Madhya Pradesh's share in power generated by the Hirakud project, development of consumptive use from the Mahanadi system by Madhya Pradesh and its impact on the working of the Hirakud reservoir, and so on. As mentioned earlier, they also agreed to establish a Joint Control Board. Reading through the proceedings of these meetings (as given in the Orissa State Water Plan), one gets the impression that these meetings did not lead to lasting and binding agreements between the two states, and the two states primarily used these meetings to air their respective viewpoints. Unless the two states can engage with each other in a meaningful dialogue and sort out issues between them, in all likelihood, the Centre may have to intervene and appoint a Tribunal to sort out issues. However, the experience of Tribunals in solving inter-state water disputes has not been all that promising. The latest example is the Cauvery Tribunal —where it took nearly 17–18 years to give the final award, and even after that there was disillusionment all around (especially in Karnataka). All the riparian states of the Cauvery basin, have now approached the Supreme Court.

The civil society organisations in Chhattisgarh and Odisha need to seize the opportunity and start a process of a meaningful dialogue and see how amicably the issue can be sorted out. If this does not happen, then there is all likelihood that the vested interests would try to cash in on the situation which could become intractable. Identities, vote bank politics, etc., can get enmeshed in this situation and give rise to a situation of "less water and more politics"!

What is urgently needed is the creation of an atmosphere conducive to dialogue based on facts and trust.[16] In fact, this should precede any efforts at political settlements. The first step in creating such a dialogue would be mutual accommodation. The Chhattisgarh government should assure Odisha of transparency, in the form of providing all data related to upstream developments in the basin, and take Odisha into account while planning new projects. On the other hand, perhaps Odisha should also realise that Chhattisgarh is a newly created state with its own aspirations. This needs to be acknowledged upfront, followed by exploring how the Mahanadi waters can be shared in a sustainable and just manner, with the process going beyond the 'first user principle'. Without this transparency and undertsnading between the two states, no dialogue can take place. The civil society organisations in both these states can also draw lessons from the citizen's initiative on the Cauvery — the Cauvery Family — that brought together farmers of both Karnataka and Tamil Nadu in the spirit of learning and sharing.

In the long run, the people of Chhattisgarh and Odisha have to live as neighbours and share the Mahanadi. Whatever else we might do, we cannot change that. Geographic advantages and disadvantages can only be resolved by negotiation. That is what history tells us and what common sense advocates. It is not the Mahanadi, but the politics of water as an instrument of power that divides us. We need to see the Mahanadi herself as uniting us and nurturing us through the good and bad years. However, for this to happen, it is important to rise above partisan politics.

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16 This and the following paragraph are a modified version of what Gujja, Joy and Paranjape wrote in the context of the Babhli conflict on the Godavari titled Babhli Water Conflict: Less Water, More Politics (Gujja, Joy and Paranjape, 2010).

9.5 Water Conflicts

One of the reasons for studying the Mahanadi basin is that many different types of water related conflicts are emerging in the basin. The Forum tried to document some of these conflicts in the earlier phases of the Forum's work. *Water Conflicts in India: A Million Revolts in the Making* (Joy et al., 2008) and *Water Conflicts in Odisha: A Compendium of Case Studies* (Choudhury et al., 2012) capture some of the important conflicts in the basin.

Water conflicts in the basin have been occuring for a long time now. In particular, it is relevant to mention the conflict that took place when a part of the Seonath river was privatised. The Seonath river is a tributary of the Mahanadi, and it was contracted to a private corporation — Radius Water — a division of the Kailash Engineering Limited in 2001. The conflict did not start immediately after the signing of the contract. It took a while for the people to realise the reality. Initially, the local people were not aware that a private firm is managing the new barrage that had sprung up across the river. It is relevant to highlight that no prior information was given to people about the contract. However, after a few months of signing the contract, Radius Water informed the local fishermen that they were no longer allowed to fish in certain areas alleging safety reasons. Moreover, the corporation also banned farmers who owned land near the river from lifting water from the river with motor pumps (Das and Pangare, 2007). This saw the first mobilisation of the people against water privatisation in the country.

Another important conflict that is worth mentioning is the one over the Kelo river. The Kelo river is a minor perennial tributary of the Mahanadi. The issue here was the permission granted by the Chhattisgarh government to Jindal Steel and Power Limited (JSPL) to extract water through a combination of stop dams and intake wells from the Kelo river. The permission granted to JSPL allowed the abstraction of about 0.88 Mm^3 from the Kelo river every month, which was about a tenth of the flow in the river. After this happened, the local people got organised and started to complain about the situation. In 1998, the Kelo Bachao Sangharsh Samiti (KBSS) launched a campaign to save the Kelo by asserting people's rights to natural resources, in particular water. Additionally, they filed a public interest litigation against JSPL (Kashwan and Sharma, 2008). Once again, this situation illustrates the need for the government to stop allowing such disastrous privileges to private companies that clearly put safe access to water in danger for local people and ecosystems.

The other well known conflict is over the reallocation of water from the Hirakud dam to industries (as discussed in the section 9.3 on contending water uses). This also led to a massive mobilisation of the farmers from the command area of the project, which finally forced the government to be sensitive and also take certain corrective steps (Choudhury et al., 2012)

There have been conflicts on other fronts too. For example, water pollution has become an issue of contestation in the basin. The latest is the inter-state issues. As discussed earlier in section 9.4 on inter-state issues, some of the barrages that are being constructed in the Chhattisgarh part of the basin are becoming a cause of tension between the two states.

In short, different types of conflicts are being played out in the Mahanadi basin and how all the concerned parties respond to these emerging conflicting situation would decide the future of both the river and its people.

10. In Lieu of a Conclusion

This report does not have a conclusion because it is only the beginning of a much longer engagement. The purpose of this report is only to layout the situation as it exists in the basin, provide basic information of the basin in terms of data and also bring out some of the critical issues. The Forum is trying to engage with these issues through work around three themes, namely, environmental flow in the context of river basin management, agricultural and industrial water allocation and use, and conflicts and competition around groundwater. We hope that through this engagement we would be able to bring to the table some new insights which can enable all of us to engage with the issues in a more informed manner. Hope this situation analysis of the basin serves as one of the initial steps for this long term engagement.

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Appendix

Table A.1: Factorization used in the Mahanadi basin report, based on data provided by MoWR, GoI.

Sr. No.	State	Districts	Percentage in the basin
1	Chhattisgarh	Bastar	99.6
2	Chhattisgarh	Bilaspur	100.0
3	Chhattisgarh	Dhamtari	70.2
4	Chhattisgarh	Durg	85.3
5	Chhattisgarh	Janjgir-Champa	34.7
6	Chhattisgarh	Jashpur	100.0
7	Chhattisgarh	Kabirdham	38.8
8	Chhattisgarh	Kanker	100.0
9	Chhattisgarh	Korba	100.0
10	Chhattisgarh	Koriya	100.0
11	Chhattisgarh	Mahasamund	70.4
12	Chhattisgarh	Raigarh	16.4
13	Chhattisgarh	Raipur	100.0
14	Chhattisgarh	Rajnandgaon	70.4
15	Chhattisgarh	Surguja	16.4
16	Odisha	Angul	33.6
17	Odisha	Balangir	100
18	Odisha	Bargarh	100
19	Odisha	Boudh	100
20	Odisha	Cuttack	96.9
21	Odisha	Deogarh	100
22	Odishas	Dhenkanal	15.3
23	Odisha	Ganjam	6.1
24	Odisha	Jagatsinghpur	100
25	Odisha	Jharsuguda	100
26	Odisha	Kalahandi	86.1
27	Odisha	Kendrapara	54.1
28	Odisha	Khurda	92.8
29	Odisha	Nuapada	100
30	Odisha	Nabarangpur	31.6
31	Odisha	Nayagarh	92.1
32	Odisha	Kandhamal	74.7
33	Odisha	Puri	100
34	Odisha	Raygada	1.5
35	Odisha	Sambalpur	84.3
36	Odisha	Subarnapur	100
37	Odisha	Sundargarh	42.1

Table A.2: National parks and wildlife sanctuaries located in the Mahanadi basin

Sr. No.	State	National Parks/Wildlife Sanctuaries	Location	Total area in km2	Flora	Fauna	Particulars
1.	Chhattisgarh	Achanakmar Wildlife Sanctuary	Bilaspur	914	Sal, bija, saja, haldu, teak, tinsa, dhawara, lendia, khamar, and over 600 species of medicinal plants	Tiger, leopard, bison, flying squirrel, Indian giant squirrel, chinkara, wild dog, hyena, sambar, chital and over 150 species of birds	Gond and Baiga tribes reside in the core area
2.	Chhattisgarh	Barnawapara Sanctuary	Basna, Mahasamund	244.66	Teak, sal, bamboo, terminalia	Tigers, sloth bear, flying squirrels, jackals, four-horned antelopes, leopards, chinkara, black buck, jungle cat, barking deer, porcupine, monkey, bison, striped hyena, wild dogs, chital, sambar, nilgai, gaur, muntjac, wild boar, cobra, python	Only the southern part of the sanctuary exist in the basin
3.	Chhattisgarh	Sitanadi Sanctuary	Dhamtari, Raipur	553.36	Semal, mahua, harra, ber and tendu	Tigers, leopards, flying squirrels, jackals, four-horned antelopes, chinkara, black buck, jungle cat, barking deer, porcupine, monkey, bison, striped hyena, sloth bear, wild dogs, chital, sambar, nilgai, gaur, muntjac, wild boar, cobra, python, parrots, bulbul, peafowl, pheasant, crimson breasted barbet, teetar, tree pie, racket-tailed drongos, egrets, and heron	The forest is mainly covered by sal, teak and bamboo
4.	Odisha	Bhitarkanika National Park and Wildlife sanctuary	Kendrapara	672	62 species of mangrove	Spotted deer, Sambar, Indian wild boars, Asiatic Jackal, Fishing cat, Jungle cat, Leopard, Hyena, Common mongoose, Otter, Small Indian civet, Indian porcupine, Rhesus macaque, Gangetic dolphin, Indian mole rat, 10 species of turtles, crocodiles, 9 species of lizards, Indian chameleon, Spotted Indian house gecko, sand skink, python, Common vine snake, Golden tree snake, Indian red snake, Common Kukhi snake, Common worm snake, Banded kraits, Common Indian Kraits, Estuarine sea snakes, Green viper, Russel's viper	145 km2 is dedicated to National Park and is the 2nd largest mangrove ecosystem in India. Sanctuary includes mangrove forests, rivers, creeks, estuaries, back water, accreted land and mud flats

Sr. No.	State	National Parks/Wildlife Sanctuaries	Location	Total area in km2	Flora	Fauna	Particulars
5.	Odisha	Chilika Wildlife Sanctuary	Chilika lake	1100	102 species of algae, 727 species of dicotyledons exist	Migratory and resident birds- flamingo, White Bellied Sea eagle, Brahminy kite, Spotbilled pelican, Barheaded goose, Openbilled stork, spoonbill, Brahimny duck, Wigeon, pintail, shoveller, Ibis, stilt, heron, egret, avocet, gull, tern, king fisher; blackbuck, spotted deer, golden jackals, hyenas	Declared as Ramsar site and Chilika lake is the largest lagoon in India
6.	Odisha	Chandaka Forest and Elephant reserve	Cuttack	175.79		Elephants, wild dog, Barking Deer, wild boar, red jungle fowl dab chicks, hyena, python and open bill stork, pangolin, monitor lizard, Crested Serpent Eagle, Great Horned owl, Red Jungle Fowl, Stone Curlew	
7.	Odisha	Debrigarh sanctuary	Baragarh	346.91	Bija, sal, sisoo, bandhan, manul, asana, ainla, dhaura, karada, harda, behada, bamboo	Tigers, leopards, gaur, sambar, spotted deer, four horned antelope, sloth bear, wild boar, langur, porcupine, migratory birds like Great Crested grebe, Brahminy duck, pintail, shoveller, godwal, Tufted pochard.	
8.	Odisha	Satkoshia sanctuary	Angul, Budh, Cuttack and Nayagarh	796	400 species- 126 trees, 98 shrubs, 125 herbs and 51 climbers	Gharial, Tiger, spotted deer, leopard, sambar, barking deer, Chousingha, Mouse deer, Rhesus macaque, langur, porcupine, hare, Civet cat, Ratel, wild dog	Popular for sal forests
9.	Odisha	Ushakothi Wildlife sanctuary	Sambalpur	304.03	sandalwood, Arjun, Neem, Acacia, Sal and Casuarinas	Black panthers, tigers, elephants, sloth bears, Racket trail drangos, Flying squirrels	

Source: Odisha State Forest Dept, n.d.(b) and Sanctuaries India, 2016

Tables A.3-A.4: Major mineral based industries in the Mahanadi basin

Table A.3: Important mineral based industries in Odisha

Sr. No.	Industry/ Plant	Capacity ('000 tpy)
a)	**Aluminium/ Alumina**	
1.	Hindalco Industries Ltd, Hirakud *(Proposed expansion to 213 th tonnes per year)	161.4* (aluminium)
2.	NALCO, Damanjodi	2100 (alumina)
3.	NALCO, Angul	460 (aluminium)
4.	Vendanta Aluminium Ltd, Lanjigarh, Kalahandi	1000 (alumina)
5.	Vendanta Aluminium Ltd, Jharsuguda, Sambalpur	500 (aluminium)
b)	**Asbestos Products**	
6.	UAL Industries Ltd. Korian, Dhenkanal	30
c)	**Cement**	
7.	Bargarh Cement Ltd, Bargarh	960
8.	Ultra-Tech Cement Ltd, Jharsuguda	800
9.	OCL India Ltd, Rajgangpur, Jharsuguda	2000
10	toshali Cements Pvt Ltd, Ampavalli, Koraput	180
d)	**Fertilizer**	
11	OCF-Paradeep	325.20 (N2) 802.8 (P2O5)
12.	Paradeep Phosphates Ltd, Paradeep	129.6 (N2) 331.2 (P2O5)
13.	SAIL Fertilizer Plant, Rourkela, Sundargarh	360 (CAN)
e)	**Iron and Steel**	
14.	Rourkela steel plant, Rourkela, Sundargarh	3070 (sinter) 2000 (pig iron) 1671 (saleable steel) 1900 (crude/liquid steel) 85 (tin plates)
15.	Visa Steel Lts, Kalinganagar, Jajpur	225 (pig iron) 300 (sponge iron) 50 (charge-chrome)
16.	OCL India Ltd, Lamloi, Sundargarh	120 (sponge iron) 85 (billets)
17.	Orissa Sponge iron Ltd, Palaspanga, Keonjhar	250 (sponge iron) 100 (steel ingot)
18.	Neelachal Ispat Nigam Ltd, Dubri, Jajpur	1711 (sinter) 1110 (pig iron) 1100(crude/ liquid steel) 13 (fertilizer)
f)	**Pig Iron**	
19.	IDCOL, Kalinga Iron Works Ltd, Barbil, Keonjhar	170

Sr. No.	Industry/ Plant	Capacity ('000 tpy)
g)	**Sponge Iron**	
20.	Action Ispat & Power (P) Ltd, Pandripather, Jharsuguda	250
21.	Adhunik Metaliks Ltd, Chandrihariharpur, Surguja	180
22.	Beekay Steel & Power Ltd, Uliburu, Barbil	105
23.	Bhusan Steels & Strips Ltd, Meramandali, Angul and Dhenkanal	300
24.	Crackers India (Pvt) Ltd, Bobhardhanpur, Keonjhar	60
25.	Deepak Steel & Power Ltd, Topadihi, Keonjhar	144
26.	Dinabandhu Steel & Power Ltd, Kalinganagar, Jajpur	60
27.	Jay Iron & Steel Ltd, Balanda, Rourkela, Sundargarh	60
28.	MGM Steel Ltd. Nimidha, Dhenkanal	100
29.	Ganesh Sponge Pvt Ltd, Krushnachandrapur, Angul	30
30.	Kusum Powerment Pvt. Ltd, Kutugaon, Keonjhar	100
31.	Mayur Electro Ceramics Pvt. Ltd, Pratapgarh, Mayurbhanj	15
32.	Neepaz Metaliks Pvt Ltd, Sundargarh	60
33.	Rexon Strips Ltd. Kumakela, Sundargarh	60
34.	Rungta Mines Ltd Unit-I, Karakola, Barbil, Keonjhar Unit-II, Kamando, Sundargarh	330
35.	Scan Sponge Iron Ltd, Rambahal, Sundargarh	60
36.	Scaw Industries Pvt Ltd, Gundichapada, Dhenkanal	100
37.	Spinge sales (India) Pvt Ltd, Kutugaon, Keonjhar	60
38.	Sree Metallic Ltd, Loidapada, Keonjhar	174
39.	Suraj Products Ltd, Barpalli, Sundargarh	45
40.	Surya Sponge Iron Ltd, Budhakendua, Jajpur	84
41.	Tata Sponge Iron Ltd, Joda, Keonjhar	390
42.	Vikram Pvt Ltd, Tumkela, Sundargarh	60
h)	**Ferro Alloys**	
43.	Balasore Alloys Ltd, Balgopalpur, Balasore	100
44.	FACOR, Charge Chrome Plant, Randia, Bhadrak	65
45.	IDCOL, Ferro Chrome & Alloys Ltd, Jajpur	18
46.	Indian Charge Chrome Ltd, Choudwar, Cuttack.	62.5
47.	Indian Metals & Ferro Alloys Ltd, Therubali, Cuttack	190
48.	Nav Bharat Ferro Alloys Ltd, Khargprasad, Dhenkanal	75
49.	Rohit Ferro-Tech Ltd, Kalinganagar, Jajpur	110
50.	Jaypore Sugar Co. Ltd, Rayagada	22.5
51.	Superb Metal Alloys Pvt Ltd, Rairangpur	0.3
52.	Tata Steel Ltd, Ferro-Manganese Plant, Joda, Keonjhar	30.5
53.	Tata Steel Ltd, Charge Chrome Plant, Bamnipal, Keonjhar	55.2

Source: Indian Minerals Year Book 2012 Vol. I, Indian Bureau of Mines

Table A.4: Important mineral based industries in Chhattisgarh

Sr. No.	Industry/ Plant	Capacity ('000 tpy)
a)	**Aluminium**	
1.	Bharat Aluminium Co. Ltd, Korba	200 (Alumina)
	(Korba plant- 1 capacity of 100,000 tonnes per year is non-operational 350 (Aluminium)	
b)	**Cement**	
2.	ACC Ltd, Jamul, Durg	1580
3.	Ambuja Cements Ltd, Rawan, Raipur	1146
4.	CCI Ltd, Akaltara, Janjgir-Champa	400
5.	CCI Ltd, Mandhar, Raipur	380
6.	Century Cement, Baikunth, Raipur	2100
7.	Grasim Cement, Rawan, Raipur	2500
8.	Lafarge India Pvt Ltd, Arasmeta, Janjgir-Champa	2240
9.	Lafarge India Pvt Ltd, Sonadih, Raipur	400
10.	Ultra Tech Cement Ltd, Hirmi, Raipur	2750
c)	**Fertilizer**	
11.	BEC Fertilizers Sirgitti, Bilaspur	66 (SSP)
12.	Dharamsi Morarji Chemical Co. Ltd, Kumhari, Durg	183 (SSP & H_2SO_4)
13.	Jairam Phosphates Ltd, Farahad, Rajnandgaon	66 (SSP)
		49.5 (H_2SO_4)
d)	**Iron & Steel**	
14.	Bhilai Steel Plant, Bhilai	6334 (Sinters)
		4700 (Pig iron)
		3153 (saleable steel)
		3925 (crude/liquid steel)
		30 (refractory bricks)
		45 (H_2SO_4)
		53.2 (Amm. sulphate)
15.	Jindal Steel & Power Ltd, Raigarh	1600 (hot metal)
		1370 (Sponge iron)
		36 (Ferro chrome)
		3000 (crude/liquid steel)
16.	Jayaswal NECO Industries Ltd, Siltara, Raipur	750 (Pig iron)
		400 (sponge iron)
		800 (sinter)
		400 (steel)
17.	Sarda Energy & Minerals Ltd, (formerly Raipur Alloys & Steel Ltd), Siltara, Raipur	360 (sponge iron)
		240 (finished steel)
		60 MVA (Ferro alloys)
18.	Shri Bajrang Power & Ispat Ltd, Urla, Raipur	210 (sponge iron)
		130 (steel)
e)	**Sponge iron**	
19.	API Ispat & Power tech Pvt Ltd, Siltara Billets, Raipur	105
20.	Alliance Integrated Metallics Ltd, Bemta, Raipur	500
21.	Anjani Steel Ltd, Ujalpur, Raigarh	36
22.	Arti Sponge & Power Ltd, Siltara, Raipur	45
23.	Ambika Ispat (I) Pvt Ltd, Tarainal, Raigarh	30
24.	Baldev Alloys Pvt Ltd, Siltara, Raipur	30
25.	Bhagavati Power & Steel Pvt Ltd, Siltara, Raipur	60
26.	B.S. Sponge Pvt Ltd, taraimal, Raipur	30
27.	Devi Iron & Power Ltd, Tandira, Raipur	30
28.	Drolia Elctro Steel Pvt Ltd, Siltara, Raipur	66
29.	Euro Pratik Ispat Pvt Ltd, Charoda, Raipur	30
30.	Gravity Treksim Pvt Ltd, Siltara, Raipur	30
31.	Godavari Ispat & Power Ltd, Siltara, Raipur	495
32.	Gopal Sponge & Power Pvt Ltd, Siltara, Raipur	30

Sr. No.	Industry/ Plant	Capacity ('000 tpy)
33.	Gitanjali Ispat & Power Pvt Ltd, Sirgititi, Bilaspur	30
34.	GR Sponge & Power Ltd, Siltara, Raipur	37
35.	Hare Krishna Sponge Pvt Ltd, Siltara, Raipur	30
36.	HEG Ltd, Borai, Durg	120 (Sponge iron) 100 (Billets)
37.	Hi-Tech Power & Steel Ltd, Parsada, Raipur	30
38.	Ind Synergy Ltd, Kotmar, Raigarh	300
39.	Indian Ispat & Power, Siltara, Raipur	30
40.	Kalindi Ispat Pvt Ltd, Belpan, Bilaspur	60
41.	Khetan Sponge & Infrastructure Pvt Ltd, Sarora, Raipur	30
42.	Maa Kali Alloys (Ind.) Pvt Ltd, Pali, Raigarh	30
43.	Mangal Sponge & Steel Pvt Ltd, Bilha, Bilaspur	30
44.	Mangal Ispat Pvt Ltd, Natvarpur, Raigarh	30
45.	Millennium High-Tech Industries Ltd, Parsada, Raipur	30
46.	MSP Steel & Power Ltd, Raigarh	90
47.	Monnet Ispat Ltd, Hasaud, Raipur	1000
48.	NR Sponge Pvt Ltd, Raipur	60
49.	Nalwa Sponge Iron Ltd, Taraimal, Raigarh	198
50.	Nakoda Ispat Ltd, Siltara, Raipur	66
51.	Navdurga Fuse Pvt Ltd, Raigarh	60
52.	Nova Iron & Steel Ltd, Dagori, Bilaspur	150
53.	Nutan Ispat & Power Ltd, Jaroda, Raipur	30
54.	PD Industries Pvt Ltd, Siltara, Raipur	30
55.	Prakash Industries Ltd, Hathnewra, Janjgir-Champa	450
56.	Shree Radhe Industries, Silpahari, Bilaspur	60
57.	Raigarh Ispat & Power Ltd, Delari, Raigarh	30
58.	Rameswaram Steel & Power Ltd, Ghargoda, Raigarh	30
59.	Salasar Sponge & Power Pvt Ltd, Gerwani, Raigarh	30
60.	Sree Nakoda Ispat Ltd, Siltara, Raipur	66
61.	Topworth Steel Pvt Ltd, Rosmada, Durg	60
62.	Shakambari Steel & Power Ltd, Raigarh	30
63.	Shivalaya Ispat & Power Pvt Ltd, Guma, Raipur	30
64.	Sidhi Vinayak Sponge Iron Pvt Ltd, Raigarh	30
65.	Shakuni Sponge Iron Pvt Ltd, Shirgitti, Bilaspur	30
66.	S.K. Sarawagi & Co Pvt Ltd, Siltara, Raipur	60
67.	SKS Ispat & Power Ltd, Siltara, Raipur	270
68.	Shovshakti Steel Pvt Ltd, Chakradharpur, Raigarh	30
69.	Shri Sita Ispat & Power Pvt Ltd, Berjhara, Raipur	30
70.	Shree Shyam Sponge & Power Ltd, Bachera, Raipur	30
71.	Singhal Enerprises Pvt Ltd, Taraimal, Raigarh	194
72.	Sunil Sponge Pvt Ltd, Siltara, Raipur	30
73.	Trimula Sponge Iron Pvt Ltd.	30
74.	Vandana Global Ltd, Siltara, Raipur	210
75.	Vaswani Industries Ltd, Siltara, Raipur	30
76.	Vidhyan Minerals India Pvt Ltd, Bilaspur	30
e)	**Ferro Alloys**	
77.	Alok Ferro Alloys Ltd	11
78.	Chhattisgarh Electricity Co. Ltd, Siltara, Raipur	36
79.	Deepak Ferro Alloys Ltd, Urla, Raipur	5
80.	Indsil Energy& Electro Chemical Ltd, Urla, Raipur	24
81.	Hira Power & Steel Ltd, Urla, Raipur (formerly Jain Carbides & Chemicals Ltd)	17
82.	Monnet Ispat Ltd, Hasand, Raipur	80
83.	Nav-chrome Ltd, Urla, Raipur	50
84.	Standard Chrome Ltd, Barmuda, Raigarh	15
85.	Tirumala Balaji Alloys Pvt Ltd, Raigarh	21

Source: Indian Minerals Year Book 2012 Vol. I, Indian Bureau of Mines

Table A.5: Various species reported in the Mahanadi basin

Sr. No.	Name of species	Hora (1940)	Jayarama and Majumdar (1976)	Desai and Shrivastav (2004)	Om Prakash, Singh, Vardia Chari (2004)	Tamboli and Jha (2010)
	Family-Clupeidae					
1.	*Gonialossa manmna*	-	+	-	-	-
2.	*Gudusia chapra*	-	-	+	+	+
	Family- Notopteridae					
3.	*Chitala chitala*					
4.	*Notopterus notopterus*	-	+	+	+	+
	Family- Cyprinidae					
5.	*Amblypharyngodon mola*	+	+	+	+	+
6.	*Aspidoparia morar*	-	+	+	-	-
7.	*Barilius benedelisis*	+	+	+	+	+
8.	*Barilius barna*	+	+	-	-	-
9.	*Barilius barils*	-	-	+	-	-
10	*Barilius vagra*	-	+	-	-	-
11.	*Catla catla*	-	+	+	+	+
12.	*Chela lubuca*	+	-	+	-	-
13.	*Cirrhinus mrigala*	-	-	+	+	+
14.	*Cirrhinus reba*	-	-	+	+	+
15.	*Ctenophyrngodon idella*	-	-	-	+	-
16.	*Cyprinus carpio*	-	-	-	+	+
17.	*Danio aequipinnatus*	+	-	-	-	-
18.	*Danio devario*	-	-	+	+	-
19.	*Danio rerio*	+	+	-	-	-
20.	*Esomos* danricus	+	+	+	-	-
21.	*Garra annandelai*	-	-	-	+	+
22.	*Garra gotlya gotlya*	-	-	+	-	-
23.	*Garra mullya*	+	-	-	-	-
24.	*Gonoproktoptreus kolus*	-	-	-	+	-
25.	*Hypophthalmichthys molitrix (Val.)*	-	-	-	+	-
26.	*Hypophthalmichthys molitrix (Rich.)*	-	-	-	+	-
27.	*Labeo angra*	-	-	-	+	-
28.	*Labeo bata*	-	+	+	+	+
29.	*Labeo boga*	-	-	-	+	-
30.	*Labeo boggut*	+	-	-	+	+
31.	*Labeo calbasu*	-	-	+	+	+
32.	*Labeo fimbriatus*	-	-	+	-	-
33.	*Labeo gonius*	-	-	+	+	+
34.	*Labeo rohita*	-	+	+	+	+
35.	*Orichthys cosuatus*	+	-	-	-	-
36.	*Osteobrama cotio*	-	+	+	+	+
37.	*Osteobrama vigorsii*	-	-	+	-	-
38.	*Parluciosoma daniconius*	+	+	+	+	+
39.	*Puntius chola*	-	-	-	+	+
40.	*Puntius dorsalis*	+	-	-	+	-
41.	*Puntius gelius*	+	+	-	-	-
42.	*Puntius guganio*	+	-	+	-	-
43.	*Puntius phutunio*	-	-	+	-	-
44.	*Puntius sarana*	+	+	+	+	+
45.	*Puntius sophore*	+	+	+	+	+
46.	*Puntius tetraripagus*	+	-	-	-	-
47.	*Puntius ticto*	+	+	+	+	+
48.	*Salmostoma bacalia*	+	+	+	+	+
49.	*Salmostoma phulo*	-	-	+	-	-
	Family- Amblycepidae					
50.	*Amblyceps mangois*	+	-	-	-	-

Sr. No.	Name of species	Hora (1940)	Jayarama and Majumdar (1976)	Desai and Shrivastav (2004)	Om Prakash, Singh, Vardia Chari (2004)	Tamboli and Jha (2010)
	Family- Cobitidae					
51.	*Lepidocephalichthys guntea*	+	+	+	+	+
52.	*Noemacheilus botia*	+	-	-	+	+
53.	*Noemacheilus denisonii*	+	-	+	-	-
	Family- Siluridae					
54.	*Ompok bimaculatus*	-	+	+	+	+
55.	*Ompok pabda*	-	-	-	-	+
56.	*Ompok pabo*	-	-	-	-	+
57.	*Wallgo attu*	-	+	+	+	+
	Family- Bagridae					
58.	*Mystus aor*	+	-	+	+	+
59.	*Mystus seenghala*	-	+	+	+	+
60.	*Mystus bleekeri*	-	-	+	+	+
61.	*Mystus cavassius*	+	+	+	+	+
62.	*Mystus tengara*	+	+	-	+	+
63.	*Mystus vitatus*	+	+	+	+	+
64.	*Rita rita*	-	-	-	+	+
65.	*Rita chrysea*	-	+	-	-	-
	Family- Sisoridae					
66.	*Bagarius bagarius*	+	-	-	-	+
67.	*Erithistes hara*	+	-	-	-	-
68.	*Gagata cenia*	-	+	-	-	-
	Family- Schilbeidae					
69.	*Ailia colia*	-	+	-	-	+
70.	*Clupisoma bastari*	-	-	+	-	-
71.	*Clupisoma garua*	-	+	-	-	-
72.	*Eutropiichthys vacha*	-	-	-	+	+
73.	*Pseudeotropius atherinoides*	+	-	-	+	-
	Family- Pangasiidae					
74.	*Pangasius pangasius*	-	-	-	+	-
	Family- Sacchobranchidae					
75.	*Heteropneustes fossilis*	+	-	-	+	+
	Family- Claridae					
76.	*Clarias batrachus*	+	+	-	+	+
77.	*Clarias gariepinus*	-	-	-	+	+
	Family- Belonidae					
78.	*Xenentodon cancila*	+	+	+	+	+
	Family- Mugilidae					
79.	*Rhinomugli corsula*	-	+	+	+	+
	Family- Channidae					
80.	*Channa gachua*	+	-	-	+	+
81.	*Channa marulius*	-	-	-	+	+
82.	*Channa orientalis*	-	-	+	-	-
83.	*Channa punctatus*	+	+	-	+	+
84.	*Channa striatus*	-	+	+	+	+
	Family- Centropomidae					
85.	*Chanda nama*	-	+	+	+	+
86.	*Chanda ranga*	+	+	+	+	+
	Family- Sciaenidae					
87.	*Sciaena coitor*	-	-	-	-	+

Sr. No.	Name of species	Hora (1940)	Jayarama and Majumdar (1976)	Desai and Shrivastav (2004)	Om Prakash, Singh, Vardia Chari (2004)	Tamboli and Jha (2010)
	Family- Nandidae					
88.	*Badis badis*	+	+	-	-	-
89.	Nandus nandus	+	-	+	+	+
	Family- Cichlidae					
90.	Oreochromis mossambicus	-	-	-	+	+
91.	Oreochromis nilotichus	-	-	-	+	-
	Family- Anabantidae					
92.	Anabas oligolepis	-	-	-	+	-
93.	Anabus testudineus	-	-	-	+	+
94.	Colisa fasciatus	-	-	-	+	+
	Family- Gobiidae					
95.	Glossogobius giuris	+	+	+	+	+
	Family- Mastacembelidae					
96.	Macrognathus aculeatus	+	+	-	+	+
97.	Mastacembelus armatus	+	+	+	+	+
98.	Mastacembelus puncalus	+	+	+	+	+
	Family- Tetrodontidae					
99.	Tetraodon cutcutia	-	-	+	+	+
	TOTAL	**43**	**42**	**48**	**65**	**58**

Source: Adapted from Kumar, Charan and Kumar, 2013

Forum Publications

Books and Reports

- Water Conflicts in India: A Million Revolts in the Making (Routledge)
- 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
- Right to Sanitation in India: Nature, Scope and Voices from the Margins

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
- Adivasis and Right to Sanitation
- Right to Sanitation: A Gender Perspective
- Dalits and Right to Sanitation

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 for the last ten years. 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 of on backstopping conflict resolution. Apart from the core activities like documentation, capacity building, dissemination and outreach, the Forum would be intensively involved in right to water and sanitation, agriculture and industrial water use, environmental flows in the context of river basin management and 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.

Contact:
Forum for Policy Dialogue on Water Conflicts in India
c/o SOPPECOM, 16 Kale Park, Someshwarwadi Road,
Pashan, Pune 411008, Maharashtra, India
Phone: 0091-20-2025 1168, 2588 6542
Fax: 0091-20-2588 6542
URL: www.waterconflictforum.org; www.conflicts.indiawaterportal.org