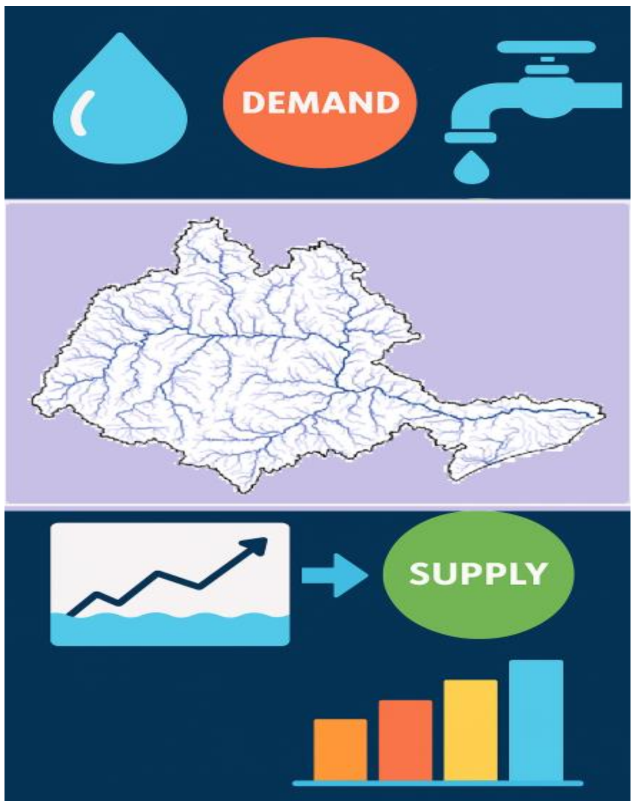
National River Conservation Directorate
Ministry of Jal Shakti,
Department of Water Resources,
River Development & Ganga Rejuvenation
Government of India

सत्यमेव जयते

Water Demand & Supply
Mahanadi River Basin



October 2025

cMahanadi

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Water Demand & Supply

Mahanadi River Basin

National River Conservation Directorate (NRCD)

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The Centre for Mahanadi River Basin Management Studies (cMahanadi) is a Brain Trust dedicated to River Science and River Basin Management. Established in 2024 by NIT Raipur and NIT Rourkela, under the supervision of cGanga at IIT Kanpur, the center serves as a knowledge wing of the National River Conservation Directorate (NRCD). cMahanadi is committed to restoring and conserving the Mahanadi River and its resources through the collation of information and knowledge, research and development, planning, monitoring, education, advocacy, and stakeholder engagement.
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www.cganga.org

Acknowledgment

This report is a comprehensive outcome of the project jointly executed by NIT Raipur (Lead Institute) and NIT Rourkela (Fellow Institute) under the supervision of cGanga at IIT Kanpur. It was submitted to the National River Conservation Directorate (NRCD) in 2024. We gratefully acknowledge the individuals who provided information and photographs for this report.

Disclaimer

This report is a preliminary version prepared as part of the ongoing Condition Assessment and Management Plan (CAMP) project. The analyses, interpretations and data presented in the report are subject to further validation and revision. Certain datasets or assessments may contain provisional or incomplete information, which will be updated and refined in the final version of the report after comprehensive review and verification.

Team

Dr. Samir Bajpai, cMahanadi, NIT Raipur

Dr. Mani Kant Verma, cMahanadi, NIT Raipur

Dr. Shashikant Verma, cMahanadi, NIT Raipur

Dr Vinod Tare, cGanga, IIT Kanpur

Dr. Kishanjit Kumar Khatua, cMahanadi, NIT Rourkela

Dr. Kakoli Karar Paul, cMahanadi, NIT Rourkela

Mis. Jayashree Ojha, cMahanadi, NIT Rourkela

Preface

In an era of unprecedented environmental change, understanding our rivers and their ecosystems has never been more critical. This report aims to provide a comprehensive overview of our rivers, highlighting their importance, current health, and the challenges they face. As we explore the various facets of river systems, we aim to equip readers with the knowledge necessary to appreciate and protect these vital waterways.

Throughout the following pages, you will find an in-depth analysis of the principles and practices that support healthy river ecosystems. Our team of experts has meticulously compiled data, case studies, and testimonials to illustrate the significant impact of rivers on both natural environments and human communities. By sharing these insights, we hope to inspire and empower our readers to engage in river conservation efforts.

This report is not merely a collection of statistics and theories; it is a call to action. We urge all stakeholders to recognize the value of our rivers and to take proactive steps to ensure their preservation. Whether you are an environmental professional, a policy maker, or simply someone who cares about our planet, this guide is designed to support you in your efforts to protect our rivers.

We extend our heartfelt gratitude to the numerous contributors who have generously shared their stories and expertise. Their invaluable input has enriched this report, making it a beacon of knowledge and a practical resource for all who read it. We hope that this report will catalyze positive environmental action, fostering a culture of stewardship that benefits both current and future generations.

As you delve into this overview of our rivers, we invite you to embrace the opportunities and challenges that lie ahead. Together, we can ensure that our rivers continue to thrive and sustain life for generations to come.

Centres for Mahanadi River Basin
Management Studies (cMahanadi)
NIT Raipur & NIT Rourkela

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ABBREVIATIONS

BCM	Billion Cubic Meters
CCA	Cultivable Command Area
CEA	Central Electricity Authority
CG	Chhattisgarh
COC	Cycle of Concentration
CSE	Centre for Science and Environment
CSEB	Chhattisgarh State Electricity Board
CPCB	Central Pollution Control Board
CWINC	Central Water-Power Irrigation and Navigation Commission
CWC	Central Water Commission
DES	Directorate of Economics and Statistics
DoWR	Department of Water Resources
DPR	Detailed Project Report
EMP	Environment Management Plan
FOT	Farmer's Organization and Turnover
FRL	Full Reservoir Level
GCA	Gross Command Area
GIA	Gross Irrigable Area
GoC	Government of Chhattisgarh
GoI	Government of India
GoO	Government of Odisha
GRP	Green Rating Project
GSDP	Gross State Domestic Product
GTOPO	Global Topological Elevation Model
IRRI	International Rice Research Institute
LBC	Left Bank Canal
LSC	Live Storage Capacity
LULC	Land Use Land Cover
MAF	Million Acre Feet
MCM	Million Cubic Meters

MoA	Ministry of Agriculture
MoWR	Ministry of Water Resources
MSL	Mean Sea Level
MT	Metric Tonne
MTPA	Metric Tonne Per Annum
MW	Mega Watt
MWh	Mega Watt-hours
NAS	Net Area Sown
NIA	Net Irrigable Area
NRLD	National Register for Large Dams
NRSC	National Remote Sensing Centre
NTPC	National Thermal Power Corporation Limited
O&M	Operation and Maintenance
OD	Odisha
OWPO	Orissa Water Planning Organization
OWRCP	Orissa Water Resources Consolidation Project
QGIS	Quantum Geographic Information System
RBC	Right Bank Canal
RBO	River Basin Organization
SAIL	Steel Authority of India
SECL	Southeastern Coalfields Limited
SRI	System Rice Intensification
SSC	Slow Speed Classifiers
SWRDP	State Water Resources Development Policy
WAC	Water Allocation Committee
WAPCOS	Water and Power Consultancy Services Limited
WRIS	Water Resources Information System
WUA	Water User Association

Executive Summary

The Mahanadi River Basin, spanning over 141,500 km² across Chhattisgarh, Odisha, and small portions of neighboring states, remains one of eastern India's most economically and ecologically significant river systems. Its vast network of rivers, including major tributaries such as the Seonath, Hasdeo, Mand, Ib, Ong, and Tel, supports thriving agriculture, expanding industries, rapidly growing urban centers, and millions of rural households. This report presents an integrated understanding of water demand and supply conditions for the basin, examining domestic and industrial requirements, sectoral development trends, supply projections, and the increasing pressure on water resources driven by demographic, economic, and climatic changes.

The basin's hydrology is shaped by high monsoon rainfall, averaging nearly 1,291 mm annually, and a total river flow of about 66.8 BCM. However, long-term data suggest declining precipitation trends, shrinking runoff, and heightened variability. With usable water estimated at around 50 BCM, the basin's competing sectors, agriculture, domestic, industry, and ecology, intensify stress on this finite resource. The presence of major storage systems such as the Hirakud and Minimata Bango reservoirs has historically supported irrigation and flood control, yet sedimentation and rising demands have reduced operational flexibility, especially during dry seasons.

Demographically, both Chhattisgarh and Odisha continue to experience population growth, but unevenly across rural and urban regions. Chhattisgarh's share of urban population has risen significantly, driving higher per capita consumption and greater strain on municipal supply systems. Odisha, despite its slower urbanization, shows a steady rise in domestic water demand due to improved service coverage and gradual shifts in settlement patterns. Projections indicate that domestic water requirements across both states will increase steadily toward 2050, with the Odisha portion of the basin expected to consume nearly 0.72 BCM annually and the Chhattisgarh basin segment expecting urban demand to approach 900 MCM. Rural consumption, though comparatively lower, continues to rise as accessibility and living standards improve.

District-level assessments underline significant spatial variations in domestic demand. Metropolitan and industrializing districts such as Raipur, Durg, Bilaspur, Korba, Raigarh, and Jharsuguda demonstrate pronounced increases in consumption, driven by migration, industrial expansion, and densification. Conversely, forested and tribal districts, such as Kanker, Jashpur, Surajpur, and Gariabandh, exhibit modest yet steady increases as rural water infrastructure expands. Urban centers, particularly those near industrial corridors, account for the highest growth rates, reinforcing the need for integrated urban water supply planning.

The industrial sector emerges as the most transformative driver of rising water demand. Over two decades, Chhattisgarh and Odisha have undergone major economic restructuring, shifting from agriculture-led economies to mineral- and industry-driven growth. Both states exhibit strong upward trends in Gross State Domestic Product (GSDP), supported by rapid expansion in mining, steel production, aluminium processing, cement manufacturing, and particularly coal-based thermal power generation. Chhattisgarh's industrial water allocations increased more than threefold since 2007, while Odisha's rose from around 200 MCM in 2008 to nearly 944 MCM.

The power sector dominates this demand, thermal power units alone require enormous volumes for cooling, contributing nearly 98% of total industrial water consumption in the basin.

Industrial hubs such as Korba, Raigarh, Bhilai-Durg, Jharsuguda, and Angul–Talcher form the backbone of this water-intensive landscape. Korba exemplifies the steepest rise, with water allocated to power units skyrocketing from 307 MCM in 2007 to over 1,000 MCM a decade later. Similar patterns are evident in Odisha, where rapid power sector growth has raised serious concerns about long-term sustainability and interstate competition for shared basin waters. The clustering of heavy industries near major reservoirs and along river stretches has further intensified seasonal shortages and heightened the risk of conflict among sectors and states.

District-wise industrial demand across Chhattisgarh reveals clear spatial disparities. Industrially strong districts, Korba, Raigarh, Durg, and Raipur, exhibit large, concentrated water use patterns. Blocks hosting steel plants, power plants, coal mines, and manufacturing estates show extremely high water withdrawals, often exceeding 100 MCM annually. In contrast, districts with limited industrial presence, such as Balod, Mahasamund, Kanker, Surajpur, and Bemetara, report negligible industrial demand. This uneven distribution underscores the necessity for region-specific strategies that address localized stress while preventing over-extraction in industrial hotspots.

The cumulative demand trend observed over the years displays classic logistic growth characteristics. Initial low growth in industrial demand was followed by rapid escalation in the 2007–2015 period, aligned with liberalized industrial policies, new thermal power installations, and large-scale mineral exploitation. The subsequent plateauing of the cumulative demand curve indicates potential saturation of large thermal projects and greater attention to recycling technologies and regulatory controls. Yet, the continued rise in overall water requirements signals that future supply systems must be more resilient and diversified.

Supply-side assessments show an overwhelming dependence on surface water. In 2023, surface water contributed more than 95% of total supply, with groundwater playing only a supplementary role. Future demand projections indicate an increasing reliance on groundwater, from 629 MCM currently to an additional projected requirement of nearly 700 MCM. This shift highlights vulnerabilities, as several basin districts already face groundwater quality and recharge issues. Managing this transition will require coordinated strategies involving recharge enhancement, reduced leakage, regulated abstraction, and conjunctive use policies.

Comparative basin-level analyses illustrate that the Mahanadi Basin bears the predominant share of water diversion in the region. With nearly 2,028 MCM diverted for various uses, far above Godavari and Brahmani systems, the basin supports extensive irrigation, industrial, and urban activities. Agricultural water demand remains particularly significant, especially in the Odisha delta region where paddy cultivation dominates. While agriculture is projected to remain the largest consumer through 2050, industrial and domestic sectors are rapidly expanding their share in the water budget.

The report also highlights substantial policy efforts by both states to stimulate industrial growth. Chhattisgarh's Industrial Policy (2014–19) aimed for regional industrialization through SME promotion and land bank development, while Odisha's IPR-2015 focused on large-scale capital investment, high-value manufacturing, and export-oriented sectors. Both policies succeeded in attracting industries, but they also intensified pressure on water allocations, further underscoring the need for integrated basin management. Therefore, the overall, findings paint a picture of a rapidly evolving basin where rising domestic needs, industrial expansion, fluctuating hydrology, and limited storage capacities converge to exert unprecedented pressure on water resources. Ensuring long-term sustainability will require coordinated interstate planning, modernization of irrigation systems, widespread adoption of water-efficient technologies in industries, robust groundwater management, and climate-resilient water infrastructure.

The Mahanadi Basin Profile

The Mahanadi Basin, located almost entirely within the states of Chhattisgarh and Odisha, covers an area of approximately 141,589 km^2. Its major tributaries include the Seonath, Hasdeo, and Mand rivers in Chhattisgarh, and the Ib, Tel, and Ong rivers in Odisha. Rice is the predominant crop cultivated across the basin.

Two major water resource projects the Minimata Bango Project in Chhattisgarh and the Hirakud Project in Odisha have been studied in detail for their role in regional water management. About 5,821 thousand hectares (around 40%) of the basin area constitutes the Net Area Sown (NAS) annually. Over the past two decades, the total cropped area has increased due to expansion in irrigation facilities, even as the net area sown has slightly declined in both states, more prominently in Odisha. Fallow lands have remained unchanged in Chhattisgarh but have shown a noticeable increase in Odisha.

The basin lies within a high-rainfall region, receiving an average annual precipitation of about 1,291 mm. The Mahanadi River has an average annual flow of 66.8 billion cubic meters (BCM), of which approximately 50 BCM is considered usable. However, the flow varies significantly from year to year, ranging between 20 BCM and 70 BCM. Long-term studies indicate a declining trend in rainfall and, consequently, a reduction in the annual flow of the river. To harness the available water, several water resource projects have been developed in the basin, with a combined storage capacity of about 13.72 BCM, and many more projects have been under construction since 2010. Over the past two decades, industrial activities, particularly thermal power generation, have grown rapidly, supported by numerous environmental clearances since the mid-2000s. The current installed thermal power capacity stands at 15,802 MW in Chhattisgarh and 7,103 MW in Odisha.

This industrial expansion has led to increasing competition for surface water resources, especially from large dams that were originally designed for major irrigation schemes. The most significant water-use conflicts are observed in the Hasdeo, Mand, and Ib river basins, which host extensive mining and thermal power operations and face severe water stress. Geographically, the Mahanadi originates near Pharsiya village in the hilly, forested, and largely tribal regions of southern

Chhattisgarh. It initially flows northward into the plains of central Chhattisgarh before turning eastward toward Odisha. In Odisha, the river traverses broad plains flanked by forested highlands on both sides, finally entering its vast delta before discharging into the Bay of Bengal.

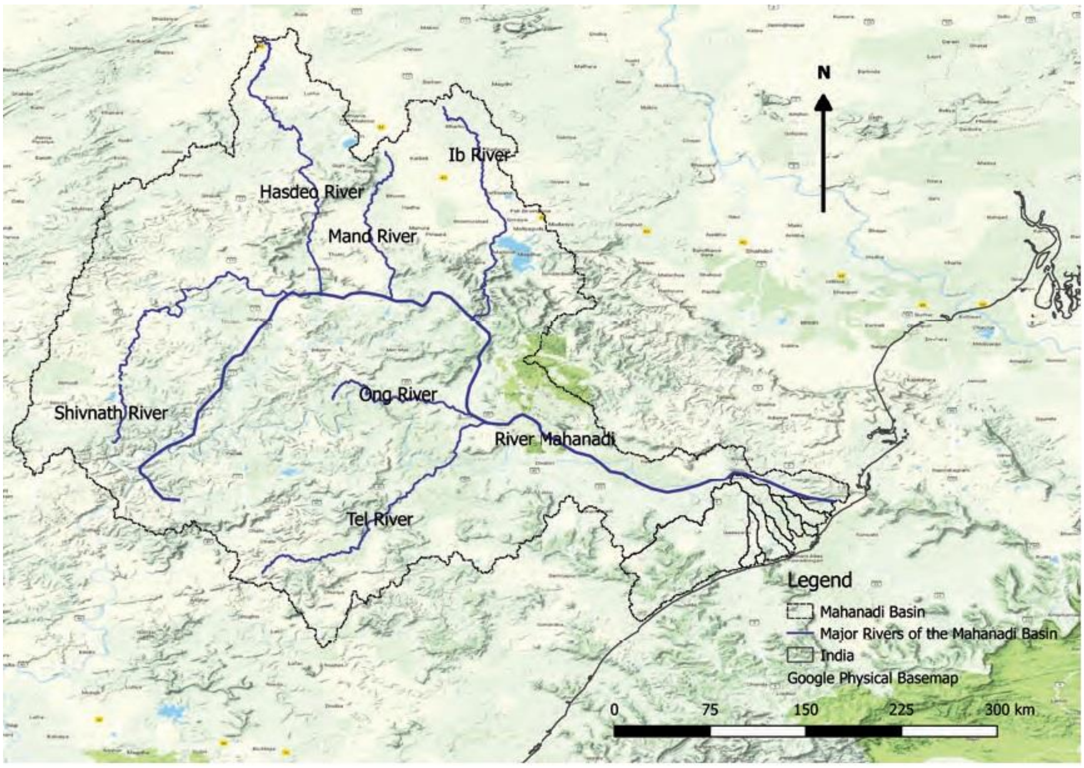
With a drainage area of about 142,000 km^2, the Mahanadi is one of the major river basins of peninsular India. Its principal tributary, the Seonath (Shivnath) River, joins the Mahanadi in the plains. The Hasdeo and Mand rivers, flowing from north to south, also merge with the Mahanadi within Chhattisgarh. In Odisha, the Ib, Ong, Tel, and Jonk rivers are the main tributaries. Among them, the Tel and Ib are the second and third largest, respectively, with the Tel joining the right bank of the Mahanadi downstream of the Hirakud reservoir, and the Ib merging on the left bank upstream of it.

Characteristics of the Mahanadi Basin

Parameters	Descriptions
Total Area	About 141,589 km^2 (73,214 km^2 in Chhattisgarh, 65,847 km^2 in Odisha, and 2,528 km^2 across Jharkhand, Maharashtra, and Madhya Pradesh) [1]
Length of River	851 km [1]
Average Annual Runoff	66.8 BCM [3]
Major Tributaries	Seonath, Hasdeo, Mand (Chhattisgarh); Ib, Ong, Tel, and Jonk (Odisha) [1]
Major Water Resource Projects	Hirakud Reservoir, Minimata Bango Project (Minimata Bango Reservoir and Hasdeo Barrage), Mahanadi Reservoir Complex (Ravishankar Sagar, Murrum Silli, and Dudhawa Reservoirs)
Population	38,660,665 [2]
Social Composition	16.5% Scheduled Castes, 19.2% Scheduled Tribes [2]
Employment Pattern	30% Cultivators, 27% Agricultural Labourers, 3% Industrial Workers
Rainfall	1,291 mm (average annual) [2]
Soil Type	Red and Yellow Soils
Major Crops	Rice, Gram, Khesari
Irrigation	76 Projects (22 Major and 54 Medium), with an estimated 1,711 Th Ha of culturable command area under major projects [3]
Major Cities	Raipur, Bilaspur (Chhattisgarh); Bhubaneswar, Cuttack (Odisha)

Major Industries / Industrial Zones	Thermal Power, Iron and Steel, Mining (Coal and Bauxite)

Sources: [1] Central Water Commission, 2011 [2] Ministry of Water Resources, 2014 [3] Central Water Commission, 2012



Rivers of the Mahanadi Basin

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

1. INTRODUCTION

Supply and demand are among the most foundational principles that shape economic decision-making, and these dynamics are equally vital in the governance of water resources, especially in semi-arid regions such as Chhattisgarh. Water, unlike most economic commodities, possesses social, ecological, and political dimensions that elevate the complexity of its management. It serves a wide spectrum of uses, ranging from domestic consumption and agricultural irrigation to fisheries, hydropower, industrial production, wastewater treatment, environmental protection, and even recreational activities. Because of this multidimensional role, the balance between water availability and water use directly influences human well-being, ecological stability, and economic progress across water-dependent landscapes.

Nowhere is this more evident than in large river basins that sustain dense populations, expanding agricultural frontiers, and rapidly growing industrial corridors. The Mahanadi River Basin stands out as a strategically important hydrological system in India, spanning nearly 142,000 square kilometres across Chhattisgarh and Odisha, and supporting millions of livelihoods. Its extensive network of tributaries, such as the Seonath, Hasdeo, Mand, Ib, Ong, Tel, and Jonk connects forested uplands, tribal heartlands, rich farmlands, mining clusters, and industrial zones. Historically, the basin has been endowed with abundant rainfall and fertile soils, reinforced by major reservoirs like Hirakud and Minimata Bango, enabling substantial irrigation development, hydropower generation, and domestic water provision. These features are reflected in the basin's overall hydrological profile, which records an annual rainfall of around 1,291 mm and runoff exceeding 66 BCM, as summarised in Table 1.

However, this natural abundance is increasingly challenged by demographic shifts, rapid urbanisation, industrial growth, and changing rainfall regimes. Both Chhattisgarh and Odisha have experienced significant population increases over the past five decades, accompanied by changing settlement patterns. Urban centres in Chhattisgarh have grown particularly rapidly, recording an urban CAGR of more than 3% prior to 2011. Odisha, though still predominantly rural, has seen a steady rise in urban populations along the Mahanadi's corridor and deltaic regions. These transitions elevate domestic water requirements, expand municipal service obligations, and increase pressure on both surface and groundwater sources. Domestic water demand in the basin has risen sharply, for instance, in Odisha's Mahanadi region alone, demand increased from approximately 0.45 BCM in 2018 and is projected to reach nearly 0.72 BCM by 2050 (Table 1).

Agriculture continues to dominate total water withdrawals across the Mahanadi Basin. Nearly 40% of the basin's area is under annual cropping, much of it devoted to rice, which is among the most water-intensive crops cultivated in India. Despite receiving substantial monsoon rainfall, agricultural withdrawals remain high throughout the year due to uneven rainfall distribution, climatic uncertainties, and heavy dependence on controlled irrigation during critical crop stages. Large-scale irrigation systems such as Hirakud, Mahanadi Reservoir Complex, and Hasdeo Bango, have historically buffered seasonal shortages, but these systems are now strained by sedimentation, rising evapotranspiration, and competing municipal and industrial demands. As reflected in Table 1, surface irrigation withdrawals in Odisha alone exceed 8,000 MCM annually, and rice cultivation accounts for roughly two-thirds of agricultural water use.

The most transformative shift in the basin's water dynamics stems from rapid industrialisation. Over the last two decades, both states have leveraged their mineral-rich landscapes to expand thermal power generation, steel manufacturing, aluminium smelting, and large-scale mining operations. Chhattisgarh's thermal power capacity has grown above 15,000 MW, while Odisha's capacity has surpassed 7,000 MW. This surge has driven industrial water allocations upward at an unprecedented rate, particularly for cooling needs in thermal power plants. Between 2007 and 2017, industrial water allocations in Chhattisgarh rose from about 307 MCM to more than 1,000 MCM for thermal power generation alone. Similar trajectories are observed across Odisha. As noted in Table 1, the thermal power sector accounts for nearly 98% of the basin's industrial water use, illustrating its overwhelming dominance.

Table 1: Summary of Critical Water Use, Availability, and Basin Characteristics for the Mahanadi River System

Category	Key Statistics
Rice Irrigation Demand	Rice consumes ≈ 9,584 MCM, ~64% of irrigation withdrawals.
Industrial Water Allocation (Basin-wide)	Very high-use zones (>10 MCM) around Bhilai, Angul–Talcher, Jharsuguda, Hirakud.
Industrial Sector Water Demand (Mahanadi Basin)	Thermal power dominates at ≈ 24,360 MCM/year (~98% of total industrial use); Steel ≈ 323 MCM; Aluminium ≈ 7 MCM.
Domestic Demand Growth – Chhattisgarh	Basin-wide domestic demand increased from ~1,135 MLD (1991) to ~1,738 MLD (2011).
Industrial Demand – Chhattisgarh (District-wise)	Korba industrial demand rose to ~204.88 MCM (2011); Raigarh ~130.48 MCM; Durg previously peaked at ~346.63 MCM.
Water Supply Scenario – Chhattisgarh (Industry)	Current supply: Surface ≈ 28,619.5 MCM; Groundwater ≈ 629 MCM; Future requirement adds ≈ 1,938 MCM.
Basin-wise Diversion	Mahanadi has highest diversion ≈ 2,028 MCM vs. Godavari (195 MCM) and Brahmani (243 MCM).
Basin-wise Water Demand (All Basins)	Mahanadi ≈ 1,120 MCM (85% of total), Godavari ≈ 145 MCM, Ganga ≈ 45 MCM.
Odisha Water Balance (2001→2051)	Total demand increases 54,990 → 84,163 MCM; net surplus drops to ~6,837 MCM.
Chhattisgarh Water Balance (Basin Resources)	Usable surface water ≈ 41,720 MCM; actual use ~18,249 MCM; groundwater resource ≈ 14,548 MCM.
Population Drivers	Urban CAGR ~3.3%; rural ~1.59% (Chhattisgarh); Odisha rural population dominates at 83%.
Projected Scenarios – Chhattisgarh (2050)	Base-case deficit ~2,812 MCM; High-growth deficit ~5,005 MCM; Conservation-case deficit ~2,773 MCM.

At the basin scale, the Mahanadi accounts for the vast majority of regional water diversion and sectoral demand, contributing to about 85% of the total water demand among the major basins assessed in the study. Surface water remains the primary source of supply, more than 95% of all water use is supported by rivers and reservoirs. Yet, with growing domestic and industrial pressures, reliance on groundwater is gradually increasing, especially in rural and peri-urban areas where piped surface systems are limited. This trend raises concerns given that groundwater in parts of the delta and coastal areas is vulnerable to salinity intrusion, seasonal decline, and localised quality deterioration.

These pressures unfold in the context of significant economic growth in both states. Chhattisgarh has nearly doubled its economy in real terms, driven by construction, energy production, and mineral processing. Odisha has strengthened its industrial base, attracting manufacturing investments and expanding service sectors. While these developments have generated employment and economic diversification, they have also intensified competition for water in industrial clusters such as Korba–Raigarh, Raipur–Durg, and Angul–Talcher, areas that are already high-demand zones, as reflected in the industrial water statistics summarized in Table 1.

Collectively, the rising domestic demand, expanding irrigation requirements, surging industrial withdrawals, and growing urban footprints underline the urgency for integrated, basin-wide water management. The Mahanadi Basin is approaching a critical juncture where efficient allocation, conservation, technological innovation, and policy reforms must converge to ensure water security for future generations. This report presents a comprehensive assessment of these supply and demand patterns, offering insights into demographic drivers, sectoral pressures, hydrological trends, and future projections. The findings provide a robust foundation for designing resilient, equitable, and sustainable water management strategies capable of supporting the long-term prosperity of millions who depend on the Mahanadi River Basin.

On the demand side, irrigation still claims the largest share- via Hirakud commands and delta networks-while rising municipal and industrial needs around Sambalpur, Jharsuguda, Angul, Dhenkanal and the Bhubaneswar–Cuttack corridor intensify allocation trade-offs and heighten the value of efficiency, reuse and seasonal storage. Odisha's State Water Policy (2007), aligned to basin-scale management principles, prioritizes drinking water and promotes integrated planning, while ongoing initiatives such as a state-wide water-resources census aim to strengthen data-driven decisions across irrigation, industry, fisheries and domestic supply. Together, these supply-demand dynamics-seasonal flow, sediment-constrained storage, groundwater dependence, urban–industrial growth, and policy reforms-frame the core management challenge for the Mahanadi in Odisha.

The data presented in Table 2 highlights a steady and significant rise in water demand across all major sectors of the basin. Domestic water use increases from 0.45 BCM in 2018 to 0.72 BCM by 2050, reflecting rapid population growth, expanding urban footprints, and improved service levels. Livestock demand remains constant at 0.27 BCM throughout the projection period, indicating stable livestock populations and relatively unchanged water requirements. Agricultural demand shows the most pronounced increase, rising from 10.78 BCM in 2018 to nearly 18 BCM by 2050, demonstrating the sector's continued dominance and the high water needs associated with food production in the region.

Industrial water demand also grows considerably, nearly doubling between 2018 and 2030 and increasing further to 1.81 BCM by 2050, largely due to expanding industrialization and the development of energy and manufacturing corridors. Overall, total water use climbs from 12.44 BCM in 2018 to 20.76 BCM by 2050, signalling rising pressure on available water resources. Despite these increases, the utilizable water supply remains constant at 29.30 BCM, suggesting limited scope for additional resource development.

The basin's overall water balance, as shown in Table 2, narrows significantly over time from a comfortable surplus of 16.86 BCM in 2018 to just 8.54 BCM by 2050. This shrinking buffer indicates growing vulnerability to seasonal shortages, climatic variability, and competition among sectors. These findings underscore the need for improved efficiency, demand management strategies, and sustainable allocation frameworks to ensure long-term water security.

Table 2: Estimated Water Use/Demand in Mahanadi Basin: Odisha

Aspects	2018 (Baseline) water use (BCM)	Projected water use in 2030 (BCM)	Projected water use in 2050 (BCM)
Domestic	0.45	0.55	0.72
Livestock	0.27	0.27	0.27
Agriculture	10.78	13.85	17.96
Industries	0.94	1.58	1.81
Total	12.44	16.25	20.76
Utilisable water	29.30	29.30	29.30
Overall water balance	16.86	1305	8.54

2. DOMESTIC WATER REQUIREMENT

Chhattisgarh's total population was approximately 27.94 million or 29.43 million in 2020, with a projected population of 29.49 million in 2021. In 2011, 16% of the population resided in urban centers, a figure that rose to 23.24% urban and 76.76% rural in 2020. Odisha's population in 2025 is estimated to reach approximately 46.8 million, showing an 11.4% increase from the 42 million recorded in the 2011 census. Of this, most residents about 83%, live in rural areas, which equates to roughly 38.4 million people. The urban population is projected to be about 8.4 million, accounting for approximately 17–18% of the state's total.

Population is an important driver of water demand in many sectors, especially domestic sector and agriculture. Also, the way population drives water demand also depends on where the population growth takes place. Urban population growth will have a much bigger positive impact on demand for water as compared to that of rural population, for the same level of growth. Analysis of data on population of urban and rural areas in Chhattisgarh part of Mahanadi River basin for the period from 1971 to 2011 shows that the urban growth rate was very high during the first two decades (1971-81 and 1981-1991) and came down and stabilized at an CAGR of 3.3 per cent during the last decade (2001-11). However, the rural population growth rate has been fluctuating between a lowest of 1.23 per cent per annum and 2.08 per cent per annum. For future projections, an annual growth rate of 3.3 per cent was considered for urban areas and 1.59 per cent for rural areas. The growth rate considered for rural areas is the average of the decadal growth rate for four consecutive decades prior to 2011.

Odisha's water demand is predominantly influenced by its large rural population, which determines both current requirements and future projections for domestic water use. Meanwhile, steady-though modest-urbanization in districts connected to the Mahanadi River is expected to increase demand pressures for municipal water supplies, even while the population growth remains gradual. The predominance of rural residency and slow urban growth in Odisha means that policy and planning must focus on ensuring reliable water resources for rural households, while also responding to incremental increases in urban demand, especially in the context of the Mahanadi River basin.

The estimated and projected water demand in the Mahanadi Basin (Odisha), indicating a steady rise in total water use from 12.44 BCM in 2018 to 20.76 BCM by 2050, mainly due to growing agricultural and domestic requirements. Despite this increase, the utilizable water remains constant at 29.30 BCM, leading to a declining overall water balance over time.

2.1 Domestic Water Requirement Norms

- **Rural Areas:** The established norm for rural areas is 40 litres per capita per day (LPCD) for human consumption. This allocation covers specific needs: 3 LPCD for drinking, 5 LPCD for cooking, 15 LPCD for bathing, 7 LPCD for washing utensils and house, and 10 LPCD for ablution. For accessibility, one handpump or standpost is estimated to serve every 250 persons.

- **Urban Areas:** The Public Health Engineering Department (PHED) aims to provide a minimum of 70 LPCD for the urban population. For Naya Raipur City, specific norms have been adopted, with residential areas planned for 150 LPCD. General CPHEEO (Central Public Health and Environmental Engineering Organisation) norms for Indian cities range from 70 LPCD for towns with piped supply but no sewerage, to 135 LPCD for cities with piped supply and existing/contemplated sewerage, and 150 LPCD for metropolitan/mega cities with sewerage. These figure typically include water for commercial, institutional, and minor industrial uses, excluding an estimated 15% for unaccounted water.

- The past growth trends in rural and urban population estimated by the study and the projected future population of Chhattisgarh, part of the Mahanadi basin, are given in Table 2. The estimated total population of the region in 2050 is 44,385,489 and of which 40.7 per cent is expected to be in urban areas, higher a high urban population growth rate considered for projections. Under the business-as-usual scenario, the urban domestic water demand and rural domestic water demand are estimated to reach 898.60 MCM per annum and 630.9 MCM per annum, respectively, in the year 2050. The corresponding figures for the year 2030 were 497.6 MCM and 424.6 MCM, respectively.

Table 3: Past Growth Trends in Rural and Urban Population and Projected Growth in Population in Chhattisgarh Part of the Mahanadi River Basin.

Total Population of the Mahanadi River Basin in Chhattisgarh				**Annual Population Growth Rate of the Mahanadi River Basin in Chhattisgarh**			
Year	**Total**	**Rural**	**Urban**	**Year**	**Total**	**Rural**	**Urban**
1971	85,56,927	75,63,825	9,93,102	-	-	-	-
1981	1,02,60,759	85,59,653	17,01,106	1971-81	0.0183	0.0124	0.0553
1991	1,31,27,369	1,05,17,411	26,09,959	1981-91	0.0249	0.0208	0.0437
2001	1,55,12,277	1,18,86,398	36,25,878	1991-01	0.0168	0.0123	0.0334
2011	1,92,65,136	1,42,33,527	50,31,609	2001-11	0.0219	0.0182	0.0333
2050	4,43,85,489	2,63,32,978	1,80,52,511	2011-50	-	0.0155	0.0333

(Source: CWC, 2012 & 2013)

In the Odisha segment of the Mahanadi basin, domestic water demand exhibits a progressive increase corresponding to demographic expansion and urban development trends. The estimated domestic water use was 0.45 BCM (450 MCM) in the baseline year 2018, projected to rise to 0.55 BCM (550 MCM) by 2030, and further to 0.72 BCM (720 MCM) by 2050 (Figure 1). This incremental growth indicates a sustained escalation in per capita and total domestic water requirements driven by urbanization, improved service coverage, and enhanced living standards. Although the domestic sector accounts for a relatively smaller fraction of the total water use compared to agriculture, its growth rate is notably higher, signifying an increasing stress on available water resources and the necessity for efficient demand management within Odisha's portion of the Mahanadi basin.

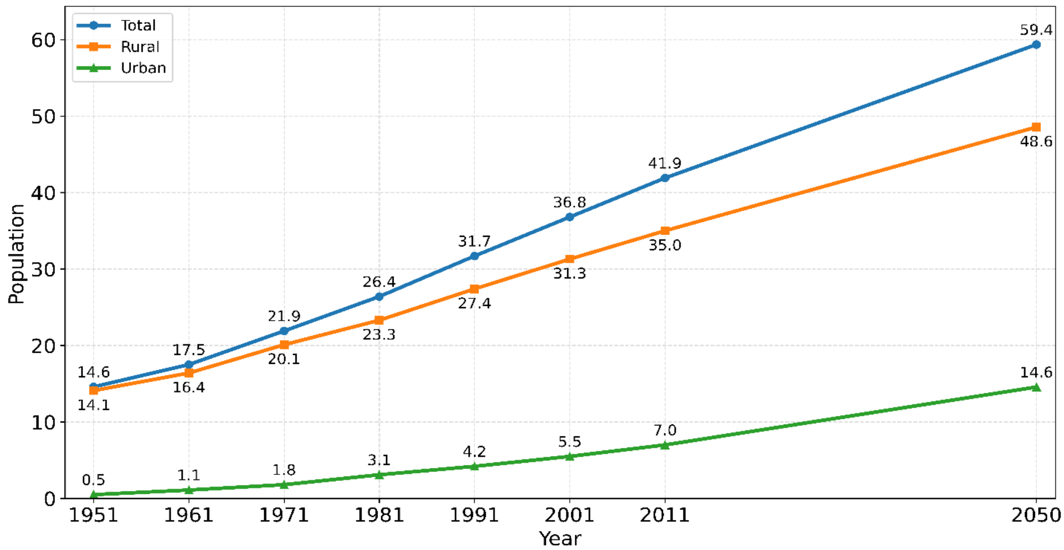


Figure 1: Past Growth Trends in Rural and Urban Population and Projected Growth in Population in Odisha Part of the Mahanadi River Basin

2.1.1 District-wise Domestic water demand for the Mahanadi River Basin Chhattisgarh

The analysis of the district-wise domestic water demand (Appendix I) reveals significant spatial and temporal variations in both urban and rural areas across the Mahanadi Basin region of Chhattisgarh. Over the two decades from 1991 to 2011, the total domestic water demand rose steadily due to population growth, urbanization, and improved access to water supply infrastructure. The total demand increased from 1135.50 MLD in 1991 to 1738.33 MLD in 2011, showing a clear upward trend. However, the rise in urban demand was more pronounced than in rural areas, emphasizing the accelerating pace of urbanization across the basin districts.

In the northern and central districts, moderate but steady growth was observed. Districts such as Balod, Baloda Bazar, and Bemetara showed a consistent rise in both urban and rural water needs. For instance, Balod's total demand increased from 8.24 MLD in 1991 to 10.23 MLD in 2011, reflecting balanced growth in both sectors. Similarly, Baloda Bazar's total demand reached 20.12 MLD in 2011, with rural areas contributing significantly due to agricultural-based livelihoods and dispersed settlements. Bemetara also recorded increasing trends across all blocks, pointing to gradual urban expansion and better rural water supply systems.

The Bilaspur and Durg districts emerged as major centers of domestic water demand, driven by dense populations and rapid industrial-urban growth. Bilaspur's Bilha and Takhatpur blocks registered significant rises, Bilha rose from 48.24 MLD in 1991 to 87.40 MLD in 2011, indicating growing urban concentration and service sector development. In Durg district, the Durg block alone accounted for 139.06 MLD in 2011, with nearly 90 percent of the demand being urban. The rising figures in Patan and Dhamdha also reflect peri-urban growth driven by proximity to industrial clusters and expanding residential areas (Appendix I).

In contrast, southern districts such as Gariabandh and Kanker demonstrated relatively lower total water requirements, reflecting their smaller populations and limited urban centers. Blocks like Chhura and Mainpur in Gariabandh showed marginal increases, primarily in rural demand, while Kanker and Narharpur recorded moderate rises due to growing administrative and service-based settlements. These districts, with their large forest cover and dispersed habitation, display lower per capita consumption rates compared to the central plains.

The Korba and Raigarh districts reflected the combined effect of industrial growth and urban expansion on domestic demand. In Korba, urban water demand surged sharply in Katghora and Korba blocks, reaching 27.61 MLD and 31.88 MLD respectively in 2011. Similarly, Raigarh's urban areas, especially in Raigarh and Pussore blocks, exhibited rising demands driven by industrial township development and population inflow. This indicates the dual role of industrialization, not only in increasing employment and settlement density but also in intensifying urban water needs.

In eastern and northern tribal districts such as Jashpur, Surajpur, and Koriya, domestic water demand remained relatively low but consistently rising. For instance, Jashpur's Pathalgaon block increased from 10.94 MLD in 1991 to 14.93 MLD in 2011, while Koriya's Baikunthpur block rose to 13.35 MLD in the same period. These trends suggest gradual improvement in household water access even in less urbanized areas, reflecting the impact of state rural water supply programs and infrastructural outreach.

The Raipur district stands out with the highest domestic demand, largely due to its role as the state capital and economic hub. Dharsiwa block's demand rose dramatically from 78.49 MLD in 1991 to 170.71 MLD in 2011, mainly driven by urban consumption. Arang and Abhanpur also witnessed growing demands linked to suburban growth and infrastructural expansion. The figures for Raipur illustrate the spatial shift from rural-dominant consumption toward a predominantly urban-based demand system, characteristic of rapid metropolitan growth.

Overall, the analysis of all districts highlights a clear pattern of rising domestic water demand with time, where urban areas experienced the sharpest increases due to migration, industrialization, and lifestyle shifts. Rural areas, though slower in growth, also showed steady improvement in accessibility and usage. The results underline the urgent need for integrated water management planning that addresses both urban expansion pressures and equitable rural supply. Continuous monitoring and infrastructure enhancement will be essential to ensure sustainable water security across all districts and blocks in the Mahanadi Basin (Appendix I).

3. INDUSTRIES IN THE MAHANADI RIVER BASIN

3.1 Overview

Industrial development has long been promoted by both the state and central governments as a key strategy for achieving economic transformation in relatively underdeveloped states such as Chhattisgarh and Odisha. Over the past two decades, both states have witnessed significant growth in their Gross State Domestic Product (GSDP), reflecting broader improvements in economic activity and production capacity. In real terms, the size of Chhattisgarh's economy has doubled (100%), while Odisha's has expanded by nearly 75% since the fiscal year 2004–05 (Directorate of Economics and Statistics, Government of Chhattisgarh, 2015; Planning and Coordination Department, Government of Odisha, 2015).

Agricultural productivity has also improved in both regions, though at differing rates. Chhattisgarh's agricultural output has nearly doubled, whereas Odisha has experienced a more modest 23% increase during the same period. It is worth noting, however, that a decade ago, Chhattisgarh's agricultural output was only half that of Odisha's, indicating that while progress has been substantial, a gap still exists in agricultural base and capacity (Directorate of Economics and Statistics, Government of Chhattisgarh, 2015).

In the industrial sector, growth patterns vary considerably. Odisha's mining sector expanded by approximately 91%, reflecting the state's rich mineral base and ongoing extraction activities. In contrast, Chhattisgarh's mining sector grew at a relatively moderate rate of 31%. Meanwhile, the construction sector in Odisha expanded by about 76%, while Chhattisgarh recorded an exponential rise of nearly 316%, largely driven by rapid infrastructure development and industrial investments.

The tertiary or service sector has emerged as a significant contributor to growth in both states, with expansion rates of approximately 110–120%. Although industrial growth has undoubtedly contributed to overall prosperity, the services sector now appears to be the dominant driver of economic advancement in both regions (Planning and Coordination Department, Government of Odisha, 2015).

Despite this progress, structural disparities remain evident. In Chhattisgarh, the share of industry in GSDP has declined from 44.1% to 38.8%, suggesting a relative slowdown in industrial expansion. Conversely, Odisha's industrial share has remained relatively stable, averaging around 23.5% over the same period. The share of the tertiary sector has increased by about 5% in both states, reflecting a transition toward service-based economies. However, this shift indicates uneven development, as the tertiary sector employs a smaller workforce, while agriculture continues to support most of the population (Directorate of Economics and Statistics, Government of Chhattisgarh, 2015; Planning and Coordination Department, Government of Odisha, 2015). In terms of agriculture's contribution, Chhattisgarh recorded a 1.5% increase in the sector's share of the economy, keeping pace with the state's overall growth, whereas Odisha experienced a 3.4% decline. This divergence underscores differences in sectoral priorities and policy outcomes between the two states.

The following section provides a state-specific analysis, drawing primarily from the Economic Surveys of Chhattisgarh and Odisha, with a particular focus on the secondary (industrial) sector. This includes an assessment of power generation, manufacturing, especially iron and steel production, and mining activities. These industries are emphasized due to their substantial share in state output and their significant demand for water resources, necessitating a critical review of current allocation and management strategies.

The distribution of industrial water allocations within the Mahanadi Basin (Table 4) shows a pronounced clustering of high-demand industrial users in regions with established heavy industrial infrastructure and proximity to major surface water reservoirs. The Bhilai–Korba–Jharsuguda–Angul corridor forms the industrial heartland of the basin, characterized by steel, aluminium, and thermal power plants that demand substantial and continuous water supplies.

- **High allocation zones (≥10 MCM):** are dominantly found near Hirakud Command, Bhilai Steel Plant, Angul–Talcher Industrial Belt, and Jharsuguda, reflecting the concentration of large-scale industrial operations that rely on major irrigation reservoirs or river intakes for cooling and processing needs.
- **Moderate allocation areas (1–10 MCM):** occur across smaller industrial clusters in Korba, Raigarh, and western Odisha, typically associated with secondary industries such as cement, sponge iron, and chemical units.
- **Low allocation zones (≤1 MCM):** are dispersed across southern and central Chhattisgarh, indicative of smaller industries that depend on local surface or groundwater sources.
- **Data-deficient (Water Info N/A):** shows regions where industrial water abstraction is either unmonitored or unreported, suggesting the need for improved data management and regulatory oversight.

Table 4: Industrial Water Allocations within the Mahanadi Basin

Category of Industrial Water Allocation	Allocation Range (MCM)	Spatial Distribution (Major Concentration Areas)	Remarks / Observations
Low Allocation	Up to 1 MCM	Scattered across the western and central basin, especially near minor industrial clusters in Raipur, Dhamtari, and small-scale industrial belts	Typically allocated to small- and medium-scale industries, including food processing and light manufacturing.
Moderate Allocation	1–10 MCM	Concentrated near industrial towns such as Korba, Raigarh, Jharsuguda, and Angul	Medium-scale industries like sponge iron, cement, and power plants.
High Allocation	More than 10 MCM	Clustered near Bhilai, Rourkela, Angul-Talcher, Jharsuguda, and the Hirakud region	Major heavy industries, steel, aluminum, and thermal power sectors dominate.
Water Info N/A	—	Scattered occurrences; limited data points across northern Chhattisgarh and western Odisha	Reflects gaps in industrial water data reporting or unregulated extraction.
Major Irrigation Projects (for reference)	—	Hirakud, Hasdeo Bango, Tandula, Sondur, and Mahanadi delta irrigation systems	Key competing users of basin water alongside industries.

3.2 Economic Profile and Sectoral Development of Chhattisgarh

3.2.1 Overview of Economic Growth

Chhattisgarh has experienced significant economic expansion over the past decade. The state's Gross State Domestic Product (GSDP) at current prices increased from Rs. 478,620 million in 2004–05 to Rs. 1,856,820 million in 2013–14, representing a nominal annual growth rate of 14.5% and an estimated real growth rate of around 10% (Directorate of Economics and Statistics, Government of Chhattisgarh, 2015).

The economic structure of the state shows notable diversification. The tertiary sector, encompassing transport, communication, banking, real estate, and other services, now accounts for approximately 40% of Chhattisgarh's total GSDP. The industrial sector, which includes manufacturing, mining, construction, and power generation, contributes about 39%, reflecting the state's growing industrial base. Meanwhile, although the agricultural sector has expanded in recent years, its relative share has been overshadowed by faster growth in tertiary activities.

3.2.2 Sector-Wise Economic Structure

The sectoral composition of Chhattisgarh's economy between 2004–05 and 2013–14 is summarized in Table 5. The data indicate a broad-based increase in real output across all major sectors, with particularly strong growth observed in construction and the tertiary sector.

3.2.3 Power Sector Development

Chhattisgarh is recognized as a power-surplus state, with electricity generation contributing substantially to its revenue base. The Korba district, often referred to as the *"Power Capital of India"*, is the primary center of power production. As of January 2015, the state had an installed thermal power capacity of 10,683 MW, comprising 6,413 MW from private producers and 4,270 MW from state and central units (Directorate of Economics and Statistics, Government of Chhattisgarh, 2015, p. 99). This capacity expanded to 15,802 MW by January 2017, indicating a nearly 48% increase within two years, largely driven by private sector investments in coal-based thermal plants (Central Electricity Authority, 2017, p. 16). The state's power exports also contribute significantly to its revenue stream, reinforcing its position as a key energy hub in central India.

Table 5. Chhattisgarh Economy – Sectoral Statistics

Sector	2004–05 (Current Prices) (Rs. million)	Share (%)	2013–14 (Constant 2004–05 Prices) (Rs. million)	Share (%)	Increase in Real Output (%)
Total GSDP	4,78,620	100	9,52,620	100	99
Agriculture (incl. animal husbandry)	70,570	14.7	1,39,200	14.6	97
Mining	53,670	11.2	88,060	9.2	64
Manufacturing	1,04,790	21.8	1,37,880	14.5	31
Construction	32,740	6.8	1,36,470	14.3	316
Electricity, Gas, Power	21,000	4.3	41,310	4.3	97
Tertiary Sector	1,64,810	34.4	3,66,460	38.5	122

(Source: Directorate of Economics and Statistics, Government of Chhattisgarh, 2015)

3.2.4 Mineral Resources and Industrial Growth

Chhattisgarh's economic development is closely tied to its abundant mineral resources, which have played a pivotal role in attracting resource-intensive industries such as steel, aluminum, and cement manufacturing. The state produces approximately 22.6% of India's coal (127 million tonnes), 19.8% of iron ore (30 million tonnes), and 7.6% of limestone (21 million tonnes) its three most significant minerals (Directorate of Economics and Statistics, Government of Chhattisgarh, 2015).

Additionally, Chhattisgarh contributes 20% of India's cement output and remains the only tin-ore producing state in the country. In 2013–14, the state hosted 202 operational mines, with mining of major minerals accounting for about 9% of the GSDP, a slight decrease from 11% in 2004–05. However, its share in state revenue increased to 25.5% (Rs. 30,280 million) in 2013–14, nearly double the Rs. 15,540 million recorded in 2009–10. The total value of minerals produced in 2013–14 was estimated at Rs. 195,660 million (Directorate of Economics and Statistics, Government of Chhattisgarh, 2015, p. 81).

The South Eastern Coalfields Limited (SECL) remains the largest mining enterprise in the state, primarily operating in Korba, Surguja, and Koriya districts. Prominent private and public sector corporations, including Vedanta, ESSAR, LANCO, Jindal, Monnet, DB Power, NTPC, Steel Authority of India Limited (SAIL), and BALCO, have established major operations in the power, steel, and aluminum industries.

Industrial growth is concentrated around major urban and industrial corridors such as Raipur (Tilda, Urla, Siltara), Bilaspur (Sirgitti, Dagori, Silpahari), and Durg (Borai). Meanwhile, Korba serves as a central industrial hub, and Raigarh continues to develop as a hub for power and mining.

3.2.5 Estimating Water Allocations and Use

To accurately assess the impact of industrial expansion on water allocation within the Mahanadi River Basin, it was necessary to estimate both the scale and spatial distribution of industrial water use. However, the absence of a comprehensive and consolidated database of large industries posed a significant challenge. To address this gap, a detailed database was developed, encompassing all major industries within the Mahanadi Basin that have received environmental clearance from the Ministry of Environment and Forests (MoEF), along with their respective water requirements.

Based on the compiled data, the total volume of water allocated to large industries in the basin is estimated to be approximately 1,130 million cubic meters (MCM) in Chhattisgarh and 944 MCM in Odisha, amounting to a combined 2,074 MCM of water designated for industrial use. Notably, a substantial portion, about 274 MCM, of these recent allocations has been sanctioned by Chhattisgarh for industrial purposes from several major barrages along the main stem of the Mahanadi River. These new water allocations have emerged as a central issue in the ongoing inter-state dispute between Chhattisgarh and Odisha.

Chhattisgarh

Industrial development in the Chhattisgarh region of the Mahanadi Basin has witnessed rapid growth over the past decade. Water allocations for coal-based thermal power plants, based on Environmental Clearances, have surged dramatically from 307 MCM to 1,017 MCM within ten years. If all these clearances result in operational plants, the total installed capacity would reach 33,268 MW, a significant increase from the 8,000 MW capacity approved since 2007. On average, these plants require approximately 30.5 MCM of water per 1,000 MW of power generation.

In addition to the power sector, iron and steel industries represent the second-largest water consumers, with allocations totaling 193 MCM to support a combined production capacity of 34 million tonnes per annum (MTPA). This marks a more than threefold increase compared to the 10 MTPA capacity in 2007, which corresponded to an estimated 60 MCM of water allocation at that time. These allocations also account for the captive thermal power plants associated with the iron and steel sector, with a total capacity of 3,568 MW, of which 3,048 MW has received clearance since 2007.

Furthermore, an additional 9 MCM of water has been allocated for aluminium industries, while mining operations covering various minerals have been allotted 65 MCM for a cumulative capacity of 339 MTPA. The total approved mining capacity has more than doubled since 2007, with new and expanded projects adding 177 MTPA of production potential. Overall, the total volume of water allocated to industrial sectors within Chhattisgarh's portion of the Mahanadi Basin stands at approximately 1,284 MCM. By extrapolating backward, the estimated industrial water allocation in 2007 was around 400 MCM, underscoring the rapid escalation of industrial water demand over the past decade.

The Figure 2 illustrates the parallel growth of cumulative water allocation (in million cubic meters, MCM) and thermal power generation capacity (in megawatts, MW) in the Chhattisgarh part of the Mahanadi basin over the period 1980–2013. From 1980 to 2007, the growth in both parameters remained relatively gradual. However, a sharp escalation occurred post-2007, corresponding to accelerated industrialization and the commissioning of several coal-based thermal power plants.

Water allocations rose steeply from around 307 MCM in 2007 to over 1,017 MCM by 2013, while the thermal power capacity increased from 8,000 MW to about 33,268 MW during the same period. This clearly indicates the direct coupling between industrial (particularly power sector) expansion and freshwater demand. The trend highlights the intensifying pressure on water resources due to thermal power development and underscores the necessity for integrated water resource management and sustainable allocation policies in industrial sectors.

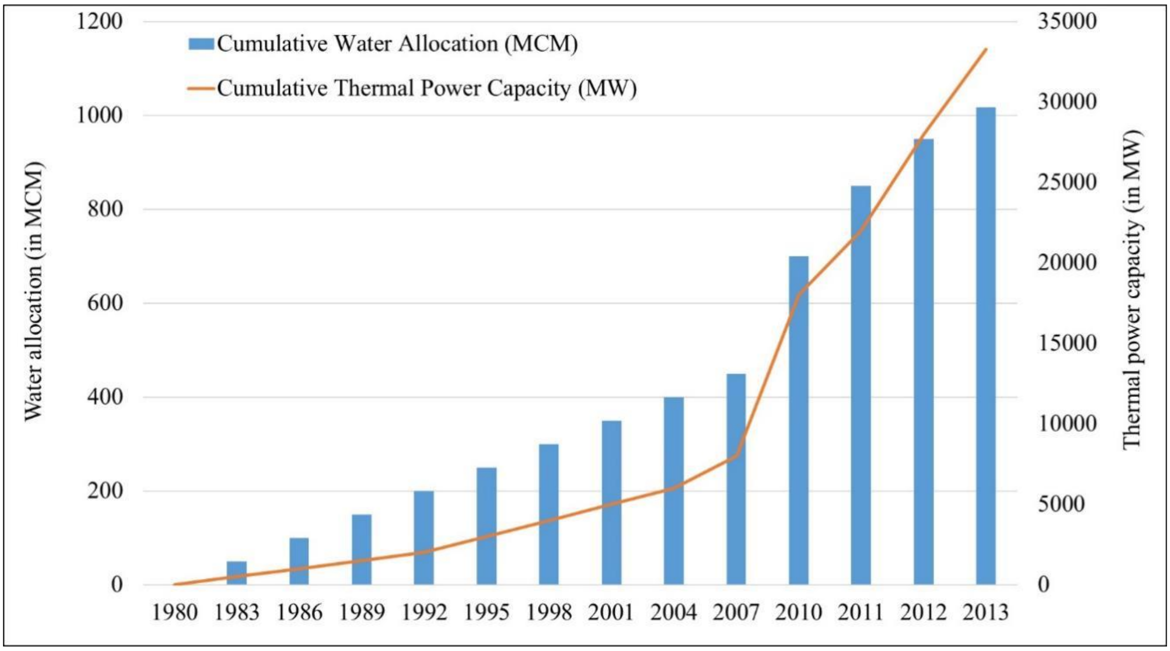


Figure 2: Trend of cumulative water allocations (in MCM) and cumulative thermal power capacity (in MW) in the Chhattisgarh part of the Mahanadi Basin.

(Source: Ministry of Environment and Forests, 2016)

Odisha

Coal-based thermal power plants constitute the major share of industrial water use in Odisha. However, the expansion of thermal power in the state began much later compared to Chhattisgarh. Currently, the total water allocation for thermal power generation in Odisha stands at approximately 644 million cubic meters (MCM), a substantial increase from just 57 MCM in 2007.

In comparison, water allocations for the iron and steel sector amount to about 179 MCM, with the largest allocations made to Bhushan Steel, Essar Steel, and Shyam DRI, collectively accounting for roughly 100 MCM, all approved after 2007. This indicates a marked increase in allocations to the steel industry over the past decade. Additionally, around 120 MCM has been allocated to the aluminium sector. Altogether, Odisha's total industrial water allocation (excluding mining) reaches approximately 944 MCM, a dramatic rise from about 200 MCM in 2008.

Interestingly, the Odisha Water Plan (2004) had projected that by 2051, industrial water demand within the Mahanadi Basin would reach only 335 MCM, assuming industries reduced their per capita water use from 900 litres per capita per day (lpcd) to 650 lpcd. The stark contrast between these projected figures and the current allocations highlights a significant and growing disparity in water resource management and planning within the basin.

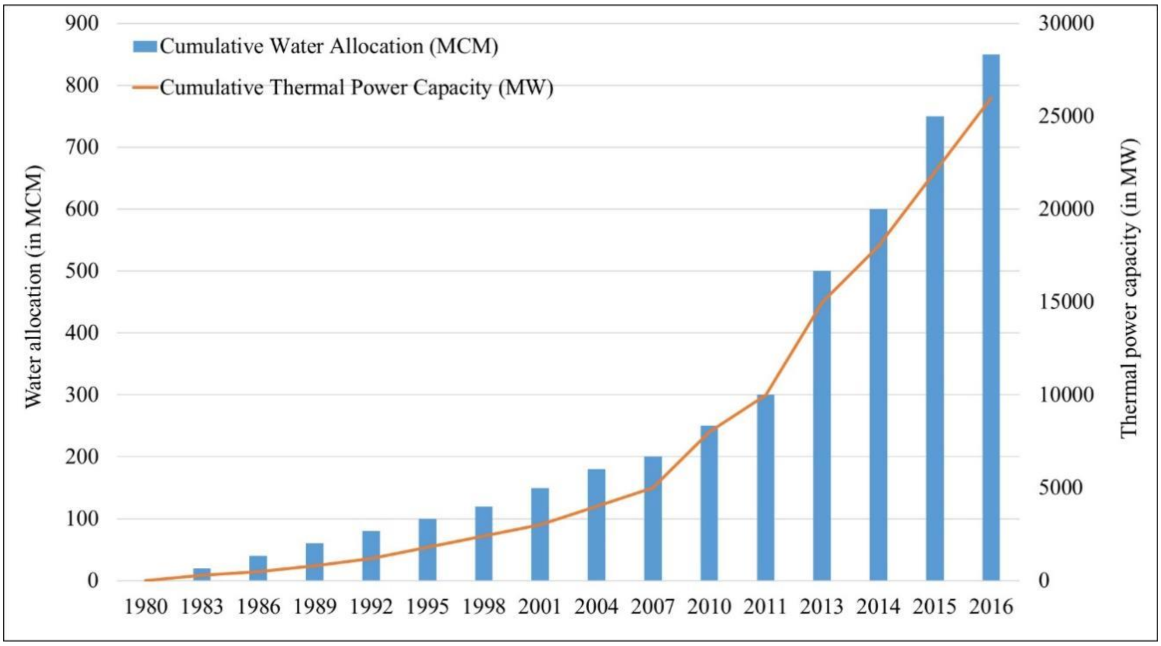


Figure 3: Cumulative water allocations (in MCM) and cumulative thermal power capacity (in MW) in the Odisha part of the Mahanadi Basin from 1980 to 2016.

(Source: Ministry of Environment and Forests, 2016)

Figure 3 depicts the progressive increase in cumulative water allocations and cumulative thermal power capacity in the Odisha part of the Mahanadi basin from 1980 to 2016. The early decades (1980–2007) witnessed a slow and steady rise in both parameters, primarily reflecting limited industrial growth and fewer thermal power installations. However, after 2007, both parameters exhibit a steep upward trend, marking the onset of rapid industrialization and expansion of thermal power generation.

By 2016, cumulative water allocation had reached approximately 850 MCM, while cumulative thermal power capacity rose to about 26,000 MW. The sharp rise in both curves indicates a strong correlation between industrial development and water demand, with thermal power plants emerging as a major water-consuming sector. This trend underscores the increasing stress on regional water resources and highlights the need for integrated water management strategies, efficient water use technologies, and sustainable industrial planning to balance energy development with water resource sustainability.

3.3 Economic Profile and Industrial Composition of Odisha

3.3.1 Overview of Odisha's Economy

Odisha's economy has shown consistent and impressive growth over the last decade. The Gross State Domestic Product (GSDP) of Odisha increased from ₹777,290 million in 2004–05 to ₹272,979 million in 2013–14, when measured in 2004–05 constant prices. This represents an average annual nominal growth rate of 13.4% and a real growth rate of 7.5% (Planning and Coordination Department, Government of Odisha, 2015).

The economic composition of Odisha reflects a clear dominance of the tertiary (services) sector, which accounts for approximately 47% of the total GSDP. The secondary sector, encompassing industries and construction, contributes around 34%, while the primary sector, which includes agriculture and allied activities, makes up the remaining share. This sectoral distribution highlights that Odisha's economy is more service-oriented compared to other mineral-rich states such as Chhattisgarh, where the industrial sector holds a larger share of the GSDP (Planning and Coordination Department, 2015).

3.3.2 Sectoral Composition of Odisha's Economy

The detailed distribution of Odisha's GSDP across major sectors during 2004–05 and 2013–14 is presented in Table 6. The data reflect significant real output growth across almost all sectors, particularly in mining, manufacturing, and services, underscoring the state's expanding industrial and tertiary base.

Table 6: Odisha's Economy – Sectoral Statistics

Sector	2004–05 (Current Prices) (Million ₹)	2013–14 (Constant 2004–05 Prices) (Million ₹)	Share in GSDP (2004–05)	Share in GSDP (2013–14)	Increase in Real Output (%)
Agriculture (including Animal Husbandry)	14,603	17,972	18.80%	13.10%	23%
Mining	5,861	9,169	7.50%	6.70%	56%
Manufacturing	9,369	17,929	12%	13%	91%
Construction	8,092	14,288	10.40%	10.40%	76%
Electricity, Gas, Power	3,197	4,090	4.10%	3.00%	28%
Tertiary Sector	32,950	69,586	42.40%	50.60%	111%
Total GSDP	**77,729**	**2,72,979**	**100%**	**100%**	–

(Source: Planning and Coordination Department, Government of Odisha, 2015)

3.3.3 Energy and Industrial Capacity

Odisha has developed a substantial power generation capacity, with approximately 7,100 MW of installed coal-based thermal power. Of this, nearly 5,000 MW is operated by the private sector, while the remainder is managed by state and central government utilities (Central Electricity Authority, 2017).

The state's industrial and mineral resource potential is remarkable. Odisha possesses 52% of India's bauxite reserves, 44% of its manganese, 33% of its iron ore, and 24% of its coal deposits (Planning and Coordination Department, 2015). Among these, coal accounts for nearly 88% of the state's total mineral reserves, with major extraction concentrated in the Angul, Jharsuguda, Sundargarh, and Sambalpur districts. In 2013–14, coal production reached 108 million tonnes (MT). Likewise, iron ore production amounted to 77 MT, predominantly extracted from Keonjhar (71%) and Sundargarh (25%), while bauxite mining activities are primarily located in Koraput district.

Out of the 595 mining leases granted in the state, 102 are currently operational, covering a total area of approximately 46,788 hectares (Planning and Coordination Department, 2015). This highlights the strategic importance of Odisha's mineral resources to both the regional and national economies.

3.3.4 Industrial Development and Key Hubs

Odisha's industrial base is anchored by large-scale steel and iron production facilities. The Rourkela Steel Plant, with a capacity of 4.5 million tonnes per annum (MTPA), remains the state's largest integrated steel manufacturing unit. Furthermore, the Government of Odisha has signed 49 Memoranda of Understanding (MoUs) with various steel producers, targeting a cumulative production capacity of 83.6 MTPA. However, the actual production as of 2015 stood at only 12.6 MTPA, along with an additional 11.4 MTPA of sponge iron capacity that is already operational (Planning and Coordination Department, 2015).

Major industrial players such as Vedanta, POSCO, Jindal, Tata Steel, and Essar have established plants across different parts of the state, contributing significantly to Odisha's industrial growth trajectory. Among the key industrial zones, Jharsuguda serves as the primary hub for sponge iron and thermal power production, while Keonjhar and Sundargarh districts collectively hold over 50% of the state's total mineral deposits (Planning and Coordination Department, 2015).

3.4 Industrial Water Requirement

Today, Chhattisgarh is advancing fast on the path of Overall development. Chhattisgarh is generously bestowed with natural resources like forests, minerals, and surface as well as groundwater. The state has undergone a radical change and is thriving with industrial activities. State rivers, namely Mahanadi, Hasdev, Kelo, Shivnath, Indravati, etc. can satisfy the needs for drinking water, agriculture, as well as industrial units. The state has started the development of a series of dams to fulfill the future needs of water supply. Chhattisgarh is one of the states of India where the best quality of electricity generation and distribution techniques are practiced. Serious planned efforts have been made towards declaring the state as a "Power Hub". The state has a good geographical location, given its connectivity to big cities and other states. Owing to the geographical advantage, this agriculturally developed State, renowned as the "Bowl of Rice," is becoming famous with great potential to advance in industrial growth, specifically steel, cement, power, and aluminum.

Chhattisgarh aspires to become the growth engine of India. Chhattisgarh's growth rate is higher than the national average. The socio-economic environment in the state has drastically changed in the past 23 years. Chhattisgarh now ranks Sixth in the 'Ease of Doing Business' ranking. Chhattisgarh has become an ideal investment destination. An ultra-mega steel plant worth Rs 18 thousand crore is being set up at Bastar by the Steel Authority of India Limited. Another ultra-mega steel plant worth Rs 25 thousand crore is being set up by the N.M.D.C. (Government of India undertaking). The Chhattisgarh Government has taken several steps to upgrade industrial infrastructure. There are 42 Industrial Zones in the State at present. Metal Park, Engineering Park, Food Park, Plastic Park, and Aluminum Park are being established. There is a proposal to establish an Industrial Zone in every district. Six-thousand-hectare land bank is being planned. Investment proposals to the tune of Rs 6.59 lakh crore had been received, which is 14 percent of the investment proposals inthe entire country. MOUs to the tune of Rs 55 thousand crore had been inked in the current fiscal.

They are related to the coal gasification, railways, steel, defense, engineering, food processing, solar energy, electronics, and information technology sectors. Chhattisgarh has progressed tremendously in the 'core' sectors like steel, cement, aluminum, and electricity generation. The focus now is on the non-core sectors like electronics, information technology,defense industry, railways, heavy engineering, 'platinum' industry, food processing, herbal processing, and services sector. Chhattisgarh has launched the 'Make in Chhattisgarh' campaign on the lines of Prime Minister Mr. Narendra Modi's 'Make in India' Mission. Our Industrial and Innovation Policies have created a favorable environment for start-ups and industrial growth (Table 7).

The status report on industrial water shows the present requirement of industrial water, and its future scenario, and describes the best practices for water saving in the industrial sector. It also includes the identification of a set of problem solutions to address the key issue, giving the pros and cons of the solutions. The status report assesses the impact of climate change on the industrial sector & suggests accordingly how to mitigate its impact and what could be adaptation measures.

Table 7: Surface water distribution for industries by Water Resources Department

S.No.	Year of Agreement	Allotted Water (MCM)	Cumulative Demand (MCM)	Proposed Power Generation (MW)
1	1988	1.78	1.78	0
2	1993	4.98	6.76	0
3	1995	3.32	10.08	0
4	1997	23.355	33.435	80
5	2000	2.369	35.804	0
6	2002	79.88	115.684	1055
7	2004	44.72	160.404	450
8	2005	16.373	176.777	165.8
9	2006	69.08	245.857	38
10	2007	140.79	386.647	2770
11	2008	256.57	643.217	5709.2
12	2009	482.521	1125.74	13392.8

13	2010	317.791	1443.53	10436
14	2011	243.714	1687.24	8761.25
15	2012	100.77	1788.01	3858.5
16	2013	80.16	1868.17	2641
17	2014	2.4	1870.57	65
18	2016	67.895	1938.47	2648.5
19	2017	108.903	2047.37	2980
20	2018	74.586	2121.96	3052.6
21	2019	24.586	2146.54	1354
22	2020	31.237	2177.78	1396
23	2021	4.946	2182.73	636
24	2022	8.848	2191.57	171
25	2023	21.767	2213.34	62
26	**TOTAL**	**2213.34**	**28619.5**	**61722.7**

(Source: CGWRD)

They are related to the coal gasification, railways, steel, defence, engineering, food processing, solar energy, electronics, and information technology sectors. Chhattisgarh has progressed tremendously in the 'core' sectors like steel, cement, aluminium, and electricity generation. The focus now is on non-core sectors like electronics, information technology, the defence industry, railways, heavy engineering, the 'Platinum' industry, food processing, herbal processing, and the services sector. Chhattisgarh has launched the "Make in Chhattisgarh' campaign on the lines of Prime Minister Narendra Modi's 'Make in India' Mission. Our industrial and innovation policies have created a favourable environment for start-ups and industrial growth. The status report on industrial water shows the present requirement for industrial water, its future scenario, and the best practices for water saving in the industrial sector. It's also including the identification of a set of problem solutions to address the key issue, giving the pros and cons of the solutions. The status report assesses the impact of climate change on the industrial sector and suggests accordingly how to mitigate its impact and what adaptation measures could be taken.

3.4.1 District-wise Industrial Water Demand of Mahanadi River Basin Chhattisgarh

The district-wise industrial water requirement data (Appendix II) reveals a dynamic shift in the water demand pattern across Chhattisgarh's industrial landscape over the years 1991, 2001, and 2011. Significant variations are observed not only among districts but also within individual blocks, reflecting the diverse pace of industrialization and infrastructural growth. Broadly, the findings indicate a substantial rise in industrial water consumption in several key industrial hubs, particularly in districts such as Korba, Raigarh, Durg, and Raipur, while other areas such as Surajpur and Kanker show minimal industrial expansion and corresponding water demand.

In the Durg–Bhilai industrial belt, the data highlights exceptionally high industrial water requirements in the Durg block, peaking at 346.63 MCM in 2001 before reducing to 7.19 MCM in 2011, suggesting industrial saturation or a shift toward water-efficient technologies (Appendix II). Similarly, the Patan and Dhamdha blocks show negligible demand, reflecting their limited industrial presence. This pattern underscores the dominance of steel and heavy industries in Durg, which historically contributed to its water-intensive profile but have since stabilized due to modernization and recycling practices.

The Korba district stands out as another major industrial center, with its Korba block showing an extraordinary rise from 0.006 MCM in 1991 to 204.88 MCM in 2011. The Katghora block also displayed significant demand, reaching 28.75 MCM in 2011, confirming Korba's role as a core coal-based and thermal power production hub (Appendix II). However, the surrounding blocks such as Pali and Poundi-Uproda maintained minimal requirements, indicating concentrated industrial activity around energy generation sites rather than evenly distributed industrialization.

Raigarh district demonstrates a similarly uneven distribution, where the Raigarh and Pussore blocks recorded the highest water demand at 130.48 MCM and 45.79 MCM respectively in 2011. This rise corresponds to the proliferation of thermal power and steel plants during the decade. In contrast, other blocks like Baramkela and Sarangarh showed modest figures, underscoring the spatial clustering of industries around mineral-rich and infrastructurally advanced zones (Appendix II). The trend suggests that water resource management in such districts must prioritize industrial corridors where water stress risks are higher.

Raipur, the state's administrative and economic hub, also witnessed notable fluctuations. The Tilda block reported an increase from 0.057 MCM in 2001 to 51.30 MCM in 2011, indicating significant industrial expansion. Similarly, Dharsiwa and Arang blocks maintained moderate but consistent demands linked to industrial estates and manufacturing clusters. Meanwhile, Abhanpur displayed a minor rise, suggesting emerging industrial activity (Appendix II). These figures collectively highlight the central region's gradual transformation into a diversified industrial zone with growing water dependency.

In contrast, districts like Balod, Mahasamund, and Bemetara recorded minimal industrial water demand, reflecting their predominantly agrarian economies with limited industrial bases. For instance, Balod's Gunderdehi and Gurur blocks showed incremental rises to 0.0218 MCM and 0.0662 MCM respectively in 2011, indicating small-scale local industries (Appendix II). Similarly, Mahasamund's Mahasamund block reached 1.075 MCM in 2011, pointing toward modest industrial growth. Peripheral and forested districts such as Kanker, Surajpur, and Jashpur exhibited negligible water demand throughout the period, aligning with their low industrial footprint.

Overall, the assessment of industrial water demand across all districts and blocks reveals a strong concentration of water-intensive industries within the central and eastern parts of Chhattisgarh, particularly around Durg, Korba, Raipur, and Raigarh. These areas have witnessed fluctuating, yet substantial water demand driven by thermal power, mining, and metallurgical industries. In contrast, the northern and southern districts remain largely underdeveloped industrially, emphasizing a spatial disparity in industrial water utilization. The findings underscore the need for region-specific water resource management strategies that balance industrial development with sustainable water use and conservation (Appendix II).

3.5 Analysis of Cumulative Demand Growth and Saturation Trends

As shown in Figure 4, the cumulative demand trend exhibits a typical S-shaped growth pattern over the observed period. During the initial phase (up to approximately time step 8), the curve remains nearly flat, indicating minimal or negligible demand accumulation. This suggests that consumption or requirement levels were low during this early stage (Figure 4). Between time steps 9 and 15, the curve rises sharply, representing a period of rapid demand escalation. This steep segment indicates an accelerated accumulation rate, which could be associated with increased operational activity, seasonal factors, or a surge in market needs. Such a trend is consistent with logistic-type cumulative behaviors often reported in production and resource utilization studies (Figure 4). After time step 16, the curve begins to flatten, signifying a saturation phase where cumulative demand approaches its maximum level. The plateau near approximately 2,100–2,200 units implies that most potential demand has been fulfilled, and further increases are marginal. Overall, the curve demonstrates three distinct phases:

1. **Latent Phase (slow growth)** – limited demand accumulation.
2. **Accelerated Growth Phase (steep increase)** – rapid expansion of demand.
3. **Saturation Phase (plateau)** – stabilization of total demand.

This cumulative pattern reflects a balanced progression from demand emergence to saturation, aligning with typical system growth dynamics observed in industrial, supply chain, or energy consumption contexts (Figure 4).

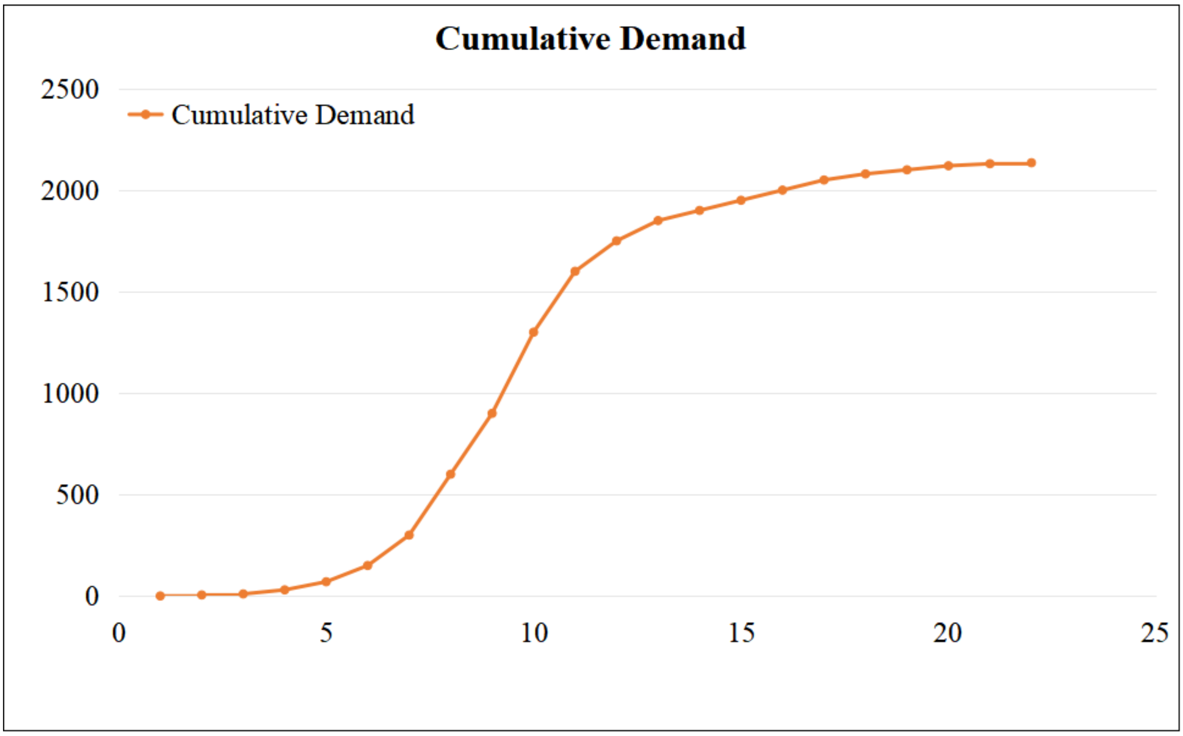


Figure 4: Cumulative Demand Curve Showing Phased Growth Pattern

3.6 Assessment of Water Supply Sources and Future Demand Projections

Table 8 presents the current and projected water supply scenario from both surface and groundwater sources. The data illustrate the relative contribution of these sources for the year 2023 and the additional demand anticipated for the near future.

In 2023, the surface water supply is estimated at 28,619.5 million cubic meters (MCM), while groundwater availability accounts for 629.19 MCM, resulting in a total supply of 30,095.376 MCM. This clearly indicates that surface water forms the dominant component of the total water supply system, contributing over 95% of the available resources. Groundwater, on the other hand, represents a relatively small share, often serving as a supplementary or backup source in regions where surface storage or conveyance is limited.

The future demand, which is still pending approval at the government level, is projected to require an additional 1,243.263 MCM of surface water and 695.374 MCM of groundwater, leading to an expected incremental total of 1,938.637 MCM. These figures suggest a growing reliance on groundwater resources, whose share increases from roughly 2% in the current year to more than 35% of the projected additional demand. This shift highlights the need for integrated water resource management to ensure sustainability and to avoid over-extraction of groundwater reserves.

When both current and future figures are combined, the overall water availability from both sources is projected to reach approximately 5,034.013 MCM, comprising 3,709.449 MCM from surface water and 1,324.564 MCM from groundwater. This cumulative projection underscores the importance of strategic planning and balanced utilization between surface and groundwater to meet future demand efficiently and equitably. Therefore, the data indicate that while surface water remains the primary source, there is a noticeable increase in dependence on groundwater in the future scenario. Policymakers and planners must therefore emphasize water conservation, recharge enhancement, and optimized allocation to ensure sustainable resource management in the coming years.

Table 8: Industrial Water Scenario for Chhattisgarh (Demand Side)

S.No.	Year	Source of Supply (MCM)		Total
		Surface Water	Ground Water	
1	2023	28619.5	629.19	3095.376
2	Future Demand (Pending at the govt. level)	1243.263	695.374	1938.637
Total (1) + (2)		**3709.449**	**1324.564**	**5034.013**

(Source: CSIDC)

3.7 Comparative Analysis of Supply, Demand, and Cumulative Demand Dynamics

Figure 5 illustrates the temporal variation of supply, demand, and cumulative demand over a defined period. The graph shows distinct behavioral patterns among the three parameters, revealing critical insights into the balance between supply availability and consumption trends.

The supply line remains almost constant throughout the observation period, indicating a steady and controlled provision of resources. This consistency may suggest regulated production, a fixed allocation policy, or stable infrastructure capacity. Despite fluctuations in demand, the supply level appears unaffected, implying that the system is designed to meet the expected consumption without short-term adjustments.

In contrast, the demand line exhibits noticeable fluctuations. Initially, demand is low but begins to rise sharply around the mid-period, reaching a distinct peak before gradually declining toward the later stages. This variation indicates seasonal or cyclic consumption behavior, which could be influenced by external factors such as climatic variations, operational intensity, or user requirements. The subsequent decline in demand may reflect saturation, reduced activity, or demand stabilization following the high-consumption phase.

The cumulative demand curve follows an S-shaped trend, starting slowly, increasing rapidly during the middle phase, and finally plateauing toward the end. This pattern is characteristic of logistic growth behavior, where initial accumulation is limited, followed by a phase of accelerated consumption and eventual stabilization once the maximum potential demand has been met. The curve surpasses the constant supply level around the middle of the timeline, signifying the point where cumulative consumption overtakes the available supply, a critical threshold for sustainable resource management. Overall, the figure reveals a temporal mismatch between supply and cumulative demand, emphasizing the need for dynamic supply management strategies to accommodate fluctuations in demand without compromising long-term sustainability. The data suggest that while the supply system is robust, planning for demand surges and replenishment cycles is essential for maintaining equilibrium between availability and consumption.

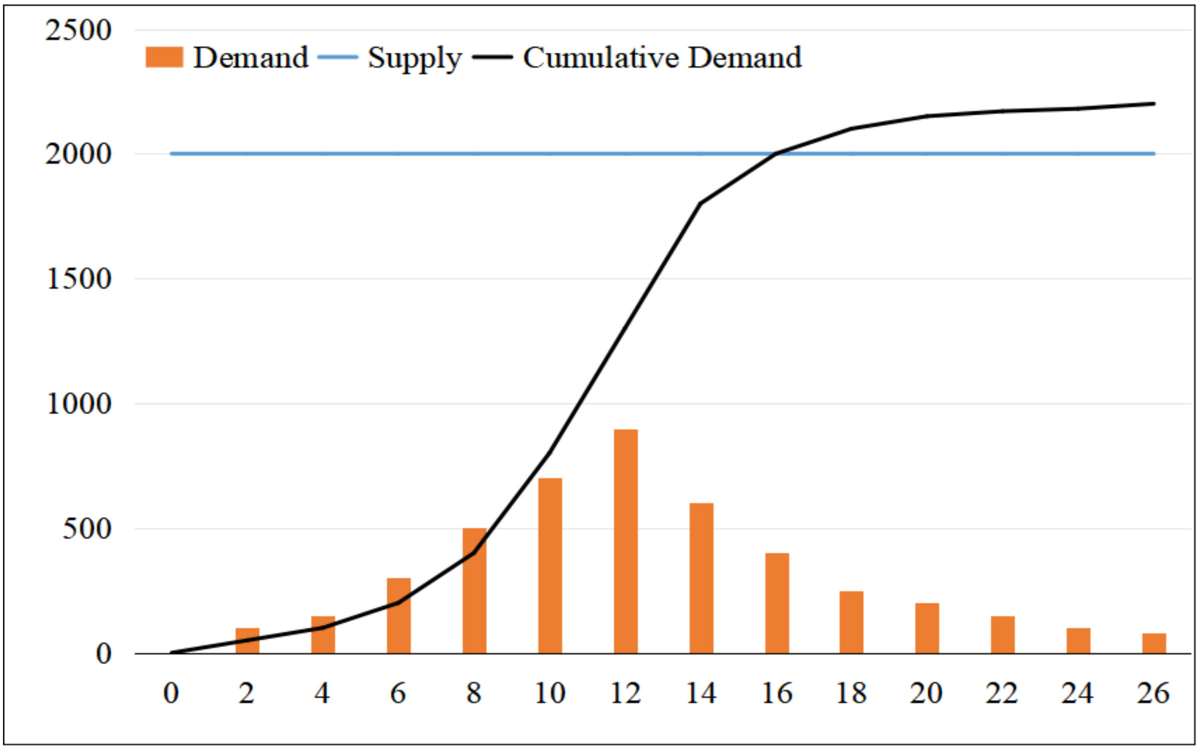


Figure 5: Trends of Supply, Demand, and Cumulative Demand Over Time

3.8 Basin-wise Assessment of Water Diversion from Major River Systems in Central and Eastern India

As shown in Table 9, the Mahanadi Basin exhibits the highest total water diversion volume (2028.23 MCM) among all basins, significantly surpassing the Godavari (194.68 MCM) and Brahmani (243 MCM) basins. This indicates that the Mahanadi River system plays a dominant role in regional water allocation and use, likely due to its extensive network of irrigation projects and multipurpose reservoirs. The Ganga Basin shows a negligible diversion (0.267 MCM), while the Narmada records none, highlighting spatial disparities in inter-basin water utilization. Such trends underscore the hydrological and developmental prominence of the Mahanadi Basin in eastern India and the relatively lower diversion dependency in adjacent river systems.

Table 9: Basin-wise distribution of total water diversion (in MCM) from major Indian rivers

S. No.	Mahanadi	Godavari	Ganga	Brahmani	Narmada
1	1.78	0	0	0	0
2	4.98	0	0	0	0
3	3.32	0	0	0	0
4	8.78	14.3	0.267	0	0
5	2.37	0	0	0	0
6	79.88	0	0	0	0

7	57.32	5.4	0	0	0
8	16.37	0	0	0	0
9	3.08	66	0	0	0
10	104.79	36	0	0	0
11	241.57	0	0	0	0
12	333.18	58.34	0	135	0
13	402.94	2.35	0	0	0
14	191.74	0	0	108	0
15	157.72	0	0	0	0
16	99.26	0.9	0	0	0
17	2.4	0	0	0	0
18	120.9	0	0	0	0
19	143.11	11.39	0	0	0
20	52.74	0	0	0	0
Total	**2028.23**	**194.68**	**0.267**	**243**	**0**

(Source: CGWRD)

3.9 Assessment of Basin-wise Water Demand Distribution

The basin-wise analysis of water requirements (Table 10) indicates that the Mahanadi Basin is the most water-demanding system in the study region, accounting for approximately 85% of the total water demand (1120.29 MCM). This dominant share reflects the basin's extensive agricultural activities, particularly paddy cultivation during the Kharif season, which is highly water intensive.

The Godavari Basin contributes the second-largest demand at 145.18 MCM, representing nearly 11% of the total requirement. This can be attributed to irrigation and limited industrial activities in the basin's upper and middle reaches. In contrast, the Ganga Basin shows a relatively smaller demand of 45.00 MCM, indicating localized agricultural and domestic uses within its limited spatial coverage in the region.

The Brahmani and Narmada Basins exhibit negligible water demand (0.07 MCM and 0.00 MCM, respectively), highlighting minimal water-dependent activities or surface water utilization within these sub-basins. Overall, the data suggest a strong spatial concentration of water demand within the Mahanadi Basin, emphasizing the need for efficient resource management and sustainable irrigation practices to balance future agricultural and ecological needs.

Table 10: Basin-wise water requirement across major river basins (in MCM)

Basin Name	Water Demand (MCM)
Mahanadi Basin	1120.29
Godavari Basin	145.18
Ganga Basin	45
Brahmani Basin	0.07

Narmada Basin	0
Total Demand	**1310.54**

(Source: CGWRD)

3.10 Estimated Industrial Water Demand for Core Sectors in the Mahanadi Basin

The industrial water demand assessment for the core sectors in the Mahanadi Basin (Table 11) indicates that the thermal power sector overwhelmingly dominates total water consumption, accounting for nearly 98% (24,360 MCM/year) of the total estimated demand. This is primarily due to the high cooling water requirements associated with thermal power generation, which relies heavily on surface water sources such as rivers and reservoirs.

The steel and iron sector is the second-largest consumer, with a total water demand of approximately 323.2 MCM/year, led by the Bhilai Steel Plant, one of India's largest integrated steel facilities. The aluminium sector, represented by BALCO (Bharat Aluminium Company), contributes a comparatively minor demand of 7.02 MCM/year, while the cement sector shows the lowest water footprint (5.874 MCM/year) due to its relatively low water intensity (0.3 cum/ton). Overall, the analysis reveals that industrial water use in the Mahanadi Basin is highly skewed toward the energy and metallurgy sectors, highlighting the critical role of efficient water management, recycling, and adoption of cooling water reuse technologies in mitigating stress on the basin's water resources.

Table 11: Estimated annual water demand (MCM) of core industrial sectors within the Mahanadi Basin

Sector / Industry	Production (Million Ton/Year)	Water Use Intensity (cum/ton)	Annual Water Demand (MCM)
(A) Steel & Iron			
Bhilai Steel Plant	9.74	20	194.8
Jindal Steel Plant	2.92	20	58.4
NMDC	3.5	20	70
Subtotal (A)	**16.16**	—	**323.2**
(B) Aluminum			
BALCO	0.351	20	7.02
Subtotal (B)	**0.351**	—	**7.02**
(C) Cement	19.58	0.3	5.874
Subtotal (C)	**19.58**	—	**5.874**
(D) Thermal Power	6960	3.5	24,360

Subtotal (D)	**6960**	**—**	**24,360**
Total Industrial Water Demand	**—**	**—**	**24,696.09**

(Source: Directorate of Economics and Statistics, Government of Chhattisgarh, 2015)

3.11 Industrial Policy 2014-2019

As shown in Table 12, both Chhattisgarh and Odisha aimed to drive industrial diversification and attract private investment during the 2014–2019 policy period. Chhattisgarh's approach primarily emphasized regional industrial development, promoting small and medium enterprises and fostering cluster-based growth to enhance local employment. The creation of a 10,000-hectare land bank and financial incentives for private industrial parks underscored its focus on infrastructure-led growth.

Table 12: Comparative Overview of Industrial Policies (2014–2019) for Chhattisgarh and Odisha.

Feature	Chhattisgarh Industrial Policy (2014–2019)	Odisha Industrial Policy Resolution (2015)
Policy Duration & Introduction	Formulated for the period 2014–2019 and implemented in early 2015 by the state government.	Introduced in 2015 to promote industrial expansion and investment up to 2019.
Core Objective	To attract new industries, boost investment, and enhance employment opportunities within the state.	To strengthen manufacturing output, diversify the industrial base, and position Odisha as an investment hub.
Targeted Investment & Employment	Focused on small- and medium-scale enterprises and local entrepreneurship development.	Aimed at attracting approximately ₹1.73 lakh crore in investment and generating around 300,000 jobs.
Priority Sectors	Textiles, pharmaceuticals, bicycles, electronics, and agro-based industries.	Food processing, petrochemicals, IT/ITeS, automobiles, tourism, textiles, and emerging sectors like electric vehicles and renewable energy.
Land & Infrastructure Provisions	Development of a 10,000-hectare land bank for industrial use and establishment of private industrial parks with government subsidies.	Provision of industrial parks, land at concessional rates, and infrastructure development through Industrial Development Corporations.

Major Incentives	Financial grants for cluster development (up to ₹50 lakh) and private industrial parks (up to ₹5 crore); relaxed norms for mega-project status.	Exemptions in stamp duty, VAT/SGST reimbursement, entry tax relief, and interest subsidies up to 5% for five years.
Focus on Ease of Doing Business	Simplified approval systems and incentives for locally established enterprises.	Streamlined investment approval through a single-window system and dedicated investor facilitation.
Industrial Approach	Emphasized inclusive industrialization with a focus on underdeveloped regions and cluster-based growth.	Promoted high-value manufacturing and "new-age" industries with a strong emphasis on export-oriented production.
Policy Outcome Expectation	Expected to strengthen small industries and create balanced regional growth.	Intended to raise manufacturing's share to about 15% of the state's GDP and enhance technological competitiveness.
Implementation Agencies	Department of Industries, Government of Chhattisgarh.	Department of Industries, Government of Odisha, and IPICOL (Industrial Promotion & Investment Corporation of Odisha Limited).

Conversely, Odisha's Industrial Policy Resolution (IPR-2015) adopted a more investment-intensive and sector-diverse model, targeting high-value manufacturing sectors such as automobiles, petrochemicals, IT/ITeS, and renewable energy. The policy's financial incentives, including stamp duty exemptions, SGST reimbursements, and interest subsidies, were designed to attract large-scale investors while ensuring employment creation. Overall, while both states focused on industrial expansion and employment generation, Odisha's policy leaned toward capital-intensive industrialization, whereas Chhattisgarh emphasized inclusive regional development and grassroots entrepreneurship (Table 12). Both models contributed to enhancing the states' competitiveness and aligning with India's broader "Make in India" vision during the mid-2010s.

4. AGRICULTURE AND ITS WATER USE IN THE MAHANADI RIVER BASIN

In both Chhattisgarh and Odisha, agriculture remains the primary source of livelihood for most of the population. In both states, rainfed rice dominates cultivation, accounting for about 70–75% of the gross cropped area. In irrigated regions, rice covers over 90% of the sown area.

The overview of the agricultural landscape and the allocation and use of water for agriculture across the Mahanadi Basin. It examines key aspects such as changes in the total cropped area, cropping patterns, and irrigation trends over the past two decades to project possible future water-use scenarios in this sector. The analysis is primarily based on secondary data from government sources, particularly from the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India. Later sections of the report incorporate field observations to validate and refine these trends derived from secondary data.

The findings indicate a notable acceleration in agricultural development in Chhattisgarh. This progress has been supported by the expansion of Kharif season surface irrigation in the plains of Dhamtari, Durg, Raipur, and Janjgir-Champa districts, while groundwater irrigation has played a key role in the agricultural growth of western Chhattisgarh, including Bilaspur, Kawardha, and Durg. Although Rabi irrigation is gradually increasing in Chhattisgarh, it remains less widespread than in Odisha.

In contrast, Odisha's agriculture appears to be declining, as reflected by a reduction in the gross cropped area over the last two decades. The increase in culturable wastelands and fallow lands largely explains this change, according to available land-use statistics. Irrigation facilities are concentrated in the delta regions and western Odisha, where the irrigated area has expanded significantly over time. Chhattisgarh also shows signs of agricultural diversification, with the proportion of land under rice cultivation decreasing in favor of pulses and oilseeds, which are mainly Rabi crops. In Odisha, the share of land under rice has remained relatively stable, while the area under pulses has increased and that under oilseeds has declined.

4.1 Seasonal Variations in Cropping

Chhattisgarh

According to the statistics published by the Directorate of Economics & Statistics, Ministry of Agriculture, Government of India (2013–14), the total gross cropped area across the 15 districts of Chhattisgarh within the Mahanadi Basin is approximately 4,010 thousand hectares. Out of this, the Kharif cropped area accounts for about 3,296 thousand hectares, while the Rabi cropped area covers around 693 thousand hectares. This reflects a cropping intensity of roughly 121% in the Chhattisgarh portion of the Mahanadi Basin. Notably, the Kharif cropped area has shown a consistent increase of nearly 200 thousand hectares since the formation of the state, whereas the Rabi cropped area reached its peak in 2005–06 and has shown a gradual decline thereafter.

As illustrated in Figure 6, the gross cropped area (GCA) in the Mahanadi Basin exhibits a steady trend between 2000–01 and 2013–14, fluctuating around 3700–4000 thousand hectares. The Kharif cropped area consistently accounts for the majority share, representing approximately 80–85% of the total cropped area. This dominance indicates the heavy reliance of the basin's agricultural system on monsoon rainfall.

Meanwhile, the Rabi cropped area shows a gradual increase over the study period, rising from around 600 to 750 thousand hectares, suggesting a modest but consistent improvement in irrigation infrastructure and water availability during the dry season. The stabilization of both Kharif and Rabi cropped areas after 2007–08 may reflect saturation in cultivated land expansion and a shift toward productivity-based improvements rather than area expansion. Overall, the data suggest that while the Mahanadi Basin's agriculture remains predominantly monsoon-dependent, efforts toward enhancing Rabi season cultivation have contributed to a more balanced annual cropping pattern (Figure 6).

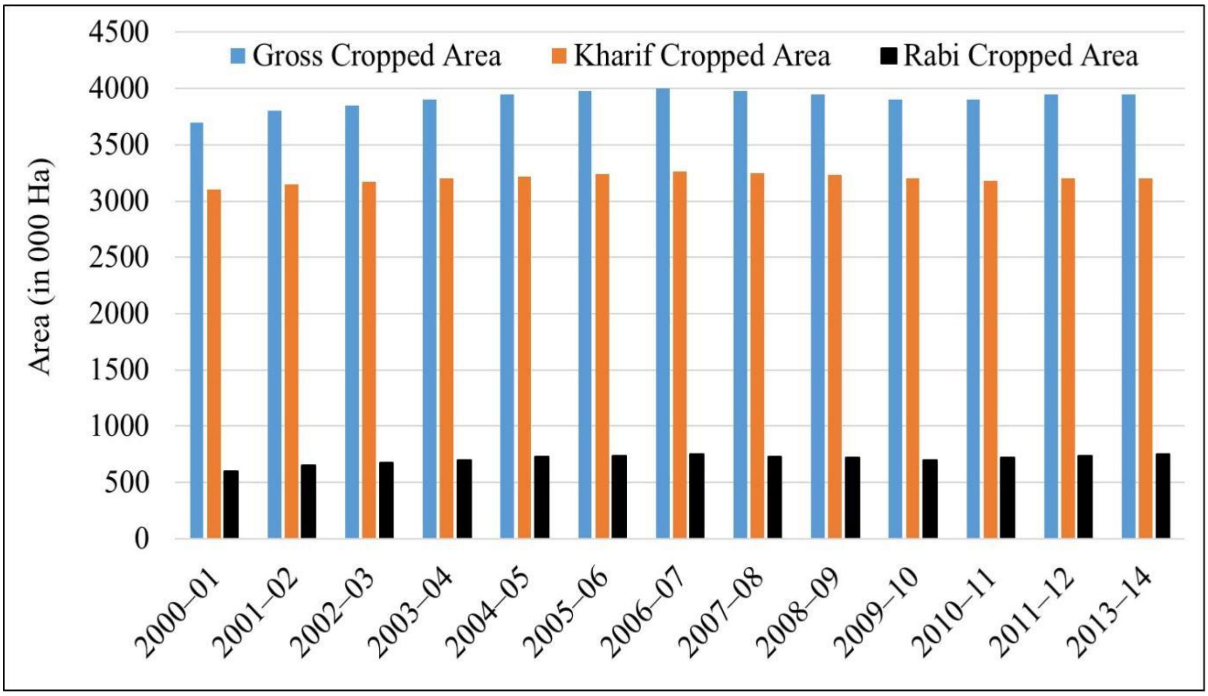


Figure 6: Temporal variation in Gross, Kharif, and Rabi Cropped Areas of the Mahanadi Basin

(Source: Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, District-wise, Season-wise Cropped Area, Chhattisgarh)

Odisha

In comparison, the Mahanadi districts of Odisha have experienced a decline in the gross cropped area from 4,506 thousand hectares to 4,122 thousand hectares in 2013–14, representing a reduction of approximately 8.5 percent. According to land use data, this decrease can be attributed to a shift toward fallow lands and culturable wastelands. The total cropped area during the Kharif season stands at about 2,712 thousand hectares, while the Rabi season covers around 1,396 thousand hectares, reflecting a high cropping intensity of nearly 151 percent. Over time, the Kharif cropped area has decreased considerably from 3,066 thousand hectares to 2,712 thousand hectares, whereas the Rabi cropped area has shown a recovery, increasing again to 1,396 thousand hectares after a notable decline in the late 1990s.

As illustrated in Figure 7, the gross cropped area (GCA) of the Mahanadi Basin demonstrates a declining trend from 1993–94 to 1999–00, followed by stabilization and slight recovery after 2000–01. The Kharif cropped area remained dominant throughout the period, accounting for approximately 75–80% of the total cropped area, emphasizing the region's heavy dependence on monsoon-based agriculture.

The Rabi cropped area, though comparatively smaller, exhibits a noticeable fluctuation during the early years and a gradual increase after 2000–01, rising from about 650 to 750 thousand hectares. This increase reflects improved irrigation facilities and better water resource management, likely driven by the development of canal systems and groundwater utilization during the dry season. The overall stabilization of the GCA after 2000–01 suggests that while land expansion reached its limit, productivity and cropping intensity improved through more efficient water use and diversification of Rabi crops. Therefore, the figure signifies a transition from purely rainfed to semi-irrigated agricultural systems within the basin (Figure 7).

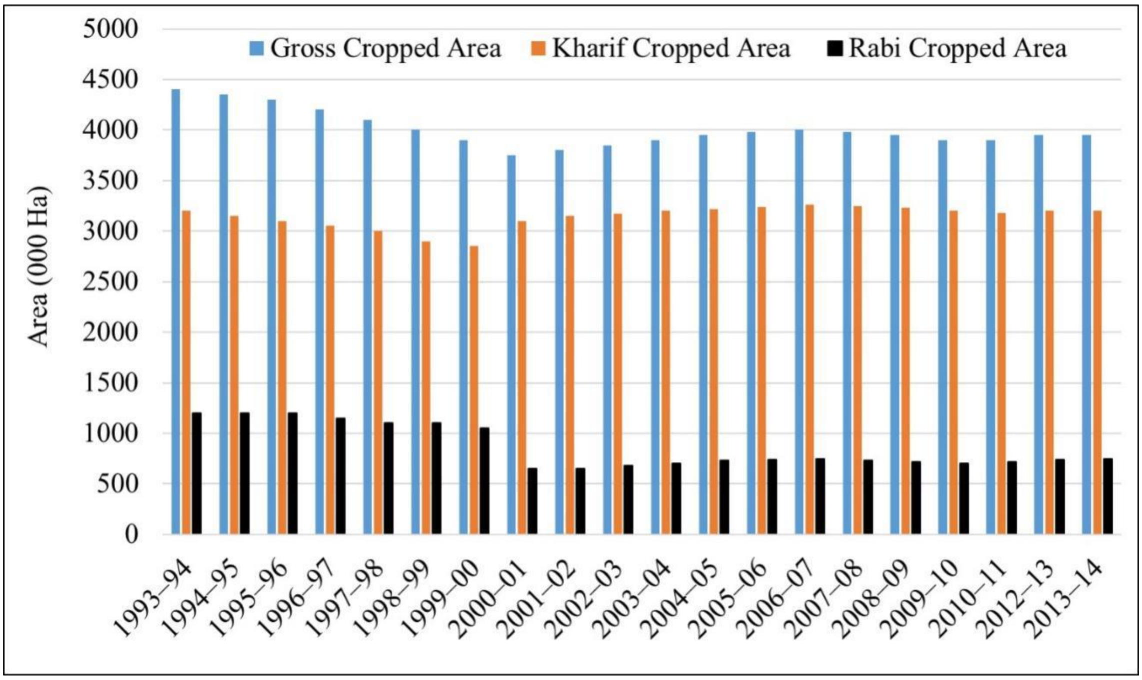


Figure 7: Temporal variation in Gross, Kharif, and Rabi Cropped Areas of the Mahanadi Basin

(Source: Statistics Cell, Ministry of Agriculture, Government of Odisha, District-wise, Season-wise Cropped Area, Odisha)

4.2 Geographical Variations in Cropping

Kharif Season

In the plains of Chhattisgarh, more than 50 percent of the geographical area is cultivated during the Kharif season, with Durg, Mahasamund, and Janjgir-Champa having the highest sown areas.

Notably, Durg and Raipur districts together contribute nearly one-third of the total Kharif cropped area in the state. These regions benefit from extensive surface irrigation systems, primarily fed by the Mahanadi River, including the major Mahanadi Reservoir Project.

In contrast, the upland districts located in the northern and southern parts of Chhattisgarh, such as Koriya, Surguja, Kanker, and Bastar, are predominantly forested. The western highland districts, including Bilaspur, Kawardha, and Rajnandgaon, have 40 percent or less of their geographical area under cultivation. These areas lack large-scale surface irrigation infrastructure, although groundwater irrigation is gradually expanding.

In Odisha, the western plains districts of Balangir, Bargarh, Nuapada, Kalahandi, and Subarnapur, along with the coastal district of Kendrapara, record the highest share of Kharif cropping. On average, around 60 percent of their geographical area is sown during the Kharif season. Balangir, Bargarh, and Kalahandi alone account for about 38 percent of Odisha's total Kharif cropped area. While much of this land is rainfed, it also benefits from major surface irrigation projects such as Hirakud, Indravati, and the Mahanadi Delta Project.

Districts like Jharsuguda and Sambalpur, located along the Mahanadi River, and the central districts of Boudh, Kandhamal, Nayagarh, and Angul have higher forest cover and limited irrigation potential. In other coastal districts, Cuttack, Jagatsinghpur, and Puri, approximately 40 percent of the geographical area is sown during the Kharif season. However, Kharif cropping in the deltaic region remains highly vulnerable to flooding, making its agricultural pattern distinct from other parts of the state.

As shown in Figure 8, the spatial distribution of Kharif cropping intensity in the Mahanadi Basin during 2013–14 reveals significant regional variation between the upper, middle, and lower basin districts. The central basin areas of Chhattisgarh, particularly Raipur (9.4%), Durg (8.7%), and the Bargarh–Kalahandi–Bolangir belt (5–6%), exhibit the highest Kharif cropping intensity, primarily due to better irrigation infrastructure, fertile alluvial soils, and higher rainfall.

In contrast, southern districts (e.g., Bastar, Nabarangpur) and eastern coastal districts (e.g., Puri, Kendrapara, Ganjam) show relatively low Kharif cropping intensity (below 2%), likely reflecting rainfed cultivation, lower irrigation access, and land-use competition with urban and forested areas.

The northern upland areas (Koriya, Surguja, Korba) also display low intensities (<2%) because of their topography and forest cover. Overall, the pattern signifies that Kharif cultivation is concentrated in the middle basin, where agricultural activities are supported by favorable hydrological and soil conditions, while peripheral areas remain less intensively cropped (Figure 8).

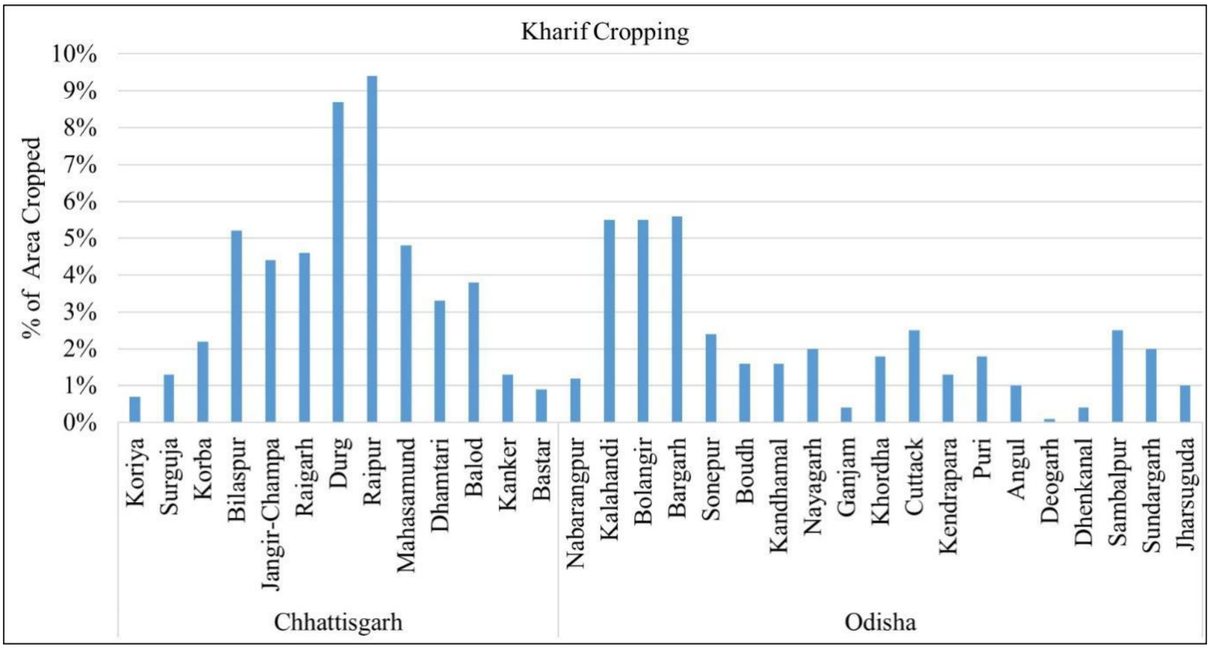


Figure 8: Distribution of Kharif Cropping Intensity (% of Area Cropped) in the Mahanadi Basin

(Source: Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, 2014, and Statistics Cell, Ministry of Agriculture, Government of Odisha, District-wise, Season-wise Cropped Area, Chhattisgarh & Odisha)

Rabi Season

In Chhattisgarh, the western districts of Durg, Kawardha, and Bilaspur have the highest proportion of land cultivated during the Rabi season, accounting for approximately 29%, 19%, and 16% of their total geographical area, respectively. In contrast, the plains districts such as Raipur, Mahasamund, and Janjgir-Champa, which are extensively irrigated during the Kharif season, receive much less irrigation in Rabi. Consequently, less than 5% of their area is under Rabi cultivation. Notably, Durg and Bilaspur districts together contribute nearly 53% of Chhattisgarh's total Rabi cropped area.

In Odisha, the low-lying coastal districts of Cuttack, Jagatsinghpur, and Puri record the highest share of their geographical area under Rabi cultivation, with more than 40% of their land sown during this season. Much of this cultivation is supported by irrigation from the Mahanadi Delta Project. In contrast, Rabi cropping in western Odisha districts such as Bargarh, Sonepur, Sambalpur, and Kalahandi depends primarily on surface irrigation, mainly provided by the Hirakud Project. Here, the Rabi sown area ranges between 20% and 25% of the total geographical area, compared to about 60% during the Kharif season. Overall, the districts of Cuttack and Kalahandi are the most significant contributors, together accounting for around 25% of Odisha's total Rabi cropped area.

As illustrated in Figure 9, the Rabi cropping intensity in the Mahanadi Basin during 2013–14 shows strong spatial disparities between districts. The western and central basin areas, particularly Durg (11.9%), Bargarh (6.0%), Bolangir (5.5%), and Bilaspur (5.8%), record the highest Rabi cropping intensity, reflecting better irrigation access from canal networks, groundwater exploitation, and residual soil moisture from the preceding Kharif season.

The coastal Odisha districts, such as Cuttack (7.8%), Kendrapara (7.9%), and Puri (5.8%), also demonstrate significant Rabi cropping due to proximity to the deltaic irrigation systems of the lower Mahanadi and favorable climatic conditions. Conversely, upland and forest-dominated districts in the northern and southern basin, such as Kanker, Bastar, Deogarh, and Nabarangpur, show very low Rabi intensity (<1%), indicating dependence on rainfed Kharif crops and limited irrigation facilities. Overall, the spatial pattern reveals that Rabi cropping is highly concentrated in the irrigated command areas, while large portions of the basin remain single-cropped and rain-dependent (Figure 9).

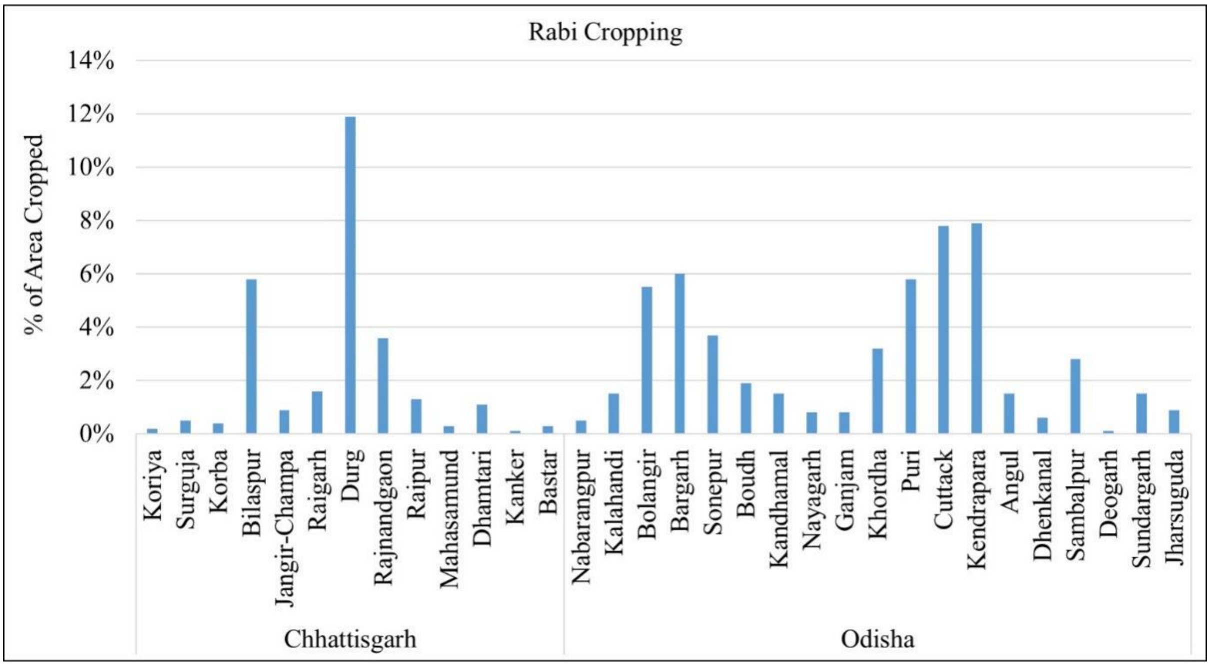


Figure 9: Distribution of Rabi Cropping Intensity (% of Area Cropped) in the Mahanadi Basin

(Source: Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, 2014, and Statistics Cell, Ministry of Agriculture, Government of Odisha, District-wise, Season-wise Cropped Area, Chhattisgarh & Odisha)

4.2.1 Cropping Patterns

Chhattisgarh

Since 2000–01, Chhattisgarh has witnessed an overall increase in its total gross cropped area from 3,620 thousand hectares (Th Ha) to 4,010 Th Ha. The gross cropped area under cereals has shown only a modest rise, from 2,942 Th Ha (81%) to 3,090 Th Ha (77%), while the area under pulses has grown significantly, from 508 Th Ha (14%) to around 692 Th Ha (17%).

During the Kharif season, cereals dominate the cropping pattern, covering about 3,015 Th Ha (91%) of the total 3,296 Th Ha sown area. Among cereals, rice alone accounts for 2,932 Th Ha (89%) of the total Kharif sown area. Oilseeds and pulses occupy approximately 5% and 4% of the Kharif area, respectively. Notably, the Kharif area under cereals has expanded since 2000–01, when cereals were grown on 2,888 Th Ha (93%) of the Kharif sown area. Meanwhile, the share of oilseeds in the Kharif season has increased from 2% to 5% over the same period.

In the Rabi season, pulses, mainly gram and khesari, constitute the largest crop group, covering about 573.5 Th Ha (83%) of the sown area. Cereals and oilseeds account for 11% and 6%, respectively. The rise in Rabi cultivation is primarily due to the expansion of pulses, which occupied only 366 Th Ha (74%) in 2000–01. In contrast, the share of oilseeds has declined sharply from 15% in 2000–01 to the current 6%. Among the districts, Raipur and Durg together contribute the largest share of cereal cultivation, accounting for 34% of the total sown area. Durg also leads in pulse cultivation, representing about 33% of the total pulse area, followed by Bilaspur, which accounts for around 16% (Figure 10).

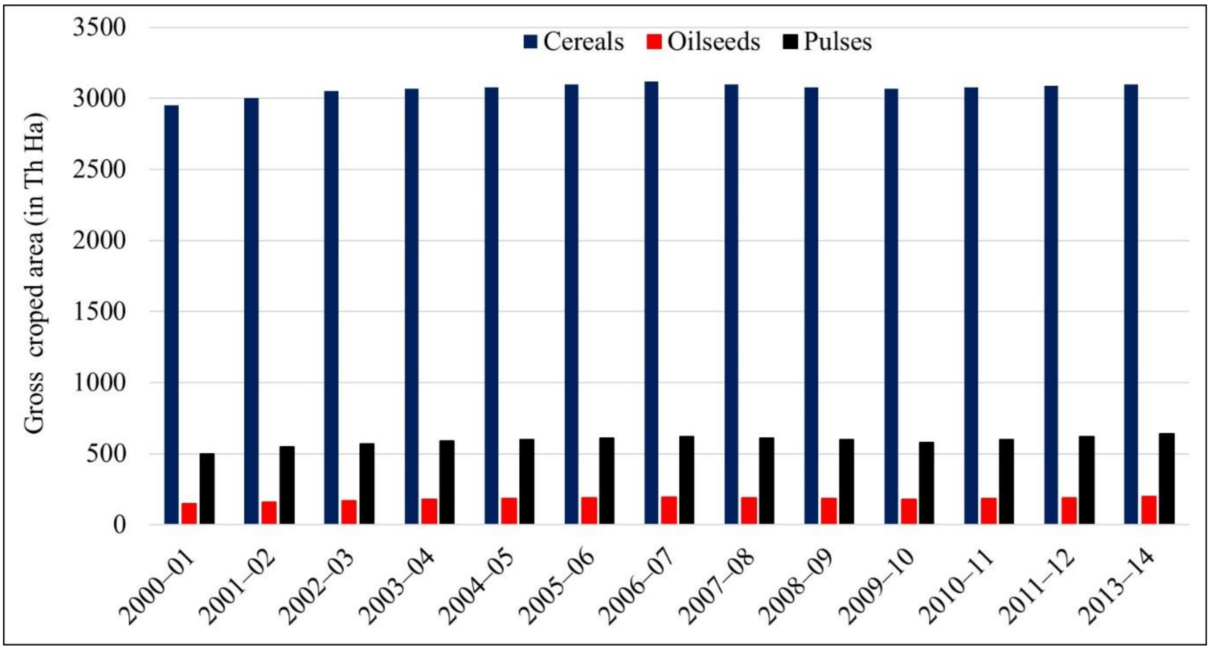


Figure 10: Temporal variation in Gross Cropped Area under major crop groups in the Mahanadi Basin

(Source: Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, District-wise, Year-wise, Crop-wise, Cropped Area, Chhattisgarh)

As depicted in Figure 10, cereals dominate the gross cropped area of the Mahanadi Basin throughout the study period (2000–01 to 2013–14), consistently accounting for around 80–85% of the total cultivated land. This predominance is largely due to the extensive cultivation of paddy (rice) as the principal Kharif crop, which thrives under the basin's monsoon-dependent irrigation system. The pulses occupy the second-largest share, showing a gradual increase from about 500 to 640 thousand hectares, reflecting growing diversification and improved awareness of soil fertility management through legume cultivation. Oilseeds, on the other hand, represent the smallest proportion of the cropped area (about 150–200 thousand hectares) with only a modest increase over time, indicating limited expansion due to climatic and soil constraints. Overall, the temporal stability of cereal dominance coupled with a slight rise in pulses suggests a gradual shift towards crop diversification without major alteration in the region's traditional rice-based cropping pattern (Figure 10).

As illustrated in Figure 10, cereals continue to dominate the agricultural landscape of the Mahanadi Basin, with the Kharif season accounting for most of the cropped area, approximately 90–95% of total cereal cultivation in both 2000–01 and 2013–14. This dominance reflects the rainfed nature of agriculture in the basin, where monsoon-dependent paddy (rice) is the principal crop. The Rabi cereals area shows a marginal increase, indicating a slight expansion of irrigated cropping during the dry season, possibly due to improved irrigation infrastructure and water availability. Pulses, on the other hand, have shown a notable increase in Rabi cultivation (from ~380 to 480 thousand hectares), highlighting their growing role as a winter-season crop that supports soil fertility improvement through nitrogen fixation. Kharif pulses show only a minor increase, suggesting limited adaptability to heavy monsoon conditions.

Oilseeds maintain a relatively small share of the total cropped area across both seasons, though a marginal increase is observed by 2013–14, potentially reflecting diversification efforts and market-driven cultivation incentives. Overall, the data emphasize that while cereals remain the staple and dominant crop, there is a gradual trend toward diversification and enhanced Rabi season utilization in the basin (Figure 11).

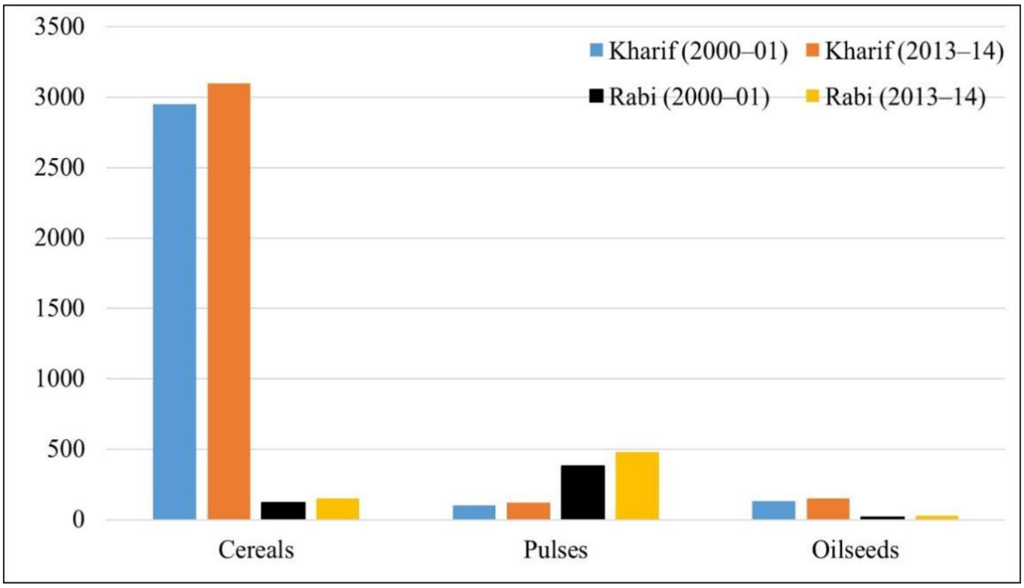


Figure 11: Comparison of gross cropped area under major crop groups (Cereals, Pulses, and Oilseeds) during Kharif and Rabi seasons in the Mahanadi Basin

(Source: Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, District-wise, Season-wise, Crop-wise, Cropped Area, Chhattisgarh)

Odisha

The gross cropped area in Odisha has declined from 4,414 thousand hectares (Th Ha) to 4,122 Th Ha over the study period (Figure 12). Like Chhattisgarh, the agricultural system in Odisha is predominantly rice-based, with paddy being cultivated across three main growing seasons Autumn, Winter, and Rabi.

The gross cropped area under cereals recorded a marginal decrease from 2,304 Th Ha (52%) in 1993–94 to 2,167 Th Ha (53%) in 2013–14. In contrast, the area under pulses showed a slight increase from 1,076 Th Ha (24%) to 1,163 Th Ha (28%) during the same period (Figure 6). Comparatively, the area under cereals in Odisha is smaller than in Chhattisgarh, whereas the area under pulses is significantly larger. The Kharif (Autumn + Winter) area under rice declined from 2,011 Th Ha to 1,833 Th Ha (67%) between 1993–94 and 2013–14, representing a portion of the total Kharif cereal area of 1,938 Th Ha (71%). Other key Kharif crops include pulses (396 Th Ha), oilseeds (120 Th Ha), and vegetables (124 Th Ha), contributing to a total Kharif cropped area of 2,712 Th Ha. Among all crop groups, pulses and fibres have shown an increase in area since 1993–94, whereas oilseeds, vegetables, and other crops have experienced a decline.

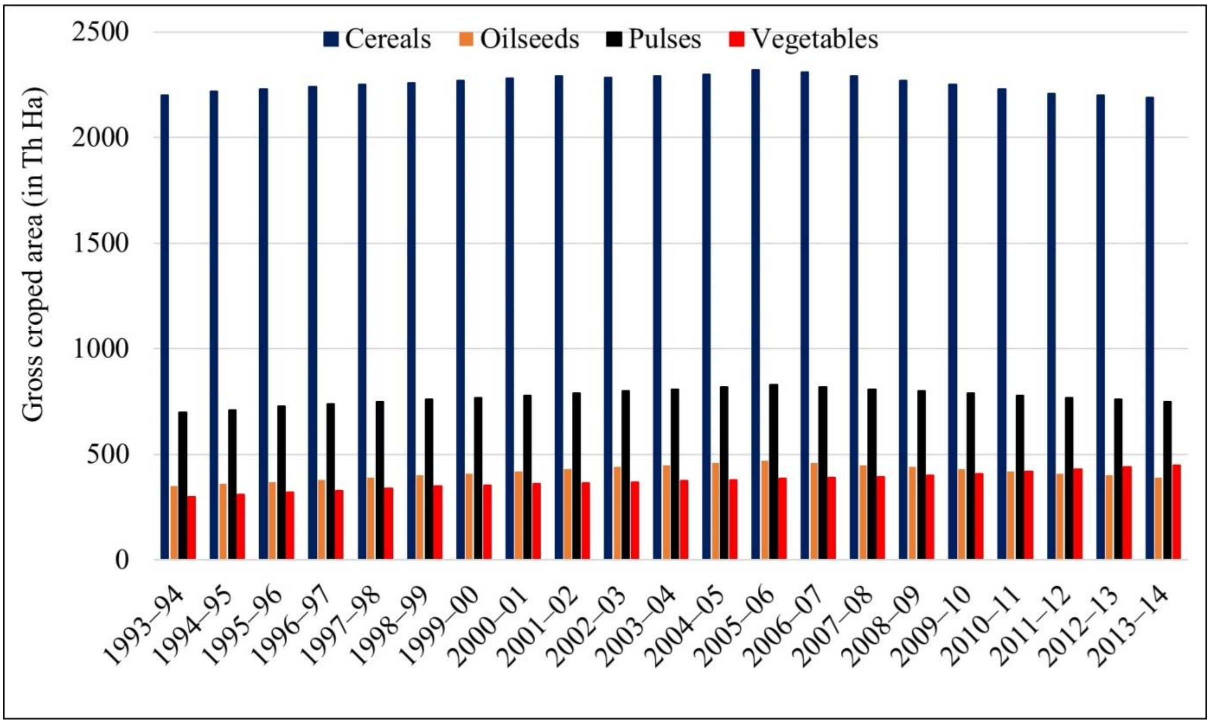


Figure 12: Change in gross cropped area and crop distribution in Odisha from 1993–94 to 2013–14

(Source: Statistics Cell, Ministry of Agriculture, Government of Odisha, 2015 – District-wise, Year-wise, Crop-wise, Cropped Area, Odisha)

In the Rabi season, the total cropped area is approximately 1,395 Th Ha, which is about half of the Kharif cropped area. Pulses dominate this season, occupying 766 Th Ha (55%) of the total area in 2013–14, followed by cereals (16%), oilseeds (14%), and vegetables (13%). Notably, rice covers only 216 Th Ha (15%) of the Rabi cropped area. District-wise, Balangir, Bargarh, and Kalahandi are the major cereal-producing regions, accounting for approximately 35% of the gross cropped area under cereals. Among these, Kalahandi stands out as the largest producer of oilseeds and pulses in Odisha.

The data (Figure 13) highlights a noticeable shift in the cropping pattern within the Mahanadi Basin between 1993–94 and 2013–14. While cereal cultivation continued to dominate both Kharif and Rabi seasons, the total area under cereals slightly declined from 2,200 Th Ha to 2,100 Th Ha in Kharif. In contrast, pulses and vegetables showed a considerable increase in Rabi cropping from 650 Th Ha to 800 Th Ha for pulses and 300 Th Ha to 350 Th Ha for vegetables, indicating greater diversification and intensified use of land during the dry season. The expansion of oilseeds and spices & condiments also suggests growing interest in high-value crops, possibly due to better irrigation access and market demand. Overall, the trend reflects gradual intensification and diversification of agriculture in the basin, with improved utilization of Rabi season opportunities (Figure 13).

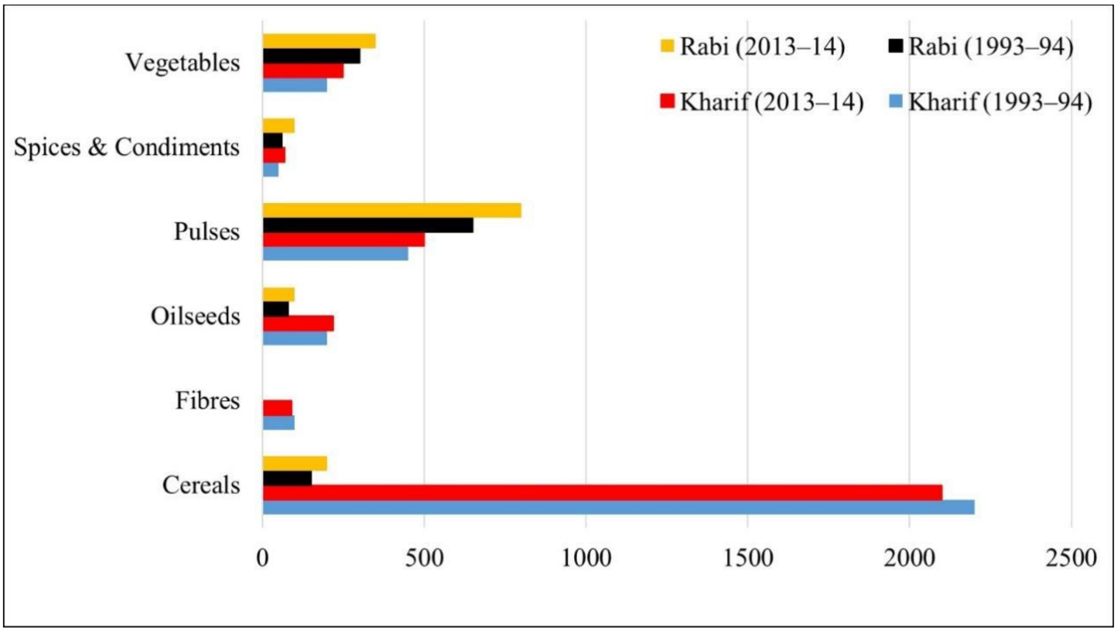


Figure 13: Gross cropped area under major crops during Kharif and Rabi seasons in the Mahanadi Basin for 1993–94 and 2013–14

(Source: Statistics Cell, Ministry of Agriculture, Government of Odisha, 2015 – District-wise, Season-wise, Crop-wise, Cropped Area, Odisha)

4.3 Irrigation Coverage – Seasons and Crops

Chhattisgarh

Large tracts of the plains of Chhattisgarh within the Mahanadi Basin are well-equipped with irrigation infrastructure. The state government has made consistent efforts to enhance agricultural productivity by expanding the irrigated area from 950 thousand hectares (Th Ha) in 2000–01 to 1,597 Th Ha in 2013–14. Currently, irrigation in the Kharif season covers about 35% of the total sown area (1,163 Th Ha out of 3,296 Th Ha), while in the Rabi season, it accounts for 27% (190 Th Ha out of 693 Th Ha). Among the districts, Bilaspur, Durg, Dhamtari, Janjgir-

Champa, and Raipur, all located in the plains of Chhattisgarh, are the most extensively irrigated during the Kharif season, with approximately 50% of their sown area under irrigation. Janjgir-Champa stands out with about 75% of its sown area irrigated. In contrast, Kawardha in western Chhattisgarh is highly irrigated during the Rabi season, where around 49% of the sown area receives irrigation. Most of the Rabi irrigation is concentrated in Kawardha and Durg districts (Figure 14).

Rice remains the predominant irrigated crop, occupying nearly 100% of the irrigated area in both the Kharif (1,159 Th Ha) and summer (169 Th Ha) seasons. In the Rabi season, irrigation primarily supports wheat and gram cultivation. Over the years, gram has gained considerable importance. Its share of the Rabi irrigated area increased from about 10% in 2000–01 to 60% in 2013–14, while the share of wheat declined from 68% to 30% during the same period. Additionally, fruits and vegetables account for nearly 70% of the irrigated "whole year" crops. Overall, there has been a noticeable diversification in the irrigated crop pattern. In 2000–01, rice comprised about 91% (868 Th Ha) of the total irrigated area, whereas by 2013–14, its share had declined to 83% (1,330 Th Ha). Meanwhile, pulses (including gram) increased from 1% (7 Th Ha) to 8% (123 Th Ha). The districts of Raipur, Durg, and Janjgir-Champa together account for almost 60% of the irrigated cereals in the state. Notably, Durg district has the largest irrigated area under pulses and vegetables, contributing about 57% of the irrigated pulses in Chhattisgarh.

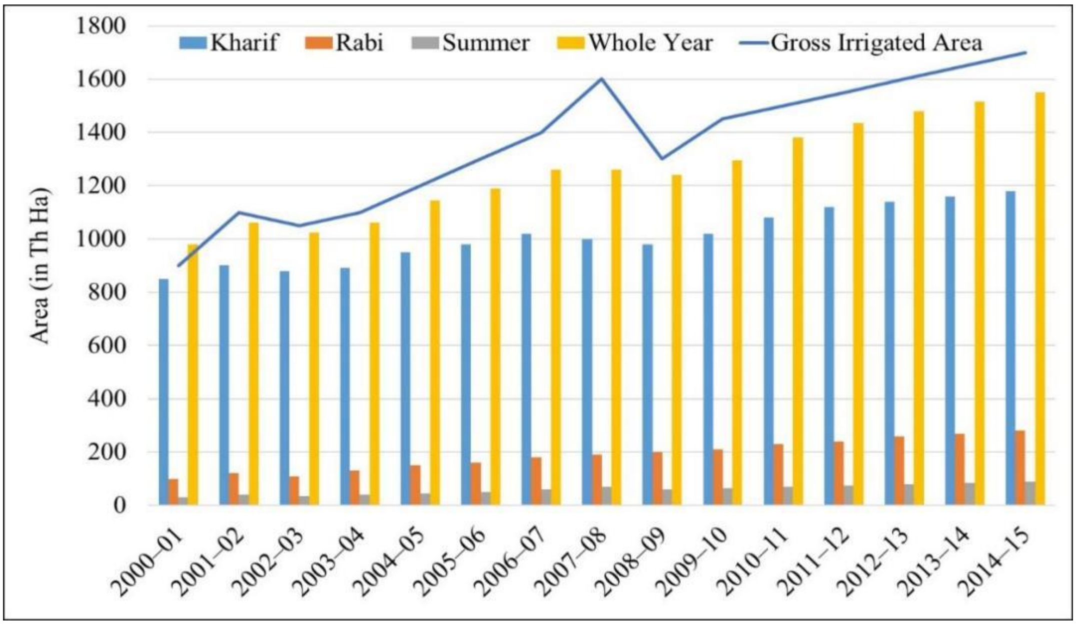


Figure 14: Seasonal and annual irrigated area in the Mahanadi Basin from 2000–01 to 2014–15

(Source: Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, District-wise, Season-wise, Source-wise, Irrigated Area, Chhattisgarh)

The temporal trend in irrigated area within the Mahanadi Basin (Figure 14) indicates a steady and consistent increase in both seasonal and gross irrigated extents from 2000–01 to 2014–15. The Kharif season maintained the highest share of irrigation throughout, increasing from approximately 850 Th Ha to 1180 Th Ha. Meanwhile, Rabi irrigation more than doubled during this period, reflecting enhanced utilization of stored surface water and groundwater for dry-season cultivation. The summer irrigation area, though small in magnitude, also exhibited gradual growth, signifying intensified cropping practices and improved water availability. Overall, the gross irrigated area showed a significant rise from around 900 Th Ha to 1700 Th Ha, demonstrating sustained agricultural expansion facilitated by improved irrigation infrastructure and management in the basin (Figure 14).

Odisha

The Odisha region of the Mahanadi Basin is well irrigated, with a significant improvement in irrigation coverage since 2003–04, following an earlier period of decline. At present, approximately 39% (1,065 Th Ha out of 2,712 Th Ha) of the Kharif sown area and 47% (658 Th Ha out of 1,395 Th Ha) of the Rabi sown area are under irrigation. The deltaic districts of Cuttack, Jagatsinghpur, and Puri record the highest irrigation coverage during the Kharif season, with over 70% of their cultivated land being irrigated, making them the most intensively irrigated zones in the basin (Figure 15).

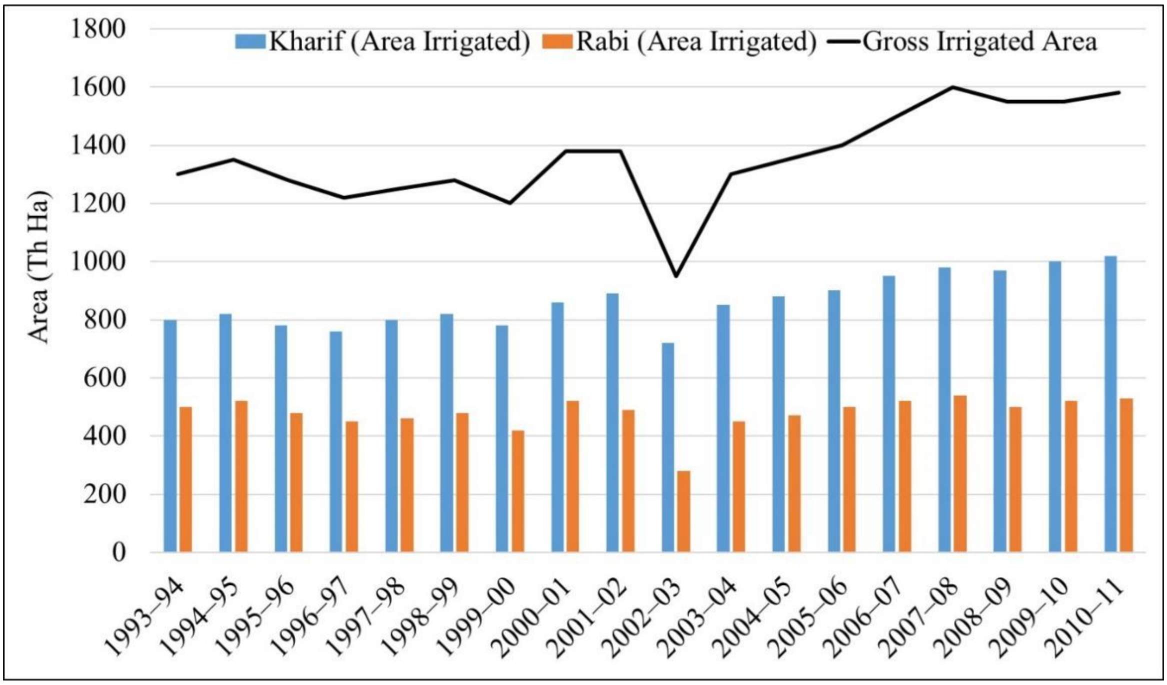


Figure 15: Temporal variation in Kharif and Rabi irrigated areas and gross irrigated areas in the Mahanadi Basin (1993–94 to 2010–11)

(Source: Statistics Cell, Ministry of Agriculture, Government of Odisha, District-wise, Season-wise, Source-wise, Irrigated Area, Odisha)

In contrast, during the Rabi season, the western Odisha districts of Bargarh (79%), Nabarangpur (73%), and Sambalpur (61%) exhibit the highest levels of irrigation. Notably, the districts of Bargarh, Kalahandi, and Cuttack together account for a major share of the Rabi irrigated area within the basin (Figure 15). Rice is the dominant irrigated crop during the Kharif season, occupying about 894 Th Ha (84%) of the total irrigated area. In the Rabi season, both rice and vegetables are the major irrigated crops, covering 215 Th Ha (32.6%) and 172 Th Ha (26%), respectively.

The temporal variation in irrigated area within the Mahanadi Basin from 1993–94 to 2010–11 reveals a gradual increase in both Kharif and Rabi irrigated areas. The Kharif irrigated area shows a consistent upward trend, rising from approximately 800 Th Ha in 1993–94 to over 1000 Th Ha in 2010–11, indicating improved access to surface and canal irrigation systems during the monsoon period. The Rabi irrigated area, although smaller in magnitude, also increased steadily from about 500 Th Ha to 530 Th Ha, reflecting the expansion of groundwater and storage-based irrigation during the dry season.

The gross irrigated area demonstrates noticeable inter-annual variability, particularly around 2002–03 when a sharp decline occurred due to reduced rainfall and drought conditions. Following this period, irrigation levels recovered steadily, reaching around 1580 Th Ha by 2010–11, which suggests continuous investment in irrigation infrastructure and better water management practices in the basin (Figure 15).

4.4 Sources of Irrigation

Chhattisgarh

As shown in Table 13, most of the surface irrigation in Chhattisgarh is facilitated through 12 major and 29 medium irrigation projects, collectively covering a culturable command area (CCA) of 1,254 thousand hectares (Th Ha), comprising 1,103 Th Ha under major projects and 151 Th Ha under medium projects. The ultimate irrigation potential from these systems stands at 1,237 Th Ha, with 1,076 Th Ha attributed to major projects and 161 Th Ha to medium projects.

Over time, canal irrigation has shown significant progress, expanding to approximately 918 Th Ha in 2013–14, marking a 43% increase since 2000–01. During the same period, well irrigation has nearly tripled, growing from 198 Th Ha to 589 Th Ha, and now contributes about 36% of the total gross irrigated area in the state. In contrast, canal irrigation continues to dominate, accounting for 58% of the total. This clearly indicates a notable shift toward groundwater-based irrigation, which was previously minimal.

Dependence on other sources such as tanks (2%) and miscellaneous sources (3%) remains relatively low. However, the distribution of irrigation sources varies significantly across districts. For instance, Raipur, Durg, and Janjgir-Champa together account for nearly 67% of the gross canal-irrigated area in Chhattisgarh, whereas Bilaspur, Durg, and Kawardha collectively contribute around 57% of the gross well-irrigated area.

Table 13: Source-wise distribution of irrigation in Chhattisgarh

Name of the Project	Irrigation Potential Created (Th Ha) (2014–15)	
	Culturable Command Area (Th Ha)	**Ultimate Irrigation Potential (Th Ha)**
Jonk Diversion	15.5	14.57
Hasdeo–Bango	285	433.5
Kelo (ongoing)	24.39	22.81
Kharang	66.4	56.3
Kodar (ongoing)	21.7	23.47
Mahanadi	301	264.31
Mand	11.1	13.1
Maniyari	64.77	55
Pairi	33.6	42.98
Rajeev Samvardhan Yojana	28	28
Sondur Reservoir Project	12.26	38.47
Tandula	246.3	84
Total	**1103**	**1076**

(Source: Central Water Commission, 2016b)

Odisha

Surface irrigation in Odisha is supported by 11 major irrigation projects (Table 14) and 29 medium irrigation projects, together covering a culturable command area (CCA) of approximately 738 thousand hectares (Th Ha) comprising 611 Th Ha under major projects and 126 Th Ha under medium projects. The ultimate irrigation potential is estimated at 641 Th Ha (Major: 520 Th Ha; Medium: 121 Th Ha).

In Odisha, the irrigation sources are categorized into four types:

1. Major and medium flow projects (canal irrigation),
2. Minor flow projects (canal/tank irrigation),
3. Minor lift projects (well irrigation), and
4. Other sources including private lift irrigation, shallow tube wells, water harvesting structures (WHCs), creeks, and dugwells.

The first two categories collectively represent surface or canal irrigation, while the third denotes groundwater irrigation. The fourth category is a combination of both surface and groundwater sources; although the exact proportion is unavailable, groundwater is likely to dominate within this group (Ministry of Agriculture, Government of Odisha, 2014).

The gross irrigation potential created in Odisha amounts to 5005 Th Ha, of which the actual irrigated area is about 3521 Th Ha, indicating nearly 70% utilization of the potential. Between 1980–81 and 2013–14, the potential created under major and medium projects nearly doubled from 1110 Th Ha to 2014 Th Ha. However, their share in the state's total irrigation potential declined from 66% to 40% over the same period.

Simultaneously, the potential under minor flow projects increased from 287 Th Ha to 682 Th Ha, while minor lift projects exhibited the fastest growth from 33 Th Ha to 1059 Th Ha, now contributing around 21% of the state's total irrigation potential. The "other sources" category also expanded substantially, from 255 Th Ha to 1249 Th Ha (Ministry of Agriculture, Government of Odisha, 2014). Overall, canal irrigation in Odisha remains geographically concentrated, with Bargarh, Kalahandi, Cuttack, and Puri districts accounting for nearly 89% of the state's major and medium irrigation potential. High groundwater irrigation potential is also observed in several of these canal-irrigated districts, particularly Bargarh, Kalahandi, and Cuttack, along with Balangir and Jagatsinghpur, which possess significant groundwater resources.

Table 14: Irrigation Potential and Culturable Command Area of Major Projects in the Mahanadi Basin

Name of the Project	Irrigation Potential Created (2014–15)	
	Culturable Command Area (CCA)	Ultimate Irrigation Potential
Hirakud	157.8	261.2
Delta Stage I, II	78.3, NA	NA
Lower Indra	29.9	38.8
Lower Suktel	31.8	29.8
Mahanadi Birupa Barrage	NA	NA
Mahanadi Chitrotpola	19.54	25.16
Naraj Barrage	183.2	NA
Salki	19.9	20.1
Sunder	4.6	6.07
Upper Indravati	76.27	125.08
Total	**601.3**	**506.21**

(Source: Central Water Commission, 2016b)

4.5 Estimated Water Allocations and Use

An estimate of water allocation and utilization is essential to project future trends in water availability across different sectors within the river basin. While data on the number and storage capacity of water resource projects in the basin are available from the National Register of Large

Dams (CWC), there is no consolidated secondary source that specifies how water from each project is distributed among various sectors such as irrigation, domestic, and industrial use. Likewise, comprehensive information on the actual usage of this allocated water is also lacking.

To address this gap, field visits were conducted to some of the major water resource projects within the basin. The data collected from these sites were then extrapolated to develop basin-wide estimates of water allocation and use. Specifically, allocations for irrigation from the four largest projects in the Mahanadi Basin the Mahanadi Reservoir Project, Minimata Bango, Hirakud, and Mahanadi Delta were analyzed to estimate the total irrigation water allocation for the basin. The known allocations for these projects, as obtained from various project reports, are presented in Table 15.

Table 15: Design Allocation, Irrigated Area, and Water Allocation per Unit Area for Major Irrigation Projects in the Mahanadi Basin

Project	Season	Design Allocation to Irrigation (MCM)	Design Area to be Irrigated (Ha)	Design Water Allocated per Unit Area (mm)
Mahanadi Reservoir Project	Kharif	1935	385,410	502
	Rabi	706	130,974	539
Minimata Bango	Kharif	1454	234,600	620
	Rabi	720	127,500	565
	Summer	404	51,000	792
Hirakud	Kharif	1300	153,750	845
	Rabi	1400	76,875	1821
Mahanadi Delta Stage 1	Kharif	965	167,000	578
	Rabi	949	100,960	940
Mahanadi Delta Stage 2	Kharif	786	136,000	578
	Rabi	636	67,622	940

(Source: Government of Chhattisgarh, 2004; Department of Water Resources, Government of Orissa, 2007; Babu, Shrivastava, & Dikshit, 2015)

The figures above illustrate the average volume of water allocated for irrigation per unit area during the Kharif and Rabi seasons in Chhattisgarh and Odisha (Table 8). Estimates of the actual area irrigated by surface water sources across both seasons were developed in the section "Irrigation Coverage – Seasons and Crops."

Based on these estimates, the total water allocation was derived by multiplying the actual irrigated area with the corresponding design water allocation per unit area. In Chhattisgarh, the total annual irrigated area is approximately 1,596 thousand hectares (Th Ha). Of this, nearly 983 Th Ha (about 61%) is irrigated using surface water sources including canals, tanks, and half of the irrigation from other minor sources. In the year 2000–01, the gross irrigated area from surface sources alone was estimated at 718 Th Ha.

Seasonal distribution indicates that about 1,163 Th Ha (73%) of the total irrigation occurs during the Kharif season, followed by 191 Th Ha (12%) in the Rabi season, approximately 10.5% in the summer season, and the remaining 74 Th Ha under year-round cultivation (Table 16).

Table 16: Comparative changes in area irrigated and sources of irrigation in Chhattisgarh and Odisha within the Mahanadi Basin

Category	Particulars	Chhattisgarh (2013–14)	Chhattisgarh (2000–01)	Odisha (2013–14)	Odisha (2000–01)	Odisha (1993–94)
Source-wise Irrigated Area	Canal Irrigation / Major Flow	918	641	759	635.5	569
	Well Irrigation / Minor Flow	589	199	206	191	183
	Tank Irrigation / Minor Lift	42	45	353	239.9	179
	Other Sources	46	65	373	339.85	322
	Total	**1595**	**950**	**1691**	**1406.95**	**1254**
Season-wise Irrigated Area	Kharif	1163	821	1066	898.95	809
	Rabi	191	41	658	567.65	519
	Summer / Whole Year	169	47	74	41	—
	Total	**1597**	**950**	**1724**	**1466**	**1328**

(Source: Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, 2014, and Statistics Cell, Ministry of Agriculture, Government of Odisha, 2015 – District-wise, Season-wise, Source-wise/Project-wise, Year-wise Irrigated Area, Chhattisgarh and Odisha)

If we assume that the proportion of surface irrigation across different sources remains the same 73%, 12%, and 10.5% during both the Kharif and Rabi seasons, the corresponding surface water use for each season in 2013–14 can be estimated (see Table 17). Similarly, for the year 2000–01, the ratio of surface irrigation across the seasons is assumed to be 86%, 4%, and 5%, respectively.

The total estimated annual surface water utilization for irrigation is approximately 5,481 MCM, with the majority being used during the Kharif season. This marks a significant increase from 3,902 MCM recorded in 2000–01. In contrast, Odisha irrigates around 1,724 thousand hectares (Th Ha) annually, of which nearly 1,151 Th Ha (or 66%) is supported by surface water sources including major and minor flow projects, as well as half of other irrigation sources. In 2000–01, the gross irrigated area through surface water was estimated at 996 Th Ha.

Within the gross irrigated area, approximately 1,066 Th Ha (62%) is irrigated during the Kharif season, while 658 Th Ha (38%) occurs in the Rabi season. Assuming a similar seasonal distribution (62:38) applies to surface irrigation, the season-wise surface water use can be estimated accordingly (Table 18). Similarly, in 2000–01, the corresponding seasonal ratio for surface irrigation was approximately 61:39 percent.

Table 17: Estimated Surface Water Requirement for Irrigation, Season-wise, in the Mahanadi Basin – Chhattisgarh

Year	Season	Area Irrigated by Surface Water Sources (Th Ha)	% of Total Irrigated Area	Depth of Irrigation (m)	Surface Water Use for Irrigation (MCM)
2013–14	Kharif	718	73% of 983 Th Ha	0.561	4,028
2013–14	Rabi	118	12% of 983 Th Ha	0.539	636
2013–14	Summer	103.2	10.5% of 983 Th Ha	0.792	817.3
2000–01	Kharif	617	86% of 718 Th Ha	0.561	3,461
2000–01	Rabi	29	4% of 718 Th Ha	0.539	156
2000–01	Summer	36	5% of 718 Th Ha	0.792	285

(Source: Derived from Tables 15 and 16)

Table 18: Estimated Surface Water Requirement for Irrigation, Season-wise, in the Mahanadi Basin – Odisha

Year	Season	Total Irrigated Area (Th Ha)	% Area Irrigated by Surface Water	Area Irrigated by Surface Water (Th Ha)	Depth of Irrigation (m)	Surface Water Use (MCM)
2013–14	Kharif	1151	62%	714	0.578	4127
2013–14	Rabi	1151	38%	437	0.94	4107.8
2000–01	Kharif	996	61%	607	0.578	3508
2000–01	Rabi	996	39%	388	0.94	3647.2

(Source: Derived from Tables 15 and 16)

The total estimated annual surface water use for irrigation in Odisha is approximately 8,234 MCM, with nearly equal distribution between the Kharif and Rabi seasons. This represents an increase from 7,155 MCM in 2000–01.

Overall, the surface water use for irrigation in the Mahanadi River Basin amounts to about 13,715 MCM, which constitutes roughly 20 percent of the river's 66.87 BCM annual average flow, of which 50 BCM is considered utilizable surface water. This value has risen from 11,057 MCM in 2000–01, a 24 percent increase over 13 years, equivalent to an annual growth rate of approximately 1.84 percent. If this trend continues, the projected surface water use for irrigation by 2040 will reach around 20,572 MCM.

In terms of crop distribution, rice dominates irrigation in the region. In 2013–14, it accounted for approximately 882 Th Ha (83 percent) of the Kharif irrigated area in Odisha and 1,159 Th Ha (100 percent) in Chhattisgarh. Given that these proportions have remained stable since 2000–01, it can be reasonably assumed that nearly all 4,028 MCM of Kharif surface water use in Chhattisgarh, 817 MCM of summer water use, and 3,425 MCM (83 percent of Kharif surface water use) in Odisha are utilized for rice cultivation during the Kharif season.

Similarly, in the Rabi season, rice covers about 207 Th Ha (32 percent) of the sown area. Assuming the same proportion of water use, approximately 1,314 MCM of surface water is consumed for rice irrigation during this period. Together, these result in a total water requirement of 9,584 MCM for rice irrigation, equivalent to 64 percent of the total surface water used for irrigation (13,715 MCM) in the basin. If rice water demand continues to expand at the same rate as the overall irrigation water use (24 percent since 2000–01), then the rice water requirement would have been around 7,729 MCM in 2000–01 and is projected to rise to 14,376 MCM by 2040.

4.6 Projected Water Demand–Supply Scenarios and Deficit Assessment for the Mahanadi River Basin

Chhattisgarh

The Chhattisgarh part of the Mahanadi River Basin, which constitutes a significant share of the basin's catchment and water resources, faces evolving challenges in balancing water demand and supply due to rapid development, agricultural intensification, and climatic variability. The scenario-based projections for 2010–2050 illustrate how different socio-economic and climatic pathways will shape the future of water availability and sustainability in this critical region.

In the Base Case scenario, representing a moderate growth pathway with existing management conditions, the water demand in Chhattisgarh is projected to increase from 8,791.9 MCM in 2010 to 14,701.8 MCM by 2050, while the water supply rises only modestly from 7,924.4 MCM to 12,653.9 MCM (Table 19). This results in a deficit of 2,812.1 MCM, indicating mounting stress on surface and groundwater systems if current water-use patterns persist. This baseline projection underscores the growing strain from population growth, urbanization, and industrial expansion in districts such as Raipur, Durg, Bilaspur, and Janjgir-Champa, which are among the most water-demanding regions of the basin.

Under the High Growth scenario, representing an accelerated economic and infrastructural expansion, the challenge intensifies further. By 2050, water demand in the Chhattisgarh basin segment is estimated at 19,125.8 MCM, far exceeding the projected supply of 15,052.3 MCM, creating a substantial deficit of 5,004.8 MCM. This widening gap reveals that without significant interventions, the Chhattisgarh region could face periodic water shortages, particularly during lean monsoon years, directly affecting agriculture and industrial operations.

Encouragingly, the End Use Conservation scenario, which assumes implementation of water-efficient irrigation practices, industrial recycling, and public water conservation programs, shows tangible improvement. The projected deficit reduces to 2,773.1 MCM by 2050. This scenario demonstrates the potential benefits of policy-driven conservation strategies and community-level participation, especially in rural and semi-urban areas dependent on basin water for livelihood and irrigation.

The Climate Change scenarios further illuminate the complex relationship between hydrology and changing climate in the Chhattisgarh basin. Under the Climate Change (Trend Analysis) case, a steady warming pattern and minor shifts in rainfall distribution led to a deficit of 2,373.2 MCM by 2050. However, under the Climate Change (IITM Projections) scenario, which reflects higher precipitation and slightly improved surface runoff predicted by the Indian Institute of Tropical Meteorology, the deficit narrows to 1,683.9 MCM. These projections suggest that while climate variability may introduce periods of high rainfall and short-term relief, the overall water balance will still be dominated by increasing demand pressures.

From a regional perspective, the Chhattisgarh portion of the Mahanadi Basin, covering major sub-basins such as Seonath, Hasdeo, and Mand, serves as both a water-rich and agriculturally productive area. However, increasing groundwater extraction, changing cropping patterns, and industrialization near Raigarh and Korba are likely to heighten the basin's vulnerability. The spatial and temporal variations in rainfall further complicate management, emphasizing the need for robust water storage and distribution systems.

To ensure long-term sustainability, Chhattisgarh must prioritize Integrated Water Resources Management (IWRM) approaches that balance supply augmentation with demand regulation. Strengthening catchment area treatment, promoting rainwater harvesting, recycling treated wastewater, and introducing smart irrigation technologies such as drip and sprinkler systems are essential steps. Additionally, reservoir operation optimization and inter-sectoral allocation reforms will be critical for equitable water distribution across agriculture, domestic, and industrial sectors.

Therefore, the findings clearly demonstrate that the Chhattisgarh segment of the Mahanadi River Basin will transition from a condition of manageable water balance in 2010 to a state of pronounced stress by 2050 under most scenarios. Unless proactive conservation and management policies are adopted, the basin's natural water endowment could be significantly strained. The scenario-based analysis thus provides an important decision-making framework for policymakers, planners, and water resource managers to secure the future water sustainability of the Chhattisgarh region within the larger Mahanadi River Basin system.

Table 19: Projected water demand, supply requirements, and supply availability under various developmental and climate change scenarios for the Chhattisgarh part of the Mahanadi River Basin

Scenario	2010 (MCM)			2020 (MCM)			2030 (MCM)			2050 (MCM)		
	Water Demand	Supply Requirements	Water Supply	Water Demand	Supply Requirements	Water Supply	Water Demand	Supply Requirements	Water Supply	Water Demand	Supply Requirements	Water Supply
Base Case	8791.9	9326.8	7924.4	9931.6	10516.1	9540.3	11267.3	11906.2	10105	14701.8	15466	12653.9
Deficit (MCM)	—	—	—	—	—	**975.8**	—	—	**1801.2**	—	—	**2812.1**
High Growth	8791.9	9326.8	7924.4	10568.8	11182.9	10118.5	12789.6	13494.8	11225.1	19125.8	20057.1	15052.3
Deficit (MCM)	—	—	—	—	—	**1064.4**	—	—	**2269.7**	—	—	**5004.8**
End Use Conservation	8791.9	9326.8	7924.4	9858.6	10436.5	9470.1	11188.1	11819.8	10050.8	14608.4	15364.1	12591
Deficit (MCM)	—	—	—	—	—	**966.4**	—	—	**1769**	—	—	**2773.1**
Climate Change (Trend Analysis)	8791.9	9326.8	7924.4	9931.6	10516.1	9914.5	11267.3	11906.2	10657.7	14701.8	15466	13092.8
Deficit (MCM)	—	—	—	—	—	**601.6**	—	—	**1248.5**	—	—	**2373.2**
Climate Change (IITM Projections)	8791.9	9326.8	7924.4	9931.6	10516.1	9914.5	11267.3	11906.2	11007.9	14701.8	15466	13782.1
Deficit (MCM)	—	—	—	—	—	**601.6**	—	—	**898.3**	—	—	**1683.9**

Odisha

The Odisha reach of the Mahanadi running from the Satkosia Gorge to the Naraj delta head and out to the Bay of Bengal, hosts a large share of the basin's population, command area and industry within districts such as Sambalpur, Bargarh, Subarnapur, Angul, Cuttack, Khordha, Jagatsinghpur, Nayagarh and Jharsuguda. Odisha's own planning baselines put the state's average annual water resources at about 141.41 BCM with 108.15 BCM utilizable (surface + ground), figures that define the physical ceiling for allocations across the Mahanadi sub-basins in the state. Created storage in Odisha was about 17.01 BCM (with additional capacity under construction when assessed), which is the principal cushion against monsoon variability and rising multi-sector demand.

Within the basin infrastructure, live storage already completed across the Mahanadi basin is reported at roughly 12.8–13.0 BCM, and broader assessments cite about 14.47 BCM when including projects under completion capacities in which Odisha's Hirakud system is the dominant component for downstream irrigation, hydropower and flood moderation. Operationally, that storage now serves more purposes than irrigation alone, so seasonal reliability increasingly hinges on how that live capacity is scheduled across kharif and rabi, and on protection of environmental flows through Satkosia and the delta.

Observed demand growth has been rapid. Table 20 document total water requirements of ~55 BCM (2001) rising to ~84 BCM (2005), driven mainly by agriculture (≈23 → ≈49 BCM), with domestic use increasing (≈2.0 → ≈3.0 BCM) and industry nearly tripling (≈0.7 → ≈2.0 BCM). While those are statewide numbers, the bulk of canal irrigation and a large fraction of urban-industrial withdrawals fall inside the Mahanadi corridor, implying that the Odisha segment of the basin bears a disproportionate share of the rising curve. In years with weak or poorly distributed monsoon rain, this shows up as rabi-season shortfalls at canal tails and peri-urban panchayats even when annual totals look comfortable.

Groundwater provides only a partial buffer. The latest Central Ground Water Board assessment places Total Annual Groundwater Recharge for Odisha at ~17.35–17.46 BCM, with Annual Extractable around 15.94 BCM and a stage of extraction ≈ 46% statewide-figures that mask higher local stress in fast-growing coastal and peri-urban blocks within the Mahanadi delta. As demand rises, conjunctive use helps in the short run, but the assessment cautions against relying on aquifers to permanently bridge seasonal canal deficits. Block-wise management linked to these extraction stages is therefore essential for the basin's Odisha reach.

Looking to 2010–2050, a Base-case (moderate growth with present management extended) implies continued pressure from irrigation expansion in Bargarh–Sambalpur–Subarnapur commands, urban growth around Cuttack–Bhubaneswar, and industrial corridors (Jharsuguda–Angul–Cuttack). Under such a pathway, the system remains volume-adequate in average years but becomes seasonally reliability-limited: pre-monsoon and rabi deficits recur at distributary tails, and groundwater drawdowns increase in the delta unless efficiency measures spread. State annual reports already flag rising consumption from population, lifestyle, industry and agriculture as the structural drivers behind this tightening.

A High-growth variant (accelerated urban-industrial expansion) shifts more of the fixed live storage to non-agricultural withdrawals in lean months, crowding irrigation in dry years and increasing the frequency of local deficits. In contrast, an End-use conservation pathway-lining and volumetric delivery in canals, targeted micro-irrigation on paddy–pulses rotations, and mandated treated-wastewater reuse for industries-recovers several BCM-equivalent at state scale. Given the sectoral shares above, even 10–15% irrigation efficiency gains combined with industrial recycle targets are enough to erase many rabi-season gaps in vulnerable distributaries and to slow groundwater decline in coastal blocks. These directions are consistent with the state's policy reviews and scheme guidance.

Climate change adds an operational risk more than a simple volume change. Studies for the upper and middle Mahanadi indicate warming with altered rainfall distribution that can increase peak monsoon pulses yet prolong dry spells, complicating Hirakud inflow management and carry-over storage into rabi. The practical effect in Odisha's reach is a narrower operating window: the same annual quantum may arrive in fewer, bigger bursts, demanding dynamic reservoir rules that hedge across seasons while protecting environmental flows through Satkosia and the deltaic wetlands.

Putting these threads together, the Odisha part of the Mahanadi is best viewed as management-limited rather than volume-limited in many years: annual endowment is sizable, basin live storage is substantial, and yet seasonal reliability is stressed by the timing of inflows, allocation trade-offs, and efficiency gaps. Without a pivot to conservation, reuse and conjunctive governance guided by CGWB stages, rabi shortfalls and local aquifer stress will intensify in the delta and peri-urban belts. With that pivot, the same infrastructure can meet 2050 demands more equitably and with better ecological outcomes.

Table 20: Odisha State Water Balance: Sector-wise Surface and Groundwater Demand

Sector	2001 Demand Surface	2001 Demand Ground	2051 Demand Surface	2051 Demand Ground
Domestic	798	1,198	1,202	1,803
Agriculture	18,000	4,688	40,000	9,408
Industry	606	100	1,750	200
Environment	21,000	8,400	21,000	8,400
Others	100	100	200	200
Total	**40,504**	**14,486**	**64,152**	**20,011**

Table 20 shows Odisha's state-wide water balance by source and sector for 2001 and projected 2051. Total demand rises ~53% (54,990→84,163 MCM), led by agriculture (surface 18,000→40,000; groundwater 4,688→9,408 MCM). Domestic and industrial needs also increase with population and growth. Environmental allocations remain large (surface 21,000; groundwater 8,400 MCM), limiting consumptive supply. Available water is assumed constant (surface 70,000; groundwater 21,000 MCM), so by 2051 the tighter margin implies stronger reliance on storage, seasonal regulation, spatial redistribution, and groundwater management to meet peaks. (Government of Odisha's State Water Plan (2004), State Water Balance).

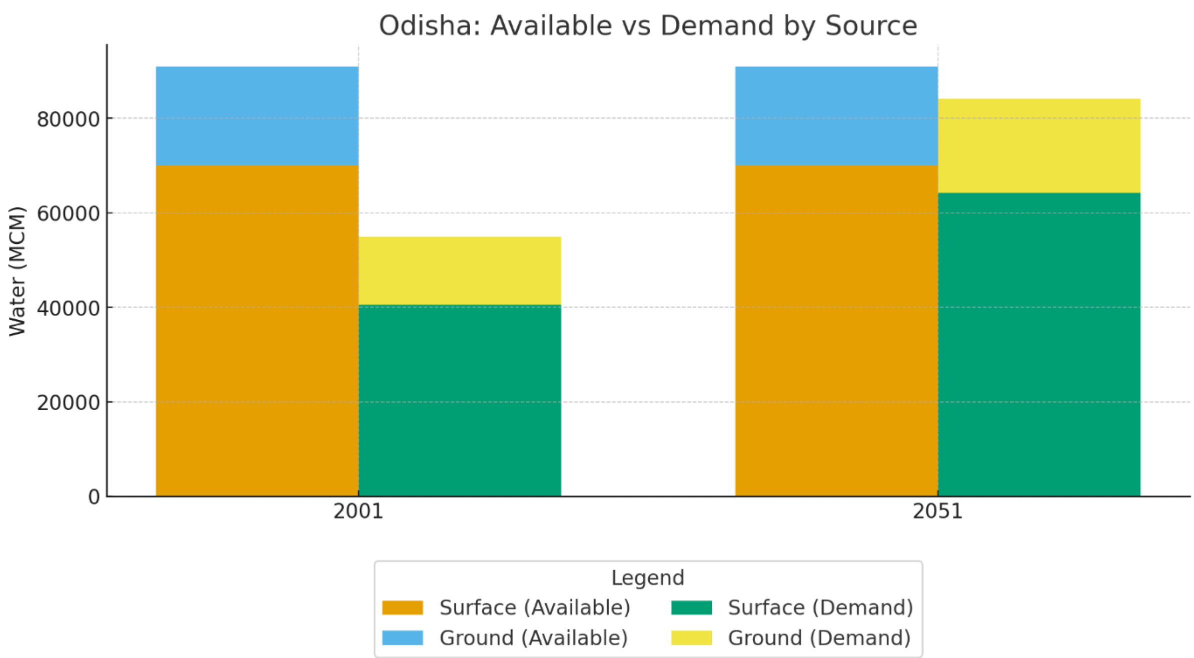


Figure 16: Availability vs. demand for the Odisha state

(Source: Odisha's State Water Plan, 2004)

The Figure 16 compares Odisha's total water availability and demand in 2001 and 2051, disaggregated by surface and groundwater. While state-wide availability remains essentially constant at ~91,000 MCM (70,000 MCM surface; 21,000 MCM groundwater) in both years, total demand rises steeply from 54,990 MCM in 2001 to 84,163 MCM in 2051. This compresses the net surplus from about +36,010 MCM to only +6,837 MCM, indicating a system moving toward near closure. The tightening is driven primarily by surface-water demand growth (40,504 → 64,152 MCM) against flat surface availability, while groundwater shifts from a comfortable margin to a small residual surplus (14,486 → 20,011 MCM demand versus 21,000 MCM available). By 2051, even though the annual balance remains slightly positive, the markedly reduced buffer suggests heightened vulnerability to interannual variability, localized deficits, and the need for demand management, conjunctive use, and targeted aquifer protection.

5. SOURCES OF WATER SUPPLY WITHIN DELINEATED ADMINISTRATIVE AND NATURAL BOUNDARIES

Chhattisgarh

Chhattisgarh benefits from a good average annual rainfall of approximately 1400 mm, with about 90% occurring during the monsoon season from June to September. Specifically, the Mahanadi basin receives an average annual rainfall of about 1292 mm, with variations from 1200-1400 mm, and some areas recording up to 1600 mm. However, the rainfall exhibits erratic temporal and spatial distribution, which poses a threat of drought due to uneven occurrence rather than deficient rain. The mean annual runoff of the Mahanadi basin is estimated at approximately 67 billion cubic meters (BCM).

➢ Surface Water Resources

The estimated surface water flowing through rivers in Chhattisgarh amounts to 48,296 million cubic meters (MCM). The usable surface water in the state is calculated to be 41,720 MCM. Despite this potential, only about 18,249 MCM of surface water is currently utilized, indicating a significant untapped resource. The Mahanadi basin has a total surface water storage capacity of 14.24 BCM 3 or 14207.80 MCM, which represents only 21.2% of the mean annual runoff. The overall utilizable potential of the Mahanadi basin is stated as 50 BCM.

➢ Groundwater Resources

The estimated groundwater resources in Chhattisgarh are 14,548 MCM. Current exploration and utilization stand at approximately 18.31% of this estimated groundwater. The utilizable groundwater resource of the Mahanadi basin is about 16.5 BCM.3 While one report indicates groundwater utilization in the basin is only about 4% of the utilizable potential, another suggests an accelerating use of this resource.

Table 21 provides an overview of the available and utilized water resources in the Mahanadi Basin, highlighting the comparative status of surface and groundwater use. The surface water potential is estimated at 48,296 MCM, out of which 41,720 MCM is considered usable. Presently, about 18,249 MCM (43.74%) of this usable potential is being utilized, indicating substantial remaining capacity for future use.

In contrast, the groundwater potential is estimated at 14,548 MCM, and the current utilization stands at 2,665 MCM, representing only 18.31% of the total available resource. This suggests that groundwater exploitation in the basin is relatively low compared to surface water use. Overall, the data reveal that while the basin possesses a significant water potential, the utilization level remains moderate, particularly for groundwater. This indicates an opportunity for optimized water management, balanced surface, groundwater usage, and strategic planning to ensure long-term water security and sustainability in the basin.

Table 21: Water Resources Potential and Current Utilization in Chhattisgarh

Resource Type	Estimated Total Potential (MCM)	Usable Potential (MCM)	Current Utilization (MCM)	Percentage Utilization (of Usable Potential)
Surface Water	48,296	41,720	18,249	43.74%
Groundwater	14,548	14,548 *(Est.)*	2,665 *(18.31% of Est.)*	18.31%

(Source: CGWRD)

Odisha

The Mahanadi River Basin, one of the major river systems in eastern India, extends across multiple states including Chhattisgarh, Odisha, Jharkhand, and Maharashtra. The Odisha part of the Mahanadi River Basin covers a significant geographical area characterized by complex hydrological, climatic, and topographical conditions. This segment of the basin contributes substantially to the overall surface and groundwater potential of the Mahanadi system, playing a vital role in supporting agriculture, domestic use, industry, and ecosystem sustenance in the state.

The delineation of administrative boundaries (such as districts, blocks, and municipalities) alongside natural boundaries (such as sub-basins, watersheds, and catchment zones) provides a clear framework for understanding the distribution and utilization of available water resources. Within these delineated boundaries, water supply sources are derived from diverse origins, including rivers, reservoirs, groundwater, and rainfall. An integrated assessment of these sources is essential for sustainable water resource management and long-term planning in the Odisha segment of the basin.

The Odisha portion of the Mahanadi River Basin covers approximately 65,847 km^2, encompassing several key districts such as Sambalpur, Bargarh, Jharsuguda, Angul, Cuttack, Jagatsinghpur, Dhenkanal, Nayagarh, Puri, and Kendrapara. The basin is divided naturally into several sub-basins, primarily drained by tributaries such as the Ib, Ong, Tel, and Jonk rivers, which contribute significantly to the surface water potential.

The administrative delineation aids in regional water management and allocation, while the natural delineation (based on hydrological boundaries) assists in planning for watershed management, flood control, and groundwater recharge. Together, these frameworks allow for an integrated approach to water governance within the Odisha part of the basin.

➢ Major Sources of Water Supply

1. Surface Water (Rivers and Tributaries)

Surface water forms the principal source of supply in the Mahanadi Basin within Odisha. The Mahanadi River, along with its tributaries, the Ib, Ong, Tel, Jonk, and Brahmani-linked distributaries, serves as a lifeline for irrigation, drinking water, and hydropower generation. Major barrages and diversion structures such as Hirakud Dam regulate and store water for multipurpose uses. These river systems sustain a vast irrigation network covering major agricultural belts of western and coastal Odisha. The interconnection of tributaries ensures perennial flow, although seasonal variability and monsoon dependence influence their availability.

2. Reservoirs and Storage Structures

The Odisha basin segment contains several large, medium, and small reservoirs designed for irrigation, domestic, and industrial supply. The Hirakud Reservoir, one of Asia's longest dams, remains the most significant surface storage, regulating flows of the Mahanadi River. Other important reservoirs include Mandira, Pitamahal, Tikarapara, and Rengali, which collectively augment surface water availability throughout the basin.

These reservoirs also play a crucial role in flood moderation, hydropower generation, and water supply to industrial centers in Jharsuguda, Angul, and Cuttack districts. However, siltation and fluctuating inflows pose challenges to long-term storage efficiency.

3. Groundwater Resources

Groundwater serves as a vital supplementary source of supply, particularly in regions where surface water access is limited. The alluvial and hard rock aquifers across Odisha exhibit varied recharge capacities. Western districts such as Bargarh, Sambalpur, and Bolangir have moderate to high groundwater potential due to favorable hydrogeological conditions, whereas coastal districts often face salinity intrusion issues due to over-extraction and tidal influence.

Groundwater abstraction supports drinking water schemes, rural domestic needs, and small-scale irrigation. Continuous monitoring and artificial recharge through check dams, percolation tanks, and recharge wells are necessary to sustain these aquifers.

4. Rainfall and Direct Precipitation

Rainfall contributes directly to both surface runoff and groundwater recharge in the basin. The average annual rainfall over the Odisha portion of the Mahanadi Basin ranges from 1,200 to 1,600 mm, with around 80–85% occurring during the southwest monsoon season (June–September). Effective rainfall management through rainwater harvesting, watershed conservation, and soil moisture retention practices is essential to mitigate seasonal water scarcity and enhance supply reliability.

The variability in monsoon patterns, influenced by climate change, often results in uneven distribution, affecting both recharge and availability across sub-basins. Integrating rainfall-based water harvesting systems with local supply schemes can strengthen water security, especially in drought-prone and upland areas.

6. CONCLUSIONS

The assessment of water demand and supply across the Mahanadi River Basin reveals a system undergoing rapid demographic, economic, and industrial transformation, resulting in increasingly complex pressures on its water resources. Despite being a high-rainfall basin with an average annual precipitation of around 1,291 mm and substantial surface water availability, the basin is exhibiting signs of intensifying competition among sectors, spatial disparities in water use, and growing vulnerabilities linked to climate and development patterns. The analysis underscores that the sustainability of the basin hinges on integrated, data-driven, and equitable water governance strategies capable of meeting the expanding needs of both Chhattisgarh and Odisha.

The domestic water requirement analysis shows a clear and consistent rise in demand across all districts and blocks. Urban growth has been the most significant driver of this increase, with urban centers in Chhattisgarh, particularly Raipur, Durg, Korba, and Bilaspur, showing the highest escalation. The total domestic water demand in the Chhattisgarh portion of the basin rose from 1135.50 MLD in 1991 to 1738.33 MLD in 2011, with districts such as Raipur, Korba, and Durg emerging as major demand hotspots. This growth aligns with accelerating urbanization trends, expanding service sectors, and improved access to water supply networks. Meanwhile, rural demand has also increased gradually, supported by the expansion of rural water supply schemes and growing populations, though the rise remains steadier and less steep than in urban zones. The Odisha segment shows a comparable upward trajectory, with domestic demand projected to rise from 0.45 BCM in 2018 to 0.72 BCM by 2050. The growing urban footprint of the state, especially around Bhubaneswar–Cuttack, Jharsuguda, Angul, and Sambalpur, indicates a shift toward more water-intensive lifestyles and infrastructure. These trends collectively illustrate that domestic water demand will continue to grow steadily, driven by population expansion, migration to urban centers, and enhanced service delivery expectations.

Parallel to demographic pressures, industrial development has become a defining contributor to water stress in the basin. Over the past two decades, both Chhattisgarh and Odisha have experienced substantial industrial expansion, particularly in the thermal power, steel, aluminium, cement, and mining sectors. In Chhattisgarh, water allocations to coal-based thermal power plants rose sharply from 307 MCM in 2007 to 1,017 MCM by 2013, corresponding to an increase in operational and approved power capacity reaching approximately 33,268 MW. Iron and steel industries received 193 MCM of allocations, nearly tripling their 2007 demand. Korba, Raigarh, Durg–Bhilai, and Raipur have become major industrial corridors with exceptionally high water consumption. The Korba block alone jumped from negligible industrial water use in 1991 to over 200 MCM by 2011. Odisha experienced a later but rapid surge in industrial demand, with thermal power allocations rising from just 57 MCM in 2007 to about 644 MCM. Steel and aluminium sectors similarly recorded significant increases. Jharsuguda, Angul, Rourkela, and Sundargarh have become centers of heavy industrial activity, supported by abundant mineral reserves. The cumulative industrial water allocation in Odisha now stands at around 944 MCM, far exceeding the projections made in the Odisha Water Plan (2004), which anticipated only 335 MCM of industrial requirement by 2051. This large discrepancy highlights a major need for updated, realistic, and sector-responsive planning tools.

Agriculture remains the largest water-consuming sector across the Mahanadi Basin, especially within Odisha. In 2018, agricultural water use was estimated at 10.78 BCM and is projected to rise to nearly 18 BCM by 2050. The predominance of paddy cultivation, the expansion of irrigation networks, and seasonal groundwater reliance underpin this substantial demand. While agricultural growth has contributed positively to food security and rural livelihoods, the slow modernization of irrigation practices and limited adoption of water-efficient cropping systems continue to exert pressure on surface and groundwater resources. The Hirakud command area, the Mahanadi delta systems, and the Hasdeo and Seonath plains are notable agricultural hotspots where water allocation will increasingly require rationalization to balance agricultural efficiency with ecological sustainability.

Hydrologically, the basin displays significant intra- and inter-annual variability. The average annual runoff of the Mahanadi River is about 66.8 BCM, but actual flow varies widely, from as low as 20 BCM in drought years to nearly 70 BCM in wet years. While the utilizable water for

Odisha stands at 29.30 BCM, this static availability contrasts sharply with rising demand across all sectors, resulting in a shrinking water balance. Moreover, sedimentation in major reservoirs such as Hirakud has reduced storage efficiency, constraining dry season releases and altering multi-sector water distribution. In Chhattisgarh, the construction of numerous barrages and reservoirs since 2010 has expanded storage but also raised interstate concerns over downstream flow reduction. Odisha has repeatedly highlighted decreased inflows from upstream, especially during lean months, as industrial and irrigation withdrawals in Chhattisgarh have grown rapidly. These tensions point to the need for coordinated, transparent, and scientifically informed interstate water-sharing frameworks.

Spatial analysis further reveals that water demand and industrialization are highly uneven across the basin. Central Chhattisgarh, particularly the Raipur–Bhilai–Korba–Raigarh belt, has emerged as a zone of intense water use, contrasted by the tribal and forest-dominated districts of the north and south, where water demand remains relatively low. In Odisha too, the Angul–Jharsuguda–Sambalpur industrial cluster shows rising water competition, while the coastal delta remains heavily dependent on the seasonal monsoon-fed flows of the Mahanadi. These spatial disparities indicate the importance of localized water management approaches that align with district-level growth patterns, agricultural needs, and ecological characteristics.

The analysis of supply versus demand dynamics reveals an emerging imbalance. While surface water currently constitutes over 95% of the basin's supply, groundwater dependence is increasing rapidly, especially in regions facing seasonal scarcity or where surface infrastructure is inadequate. Future projections suggest that groundwater may constitute more than one-third of additional demand in the coming years. Without strict regulation, recharge enhancement, and conjunctive use strategies, groundwater tables already stressed in peri-urban and industrial zones, may face further depletion. The cumulative demand curves show an S-shaped pattern, with a recent steep upward trajectory indicating rapid consumption growth and eventual saturation. This pattern is typical of systems reaching their capacity limits, underscoring the need for urgent resource optimization and demand management.

Industrial water demand projections indicate that thermal power plants remain overwhelmingly dominant, accounting for nearly 98% of total industrial water use in the basin. The steel, aluminium, and cement sectors collectively consume less than 500 MCM/year in comparison. This extreme skew highlights a structural vulnerability any further expansion of thermal power capacity will significantly exacerbate water stress unless alternative cooling technologies such as dry cooling, hybrid cooling, and wastewater-based cooling are adopted at scale. Similarly, steel and aluminium industries must expand recycling practices and shift toward closed-loop water systems to limit their freshwater dependency.

Climate change adds another dimension of uncertainty. Increasing variability in rainfall, rising temperatures, and shifts in monsoon behavior threaten to intensify water shortages in dry months and increase run-off losses during extreme rainfall events. Managing this variability requires greater storage resilience, watershed interventions, and green infrastructure such as revived tanks, wetlands, and groundwater recharge structures. Additionally, policies supporting industrial and agricultural adaptation, such as risk-responsive cropping systems, efficient irrigation technologies, and water-neutral industrial expansion will be essential.

Overall, the combined evidence from population projections, industrial expansion patterns, agricultural demands, and hydrological assessments demonstrates that the Mahanadi River Basin is entering a critical phase of its water management journey. The basin's water resources, though substantial, are finite. With competing demands rising across sectors and regions, the risk of conflict, both ecological and socio-economic, is growing. Addressing these challenges requires a shift toward integrated basin-scale planning, stronger interstate coordination, advanced monitoring and modelling systems, responsible industrial allocation policies, and a concerted push toward water-use efficiency across all sectors. Only through such comprehensive and forward-looking strategies can the basin continue to support the millions of people, industries, ecosystems, and agricultural landscapes that depend on its waters today and into the future.

6.1 Data Gap and Uncertainties

Figure 17 clearly highlights the major data gaps and uncertainties affecting water-resource assessment across the basin. It underscores the persistent challenges in developing an integrated water-use inventory, particularly for the industrial sector, where information remains fragmented and often difficult to validate. The illustration also draws attention to uncertainties around future water allocations, demonstrating how pending approvals and evolving industrial growth trajectories can influence long-term demand projections.

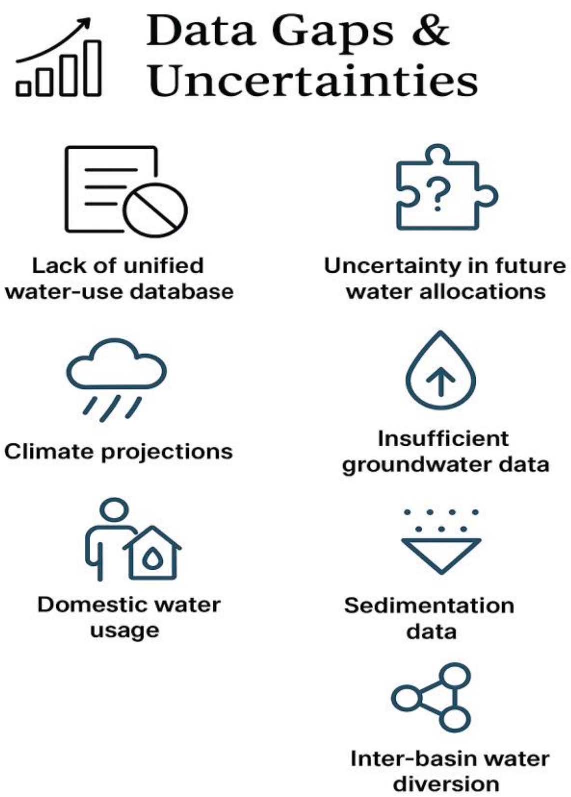


Figure 17: Infographic illustrating key data gaps and uncertainties

Groundwater emerges as another area of concern, with inconsistent or limited datasets on recharge, extraction rates, and spatial variability. Further emphasizes the role of climate-related uncertainties, pointing to fluctuating rainfall patterns and temperature shifts that complicate hydrological forecasting. Sedimentation-related data gaps also add complexity, as insufficient updates on reservoir siltation affect the accuracy of storage and supply assessments. The graphic additionally highlights uncertainties in domestic water-use information, especially in rural and peri-urban regions where monitoring is inconsistent. Finally, the illustration notes the lack of comprehensive data on inter-basin water diversions, an important factor that affects overall basin-level water balance and long-term planning.

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Appendix

Appendix -I District-wise Domestic Water Demand

District	Name of the Block	Population								
		1991			2001			2011		
		Total Demand (MLD)	Urban Demand (MLD)	Rural Demand (MLD)	Total Demand (MLD)	Urban Demand (MLD)	Rural Demand (MLD)	Total Demand (MLD)	Urban Demand (MLD)	Rural Demand (MLD)
Balod	Balod	8.242845	2.929635	5.31321	9.276075	2.832435	6.44364	10.226125	3.164805	7.06132
	Dondi	5.77381	0	5.77381	13.685005	7.232895	6.45211	13.787055	7.424055	6.363
	Dondi Luhara	17.52702	7.55811	9.96891	11.68853	0	11.68853	14.20925	0.81594	13.39331
	Gunderdehi	10.60878	0	10.60878	12.75806	0	12.75806	15.207865	1.817775	13.39009
	Gurur	7.5523	0	7.5523	9.16524	0	9.16524	10.271125	0.509625	9.7615
Baloda Bazar	Baloda Bazar	12.483665	2.345355	10.13831	11.923075	3.085155	8.83792	20.1275	5.49666	14.63084
	Bhatapara	12.73659	6.13818	6.59841	13.06768	6.76593	6.30175	17.970555	7.767495	10.20306
	Bilaigarh	11.645055	1.166265	10.47879	12.10274	1.11078	10.99196	16.884785	2.148525	14.73626
	Kasdol	10.90635	0	10.90635	11.20651	0	11.20651	16.68649	3.00807	13.67842
	Palari	9.72776	0	9.72776	8.37347	0	8.37347	14.709385	1.156545	13.55284
	Simga	9.934825	1.829385	8.10544	10.426515	1.774305	8.65221	15.79726	2.85741	12.93985
Bemetara	Bemetara	11.091025	2.577555	8.51347	11.889195	3.147525	8.74167	16.94852	3.85236	13.09616
	Berla	8.67573	0	8.67573	9.65643	0	9.65643	13.452045	0.697275	12.75477

	Nawagarh	9.13444	0	9.13444	8.94894	0	8.94894	14.909575	2.313495	12.59608
	Saja	9.84134	0.84186	8.99948	10.512345	0.917865	9.59448	15.239845	3.203415	12.03643
Bilaspur	Bilha	48.24386	33.40386	14.84	65.860535	48.962745	16.89779	87.403015	64.975365	22.42765
	Kota	12.751995	3.991005	8.76099	15.04624	4.70745	10.33879	18.782725	5.810535	12.97219
	Masturi	13.8257	0	13.8257	13.95646	0	13.95646	21.393715	1.148175	20.24554
	Takhatpur	14.026365	1.988955	12.03741	16.39679	2.40057	13.99622	24.045245	6.655635	17.38961
Dhamtari	Dhamtari	18.807805	9.363195	9.44461	22.821815	11.084985	11.73683	26.626315	14.617395	12.00892
	Kurud	11.58246	1.84518	9.73728	14.145495	1.548855	12.59664	16.71736	2.87955	13.83781
	Magarlod	6.16812	0	6.16812	7.32984	0	7.32984	8.9083	0.8478	8.0605
	Nagri	9.91067	0	9.91067	11.17382	0	11.17382	13.342745	1.784835	11.55791
Durg	Dhamdha	15.408815	5.305365	10.10345	19.286895	7.624125	11.66277	23.156735	8.842365	14.31437
	Durg	98.93376	87.47784	11.45592	122.706165	109.780245	12.92592	139.062835	125.014185	14.04865
	Patan	19.51766	7.41123	12.10643	25.884935	12.731445	13.15349	30.121955	15.277545	14.84441
Gariabandh	Bindranavagarh (Gariyaband)	5.4976	1.12806	4.36954	5.79068	0	5.79068	7.338715	1.419795	5.91892
	Chhura	5.82505	0	5.82505	6.98096	0	6.98096	8.539275	0.822825	7.71645
	Deobhog	4.84848	0	4.84848	5.38027	0	5.38027	6.59484	0	6.59484
	Mainpur	6.34956	0	6.34956	7.33852	0	7.33852	8.70688	0	8.70688
	Rajim	8.09592	0	8.09592	10.18591	0	10.18591	13.28551	3.21867	10.06684

Gaurela-Pendra-Marwahi	Marwahi	2.19975	0	2.19975	2.54611	0	2.54611	2.99243	0	2.99243
	Pendra	3.591455	1.066905	2.52455	4.05669	1.13454	2.92215	4.67854	1.29222	3.38632
	Pendra Road Gorella	5.160425	1.280745	3.87968	5.983945	1.370385	4.61356	7.06425	1.6389	5.42535
Janjgir - Champa	Akaltara	9.6093	2.41029	7.19901	11.389435	2.749545	8.63989	13.80188	3.06612	10.73576
	Baloda	5.791355	1.289655	4.5017	6.738105	1.529685	5.20842	8.11128	1.84005	6.27123
	Champa	11.58115	4.06161	7.51954	14.351835	5.123385	9.22845	18.19391	7.08372	11.11019
	Dabhra	8.22332	0	8.22332	9.58783	0	9.58783	12.55064	2.09817	10.45247
	Jaijaipur	7.60543	0	7.60543	8.81195	0	8.81195	12.01392	1.07271	10.94121
	Malkharoda	7.09758	0	7.09758	8.02613	0	8.02613	10.79397	0.98172	9.81225
	Nawagarh	16.94805	4.19202	12.75603	20.88951	5.4837	15.40581	25.49558	7.88211	17.61347
	Pamgarh	8.367055	1.044495	7.32256	10.19496	1.16181	9.03315	12.695265	2.207655	10.48761
	Sakti	10.202555	3.018735	7.18382	11.67615	3.56994	8.10621	14.35201	4.15098	10.20103
Jashpur	Bagicha	6.00936	0	6.00936	6.82213	0	6.82213	8.367045	0.927585	7.43946
	Duldula	1.74902	0	1.74902	1.96749	0	1.96749	2.19954	0	2.19954
	Farsabahar	6.26836	0	6.26836	6.88464	0	6.88464	7.59486	0	7.59486
	Jashpur	0.493185	0.172935	0.32025	0.60499	0.23679	0.3682	0.74388	0.33102	0.41286
	Kansabel	4.32572	0	4.32572	4.8447	0	4.8447	5.37145	0	5.37145
	Kunkuri	5.03209	0	5.03209	5.77185	0	5.77185	7.57099	1.86921	5.70178

	Manora	0.98	0	0.98	1.08955	0	1.08955	1.22381	0	1.22381
	Pathalgaon	10.945775	1.473795	9.47198	12.44251	1.88406	10.55845	14.92934	3.16143	11.76791
Kwrdha	Bodla	5.55422	0	5.55422	6.5422	0	6.5422	9.07607	0.51759	8.55848
	Kawardha	10.71453	3.22866	7.48587	13.002825	4.376025	8.6268	19.25471	6.95466	12.30005
	Pandariya	12.03284	1.39725	10.63559	13.50989	1.68129	11.8286	19.38537	3.12255	16.26282
	Sahaspur Lohara	6.90907	0	6.90907	7.59038	0	7.59038	11.112765	0.947295	10.16547
Kdagaon	Bade Rajpur	0.70245	0	0.70245	0.82509	0	0.82509	1.042475	0.205065	0.83741
	Keskal	1.50871	0	1.50871	1.80726	0	1.80726	2.31927	0.48114	1.83813
	Makdi	0.00539	0	0.00539	0.00686	0	0.00686	0.00812	0	0.00812
Korba	Kartala	7.62762	0	7.62762	8.48757	0	8.48757	10.20572	0	10.20572
	Katghora	16.734205	4.993245	11.74096	30.32181	23.72193	6.59988	34.57994	27.61452	6.96542
	Korba	25.20354	16.80669	8.39685	33.622705	25.816725	7.80598	41.200305	31.888485	9.31182
	Pali	8.54392	0	8.54392	11.12986	0	11.12986	14.27063	0.74439	13.52624
	Poundi-Uproda	10.19844	0	10.19844	11.11649	0	11.11649	13.21481	0	13.21481
Koriya	Baikunthpur	9.23662	3.81834	5.41828	11.05941	4.24386	6.81555	13.356275	7.013925	6.34235
	Khadganva	7.72774	2.6946	5.03314	16.18963	10.09746	6.09217	16.667245	9.356445	7.3108
	Manendragarh	11.419485	8.436015	2.98347	7.617435	4.453785	3.16365	8.55641	5.03793	3.51848
	Sonhat	0.76587	0	0.76587	0.86569	0	0.86569	1.05868	0	1.05868

Mahasamund	Bagbahra	11.662405	1.998135	9.66427	12.166895	2.260845	9.90605	14.804515	2.636415	12.1681
	Basna	9.22866	0	9.22866	10.34832	1.19043	9.15789	12.965615	1.396575	11.56904
	Mahasamund	15.76181	5.28876	10.47305	18.31247	6.3585	11.95397	22.505505	8.343945	14.16156
	Pithora	12.15936	1.19232	10.96704	12.67478	1.07109	11.60369	14.87444	1.13778	13.73666
	Saraipali	11.565845	1.872315	9.69353	13.064725	2.305935	10.75879	14.952585	2.705805	12.24678
Mungeli	Lormi	12.946075	1.400625	11.54545	15.473775	1.640655	13.83312	20.22046	2.04552	18.17494
	Mungeli	13.20484	3.5559	9.64894	14.940235	4.267755	10.67248	19.81521	4.92075	14.89446
	Pathariya	7.67368	0	7.67368	7.94766	0	7.94766	13.332545	1.867455	11.46509
Raigarh	Baramkela	8.10936	0	8.10936	9.59147	0	9.59147	11.412185	1.691145	9.72104
	Gharghoda	4.80467	0.9504	3.85427	5.431945	1.093905	4.33804	6.174325	1.276425	4.8979
	Kharsia	8.49307	2.04201	6.45106	10.17121	2.34738	7.82383	11.774925	2.556765	9.21816
	Lailunga	6.8383	0	6.8383	7.94717	0	7.94717	9.67643	1.10808	8.56835
	Pussore	7.28497	0	7.28497	8.6863	0	8.6863	10.09436	0.64044	9.45392
	Raigarh	19.097085	12.185775	6.91131	24.34788	15.64758	8.7003	32.128775	22.021335	10.10744
	Sarangarh	12.616345	1.879605	10.73674	14.441575	1.951965	12.48961	17.04422	2.01879	15.02543
	Tamnar	4.82937	0	4.82937	5.51796	0	5.51796	6.85825	0	6.85825
	Udaipur (Dharamjaigarh)	11.469945	1.484865	9.98508	13.465395	1.835595	11.6298	15.424205	1.937655	13.48655
Raipur	Abhanpur	12.378855	2.835405	9.54345	15.763585	3.454785	12.3088	19.789785	5.905845	13.88394

	Arang	15.150355	1.924695	13.22566	18.095995	2.244915	15.85108	24.08746	4.30623	19.78123
	Dharsiwa	78.491025	62.463825	16.0272	120.0146	101.80998	18.20462	170.710925	155.937285	14.77364
	Tilda	12.75191	2.77803	9.97388	14.179895	3.632715	10.54718	19.65566	6.19893	13.45673
Rajnandgaon	Ambagarh	6.21365	0.90072	5.31293	7.195225	1.149255	6.04597	8.226235	1.335015	6.89122
	Chhuikhadan	7.058945	1.615815	5.44313	7.956855	1.791045	6.16581	9.93056	1.99935	7.93121
	Chhuriya	6.80463	0	6.80463	7.80346	0	7.80346	9.86556	0.46953	9.39603
	Dongargaon	7.011795	1.257795	5.754	8.497045	1.554795	6.94225	10.388805	1.983555	8.40525
	Dongargarh	9.83725	3.33747	6.49978	11.338305	3.653775	7.68453	13.357345	3.964815	9.39253
	Khairagarh	9.76972	1.77201	7.99771	11.53815	1.97937	9.55878	14.434555	2.946645	11.48791
	Manpur	0.00007	0	0.00007	0.00007	0	0.00007	0.00007	0	0.00007
	Mohla	2.40464	0	2.40464	2.77277	0	2.77277	3.17044	0	3.17044
	Rajnandgaon	25.963345	16.925085	9.03826	31.04603	19.40895	11.63708	36.03705	22.02039	14.01666
Surajpur	Oudgi	0	0	0	0	0	0	0	0	0
	Premnagar	2.98088	0	2.98088	3.68186	0	3.68186	4.817405	0.663255	4.15415
	Ramanujnagar	4.16556	0	4.16556	5.07052	0	5.07052	6.02679	0	6.02679
	Surajpur	0.1123	0.0297	0.0826	0.14169	0.03564	0.10605	0.17175	0.05184	0.11991
	Ambikapur	0.03683	0.01674	0.02009	0.05123	0.02862	0.02261	0.06397	0.03807	0.0259
	Batouli	3.24191	0	3.24191	3.90341	0	3.90341	4.47937	0	4.47937

	Lakhanpur	0.00448	0	0.00448	0.00546	0	0.00546	0.006835	0.000675	0.00616
	Lundra	0.44149	0	0.44149	0.53417	0	0.53417	0.63168	0	0.63168
	Mainpat	1.14394	0	1.14394	1.39958	0	1.39958	1.6303	0	1.6303
	Sitapur	5.01011	0	5.01011	5.87622	0	5.87622	7.337635	1.263735	6.0739
	Udaypur	2.40695	0	2.40695	2.99033	0	2.99033	3.31905	0	3.31905
Uttar Bastar Kanker	Antagarh	0.1029	0	0.1029	0.12523	0	0.12523	0.16078	0.02484	0.13594
	Bhanupratappur	1.57122	0	1.57122	1.85066	0	1.85066	2.344325	0.358425	1.9859
	Charama	5.97093	0	5.97093	6.80253	0	6.80253	8.083295	1.310445	6.77285
	Durgkondal	0.01316	0	0.01316	0.0154	0	0.0154	0.01771	0	0.01771
	Kanker	7.70151	2.77344	4.92807	9.54781	4.20471	5.3431	11.004765	5.016195	5.98857
	Narharpur	6.27928	0	6.27928	7.03234	0	7.03234	8.022765	0.608715	7.41405
Total Mahanadi Basin		**1135.50658**	**371.16846**	**764.33812**	**1373.101155**	**511.262415**	**861.83874**	**1738.338635**	**707.744385**	**1030.59425**

Appendix -II District-wise Industrial Water Requirement

District	Name of the Block	Industrial Water Requirement (MCM)		
		1991	2001	2011
Balod	Balod	0.000276	0.019355	0.059055
	Dondi	7.180000	0.000000	0.000330
	Dondi Luhara	0.000000	0.000000	0.029043
	Gunderdehi	0.000000	0.002640	0.021830
	Gurur	0.009900	0.022143	0.066228
Baloda Bazar	Baloda Bazar	6.580000	0.147620	0.518595
	Bhatapara	0.007887	0.328905	0.281589
	Bilaigarh	0.000000	0.003300	0.023430
	Kasdol	0.001320	0.002475	0.005940
	Palari	1.308780	0.000990	0.061645
	Simga	1.789920	0.009603	1.024980
Bemetara	Bemetara	0.000000	0.000000	0.003600
	Berla	0.000000	0.011900	0.017200
	Nawagarh	0.000000	0.000000	0.002700
	Saja	0.000000	0.000000	0.004200
Bilaspur	Bilha	0.416248	1.022974	5.048100
	Kota	0.002653	0.000000	0.003670
	Masturi	0.030800	93.000000	0.585199
	Takhatpur	0.001500	0.000000	0.001262
Dhamtari	Dhamtari	0.094900	0.047450	0.022630
	Kurud	0.025550	0.043800	0.116300
	Magarlod	0.000000	0.007300	0.007300
	Nagri	0.007300	0.000000	0.023360
Durg	Dhamdha	0.044550	0.000026	0.000669
	Durg	130.809990	346.631848	7.196102
	Patan	0.000000	0.000049	0.000035
Gariabandh	(Gariyaband)	0.000000	0.007920	0.003

	Chhura	0.000000	0.000000	0.007
	Deobhog	0.000000	0.000000	0.005280
	Mainpur	0.000000	0.000000	0.003960
	Rajim	0.033000	0.006600	0.104280
Gaurela-Pendra-Marwahi	Marwahi	0.000000	0.000000	0.000
	Pendra	0.000000	0.000000	0.000
	Pendra Road Gorella	0.000000	0.001462	0.022560
Janjgir - Champa	Akaltara	0.000000	2.100000	0.601148
	Baloda	2.160000	10.225000	35.658050
	Champa	0.000000	0.000000	0.000000
	Dabhra	0.000000	21.460000	17.157
	Jaijaipur	0.000000	0.000000	0.000000
	Malkharoda	0.000000	0.000000	0.000135
	Nawagarh	0.000000	0.000000	0.001197
	Pamgarh	0.000000	0.000000	74.674976
	Sakti	0.000000	0.000000	0.0001353
Jashpur	Bagicha	0.000000	0.000000	0.000750
	Duldula	0.000000	0.000000	0.000
	Farsabahar	0.000000	0.000000	0.001200
	Jashpur	0.000000	0.000000	0.000
	Kansabel	0.000000	0.001800	0.001500
	Kunkuri	0.000000	0.000000	1.167150
	Manora	0.000000	0.000000	0.000
	Pathalgaon	0.000000	0.004350	0.034410
Kwrdha	Bodla	0.000000	0.110820	0.004320
	Kawardha	0.000000	0.000000	0.027344
	Pandariya	0.000000	0.000000	0.903580
	Sahaspur Lohara	0.000000	0.000000	0.000000
Kdagaon	Bade Rajpur	0.000000	0.000000	0.000000
	Keskal	0.000000	0.000000	0.000000
	Makdi	0.000000	0.000000	0.000000

Korba	Kartala	0.000000	0.000000	0.001320
Korba	Katghora	116.001825	0.000000	28.750
Korba	Korba	0.006220	37.600099	204.884
Korba	Pali	0.000000	0.000330	0.078730
Korba	Poundi-Uproda	0.000000	0.000000	0.000000
Koriya	Baikunthpur	0.000000	0.000000	0.0016200
Koriya	Khadganva	0.000000	0.000000	0.004050
Koriya	Manendragarh	0.000000	0.000000	0.000
Koriya	Sonhat	0.000000	0.000000	0.000
Mahasamund	Bagbahra	0.000990	0.021285	0.012540
Mahasamund	Basna	0.000000	0.014850	0.007260
Mahasamund	Mahasamund	0.000990	0.067650	1.075355
Mahasamund	Pithora	0.000660	0.004125	0.012210
Mahasamund	Saraipali	0.001980	0.004785	0.005940
Mungeli	Lormi	0.000000	0.000000	0.008180
Mungeli	Mungeli	0.000000	0.001080	0.010965
Mungeli	Pathariya	0.000000	0.001620	0.184342
Raigarh	Baramkela	0.000000	0.004320	0.023340
Raigarh	Gharghoda	0.000000	0.031680	0.043800
Raigarh	Kharsia	0.000000	0.000000	12.793560
Raigarh	Lailunga	0.000000	0.000000	0.022620
Raigarh	Pussore	0.000000	0.691900	45.790260
Raigarh	Raigarh	6.421000	231.329000	130.484830
Raigarh	Sarangarh	0.000000	0.000000	0.010455
Raigarh	Tamnar	0.000000	60.799932	6.983190
Raigarh	Udaipur (Dharamjaigarh)	0.000000	3.668250	0.182180
Raipur	Abhanpur	0.241910	0.000000	0.050082
Raipur	Arang	23.078690	0.000000	0.109940
Raipur	Dharsiwa	0.014090	29.718300	0.410560
Raipur	Tilda	87.759301	0.057300	51.296240
Rajnandgaon	Ambagarh	0.001500	0.000000	0.000000

	Chhuikhadan	0.000000	0.000000	0.002100
	Chhuriya	0.000000	0.000300	0.005000
	Dongargaon	0.015300	0.025900	0.005709
	Dongargarh	0.003400	0.005580	0.002868
	Khairagarh	0.000000	0.000000	0.083990
	Manpur	0.000000	0.000000	0.000000
	Mohla	0.000000	0.000000	0.000000
	Rajnandgaon	0.160254	0.520740	0.130399
Surajpur	Oudgi	0.000000	0.000000	0.000000
	Premnagar	0.000000	0.000000	0.000000
	Ramanujnagar	0.000000	0.000000	0.000000
	Surajpur	0.000000	0.000000	0.000000
	Ambikapur	0.000000	0.000000	0.000
	Batouli	0.000000	0.000000	0.00108
	Lakhanpur	0.000000	0.000000	0.000
	Lundra	0.000000	0.000000	0.000
	Mainpat	0.000000	0.000000	0.000
	Sitapur	0.000000	0.000000	0.000
	Udaypur	0.000000	0.000000	0.000
Uttar Bastar Kanker	Antagarh	0.000000	0.000000	0.000
	Bhanupratappur	0.000000	0.000000	0.000
	Charama	0.000000	0.008886	0.0013860
	Durgkondal	0.000000	0.000000	0.000
	Kanker	0.000000	0.008008	0.0108780
	Narharpur	0.000000	0.002184	0.0008250
Total Mahanadi Basin		**384.212684**	**839.808434**	**628.985**