सत्यमेव जयते

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

MAHANADI RIVER AT A GLANCE

JUNE 2024

Centres for Mahanadi River Basin Management Studies

Centre for Ganga River Basin Management and Studies

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Centre for Ganga River Basin Management and Studies

National River Conservation Directorate (NRCD)

The National River Conservation Directorate, functioning under the Department of Water Resources, River Development & Ganga Rejuvenation, and Ministry of Jal Shakti providing financial assistance to the State Government for conservation of rivers under the Centrally Sponsored Schemes of 'National River Conservation Plan (NRCP)'. National River Conservation Plan to the State Governments/ local bodies to set up infrastructure for pollution abatement of rivers in identified polluted river stretches based on proposals received from the State Governments/ local bodies.

www.nrcd.nic.in

Centres for Mahanadi River Basin Management Studies (cMahanadi)

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.

www.cmahanadi.org

Centre for Ganga River Basin Management and Studies (cGanga)

cGanga is a think tank formed under the aegis of NMCG, and one of its stated objectives is to make India a world leader in river and water science. The Centre is headquartered at IIT Kanpur and has representation from most leading science and technological institutes of the country. cGanga's mandate is to serve as think-tank in implementation and dynamic evolution of Ganga River Basin Management Plan (GRBMP) prepared by the Consortium of 7 IITs. In addition to this, it is also responsible for introducing new technologies, innovations, and solutions into India.

www.cganga.org

Acknowledgment

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जल शक्ति मंत्री
भारत सरकार

Minister for Jal Shakti
Government of India

संदेश

मानव सभ्यता का विकास नदियों के किनारे हुआ है, और इसे सुरक्षित रखने के लिए नदियों का संरक्षण अत्यंत आवश्यक है। भारत की नदियों के स्वास्थ और सुरक्षा के लिए 2019 में संसद के संयुक्त सत्र में राष्ट्रपति ने गंगा नदी के उदाहरण पर अन्य प्रमुख नदियों के बेसिन प्रबंधन की आवश्यकता पर बल दिया था। इस उद्देश्य की पूर्ति हेतु छह प्रमुख नदियों के बेसिन प्रबंधन में सी–गंगा के समग्र समन्वय से 12 प्रतिष्ठित शैक्षणिक संस्थाओं को शामिल करने का निर्णय लिया गया। राष्ट्रीय नदी संरक्षण निदेशालय द्वारा संचालित कंडीशन एसेसमेंट एंड मैनेजमेंट प्लान (कैंप) प्रोजेक्ट नदियों के समग्र बेसिन प्रबंधन को साकार करने का प्रयास है।

नदियों के संरक्षण और उनके प्रबंधन के लिए इस तरह की पहल से न केवल हमारे प्राकृतिक संसाधनों का बचाव होगा, बल्कि स्थानीय समुदायों के जीवन और संस्कृति को भी संरक्षित किया जा सकेगा। यह अत्यंत हर्ष का भविष्य है कि इस प्रोजेक्ट के तहत तैयार की गई ''रिवर एट ए ग्लांस'' रिपोर्ट का लोकार्पण होने जा रहा है। जैसे किसी व्यक्ति के बाह्य स्वरूप से उसकी पुरी पहचान नहीं होती, वैसे ही नदी के व्यवहार और चुनौतियों को सिर्फ मुख्यधारा से नही समझा जा सकता। इसके लिए नदी के इतिहास, उसके किनारे बसे नगरों और गांवों की संस्कृति, सहायक नदियों और उस क्षेत्र के भूगोल को भी समझाना पड़ता है। इसी रिपोर्ट के जरिए नदी की पूरी प्रकृति, उसकी चुनौतियाँ, सहायक नदियां और आसपास के क्षेत्रों की सांस्कृतिक–भौगोलिक स्थिति को समझने के जो कोशिश की गई है, वह बहुत महत्वपूर्ण है।

हमें विश्वास है कि यह रिपोर्ट नदी, जल और पर्यावरण के क्षेत्र में काम करने वाले व्यक्तियों, संस्थाओं और हितकारकों के लिए अत्यधिक उपयोगी साबित होगी। रिपोर्ट के प्रकाशन और लोकार्पण के इस विशेष अवसर पर बधाई।

सीआर पाटील

सत्यमेव जयते

जल शक्ति राज्य मंत्री
भारत सरकार, नई दिल्ली

Minister of State for Jal Shakti
Government of India, New Delhi

संदेश

नदियां हमारे जीवन के लिए अत्यावश्यक संसाधन हैं और उनका पर्यावरणीय, सामाजिक, और आर्थिक महत्व भी बहुत अधिक है। नदियों का संरक्षण भविष्य की पीढ़ियों के लिए जीवन की गुणवत्ता सुनिचित करने की दिशा में एक महत्वपूर्ण कदम है। देश की छह प्रमुख नदियों के बेसिन प्रबंधन के लिए शीर्ष तकनीकी शिक्षण संस्थाओं के सहयोग से राष्ट्रीय नदी संरक्षण निदेशालय का कैंप (कंडीशन एसेसमेंट एंड मैनेजमेंट प्लान) प्रोजेक्ट संरक्षण के लिए वर्तमान सरकार की प्रतिबद्ता दर्शाता है। भारत सरकार के नमामि गंगे मिशन के अंतर्गत किये प्रयासों से आज गंगा नदी के पुनर्जीवन को वैशिक मान्यता मिल चुकी है। उम्मीद है की ऐसी ही सफलता हमें कैंप प्रोजेक्ट में भी मिलेगी।

मुझे यह देखकर बहुत प्रसन्नता हो रही है की कैंप प्रोजेक्ट आरंभ होने के बाद काम ने भी गती पकड़ ली है। इस प्रोजेक्ट के अंतर्गत ''रिवर एट ए ग्लेंस'' रिपोर्ट के प्रकाशन के लिए हार्दिक बधाई। यह रिपोर्ट नदी के संबंध में संपूर्ण जानकारी देती है, इस विस्तारित रिपोर्ट से नदी को प्रभावित करने वाले विभिन्न कारकों को समझने में सहायता मिलेगी। इन जानकारीयों का इस्तेमाल नदियों से संबंधित योजनाएं बनाने में मददगार साबित होगा।

नदी बेसिन प्रबंधन के लिए उठाए गए इन कदमों से न केवल जल संरक्षण सुनिश्चित होगा, बल्कि पर्यावरण संरक्षण और कृषि की स्थिरता भी बनी रहेगी। यदि हम आज जल संरक्षण और प्रबंधन के लिए ठोस कदम उठाते हैं, तो भविष्य में हम एक स्थिर समृद्ध समाज की दिशा में बढ़ सकते हैं।

डा. राज भूषण चौधरी

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. It is our hope that this report will serve as a catalyst for 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.

cMahanadi and cGanga

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Abbreviations and Acronyms

km	:	Kilometre
cMahanadi	:	Centre for Mahanadi River Basin Management and Studies
MRB	:	Mahanadi River Basin
GIS	:	Geographical Information System
Sq	:	Square
Mm	:	Millimetre
°C	:	Degree Centigrade
DEM	:	Digital Elevation Model
m	:	Metre
HE	:	Hydroelectric
SRTM	:	Shuttle Radar Topographic Mission
MSL	:	Mean Sea Level
LULC	:	Land Use Land Cover
IMD	:	Indian Meteorological Department
BALCO	:	Bharat Aluminium Company Ltd.
CSEB	:	Chhattisgarh State Electricity Board
BCM	:	Billion Cubic Meter
HHs	:	Households
NTPC	:	National Thermal Power Corporation

1. INTRODUCTION

The Mahanadi River basin, which is among the largest in India, extends across several states, including Chhattisgarh, Odisha, and portions of Madhya Pradesh and Maharashtra. This river originates on the slopes of the Eastern Ghats and flows through a varied terrain that includes lush woods and fertile plains. The Mahanadi River serves as a vital resource for both agriculture and industry, as well as having significant cultural and ecological importance. The waters of this region provide essential support to a wide range of ecosystems and are critical for millions of people's livelihoods. They have a significant impact on the area's socioeconomic and environmental well-being.

This mighty river has nurtured civilizations along its banks, providing water for drinking, irrigation, and industrial use. One of the largest rivers of India, Mahanadi originates from the foothills of the Sihawa mountain of Chhattisgarh in the Dhamtari district (40 km south-east of Raipur). From its source, the Mahanadi embarks on a majestic journey, winding its way through the heartland of Chhattisgarh and Odisha, covering a vast expanse of diverse terrains. As it flows through these states, the river supports a rich tapestry of ecosystems, agricultural lands, and human settlements, before finally merging with the Bay of Bengal at Jagatsinghpur.

The name 'Mahanadi' translates to 'Great River,' aptly reflecting its immense historical and cultural importance. This mighty river has nurtured civilizations along its banks, providing water for drinking, irrigation, and industrial use. At almost 900 km long, it is one of India's largest rivers, flowing for about a thousand kilometers through Chhattisgarh and Odisha.

1.1 Religious Significance of Mahanadi

The Mahanadi River holds profound mythological significance in Indian culture, celebrated for centuries as a life-giving force and a symbol of fertility and sustenance. Mahanadi is also called as holy Ganga in Chhattisgarh and Odisha. Additionally, also known as "Ganga Chitrotpala" in ancient historical documents.

Being one of the oldest rivers in India, the history of Mahanadi is prevalent from time to time from the Puranas. It is mentioned in historical texts that Mahanadi and its tributaries originated from the ancient Shuklamat Mountain. In ancient times, this river was known as Dim Vahini. The religious significance of the Mahanadi River is further enhanced as it either has a lot of temples or is located in the vicinity.

Figure 1 Origin of Mahanadi River

Table 1 Significant places along the main stream of Mahanadi river

S.No	Place, District	River	Significance
1	Sehawa, Dhamtari	Mahanadi	Origin of Mahanadi, Shrangi Rishi Ashram
2	Rajim, Raipur	Confluence of Mahanadi, Sondur & Pairi	Prayag of Chhattisgarh. Temples like Rajiv Lochan mandir, Kaleswar Mahadev
3	Champaranya, Raipur	Mahanadi	Birthplace of Sri Vallabhacharya, Vaishnava guru of Pushtimarga sect.
4	Arang	Mahanadi	Ancient "city of temples", Finds mention in the Mahabharat epic
5	Sirpur, Mahasamund	Mahanadi	The historical town of archeological significance. Finds mention in the travels of Chinese pilgrim Hieun Tsang.
6	Kharod, Janjgir Champa	Mahanadi	Known as Kashi of Chhattisgarh
7	Cuttack	Mahanadi	Birthplace of Netaji Subhas Chandra Bose and the former capital of Odisha (Utkala). Temples like Kataka Chandi Temple and Dhabaleswar Temple. Bali Jatra Festival.
8	Sambalpur	Mahanadi	One of the oldest cities and trading hub in Odisha. Samaleswari Temple, Leaning Temple of Huma and Hirakud Dam.
9	Kantilo , Nayagarh	Mahanadi	It is believed that the Lord Jagannath's image was originally worshipped here. Nilamadhav Temple
10	Sonepur	Mahanadi	Known for its numerous Shakti Peethas. Temples like Maa Lankeswari Temple and Sureswari.

a. Arang

b. Champaranya

c. Sirpur

d. Kharod, Janjgir Champa

e. Rajim

f. Sihawa,Mahanadi

Figure 2 Sites of cultural and religious significance in Chhattisgarh

It plays a major role in people's lives and all major religious functions and festivals. The waters of Mahanadi are considered auspicious for any occasion. It is believed that the water of Mahanadi has the power to transform bad into good.

In Hindu mythology, the Mahanadi is enveloped in a rich tapestry of legends and tales that underscore its divine origins and immense significance. One prominent legend attributes the creation of the Mahanadi to Lord Shiva, a principal deity in Hinduism known as the destroyer and transformer. According to this tale, Shiva pierced the Earth with his trident (trishul), causing a gush of sacred waters to flow forth, which formed the river Mahanadi. Temples along the riverbanks, particularly in Odisha, frequently conduct rituals that pay homage to both the river and Shiva.

Another legend intricately weaves the Mahanadi River into the epic narrative of the Ramayana, one of ancient India's most revered texts. It is believed that during their period of exile, Lord Rama and his wife, Sita, journeyed along the banks of the Mahanadi. This connection not only enriches the river's mythological allure but also positions it as a silent witness to pivotal events in Indian history and mythology.

1.2 Description of MRB

The Mahanadi River Basin, an integral hydrological and ecological region of India, spans majorly in Chhattisgarh (52.42%) and Odisha (47.14%), with minor parts extending into Maharashtra (0.23%), Madhya Pradesh (0.11%), and Jharkhand (0.1%).

The Mahanadi is the 8th largest basin, having a total catchment area of 143687.75 Sq.km (the area given is a GIS-based basin area), which is nearly 4.37% of the country's total geographical area. The geographical extent of the basin lies between 80°28' and 86°43' east longitudes and 19°8' and 23°32' north latitudes. It is physically bounded in the north by Central India hills, in the south and east by the Eastern Ghats, and in the west by Maikala hill range. The basin is circular, with a maximum length and width of 587 km and 400 km, respectively.

Figure 4 gives a detailed view of the basin where the drainage network and its pattern across the basin are also shown. Major hydro meteorological stations and flood forecasting sites are also shown in the map. Table 2 provides a glance at salient features of the basin.

The Mahanadi River, from which the basin derives its name, is one of the major rivers in the Indian subcontinent. It originates from the Sihawa hills in the Dhamtari district of

g. Samaleswari Temple, Sambalpur

h. Dhabaleswar Temple, Cuttack

i. Leaning Temple of Huma, Sambalpur

j. Sureswari Temple, Sonepur

k. Bali Jatra Ground, Cuttack

l. Kataka Chandi Temple, Cuttack

m. Maa Lankeswari Temple, Sonepur

n. Nilamadhav Temple, Kantilo

Figure 3 Sites of cultural and religious significance in Odisha

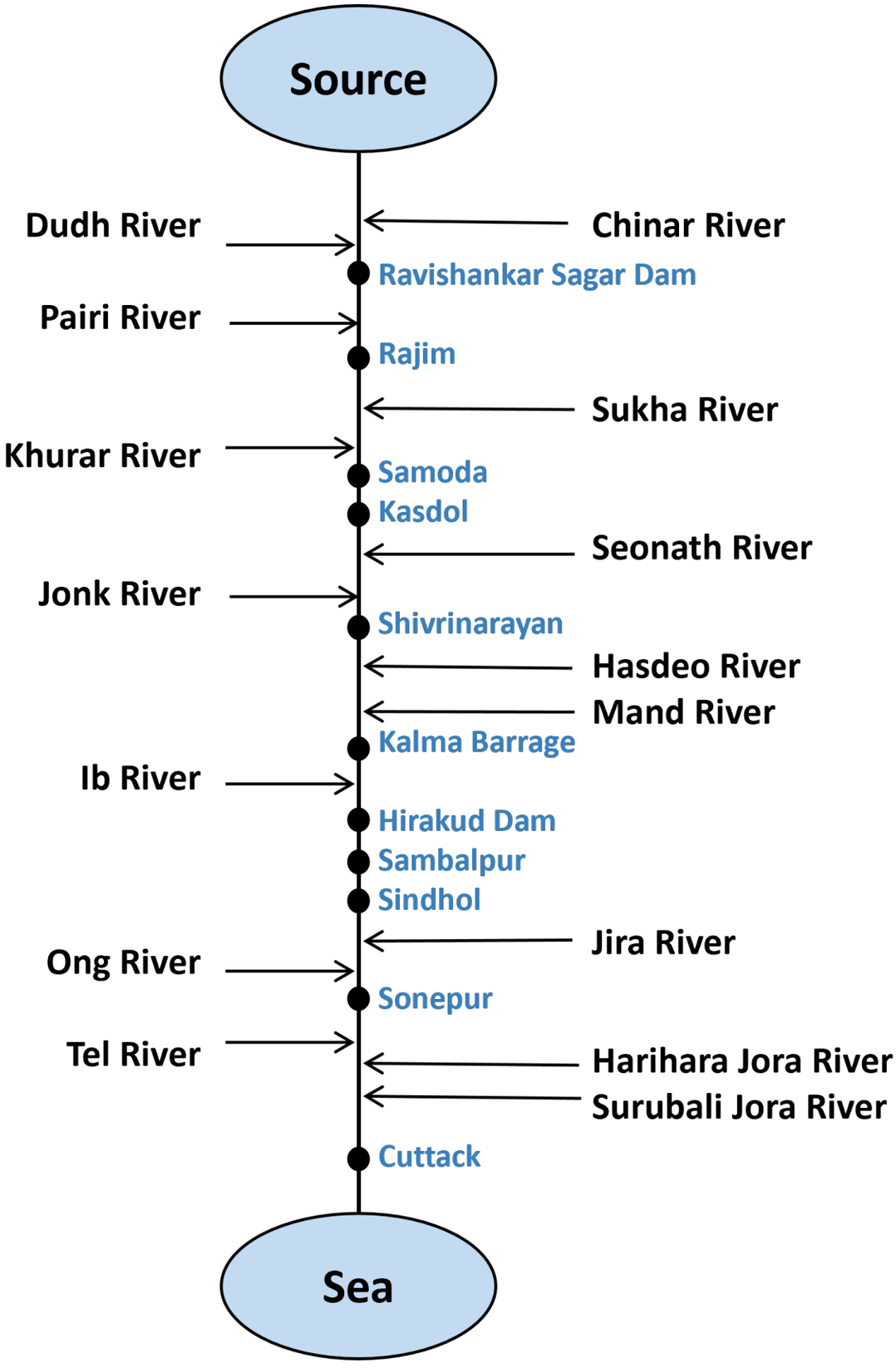

Figure 4 Line Diagram of Mahanadi River

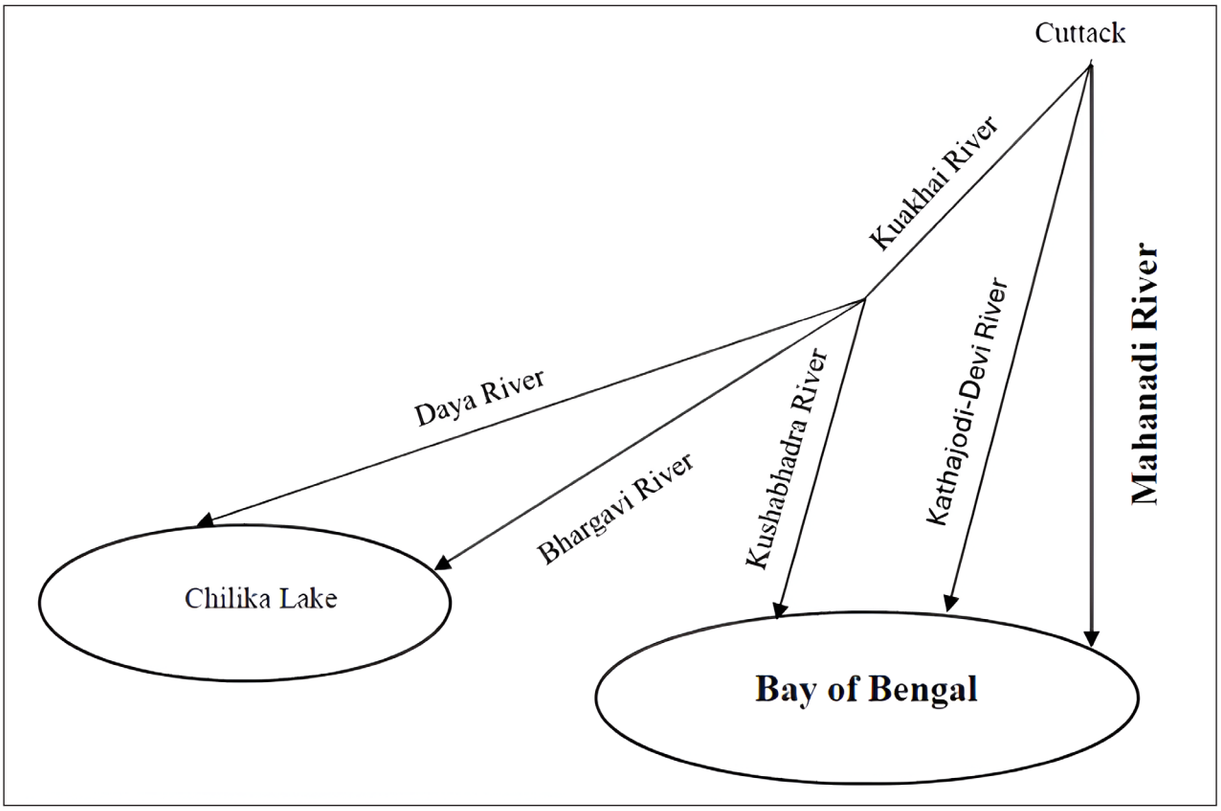

Figure 5 Major Distributaries of Mahanadi River

Chhattisgarh at an elevation of about 442 m. The river traverses a course of approximately 858 km before emptying into the Bay of Bengal. The Average annual runoff of Mahanadi is 66.9 BCM.

The basin receives uneven rainfall thus drought is prevalent in some districts. Fourteen districts in the basin are covered under the drought-prone area programme. Districts Jagatsinghpur, Puri and Kendraparha which are situated near coastal parts of Mahanadi face waterlogging problem. The Mahanadi basin experiences four distinct seasons, namely the cold weather, the hot weather, the south-west monsoon and the post monsoon. In the cold weather, the winds are generally light and blow either from the north or the north-east and the atmosphere is bright, thus making winters pleasant. The hot season commences in March lasts till the middle of June till the south-west monsoon sets in. Thunderstorms are quite frequent in hot season bringing some rainfall comparatively higher in hilly regions.

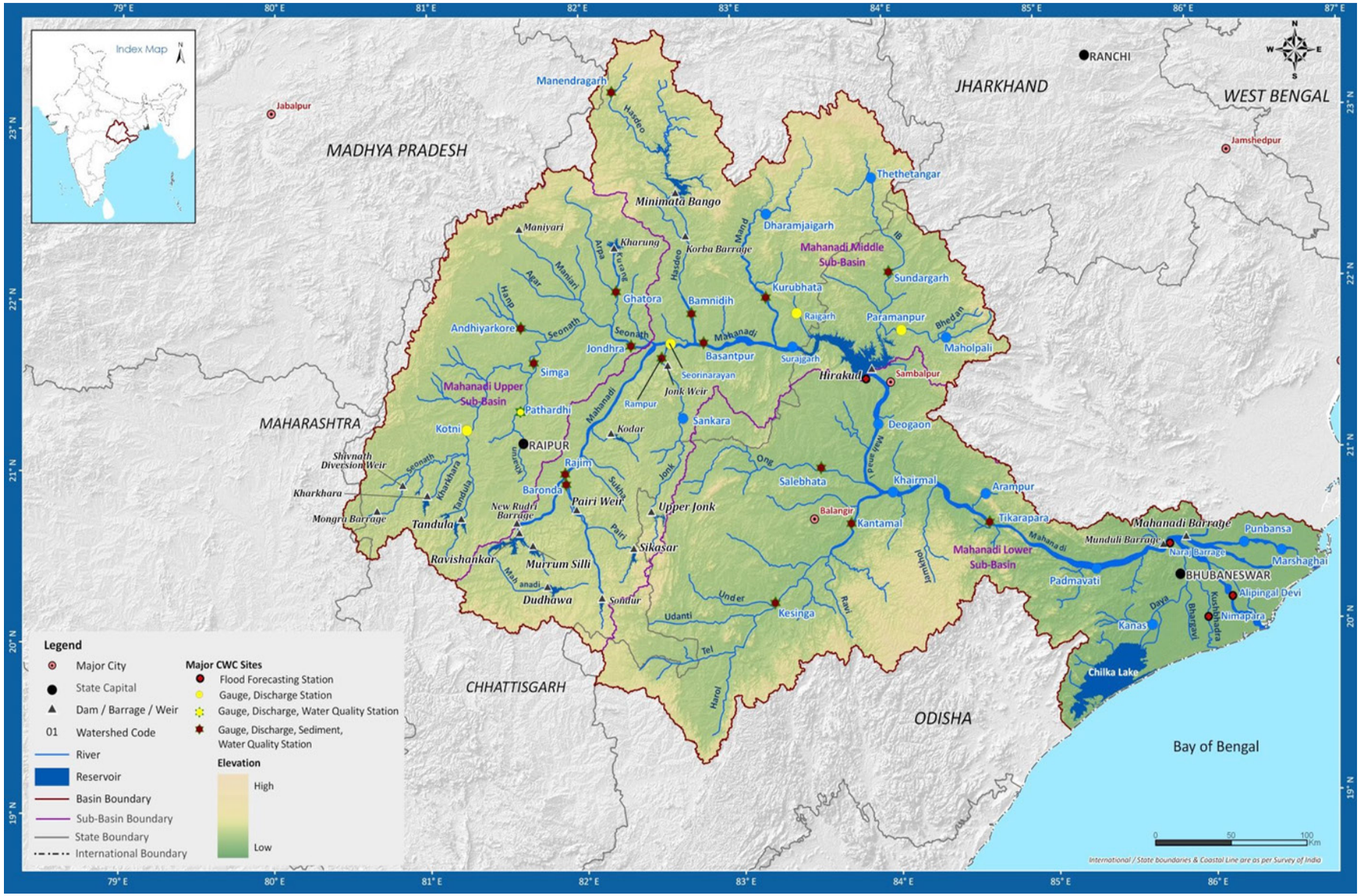

Figure 6 Mahanadi River basin MAP

Source: CWC & NRSC report, 2014

Table 2 Salient feature of Mahanadi River Basin

Sl. No.	Features	Description
1	Basin Extent	80° 28' to 86° 43' E 19° 8' to 23° 32' N
2	Area (Sq.km)	141589
3	States in the basin	Chhattisgarh (52.42%), Odisha (47.14%), Maharashtra (0.23%), Madhya Pradesh (0.11%), and Jharkhand (0.1%)
4	Districts	45
5	Parliamentary Constituencies (2009)	32
6	Mean Annual Rainfall (mm)	1291.92
7	Mean Maximum Temperature (° C)	39.56
8	Mean Minimum Temperature (° C)	20.01
9	Total Population (As per Census 2001)	28322294
10	Number of villages (As per Census 2001)	38285
11	Highest Elevation (m)	1321 (SRTM DEM)
12	Avg. Annual Water Potential (BCM)	66.9
13	Utilizable Surface Water (BCM)	50
14	Number of Sub-basins	3
15	Number of Watersheds	227
16	Number of water resources structures	Dams (253) Barrages (14) Weir (13) Anicuts (0) Lifts (1) Power House (6)
17	Highest Dam	Minimata (Hasdeo) Bango Dam (87 m)
18	Longest Dam	Hirakud Dam (4800 m)
19	Highest Barrage	Karra Nalla Barrage (18.89 m)
20	Longest Barrage	Mahanadi Barrage (1928 m)
21	Number of Irrigation projects	Major : 24 Medium: 50 ERM: 16
22	Number of HE projects	5
23	Number of Ground water observation wells	1147
24	Number of Hydro-Observation sites	49 existing, 1 closed
25	Number of Flood Forecasting Sites	4
26	Water tourism sites	12 Water tourism sites, 14 Wildlife Sanctuaries / National Parks

2. BASIN DEMOGRAPHY WITH URBAN AND RURAL DATA AT VARIOUS ADMINISTRATIVE LEVELS AND BASIN SEGMENTS

2.1 Demographic Context of Mahanadi Basin

2.1.1 Chhattisgarh Region

The Mahanadi River and its tributaries drain through 15 districts in Chhattisgarh which forms the initial course of the basin, forming the middle and upper part of the basin. Most of the districts lie completely within the basin while a few others lie partially within it. As per the 2011 census, the approximate population in the basin is 22 million (22,047,812).

Between 2001 and 2011, the decadal increase in population for the Chhattisgarh region of the basin was 2.42% the total number of households (HHs) in the basin is about 4,871,507 and the population density is 241 persons per square km. As per population statistics for 2011, Raipur is the most populated district in the basin, followed by Durg (Census, 2011).

2.1.2 Odisha Region

As the Mahanadi River meanders into Odisha, it traverses through another 22 districts, defining the middle and lower stretches of the basin. While most of these districts are entirely encompassed by the river's basin, a few are only partially included, illustrating the extensive reach and significant influence of the Mahanadi across these regions.

As per the 2011 census, the approximate population in the basin of Odisha was 16.6 million (16,612,853). Between 2001 and 2011, the decadal increase in population for the Chhattisgarh region of the basin was 2.42%, the total number of households (HHs) in the basin is about 3,921,526 and the population density is 245 persons per square km. As per population statistics 2011, Cuttack is the third most populated district In the Basin. (Census, 2011).

2.2 Rural and Urban Population

2.2.1 Chhattisgarh Region

In the Mahanadi basin of Chhattisgarh, 96.95% (16,580,955) of the population live in rural areas (Census, 2011). Between 2001 and 2011, rapid urbanization has taken place in Jashpur and Kanker districts of Chhattisgarh.

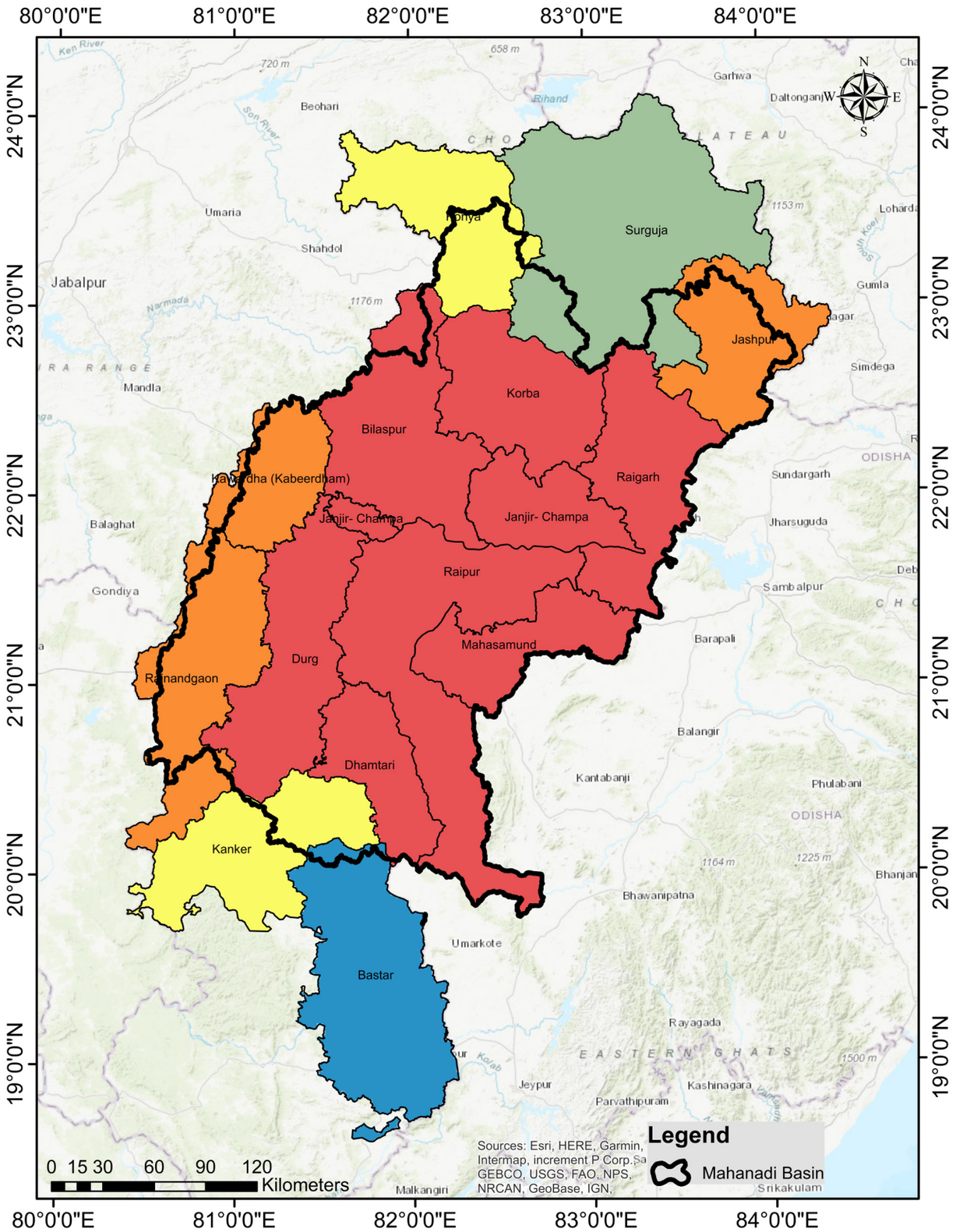

Figure 7 Proportion of District within Mahanadi Basin in Chhattisgarh

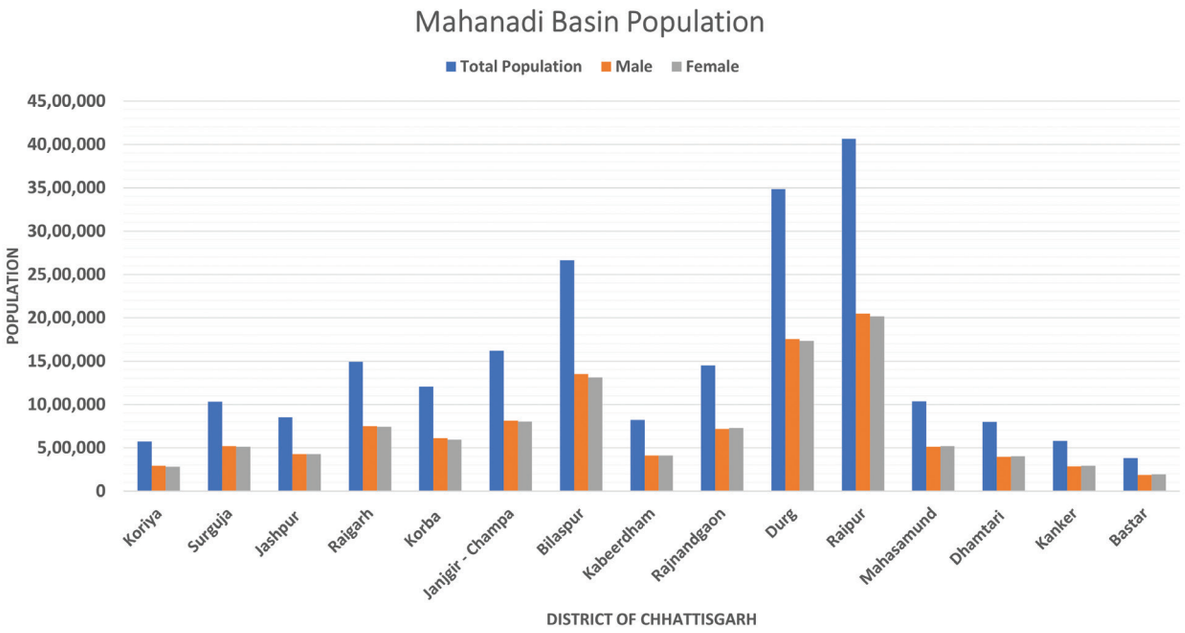

Figure 8 Population Graph of Basin as per census 2011 in Chhattisgarh

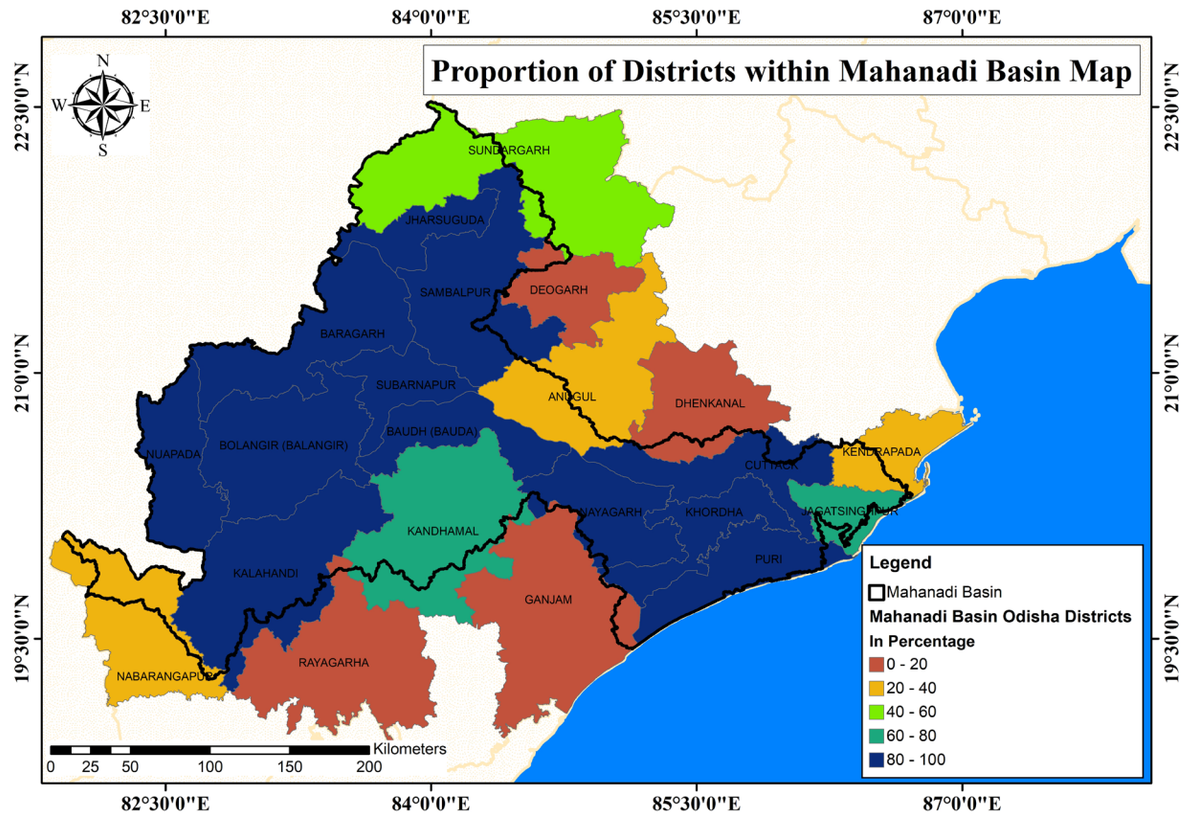

Figure 9 Proportion of District within Mahanadi Basin in Odisha

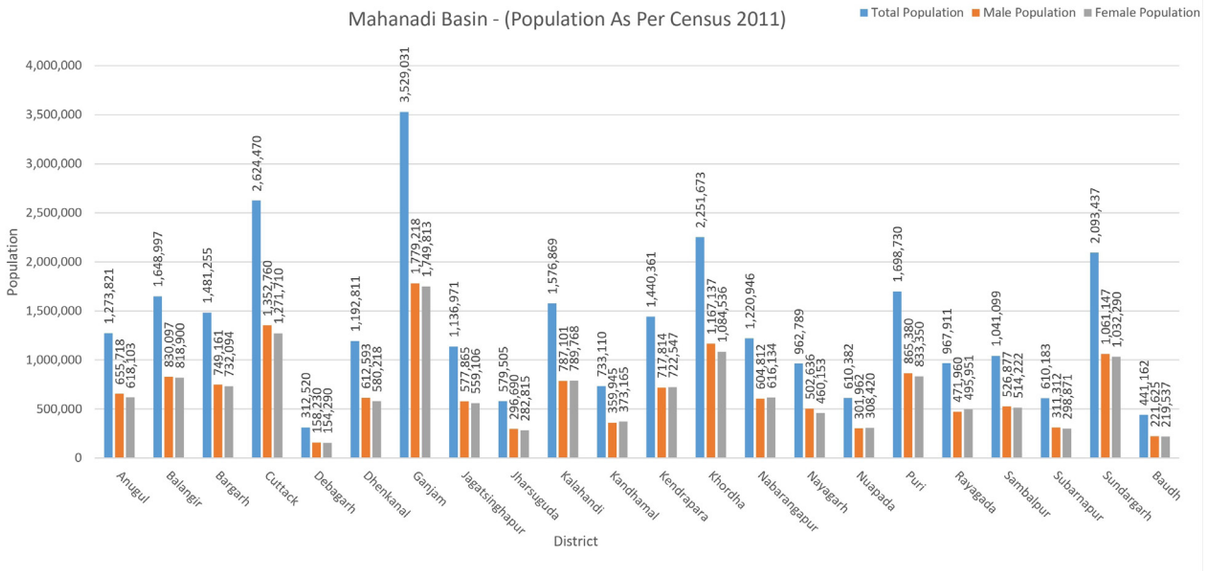

Figure 10 Mahanadi Basin Population (2011) in Odisha

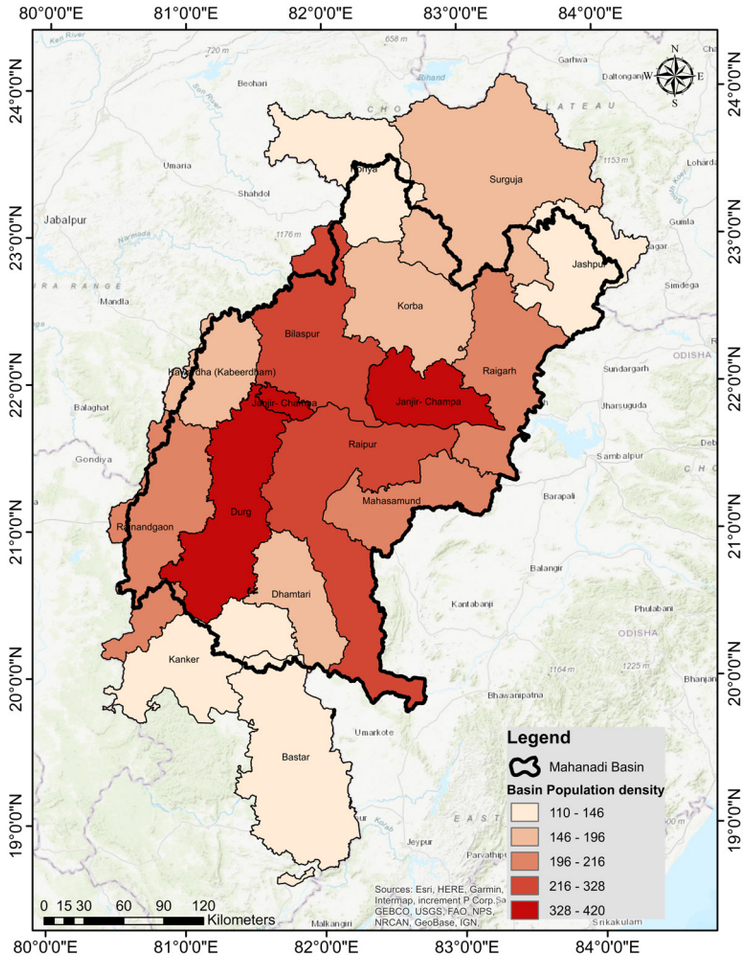

Figure 11 Basin Population Density Map of Chhattisgarh region

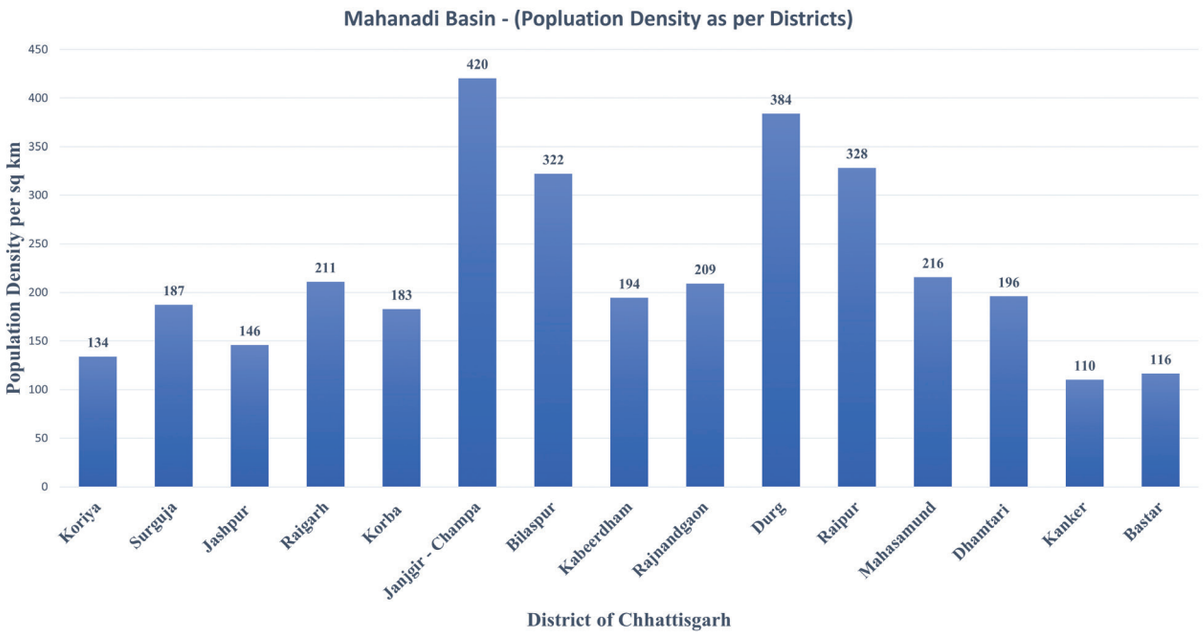

Figure 12 Population Density Graph of Basin as per census 2011 of Chhattisgarh region

2.2.2 Odisha Region

In the Mahanadi basin of Odisha, 79.86% (13,268,042) of the population live in rural areas (Census, 2011). Between 2001 and 2011, rapid urbanization took place in the Ganjam and Khordha districts of Odisha.

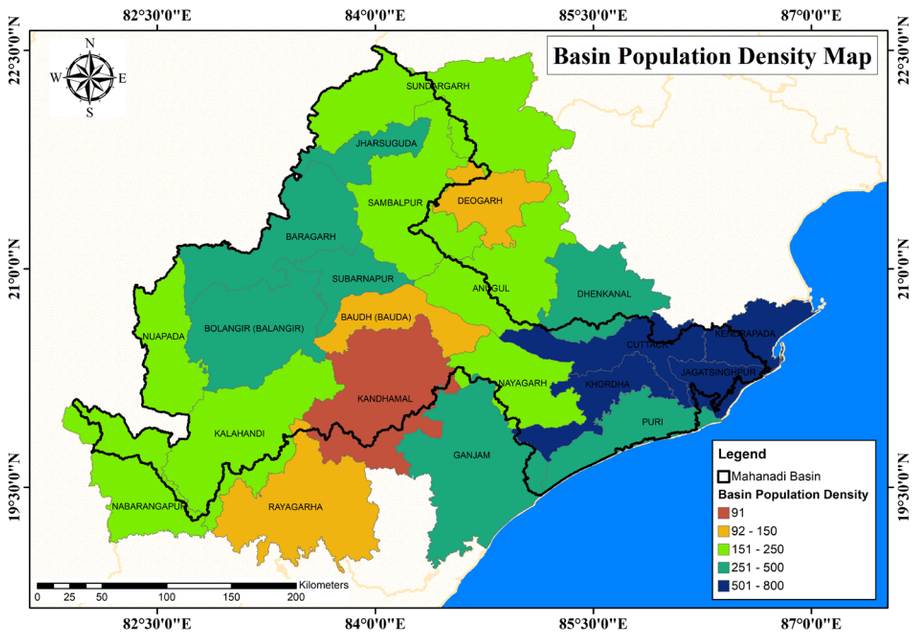

Figure 13 Basin Population Density Map of Odisha region

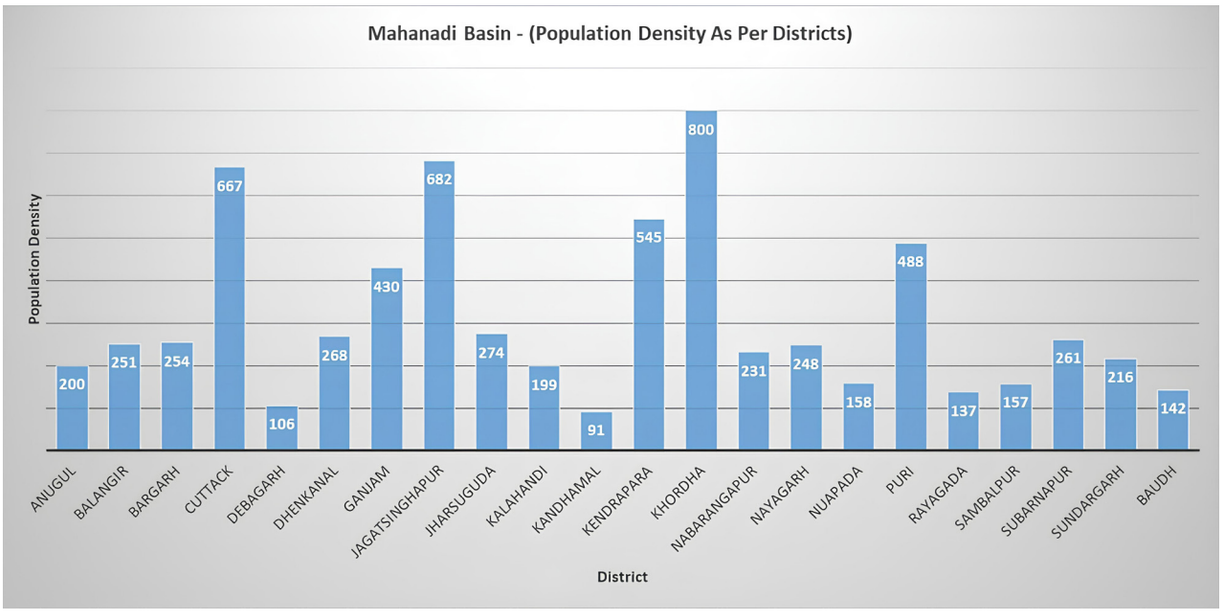

Figure 14 Population Density Graph of Basin as per census 2011 of Odisha region

3. DIVIDING THE BASIN INTO SUB-BASINS/ SEGMENTS BASED ON FACTORS LIKE TOPOGRAPHY, GEOMORPHOLOGY, CLIMATE VARIATIONS, LAND COVER - LAND USE, DEGRADATION OF CATCHMENT/ RIVER STRETCHES, DEGREE OF POLLUTION, ETC.

3.1 General Topography

The Mahanadi Basin exhibits a diverse topography, with the lowest elevations in the coastal reaches and the highest in the northern hills. The basin is segmented into 12 distinct elevation zones based on data from the Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM). The outer boundaries of the basin, marked in green, highlight the presence of the high-elevation regions. These hills and mountains represent the highest elevations in Odisha. The highest point in the basin reaches 1326 m, located in the steep hilly terrain of the upper Mahanadi region. The majority of the Mahanadi Valley's plains fall within the 200-400 m elevation zone, making these areas vital for agriculture due to their relatively flat terrain. The upper sub-basin of the Mahanadi, particularly its northern part, is characterized by hilly terrain with elevations ranging from 750 to 1000 m. In contrast, the central flank of the upper Mahanadi, drained by the Seonath River, is predominantly a plain area with elevations between 200 and 300 m, flanked by higher hills to the west, which rise between 300 and 400 m. This varied topography influences the region's hydrology, agriculture, and settlement patterns, with higher elevations serving as crucial watersheds and lower plains supporting intensive farming and human habitation.

As we move westward from the coast, the elevation increases (depicted in yellow and orange hues), representing the central highlands of Odisha. These regions are less elevated than the western parts of the basin but play a crucial role in the hydrology of the area. The highlands act as watersheds, influencing the flow of rivers and streams that support agriculture and water supply in the lower regions. The middle Mahanadi sub-basin has high hilly terrain in its north-eastern stretch. This part has highest elevation which falls between 750-1000 m. The area near the upper reaches of the Mahanadi River has an elevation between 500-750 m. The central tableland, which divides the Mahanadi middle and lower sub-basin, has a general elevation of 400-500 m.

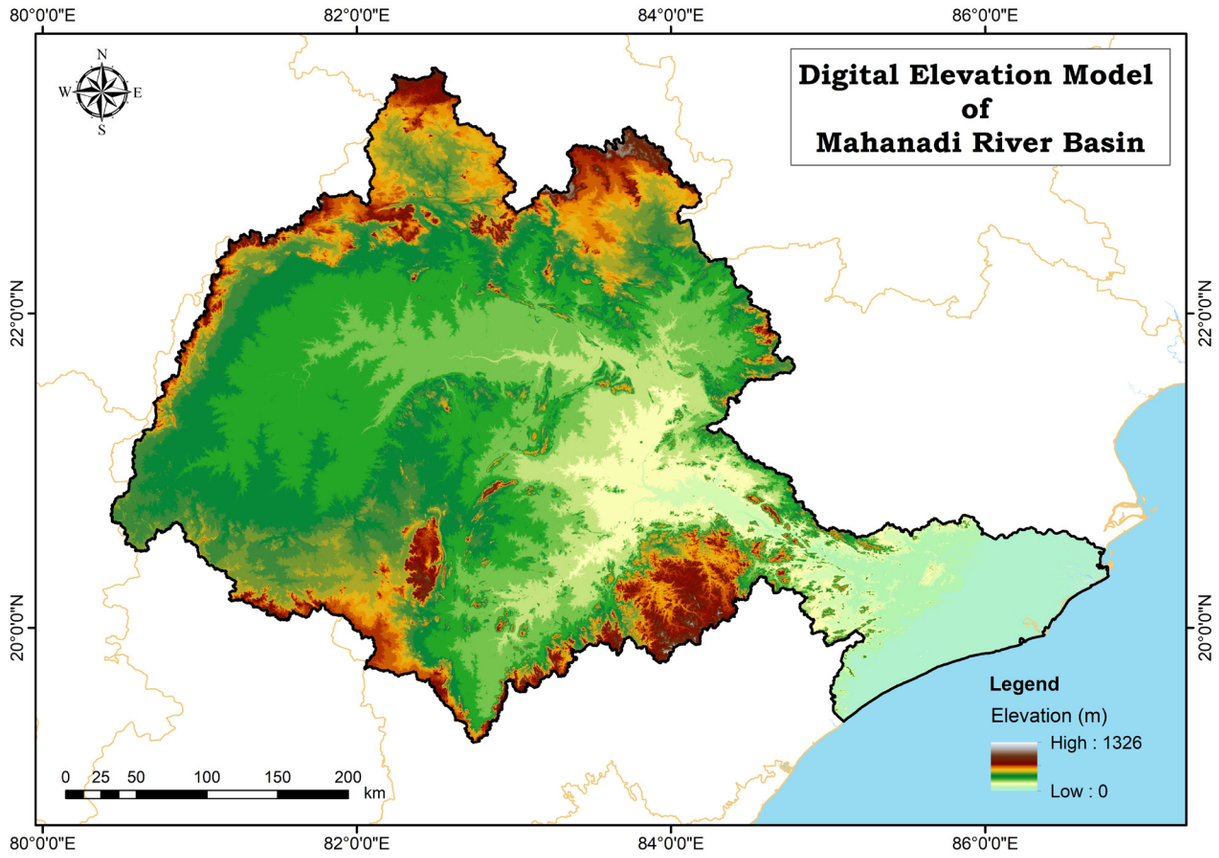

Figure 15 Elevation Map of Mahanadi River Basin

3.2 Land Use/ Land Cover

The Mahanadi River Basin displays a rich tapestry of land use and land cover that includes a wide array of ecological, agricultural, and urban elements. This region is marked by its extensive agricultural areas, primarily situated in the fertile plains and expansive delta, where paddy fields dominate. The Land use /Land cover map for year 2022-23 depicts major part of the basin is covered with agricultural land. Out of this total agriculture, the crop area accounts for nearly 50%. The river's floodplains are extensively utilized for paddy cultivation, owing to the fertile alluvial soil. These areas also cultivate pulses, oilseeds, and a variety of vegetables, supporting the state's agricultural economy and food supply. Except in the districts Durg and Raipur and coastal plains, the basin have a fair area under forests, with forest covering scrub forest covering about 30%. The forests within the Mahanadi Basin, especially those in the upper and middle reaches, are integral to the region's ecological health. These forests, which are part of the biodiverse Eastern Ghats, play crucial roles in providing wildlife habitat, sequestering carbon, and conserving soil, thus maintaining environmental stability and supporting biodiversity. About 5% of the basin area is covered

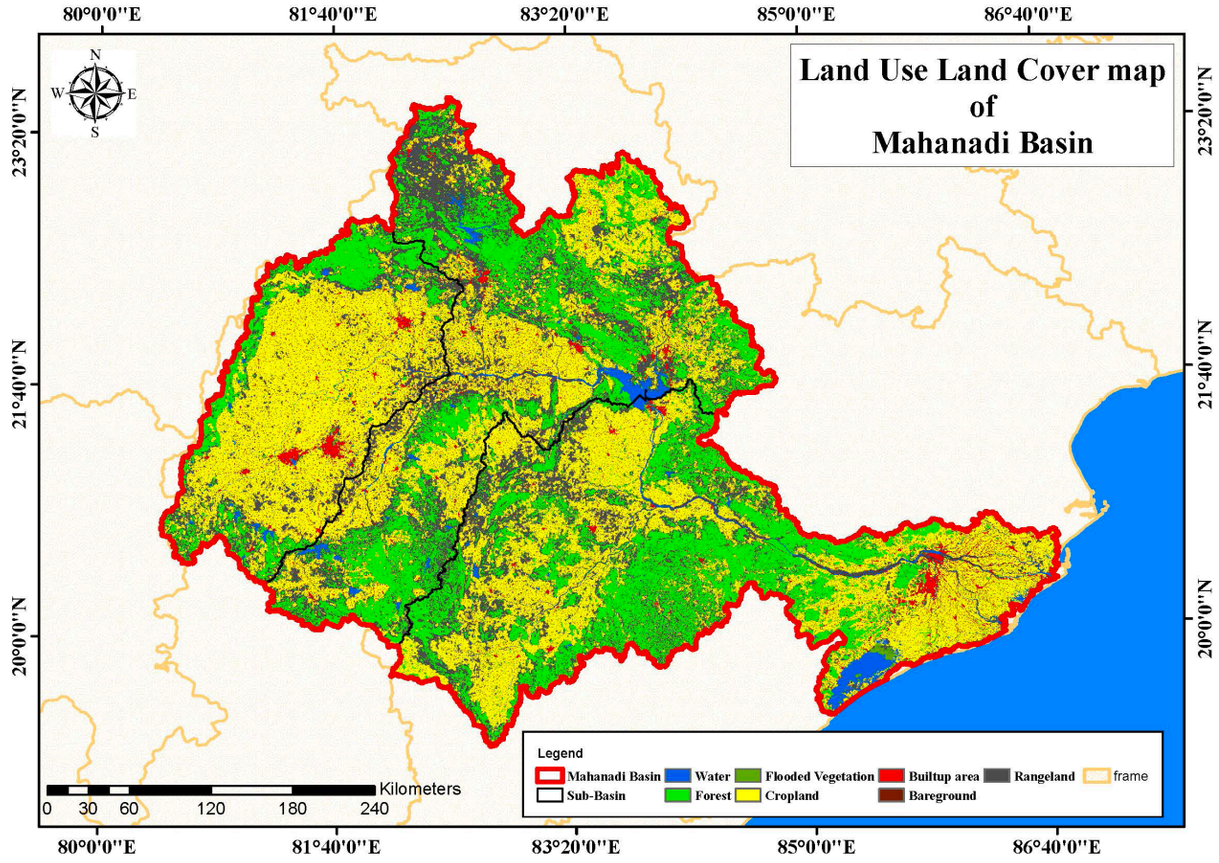

Figure 16 LU/LC Map of Mahanadi River Basin

by water bodies, which include reservoirs, lakes, rivers, etc. The inland wetland covers approximately 28 ha of land.

The two largest water bodies in the basin are Hirakud Reservoir and Chilka Lake, which can be easily identified on the LULC map. Moreover, the LULC pattern along the Mahanadi in Odisha is interspersed with urban areas, especially near major cities like Cuttack and Sambalpur. Urbanization has significantly transformed parts of the basin, with cities like Cuttack, Sambalpur, and Bhubaneswar experiencing rapid growth. This urban expansion has escalated the demand for both land and water resources, impacting the natural landscape. Accompanying this urban growth are robust industrial activities, notably in the steel, aluminium, and power sectors, which have reshaped land use patterns and exerted considerable influence on the regional environment. The integration of these diverse land uses within the Mahanadi Basin underscores the complex interaction between natural resources and human activities, highlighting the challenges of managing such a multifaceted watershed.

3.3 Soil

In the Mahanadi Basin, the distribution of soil types varies significantly, each with unique properties that influence agricultural productivity and land management practices. Sandy-loam soils, comprising around 50% of the basin, are predominantly found along riverbanks and floodplains. These soils offer excellent drainage but have a lower capacity for nutrient retention, making them suitable for crops that do not require nutrient-rich soil. Clay loam soils account for approximately 20% of the basin and are extensively present in the middle and lower parts. These soils strike a good balance between drainage and nutrient retention, supporting a variety of crops such as rice, wheat, and pulses.

Overall, the soil diversity across the Mahanadi Basin requires tailored agricultural practices to optimize crop yields and ensure sustainable land use. Understanding the specific properties of each soil type helps in selecting appropriate crops, implementing effective irrigation strategies, and adopting soil conservation measures to maintain soil health and productivity.

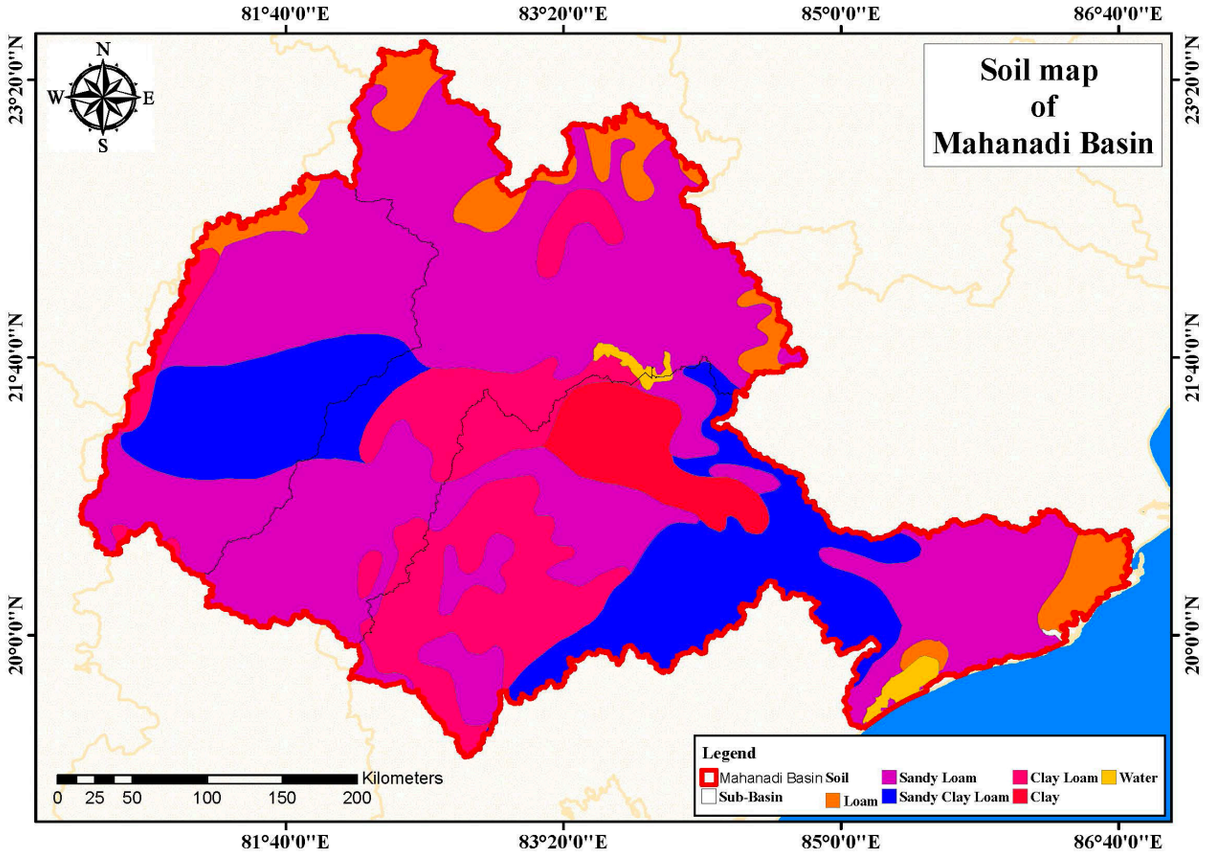

Figure 17 Soil Map of Mahanadi River Basin

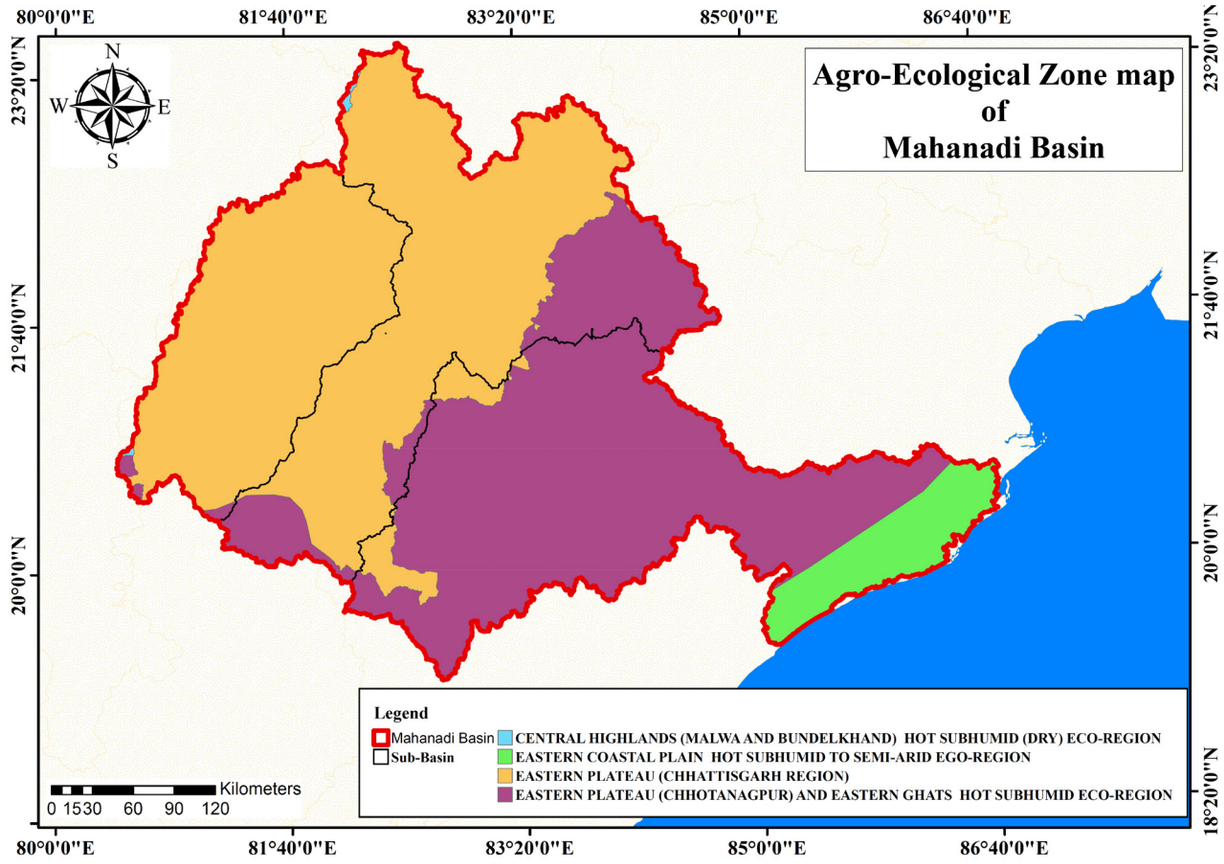

Figure 18 Agro-Climatic Map of Mahanadi River Basin

3.4 Agro-Climatic Zones

For effective resource development, India has been systematically divided into fifteen distinct agricultural regions. This division is based on comprehensive agro-climatic features, which include soil type, climate (encompassing temperature and rainfall and their variations), and the availability of water resources. These regions are carefully demarcated to optimize agricultural practices and resource management according to the specific characteristics of each area.

A major portion of the Mahanadi Basin, excluding the coastal plains, is classified under the 'Eastern Plateau and Hills' agro-climatic region. This extensive area is characterized by varied topography, including undulating plateaus and hilly terrains. The agro-climatic conditions in this region support a diverse range of agricultural activities, with crops such as maize thriving due to the moderate rainfall and favourable soil conditions. The coastal plains of the Mahanadi Basin fall under the 'East Coast Plains and Hills' agro-climatic region. This region experiences a unique climate influenced by its proximity to the Bay of Bengal, receiving moderate rainfall that supports the cultivation of crops like jute, which is well-suited to the coastal environment.

3.5 Rainfall

The average annual variations in the basin based on daily rainfall data (0.250 X 0.250) for the period 1971-2024, collected from IMD, is shown in Figure 17. The data reveals significant spatial differences in precipitation across the basin. Most of the Upper Mahanadi Basin receives an average annual rainfall of 1000-1200 mm. In contrast, the Middle and Lower Mahanadi sub-basins receive higher rainfall, averaging between 1200-1600 mm annually. A substantial portion of the basin's annual rainfall, about 80-90%, occurs during the southwest monsoon season, which spans from June to September, comparatively less rainfall from the southwest monsoon, approximately 60-70% of their average annual total. Instead, these deltaic regions benefit from the northeast monsoon, which occurs from October to December, contributing 10-22% of their annual rainfall. This distribution pattern underscores the critical role of both monsoon systems in influencing the hydrological dynamics of the Mahanadi Basin, necessitating tailored water management and agricultural planning strategies to accommodate these variations and optimize resource utilization throughout the year.

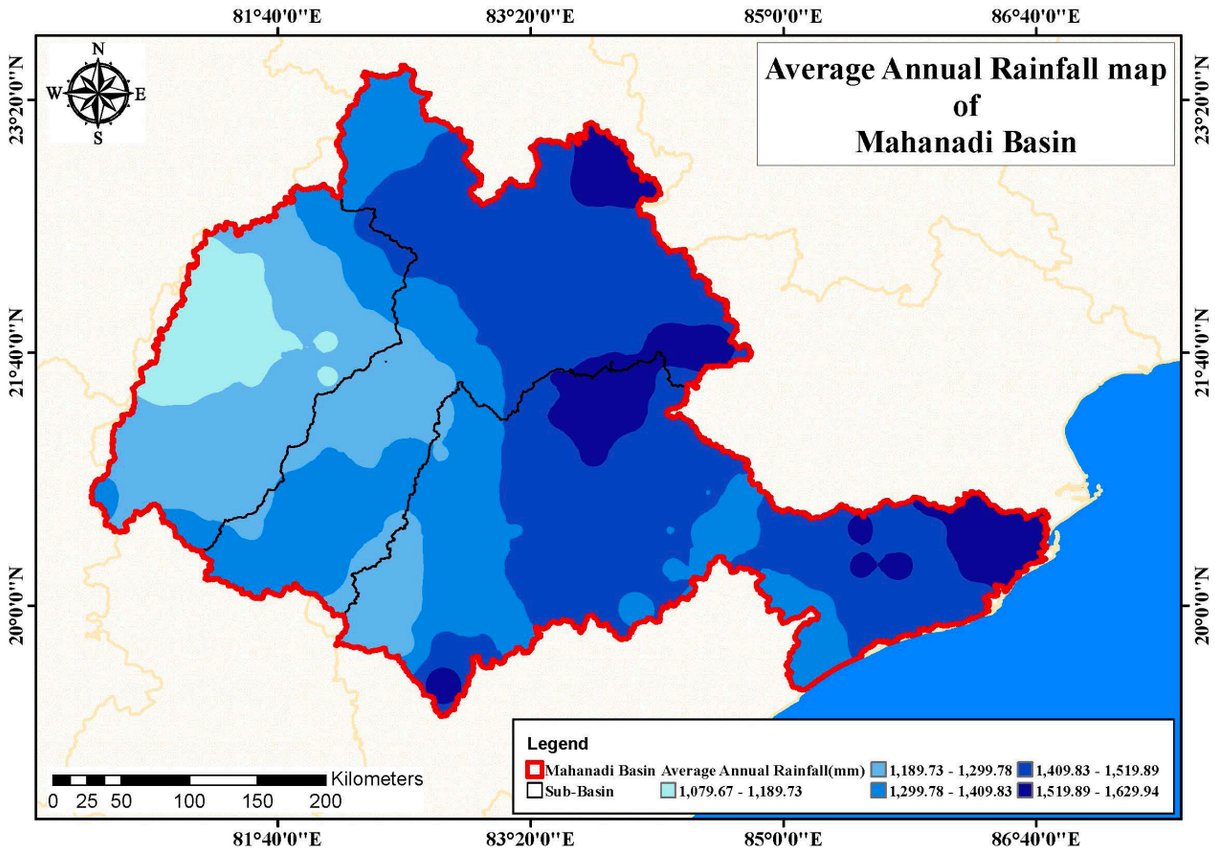

Figure 19 Annual Average Rainfall Map of Mahanadi River Basin

3.6 Tributaries and Their Elevation Characteristics

The Mahanadi flows for a total length of about 858 km of which, 357 km is in Chhattisgarh and the balance of 494 km is in Odisha. The river enters Odisha State below Raigarh and crosses the Eastern Ghats to enter the plains of Odisha near Cuttack. It finally debouches into the Bay of Bengal through a series of branches. After a run of about 450 km through the various districts in Chhattisgarh (earlier Madhya Pradesh), where it receives water from its major tributaries-the Seonath and Jonk. There the tributary "Tel" joins the river. The river flows in an easterly direction thereafter, up to Naraj.

The principal tributaries of the river upstream of Hirakud are Seonath, Hasdeo, Jonk, Mand and Ib, while Tel and Ong join in downstream of Hirakud. A description of the major tributaries of the Mahanadi, is given in the Table 3.

3.7 Impact of Elevation on River Dynamics

- Flow Velocity and Energy: Higher elevations in the upper reaches provide the river with greater potential energy, resulting in higher flow velocities and increased erosion capacity. As the river descends to lower elevations, its velocity decreases, promoting sediment deposition.
- Sediment Transport: The steep gradients in the upper reaches facilitate rapid sediment transport, while the flatter middle and lower reaches act as deposition zones, contributing to the formation of fertile alluvial plains.

Table 3 Sub-basins of Mahanadi and their catchment areas

S.N.	Name of River	Elevation of source	Length of Tributary in km	Catchment area in Sq.km	Annual Rainfall in mm	No. of Rain gauge stations	% of Total Area
1	Main River Mahanadi	442	851	48,230	1405	29	34.1
2	Pairi	488	113	3503	1213.1	1	2.5
3	Seonath	533	383	30761	1159.6	9	21.7
4	Jonk	762	196	3673	1251.2	2	2.6
5	Hasdeo	915	333	9803	1386.6	5	6.9
6	Mand	686	242	5237	1465.3	2	3.7
7	Ib	762	251	12447	1375.4	3	8.8
8	Ong	457	204	5128	1395.7	1	3.6
9	Tel	700	296	22818	1286.1	2	16.1

Source: Mahanadi Basin, Meteorological Yearbook (June 2016-May 2017) Hydrological Observation Circle, Bhubaneshwar, September 2017

- Flooding and Drainage Patterns: The floodplains in the middle and lower reaches are prone to seasonal flooding, which replenishes soil fertility but also poses challenges for agriculture and settlements.
- Ecosystem Distribution: Variations in elevation and topography create diverse habitats, supporting a wide range of flora and fauna. Forested hills, agricultural plains, and urban areas each host distinct ecosystems.

3.8 Degradation of catchment River stretches

The degradation of catchment river stretches in the Mahanadi River Basin is a complex and widespread issue affecting both Chhattisgarh and Odisha. This degradation is the result of various anthropogenic activities and natural processes, impacting the river's water quality, quantity, and overall ecological health.

In the upper catchment areas of Chhattisgarh, the degradation is primarily driven by deforestation, intensive agriculture, and rapid urbanization. The forests in the Mahanadi's origin region, particularly around Pharsiya village in Dhamtari district, have been steadily depleted, reducing the natural filtering capacity of the landscape. This has led to increased soil erosion and sedimentation in the river, altering its flow characteristics and habitat quality.

As the river flows through the industrial belts of Chhattisgarh, including areas around Raipur, Bilaspur, and Korba, the catchment degradation intensifies. Industrial activities, particularly coal mining and thermal power plants, have severely impacted the landscape. Open-cast mining in regions like the Korba coalfields has led to large-scale land use changes, increased sedimentation, and acid mine drainage. These activities not only pollute the river but also alter the natural hydrology of the catchment areas.

The middle stretches of the Mahanadi, flowing through the plains of Chhattisgarh and entering Odisha, face degradation from intensive agriculture. The widespread use of chemical fertilizers and pesticides in these regions has led to nutrient loading and chemical contamination of the river. Soil erosion from agricultural lands further contributes to siltation problems, particularly evident in the reduced storage capacity of the Hirakud Dam reservoir.

In Odisha, the catchment degradation continues with different characteristics. The construction of the Hirakud Dam, while providing benefits like flood control and irrigation, has significantly altered the river's flow regime. This has led to changes in sediment

transport patterns, affecting both upstream and downstream ecosystems. The lower reaches of the Mahanadi in Odisha, particularly the delta region, face unique degradation challenges. Intensive agriculture, aquaculture, and urban expansion in the delta have led to the loss of natural floodplains and wetlands. These changes have reduced the landscape's natural capacity to filter pollutants and buffer against floods. Additionally, the altered flow regime due to upstream dams and barrages has impacted the delicate balance of freshwater and saltwater in the delta, affecting both agriculture and natural ecosystems.

Throughout the basin, encroachment on river floodplains for urban and agricultural expansion has been a significant factor in catchment degradation. This has reduced the river's natural flood absorption capacity and led to more severe flooding events in recent years. The loss of riparian vegetation along the river banks has further exacerbated erosion and reduced the river's natural purification capabilities. Climate change is exacerbating these degradation processes. Changing rainfall patterns, including more intense but less frequent rainfall events, are leading to increased erosion and flash flooding in the catchment areas. This not only impacts water availability but also accelerates the transport of pollutants and sediments into the river system.

Addressing the degradation of catchment river stretches in the Mahanadi basin requires a comprehensive and integrated approach. This includes afforestation programs in the upper catchments, sustainable agricultural practices in the middle reaches, improved urban planning and waste management, and ecological restoration in the delta region. Additionally, better regulation of industrial activities, particularly mining and power generation, is crucial to mitigate their impact on the catchment areas.

Collaborative efforts between Chhattisgarh and Odisha are essential for effective basin-wide management. This includes joint monitoring programs, shared data on water quality and quantity, and coordinated policies for land use and water resource management. Engaging local communities in conservation efforts and promoting sustainable livelihood options that are less detrimental to the river ecosystem are also key components of any successful restoration strategy for the Mahanadi River Basin.

3.9 Degree of pollution

The Mahanadi River Basin, encompassing diverse stretches and tributaries across central and eastern India, faces significant pollution challenges that impact its water quality and ecosystem health. In this section we present a brief status of the degree of pollution in Mahanadi River Basin and Its Tributaries.

The Mahanadi River Basin, traversing through Chhattisgarh and Odisha, is plagued by numerous pollution hotspots that significantly impact its water quality and ecosystem health. These hotspots are characterized by intense pollution levels due to concentrated industrial, urban, or agricultural activities.

In Chhattisgarh, the Upper Mahanadi Sub-basin contains several notable pollution hotspots. The area around Raipur city is a major concern, where industrial discharges from steel plants and chemical industries combine with urban sewage to create a toxic cocktail. The confluence of the Seonath River near Shivrinarayan is another hotspot, where pollutants from multiple sources converge. Bilaspur city and its surroundings form another significant hotspot, particularly at the confluence of the Arpa River, where industrial effluents and urban waste accumulate.

Moving downstream, the stretch from Bilaspur to Korba is home to some of the most severe pollution hotspots in the basin. Korba, identified by the Central Pollution Control Board as a severely polluted industrial cluster, is a major pollution epicenter. The area is dominated by thermal power plants and aluminum industries, which release substantial amounts of heavy metals, fly ash, and thermal pollution into the river. The downstream areas of Korba witness a convergence of multiple industrial effluents, creating a zone of intense pollution.

The Durg-Bhilai urban complex forms another major hotspot, with the Bhilai Steel Plant and associated industries contributing heavily to water pollution. The areas downstream of this complex show high levels of heavy metals and organic pollutants.

In the Lower Mahanadi Sub-basin of Chhattisgarh, pollution hotspots are primarily found in the downstream areas near the Chhattisgarh-Odisha border. Here, the cumulative effect of upstream pollution sources creates zones of concentrated contamination.

Among the tributaries, several pollution hotspots stand out. The confluence of the Seonath and Kharun rivers is a major hotspot, where industrial pollution from Durg and Rajnandgaon meets the urban pollution from Raipur. In the Hasdeo River, areas downstream of major coal mines in the Hasdeo-Arand region form significant pollution hotspots, characterized by acid mine drainage and heavy metal contamination. The Ib River also has notable hotspots downstream of major coal mines in the Ib Valley, where the water quality is severely degraded by mining activities.

As the Mahanadi enters Odisha, the nature of pollution hotspots changes somewhat. The area around Sambalpur and the Hirakud Dam forms a complex pollution zone. While the dam acts as a sink for upstream pollutants, it also creates issues of eutrophication and altered water quality downstream. The stretch near Cuttack city is another significant hotspot, where urban sewage and industrial effluents from the city and surrounding areas converge.

In the delta region of Odisha, pollution hotspots are more diffuse but still significant. Areas of intensive agriculture and aquaculture create zones of nutrient pollution and pesticide contamination. The points where various distributaries of the Mahanadi meet the Bay of Bengal form unique pollution hotspots, where the interaction of freshwater pollution with saline water creates complex environmental challenges.

These pollution hotspots across the Mahanadi Basin represent areas of critical concern, where the concentration of pollutants poses severe risks to aquatic life, human health, and overall ecosystem functioning. They are the result of years of uncontrolled industrial growth, inadequate urban planning, and insufficient pollution control measures. Addressing these hotspots requires targeted interventions, including advanced effluent treatment, strict industrial regulation, improved urban waste management, and comprehensive river basin management approaches.

4. SIGNIFICANCE OF DIFFERENT SEGMENTS/ SUB-BASINS OF RIVER BASIN DISCUSSED FROM VARIOUS ASPECTS

The Mahanadi River basin, spanning the regions of Odisha and Chhattisgarh, plays a significant role in the states' ecological, historical, social, cultural, behavioral, political, economic, socio-cultural, socio-political, and socio-economic landscapes. Here is a detailed overview of each aspect:

4.1 Economic

4.1.1 Agriculture

The Mahanadi River is crucial for irrigation, supporting agriculture, which is the primary livelihood for many in both Odisha and Chhattisgarh. The fertile plains of the Mahanadi basin are particularly well-suited for cultivating rice, the staple crop of the region. In addition to rice, farmers grow a variety of pulses, oilseeds, and vegetables, contributing to agricultural diversity and food security.

The river's extensive network of tributaries and canal systems facilitates year-round farming and enables the practice of multiple cropping patterns. This irrigation infrastructure ensures that water is available even during dry seasons, allowing farmers to cultivate their fields continuously and increase their agricultural productivity. The ability to grow multiple crops throughout the year not only enhances food production but also supports the livelihoods of thousands of farming households in the region.

Furthermore, the Mahanadi's irrigation systems have been instrumental in transforming the agricultural landscape of Odisha and Chhattisgarh, enabling the adoption of modern farming techniques and improving crop yields. By providing a reliable source of water, the Mahanadi River ensures that the agricultural sector remains resilient to climatic variations and continues to be a cornerstone of the region's economy.

4.1.2 Industry

The Mahanadi basin is a significant industrial region, underpinned by its abundant water resources that support various industrial activities. These activities include power generation and the

operation of industries such as steel, cement, and aluminium manufacturing, all of which are vital to the economic development of the region.

Prominent industrial hubs within the Mahanadi basin include Hirakud Aluminum Plant (Hindalco), Paradip Port and Industries, Bhushan Steel Plant (Dhenkanal), Jharsuguda, Sambalpur, Choudwar, Cuttack, Paradeep Phosphates Limited, Bhushan Power and Steel Limited (Sambalpur), Bhilai, Korba.

In addition to these industrial activities, the Mahanadi basin is rich in coal deposits, which are crucial for sustaining both local and national energy needs. Key coalfields in the region include Hingula, Basundhara, Bharatpur, Belpahar & Kaniha Open Cast Coal Mines, Talcher, Ib Valley. These coalfields are pivotal in providing the necessary fuel for power plants and industrial operations, making the Mahanadi basin an energy hub for the country. The synergy between water resources and industrial activities in the basin underscores its importance in the economic landscape of Odisha, Chhattisgarh, and India.

4.1.3 Fishing

The Mahanadi River supports a significant fishing industry, providing livelihoods for numerous local fishing communities along its banks. The river's diverse aquatic ecosystem offers a rich variety of fish species that are harvested and sold in both local and regional markets, contributing to the economic well-being of the communities.

One of the most prominent fishing areas in the region is Chilika Lake, which accounts for a substantial portion of the fishing industry in Odisha. Chilika Lake, Asia's largest brackish water lagoon, is located at the mouth of the Daya River, a tributary of the Mahanadi. This unique ecosystem supports a wide range of fish species, including commercially valuable ones like prawns, crabs, and various finfish, which are essential for both local consumption and export.

4.2 Socio-Cultural Aspects

4.2.1 Cultural Significance

The Mahanadi River holds immense cultural and religious significance for the people of Odisha, Chhattisgarh, and the surrounding regions. Numerous festivals and rituals are deeply intertwined with the river, reflecting its importance in the spiritual and cultural life of the communities along its banks.

One of the prominent festivals associated with the Mahanadi River is the Kalinga Mahotsav. This festival commemorates the historic Battle of Kalinga, which took place near the Dhauli Hills on

the banks of the Daya River, a tributary of the Mahanadi. Another significant festival is Kartik Purnima, celebrated on the full moon day of the Hindu month of Kartik. Boita Bandana, symbolizes the ancient maritime heritage of Odisha and pays homage to the seafaring traditions of the region. Bali Jatra, also known as the Voyage to Bali, is one of the grandest festivals celebrated along the Mahanadi River. Held in the city of Cuttack at Gadagadia Ghata.

In Chhattisgarh, the river holds similar cultural and religious importance. Festivals such as Chhath Puja and various local fairs are celebrated with great enthusiasm along the riverbanks. The temples and pilgrimage sites along the river are integral to the cultural identity of the local communities.

4.2.2 Heritage and Traditions

The Mahanadi basin is a treasure trove of heritage sites and traditional practices, reflecting the rich cultural tapestry of the region. The area is renowned for its folk music, art forms, and dance, with Odissi dance being one of the most prominent classical dance forms originating from this region. Odissi, characterized by its graceful movements and intricate expressions, has its roots in the temples of Odisha and is a testament to the region's artistic heritage.

The basin's cultural landscape is further enriched by various folk music traditions, which include soulful renditions that narrate the tales of the land and its people. Art forms in the Mahanadi basin are diverse and vibrant. Pattachitra, a traditional scroll painting style, and intricate handloom weaving, especially the famous Sambalpuri sarees, are notable examples of the region's artistic excellence. These art forms often depict themes from local myths, legends, and folklore, providing a visual narrative of the region's cultural history.

In Chhattisgarh, the heritage and traditions are equally rich. The region is known for its folk music, dance, and art forms such as Pandwani (a traditional storytelling art form). The river and its surroundings inspire many local myths, legends, and folklore. In essence, the Mahanadi basin is a living repository of cultural heritage, where traditional practices, art forms, and folklore continue to inspire and sustain the region's.

4.3 Behavioural Aspects

The Upper Mahanadi segment stretches from the river's source in the highlands of Chhattisgarh to the Hirakud Dam. This section is characterized by its steep gradient and high rainfall, resulting in rapid flow and significant erosion. The river's behavior in this segment is particularly dynamic, with strong seasonal variations. During monsoons, the upper Mahanadi experiences high-velocity flows that carry substantial amounts of sediment, shaping the landscape and contributing to the river's overall sediment load. This segment's behavior is crucial for hydropower generation, as the

steep gradient and high flow rates are ideal for electricity production. The Hirakud Dam, located at the end of this segment, plays a vital role in harnessing this energy potential.

The Middle Mahanadi segment extends from the Hirakud Dam to the beginning of the delta in Odisha. This section exhibits a marked change in the river's behavior compared to the upper segment. The gradient becomes more moderate, and the river valley widens, allowing for the formation of extensive floodplains. The behavior of the river in this segment is largely influenced by the Hirakud Dam, which regulates the flow and significantly alters the natural hydrological regime. This regulation has profound implications for flood control, irrigation, and agriculture in the region.

The Lower Mahanadi, also known as the Mahanadi Delta, begins where the river starts to branch out into numerous distributaries before meeting the Bay of Bengal. The river's behavior in this segment is distinctly different from the upper and middle segments. Here, the gradient becomes very gentle, and the river's flow slows considerably. The delta is characterized by complex hydrological behavior influenced by both riverine and tidal processes. The river deposits large amounts of sediment in this region, constantly reshaping the landscape and creating a dynamic environment of shifting channels and islands. This segment's behavior is crucial for the region's ecology, supporting diverse ecosystems including coastal mangrove forests. It's also vital for agriculture and aquaculture, with the fertile delta soils and abundant water supporting intensive farming and fisheries.

4.4 Socio-Political Aspects

4.4.1 Governance and Development

The state governments of Chhattisgarh and Odisha have implemented various development projects in the Mahanadi basin, focusing on infrastructure, irrigation, and environmental conservation efforts. In Chhattisgarh, the government has prioritized the development of dams and irrigation projects to support agriculture and ensure water availability throughout the year. These initiatives are aimed at boosting agricultural productivity and supporting rural communities.

In Odisha, the government has concentrated on infrastructure projects like roads, bridges, and urban development to enhance connectivity and economic growth. Additionally, efforts have been made to conserve the environment by implementing policies to prevent pollution and over-extraction of water from the river.

Political movements and parties in both states often highlight issues related to the river basin, such as water management, flood control, and the rehabilitation of communities displaced by industrial and infrastructure projects. These issues are central to the political discourse in both states and play a significant role in shaping governance strategies.

4.5 Socio-Economic Aspects

4.5.1 Livelihood

A significant portion of the population in the Mahanadi basin relies on agriculture, fishing, and related activities for their livelihoods. The river's fertile plains support the cultivation of staple crops such as rice, pulses, oilseeds, and vegetables. Fishing is another critical livelihood activity supported by the Mahanadi River. The diverse aquatic ecosystem of the river and its associated water bodies, such as Chilika Lake, provides a rich variety of fish species. The river also supports secondary economic activities such as trade, transport, and small-scale industries. Markets and trading centres have developed along the riverbanks, enabling the exchange of goods and services and fostering economic growth.

4.5.2 Health and Education

The socio-economic development in the Mahanadi basin has led to improvements in health and education facilities. Access to clean water from the river has had a positive impact on public health, reducing the prevalence of waterborne diseases. However, there are still challenges in providing adequate healthcare services, especially in rural and remote areas. Efforts by the government and NGOs focus on improving healthcare infrastructure, increasing the availability of medical professionals, and promoting health awareness campaigns.

Education facilities in the region have also seen progress, with increased enrolment rates and the establishment of new schools and colleges. Nevertheless, disparities remain, particularly in rural areas where access to quality education is limited. Government initiatives and NGOs are working towards enhancing educational opportunities, providing scholarships, and supporting teacher training programs to improve the overall quality of education.

4.5.3 Infrastructure

The presence of the Mahanadi River has prompted the development of significant infrastructure projects, enhancing connectivity and boosting the regional economy. The construction of dams, such as the Hirakud Dam, has not only provided irrigation but also facilitated hydroelectric power generation, contributing to the energy needs of the region. Bridges and roads have been built to connect urban and rural areas, improving transportation and access to markets, healthcare, and education.

Urban centers in the basin, such as Cuttack, Sambalpur, Puri, Khordha, Raipur, and Bilaspur, benefit from the river's resources, facilitating urban development and growth. These cities have seen expansions in industrial activities, commercial enterprises, and residential areas, driven by the availability of water and improved infrastructure.

5. BIODIVERSITY AT A GLANCE

The Mahanadi River Basin is characterized by diverse ecosystems, which support a rich array of flora and fauna. This section presents the overview of the biodiversity in the Mahanadi River Basin.

5.1 Flora Diversity of Mahanadi River Basin

The Mahanadi River Basin hosts a rich diversity of plant species, contributing significantly to its ecological wealth. This diversity is shaped by the basin's varied topography, climate, and soil types, ranging from tropical moist deciduous forests to tropical dry deciduous forests and riparian vegetation.

The basin is home to a variety of plant species, including:

a) **Tropical Moist Deciduous Forests:** These forests are widespread in the upper reaches of the basin, particularly in Chhattisgarh. They are characterized by species such as Sal (Shorea robusta), Teak (Tectona grandis), and Bamboo.

b) **Tropical Dry Deciduous Forests:** Found in the middle and lower reaches of the basin, especially in Odisha. Dominant species include acacia, Neem (Azadirachta indica), Mahua (Madhuca indica), Palas (Butea monosperma).

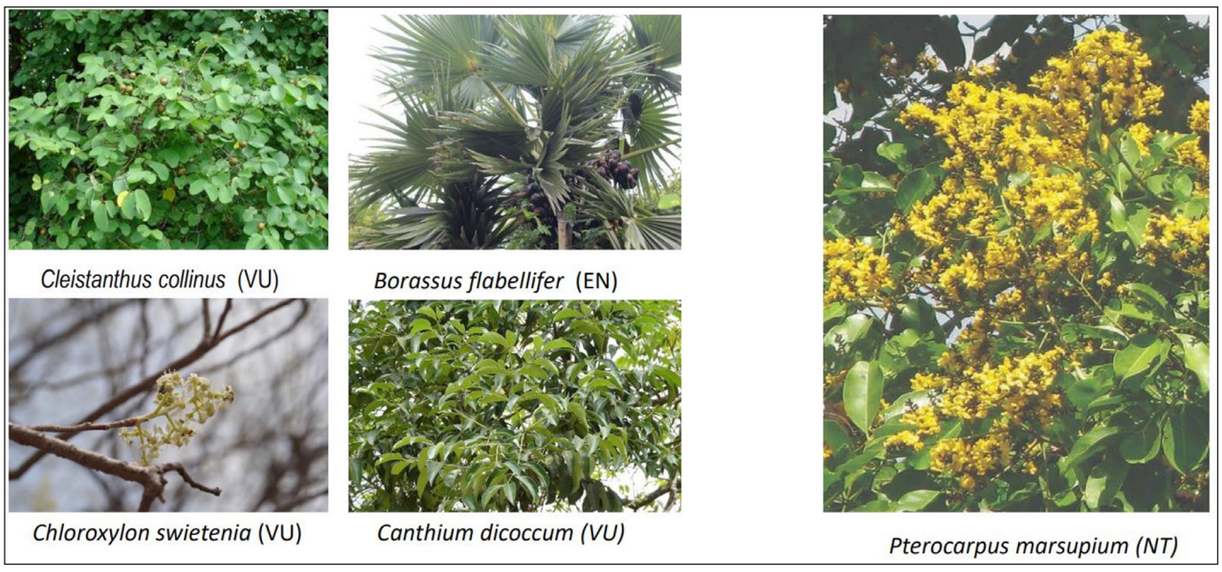

Figure 20 Threatened Flora of Mahanadi River Basin

c) **Riparian Vegetation:** Along the riverbanks, the vegetation includes a mix of grasses, reeds, and trees adapted to the wet conditions, such as willows and certain types of palms.
d) **Mangroves (In Delta Regions):** Avicennia spp., Rhizophora spp.
e) **Medicinal Plants:** Ashwagandha (Withania somnifera), Brahmi (Bacopa monnieri), Giloy (Tinospora cordifolia).
f) **Endemic and Endangered Plants:** Hopea odorata, Boswellia serrata.
g) **Rare and Economically Important Plants:** Santalum album (Indian Sandalwood), Pterocarpus santalinus (Red Sanders).

5.2 Fauna Diversity in the Mahanadi River Basin

The Mahanadi River Basin is a biodiversity hotspot, supporting a wide array of animal species across its varied ecosystems. This diversity is influenced by the basin's rich habitats, including forests, wetlands, riverine systems, and grasslands. Mahanadi River Basin supports diverse taxa of Herpetofauna which includes Amphibians and Reptiles.

Reptiles: The basin is home to several reptile species, including:
a) **Crocodilians:** Mugger Crocodile (Crocodylus palustris), Gharial (Gavialis gangeticus).
b) **Snakes:** Indian Python (Python molurus), Spectacled Cobra (Naja naja).
c) **Turtles and Tortoises:** Indian Flapshell Turtle (Lissemys punctate), Indian Tent Turtle (Pangshura tentoria).

Amphibians: The basin is home to several amphibian species, including:
a) **Frogs and Toads:** Indian Bullfrog (Hoplobatrachus tigerinus), Common Indian Toad (Duttaphrynus melanostictus)
b) Caecilians (Ichthyophis spp.)

Figure 21 Herpetofauna diversity of Mahanadi River Basin

Mammals: The basin is home to several mammal species, including:

a) **Big Cats:** Bengal Tiger (Panthera tigristigris), Leopard (Panthera pardus)
b) **Elephants:** Asian Elephant (Elephas maximus)
c) **Herbivores:** Indian Bison (Bos gaurus), Chital (Axis axis), Sambar Deer (Rusa unicolor)
d) **Primates:** Bonnet Macaque (Macaca radiata) and Hanuman Langur (Semnopithecus entellus)
e) **Other Mammals:** Sloth Bear (Melursus ursinus), Indian Pangolin (Manis crassicaudata).

Birds: The basin is home to several bird species, including:

a) **Wetland and Water Birds:** Sarus Crane (Antigone antigone), Painted Stork (Mycteria leucocephala), Black-bellied Tern (Sterna acuticauda).
b) **Raptors:** White-rumped Vulture (Gyps bengalensis), Crested Serpent Eagle (Spilornis cheela).
c) **Forest Birds:** Indian Peafowl (Pavo cristatus), Red Junglefowl (Gallus gallus).

Fish: The basin is home to several fish species, including:

a) **Riverine Fish:** Rohu (Labeorohita), Catla (Catlacatla), and Mrigal (Cirrhinus cirrhosus).
b) **Catfish:** Walking Catfish (Clarias batrachus), Mystus spp.

Figure 22 Fish Diversity of Mahanadi River Basin

6. CURRENT STATE OF THE BASIN AND THE RIVER INCLUDING MAJOR TRIBUTARIES

6.1 Mahanadi River in Chhattisgarh and Odisha: An Overview

The Mahanadi River, one of the major rivers of India, originates in the state of Chhattisgarh and serves as a lifeline for the region. Rising from the Sihawa hills in Dhamtari district, the river traverses a significant portion of Chhattisgarh before flowing into Odisha and eventually emptying into the Bay of Bengal. The river's course through Chhattisgarh spans approximately 357 km. After entering Odisha, the Mahanadi passes through several districts, providing vital resources for agriculture, industry, and domestic use before emptying into the Bay of Bengal. The Mahanadi basin in Odisha is characterized by rich alluvial plains, extensive forests, and a variety of flora and fauna. The river's course through Odisha spans approximately 494 kilometres, receiving numerous tributaries and supporting diverse ecosystems and communities along its path.

6.1.1 Mahanadi River Delta System

As the Mahanadi River approaches its mouth, it forms a vast and intricate delta before emptying into the Bay of Bengal. The Mahanadi River Delta spans across several districts, including Kendrapara, Jagatsinghpur, and Puri. This deltaic region is characterized by its fertile alluvial soils, extensive mangrove forests, and a network of distributaries. The delta supports a dense population engaged primarily in agriculture and fishing. The region is also ecologically significant, hosting a variety of wildlife, including endangered species in the Bhitarkanika National Park. The delta's wetlands and mangroves play a critical role in coastal protection and biodiversity conservation. However, the area faces challenges such as flooding, saline water intrusion, and environmental degradation due to human activities.

6.2 Tributaries and Hydrological Contributions

6.2.1 Chhattisgarh Region

Several tributaries join the Mahanadi in Chhattisgarh, enhancing its flow and contributing to the river's hydrological complexity. Notable tributaries include:

I. Seonath River

a) **Drainage Area:** Covers parts of Rajnandgaon, Durg, and Bilaspur districts.
b) **Land Use:** Mix of agricultural lands, small towns, and industrial zones.
c) **Impact:** Moderately impacted by agricultural runoff and smaller industries, leading to moderate pollution levels.

II. Jonk River

a) **Drainage Area:** Drains parts of Mahasamund district.
b) **Land Use:** Predominantly agricultural with some rural settlements.
c) **Impact:** Affected by agricultural activities and small-scale industries, contributing moderate levels of runoff and wastewater discharge.

III. Mand River

a) **Drainage Area:** Flows through Korba and Bilaspur districts.
b) **Land Use:** Initially forested regions, later affected by coal mining areas.
c) **Impact:** Initially contributes clean water but picks up pollution from mining activities downstream.

IV. Tandula River

a) **Drainage Area:** Covers parts of Durg and Balod districts.
b) **Land Use:** Agricultural and industrial areas, including steel and cement industries.
c) **Impact:** Significantly impacted by industrial activities and urban runoff.

V. Kharun River

a) **Drainage Area:** Drains the Raipur district.
b) **Land Use:** Urban and industrial areas.
c) **Impact:** Heavily impacted by urban runoff and industrial discharges, particularly from Raipur.

VI. Arpa River

a) **Drainage Area:** Flows through Bilaspur district.
b) **Land Use:** Urban and industrial development.
c) **Impact:** Experiences significant pollution from urban and industrial discharges.

VII. Hasdeo River

a) **Drainage Area:** Originates in Surguja and flows through Korba and Bilaspur districts.
b) **Land Use:** Initially forested areas, then coal mining and industrial zones.
c) **Impact:** Faces severe pollution from coal mining and industrial activities, particularly in Korba.

6.2.2 Odisha Region

Several tributaries join the Mahanadi in Odisha, enhancing its flow and contributing to the river's hydrological complexity. Notable tributaries include:

I. Ib River

a) Drainage Area: Covers parts of Sundargarh, Jharsuguda, and Sambalpur districts.
b) Land Use: Predominantly agricultural with some urban and industrial areas.
c) Impact: Moderately impacted by agricultural runoff and small-scale industries, leading to moderate pollution levels.

II. Ong River

a) **Drainage Area:** Drains parts of Balangir and Bargarh districts.
b) **Land Use:** Predominantly agricultural with some rural settlements.
c) **Impact:** Affected by agricultural activities, contributing moderate levels of runoff.

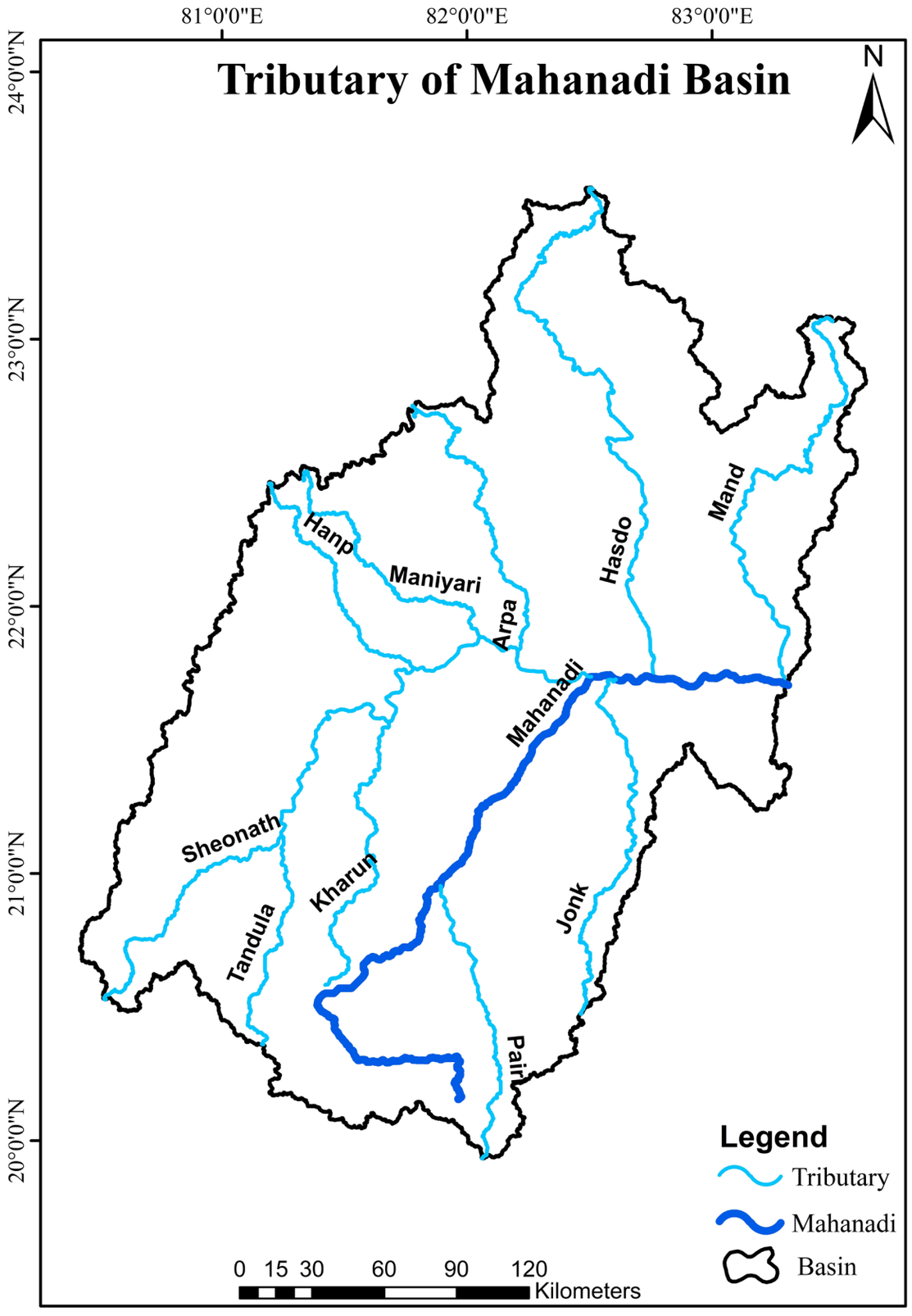

Figure 23 Tributaries of Mahanadi River in Chhattisgarh region

III. Tel River

a) **Drainage Area:** Flows through Kalahandi, Balangir, Sonepur, and Boudh districts.
b) **Land Use:** Initially forested regions, later agricultural and urban areas.
c) **Impact:** Initially contributes clean water but picks up pollution from agricultural and urban runoff downstream.

The Mahanadi River Basin is facing a multifaceted crisis. These challenges impact the ecosystem, economic activities, and communities relying on the river. Pollution from industries and cities, excessive sand mining, agricultural runoff laden with fertilizers and pesticides, and deforestation in the catchment area that reduces water retention capacity and increases sedimentation in reservoirs, are all degrading the river's health. Land-use changes that prioritize short-term economic gains over long-term sustainability, such as encroachment on floodplains and conversion of wetlands to agriculture, further exacerbate the problems. Addressing land use changes and promoting sustainable development practices are key to the river's conservation.

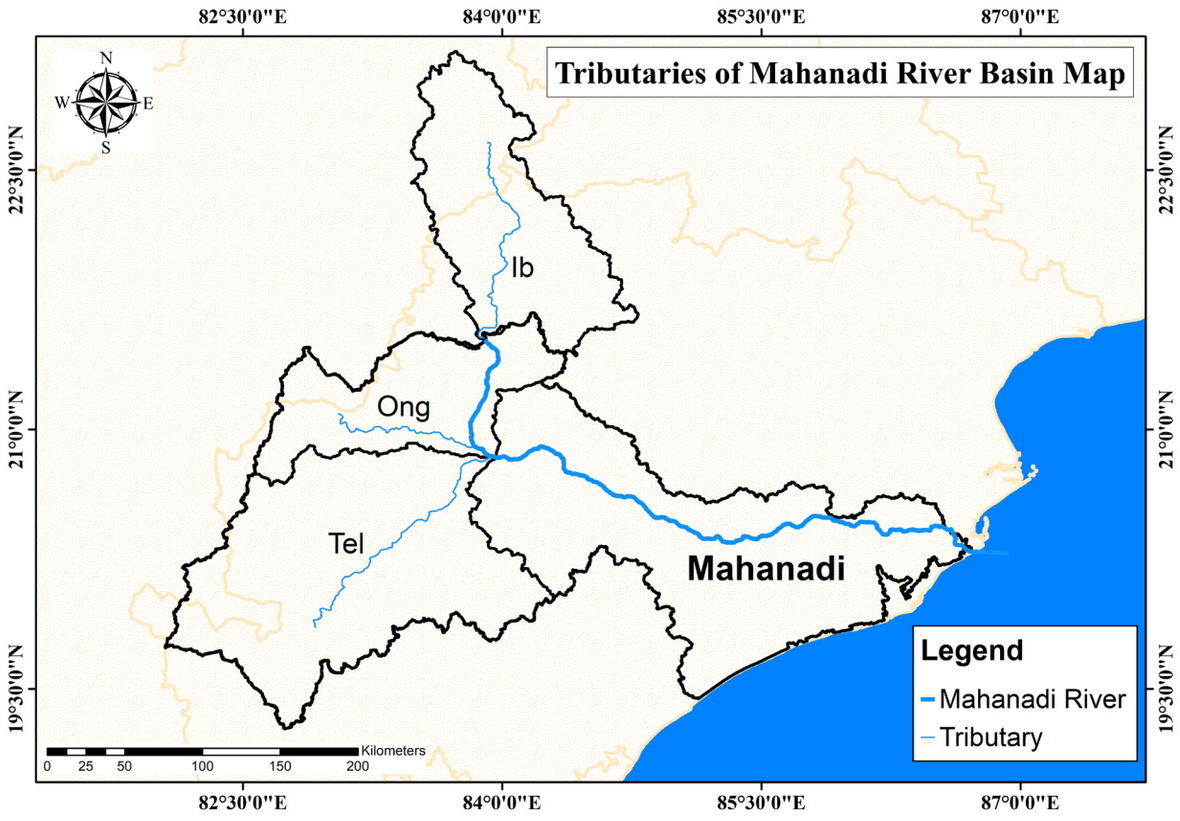

Figure 24 Tributaries of Mahanadi River in Odisha region

6.2.3 Distributaries in Mahanadi River Delta System

The Mahanadi River Delta system is a complex network of distributaries that branch off from the main river as it approaches the Bay of Bengal. These distributaries play a crucial role in irrigation, agriculture, and maintaining the ecological balance of the region.

I. Kathajodi River:

a) **Origin:** Branches off from the Mahanadi River near Naraj, Cuttack.
b) **Significance:** One of the primary distributaries, it flows parallel to the Mahanadi and supports agricultural activities in the region.
c) **Confluence:** Merges with other distributaries before reaching the Bay of Bengal.

II. Kuakhai River:

a) **Origin:** Splits from the Kathajodi River.
b) **Significance:** Plays a vital role in water distribution and irrigation.
c) **Confluence:** Further divides into several smaller distributaries.

III. Devi River:

a. **Origin:** Branches off from the Kuakhai River.
b. **Significance:** Important for irrigation and supports local agriculture.
c. **Confluence:** Flows through Jagatsinghpur district and empties into the Bay of Bengal.

IV. Bhargavi River:

a) **Origin:** Originates from the Kuakhai River.
b) **Significance:** Supports irrigation and agriculture in the Khurda and Puri districts.
c) **Confluence:** Empties into the Bay of Bengal near Puri.

V. Daya River:

a) **Origin:** Branches off from the Kuakhai River.
b) **Significance:** Historically important and supports irrigation. It flows into Chilika Lake.
c) **Confluence:** Empties into Chilika Lake, which then drains into the Bay of Bengal.

VI. Kushabhadra River:

a) **Origin:** Another distributary from the Kuakhai River.
b) **Significance:** Supports agriculture and is known for its scenic beauty near Konark.
c) **Confluence:** Empties into the Bay of Bengal near the Puri district.

6.3 Industrial Impacts and Highly Disturbed Areas

Industrial activities and urban sprawl heavily pollute the Mahanadi River in Chhattisgarh and Odisha. From power plants to steel factories, industries dump wastewater. Industrial zones in the cities of Bhilai, Raipur, Raigarh, Angul, Jharsuguda, and Paradeep along with coal mining activities in places like Korba and Talcher, further contaminates the river with runoff. Cities like Raipur and Cuttack add sewage and polluted rainwater. This noxious combination of industrial effluent, mining discharge, and municipal wastewater severely degrades the river's health, making it a major challenge to maintain water quality.

6.4 Land Use and Anthropogenic Influences

Land use patterns along the Mahanadi River in both Chhattisgarh and Odisha significantly influence its health and sustainability. The upper reaches of the river are predominantly forested, providing crucial ecological benefits. However, the middle and lower reaches see extensive agricultural and industrial land use. Agricultural practices in these areas contribute to soil erosion and runoff, which carry sediments and agrochemicals into the river. Urbanization, particularly in cities like Raipur, Durg, Bhilai, Bilaspur of Chhattisgarh and Cuttack, Sambalpur, and Puri of Odisha state brings increased wastewater discharge and solid waste, further straining the river's capacity to sustain its ecosystems. The changes in land cover from forest to agriculture and urban areas negatively impact the river's hydrology and water quality, highlighting the need for sustainable practices and pollution management strategies to protect this crucial resource.

7. MAP SENSITIVE/ VULNERABLE/ UNDISTRIBUTED AREAS ON THE BASIS OF HUMAN INTERVENTIONS, ANTHROPOGENIC POLLUTION, SEDIMENT TRANSPORT AND DEPOSITION, LAND USE ETC.

7.1 Overview

The Mahanadi River Basin and its tributaries in Chhattisgarh state and Odisha present a complex ecosystem significantly impacted by various environmental and anthropogenic factors. This comprehensive analysis classifies and maps sensitive, vulnerable, and undisturbed areas along these rivers, providing crucial insights into the status of Mahanadi River Basin. The classification and mapping of the sensitive, vulnerable, and undisturbed areas along these rivers is presented in Table 4 and Figure 25 below:

7.2 Classify areas based on least disturbed/ undisturbed, moderately and highly disturbed

7.2.1 Least Disturbed Areas

These areas are relatively pristine, with minimal human interference, and support rich biodiversity. In the upper reaches of the Mahanadi River, the area is less affected by urbanization and industrial activities, maintaining a largely natural flow and ecosystem. Similarly, the upper reaches of the Hasdeo River, which flow through the dense forests of Surguja district, retain much of their natural state with minimal anthropogenic influences. The upper reaches of the Mand River, located in forested regions around Korba, are also away from major human settlements and industrial activities, preserving a largely natural environment.

In Odisha, the upper reaches of the Ong River flow through the forested regions of Bargarh district, retaining much of their natural state with minimal human impact. The upper reaches of the Tel River, located in the forested regions of Kalahandi district, remain largely undisturbed, away from major human settlements and industrial activities. Additionally, the upper reaches of the Ib River flow through the dense forests of Sundargarh district, maintaining a relatively undisturbed and natural ecosystem.

Table 4 Classification of Sensitive/ Vulnerable/ Undisturbed Area

River	Sensitive Areas	Vulnerable areas	Undisturbed area
Mahanadi River	• Raipur: Capital city, home to steel, aluminum, and cement industries • Bilaspur: Major industrial hub with thermal power plants • Korba: Known for coal mining and aluminum production (BALCO) • Sambalpur: Industrial pollution from Hirakud Dam area • Bhubaneswar: Capital City, Urban pollution and industrial effluents • Cuttack: Urban pollution and industrial effluents	• Agricultural regions in Durg and Raigarh districts with heavy pesticide use • Areas around Jindal Steel and Power Ltd. in Raigarh • Agricultural regions in Cuttack and Puri districts with heavy pesticide • Areas around Paradeep port and IOCL refinery	• Portions flowing through Satkosia Gorge Sanctuary • Stretches near Sirpur-Kagaznagar • Portions flowing through Satkosia Gorge Sanctuary • Stretches near the Mahanadi Wildlife Division
Seonath River	• Durg-Bhilai urban complex: Steel plants (Bhilai Steel Plant) • Rajnandgaon: Textile and rice milling industries	• Bauxite mining areas in Balod district • Coal mining regions near Dipka and Gevra	• Stretches in rural Kawardha district
Jonk River	• Mahasamund: Small-scale industries and rice mills	• Intensive agriculture zones in Nuapada district (Odisha border)	• Upper reaches in Gariaband district forests
Mand River	• Coal mining regions in Raigarh district (South Eastern Coalfields Limited) • Areas near Jindal Power Limited's thermal power plant in Tamnar	• Soil erosion-prone areas in Janjgir-Champa district	• Portions flowing through less populated regions of Raigarh district
Tandula River	• Near Durg city: Industrial effluents from small-scale industries	• Deforested areas in Balod district	• Stretches within Barnawapara Wildlife Sanctuary
Kharun River	• Sections near Raipur city: Urban pollution and industrial discharge • Naya Raipur Development Area: Rapid urbanization	• Agricultural areas in Durg district with high fertilizer use	• Upper reaches in Balod district

River	Sensitive Areas	Vulnerable areas	Undisturbed area
Arpa River	• Near Bilaspur city: Urban sewage and industrial pollution • Korba: Thermal power plants (NTPC, CSEB) and coal mining	• Areas prone to industrial effluent discharge from Sipat Thermal Power Station	• Sections in rural Bilaspur district
Hasdeo River	• Coal mining regions in Korba district (South Eastern Coalfields Limited) • Areas affected by NTPC's Sipat Thermal Power Plant	• Regions impacted by Jindal Power's thermal plant in Tamnar • Areas prone to ash pond leakage from power plants	• Portions flowing through Hasdeo Arand forests
Ib River	• Jharsuguda: Industrial pollution from Vedanta Aluminum plant • Rajnandgaon: Textile and rice milling industries	• Coal mining regions in Ib Valley	• Upper reaches near Sundargarh forest areas
Tel River	• Bhawanipatna: Urban pollution and agricultural runoff • Titlagarh: Industrial effluents	• Areas around Sonepur: Intensive agriculture with heavy fertilizer use	• Portions flowing through less populated regions of Kalahandi and Balangir districts
Ong River	• Dhenkanal: Industrial pollution from industries along the river • Angul: Impacts from aluminum and steel industries	• Agricultural regions with intensive farming practices in Dhenkanal and Angul districts	• Upper reaches in forested areas of Dhenkanal district
Kuakhai River	• Bhubaneswar: Urban pollution and sewage discharge • Cuttack: Industrial effluents and urban development impacts	• Agricultural areas in Cuttack and Khordha districts with pesticide and fertilizer use	• Portions flowing through Chandaka Wildlife Sanctuary
Devi River	• Puri: Tourism-related pollution and solid waste • Khurda: Industrial activities urban and growth	• Agricultural areas with chemical runoff in Puri and Khurda districts	• Sections near Chilika Lake and Nalabana Bird Sanctuary

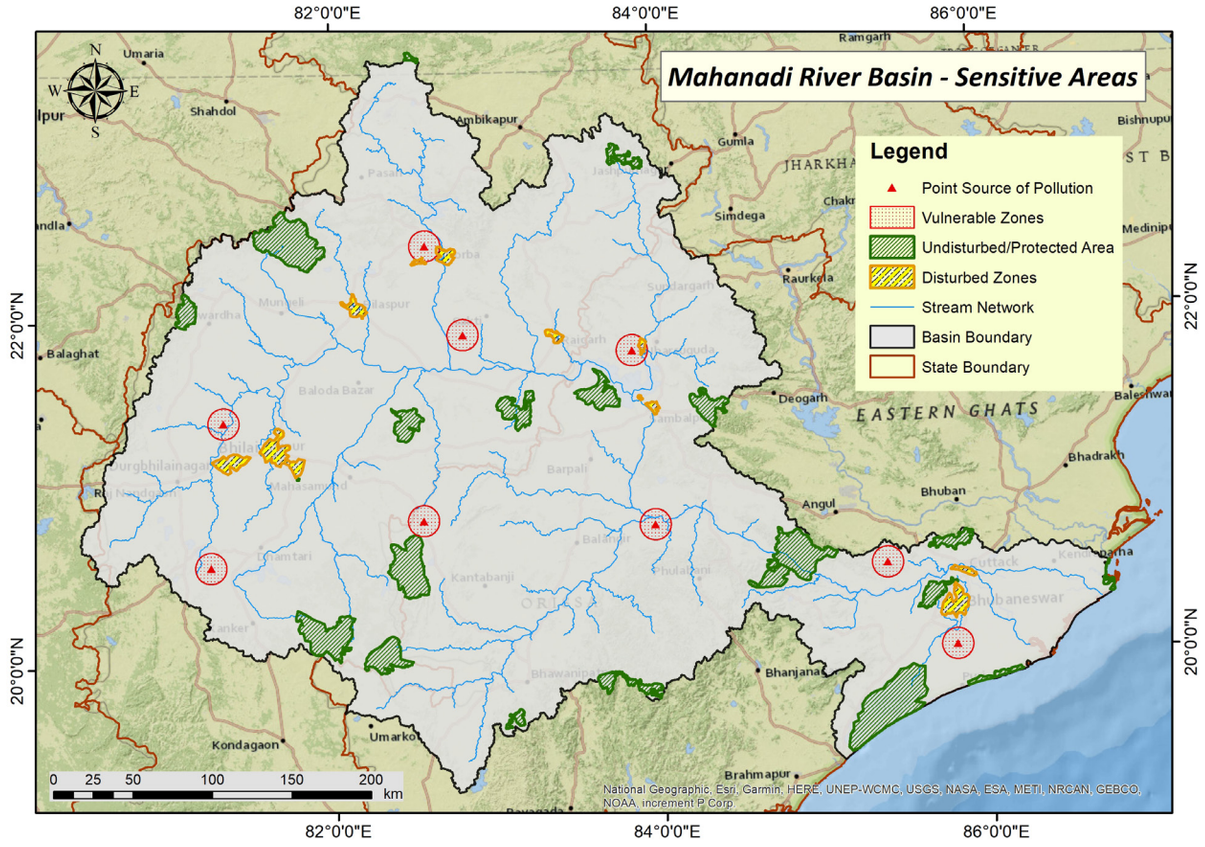

Figure 25 Undisturbed, disturbed and vulnerable zone in the Mahanadi Basin

7.2.2 Moderately Disturbed Areas

These areas experience moderate levels of human activities such as agriculture, small-scale industries, and urbanization, but still retain some ecological integrity.

In the middle reaches of the Mahanadi River, areas around Raipur and Mahasamund, as well as Sambalpur and Cuttack in Odisha, face moderate disturbance from agricultural runoff, urban development, and small-scale industries. Wastewater discharge from towns significantly affects water quality in these areas.

The Seonath River, flowing through agricultural areas and towns like Durg and Bhilai, experiences moderate impacts from agricultural runoff and smaller industries, leading to pollution. Similarly, the Jonk River, passing through rural areas near Khariar Road and Bagbahara, is affected by agricultural activities and small-scale industries, resulting in moderate levels of runoff and wastewater discharge.

In the middle reaches of the Hasdeo River, particularly in areas like Korba, there is moderate disturbance from agricultural activities and minor urban development, along with industrial runoff and wastewater discharge impacting water quality. The Arpa River, flowing through regions near Pendra and Gaurela, also experiences moderate levels of pollution and runoff due to urban development and agricultural activities.

The middle reaches of the Tel River, located in areas like Balangir and Sonepur, face moderate disturbance from agricultural activities and minor urban development, with industrial runoff and wastewater discharge affecting water quality. The lower reaches of the Ong River, flowing through agricultural areas and small towns, are moderately impacted by agricultural runoff and smaller industries, contributing to pollution levels.

Similarly, the middle reaches of the Ib River in places like Jharsuguda experience moderate disturbance from agricultural activities and minor urban development, with industrial runoff and wastewater discharge impacting water quality. The Kuakhai River, passing through regions near Bhubaneswar, suffers from moderate pollution and runoff due to urban development and agricultural activities.

7.2.3 Highly Disturbed Areas

In the lower reaches of the Mahanadi River, major cities like Bilaspur and Cuttack, along with industrial zones, face heavy impacts from urban runoff, industrial wastewater discharge, and mining activities, especially coal mining. This affects water quality and ecosystem health.

The Kharun River, close to Raipur, is highly impacted by significant industrial activities including steel plants and manufacturing units, alongside extensive urban runoff, contributing to high pollution levels. The Tandula River in areas around Durg and Bhilai experiences substantial wastewater discharge and pollution from steel and cement industries. The Arpa River, flowing through densely populated and industrialized regions of Bilaspur, suffers from significant pollution due to urban runoff, industrial discharge, and wastewater from residential areas.

The lower reaches of the Hasdeo River are heavily impacted by coal mining and industrial activities around Korba, including thermal power plants, resulting in severe pollution from

industrial runoff and wastewater discharge. The Mand River is affected by industrial activities in the Korba region, particularly coal mining and power generation, leading to significant runoff and wastewater discharge.

The Seonath River, near Bhilai, faces high levels of industrial runoff and wastewater discharge due to the presence of the Bhilai Steel Plant and other industrial activities. Near Paradeep, the Tel River experiences significant pollution from industrial and agricultural activities, particularly around Sonepur.

The lower reaches of the Ib River, impacted by industrial activities in Jharsuguda and Sundargarh, including coal mining and power generation, also suffer from substantial wastewater discharge and pollution from industrial runoff. The Devi River, influenced by urbanization and industrial activities in Bhubaneswar, experiences significant pollution from urban runoff and wastewater discharge. Similarly, near urban areas like Cuttack and Paradeep, the Devi River faces pollution from port activities and extensive urban runoff. The Kuakhai River, also affected by urbanization and industrial activities around Bhubaneswar, suffers from significant pollution from urban runoff and wastewater discharge.

8. SUMMARY

The Mahanadi River, with its extensive drainage network and varied landscapes, is a vital water resource for Chhattisgarh and Odisha. Its journey from the pristine forests of the Sihawa hills to the industrial zones reflects the complex interplay of natural and anthropogenic influences. While certain sections of the river remain relatively undisturbed, others face significant environmental pressures. Sustainable management and conservation efforts are imperative to protect the river's ecological integrity and ensure it continues to support the diverse needs of the region's ecosystems and communities.

The future of the Mahanadi River in Chhattisgarh and Odisha hinges on sustainable management practices that balance development along with environmental conservation. Integrated river basin management approaches that consider the entire watershed, from headwaters to the mouth, are essential. Policies promoting pollution control, sustainable agriculture, and industrial regulation can help reduce the river's pollutant load. Enhancing green cover in the basin, improving urban infrastructure for wastewater treatment, and monitoring industrial discharges are critical steps toward ensuring the river's long-term health and sustainability.

Involving local communities in conservation efforts and raising awareness about the importance of biodiversity can help in preserving the rich flora and fauna of the Mahanadi River Basin for future generations. Some strategies include:

i. **Protected Areas:** Establishing and managing national parks, wildlife sanctuaries, and biosphere reserves.
ii. **Reforestation and Afforestation:** Planting native species to restore degraded forests.
iii. Sustainable Forestry Practices: Promoting sustainable harvesting and management of forest resources.
iv. **Community Involvement:** Engaging local communities in conservation efforts and promoting traditional knowledge for sustainable use of plant resources.
v. **Research and Monitoring:** Conducting studies to monitor plant health and biodiversity, and developing strategies for conservation and sustainable use.

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11) Chhattisgarh Water Resource Department, Government of Chhattisgarh
12) Department of Water Resources, Government of Odisha
13) Chhattisgarh Environment Conservation Board
14) State Pollution Control Board, Government of Odisha
15) Department of Housing and Environment, Government of Chhattisgarh

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