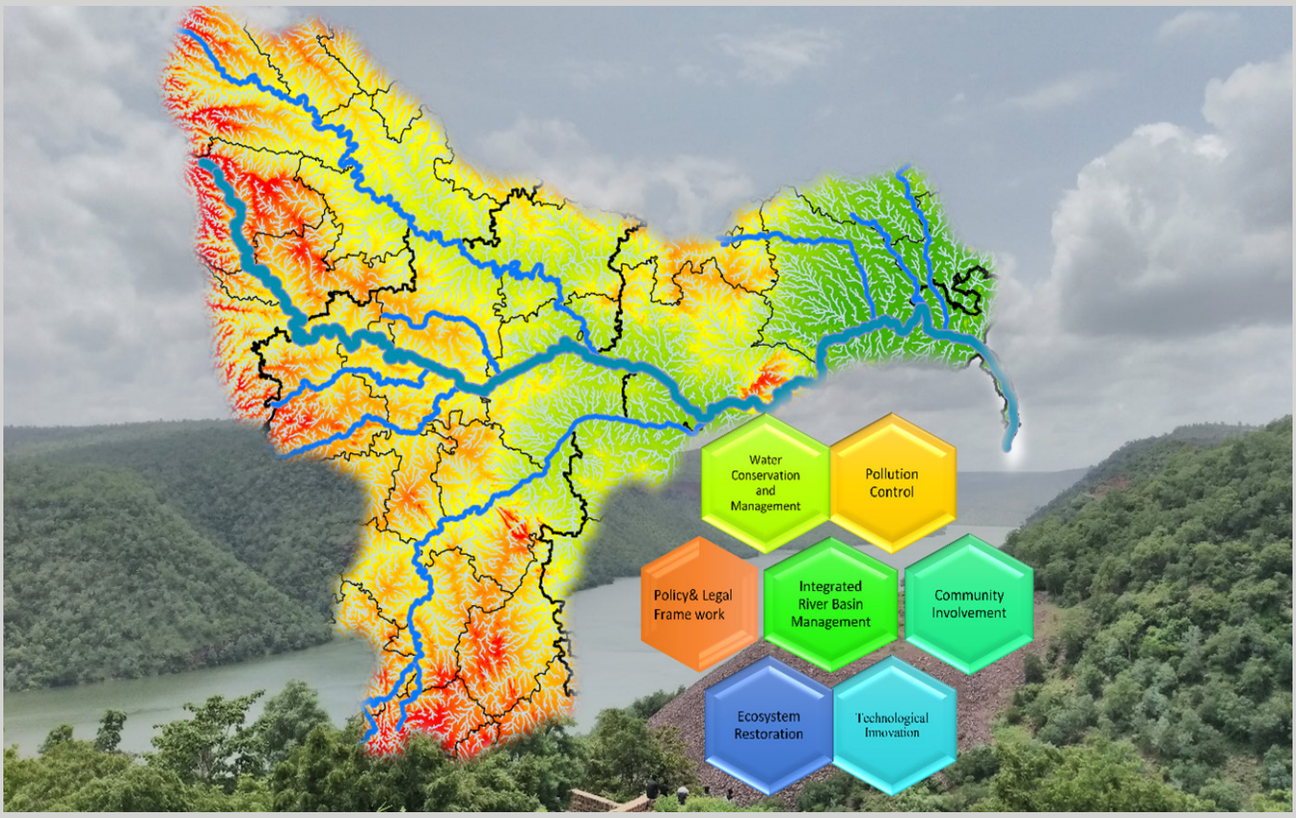
सत्यमेव जयते

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



KRISHNA RIVER AT A GLANCE

MARCH 2025

Version - 2

Centres for Krishna River Basin Management Studies

Centre for Ganga River Basin Management and Studies

KRISHNA

RIVER AT A GLANCE

MARCH - 2025

Version - 2

Centres for Krishna River Basin Management Studies

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 Krishna River Basin Management Studies (cKrishna)

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

www.ckrishna.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

This report is a comprehensive outcome of the project jointly executed by NIT Warangal (Lead Institute) and NIT Surathkal (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.

Suggested Citation

cKrishna and cGanga (2024), Krishna River at a Glance, NRCD, DoWR, RD & GR, Ministry of Jal Shakti, Government of India.

Team

N V Umamahesh, cKrishna, NIT Warangal
K Venkata Reddy, cKrishna, NIT Warangal
P V Rao, cKrishna, NIT Warangal
Ajey Patel, cKrishna, NIT Warangal
Shashi Mesapam, cKrishna, NIT Warangal
Hari Prasad Reddy P, cKrishna NIT Warangal
Manali Pal, cKrishna, NIT Warangal
Sridhar Pilli, cKrishna, NIT Warangal
Vamsi Krishna Vema, cKrishna, NIT Warangal
Jew Das, cKrishna, NIT Warangal
Lita Kumar Ray, cKrishna, NIT Warangal
Sumanth C, cKrishna, NIT Warangal
Vinod Tare, cGanga, IIT Kanpur

S Shrihari, cKrishna, NITK Surathkal
B. Manu, cKrishna, NITK Surathkal
Arun Kumar Thalla, cKrishna, NITK Surathkal
Devatha C P, cKrishna, NITK Surathkal
Anupama Surenjan, cKrishna, NITK Surathkal
Jacklin Jeke Nilling, cKrishna, NITK Surathkal
Saranya P, cKrishna, NITK Surathkal
Laxman Nandagiri, cKrishna, NITK Surathkal
Dwarakish G S, cKrishna, NITK Surathkal
Varija K, cKrishna, NITK Surathkal
Ramesh H Gowda, cKrishna, NITK Surathkal
Shwetha H R, cKrishna, NITK Surathkal
Chandan Pradhan, cKrishna, NITK Surathkal

सत्यमेव जयते

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.

cKrishna and cGanga

CONTENTS

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

°	Degree
′	Minute
%	Percentage
°C	Degree Celsius
cu.	Cube
e.g.	For Example
km	Kilometre
kg	Kilogram
m	Metre
sq.	Square
GIS	Geographic Information System
SRTM	SRTM - Shuttle Radar Topography Mission
IMD	India Meteorological Department
WRIS	Water Resources Information System
CWC	Central Water Commission
CPCB	Central Pollution Control Board
LIP	Lift Irrigation Projects
APMIP	Andhra Pradesh Micro Irrigation Projects
HNSI	Handri Neeva Sujala Sravanthi
ERM	Extension, Renovation & Modernization
UNESCO	United Nations Education, Scientific and Cultural Organisation
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
ESRI	Environmental Systems Research Institute
PCB	Pollution Control Board

1. INTRODUCTION

Rivers have always been the lifelines of civilizations, providing water, food, transport, and fertile land for agriculture. They are biodiversity hotspots, supporting diverse flora and fauna, and play a crucial role in economic development by facilitating agriculture, industry, and energy production. Rivers also hold immense cultural and spiritual significance, featuring prominently in traditions and rituals. Rivers served as vital trade routes, fostering economic exchanges and cultural interactions, and supported agriculture by providing irrigation and fertile soil, enabling the growth of societies.

The Krishna River also known as Krishnaveni is one of the longest rivers in the Deccan plateau is the third-longest river in India, after the Ganges and Godavari. The Krishna River is a significant river in India, originating in the Western Ghats near Mahabaleshwar in Maharashtra. Flowing eastward across the Indian states of Maharashtra, Karnataka, Telangana and Andhra Pradesh, it eventually empties into the Bay of Bengal. Spanning approximately 1,400 kilometres, the Krishna River has a drainage basin covering around 258,948 square kilometres (Fig. 1).

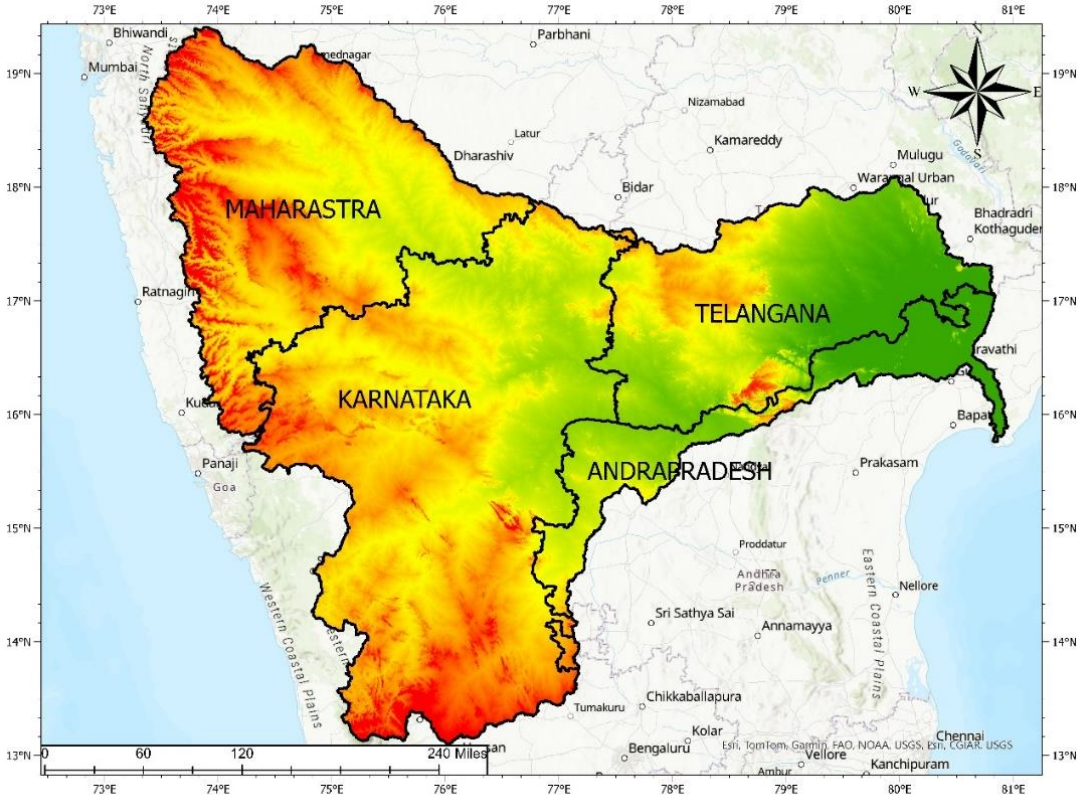


Fig. 1. Drainage area of River Krishna covering four states

Historically, the Krishna River has been the lifeline for ancient kingdoms such as the Satavahanas and the Vijayanagara Empire. It holds religious importance in Hinduism, with numerous temples and pilgrimage sites along its course, including the famous Pandharpur in Maharashtra. Festivals like the Krishna Pushkaralu, held every twelve years, attract millions of devotees to bathe in the river, showcasing its cultural vitality. Fig.. shows the origin point of River Krishna.

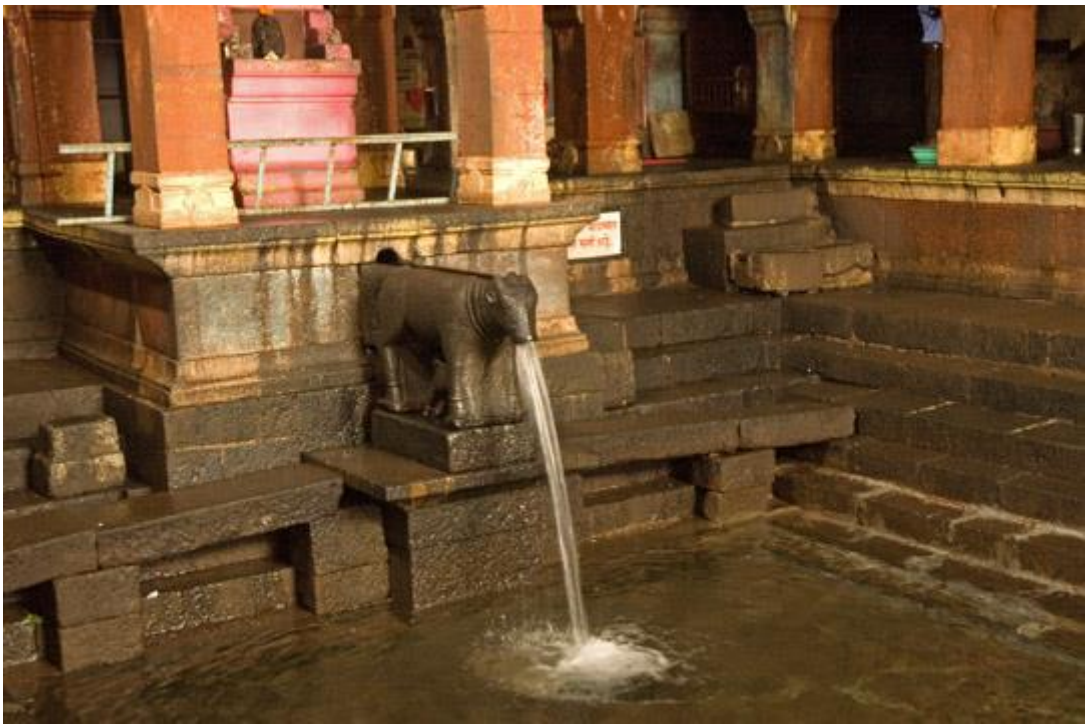


Fig. 2. Krishnabai temple, the origin of Krishna River at Mahabaleswar, Maharastra.

The Krishna River has 13 major tributaries, which contribute to its water flow and overall hydrology. Some of the major tributaries of the Krishna River include:

- **Bhima River**: The Bhima River is one of the largest tributaries of the Krishna River. It originates in the Bhimashankar hills in Maharashtra and flows south east ward, joining the Krishna River near Raichur in Karnataka.
- **Tungabhadra River**: The Tungabhadra River originates in the Western Ghats near Chikmagalur district in Karnataka. It flows eastward, forming the border between Karnataka and Andhra Pradesh before joining the Krishna River near Kurnool.
- **Ghataprabha River**: The Ghataprabha River originates in the Western Ghats near Khanapur in Karnataka. It flows eastward, joining the Krishna River near Raibag in Karnataka.

- **Malaprabha River**: The Malaprabha River originates in the Western Ghats near Hubli-Dharwad in Karnataka. It flows southeastward, joining the Krishna River near Kudalasangama in Karnataka.
- **Musi River**: The Musi River originates in the Ananthagiri Hills near Vikarabad in Telangana, India. It flows through several regions, including the capital city of Hyderabad, where it plays a significant role in the city's geography and history. It eventually merges with the Krishna River near the village of Vadapally in the Nalgonda district.
- **Munneru River**: The Munneru River originates in the Khammam district of Telangana, India. It flows through several regions, including Khammam and parts of Krishna district in Andhra Pradesh. Beyond Khammam, the Munneru River traverses through the rural landscapes of Telangana and Andhra Pradesh, passing through towns like Wyra and Madhira. It eventually merges with the Krishna River near the town of Muktyala in the Krishna district of Andhra Pradesh.
- **Panch Ganga River**: The Panch Ganga River originates in the Western Ghats of Maharashtra, India. It flows through various regions, including the Kolhapur district. The river traverses through the lush, green landscapes of Maharashtra, passing through significant towns like Ichalkaranji and Shirol. Along its journey, it receives water from five tributaries, hence its name "Panch Ganga" which means "Five Rivers." Eventually, the Panch Ganga River merges with the Krishna River near the town of Narsobawadi in the Kolhapur district.
- **Dudhganga River**: The Dudhganga River also has its origin in the Western Ghats of Maharashtra, India. It flows through the picturesque terrains of the Kolhapur district, enriching the agricultural lands of the region. The river passes through towns like Nipani and Chikodi. As it flows, it supports various rural communities and agricultural activities. Finally, the Dudhganga River merges with the Krishna River near the town of Narsobawadi in the Kolhapur district, contributing to the Krishna River's flow.

Figure. 3 shows the map of the Krishna River and its major tributaries. Figure 4. presents the tree diagram of the Krishna River and its tributaries. Table 1. provides details of the major tributaries, including their confluence points, origin points, and lengths.

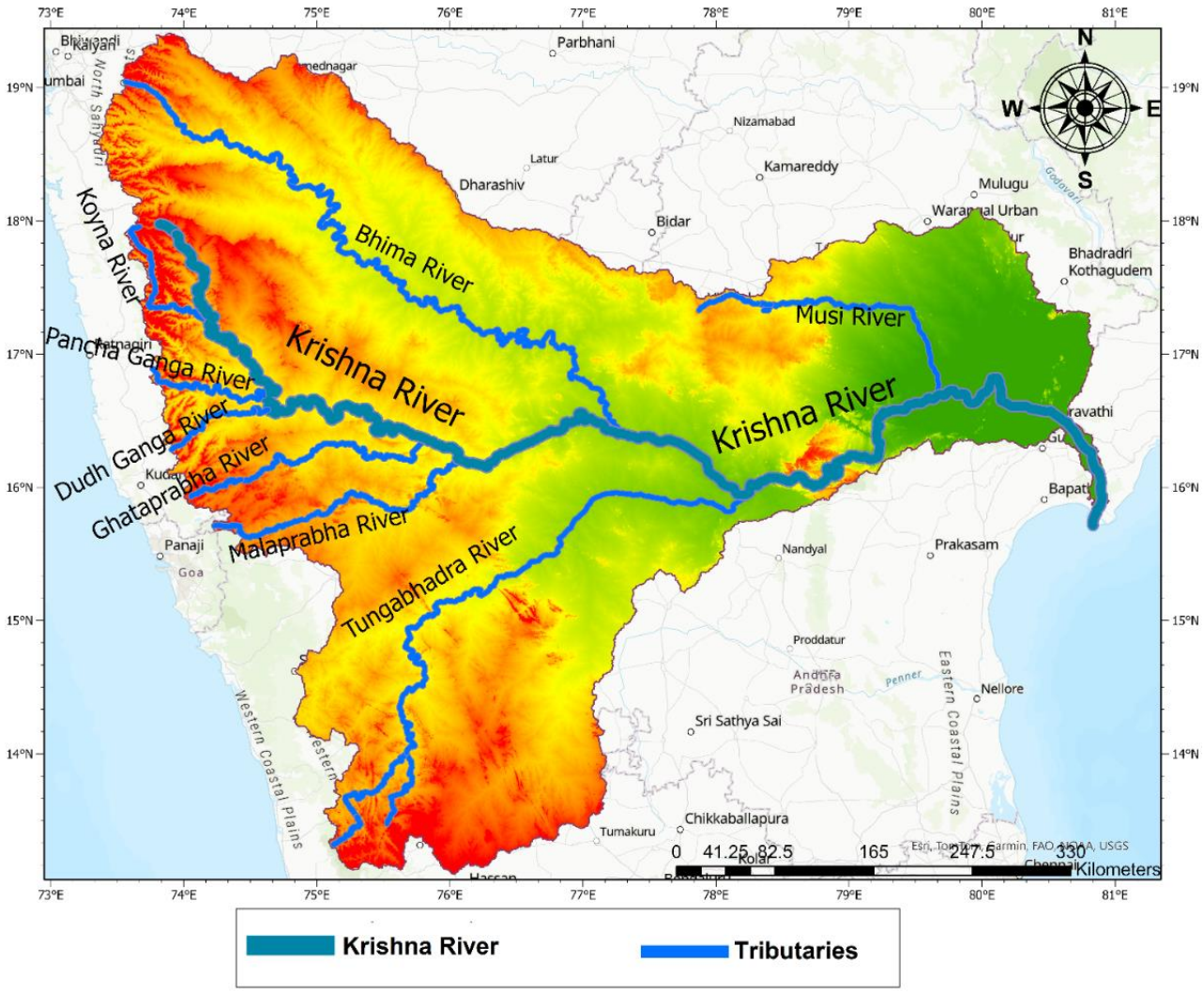


Fig. 3. Krishna River and its major tributories

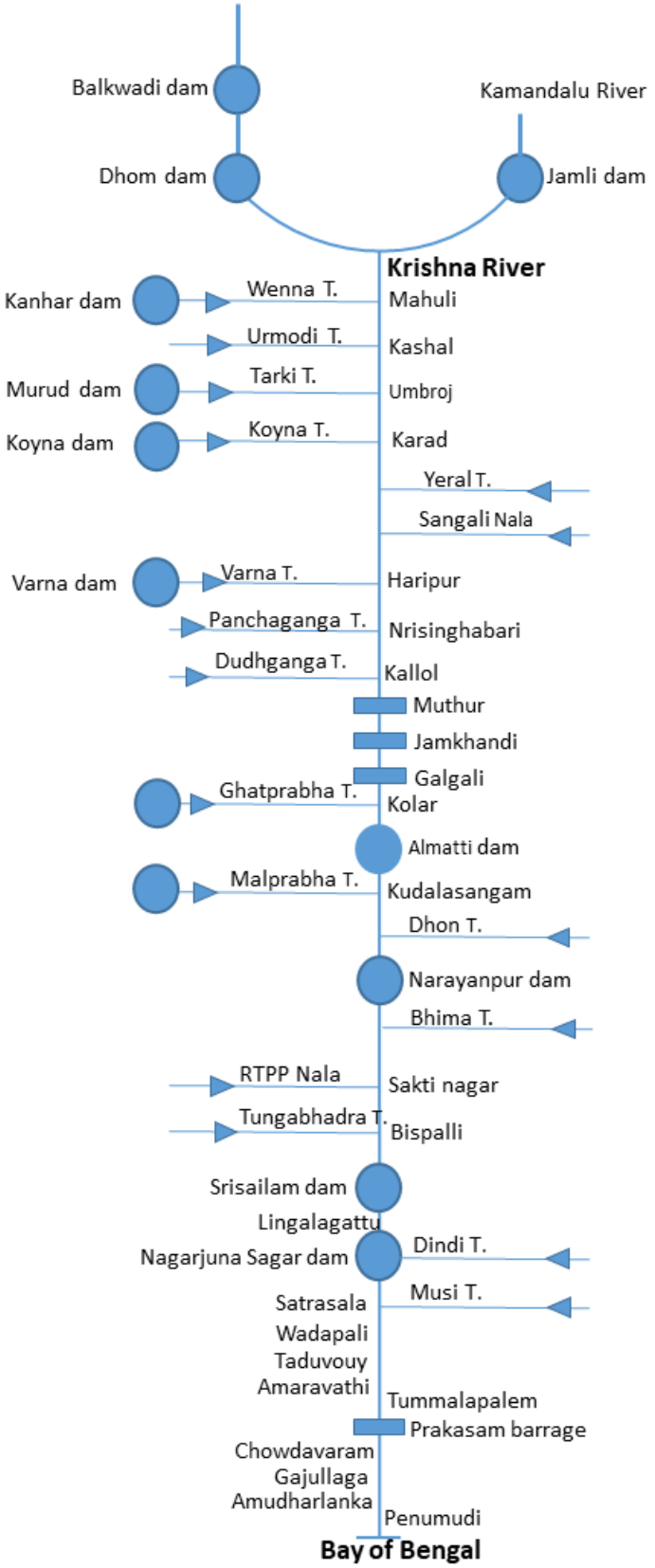
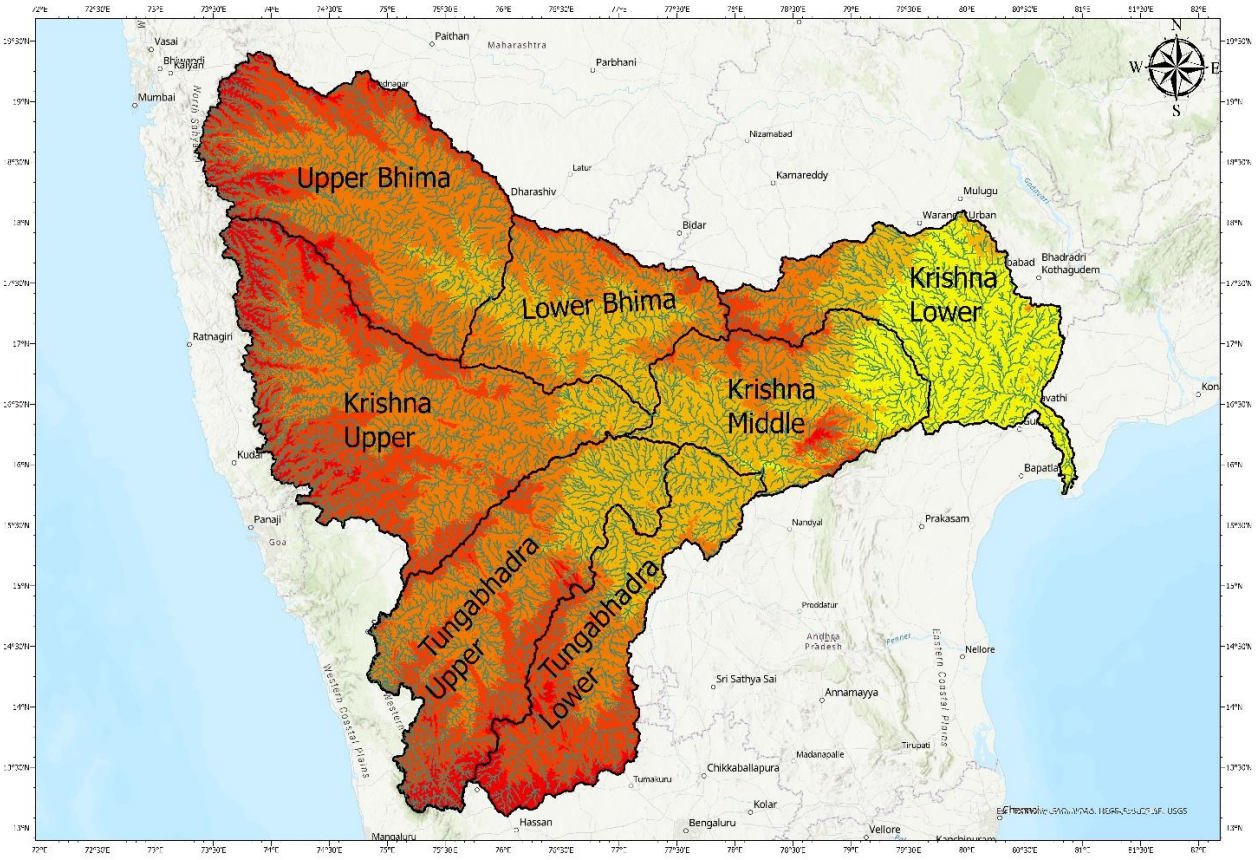


Fig. 4. Tree diagram showing Krishna and its tributaries

Table 1. Details of the major tributaries, their origin points, confluence points, and lengths.

MAJOR TRIBUTARIES OF KRISHNA RIVER				
S.No	NAME	ORIGIN	CONFLUENCE	LENGTH (Kilometre)
1	BHIMA RIVER	Bhimashnakar, Maharastra	Raichur, Karnataka	860.67
2	TUNGABHADRA RIVER	Shivamogga, Karnataka	Alampur, Telangana	551.56
3	MUSI RIVER	Ananthagiri Hills, Telangana	Wadapally, Telangana	352.02
4	MALAPRABHA	Jamboti, Karnataka	Kudalasangama, Karnataka	325.74
5	GHATAPRABHA	Chaukal, Maharastra	Kudalasangama, Karnataka	298.73
6	MUNNERU RIVER	Nallamala Hills, Andhra Pradesh	Wadapally, Telangana	217.79
7	KOYNA RIVER	Mahabaleshwar, Maharastra	Karad, Maharastra	151
8	PANCH GANGA RIVER	Prayag Sangam, Maharastra	Kurundvas, Maharastra	128.68
9	DUDH GANGA RIVER	Prayag Sangam, Maharastra	Narsobawadi, Maharastra	129.78

The Krishna basin is split into 7 sub-basins namely Bhima lower sub-basin (9.28%), Bhima upper sub-basin (17.58%), Krishna lower sub-basin (15.5%), Krishna middle sub-basin (8.73%), Krishna upper sub-basin (21.4%), Tungabhadra lower sub-basin (16.31%), and Tungabhadra upper sub-basin (11.2%) as shown in Fig. 5.



Source: SRTDEM, 30m

Fig. 5. Sub-Basins of Krishna River Basin

1.1 Upper Bhima and Lower Bhima Sub-Basin

The Bhima Lower Sub-Basin includes several important tributaries such as the Bhima, Dom, Bori, Chikka, Chinamagera, Dodda Halla, Dogi Halla, Jandori, Garaganji Halla, Hippargi Halla, Hire Hill, and Kanga rivers. This sub-basin covers the regions of Osmanabad, Bidar, Latur, Solapur, Bijapur, Medak, Mahaboobnagar, Gulburga, Sangli, and Rangareddy. The population within this sub-basin is approximately 3,986,938, encompassing 10 districts and 2,213 villages. There are 68 dams constructed in this sub-basin to support its water management needs. Agriculture is a significant activity, with key crops including sugarcane, grapes, pomegranates, wheat, rice, and cotton. Additionally, the region is culturally significant with sites such as Pandharpur. Fig. 6. illustrates the geographical extent of the Lower Bhima Sub-Basin.

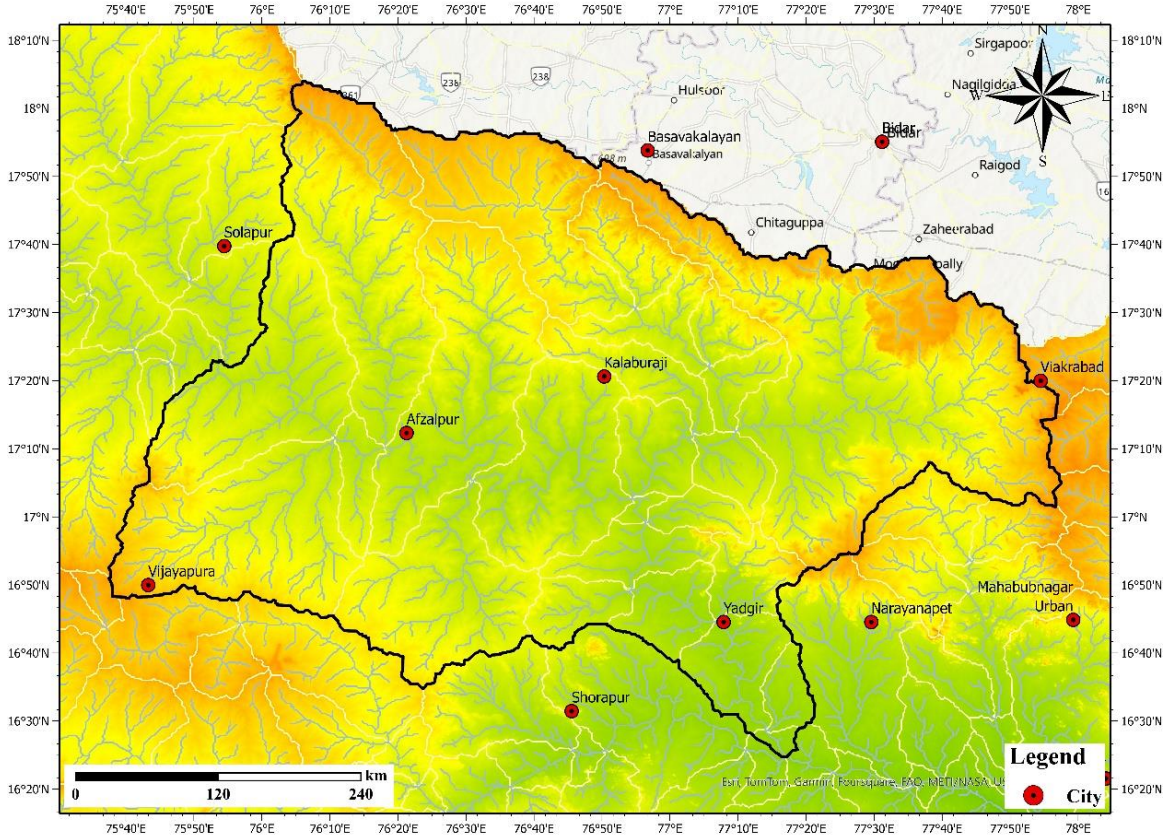


Fig. 6. Bhima Lower Sub-Basin

The Bhima Upper Sub-Basin includes several important tributaries such as the Bhima, Bor, and Dodda Halla rivers. This sub-basin covers the regions of Ahmednagar, Belgaum, Osmanabad, Pune, Thane, Solapur, Bid, Satara, Bijapur, Raigarh, and Sangli. The population within this sub-basin is approximately 13,793,138, encompassing 11 districts and 4,648 villages. There are 273 dams constructed in this sub-basin to support its water management needs. Agriculture is a significant activity, with key crops including sugarcane, grapes, pomegranates, wheat, and pulses. Additionally, the region is culturally significant with sites such as Bhimashankar, Siddhatek Siddhivinayaka, Tulja Bhavani, Koyna Mandir, and Shree Datta Mandir. Fig. 7. illustrates the geographical extent of the Upper Bhima Sub-Basin.

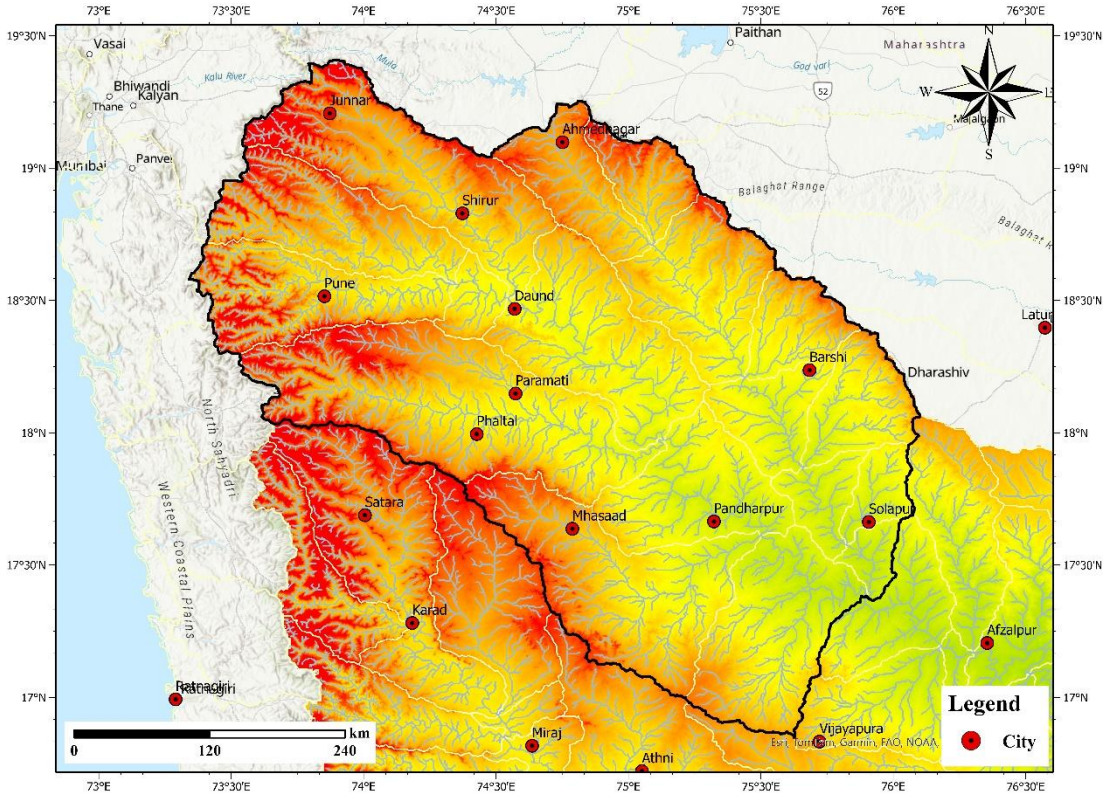


Fig. 7. Bhima Upper Sub-Basin

1.2 Krishna Upper, Middle and Lower Sub-Basins

The tributaries feeding the Krishna Upper Sub-Basin include Ghatprabha, Malprabha, Chinkodi Halla, Dudhganga, Vedganga, Kappur Halla, Jabapur Halla, Adda Halla, Agrani, Badachi Halla, Beeni Halla, Betgeri Halla, Chail Halla, Don rivers, Panchganga, and Warana. Encompassing a vast geographical area across Belgaum, Bagalkot, Dharwad, Haveri, Pune, Sindhudurg, Kolhapur, Ratnagiri, Solapur, Koppal, Raichur, Satara, Biljapur, Mahabubnagar, Raigarh, Gadag, Gulbarga, and Sangli regions, this sub-basin supports a population of approximately 14,750,672 people spread across 18 districts and 6,313 villages. The region is fortified by 188 dams, crucial for managing water resources for agriculture. Major crops grown include jowar, millet, maize, cotton, groundnuts, paddy, wheat, and sugarcane, which are vital for the agricultural economy. Culturally rich sites such as the Mahalakshmi Temple, Ammabai Temple, Warananagar, Narsobawadi, Sangameshwar, Chandoli, Jyothiba Temple, Kasi Vishweshwar Temple, and Kundalasangama highlight the sub-basin's historical and religious significance in the southern Indian landscape. Fig. 8. illustrates the geographical extent of the Krishna Upper Sub-Basin.

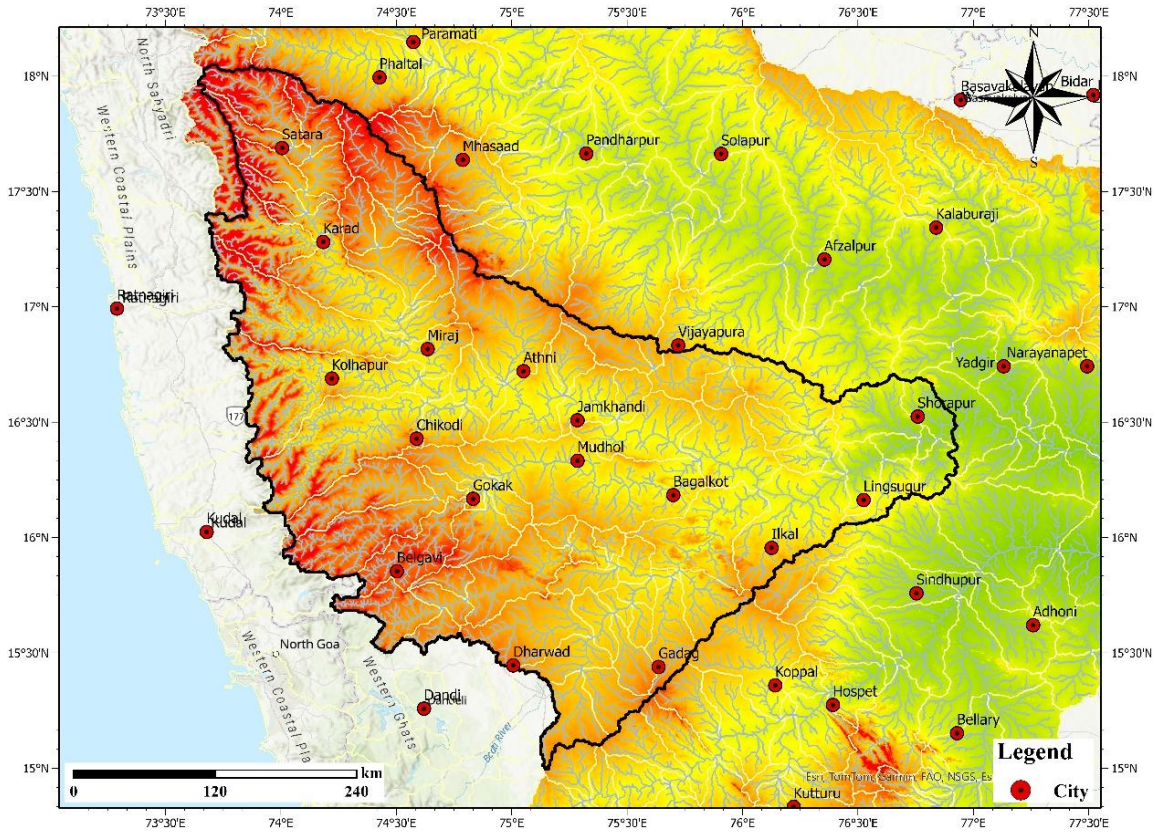


Fig. 8. Krishna Upper Sub-Basin

The Krishna Middle Sub-Basin is sustained by a network of tributaries including the Krishna, Bheemanapalli Vagu, Chinna Vagu, Dindi, and Pedda Vagu rivers, spanning across Prakasham, Kurnool, Nalgonda, Raichur, Mahabubnagar, Gulbarga, Guntur, and Rangareddy regions. With a population of approximately 4,203,377 spread across 8 districts and 1,851 villages, the sub-basin supports a thriving agricultural economy focused on crops like paddy, maize, cotton, pulses, and vegetables. It is fortified by 34 dams that regulate water for irrigation and other essential needs. Culturally rich sites such as the Sri Ranganayaka Swamy Temple and Mallikarjuna Swamy Temple underscore the region's historical significance and communal life, highlighting its pivotal role in southern India's landscape and livelihoods. Fig. 9 illustrates the geographical extent of the Krishna Middle Sub-Basin.

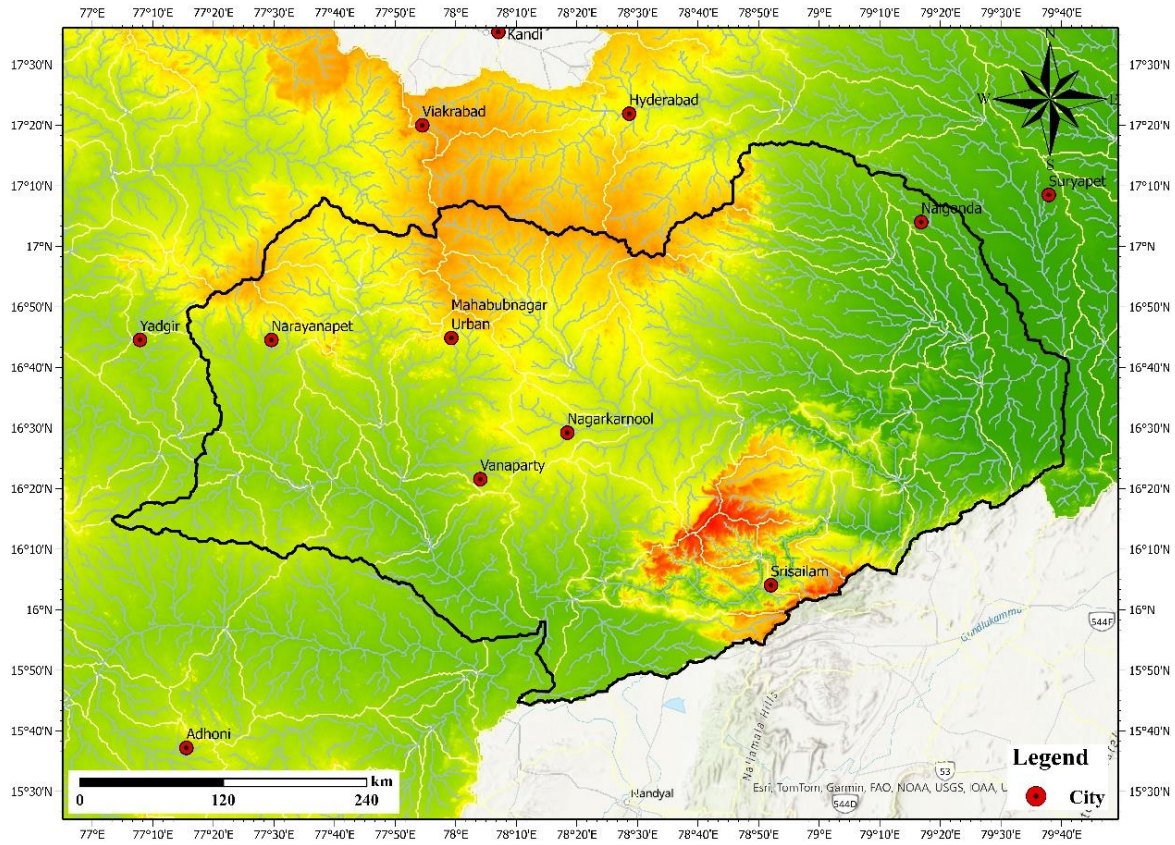


Fig. 9. Krishna Middle Sub-Basin

The Krishna Lower Sub-Basin is fed by a diverse array of tributaries including the Krishna, Munneru, Musi, Kongal, Haliya, Bukler, Aler, Akeru, Paleru, Shamirpet Vagu, and Yashvanthapuram Vagu rivers. Encompassing regions such as Hyderabad, Krishna, Prakasham, Khammam, Karimnagar, Nalgonda, Warangal, Medak, Mahabubnagar, Guntur, and Rangareddy, this sub-basin supports a sizable population of 15,594,812 spread across 11 districts and 3,704 villages. It is facilitated by 29 dams that regulate water resources crucial for agriculture, which includes the cultivation of rice, maize, cotton, chilies, and tobacco. The sub-basin is also culturally significant, home to revered sites such as Chilkur Balaji, Sangi Temple, Sriramalingeshawara Swamy, Yogimallavaram, Kanakadurga, Magalagiri, Panakala Narasimha Swamy, and Yadradri, highlighting its historical and religious heritage within southern India. Fig. 10 illustrates the geographical extent of the Krishna Lower Sub-Basin.

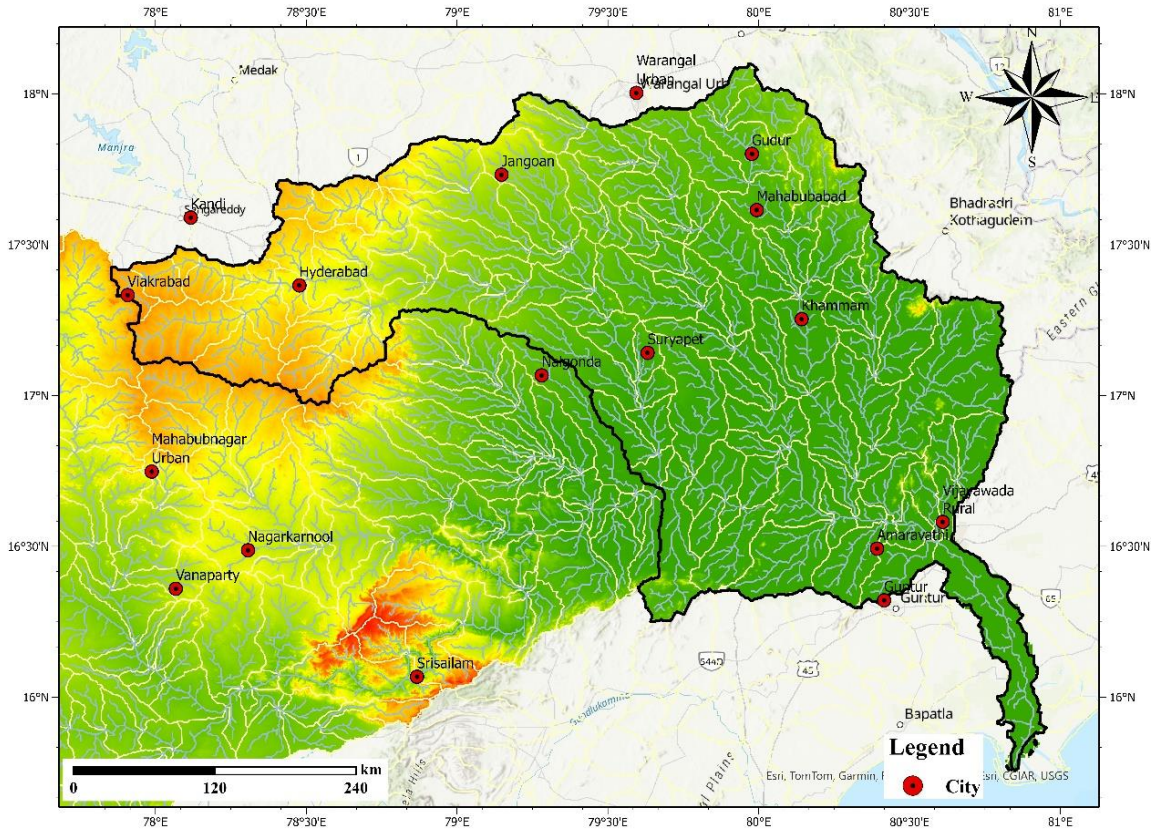


Fig. 10. Lower Krishna Sub-basin

1.3 Tungabhadra Upper and Lower Sub-Basin

The Tungabhadra Upper Sub-Basin is sustained by several tributaries including the Tungabhadra, Vardha, Kumadvati, Karala Halla, Dodda Halla, Hire Halla, and Vadagatte Halla rivers. Spanning across Bellary, Chitradurga, Dakshina Kannada, Dharwad, Davanagere, Haveri, Udupi, Chikmagalur, Shimoga, Uttara Kannada, Koppal, and Gadag regions, this sub-basin supports a population of approximately 5,999,712 people distributed across 12 districts and 4,349 villages. It is fortified by 31 dams that play a crucial role in managing water resources for agriculture. Major crops grown include jowar, millet, maize, cotton, groundnuts, and paddy, which are essential for the agricultural economy of the region. Culturally significant sites such as Navabrindavana and Shringeri Sharada Peeth Temple highlight the sub-basin's rich cultural heritage, contributing to its historical significance in southern India. Fig. 11 illustrates the geographical extent of the Tungabhadra Upper Sub-Basin.

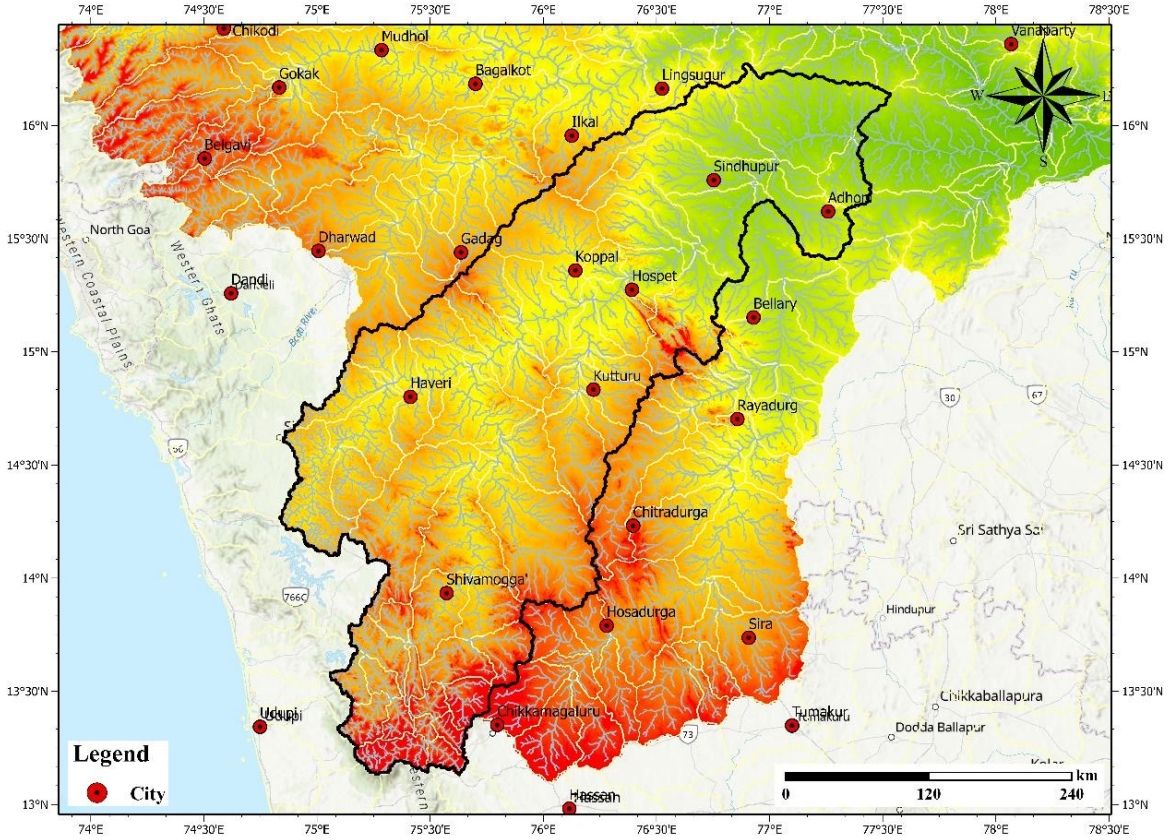


Fig. 11. Upper Tungabhadra Sub-Basin

The Tungabhadra Lower Sub-Basin is fed by tributaries including the Tungabhadra, China Hagari, Dodda Halla, Garchi Vanka, Hagari, Kangagina Halla, Komtivani Vanka, Nari Halla, and Cindhnur N rivers. It spans across Bellary, Hassan, Ananthapur, Bagalkot, Chitradurga, Davanagere, Chikmagalur, Kurnool, Koppal, Raichur, Mahabubnagar, and Tumkur regions, supporting a population of approximately 8,013,034 people across 12 districts and 4,889 villages. The sub-basin is home to 37 dams, crucial for managing water resources for agriculture. Major crops cultivated include jowar, millet, maize, cotton, groundnuts, and paddy, sustaining the agricultural economy of the region. Culturally significant sites such as the Virupaksha Temple, Raghavendra Swamy Mutt, Pampapathi, Achutharaya Temple, Vithala, Kondanagendramma, and Durga Temple underscore the sub-basin's rich cultural heritage and historical importance in southern India. Fig. 12 illustrates the geographical extent of the Tungabhadra Lower Sub-Basin.

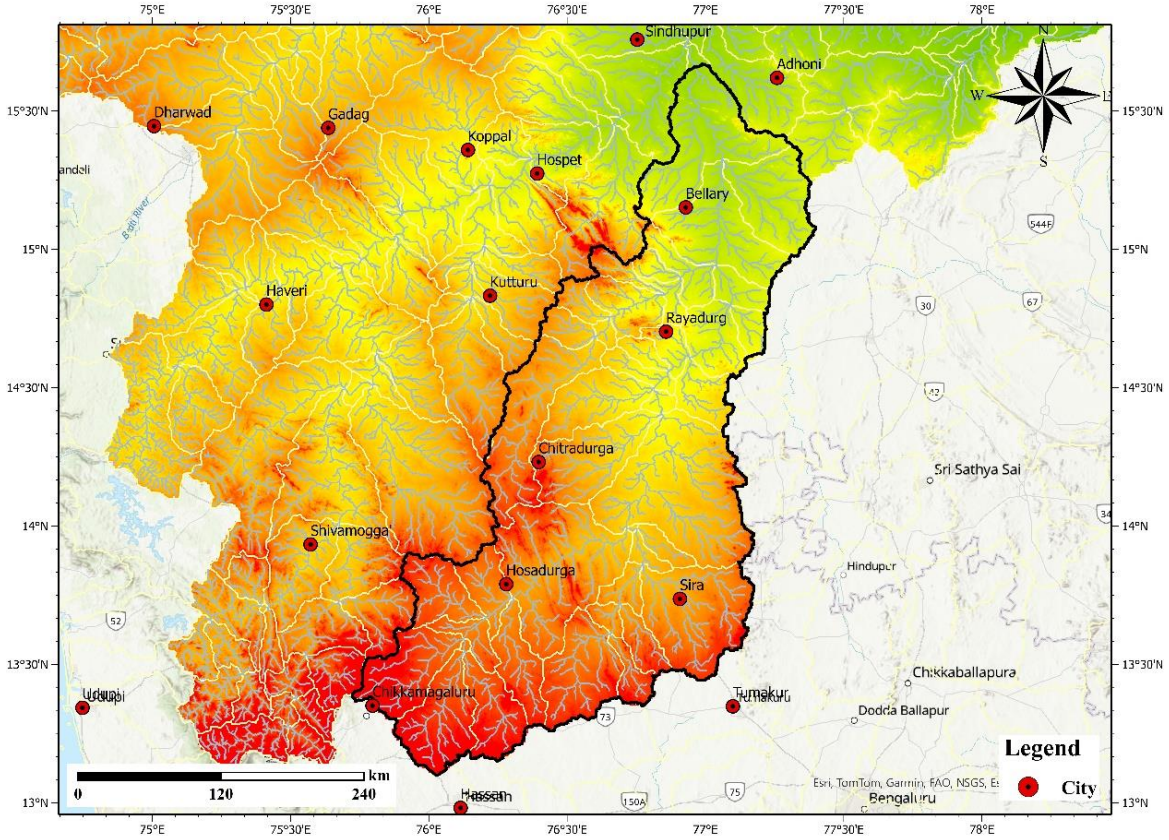


Fig. 12. Lower Tungabhadra Sub-Basin

The Krishna River Basin encompasses a significant geographic area, extending across multiple states in India. Within this expansive region, there are a total of 257 taluks (administrative subdivisions) spread over 46 districts. Fig. 13 and Fig. 14 show the districts and taluks under the Krishna basin respectively, while Table 2. and Table 3. list the names of districts and taluks respectively.

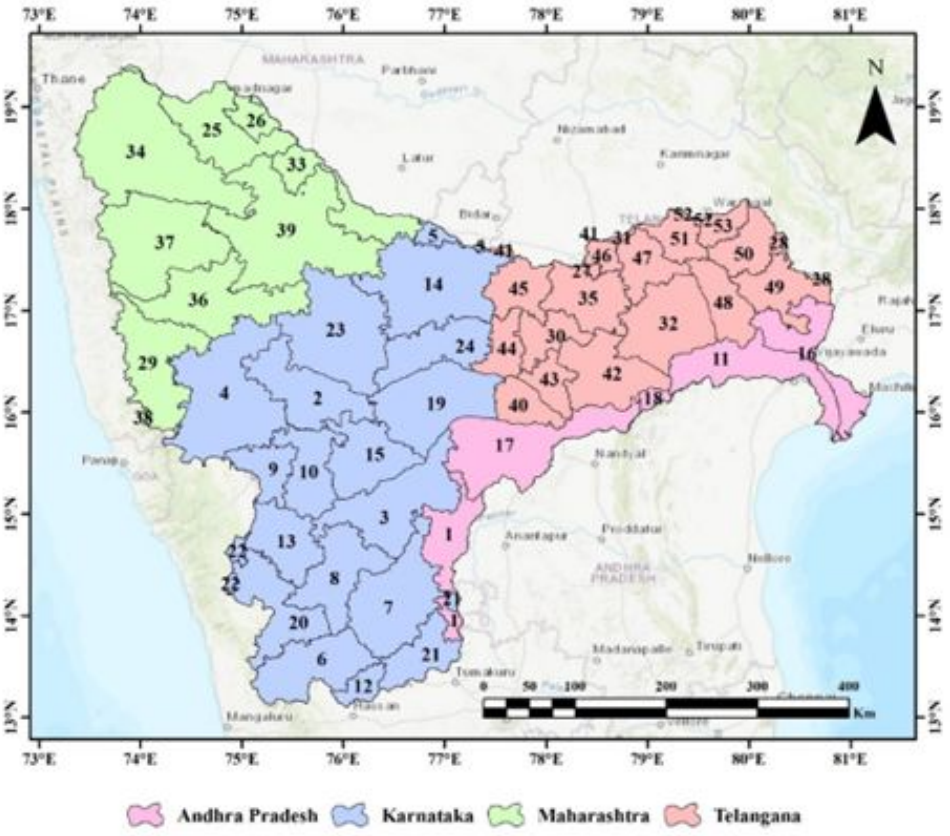


Fig. 13. Districts under Krishna River Basin

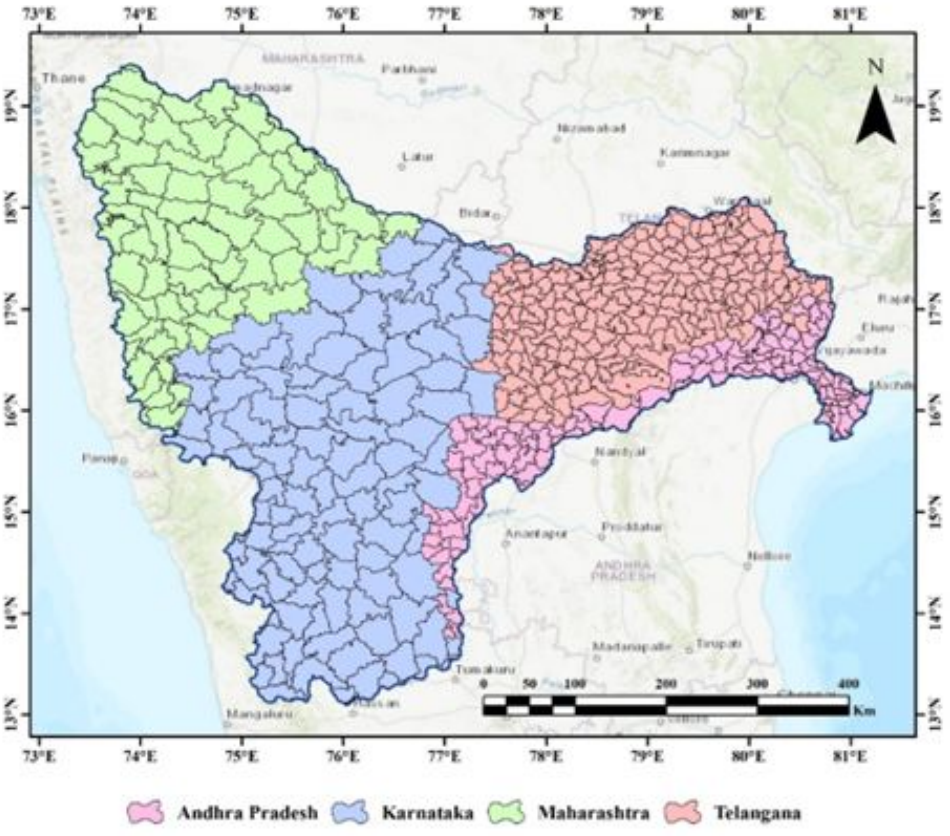


Fig. 14. Taluks (administrative subdivisions) under Krishna River Basin

State-wise Distribution of Area in the Krishna River Basin

Sl. No.	State	Area (Km^2)	Percentage (%)
1	Telangana	51608.7	19.86
2	Andhra Pradesh	26181.4	10.07
3	Maharashtra	69724.4	26.46
4	Karnataka	114321.2	43.58

Table 1 Names of districts in Krishna Basin

Sl. No.	District Name	Sl. No.	District Name
1	Anantapur	28	Bhadradri Kothagudem
2	Bagalkot	29	Kolhapur
3	Ballari	30	Mahabubnagar
4	Belagavi	31	Siddipet
5	Bidar	32	Nalgonda
6	Chikkamagaluru	33	Usmanabad
7	Chitradurga	34	Pune
8	Davangere	35	Rangareddy
9	Dharwad	36	Sangli
10	Gadag	37	Satara
11	Guntur	38	Sindhudurg
12	Hassan	39	Solapur
13	Haveri	40	Jogulamba Gadwal
14	Kalaburagi	41	Sangareddy
15	Koppal	42	Nagarkurnool
16	Krishna	43	Wanaparthy
17	Kurnool	44	Narayanpet
18	Prakasam	45	Vikarabad
19	Raichur	46	Medchal-Malkajgiri
20	Shivamogga	47	Yadadri Bhuvanagiri
21	Tumakuru	48	Suryapet
22	Uttara Kannada	49	Khammam
23	Vijayapura	50	Mahabubabad
24	Yadgir	51	Jangaon
25	Ahamadnagar	52	Warangal (Urban)
26	Bid	53	Warangal (Rural)
27	Hyderabad		

Source:hub.arcgis.com

Table 3. Name of Taluks under Krishna River Basin

S.No	Taluk	S.No	Taluk	S.No	Taluk	S.No	Taluk	S.No	Taluk
1	Gooty	52	Homnabad	103	Savanur	154	Radhanagari	205	Savantvadi
2	Kalyandurg	53	Basavana Bagevadi	104	Shiggaon	155	Shahuwadi	206	Vaibhavwadi
3	Madakasira	54	Bijapur	105	Gangawati	156	Shirol	207	Akalkot
4	Rayadurg	55	Indi	106	Koppal	157	Nilanga	208	Barsi
5	Guntur	56	Muddebihal	107	Kushtagi	158	Bhum	209	Karmal
6	Guruzala	57	Sindgi	108	Yelbarga	159	Kallam	210	Madha
7	Narasaraopet	58	Chikmagalur	109	Deodrug	160	Osmanabad	211	Malsiras
8	Repalle	59	Kadur	110	Lingsugur	161	Parenda	212	Mangalwedha
9	Sattenapalle	60	Koppa	111	Manvi	162	Tuljapur	213	Mohol
10	Tenali	61	Mudigere	112	Raichur	163	Umarga	214	Pandharpur
11	Vinukonda	62	Narasimharajapura	113	Sindhnur	164	Baramati	215	Sangole
12	Avanigadda	63	Sringeri	114	Hosanagara	165	Bhor	216	Solapur
13	Gannavaram	64	Tarikere	115	Sagar	166	Daund	217	Murbad
14	Gudivada	65	Challakere	116	Shikarpur	167	Ghod	218	Hyderabad
15	Jaggayyapeta	66	Chitradurga	117	Shimoga	168	Indapur	219	Huzurabad
16	Nandigama	67	Hiriyur	118	Sorab	169	Junnar	220	Karimnagar
17	Nuzvid	68	Holalkere	119	Tirthalli	170	Paud	221	Khammam
18	Tiruvuru	69	Hosdurga	120	Chiknayakanhalli	171	Rajgurunagar	222	Kottagudem
19	Vijayawada	70	Molakalmuru	121	Gubbi	172	Sasvad	223	Madhira
20	Adoni	71	Bhadravati	122	Koratagere	173	Shirur	224	Yellandu
21	Alur	72	Channagiri	123	Madhugiri	174	Wadgaon	225	Achampet
22	Atmakur	73	Davangere	124	Pavagada	175	Mahad	226	Alampur
23	Dhone	74	Harihar	125	Sira	176	Mangaon	227	Atamkur
24	Kurnool	75	Harpanahalli	126	Tiptur	177	Pali	228	Farooq Nagar
25	Nandikotkur	76	Honnali	127	Tumkur	178	Poladpur	229	Gadwal
26	Pattikonda	77	Jagalur	128	Karkal	179	Chiplun	230	Kalwakurti
27	Markapur	78	Dharwad	129	Mundgod	180	Devrukh	231	Kolhapur
28	Badami	79	Hubli	130	Siddapur	181	Khed	232	Korangal
29	Bagalkot	80	Kalghatgi	131	Sirsi	182	Lanja	233	Mahbubnagar
30	Bilgi	81	Kundgol	132	Shahpur	183	Rajapur	234	Makhtal
31	Hungund	82	Navalgund	133	Shorapur	184	Atpadi	235	Nagar Karnul
32	Jamkhandi	83	Gadag	134	Yadgir	185	Islampur	236	Wanparthy
33	Mudhol	84	Mundargi	135	Ahmadnagar	186	Jath	237	Gajwel
34	Athni	85	Nargund	136	Akola	187	Kavathe Mahankal	238	Narsapur
35	Bail Hongal	86	Ron	137	Karjat	188	Sangli	239	Sangareddi
36	Belgaum	87	Shirhatti	138	Parner	189	Shirala	240	Zahirabad
37	Chikodi	88	Afzalpur	139	Pathardi	190	Tasgaon	241	Bhongir
38	Gokak	89	Aland	140	Sangamner	191	Vite	242	Devarkonda
39	Hukeri	90	Chincholi	141	Shrigonda	192	Dahivadi	243	Huzurnagar
40	Khanapur	91	Chitapur	142	Ashti	193	Karad	244	Mirialguda
41	Ramdurg	92	Gulbarga	143	Jamkhed	194	Koregaon	245	Nalgonda
42	Raybag	93	Jevargi	144	Patoda	195	Mahabaleshwar	246	Ramannapet
43	Saundatti	94	Seram	145	Ajra	196	Medha	247	Suriapet
44	Bellary	95	Arsikere	146	Bavda	197	Patan	248	Chevella
45	Hagaribommanahalli	96	Belur	147	Chandgad	198	Phaltan	249	Ibrahimpatan
46	Hospet	97	Hassan	148	Gadhinglaj	199	Satara	250	Medchal
47	Huvvinahadagalli	98	Byadgi	149	Gargoti	200	Shirwal	251	Pargi
48	Kudligi	99	Hangal	150	Hatkalangda	201	Vaduj	252	Tandur
49	Sandur	100	Haveri	151	Kagal	202	Wai	253	Vikarabad
50	Siruguppa	101	Hirekerur	152	Kolhapur	203	Kankauli	254	Hanmakonda
51	Basavakalyan	102	Ranibennur	153	Panhala	204	Kudal	255	Jangaon
								256	Mulug
								257	Narsampet

2. DIVISION OF SUB-BASINS

Division of basin into subbasin based on topography, geomorphology, climatic variation landcover-landuse, degradation of Catchment River stretches, degree of pollution.

2.1 Topography

The Krishna Basin exhibits a diverse topography influenced by its geographical location and geological history. The Western Ghats, with elevations ranging from 600 to 1901 meters, form an almost unbroken line along the western edge of the basin. This range features steep, rugged terrain that contributes to significant runoff and erosion, receiving the heaviest rainfall and fostering dense vegetation and rapid water flow into the Krishna River. East of the Western Ghats lies the Deccan Plateau, with elevations generally between 300 to 600 meters. This plateau's topography consists of sparsely cultivated and undulating plains with a dry climate and poor rainfall, gently sloping eastwards and influencing the eastward flow of the Krishna River and its tributaries. The Interior Plateau, predominantly at elevations of 300 to 600 meters, is characterized by great undulating plains divided by flat-topped ranges of hills. The hillsides are marked by wide terraces, except in the southern part where hills are topped with 'tors' or rounded hummocks of bare rock formed due to constant weathering, creating a varied and rugged landscape that affects local hydrology and soil erosion patterns. The Eastern Ghats, located along the eastern boundary of the basin south of the Krishna River, are not continuous or well-defined like the Western Ghats. They comprise parallel ranges of ancient stratified rocks, creating a rugged and dissected landscape that influences local drainage patterns and contributes to the overall complexity of the basin's topography. The delta region, located at the mouth of the Krishna River, is formed by deposits of river-borne alluvium over past ages, consisting of wide, flat areas that are fertile and significant for agriculture. The process of silt deposition at the river's mouth is ongoing, gradually extending the delta into the sea, contrasting with the rest of the basin due to its extensive flatness. Overall, apart from the hills forming the watershed, the Krishna Basin is predominantly rolling and undulating, consisting of a series of ridges and valleys interspersed with low hill ranges, with large, flat areas like those seen in the Indo-Gangetic plains being rare except in the delta region. Fig. represents the Topography Map of Krishna Basin.

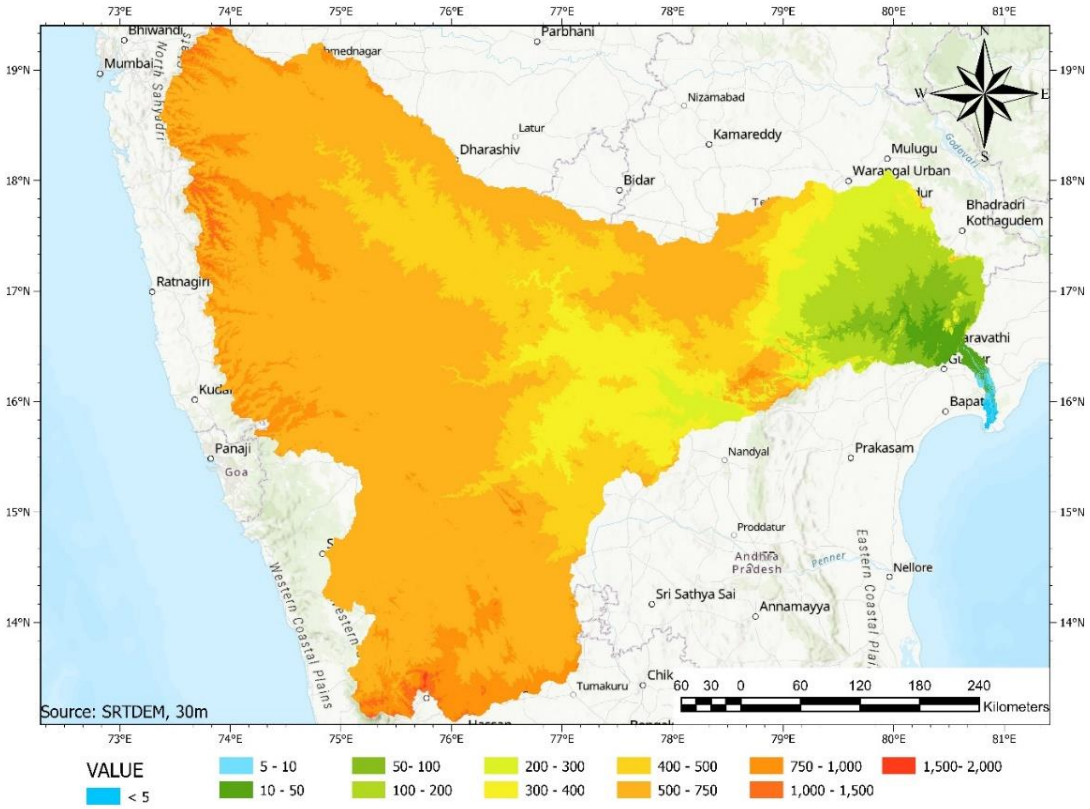


Fig. 15. Topography Map of Krishna Basin

2.2 Geomorphology

Geomorphology considers factors like topography, soil types, and drainage patterns. In the Upper Krishna Basin, the topography is characterized by the Western Ghats, with steep slopes and higher elevations, and the soil types are predominantly laterite and red soils. The drainage of this basin is managed by tributaries like the Bhima, Koyna, and Ghataprabha rivers. The Middle Krishna Basin transitions to more gently undulating plains and plateaus, with common soil types being black cotton soils and alluvial deposits. The major tributaries in this region include the Tungabhadra and Malaprabha rivers. The Lower Krishna Basin features flat plains closer to the delta region, with alluvial soils dominating this part of the basin. The main Krishna River branches out into several distributaries before emptying into the Bay of Bengal. The Bhima Sub-Basin consists of the Deccan Plateau, featuring a mix of undulating terrain and flatlands, with primarily black soils ideal for cotton and cereal crops, and is drained by the Bhima River, a significant tributary of the Krishna River. The Tungabhadra Sub-Basin includes a mix of hilly terrains and plains, with red soils in the hilly areas and black soils in the plains, dominated by the Tungabhadra River formed by the confluence of the Tunga and Bhadra rivers. The Ghataprabha and Malaprabha Sub-Basins are characterized by flat to gently sloping terrains with occasional hills, predominantly featuring black soils with patches of laterite soils,

and are drained by the Ghataprabha and Malaprabha rivers, which join the Krishna River. The Delta Region is a flat, low-lying area near the coast with rich alluvial soils, very fertile for agriculture, where the Krishna River splits into numerous distributaries, forming an extensive delta before flowing into the Bay of Bengal.

2.3 Climate Variation

The Krishna basin has a tropical climate, dominated by the southwest monsoon, which brings most of the region's precipitation. High river flows occur from August to November, with a lean flow season from April to May. The climate varies from per-humid in the west to semi-arid in the central and eastern parts, with the south-central area being truly arid. The Western Ghats significantly influence the basin's climate, acting as a barrier affecting temperature, rainfall, and humidity distribution.

Rainfall in the Krishna basin is predominantly received during the southwest monsoon, accounting for approximately 90% of the annual precipitation, with more than 70% occurring during July, August, and September. The basin's average annual rainfall ranges from 450mm to 3200mm (Fig.), with the highest amounts typically observed in the western parts. However, the basin faces challenges related to drought, with approximately 203 blocks in 30 districts across Karnataka, Andhra Pradesh, and Maharashtra being classified as drought-prone areas. These regions require focused attention and sustainable water management strategies to mitigate the impact of water scarcity during dry periods.

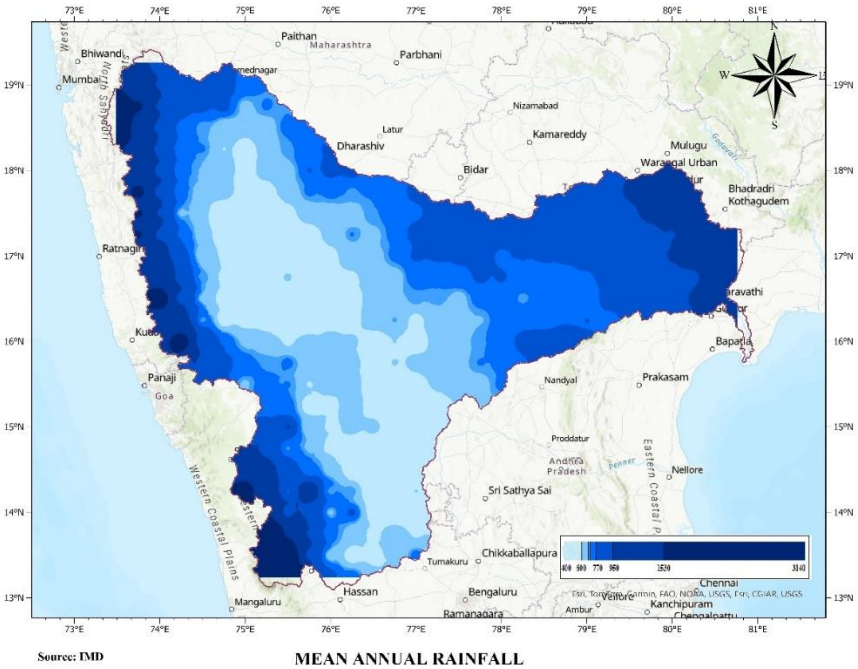


Fig. 16. Variation of Mean Annual Rainfall across the Krishna Basin

Temperature-wise, the mean maximum temperature in the basin ranges from 29.5°C to 37°C (Fig.), while the mean minimum temperature ranges from 18°C to 28°C (Fig.). The temperature profile shows that the western parts of the basin, influenced by altitude and proximity to the sea, experience more moderate temperatures, while the central and eastern regions experience more extreme temperatures.

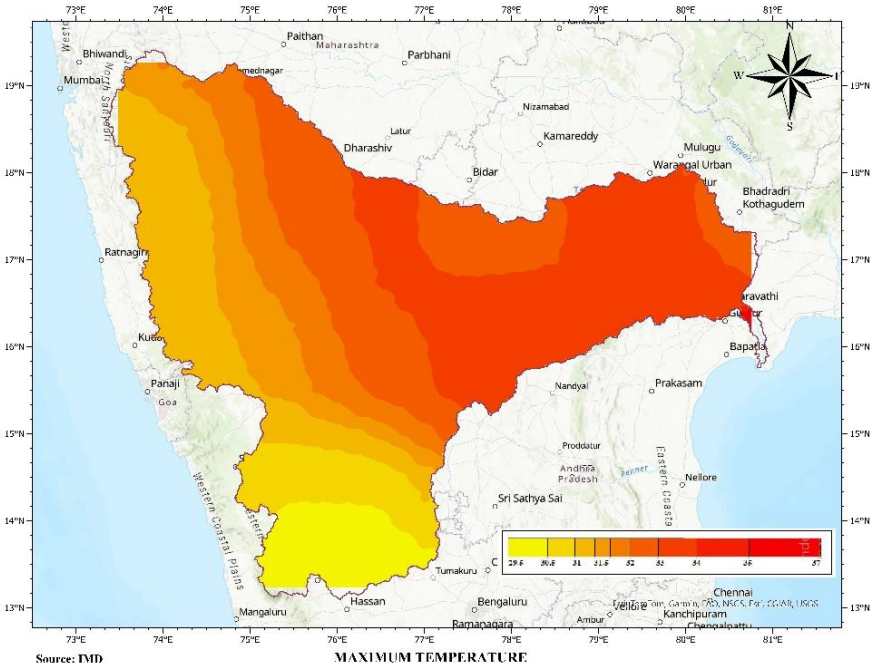


Fig. 17. Variation of Mean Maximum Temperature across the Krishna Basin

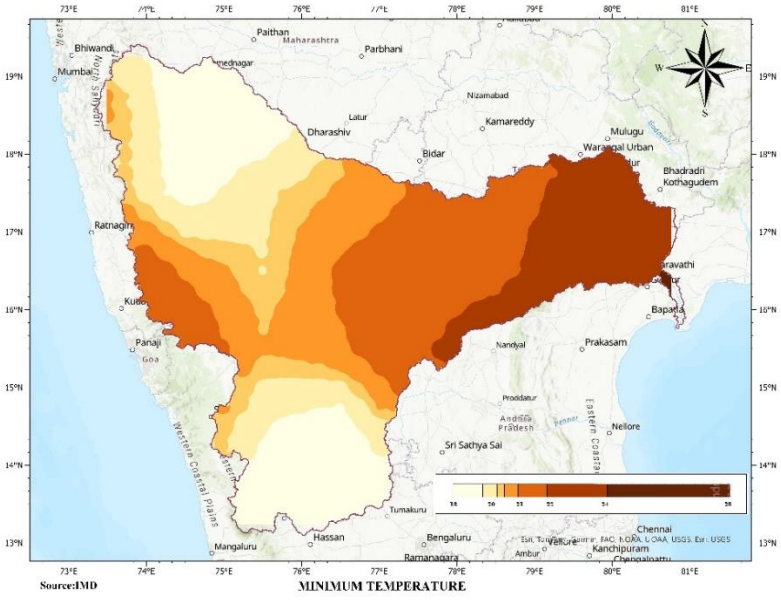


Fig. 18. Variation of Mean Minimum Temperature across the Krishna Basin

2.4 Land Use and Land cover

The land use and land cover data for the Krishna River Basin, obtained from ESRI with a 10m resolution shown in Fig. , reveal a diverse distribution of land types. Cropland is the dominant land use, covering 75.6% of the total area, reflecting the basin's significance in agriculture. Rangelands account for 4% of the basin, providing essential grazing areas and supporting biodiversity. Forest occupies 10.04% of the area, contributing to the ecological balance and offering habitat for various wildlife species. Water bodies cover 4.07% of the basin, crucial for sustaining the region's water supply and supporting aquatic life. Built-up areas, constituting 5% of the basin, are primarily concentrated in urban centres, highlighting the region's ongoing urbanization and development. This diverse land use distribution underscores the multifaceted nature of the Krishna River Basin, supporting agriculture, biodiversity, water resources, and urban development.

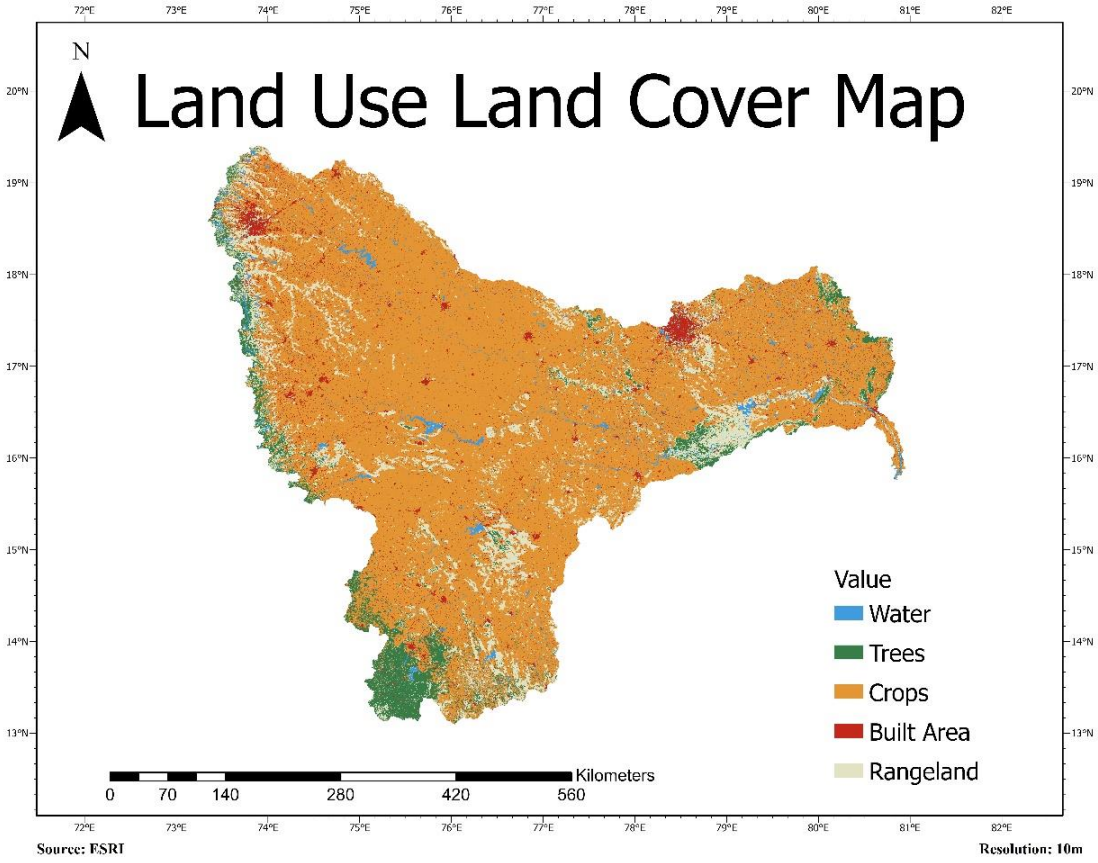


Fig. 19. Land Use Land Cover of Krishna Basin

2.5 Soil

The soil data for the Krishna River Basin, obtained from the FAO soil classification, shown in Fig. 2 reveals a diverse distribution that significantly influences the region's agriculture and hydrology. Clay soils dominate the basin, covering 46.2% of the total area. These soils have a high water-holding capacity, low permeability, and slow drainage, making them rich in nutrients but prone to waterlogging. Clay-loam soils, accounting for 43.1% of the area, offer a balanced mix of clay, silt, and sand, providing good water retention and drainage, making them fertile and suitable for a variety of crops. Loam soils, which cover 4% of the basin, consist of an equal mix of sand, silt, and clay, known for their high fertility, good drainage, and moisture retention, making them ideal for agriculture. Sandy-clay loam soils, constituting 6% of the area, have a coarser texture than loam, providing better drainage and moderate water retention, which can be beneficial in regions where quick drainage is needed. This diverse soil composition supports a range of agricultural practices and plays a crucial role in the overall productivity and sustainability of the Krishna River Basin.

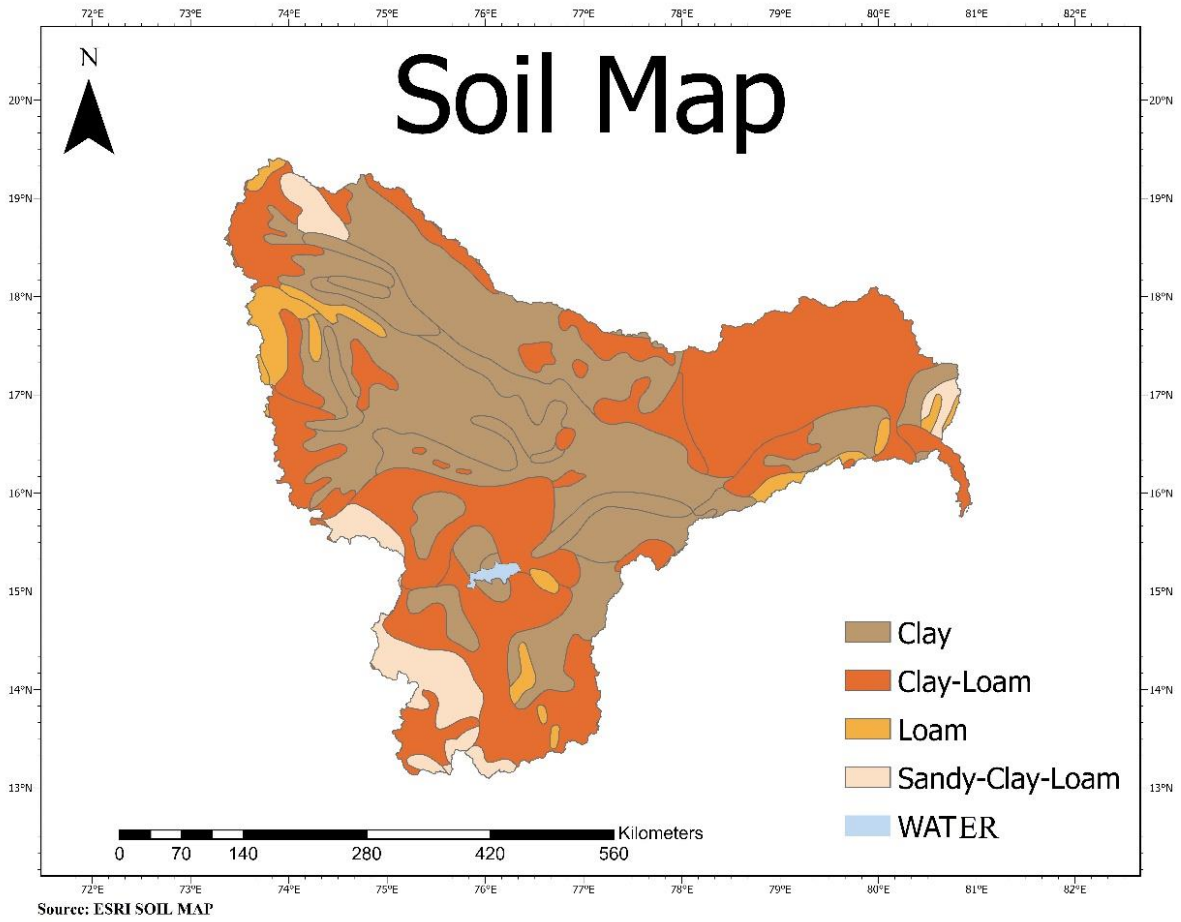


Fig. 20. Soil Map of Krishna Basin

2.6 Population

The Krishna River Basin is home to a total population of 66,341,683 people, encompassing 47 major districts. Fig. 2 shows the spread of population in million throughout the Krishna basin. Key urban areas within the basin include Pune, Hyderabad, Rangareddy, and Guntur. The urban population in these major cities constitutes 16.8% of the total population in the basin, with the majority depending on agriculture for their livelihood. Languages commonly spoken in the region include Marathi, Kannada, Telugu, and Urdu, reflecting its linguistic diversity. The basin is also culturally vibrant, hosting festivals such as Ganesh Chaturthi, Ugadi, and Makar Sankranti, which highlight its rich cultural heritage.

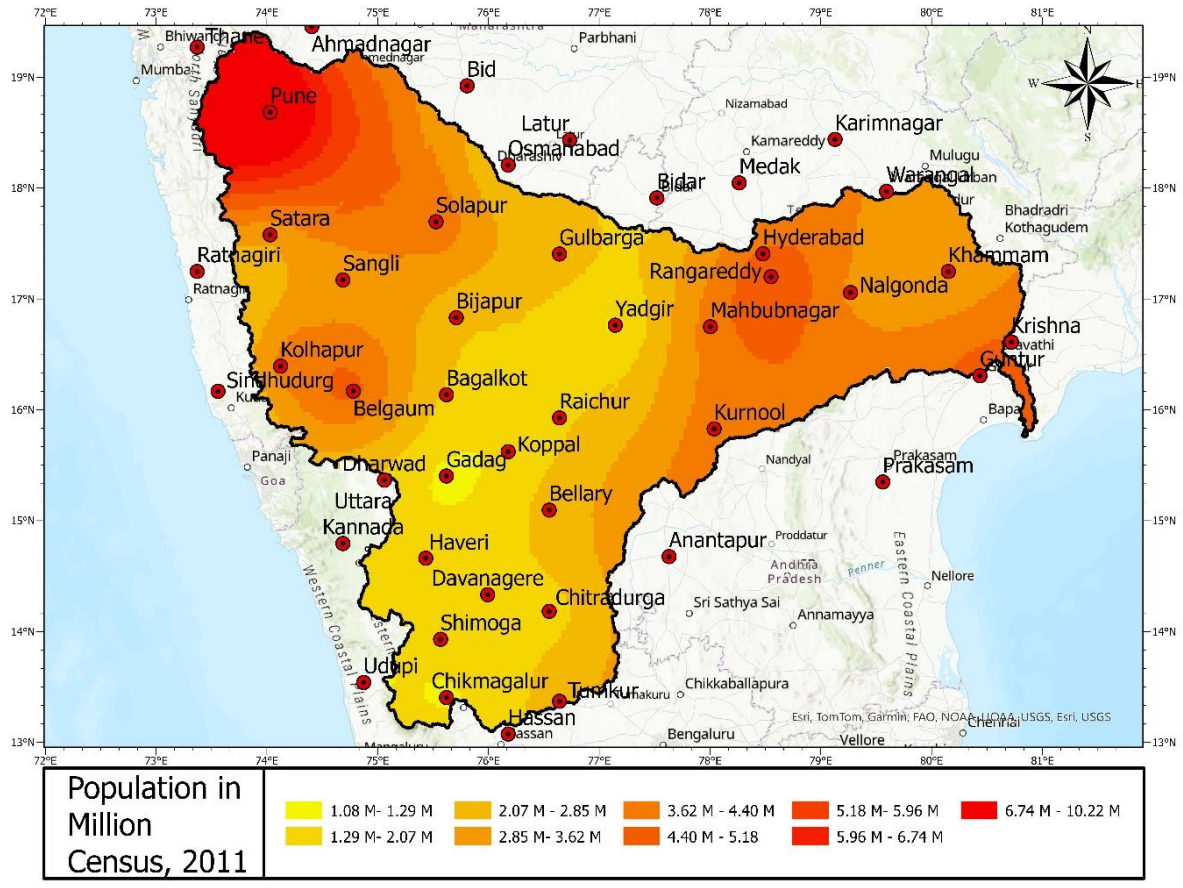


Fig. 21. Population Spread in the Krishna Sub-Basin

2.7 Degradation of River Stretches

The Krishna River Basin, which spans parts of Maharashtra, Karnataka, Telangana, and Andhra Pradesh, faces several degradation issues beyond pollution. Key factors include

sediment encroachment, riverbank erosion, hydrological alterations, habitat degradation, climate change impacts, and unsustainable agricultural practices.

- **Sediment Encroachment**

  Reservoir sedimentation impacts reservoirs like Srisailam and Nagarjuna Sagar by reducing their storage capacity due to significant sedimentation primarily driven by soil erosion in upstream areas caused by deforestation and agricultural activities. The annual average observed rate of sedimentation in 15 major reservoirs in the Krishna River Basin is more than 2.3%. This reduced water storage capacity affects water availability for irrigation and drinking purposes downstream. For instance, during dry seasons, farmers in Andhra Pradesh face water shortages for crop irrigation, affecting agricultural productivity. Riverbed aggradation, another consequence, raises the riverbed due to increased sediment load, reducing the river's channel capacity and heightening the risk of flooding during heavy rainfall. This issue is particularly prevalent in parts of Karnataka and Andhra Pradesh, where towns and agricultural fields are increasingly prone to flooding.

- **Riverbank Erosion**

  Unregulated sand mining destabilizes riverbanks, leading to severe erosion, which alters the river's course and threatens nearby agricultural lands and human settlements. This erosion can undermine bridges, roads, and other infrastructure near the river, as seen in Maharashtra where bridges have suffered damage due to undermined foundations caused by erosion. The loss of vegetative cover exacerbates this problem; deforestation and removal of riparian vegetation for agriculture and development reduce natural bank protection, increasing erosion. In Telangana, the loss of vegetative cover has led to increased soil erosion and sedimentation in the river.

- **Hydrological Alterations**

  Dams and diversion projects, such as the Almatti and Tungabhadra dams, significantly alter the natural flow regime. These structures trap sediments and disrupt downstream sediment transport, affecting the river's morphology and health. Altered flow regimes also lead to reduced water availability for downstream agricultural fields, impacting crop yields. Farmers in Andhra Pradesh and Karnataka often face water scarcity during crucial growing periods. Over-extraction of water for irrigation, industrial, and domestic use reduces the river's flow, affecting sediment transport capacity and increasing sedimentation in certain stretches, especially in the lower reaches of the river in Andhra Pradesh.

2.8 Degree of Pollution

- **Upper Bhima and Lower Bhima Sub-Basin**

  The Krishna River is heavily polluted at various points including Wai, Haripur ghat in Sangli town, and Bhima at Pandarpur, primarily due to urban sewage and oil pollution from vehicle washing. In Pandarpur, pollution is mostly non-toxic, but the river's self-purification

capacity is high. During summer, the water quality is poor, indicated by low oxygen levels (Pandarpur 3.4 mg/l, Sangli 2.5 mg/l, Wai 3.0 mg/l). Fish in these waters are of poor quality, with species like Gambusia thriving in polluted conditions. The Bhima River is also polluted at Yadgir due to sewage discharge. Industrial effluents from numerous factories, including sugar mills and manufacturing plants, further contaminate the Krishna River. The BOD load from urban wastewater and industries in the Krishna basin is significant, with urban sources contributing 82.9% and industrial sources 17.1%. Additionally, substantial quantities of chemical fertilizers and pesticides are used in the region, exacerbating the pollution problem.

- **Krishna Upper, Middle and Lower Sub-Basins**

  Rayalaseema Paper Mills Ltd. in Kurnool discharges treated effluents into the Tungabhadra River, contributing to pollution along with public waste and motor launch diesel leakage. Effluent BOD levels reach up to 20 mg/l, with daily discharges between 35,000 to 40,000 cubic meters. Fish quality has deteriorated, with notable species like Tor neilli no longer found. Additional pollution comes from various industries in Telangana, including pharmaceuticals, heavy water production, and synthetic chemicals, particularly affecting Nagarjunasagar. The Krishna basin in Andhra Pradesh faces a significant organic pollution load of 0.33 million kg of BOD per day, predominantly from urban sources. Chemical fertilizer use is high, with nitrogen being the most applied. Despite the Vijayawada Thermal Power Station's hot effluent release, water quality remains within normal limits, and no decline in fish catches has been reported. The basin hosts 427 industries, mainly chemical, metallurgical, engineering, and food processing.

- **Tungabhadra Upper and Lower Sub-Basin**

  The Tungabhadra River, a major tributary of the Krishna River in Karnataka, supports various activities including bathing, washing, power generation, irrigation, and drinking water supply. The basin hosts numerous industries such as pulp and paper, iron and steel, sugar distilleries, polyfibres, chemicals, and engineering, with 24 large, 25 medium, and 69 small-scale industries. Notable industrial areas include Bhadravathi, Harihar-Davangere, and Hospet. At Harihar, a polyfibre factory discharges effluent 54 km downstream, with BOD levels ranging from 1.0 to 5.0 mg/l and DO as low as 2.6 mg/l in May 1988. This factory uses approximately 35,000 cubic meters of water daily and discharges about 33,000 cubic meters of treated wastewater back into the river. Table details the major pollution agencies and their respective locations.

Table 4. Major pollution agencies and their pollution points

Name of Polluting Agency state	Name of Polluting Agency	Location	Polluting points
MAHARASHTRA	Krishna River at Wai, Satara District	Wai	Urban wastes, sewage, automobile effluents as diesel, etc. cattle, human bathing.
	Harlpurghat Sangli.	Sangli Town	Urban wastes, sewage, automobile effluents as diesel etc. cattle, human bathing.
	Bhima River, Pandarpur.	Pandarpur ghat.	Human and Cattle bathing, religious offerings.
ANDHRA PRADESH	Tungabhadra River, Nawab's Bungalow, Kurnool.	Kurnool Town.	Urban sewage, leakage of motor launch.
	Tungabhadra River, Mantralayam.	Mantralayam	Pilgrims religious of taking bath. Urban sewage.
KARNATAKA	Ghataprabha River, Bagalkot.	Kaholl, Bagalkot town.	Urban wastes, sewage, cattle washings.

Source: Jayaram, K. C. (1994) The Krishna River System

The industrial landscape of the Krishna Basin is diversified across several key sectors. Chemical and metallurgical industries constitute the largest segment, comprising 31.38% of the total industrial presence. Following closely are engineering industries at 22.00%, while food industries account for 23.74%. Miscellaneous industries contribute 13.51%, with textile industries making up 8.06% and mining industries representing 1.31%. In total, there are 427 industries spread across these sectors within the Krishna Basin, reflecting a varied economic profile and industrial activity in the region.

Table 5 details the major industrial pollution point source agencies on the Krishna basin.

Table 5. Major industrial pollution point sources on the Krishna basin

MAJOR INDUSTRIAL POLLUTING AGENCIES (POINT SOURCES)			
Name of the state	**Name of Factory**	**Location/Town**	**Products**
MAHARASHTRA	Ugar Kagwad Sugar Factory	Sangli	Sugar, Molasses.
	Krishna Coop. Sugar Factory, Shivnagar.	Karad	Sugar, Molasses.
	Aristocrat Baggage Factory	Satara	Moulded luggages.
	Maharashtra Scooters Ltd.	Satara	Machinery.
KARNATAKA	Dempu dairy Works, Rabkavt	Jamkhandi	Milk Products.
	Harlhar Polyfibres Ltd.	Harihar	Polyester fibre
ANDHRA PRADESH	Rayalaseema Paper Mills Ltd.	Kumool	Paper, Board.
	A.P. Drugs and Pharmaceutical Industries.	Vljayapuri North	Drugs.
	Raasi Synthetic and Chemicals	Vljayapuri North	Chemicals.
	Vljayawada Thermal Power Station	Ibrahimpatnam, Vljayawada.	Thermal Power.
	K.C.P. Sugar Mills Ltd.	Vyyuru, Vijayawada	Sugar Molasses.

Source: Jayaram, K. C. (1994) The Krishna River System

2.8.1 Plankton

- **Upper Reach**

  In the upper reaches of the Krishna River, plankton communities are notably abundant and diverse. Specific species such as Paracyclops vagus and Onychocamptus chathamensis among copepods are found exclusively in this region. Rotifers including Brachionus rubens, Brachionus anguillaris, Brachionus caudatus, Brachionus falcatus, Bosminopsis caudatus, Filinia longiseta, and Keratella tropica are absent or scarce in these upper reaches. The upper stretch supports a richer diversity of plankton life compared to the middle and lower reaches.

- **Middle Reach**

  The middle reaches of the Krishna River exhibit a moderate presence of plankton species. Rotifers like Brachionus rubens, Brachionus anguillaris, Brachionus caudatus, Brachionus falcatus, Bosminopsis caudatus, Filinia longiseta, and Keratella tropica are absent in this region, indicating a lower diversity compared to the upper reaches. However, specific

copepod species such as Paracyclops vagus and Onychocamptus chathamensis are found here, suggesting some distinct plankton populations within this stretch.

- **Lower Reach**

  The lower reaches of the Krishna River, particularly below the Prakasam barrage to its confluence, show a notable decline in plankton populations. This stretch is characterized by poor plankton diversity and abundance. Rotifers are particularly scarce, and copepods are represented by Calanoid copepods, Cyclopoid copepods, Ergasilus, and Topocyclops parasinus. Cladocerans like Diaphanosoma and Bosmina are present but in reduced numbers. The heavy floods and high silt load during the postmonsoon period contribute to this reduced plankton population in the lower reach. Table shows the fluctuations of Zoolankton at different sampling stations of Krishna system from which it can be concluded that zooplankton population was greater in premonsoon periods than in postmonsoon.

Table 6. The seasonal fluctuations of total zoolankton (numbers/litre) at the different sampling stations of the krishna system (1988-1990)

River Krishna	Premonsoon	Postmonsoon
Dhom Reservoir	11	8
Wai	6	6
Karad	6	2
Hadpurghat, Sangli	23	13
Jamkhandi	25	15
Gadwal	19	15
Nagarjunasagar	15	8
Ramapuram	17	8
Vljayawada	27	6
Nagayalanka	Not Covered	27
Panchaganga		
Kolhapur	40	Not Covered
Bhlma		
Pandarpur	8	8
Tungabhadra		
Kurnool	15	2

Source: Jayaram, K. C. (1994) The Krishna River System

2.9 Pollution stretches in Krishna River and its tributaries

The pollution stretches in the Krishna River and its major tributaries are significant, impacting various towns and communities. For the Krishna River, stretches from Shindi to Kurundwad affect Wai, Karad, Uran Islampur, Sangli, Shiroi, and Kshetra Mahuli due to sewage and industrial waste from Karad and Sangli. The section from Vadurwadi to Tintini Bridge impacts Ugarkhurd, Chikkodi, and Narayanpura primarily due to sewage, while Thangadigi to Wadapally suffers from industrial waste and sewage affecting Thangadigi and Guntur. The stretch from Amaravathi to Hamsaladeevi impacts Vijayawada with sewage coming from the city.

The Bhima River experiences pollution from Vithalwadi to Takli, affecting Koregaon, Pargaon, Nira, Narasingpur, and Takali due to sewage from Pune and Daund, and from Ghanapur to Yadgir, affecting Jevargi with sewage issues. In the Tungabhadra River, the Matralayam to Bavapuram stretch impacts Kurnool due to industrial waste and sewage, and the Harihara to Korallahalli stretch is affected by sewage from Harihara and Grasim waste. The Musi River's pollution stretch from Hyderabad to Suryapet affects Hyderabad, Rangareddy, and Nalgonda due to sewage and industrial waste from Hyderabad and Secunderabad.

The Malprabha River from Khanapur to Dharwad, Ghataprabha River from Gokak to Chigadolli, Koyna River from Karad to Papdare, and Panch Ganga River from Shirol to Kolhapur are all impacted by sewage. Specifically, the Koyna River stretch affects Karad, Patan, Papdare, and Tambave due to sewage from Karad, while the Panch Ganga River stretch impacts Shirol and Ichalkaranji due to industrial and municipal sewage from Kolhapur. Table 7. details the pollution stretches and their lengths on the Krishna River and its tributaries, and Figure 22. shows the map of the Krishna River and tributaries highlighting the pollution stretches.

Table 7. Pollution stretches and their lengths on the Krishna River and its tributaries

POLLUTION STRECHES IN KRISHNA AND ITS MAJOR TRIBUTORIES				
S.No	NAME OF TRIBUTARY	POLLUTION STRETCH	TOWN	SOURCE
1	KRISHNA RIVER	Shindi to Kurundwad	Wai, Karad, Uran Islampur, Sangli, Shiroi, Kshetra Mahuli	Sewage & Industrial waste from Karad & Sangli
		Vadurwadi to Tintini Bridge	Ugarkhurd, Chikkodi, Narayanpura	Sewage
		Thangadigi to Wadapally	Thangadigi, Guntur	Industrial waste and sewage
		Amaravathi to Hamsaladeevi	Vijayawada	Sewage from vijayawada
2	BHIMA RIVER	Vithalwadi to Takli	Koregaon,pargaon, Nira, Narasingpur,takali	Pune sewage, Daund Sewage
		Ghanapur to Yadgir	Jevargi	Sewage
3	TUNGABHADRA RIVER	Matralayam to Bavapuram	Kurnool	Industrial waste and sewage
		Harihara to Koralhalli	Ullanur, Harihar	Harihara sewage and Grasim Waste
4	MUSI RIVER	Hyderabad to Suryapet	Hyderabad, Rangareddy, Nalgonda	Sewage and industrial waste from Hyderabad and secunderabad
5	MALPRABHA	Khanapur to Dharwad	M.K Hubli, Kadrolli	Sewage
6	GHATPRABHA	Gokak to Chigadolli	Gokak	Sewage
7	KOYNA RIVER	Karad to papdarde	Karad,patan,padarde,tambave	Karad Sewage
8	PANCH GANGA RIVER	Shirol to kolhapur	Shirol, Ichalkaranji	Industrial & Municipal sewage of Kolhapur

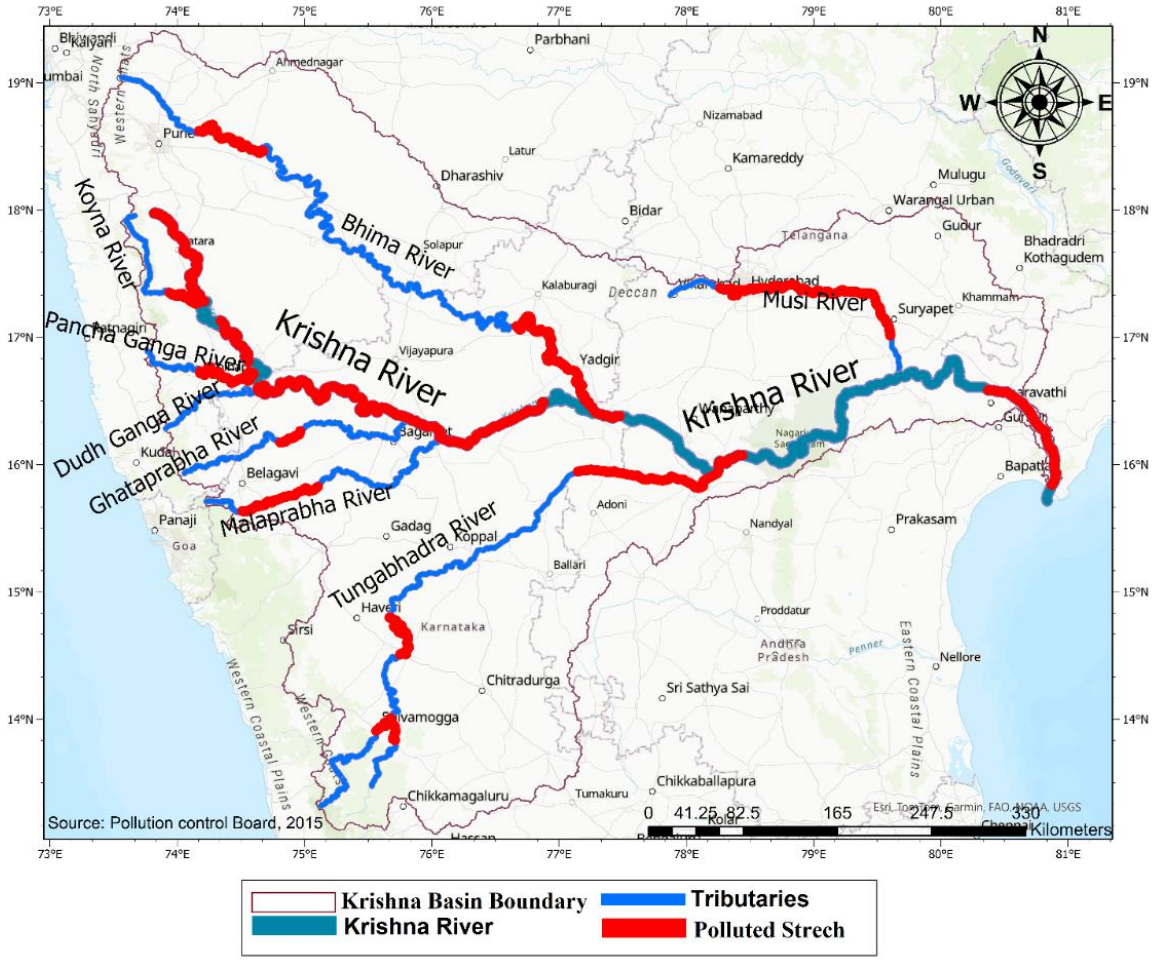


Fig. 22. Map of the Krishna River and tributaries highlighting the pollution stretches

3. SIGNIFICANCE OF DIFFERENT SUB-BASINS IN KRISHNA RIVER

The significance of different sub-basins can be evaluated based on various aspects including ecological, historical, social, cultural, behavioural, political, and economic factors.

3.1 Ecological Significance

- **Upper Bhima and Lower Bhima Sub-Basins**
  The Upper and Lower Bhima sub-basins are vital ecosystems supporting diverse flora and fauna. Key plant species include Teak (Tectona grandis), Indian Rosewood (Dalbergia latifolia), Sandalwood (Santalum album), and various bamboo and grasses. Approximately 75% of the tropical evergreen forest here is dominated by teak species like Terminalea tomentosa, Tectona grandis, and Adina. The Bhima River significantly influences agricultural patterns and local wildlife habitats.

- **Upper, Middle, and Lower Krishna Sub-Basins**
  The Krishna River basin spans diverse ecosystems and geological formations across its Upper, Middle, and Lower sub-basins. In the semi-arid Upper Krishna Sub-basin, sacred groves conserve biodiversity amidst geological features like the Deccan Traps and Cuddapah Group, crucial for studying climate change impacts. The Middle Krishna Sub-basin supports fertile soils, abundant water, and diverse agriculture, alongside wildlife sanctuaries vital for protecting 195 fish species, the highest in Andhra Pradesh. In the Lower Krishna Sub-basin near the delta, freshwater and marine biodiversity thrive, with the Krishna Wildlife Sanctuary safeguarding mangrove forests and diverse wildlife like fishing cats, otters, and estuarine crocodiles, amidst Pleistocene to recent geological formations supporting local livelihoods through fishing and agriculture

- **Upper and Lower Tungabhadra Sub-Basins**
  The Upper Tungabhadra sub-basin features diverse ecosystems significant for ecological research and conservation, with forests and water bodies providing habitats for many species. The Lower Tungabhadra sub-basin has important wetlands critical for bird species, both resident and migratory. Agricultural landscapes here rely heavily on the Tungabhadra River's water resources, influencing the region's biodiversity and ecological health.

3.2 Historical Significance

- **Upper Bhima and Lower Bhima Sub-Basins**
  The Upper and Lower Bhima sub-basins have been historically significant due to their strategic location and fertile lands. These regions have been inhabited since ancient times, with archaeological findings indicating the presence of early human settlements. The Bhima River has historically supported agriculture, which led to the establishment of prosperous communities and trade routes. The river valley has witnessed various historical events and has been a cradle for cultural and political activities throughout different eras, including under the rule of various dynasties like the Satavahanas, Chalukyas, and Yadavas.

- **Upper, Middle, and Lower Krishna Sub-Basins**
  The Krishna River basin is rich in historical heritage and cultural significance across its Upper, Middle, and Lower sub-basins. In the Upper Krishna Sub-basin, evidence of ancient civilizations like the Satavahanas and Chalukyas is prevalent, with historic temples, forts, and monuments reflecting the architectural and cultural advancements of past societies. The semi-arid conditions have influenced settlement patterns and agricultural practices over centuries. The Middle Krishna Sub-basin, historically under the rule of the Hyderabad Nizams, boasts significant cultural and architectural achievements, including palaces, mosques, and administrative buildings in cities like Hyderabad. Fertile lands and abundant water from the Krishna River supported agricultural prosperity and trade during this period. The Lower Krishna Sub-basin, particularly the delta region, has been a hub for trade and commerce due to its access to the sea. Ancient ports facilitated trade with other parts of India and foreign lands, with remnants of ancient towns, forts, and temples underscoring its historical richness. The Krishna delta's significance is further highlighted by its role in early maritime activities and cultural exchanges.

- **Upper and Lower Tungabhadra Sub-Basins**
  The Upper Tungabhadra sub-basin is historically significant due to its association with the Vijayanagara Empire, one of the most powerful South Indian kingdoms. The river provided water for the empire's capital, Hampi, which is now a UNESCO World Heritage site known for its remarkable ruins and monuments. The Tungabhadra River's strategic importance contributed to the prosperity and defense of the empire.

The Lower Tungabhadra sub-basin has historical significance due to its fertile lands and water resources, which have supported agriculture and settlement for centuries. The region has seen the rise and fall of various dynasties, including the Chalukyas and Hoysalas. Historical structures such as temples, forts, and ancient irrigation systems highlight the area's rich cultural and historical heritage.

3.3 Political Significance

- **Upper Bhima and Lower Bhima Sub-Basin**
  The Upper and Lower Bhima sub-basins hold significant political importance due to their role in water resources management and agricultural productivity in the states of Maharashtra and Karnataka. Disputes over water allocation from these sub-basins are frequent, as they are vital for irrigation, drinking water, and industrial uses. The Bhima River, being a major tributary of the Krishna River, contributes substantially to the overall water availability in the Krishna basin, making inter-state cooperation and agreements crucial. Political negotiations and treaties often focus on equitable distribution, especially during drought periods, influencing regional politics and interstate relations.

- **Krishna Upper, Middle, and Lower Sub-Basins**
  The Krishna Upper, Middle, and Lower sub-basins span across Maharashtra, Karnataka, Telangana, and Andhra Pradesh, making water management a politically sensitive issue. The Krishna Water Disputes Tribunal has been a central platform for resolving conflicts among these states over water sharing. The allocation of water resources impacts agricultural policies, industrial development, and urban planning, with each state vying for a larger share to support their socio-economic growth. Political significance is heightened by periodic monsoon failures, leading to intensified negotiations and legal battles over water rights and distribution.

- **Tungabhadra Upper and Lower Sub-Basin**
  The Tungabhadra sub-basin, divided into upper and lower regions, plays a critical role in the states of Karnataka and Andhra Pradesh. The Tungabhadra River is essential for irrigation, hydroelectric power generation, and supporting local economies. Political significance arises from the competing demands for water from the Tungabhadra Dam, which serves as a crucial resource for both agricultural and urban needs. Water sharing disputes and the management of the river's resources are central to regional politics, with state governments often engaging in negotiations and agreements to ensure equitable distribution and sustainable usage

3.4 Economic Significance

- **Upper Bhima and Lower Bhima Sub-Basin**
  The Upper and Lower Bhima sub-basins are crucial for the agricultural and industrial sectors in Maharashtra and Karnataka. The Bhima River supports extensive irrigation systems that sustain the cultivation of sugarcane, a significant cash crop in the region, along with other crops like wheat, sorghum, and pulses. Pune, a major city in the Upper Bhima sub-basin, benefits economically from the river through its role as an educational and IT hub, which

attracts investment and skilled labour. Solapur, another key city, relies on the Bhima for its extensive textile industry, particularly known for producing cotton textiles. The river's water is also essential for various industries, including sugar mills and breweries, contributing significantly to the local economy. Additionally, the river's basin is a vital source of drinking water for these cities, impacting urban water supply and public health positively.

- **Krishna Upper, Middle, and Lower Sub-Basins**

  The Krishna River basin, spanning the states of Maharashtra, Karnataka, Andhra Pradesh, and Telangana, is economically significant due to its vast agricultural, industrial, and hydroelectric potential. The upper sub-basin supports diverse agriculture, with crops like jowar, maize, and cotton. The middle sub-basin, hosting major dams like the Almatti and Narayanpur, is pivotal for irrigation, supporting paddy and horticultural crops. Hyderabad, a major city in the middle sub-basin, relies on the Krishna River for a significant portion of its water supply, supporting its large urban population and numerous industries including IT, pharmaceuticals, and manufacturing. The lower sub-basin, particularly around the Krishna delta, is a major rice-producing region, benefiting from extensive canal irrigation. Vijayawada, located in the lower sub-basin, serves as a commercial and educational centre, leveraging the river for irrigation and drinking water. Additionally, the Krishna basin is vital for hydroelectric power generation, with several dams contributing to the regional power supply and industrial development.

- **Tungabhadra Upper and Lower Sub-Basin**

  The Tungabhadra sub-basin, part of the larger Krishna basin, is critical for agricultural and industrial activities in Karnataka and Andhra Pradesh. The upper sub-basin, with the Tungabhadra Dam, provides irrigation to vast tracts of land, enabling the cultivation of rice, maize, and cotton. The city of Hospet, located near the Tungabhadra Dam, benefits economically from both agriculture and the presence of numerous industries, including steel and cement manufacturing. In the lower sub-basin, Kurnool is a significant urban center that utilizes the river for irrigation and industrial activities, including cement and textile production. The Tungabhadra River also plays a key role in supporting fisheries and sustaining the livelihoods of local communities. The basin's water resources are integral to both agricultural productivity and industrial growth in the region.

3.5 Social and Cultural Significance

- **Upper Bhima and Lower Bhima Sub-Basin**

  The Upper and Lower Bhima Sub-Basins, encompassing parts of Maharashtra and Karnataka, are rich in cultural heritage and traditions. In the Upper Bhima region, Pandharpur is a major pilgrimage centre, famous for the Vithoba Temple, which attracts millions of devotees during the Ashadhi Ekadashi and Kartiki Ekadashi festivals. These festivals are marked by massive processions and vibrant cultural activities. The town of Solapur is known for its ancient temples and the annual Solapur Mela, which showcases

local crafts, food, and performances. In the Lower Bhima region, the towns of Gulbarga and Bidar are significant for their historical monuments and religious sites. The Khwaja Bande Nawaz Dargah in Gulbarga is a key Sufi shrine, drawing pilgrims during the annual Urs festival. These areas are also known for traditional music and dance forms like Lavani and Dholki, which are integral to their cultural identity.

- **Krishna Upper, Middle, and Lower Sub-Basins**

  The Krishna River, flowing through Maharashtra, Karnataka, Telangana, and Andhra Pradesh, influences a vast cultural landscape. In the Upper Krishna sub-basin, Pune and Satara are notable cultural hubs. Pune hosts the Ganesh Chaturthi festival with grand celebrations, including processions and cultural performances. Satara is known for the Kaas Plateau, a UNESCO World Heritage Site, celebrated for its biodiversity and natural beauty. The middle sub-basin includes Hyderabad, a city rich in history and culture, known for the Charminar, Golconda Fort, and the Qutb Shahi Tombs. Festivals like Bonalu, Bathukamma, and Ramzan are celebrated with great fervor. The Lower Krishna sub-basin, particularly the Krishna delta region, is famous for its fertile lands and agricultural prosperity. Vijayawada is known for the Kanaka Durga Temple and the Krishna Pushkaralu festival, which occurs once every 12 years, attracting millions of pilgrims. The Kuchipudi dance form, originating from this region, is a significant cultural contribution to Indian classical arts.

- **Tungabhadra Upper and Lower Sub-Basin**

  The Tungabhadra River, flowing through Karnataka and Andhra Pradesh, is culturally significant due to its historical and religious landmarks. In the Upper Tungabhadra region, Hampi stands out as a major cultural site, once the capital of the Vijayanagara Empire. Hampi is dotted with numerous temples, monuments, and ruins, reflecting the grandeur of medieval South India. The annual Hampi Utsav is a cultural festival that revives the grandeur of the Vijayanagara era with music, dance, and drama performances. The Virupaksha Temple in Hampi is a key pilgrimage site, attracting devotees year-round. In the Lower Tungabhadra region, the Tungabhadra Dam supports a thriving agrarian community. The region celebrates various festivals like Ugadi (New Year) and Sankranti (Harvest Festival) with traditional fervor. The town of Kurnool, located near the lower basin, is known for the Kondareddy Buruju and the Orvakal Rock Garden. The Rayalaseema region, part of the lower sub-basin, is renowned for its rich folklore, dance forms like Veeranatyam, and vibrant local fairs and festivals.

CULTURAL SITES

Upper Bhima and Lower Bhima Sub-Basin

Pandharpur,Pandhapur

Siddheshwar Temple, Solapur

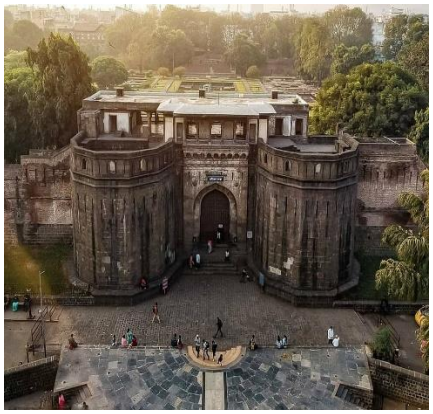
Tulja Bhavani Temple, Tuljapur

Gulbarga Fort, Gulbarga

Bidar Fort, Bidar

Dattatreya Temple, Gangapur

Krishna Upper, Middle, and Lower Sub-Basins



Shaniwar Wada, Pune

Ajinkyatara Fort, Satara

Charminar, Hyderabad

Navabrahma Temples, Alampur

Kanakadurga Temple, Vijayawada

Birla Mandir, Hyderabad

Tungabhadra Upper and Lower Sub-Basin

Virupaksha Temple, Hampi

Vittala Temple, Hampi

Lotus Mahal, Hampi

Mantralayam, Kurnool

Jogulamba Temple, Gadwal

Ahobilam, Nandyal

3.6 Behavioural Significance

The Krishna River plays a crucial role in the lives of people in Maharashtra, Karnataka, Telangana, and Andhra Pradesh. It influences their daily activities, cultural practices, and economic endeavors, shaping a unique relationship between humans and this vital water resource. Here are the key aspects of its behavioral importance:

- **Essential Resource for Daily Life and Agriculture**
  The Krishna River provides essential water for household use and agricultural irrigation, particularly through major projects like the Nagarjuna Sagar and Srisailam Dams. These projects support the agrarian economies in Andhra Pradesh and Telangana. Farmers rely on the river for irrigation, leading to the development of specific agricultural practices and water management techniques to optimize its use.

- **Cultural and Religious Connections**
  The Krishna River holds significant cultural and religious value. Festivals such as Krishna Pushkaralu draw millions of pilgrims to its banks. Important religious sites, including the Mallikarjuna Jyotirlinga in Srisailam and the Vittala Temple in Hampi, are located along the river, reinforcing its spiritual importance and fostering a deep sense of community and tradition.

- **Historical Water Disputes and Cooperation**
  The Krishna River has been the centre of longstanding disputes among the states of Karnataka, Maharashtra, Telangana, and Andhra Pradesh over water sharing. These conflicts have led to the formation of the Krishna Water Disputes Tribunal, which aims to resolve these issues. Despite tensions, these disputes necessitate ongoing cooperation and dialogue for equitable water distribution.

- **Adaptation to Environmental Changes**
  Communities along the Krishna River have adapted to changing environmental conditions, such as variable rainfall and water scarcity. In Maharashtra and Karnataka, farmers use drip irrigation and drought-resistant crops. The construction of check dams and rainwater harvesting systems helps mitigate water scarcity, demonstrating the communities' resilience and adaptability.

- **Efforts for River Conservation**
  Environmental challenges like pollution and deforestation threaten the health of the Krishna River. Initiatives such as Mission Kakatiya in Telangana focus on restoring tanks and lakes to improve groundwater recharge and reduce pollution. Community-led conservation efforts in Karnataka emphasize afforestation and sustainable farming practices to protect the river's ecosystem.

- **Economic Impact and Development**
  The Krishna River supports various economic activities, including agriculture, fishing, and hydropower generation. Projects like the Upper Krishna Project and Almatti Dam in Karnataka are crucial for regional development, providing irrigation water and electricity. The river's role in sustaining these activities directly impacts local economies and labor patterns.

- **Knowledge and Technological Innovation**
  The communities in the Krishna basin have developed extensive knowledge and innovative practices for water management and agriculture. Projects like the Andhra Pradesh Micro Irrigation Project (APMIP) promote efficient water use. This blend of traditional wisdom and modern technology helps communities manage the river sustainably and adapt to environmental changes.

4. MAJOR AND MEDIUM IRRIGATION PROJECTS

In the Krishna basin, irrigation infrastructure plays a crucial role in water management and agricultural development. The basin hosts 76 major and 135 medium irrigation projects, facilitating the distribution of water resources across the region. Table displays the major irrigation projects within the Krishna River basin. Additionally, several Lift Irrigation Projects (LIPs) are operational, including the Handri Neeva Sujala Sravanti (HNSS) Lift Irrigation Scheme, Krishna Koyna Lift Irrigation Project, Shirapur Lift Irrigation Project, Rajiv Bhima Lift Irrigation Scheme – I, and Sigatalur Left Side First Lift Irrigation Scheme. Furthermore, the basin features various Extension, Renovation, and Modernization (ERM) projects such as Neera Left Bank Canal, Extension of Krishna Canal, Modernisation of Hattikuni Canal, Ghataprabha Project Stage-III, and Modernisation of Bhadra Canal, all contributing to enhanced water utilization and agricultural productivity in the region.

Table 8. Major Irrigation Projects under Krishna Basin

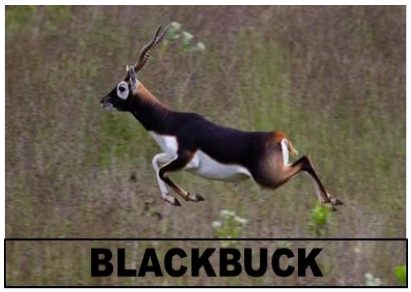
Krishna Major Irrigation Project	Maharashtra
Hippargi Irrigation Project	Karnataka
Ghatprabha medium irrigation Project	Maharashtra
Upper Krishna project stage-I	Bijapur
	Almatti dam: Almatti village in Bagewadi taluk of Bijapur district
	Narayanpur or Upper Krishna Stage-I dam: Bachihal and Siddapur village in Muddebihal taluk of Bijapur district.
Upper Krishna project stage-II	Bijapur, Gulbarga, Raichur and Bagalkot.
Malaprabha Major Irrigation Project	Mysore
Tungabhadra Right Bank High Level Canal Stage-I & II and Tungabhadra Right Bank High Level Canal	Andhra Pradesh & Karnataka
Tungabhadra Right Bank Low Level Canal	Karnataka
Khadakwasla Major Irrigation Project	Pune
Bhima Major Irrigation Project	Solapur, Pune and Ahmednagar
Jurala Major Irrigation Project	Mahboobnagar
Bhadra Major Irrigation Project	Chikmagalur and Shimoga.
Srisailam project	Andhra Pradesh
Srisailam Right Bank Canal Major Irrigation Project	Nalgonda, Kurnool and Cuddapah.
Srisailam Left Bank Canal Major Irrigation Project	Andhra Pradesh
Telugu ganga major irrigation project	Andhra Pradesh, Tamil Nadu
Nagarjunasagar project	Nalgonda, Khammam, Krishna, Guntur, Prakasam and West Godavari
Krishna Barrage (including old Krishna Delta system)	Krishna and Prakasam
Warna Major Irrigation Project	Sangli, Maharashtra
Chandrampalli Medium Irrigation Project	Gulbarga

Source: www.india-wris.nrsc.gov.in

5. BIODIVERSITY AT GLANCE

The Krishna basin hosts a variety of ecosystems, including forests, grasslands, and wetlands, supporting a rich biodiversity. Key wildlife species in the basin include Indian bison, blackbuck, and various bird species, with prominent protected areas such as:

- Nagarjunsagar-Srisailam Tiger Reserve
- Rollapadu Wildlife Sanctuary
- Bhadra Wildlife Sanctuary
- Ghataprabha Bird Sanctuary
- Gudavi Bird Sanctuary
- Koyna Wildlife Sanctuary
- Radhanagari Wildlife Sanctuary
- Great Indian Bustard Sanctuary
- Chandoli National Park
- Kudremukh National Park
- Kasu Brahmananda Reddy National Park
- Mahavir Harina Vanasthali National Park
- Mrugavani National Park
- Pakhal Wildlife Sanctuary
- Ranibennur Blackbuck Sanctuary
- Shettihalli Wildlife Sanctuary
- Daroji Sloth Bear Sanctuary, Bellary



The region's key plant species feature Teak (Tectona grandis), Indian Rosewood (Dalbergia latifolia), Sandalwood (Santalum album), and various species of bamboo and grasses. Approximately 75% of the tropical evergreen forest is dominated by teak species like Terminalea tomentosa, Tectona grandis, and Adina. Additionally, mangroves thrive in the estuarine region near Machilipatnam in Krishna district. The last surviving mangrove forests in the Krishna estuary have been declared as the Krishna Wildlife Sanctuary, which is home to numerous resident and migratory birds. The sanctuary also hosts fishing cats, otters, estuarine crocodiles, spotted deer, sambar deer, blackbucks, snakes, lizards, and jackals, with rich vegetation including plants like Rhizophora, Avicennia, and Aegiceros.

The aquatic life in the Krishna basin is notably diverse, with a rich variety of freshwater fish species, including Indian carp and catfish. A total of 195 fish species have been identified in the Krishna River system, of which 187 are considered validly occurring. The Andhra Pradesh sector of the Krishna River boasts the highest percentage of fish species at 88.46%, followed by Maharashtra at 39.74% and Karnataka at 32.05%. Table shows the families of fishes mostly occurring in the Krishna basin.

Fig 23. shows some of the types of fishes in Krishna basin.

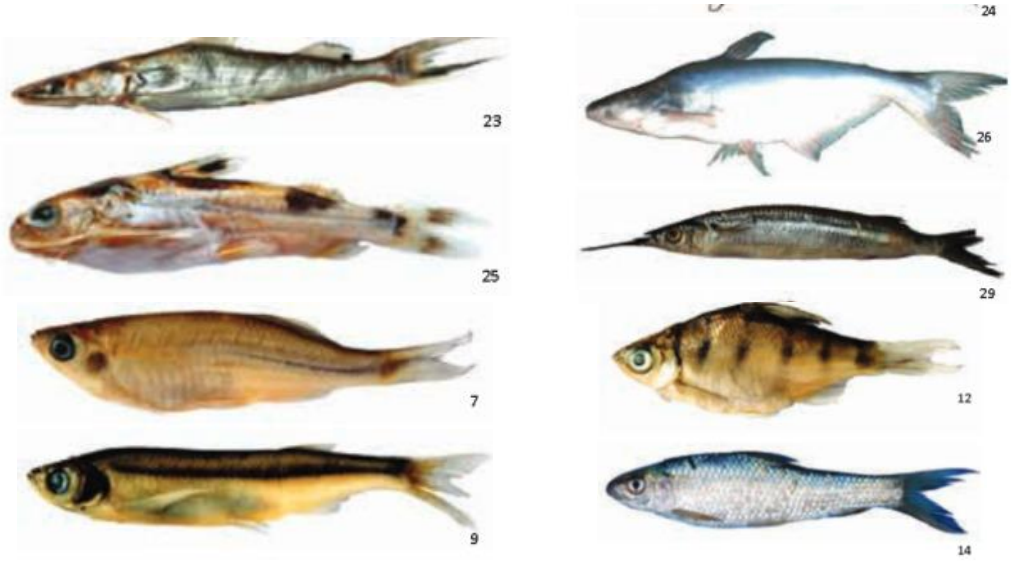


Fig. 23. Some of the Types of Fishes Occurring in Krishna Basin.

Source: Kumbar, S. M., Jadhav, S. S., Lad, S. B., Ghadage, A. B., Patil, S. S. & Shankar, C. S. (2021) On the freshwater fish fauna of Krishna River, Sangli District, Maharashtra, India. *J. Threat. Taxa* **13**(8), 19093–19101. doi:10.11609/jott.6281.13.8.19093-19101

Table 9. Families of Fishes Mostly Occurring in the Krishna Basin

Families of Fishes Mostly Occurring in The Krishna Basin	
Notopteridea	Claridae
Cyprinidae	Belonidae
Parapsilorhynchidae	Ambassidae
Alitoridae	Cichlidae
Cobitidae	Gobidae
Bagridae	Channidae
Siluridae	Mastecembalidae

Source: Kumbar, S. M., Jadhav, S. S., Lad, S. B., Ghadage, A. B., Patil, S. S. & Shankar, C. S. (2021) On the freshwater fish fauna of Krishna River, Sangli District, Maharashtra, India. *J. Threat. Taxa* **13**(8), 19093–19101. doi:10.11609/jott.6281.13.8.19093-19101

The geology of the Krishna basin is dominated in the northwest by the Deccan Traps, in the central part by unclassified crystallines, and in the east by the Cuddapah Group. The Dharwars (southwest central) and the Vindhian (east central) form a significant part of the outcrops within the unclassified crystallines. The Krishna delta is predominantly formed by Pleistocene to recent material. The Pleistocene is a geological time period that includes the last ice age when glaciers covered huge parts of the globe. The basin also features several notable waterfalls:

1. Ethipothala on Chandravanka River, a tributary of Krishna River.
2. Godchinamalaki on Markandeya River, a tributary of Ghataprabha.
3. Gokak on Ghataprabha.
4. Mallela Theertham.

6. CWC & CPCB MONITORING STATIONS IN KRISHNA RIVER BASIN

The Krishna Basin's water resources are comprehensively monitored through a dual-network system operated by the Central Water Commission (CWC) and the Central Pollution Control Board (CPCB), ensuring both hydrological integrity and water quality control across four states (Maharashtra, Karnataka, Telangana, and Andhra Pradesh). The CWC's stations (Figure 24.) focus on hydrometric monitoring, including river discharge, sediment transport, and reservoir operations at critical locations. These stations are categorized into gauging (G), sediment monitoring (S), and multi-parameter (GDSQ) sites. Whereas, the CPCB's monitoring network (Figure 25.) targets water pollution, covering various water body types, including rivers, groundwater, lakes, ponds, tanks, and drains covering various water body types. The stations are distributed across the states of Andhra Pradesh, Karnataka, Maharashtra, and Telangana. The majority of stations are located along the Krishna River and its tributaries, such as the Tungabhadra, Bhima, and Musi, with monthly monitoring being the most common frequency.

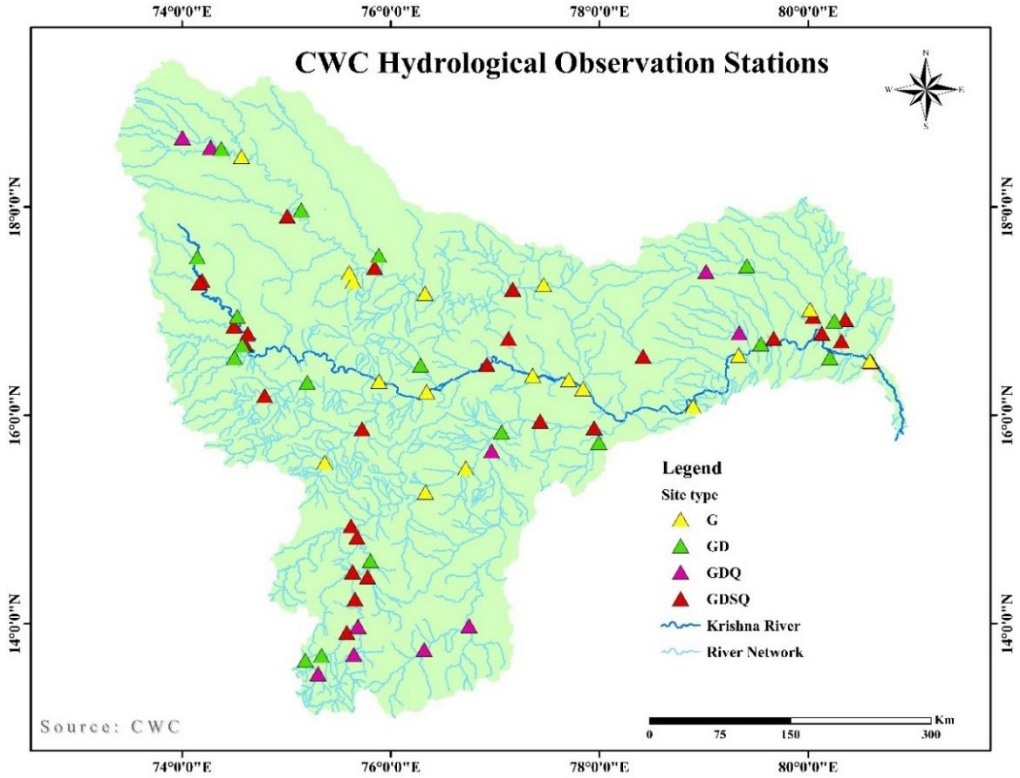


Fig. 24. CWC Hydrological Monitoring Station in Krishna River Basin

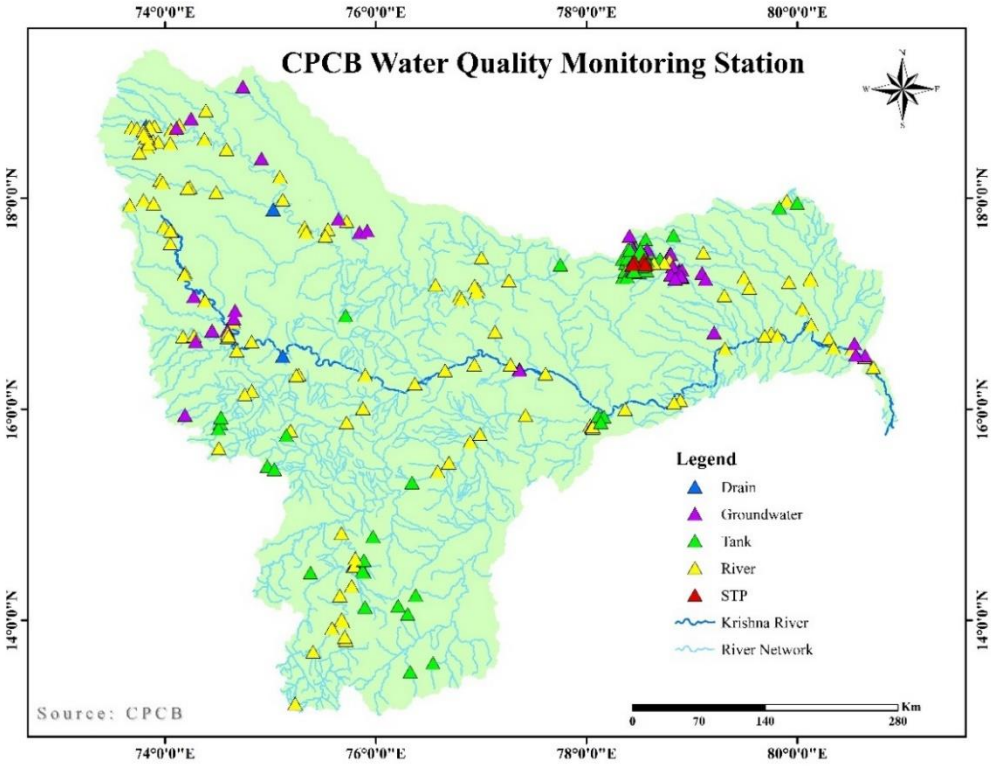


Fig. 25. CPCB Water Quality Monitoring Stations in Krishna River Basin

7. CHALLENGES FACED BY KRISHNA RIVER

- Reservoir sedimentation significantly reduces storage capacity, impacting water supply and hydropower generation, with an annual average sedimentation rate in 15 major reservoirs exceeding 2.3%.
- Riverbank erosion due to unregulated sand mining and deforestation destabilizes banks, alters the river's course, and affects agricultural lands, infrastructure, and human settlements.
- Over-extraction of water for intensive agriculture depletes river flow, especially during dry seasons, impacting downstream water availability.
- Numerous dams and diversion projects disrupt the natural flow regime, affecting sediment transport, aquatic habitats, and downstream water availability.
- Pollution from agricultural runoff, industrial discharges, and untreated sewage degrades water quality, harming aquatic life and posing health risks to humans.
- Deforestation in the Western Ghats reduces natural water regulation, increases soil erosion, and decreases biodiversity.
- Climate change exacerbates the frequency and intensity of floods and droughts, altering rainfall patterns and impacting water availability and river flow.
- Loss of riparian vegetation and habitat fragmentation disrupt ecological balance, reduce biodiversity, and impact species that rely on these habitats.
- Urbanization and industrialization increase water demand and pollution, stressing the river’s capacity to provide clean water and maintain ecological health.
- Conflicts over water sharing among states in the Krishna Basin complicate effective water management and conservation efforts.
- Invasive species introduction threatens native biodiversity and alters the ecological balance of the river system.
- Lack of integrated river basin management hampers coordinated efforts to address the diverse challenges facing the river.
- Leaks and breaches in canals contribute to water loss, reducing efficiency in water delivery to agricultural lands and urban areas.

8. MAPPING SENSITIVE, VULNERABLE, AND UNDISTURBED AREAS IN THE KRISHNA RIVER BASIN

The Krishna River Basin, spanning across Maharashtra, Karnataka, Andhra Pradesh and Telangana, is characterized by diverse ecosystems that are impacted differently by human interventions, anthropogenic pollution, sediment transport and deposition, and varied land use patterns. Mapping these areas involves identifying regions that are particularly sensitive, vulnerable, or relatively undisturbed, based on these factors (Fig.).

8.1 Human Interventions

- **Urban Centres:** Urbanization in cities like Pune, Hyderabad, and Vijayawada has led to significant land use changes and increased pollution levels. These areas experience high levels of industrial discharges, untreated sewage, and extensive infrastructure development, making them highly sensitive to further environmental stress.
- **Irrigation Projects:** Large-scale irrigation projects, such as the Nagarjuna Sagar Dam and the Srisailam Dam, have transformed the landscape. These interventions have led to significant changes in water flow patterns, sediment transport, and local ecosystems, making areas downstream vulnerable to reduced water availability and altered sediment deposition.

8.2 Anthropogenic Pollution

- **Industrial Pollution Hotspots:** Regions like Bhadravati in Karnataka and Patancheru-Bolaram in Andhra Pradesh are critical pollution hotspots. These areas are heavily affected by industrial effluents, leading to high levels of heavy metals, chemicals, and organic pollutants in the river and surrounding environments. Additionally, contaminated and chemical-laced water from the Islampur industrial area and sugar factories in the surrounding regions contribute to significant pollution. The presence of water hyacinth covering sections of the Krishna River in the Vai region in the Satara district exacerbates the issue.
- **Agricultural Runoff:** The middle Krishna sub-basin, with its extensive agricultural activities, is highly vulnerable to nutrient loading and pesticide contamination. Runoff from farmlands introduces nitrogen, phosphorus, and various agrochemicals into the river system, contributing to eutrophication and water quality degradation.

8.3 Undisturbed Areas

- **Biodiversity Hotspot:** The Western Ghats, which form the western boundary of the Krishna Basin, are a UNESCO World Heritage Site and one of the world's eight "hottest hotspots" of biological diversity. These forests are home to a wide range of endemic species of plants, animals, and birds.
- **Types of Forests:** The Western Ghats feature various types of forests, including tropical evergreen forests, semi-evergreen forests, moist deciduous forests, and shola grasslands. These forests are critical for maintaining the region's high biodiversity.
- **Koyna Wildlife Sanctuary:** Located in Maharashtra, this sanctuary is part of the Western Ghats and is known for its rich biodiversity, including species such as the Bengal tiger, Indian leopard, and several species of deer and birds.
- **Bhimgad Wildlife Sanctuary:** Located in Karnataka, this sanctuary is known for its limestone formations and the presence of endangered species like the Malabar pied hornbill and the Indian giant squirrel.
- **Nagarjunsagar-Srisailam Tiger Reserve:** Spanning Andhra Pradesh and Telangana, this is one of the largest tiger reserves in India, providing habitat for tigers, leopards, sloth bears, and several other wildlife species.
- **Riverbanks and Floodplains:** Riparian forests along the Krishna River and its tributaries, such as the Tungabhadra, Bhima, and Koyna, are crucial for stabilizing riverbanks, reducing erosion, and providing habitat for aquatic and terrestrial species.
- **Deccan Plateau:** The central part of the Krishna Basin lies on the Deccan Plateau, characterized by a mosaic of dry deciduous forests, grasslands, and savannas. These areas are home to various herbivores and predators, including blackbuck, chinkara, and the Indian wolf.
- **Pulicat Lake**: Although not directly in the Krishna Basin, Pulicat Lake, located near the river's delta, is an important wetland. It supports a variety of bird species, including flamingos, pelicans, and several migratory birds.
- **Mangrove Forests:** The delta region where the Krishna River meets the Bay of Bengal features mangrove forests. These ecosystems provide crucial nursery habitats for fish and other marine species and protect coastal areas from erosion and storms.

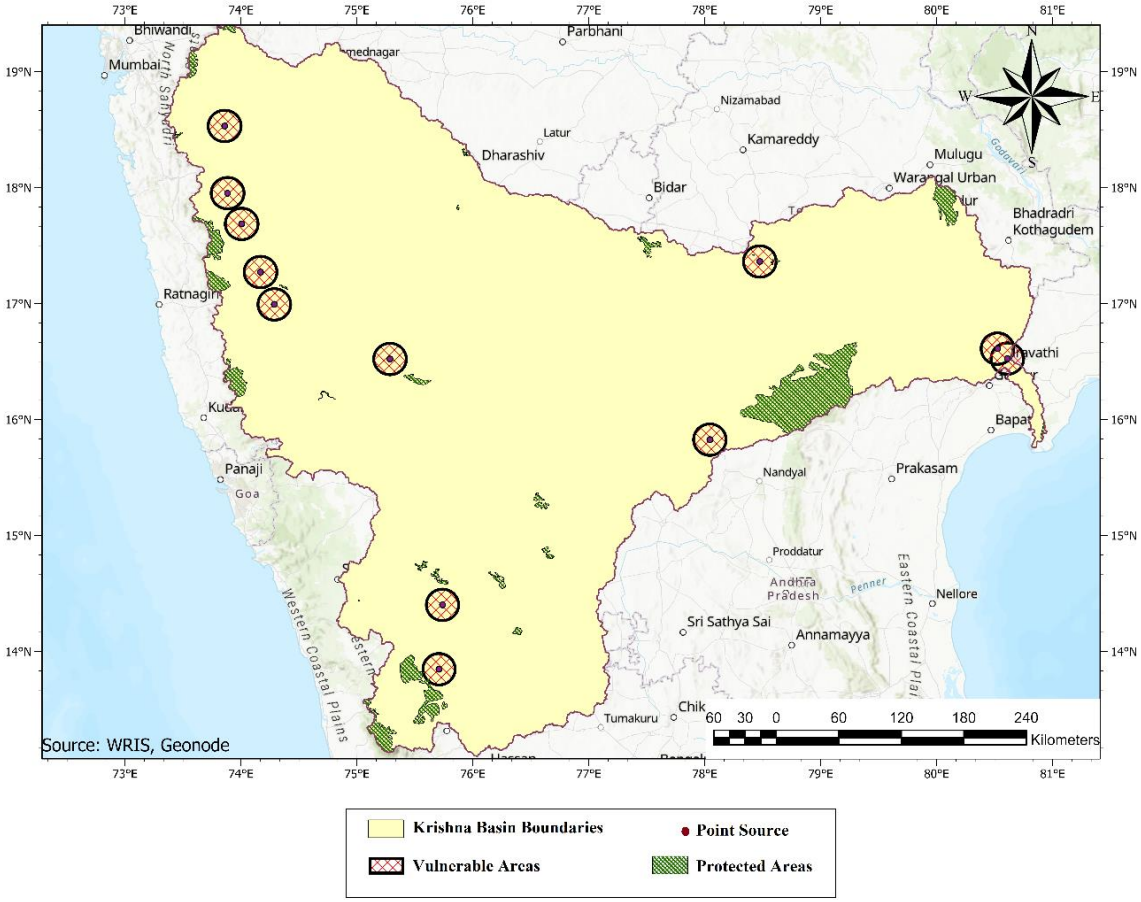


Fig. 26. Mapping Sensitive, Vulnerable, and Undisturbed Areas in the Krishna River Basin

9. ENVIRONMENTAL DISTURBANCE ZONES IN THE KRISHNA RIVER BASIN

9.1 Least Disturbed/Undisturbed Areas

In the Upper Krishna Basin within the Western Ghats, comprising districts Satara, Sangli, and Kolhapur in Maharashtra, key protected areas include the Koyna Wildlife Sanctuary and Chandoli National Park. Additionally, forested regions in Karnataka, particularly in districts Shimoga and Uttara Kannada, are home to protected areas such as the Sharavathi Valley Wildlife Sanctuary and Bhadra Wildlife Sanctuary.

9.2 Moderately Disturbed Areas:

Agricultural and Mixed Land Use Areas span districts Bijapur and Bagalkot in Karnataka, along with Raichur. These areas are characterized by predominantly agricultural activities interspersed with patches of forest and small urban centres. Industrial Zones with Pollution Control measures are found in districts Belgaum and Hubli-Dharwad in Karnataka, where moderate industrial activities are managed under strict pollution control regulations. Semi-urban Regions include Solapur in Maharashtra and Gadag in Karnataka, characterized by managed urban growth and moderate population density.

9.3 Highly Disturbed Areas:

High Population Density and Urban Centres encompass cities like Pune in Maharashtra, Hyderabad in Telangana, and Vijayawada in Andhra Pradesh, with significant human settlements, high waste generation, and resource demands. Industrial Pollution Hotspots are identified in districts Medak in Telangana and Krishna in Andhra Pradesh, where unregulated industrial activities contribute to severe water pollution. Intensive Agricultural Regions cover districts Krishna, Guntur, and Prakasam in Andhra Pradesh, known for high-intensity farming practices with extensive use of chemical inputs. Urban Encroachment is observed in cities like Vijayawada and Guntur in Andhra Pradesh, where urban expansion into riverine and floodplain areas has led to habitat destruction.

10. SUGGESTIONS AND RECOMMENDATIONS

10.1 Upper Bhima and Lower Bhima Sub-Basins

The Upper Bhima and Lower Bhima sub-basins are experiencing significant water quality issues due to pollution from urban and industrial sources. To address these challenges, it is crucial to implement stringent wastewater treatment protocols for industrial effluents, ensuring that all discharges meet the prescribed standards before entering the water bodies. Strengthening the infrastructure for sewage treatment plants in urban areas will also play a vital role in mitigating pollution. Given the high agricultural activity, promoting the use of organic fertilizers and pest management practices can help reduce the runoff of harmful chemicals into the rivers. Moreover, investing in modern irrigation techniques, such as drip irrigation and sprinklers, will enhance water use efficiency and reduce wastage. Community education programs focused on sustainable agricultural practices and pollution prevention can significantly contribute to the overall health of these sub-basins.

10.2 Krishna Upper, Middle and Lower Sub-Basin

In the Krishna basin's Upper, Middle, and Lower sub-basins, various environmental challenges require tailored management strategies. In the Upper sub-basin, groundwater over-extraction and agricultural runoff pose significant threats. Sustainable water management practices, including monitoring groundwater levels and promoting water-efficient irrigation methods like micro-irrigation, are crucial. Adopting organic farming and reducing chemical inputs can mitigate pollution, while enhancing soil health through green manure and buffer zones along riverbanks can improve water quality. Moving to the Middle sub-basin, pollution from agriculture and industry is a key concern. Integrated watershed management, including soil conservation and agro-forestry, can mitigate runoff and erosion. Strict enforcement of industrial discharge standards and upgrading sewage treatment infrastructure are essential for managing urban and industrial pollution. Precision agriculture and public awareness campaigns can further enhance sustainable practices. Finally, in the Lower sub-basin, industrial discharges and urban sewage are pressing issues demanding advanced wastewater treatment technologies and stringent regulatory enforcement. Sustainable agricultural practices and robust solid waste management in urban areas are vital for reducing pollution. Investment in rainwater harvesting and groundwater recharge infrastructure can bolster water availability. Community engagement in water conservation initiatives is pivotal for safeguarding the ecological integrity of the Lower Krishna sub-basin.

10.3 Tungabhadra Sub-Basin

The Tungabhadra sub-basin faces challenges related to both water quality and quantity. To improve water quality, it is vital to upgrade existing wastewater treatment facilities and ensure that industries comply with effluent discharge standards. Implementing advanced treatment technologies, such as membrane bioreactors and constructed wetlands, can enhance the efficiency of wastewater treatment. Addressing water quantity issues requires a focus on demand management and efficient water use. Promoting rainwater harvesting and groundwater recharge techniques can help augment water availability. Encouraging the adoption of drought-resistant crop varieties and optimizing irrigation schedules can further improve water use efficiency in agriculture. Community-based water management initiatives, involving local stakeholders in planning and decision-making, can enhance the sustainability of water resources in the sub-basin.

REFERENCES

1. Bouwer, Laurens M. 2011. "Have Disaster Losses Increased Due to Anthropogenic Climate Change?" *Bulletin of the American Meteorological Society* 92(1): 39–46.
2. Central Water Commission (CWC) reports on sedimentation in reservoirs in the Krishna Basin.
3. Das, A. K. et al. 2017. "Status of the River Krishna: Water Quality and Riverine Environment in Relation to Fisheries." *Aquatic Ecosystem Health and Management* 20(1–2): 160–74.
4. Deshpande NR, Kulkarni BD. 2014. "Assessing Hydrological Response to Changing Climate in the Krishna Basin of India." *Journal of Earth Science & Climatic Change* 05(07).
5. Gururaj, Prabhu K. 2023. "Topography of Krishna River and Its Tributaries." *Ijirt 160910 International Journal of Innovative Research in Technology* 10(2): 24–37.
6. Harini, P et al. 2017. "Geographical Information System Based Morphometric Analysis of Krishna River Basin , India." 19(1): 44–55.
7. Harshavardhan, P. L., P. C. Nayak, and Sanjeet Kumar. 2020. "Spatio-Temporal Rainfall Variability and Trend Analysis for Krishna River Basin in India." *Indian Journal of Ecology* 47(June): 54–59.
8. Jayaram, K C. 1994. "The Krishna River System." : 167p.
9. Kharat, Sanjay S., Mandar Paingankar, and Neelesh Dahanukar. 2012. "Freshwater Fish Fauna of Krishna River at Wai, Northern Western Ghats, India." *Journal of Threatened Taxa* 4(6): 2644–52.
10. Kumbar, Suresh M. et al. 2021. "On the Freshwater Fish Fauna of Krishna River, Sangli District, Maharashtra, India." *Journal of Threatened Taxa* 13(8): 19093–101.
11. Naga Sowjanya, Ponguru et al. 2022. "Climate Change Impacts on Streamflow in the Krishna River Basin, India: Uncertainty and Multi-Site Analysis." *Climate* 10(12).
12. Olawoyin, Modupeola, and Ala Mary. 2019. "North Asian International Research Journal Of." *Researchgate.Net* 7(April): 17–23. https://www.researchgate.net/profile/Bilal-Ahmad-18/publication/371338377_Indian_Citation_Index_SURVEY_OF_SCIENTIFIC_GARDENS_IN_DEGREE_COLLEGES_OF_KASHMIR_REGION/links/647f5abab3dfd73b77697c62/Indian-Citation-Index-SURVEY-OF-SCIENTIFIC-GARDENS-IN-DEGREE-C.
13. Padmavathi, P, and Ravi Birudu. 2019. "Interlinking of Krishna and Godavari Rivers: An Ecological Study Sustainable Aquaculture View Project Malacofauna View Project." (February). https://www.researchgate.net/publication/331023508.
14. Reddi, Venkata Ramana Murthy et al. 2017. "Monitoring Changes in Croplands Due to Water Stress in the Krishna River Basin Using Temporal Satellite Imagery." *Land* 6(4).
15. Reddy, N. M., and S. Saravanan. 2023. "Evaluation of the Accuracy of Seven Gridded Satellite Precipitation Products over the Godavari River Basin, India." *International*

Journal of Environmental Science and Technology 20(9): 10179–204. https://doi.org/10.1007/s13762-022-04524-x.

16. Van Rooijen, Daniel J., Hugh Turral, and Trent Wade Biggs. 2009. "Urban and Industrial Water Use in the Krishna Basin, India." *Irrigation and Drainage* 58(4): 406–28.
17. Uday Kumar, A., and K. V. Jayakumar. 2020. "Hydrological Alterations Due to Anthropogenic Activities in Krishna River Basin, India." *Ecological Indicators* 108(March 2019): 105663. https://doi.org/10.1016/j.ecolind.2019.105663.
18. Venot, Jean-Philippe;, Bharat R.; Sharma, and K. V. G. K. Rao. 2008. *The Lower Krishna Basin Trajectory: Relationships between Basin Development and Downstream Environmental Degradation*. http://dx.doi.org/10.3910/2009.125.
19. Venot, Jean Philippe, Luna Bharati, Mark Giordano, and François Molle. 2011. "Beyond Water, beyond Boundaries: Spaces of Water Management in the Krishna River Basin, South India." *Geographical Journal* 177(2): 160–70.
20. Venot, Jean Philippe, Bharat R. Sharma, and K. V.G.K. Rao. 2008. "Krishna Basin Development: Interventions to Limit Downstream Environmental Degradation." *Journal of Environment and Development* 17(3): 269–91.
21. Water Resources of the Krishna Basin: Issues and Challenges." A comprehensive report by the Krishna River Management Board (KRMB).
22. India WRIS, 2014. https://indiawris.gov.in (Accessed 15 June 2024)
23. India Census, 2011. https://www.censusindia.gov.in/ (Accessed 15 June 2024)
24. India Meteorological Department. (2023). Climate of India. https://mausam.imd.gov.in/ (Accessed 13 June 2024)
25. The Hindu, Water quality of Krishna River deteriorating, says ANU review, (Available at https://www.thehindu.com/news/national/andhra-pradesh/water-quality-of-krishna-river-deteriorating-says-anu-review/article27474296.ece)
26. The Hindu, Krishna water getting polluted. (Available at https://www.thehindu.com/news/cities/Vijayawada/krishna-water-getting-polluted/article6873442.ece)
27. NDTV, The Once Crystal Clear Waters of Krishna are Laden with pollution today, (Available at https://swachhindia.ndtv.com/the-once-crystal-clear-waters-of-krishna-are-laden-with-pollution-today-10663/)
28. Times Of India, Fish death in Krishna River Now; Residents Blame Industrial Discharge, (Available at https://timesofindia.indiatimes.com/city/kolhapur/fish-death-in-krishna-river-now-residents-blame-industrial-discharge/articleshow/97044914.cms)
29. River Stretches for Restoration of Water Quality, Pollution Control Board (Available at http://nrcd.nic.in/writereaddata/FileUpload/RESTORATION_OF_POLLUTED_RIVER_STRETCHES_.pdf)

Centres for Krishna River Basin Management Studies

Centre for Ganga River Basin Management and Studies