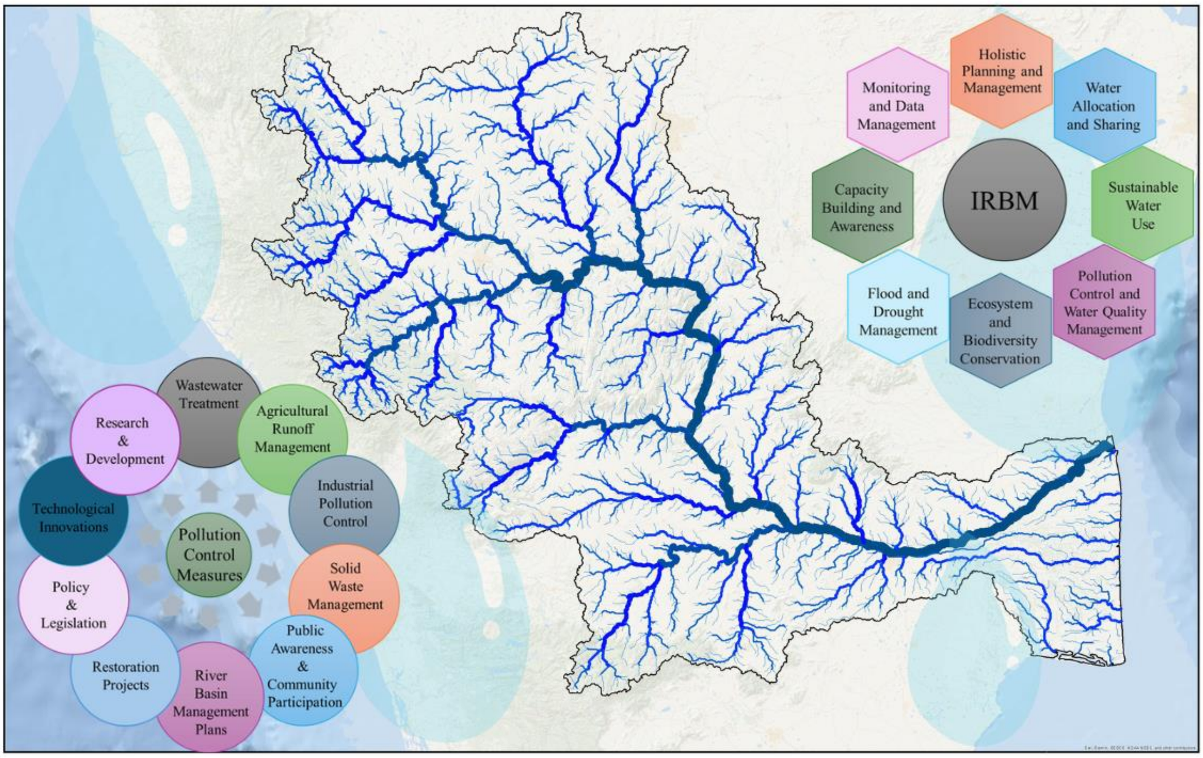
National River Conservation Directorate
Ministry of Jal Shakti,
Department of Water Resources,
River Development and Ganga Rejuvenation
Government of India

Cauvery River at a Glance



June 2024

Back of cover page

BLANK

Cauvery River at a Glance

National River Conservation Directorate (NRCD)

The National River Conservation Directorate, functioning under the Department of Water Resources, River Development and 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 Cauvery River Basin Management Studies (cCauvery)

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

www.ccauvery.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 IISc Bengaluru (Lead Institute) and NIT Tiruchirappalli (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.

Team

Prof. Praveen C Ramamurthy, IISc Bengaluru
Prof. Pradeep P Mujumdar, IISc Bengaluru
Prof. Shekhar M, IISc Bengaluru
Prof. Nagesh Kumar Dasika, IISc Bengaluru
Prof. Srinivas V V, IISc Bengaluru
Dr. Lakshminarayana Rao, IISc Bengaluru
Dr. Rajarshi Das Bhowmik, IISc Bengaluru
Dr. Bramha Dutt Vishwakarma, IISc Bengaluru
Dr. Debsunder Dutta, IISc Bengaluru
Dr. Nisha Radhakrishnan, NIT Trichy
Dr. R Manjula, NIT Trichy
Dr. S Saravanan, NIT Trichy
Dr. Aneesh Mathew, NIT Trichy
Dr. Laveti Satish, NIT Trichy
Dr. Prabu P, NIT Trichy
Dr. Vinod Tare, cGanga, IIT Kanpur

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.

Centres for Cauvery River Basin
Management Studies (cCauvery)
IISc Bengaluru (Lead Institute), NIT Tiruchirappalli (Fellow Institute)

Back of Preface/Blank Page

Blank/Continuation of Preface

Table of Contents

Continuation of Contents/Blank Page

List of Figures

List of Tables

Continuation of List of Tables/Blank Page

Abbreviations

°	Degree
′	Minute
%	Percentage
°C	Degree Celsius
cu.	Cube
e.g.	For example
km	Kilometre
kg	Kilogram
m	Metre
sq.	Square
BCM	Billion Cubic Metre
BHEL	Bharat Heavy Electricals Limited
BOD	Biochemical Oxygen Demand
BPO	Business Process Outsourcing
CE	Common Era
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CRB	Cauvery River Basin
CWC	Central Water Commission
ESRI	Environmental Systems Research Institute
ETPs	Effluent Treatment Plants
IRBM	Integrated River Basin Management
ISRO	Indian Space Research Organisation
IUCN	International Union for Conservation of Nature
LULC	Land Use/Land Cover
NGOs	Non-Governmental Organizations
NGT	National Green Tribunal
SAIL	Steel Authority of India Limited
STPs	Sewerage Treatment Plants
UNESCO	United Nations Educational, Scientific and Cultural Organization
WRIS	Water Resource Information System

Continuation of Abbreviations and Acronyms

/Blank Page

1. Introduction

The Cauvery River Basin (CRB) is one of the most significant river basins in southern India, playing a crucial role in the region's ecology, economy, and culture. Spanning approximately 85,220.39 sq. km, the basin traverses the states of Karnataka, Tamil Nadu, Kerala, and the Union Territory of Puducherry (Fig. 1). Tamil Nadu accounts for the largest share of the basin with about 55.34%, followed by Karnataka with 41.05%, while Kerala and Puducherry contribute relatively smaller portions of 3.42% and 0.18%, respectively. Geographically, it stretches between 75°27′ to 79°54′ east longitudes and 10°9′ to 13°30′ north latitudes, bordered by the Western Ghats to the west, Eastern Ghats to the east and south, and ridges separating it from neighbouring basins to the north. The river originates at Talakaveri in the Western Ghats of Karnataka and flows south-eastward through Karnataka and Tamil Nadu before emptying into the Bay of Bengal (Arulbalaji and Padmalal, 2020; Chidambaram et al., 2018).

The demographics of CRB, as updated by the 2011 Census of India, reveal notable trends in population growth, literacy rates, and industrial distribution. According to the census data, the total population of the districts in this basin is 6,55,39,314 (India Census, 2011). The growing population and density in both urban and rural areas have impacted forest cover, underscoring the need for sustainable land and forest management practices in the region. The basin is industrially significant, hosting major industries such as the cotton textile industry in Coimbatore and Mysore, cement factories in Coimbatore and Tiruchirappalli, and mineral and metal-based industries in Salem. Additionally, the Salem steel plant and various engineering industries in Coimbatore and Tiruchirappalli contribute to the basin's industrial landscape.

The Cauvery River holds immense cultural and religious importance, with numerous temples and pilgrimage sites situated along its banks. The river and its tributaries support a wide array of ecosystems, ranging from the dense forests of the Western Ghats to the fertile plains of Tamil Nadu. Agriculture is the backbone of CRB, with the river providing vital irrigation for a variety of crops, including rice, sugarcane, and coffee. Major cities such as Bengaluru, Mysuru, and Tiruchirappalli rely heavily on the river for their water supply, making its management a matter of critical importance.

However, the basin faces several challenges, including water pollution, over-extraction, and frequent interstate disputes over water allocation. The ecological health of the river is threatened by industrial discharge, agricultural runoff, and untreated sewage, leading to severe water quality degradation in many areas. Effective management and conservation strategies are essential to address these issues and ensure the sustainable use of CRB's resources. Initiatives such as integrated river basin management, pollution control measures, and community engagement are crucial for the rejuvenation and long-term sustainability of this vital water resource.

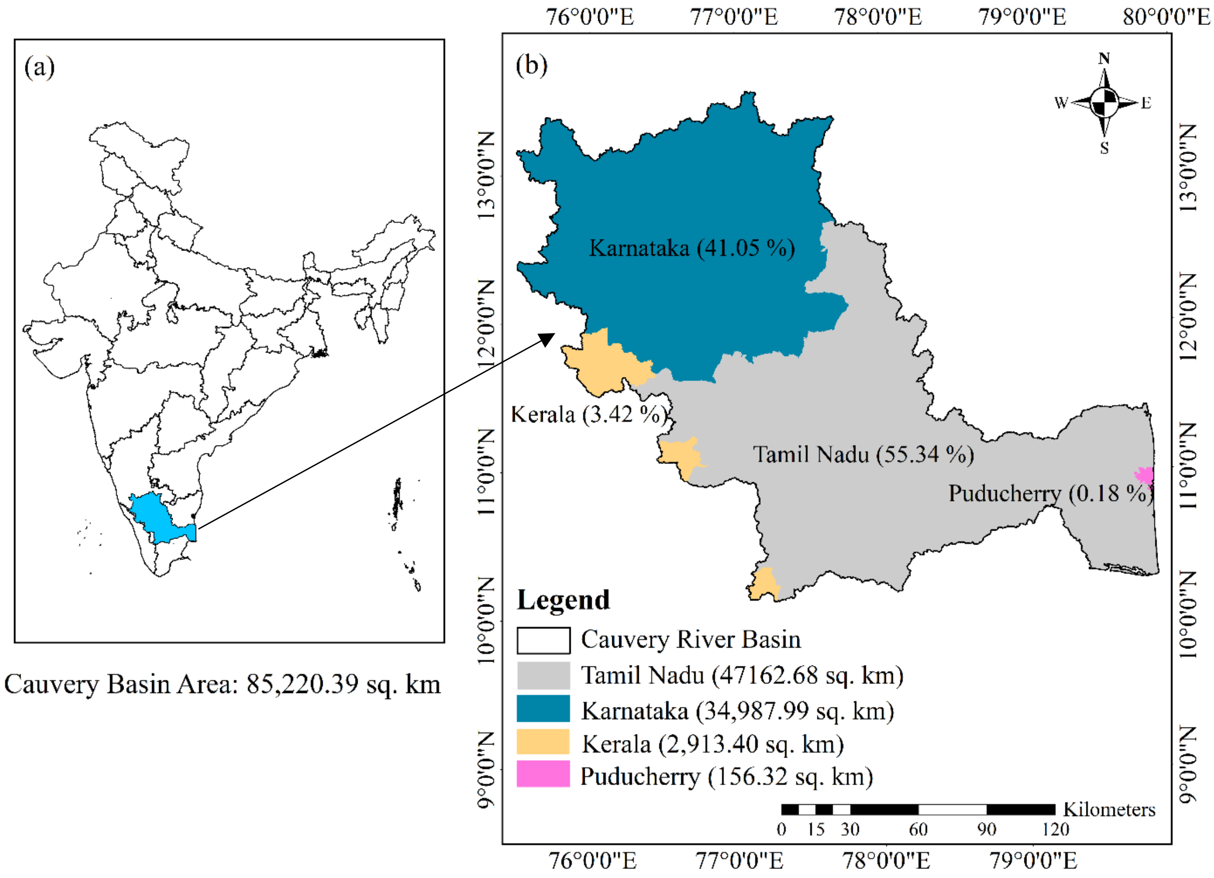


Fig. 1. Spatial extent of the CRB showing its areal distribution across Karnataka, Tamil Nadu, Kerala, and Puducherry

A line diagram of the Cauvery River typically illustrates its course from origin to mouth, marking key tributaries, major dams and reservoirs along its path (Fig. 2). The line diagram visually represents this flow, helping in hydrological studies, irrigation planning, and water-sharing disputes between Karnataka and Tamil Nadu. The summary of the Cauvery River is depicted in Table 1.

Table 1. Summary of the Cauvery River

Source	Talakaveri, Kodagu district, Karnataka, India
Major Tributaries	Left Bank: Harangi, Hemavathi, Shimsha, Arkavathi Right Bank: Lakshmana Tirtha, Kabini, Bhavani, Noyyal, Amaravati
Major Dams & Reservoirs	Harangi Reservoir, Hemavathi Reservoir, Krishna Raja Sagara (KRS) Dam, Kabini Reservoir, Chinnar Reservoir, Mettur Dam, Lower Bhavani Reservoir, Amaravathi Reservoir, Ponnaniar Reservoir, Grand Anicut (Kallanai), Uppar Reservoir, Siddhamalli Reservoir.
States Covered	Karnataka, Tamil Nadu, Kerala (partially), Puducherry (Karaikal region)
Mouth	Bay of Bengal near Poompuhar, Tamil Nadu

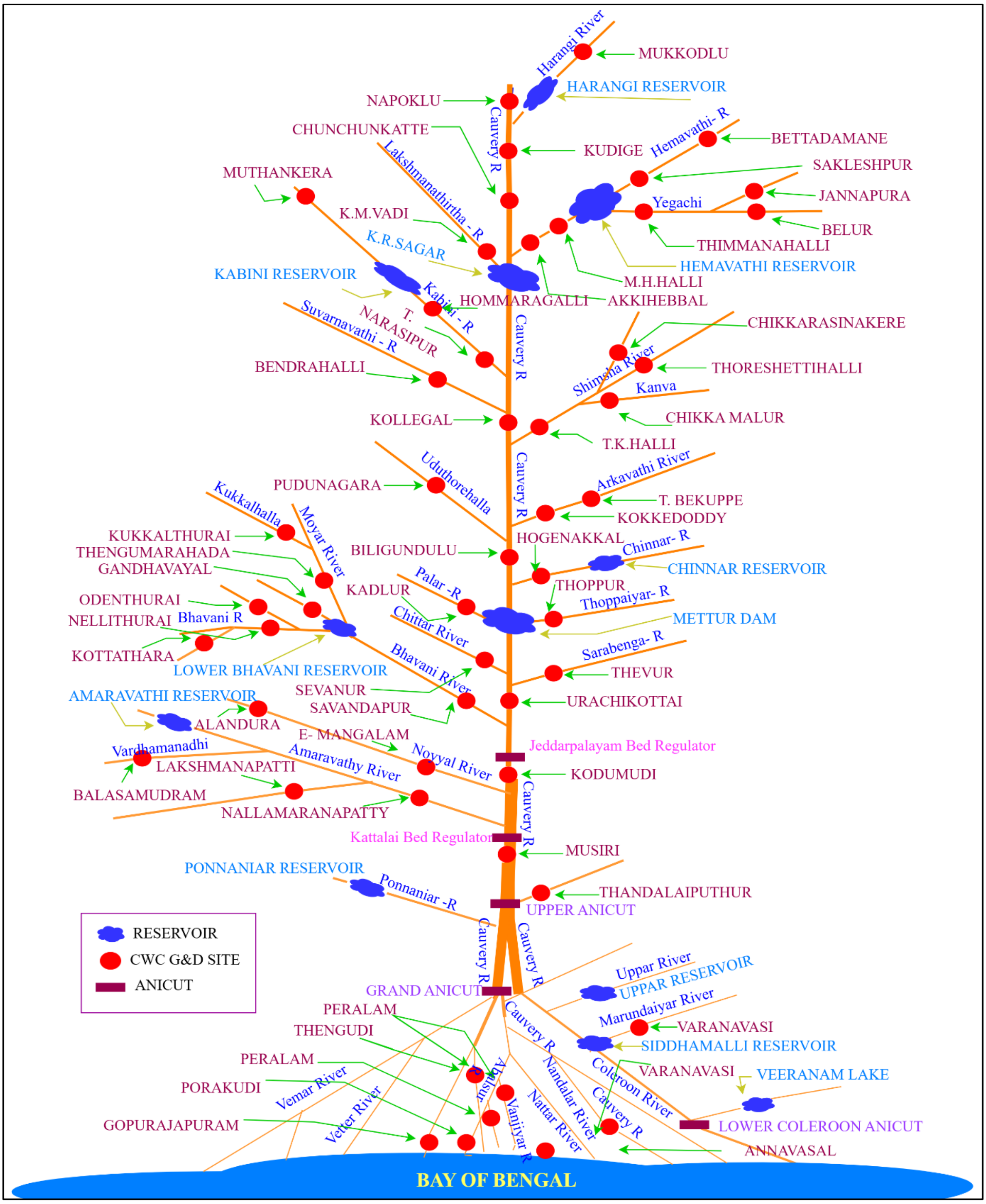


Fig. 2. Line diagram of the Cauvery River (**Source:** Water Year Book, Cauvery Basin, CWC, March – 2024, https://www.cwc.gov.in/)

CRB is divided into three major parts, i.e., upper Cauvery, middle Cauvery, and lower Cauvery (Fig. 3). Upper Cauvery basin covers an area of 10968.15 sq. km and comprises two sub-basins, forming the headwater region of the river system. The middle Cauvery basin represents the largest segment, covering an area of 57042.72 sq. km and consisting of eight sub-basins. The lower Cauvery basin extends over 17209.53 sq. km and comprises a single sub-basin corresponding to the Cauvery delta region.

The dependable yield of the basin is harnessed through a network of major, medium, and minor irrigation projects, including dams, barrages, diversion structures, and lift irrigation systems, which collectively support extensive irrigated agriculture across the basin. Spatially, the upper Cauvery sub-basins are located in the western part of the CRB, largely coinciding with the Western Ghats and characterized by higher elevations and steeper slopes that govern runoff generation. The middle Cauvery sub-basins occupy the central portion of the basin and act as a transitional zone, encompassing major tributary systems and linking the high-relief headwaters with the low-gradient plains. The lower Cauvery sub-basin, situated in eastern Tamil Nadu, is characterized by an extensive deltaic distributary network that ultimately drains into the Bay of Bengal.

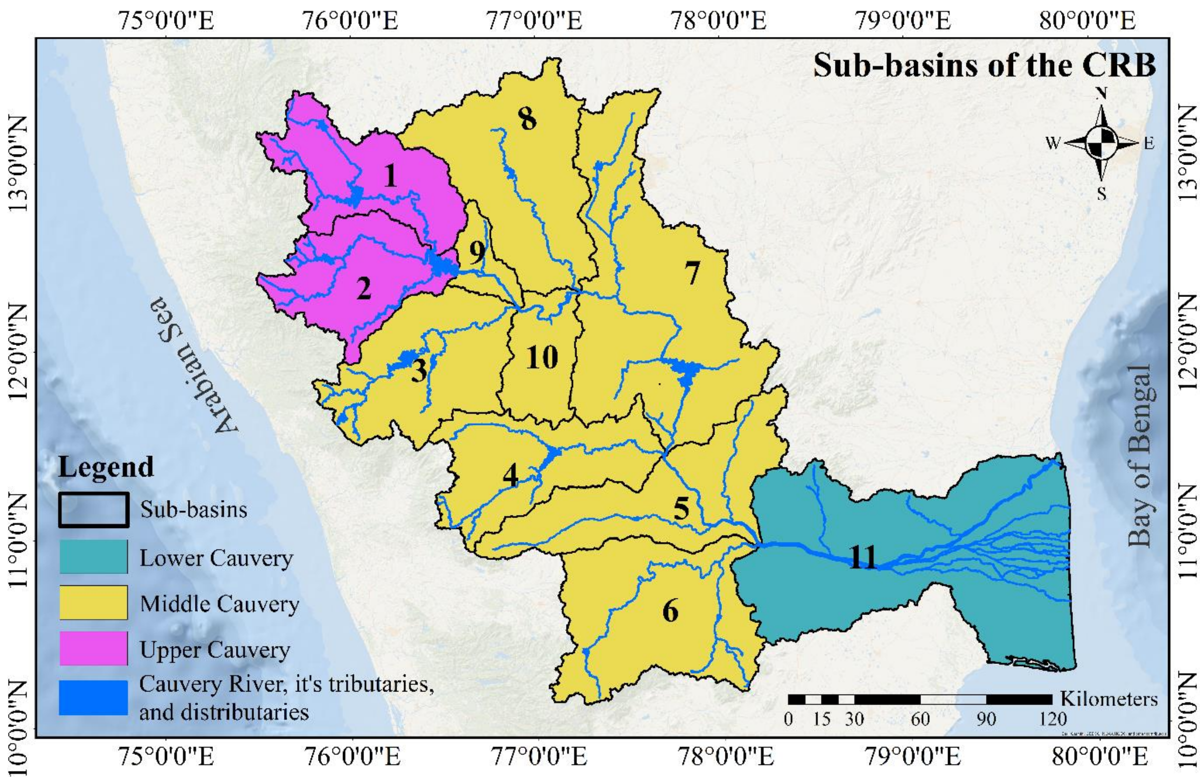


Fig. 3. Spatial distribution of sub-basins within the upper, middle, and lower Cauvery River basin

Table 2 presents the areal distribution of sub-basins within the CRB classified into upper, middle, and lower Cauvery segments. The upper Cauvery comprises the Yagachi–Hemavathi and Harangi–Talakaveri–Lakshmana Tirtha sub-basins, together accounting for 12.85% of the basin area. The middle Cauvery forms the largest segment, encompassing nine sub-basins and contributing 67.0% of the total CRB area, with the Arkavathi–Vrishabhavathi (16.31%) and Shimsha (10.22%) sub-basins being the most extensive. The lower Cauvery is represented by the Cauvery Delta, which alone constitutes 20.18% of the basin area, highlighting the significant spatial extent of the deltaic region within the CRB.

Table 2. Areal distribution of sub-basins within the CRB

Sub-basin No.	Basin Segmentation	Sub-basin Name	Area (sq. km)	Area (%)
1	Upper Cauvery	Yagachi-Hemavathi	5,589.38	6.56
2		Harangi-Talakaveri-Lakshmana Tirtha	5,358.28	6.29
3	Middle Cauvery	Kabini-Panamaram-Nugu	7,073.30	8.30
4		Moyar-Bhavani	6,480.30	7.60
5		Noyyal-Thirumanimuthu	7,643.94	8.97
6		Amaravathi-Kodavanar-Santanavardhani	9,034.69	10.60
7		Arkavathi-Vrishabhavathi	13,897.48	16.31
8		Shimsha	8,707.46	10.22
9		Lokapavani	1,293.59	1.52
10		Suvarnavathi	2,953.20	3.47
11	Lower Cauvery	Cauvery Delta	17,194.87	20.18

To assess the status of water quality of water resources and to facilitate for prevention and control of pollution in water bodies Central Pollution Control Board (CPCB) in collaboration with State Pollution Control Boards (SPCBs) in the States and Pollution Control Committees (PCCs) in Union Territories has established a National Water Quality Monitoring Network (NWMP). The present water quality monitoring network under NWMP comprises 4484 stations on surface and groundwater in 28 States and 8 Union Territories. Monitoring is carried out with a frequency on a monthly, quarterly, half yearly and yearly basis. Water samples are analysed for 9 core parameters, 19 general parameters, 9 trace metals and set of pesticides as per Guidelines on Water Quality Monitoring, 2017 issued by Ministry of Environment, Forest and Climate Change (MoEF & CC). Analysed water quality parameters are compared with the designated best use water quality criteria recommended by CPCB or primary water quality criteria for outdoor bathing notified under The Environment (Protection) Rules, 1986 or BIS Drinking Water Specifications i.e. IS:10500-2012 or water quality standards for coastal water depending on the use of water bodies.

Water quality data is used for identification of polluted water bodies, identification of pollution sources in cities for formulation of River Action Plans including interception, diversion and treatment of municipal wastewater, waste management and stricter surveillance of industrial pollution sources. Water quality data is also used for dissemination of information i.e., to reply to public queries, for filing replies in Supreme Court, High Courts and in NGT, sharing of information with Non-Governmental Organization, Students, and Researchers.

Monitoring results obtained based on present network indicate that organic pollution continues to be the predominant source of pollution of aquatic resources. The organic pollution measured in terms of bio-chemical oxygen demand (BOD) & Coliform bacterial count gives indication of extent of water quality degradation in different parts of the Country. Total & Faecal Coliform which indicate presence of pathogens in water bodies is also a major concern. Based on exceedance of bathing water quality criteria limit of BOD, 46 polluted river stretches were identified in Karnataka, Tamil Nadu, Kerala, and Puducherry during the year 2018, based on the water quality data for the years 2016 & 2017.

CPCB water quality monitoring stations (Fig. 4) play a crucial role in assessing and maintaining the health of CRB by systematically monitoring water quality at various locations, including rivers, groundwater sources, lakes, sewage treatment plants (STPs), and tanks. These stations help in identifying pollution levels, tracking seasonal variations, and evaluating the effectiveness of wastewater treatment processes. By continuously collecting data on key parameters, these monitoring stations provide critical insights for policymakers, environmental agencies, and researchers. This data enables informed decision-making for sustainable water resource management, pollution control, and restoration efforts, ensuring the protection of aquatic ecosystems and the availability of clean water for communities dependent on CRB.

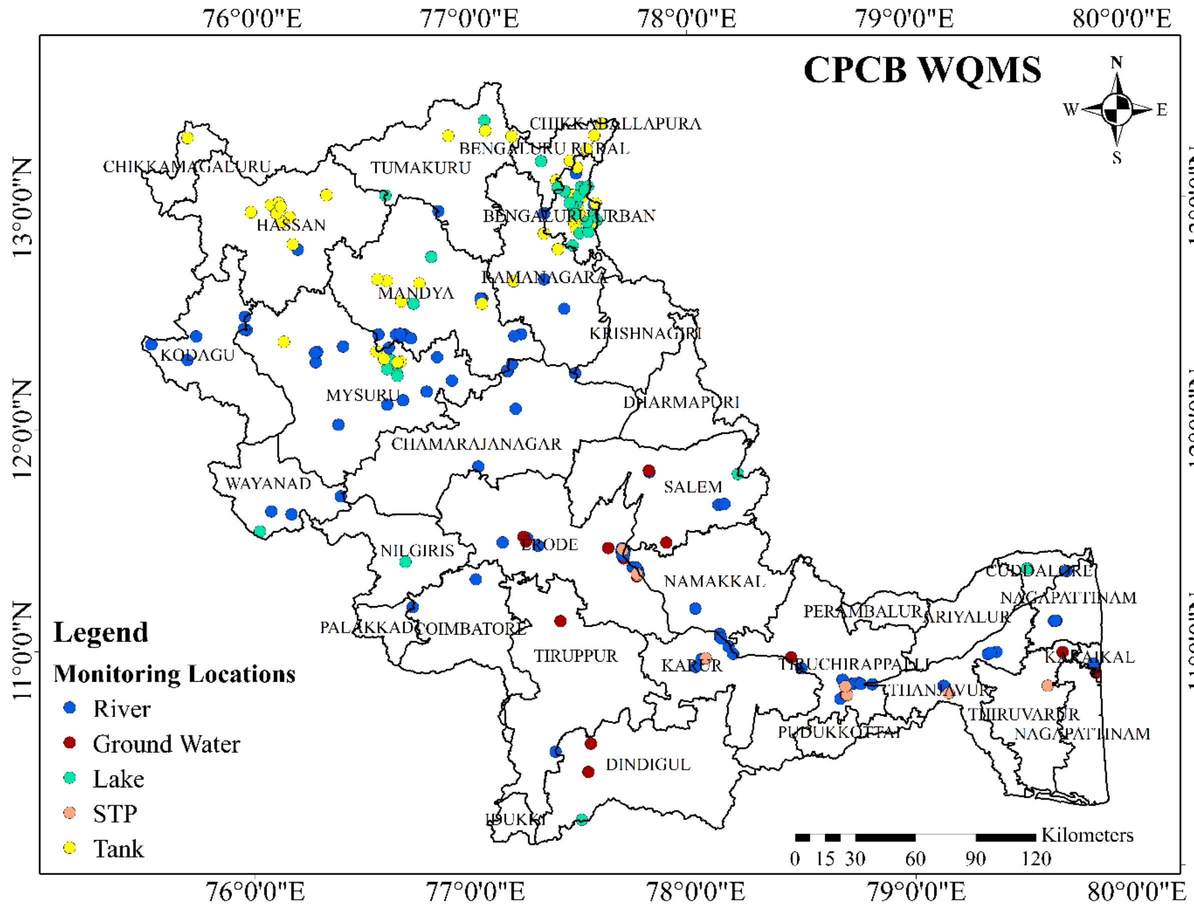


Fig. 4. CPCB water quality monitoring locations in CRB
(**Source:** https://cpcb.nic.in/nwmp-monitoring-network/)

Moreover, CWC follows a three-tier laboratory system for providing analytical facilities for the analysis of river water samples collected from 531 water quality monitoring stations belonging to the Water Quality Monitoring Network and covering all the major river basins of India. The three-tier laboratory is described below.

1. **Level-I Laboratories:** These are the field laboratories which are located at field water quality monitoring stations on various rivers of India where in-situ values of six, five physical parameters and one chemical parameter (Dissolved Oxygen) of river water are monitored. There are a total number of 295 level-I laboratories located at field water quality monitoring stations on various rivers of India.
2. **Level-II Laboratories:** There are 18 level-II laboratories located at division offices to analyse 25 physico-chemical and bacteriological parameters of river water.
3. **Level-III/II+ Laboratories:** There are five (05) regional level-III / II+ laboratories for analysis of 41 parameters including heavy metals / toxic parameters and pesticides.

The water quality monitoring stations established by CWC serve a vital function in evaluating and preserving the environmental health of CRB (Fig. 5). Strategically located at various points along the river and its tributaries, these stations provide continuous data on key water quality parameters. This systematic monitoring helps in identifying pollution hotspots, evaluating the impact of industrial and agricultural activities, and ensuring compliance with environmental regulations. The data collected from these stations support policymakers, researchers, and water resource managers in making informed decisions for sustainable water management and ecosystem conservation. Moreover, these monitoring efforts are essential for safeguarding the river's water quality, which is vital for drinking water supply, irrigation, aquatic life, and overall ecological balance in CRB.

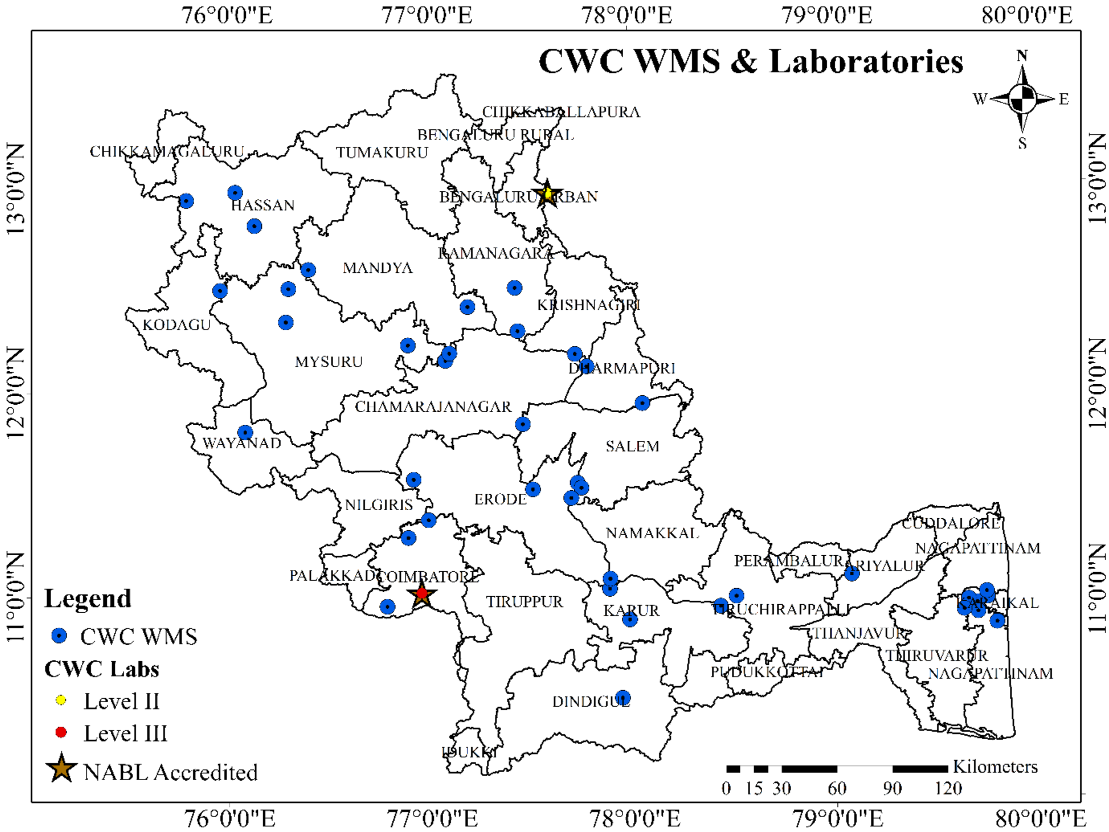


Fig. 5. CWC water quality monitoring locations and water quality laboratories in CRB (**Source:** Water Year Book, Cauvery Basin, CWC, March – 2024, https://www.cwc.gov.in/)

However, CRB is home to two National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited water quality laboratories operated by the CWC, ensuring high standards in water quality assessment and monitoring. The Lower Cauvery Water Quality Laboratory in Coimbatore plays a crucial role in analysing water parameters and supporting sustainable water management in the lower reaches of the basin. Similarly, the Upper Cauvery Water Quality Laboratory in Bangaluru is dedicated to monitoring and evaluating the water quality in the upper stretches of the river. These laboratories contribute significantly to maintaining water quality standards, aiding research, and supporting policy decisions for the effective management of the CRB.

2. Salient features of the CRB

2.1. Geographical, topographical and hydrological significance

The Cauvery River originates at Talakaveri in the Western Ghats of Karnataka at an elevation of about 1,341 m above sea level and flows southeast through Tamil Nadu, covering a total length of approximately 800 km before emptying into the Bay of Bengal. The basin covers an area of about 85220.39 sq. km, supporting diverse ecosystems and major cities such as Bengaluru, Mysuru, and Tiruchirappalli. CRB, extending across southern India, features a diverse topography with distinct geographical zones. The upper basin region is characterized by steep gradients, dense forests, and heavy monsoon rainfall, contributing to the river's flow. As the Cauvery flows eastward, it enters the middle basin, traversing Karnataka, and parts of Tamil Nadu. This area consists of undulating hills and plateaus, with elevations ranging from 100 to 1,000 m. Several significant tributaries, such as the Hemavathi, Shimsha, Arkavathi, Kabini, and Bhavani, join the Cauvery in this region, creating a complex river system. Continuing into the lower basin, predominantly in Tamil Nadu, the terrain gradually flattens into fertile plains with elevations below 100 m. This area is notable for its agricultural productivity, facilitated by the river's water and the fertile alluvial soil. The river eventually fans out into a delta before emptying into the Bay of Bengal near Poompuhar. The basin's diverse topography is integral to its hydrology, with seasonal variations in flow heavily influenced by monsoon rains, leading to high flow during the southwest monsoon and lower flow during the dry season. Key infrastructure such as the Krishna Raja Sagara dam in Karnataka and the Mettur dam in Tamil Nadu play crucial roles in water management for irrigation and supply. The ecological richness of the basin, from the dense forests of the Western Ghats to the agricultural plains and fertile delta, supports a wide range of wildlife and human activities, making the Cauvery River a vital lifeline for the regions it traverses.

Major tributaries of the Cauvery include the Hemavathi, Kabini, Bhavani, Noyyal, and Amaravati rivers. These tributaries significantly contribute to the river’s flow and the overall water resources of the basin. The basin is a crucial water resource for the states it traverses, providing water for domestic, agricultural, and industrial purposes. The basin supports extensive irrigation systems, which are vital for the region’s agriculture. The construction of numerous dams and anicuts (weirs) facilitates the distribution of water for irrigation. Major irrigation projects include the Krishnaraja Sagar Dam, the Mettur Dam, and the Grand

Anicut. The river's flow is highly seasonal, with most of the annual discharge occurring during the monsoon season (June to September). The river and its tributaries are harnessed for hydroelectric power generation. Key hydroelectric projects include the Shivanasamudra Falls Hydroelectric Project, one of the oldest in Asia, and the Mettur Dam Hydroelectric Project. The basin plays a critical role in recharging groundwater aquifers. The interaction between surface water and groundwater systems ensures the availability of water during dry periods. Effective management of surface water is crucial for maintaining groundwater levels, especially in the lower reaches of the basin.

The river's flow is regulated by a series of dams and reservoirs, which help mitigate the impacts of flooding during the monsoon season. These structures also store water for use during dry periods, ensuring a reliable water supply throughout the year. The river transports significant amounts of sediment, which is crucial for maintaining the fertility of the delta region. The annual flooding deposits nutrient-rich silt on agricultural lands, enhancing soil fertility and supporting agriculture. The basin's forests and wetlands contribute to climate regulation by sequestering carbon dioxide and moderating local temperatures. They also play a role in maintaining regional rainfall patterns. The salient features of the basin are shown in Table 3.

Table 3. Salient features of the CRB

S. No.	Features	Description
1	Basin Extent	75° 27' to 79° 54' E, 10° 9' to 13° 30' N
2	Area (sq. km)	85220.39
3	States in the basin	Tamil Nadu, Karnataka, Kerala, and Puducherry
4	Mean Annual Rainfall (mm)	1075.23
5	Mean Maximum Temperature (°C)	34.31
6	Mean Minimum Temperature (°C)	17.15
7	Avg. Annual water potential (BCM)	21.36
8	Utilizable surface water (BCM)	19
9	Number of water resources structures	Dams-96 Barrages -10 Weir/Anicuts-16 Lifts-9 Power House-24
10	Highest dam	Pillur Dam - 88 m
11	Longest dam	Lower Bhavani Dam- 8.797 km
12	Highest barrage	Kolar barrage-18 m
13	Longest barrage	Nerunjipettai Barrage-1.478 km
14	Number of irrigation projects	Major-16 Medium-42 ERM-3

15	Number of hydro-electric projects	15
16	Number of ground water observation wells	873
17	Number of hydro-observation sites	36
18	Water tourism sites	60
Source: Cauvery Basin Report Central Water Commission, Ministry of Water Resources and National Remote Sensing Centre, ISRO, Department of Space, Govt. of India. As per the available India-WRIS record.		

The CRB spans 11 districts across Karnataka, 03 districts in Kerala, 01 district in Puducherry, and 18 districts in Tamil Nadu, as summarized in Table 4.

Table 4. Districts within the CRB and their respective areal extent (**Source:** Survey of India)

S. No.	State	District	Area (sq. km)
1	Karnataka	Bengaluru Rural	976.88
2	Karnataka	Bengaluru Urban	1011.20
3	Karnataka	Chamarajanagar	5650.69
4	Karnataka	Chikkaballapura	7.22
5	Karnataka	Chikkamagaluru	750.10
6	Karnataka	Hassan	4941.88
7	Karnataka	Kodagu	2874.94
8	Karnataka	Mandya	4954.34
9	Karnataka	Mysuru	6316.19
10	Karnataka	Tumakuru	3988.62
11	Karnataka	Ramanagara	3515.94
12	Kerala	Idukki	383.57
13	Kerala	Palakkad	605.60
14	Kerala	Wayanad	1924.24
15	Puducherry	Karaikal	156.32
16	Tamil Nadu	Ariyalur	1587.28
17	Tamil Nadu	Coimbatore	2608.08
18	Tamil Nadu	Cuddalore	575.03
19	Tamil Nadu	Dharmapuri	1895.67
20	Tamil Nadu	Dindigul	4385.70
21	Tamil Nadu	Karur	2909.53
22	Tamil Nadu	Namakkal	3061.98
23	Tamil Nadu	Perambalur	616.43
24	Tamil Nadu	Thanjavur	2223.22
25	Tamil Nadu	Tiruppur	4914.36
26	Tamil Nadu	Krishnagiri	1905.80
27	Tamil Nadu	Nilgiris	2072.82
28	Tamil Nadu	Erode	5029.46

29	Tamil Nadu	Salem	3874.25
30	Tamil Nadu	Pudukkottai	735.66
31	Tamil Nadu	Tiruchirappalli	3987.53
32	Tamil Nadu	Thiruvarur	2238.15
33	Tamil Nadu	Nagapattinam	2541.73

2.2. Geomorphology

The geomorphology of CRB encompasses the study of its physical features, landforms, and the processes shaping them. The Cauvery River traverse diverse terrains, leading to a variety of geomorphological characteristics. The upper reaches of the Cauvery River originate in the Western Ghats, a major mountain range characterized by rugged terrain, high rainfall, and dense forest cover. The geomorphology of this region includes steep slopes, narrow valleys, and deep gorges. The river's headwaters, near Talakaveri in Karnataka, initially flows through a series of cascades and waterfalls. These features are a result of tectonic uplift and volcanic activity in the geological past, which have created a landscape marked by intense weathering and erosion. The Western Ghats serve as a crucial watershed, with numerous tributaries joining the Cauvery in this stretch, contributing to its perennial flow.

As the Cauvery River descends from the Western Ghats into the Mysore Plateau, the river flows through more gently undulating terrain. The middle basin is characterized by broad valleys, alluvial plains, and intermontane depressions. Here, the river meanders through a landscape influenced by both fluvial and tectonic processes. The region features extensive floodplains, sediment deposits, and river terraces formed by historical changes in river flow and sediment load. Important geomorphological features in this section include the Krishnaraja Sagara dam and reservoir, which has significantly altered the river's natural flow and sediment transport dynamics. Additionally, this stretch includes the deltaic plains where the river branches into distributaries, contributing to the formation of fertile agricultural land.

In the lower reaches, particularly as the river enters Tamil Nadu, the Cauvery flows through a predominantly flat and expansive landscape characterized by the formation of a large delta. This delta, known as the Cauvery Delta, is one of the most fertile and intensively cultivated regions in India. The geomorphology here is dominated by depositional processes, with extensive alluvial deposits forming a network of distributaries and canals. The delta is crisscrossed by numerous irrigation channels, reflecting the region's dependence on the river for agriculture. The lower basin's geomorphology also includes levees, backwaters, and floodplain lakes, which are crucial for managing flood risks and sustaining local ecosystems.

As the Cauvery River approaches its confluence with the Bay of Bengal, the river's geomorphology is influenced by coastal processes, including tidal actions and sea level changes. The interaction between fluvial and marine processes leads to the formation of estuaries, tidal flats, and mangrove swamps, which are important for maintaining coastal biodiversity and protecting against coastal erosion. The river's mouth, where it empties into the sea, is characterized by a dynamic interplay of sediment deposition and erosion, contributing to the continual reshaping of the coastal geomorphology.

2.3. Climatic variations

Climate is defined as the long-term average of variations in temperature, humidity, atmospheric pressure, wind, precipitation, and other meteorological variables specific to a region. CRB, encompassing multiple states in India, exhibits a variety of climatic zones due to its extensive geographical spread. Notably, approximately 54% of CRB lies within Tamil Nadu, particularly the middle and lower regions of the basin (India WRIS, 2014). The climate of these regions primarily depends on monsoon rainfall, making them susceptible to drought during monsoon failures. Consequently, the basin's climate ranges from dry sub humid to semi-arid. In CRB, four distinct seasons occur, i.e., winter, summer, south-west monsoon, and north-east monsoon.

2.4. Land use and land cover

The land use and land cover (LULC) classification map for CRB for 2022 was derived from Sentinel-2 satellite data, with a spatial resolution of 10 m (Fig. 6). Among various LULC classes, crop is the dominant category, covering an area of 42,469.40 sq. km (49.74%), followed by trees 21,873.50 sq. km (25.62%) and built-up area 9,568.54 sq. km (11.21%) (Fig. 6a and b). The rapid growth of population and advancements in technology have significantly altered land use patterns within CRB. These changes have unfortunately led to ecological imbalances and land degradation, particularly through soil erosion. The reduction in forest areas highlights the increased encroachment for agricultural purposes.

Moreover, CRB experiences three main crop seasons: kharif, rabi, and summer. During the kharif season, primary crops include paddy, bajra, jowar, maize, ragi, cotton, and various millets. Paddy is the predominant crop, while ragi, jowar, and other millets are essential under rainfed conditions. Horticulture crops such as coconut, betel leaves, pepper, oranges, and lemons are cultivated throughout the year. The basin also yields valuable forest products, including sandalwood, bamboo, teak, eucalyptus, blue gum, and wattle.

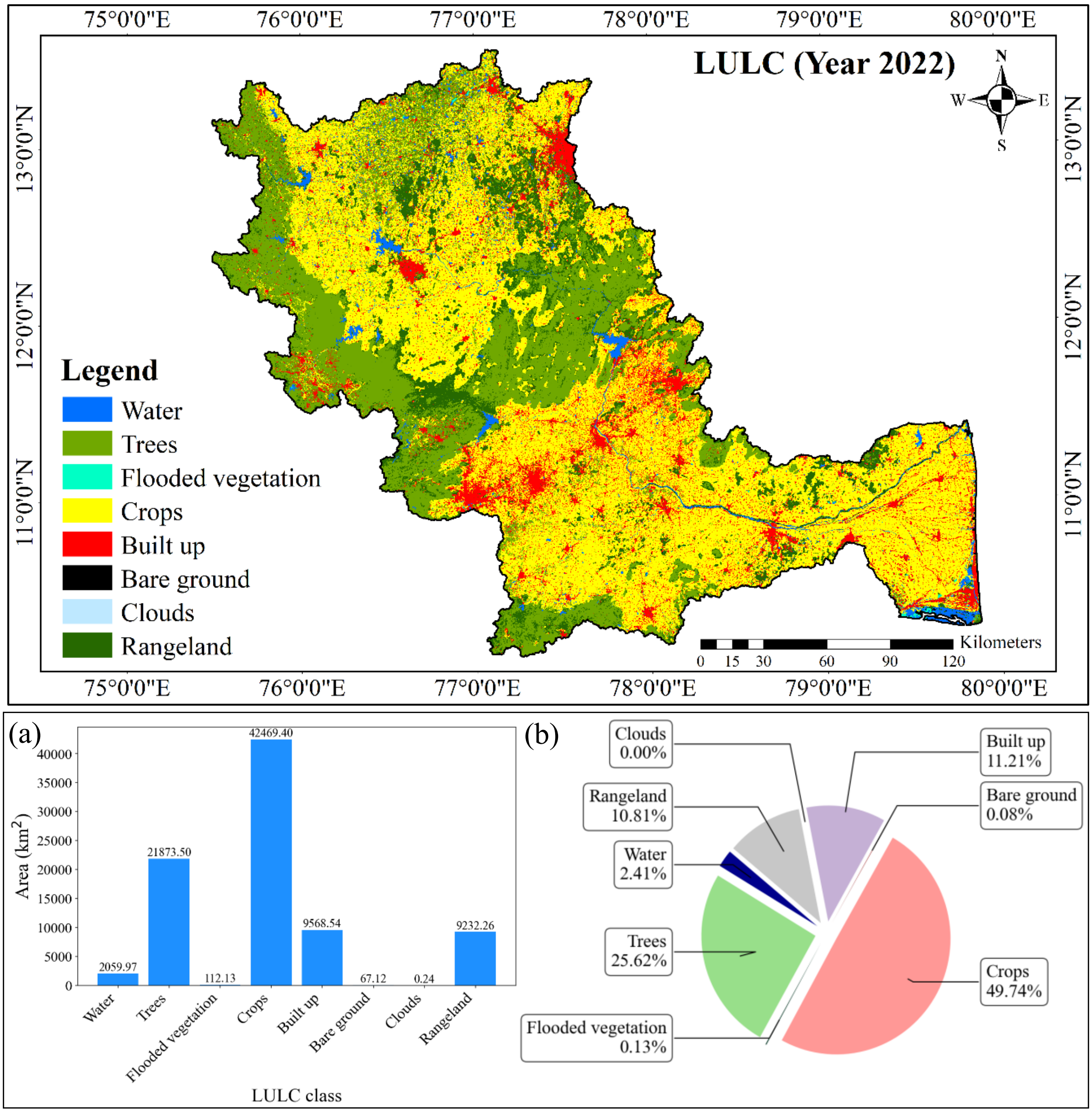


Fig. 6. LULC classification map for the year 2022 showing (a) area (sq. km) and (b) percentage distribution of each LULC class, with cloud cover accounting for 0.0003% (**Source:** https://livingatlas.arcgis.com/landcoverexplorer)

2.5. Degradation of catchment river stretch

The degradation of CRB is a pressing environmental issue, driven by a multitude of interrelated factors. Deforestation is a major concern, as large areas of forest cover have been cleared for agriculture and urban development, leading to significant habitat loss and increased soil erosion. This degradation not only diminishes the catchment's capacity to retain water but also disrupts local ecosystems. Intensive agricultural practices have further exacerbated the situation; the heavy use of chemical fertilizers and pesticides has led to nutrient runoff, polluting the river and harming aquatic life. Additionally, rapid urbanization in the region has resulted in a proliferation of impermeable surfaces, which increases surface runoff and decreases groundwater recharge, further straining water resources.

Intensive agriculture, deforestation, and topography cause severe soil erosion in districts like Palakkad, Coimbatore, and Erode. Significant erosion also occurs in Bengaluru Rural, Salem, Dharmapuri, Namakkal, Pudukkottai, and Idukki. Palakkad, Mysuru, Mandya, Wayanad, and the Nilgiris are particularly susceptible to siltation. Because of its topography and land use, Wayanad is especially vulnerable, whereas plantation activities have an impact on Nilgiris. Mandya faces difficulties from extensive irrigation and agriculture, Mysuru from agriculture and varied topography, and Palakkad from paddy cultivation, deforestation, and hilly terrain.

Brahmagiri Wildlife Sanctuary’s evergreen forest cover drops from 93.33% (1973) to 87.66% (2016). Bandipur National Park lost 15.19%, Nagarhole National Park (Rajiv Gandhi Tiger Reserve) 11%, and Cauvery Wildlife Sanctuary 18.43% forest cover. Bannerghatta National Park lost 21.9% of its deciduous forest and Biligiriranganatha Swamy Temple Tiger Reserve lost significant area of vegetation from 1973 to 2016 (https://wgbis.ces.iisc.ac.in/biodiversity/sahyadri_enews/newsletter/Issue85/article.html).

Bengaluru Urban, Bengaluru Rural, and Coimbatore face significant pollution from industrial activities, vehicular emissions, and poor waste management. Salem, Tiruchchirappalli, Karur, Chamarajanagar, Perambalur, and the Nilgiris also suffer from pollution due to steel production, textiles, chemicals, biomass burning, small-scale industries, and inadequate sanitation.

The region boasts rich and diverse flora, but this is under threat due to deforestation, pollution, erosion and invasive species (Kumar and Nagayya, 2022; Kishore et al., 2024). CRB’s flora spans 116 families, with dominant ones being Lauraceae, Fabaceae, Myrtaceae, Poaceae, and Rubiaceae. Endemic species include Artocarpus hirsutus, Atalantia wightii, Blachia umbellate, Cinnamomum species, Diospyrous paniculata, Garcinia gummi-gutta, Holigarna grahamii, Hopea pnga, Ixora brachiate, Knema attenuate, Vateria indica, Terminalia travancorensis, Syzygium malabaricum, and Syzygium densiflorum (https://wgbis.ces.iisc.ac.in/biodiversity/sahyadri_enews/newsletter/Issue85/article.html).

The Cauvery River’s ichthyofauna includes 146 fish species from 52 families (Koushlesh et al., 2021). Most fish species in CRB are classified as “least concern” on the IUCN Red List, but eight species are threatened: two “critically endangered,” four “endangered,” and two “vulnerable” (Sreenivasan et al., 2021). 15 species are endemic to the Western Ghats, with eight restricted to the Cauvery River system (Sreenivasan et al., 2021). The critically endangered ‘hump-backed’ Mahseer (Tor remadevii) is nearing extinction (Pinder et al., 2015). Invasive suckermouth catfish threaten native biodiversity (The Hindu, 2015).

Addressing these challenges requires a multi-faceted approach that includes reforestation initiatives to restore native vegetation, the promotion of sustainable agricultural practices to minimize chemical use, and stricter regulations on industrial waste management. Community engagement and education are vital for fostering a sense of stewardship over the river's resources. Comprehensive restoration efforts are essential not only for preserving biodiversity but also for ensuring water security for the millions who rely on the Cauvery River for drinking water, irrigation, and economic activities.

2.6. Degree of pollution

The Cauvery River exhibits varying degrees of pollution along its course, influenced by industrial activities, agricultural practices, urbanization, and environmental degradation. In industrial regions like Bengaluru and Mysuru, pollution is particularly severe due to the discharge of effluents containing heavy metals and organic pollutants from chemical plants and textile factories. These contaminants lead to high toxicity levels in aquatic ecosystems and make the water unsafe for human use without significant treatment (Jayakumar et al., 2015; Solaraj et al., 2010). In agricultural areas, runoff laden with fertilizers and pesticides introduces high concentrations of nitrates and phosphates into the river, causing eutrophication, algal blooms, and oxygen depletion. This nutrient pollution results in moderate to high levels of degradation, impacting aquatic life and water quality.

Urban centres such as Bangalore and Mysore contribute significantly to river pollution through untreated sewage and urban runoff, which introduce pathogens, organic waste, heavy metals, and solid pollutants, leading to high biochemical oxygen demand (BOD) and chemical oxygen demand (COD). These urban stretches are among the most degraded, characterized by severe contamination and ecological disruption. In regions affected by deforestation and land use changes, increased sedimentation from soil erosion degrades water quality, resulting in high turbidity and additional nutrient loading. Sand mining further exacerbates pollution by increasing turbidity and altering riverbeds, impacting local aquatic habitats (Mageshkumar et al., 2022; RamyaPriya and Elango, 2018). The cumulative impact of industrial discharges, agricultural runoff, urban sewage, deforestation, and sand mining underscores the complexity of the pollution issue in the CRB and necessitates a comprehensive approach to restore and protect this vital water resource.

3. Significance of different segments/sub-basins of river basin

3.1. Ecological significance

CRB is ecologically significant for several reasons, including its rich biodiversity, critical habitats, and its role in maintaining regional ecological balance. Protecting and conserving the basin is crucial not only for the environment but also for the millions of people who depend on its resources for their livelihoods and well-being. Effective management strategies and sustainable practices are essential to ensure the long-term health and vitality of CRB. The river and its tributaries host significant biodiversity, including various endemic and migratory species.

3.1.1. Ecological services

The diverse flora of the basin supports various pollinators, including bees and butterflies, which are essential for the pollination of many crops and wild plants. The forested areas of the basin contribute to climate regulation by sequestering carbon dioxide and releasing oxygen, thus mitigating the impacts of climate change.

3.1.2. Unique flora and fauna

The Western Ghats and CRB harbour many endemic species of plants (Fig. 7), insects, amphibians, reptiles, and mammals. For example, the Nilgiris Tahr, Lion-tailed Macaque, and several endemic frog species are found here. The river and its tributaries support a wide range of aquatic species, including fish like the Mahseer, which is significant for both ecological and recreational purposes.

Common name: Aatuvanchi, Neervanchi
Family: Rubiaceae
Distribution: Endemic to southern Western Ghats, in riverine vegetation
Conservation status: Vulnerable (VU-IUCN Red list)
Description: Medium-sized evergreen tree with broadly lanceolate, glossy green leaves. The flowers are yellow and arranged in terminal, tennis ball-like clusters. The fruit is small, forming a globose, fleshy mass, with minute seeds.
Uses: Medicinal

Fig. 7. International Union for Conservation of Nature (IUCN) listed Western Ghats endemic species (**Source**: https://mssbg.mssrf.org/10-iucn-wg-plants/)

3.1.3. Riverine ecosystems

The areas along the riverbanks are rich in biodiversity and play a crucial role in maintaining the ecological balance of the river system (Fig. 8). These zones support diverse vegetation that helps in soil conservation and provides habitat for various wildlife species. The Cauvery Delta is a significant wetland area that supports a variety of bird species, including migratory birds. These wetlands are critical for water purification, flood control, and as breeding grounds for fish.

Fig. 8. Pichavaram mangrove forest (major estuary in CRB)
(**Source:** https://lbb.in/chennai/pichavaram-mangrove-forest-cuddalore-chennai/)

3.1.4. Agricultural diversity

CRB is a significant agricultural backbone in southern India, known for its rich agricultural productivity and cultural heritage. The basin covers parts of the states of Karnataka, Tamil Nadu, Kerala, and Puducherry, supporting a wide range of crops including rice, sugarcane, cotton, and fruits. The agricultural practices in CRB are diverse, ranging from traditional to modern, with a mix of rain-fed and irrigated agriculture. The basin is characterized by its extensive irrigation infrastructure, including dams, reservoirs, and canals, which help in managing water resources for agriculture. However, CRB also faces challenges such as water scarcity, pollution, and conflicts over water sharing among states. During the kharif season, primary crops include paddy, bajra, jowar, maize, ragi, cotton, and various millets. Paddy is the predominant crop, while ragi, jowar, and other millets are essential under rainfed conditions (Fig. 9). Horticulture crops such as coconut, betel leaves, pepper, oranges, and lemons are cultivated throughout the year. The basin also yields valuable forest products, including sandalwood, bamboo, teak, eucalyptus, blue gum, and wattle.

Sustainable agricultural practices, efficient water management, and conservation efforts are crucial for the long-term viability of agriculture in CRB. Traditional Farming Practices: The basin supports diverse agricultural practices, including the cultivation of traditional and indigenous crop varieties. These practices contribute to agrobiodiversity and the resilience of local farming systems. Understanding and preserving the ecological significance of CRB is essential for maintaining the region's biodiversity and ecological health.

Fig. 9. Paddy field in the protected agricultural zone of Cauvery delta (**Source:** https://www.newsbricks.com/tamil-nadu/cauvery-delta-as-protected-agricultural-zone/84349)

3.2. Historical significance

The CRB in southern India holds profound historical significance (Fig. 10). Stretching across Karnataka and Tamil Nadu, it has been integral to human settlement for millennia, with archaeological evidence suggesting ancient civilizations flourished along its banks. Revered in Hindu mythology, places like Talakaveri are believed to mark its sacred origin, drawing pilgrims seeking spiritual connection. Beyond its practical utility, CRB stands as a testament to India's intertwined cultural, historical, and environmental heritage.

a) Talakaveri

Talakaveri, also known as Talacauvery, is widely regarded as the source of the Cauvery River and holds significant religious importance for many Hindus. Situated on the Brahmagiri hills near Bhagamandala in the Kodagu district (Coorg) of Karnataka, South India, Talakaveri is near the border with the Kasaragod district of Kerala. Although traditionally recognized as the river's origin, Talakaveri does not exhibit a permanent visible flow to the main river course, except during the monsoon season.

b) Somanathapura

The Chennakesava Temple, also known as the Chennakeshava Temple or Keshava Temple, is a Vaishnava Hindu temple situated on the banks of the Cauvery River in Somanathapura, Mysuru, Karnataka, India. Consecrated in 1258 CE, it was commissioned by Somanatha Dandanayaka, a general under the Hoysala King Narasimha III. This temple, renowned for its exquisite Hoysala architecture, lies 38 km (24 miles) east of Mysuru city.

c) Thanjavur

The Brihadeeswarar Temple, constructed by Raja Raja Chola I in the 11th century, is a remarkable representation of Chola architecture and has been recognised as a UNESCO World Heritage site. The temple is famous for its colossal central tower (Vimana) and elaborate carvings. Thanjavur The Maratha Palace, built in the 16th century, exemplifies the Maratha dynasty's significant impact. Notably, it features the Saraswati Mahal Library, which preserves valuable old manuscripts.

d) Srirangam

The Ranganathaswamy Temple is Srirangam's main historical landmark. This temple is a major Vaishnavite shrine dedicated to Lord Ranganatha and is considered one of the world's largest operational Hindu temples. The early mediaeval period marked the beginnings of this temple, with notable contributions from the Chola, Pandya, Hoysala, and Vijayanagara dynasties. The temple complex showcases a remarkable combination of architectural and spiritual elements, consisting of seven concentric enclosures (prakarams) and other shrines.

e) Tiruchirappalli

The Rockfort Temple is a significant historical monument in Trichy. It is a fortified temple complex that has served both as a military fortress and a place of pilgrimage. The Ucchi Pillayar Temple, located at the highest point, provides an extensive vista of the city and the river. The Jambukeswarar Temple, situated on Srirangam Island, is a place of worship specifically dedicated to Lord Shiva. It is classified as one of the Panchabhoota stalas, symbolising the elemental attribute of water.

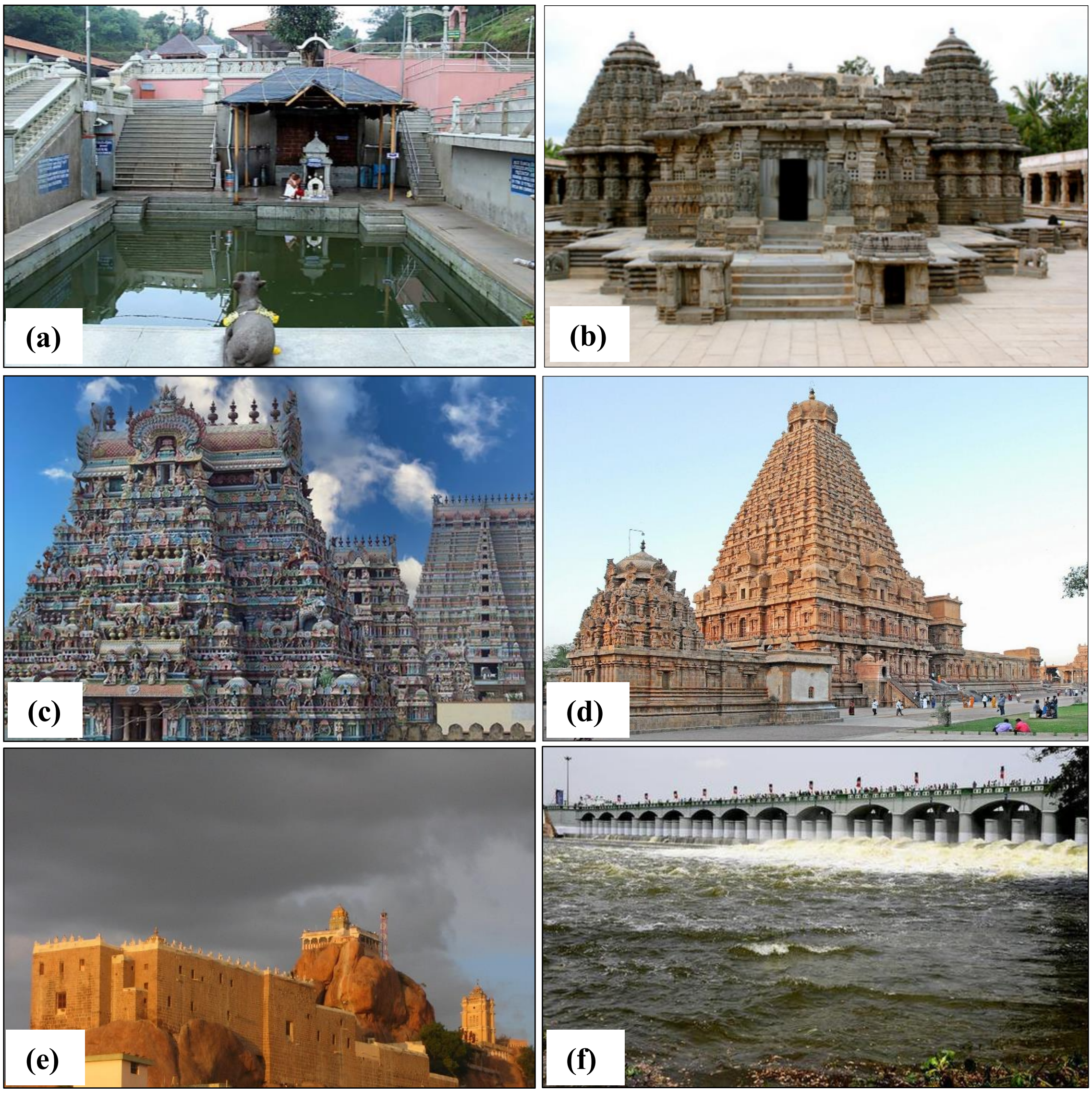


Fig. 10. Historical significance: (a) Talakaveri, (b) Chennakeshava Temple, (c) Ranganathaswamy Temple, (d) Brihadeeswarar Temple, (e) Rockfort Temple, and (f) Grand Anaicut

f) Kumbakonam

The Mahamaham Tank is renowned for its historical importance. It is particularly famous for hosting the Mahamaham festival, a grand event that takes place every 12 years. During this festival, devotees come together to bathe in the tank's hallowed waters. Kumbakonam is renowned for its several old temples, including the Adi Kumbeswarar Temple and the Sarangapani Temple, which showcase the architectural styles of the Chola and Vijayanagara dynasties.

g) Chidambaram

The Nataraja Temple at Chidambaram is a significant pilgrimage site dedicated to Lord Shiva in his cosmic dance form, known as Nataraja. The Saiva Siddhanta philosophy intricately intertwines with the architectural and ritualistic traditions of this entity. The Chidambaram Dikshitar Community comprises priests who follow a distinctive and age-old tradition of managing and conducting devotion in this temple.

h) Thiruvaiyaru

The Aiyarappar Temple, a major Shiva temple, holds tremendous religious importance in the town and is closely linked to the renowned saint-composer Tyagaraja. The Tyagaraja Aradhana is an annual music festival that pays tribute to Tyagaraja, drawing classical musicians from all around India.

i) Kaveripoompattinam

Poompuhar, also known as Kaveripoompattinam, was a prosperous port city during the Sangam era and is mentioned in Tamil literature. The city had a substantial impact on maritime commerce with ancient Rome and other areas. The Tamil epic "Silappathikaram" extensively highlights the influence of Poompuhar, emphasising its cultural and historical significance.

j) Grand Anicut (Kallanai)

Ancient Dam, constructed during the 2nd century CE under the rule of Chola monarch Karikala, the Grand Anicut stands as one of the most ancient water diversion constructions globally. It is still critical to the implementation of irrigation and water management.

k) Dharasuram

The Airavatesvara Temple in Dharasuram is a remarkable example of Chola architecture, constructed in the 12th century under the patronage of Rajaraja Chola II. UNESCO has recognised it as a World Heritage Site. The site is renowned for its elaborate stone carvings and sculptures.

l) Mayiladuthurai

It was in the lower Cauvery region, holds historical significance due to the presence of the Mayuranathaswami Temple. This temple, dedicated to Lord Shiva, is renowned for its impressive construction and serves as a significant pilgrimage site.

3.3. Social significance

CRB carries deep social significance for the communities residing along its banks and beyond. Beyond its practical importance in agriculture and water supply, the river and its tributaries are integral to the cultural identity of southern India. Throughout history, it has served as a cradle of civilization, nurturing ancient settlements, and fostering cultural exchange. The river's waters are revered in Hindu traditions, with rituals and festivals honouring its life-giving properties. Moreover, the basin's diverse communities, including farmers, fishermen, and artisans, have developed distinct ways of life shaped by its rhythms and resources. However, the basin's social fabric is also marked by challenges, notably the longstanding disputes over water sharing between states, which often exacerbate tensions and highlight the delicate balance between livelihoods and sustainable resource management. Despite these complexities, CRB remains a symbol of resilience and cultural richness, embodying the intertwined relationship between society, nature, and tradition in India's southern heartland.

3.4. Cultural significance

The Cauvery River holds immense cultural and religious importance, with numerous temples and pilgrimage sites along its course (Fig. 11). The Cauvery River is mentioned in various Hindu scriptures and epics, including the Ramayana and the Mahabharata. According to Hindu mythology, the river is said to have been created by Lord Brahma and is considered the embodiment of the goddess Cauvery. CRB is home to several pilgrimage sites, including the Talakaveri temple in Karnataka, which is believed to be the source of the river. Other important pilgrimage sites along the river include Srirangapatna, Sangama, and Srirangam.

The basin is the backdrop for several festivals and rituals. The most famous of these is the Cauvery Pushkaram, which is celebrated once every 12 years when the planet Jupiter enters the sign of Leo. During this time, pilgrims take a dip in the river to cleanse themselves of sins. The basin is known for its fertile soil and is considered the rice bowl of southern India. The river's water is used for irrigation, and its basin supports a rich agricultural tradition that is closely intertwined with the region's culture and way of life. The cultural and religious significance of the Cauvery River has also played a role in environmental conservation efforts. Several organizations and communities are involved in efforts to protect the river and its ecosystem, recognizing its importance beyond just a source of water.

Fig. 11. Cultural festivals: (a) Mahamaham, (b) Aadi Perukku, (c) Cauvery Pushkaram, and (d) Ganesh Chathurthi

3.5. Behavioural significance

The Cauvery River carries enormous importance from the perspective of human behaviour and its interactions with the river. It is deeply rooted in its ability to sustain human life, shape cultural and spiritual identities, drive economic activities, and foster adaptive behaviours. The complex interplay between the river and human communities has profoundly influenced the ways in which people interact with and manage this vital water resource. The key aspects of the significance of the Cauvery River from a human behavioural standpoint may be described as:

a) Sustenance and livelihood

The Cauvery River is the lifeline for millions of people, providing water for domestic use, agriculture, and various economic activities. This strong dependence on the river shapes human behaviour, leading to the development of intricate water management practices and a deep-rooted connection with the river.

b) Cultural and spiritual significance

The Cauvery River is deeply embedded in the cultural and spiritual fabric of the region. The river is personified as the Goddess Kaveri, and numerous cultural and religious practices, festivals, and pilgrimages are centred around the river. This reverence for the river influences human behaviour, leading to the preservation of traditional practices and the development of a strong sense of identity and belonging.

c) Conflict and cooperation

The Cauvery River has been a source of long-standing conflicts between the riparian states of Karnataka and Tamil Nadu over the equitable sharing of its waters. These conflicts have shaped human behaviour, leading to the development of legal frameworks, negotiation strategies, and political manoeuvring to assert water rights. Simultaneously, the need for cooperation has also influenced human behaviour, fostering the development of joint management mechanisms and the search for amicable solutions.

d) Adaptation and resilience

Changing climatic conditions, such as erratic rainfall patterns and increasing water scarcity, have compelled human communities in CRB to adapt their behaviour. This has led to the adoption of water-saving technologies, the diversification of livelihoods, and the development of innovative water management strategies to build resilience against water-related challenges.

e) Environmental stewardship

The degradation of the Cauvery River, due to factors like pollution, deforestation, and unsustainable practices, has influenced human behaviour towards greater environmental awareness and conservation efforts. This has led to the emergence of grassroots movements, community-based initiatives, and policy interventions aimed at protecting the river and its ecosystems.

f) Socioeconomic dynamics

The Cauvery River's role in supporting various economic activities, such as agriculture, fishing, and hydropower generation, has shaped human behaviour in terms of resource allocation, labour patterns, and the development of local economies. These socioeconomic dynamics have, in turn, influenced human interactions with the river and the management of its resources.

g) Knowledge and innovation

The long history of human interaction with the Cauvery River has led to the development of specialized knowledge and innovative practices related to water management, agricultural techniques, and the preservation of the river's ecological integrity. This knowledge has been passed down through generations, shaping human behaviour and adaptability in the face of changing environmental conditions.

3.6. Political significance

CRB holds significant political importance primarily due to water-sharing disputes between the states of Karnataka and Tamil Nadu, both of which heavily depend on the river's waters for agriculture, industry, and domestic use. The distribution of Cauvery waters has been a contentious issue for decades, leading to legal battles, protests, and political negotiations. The river basin's management and allocation of water resources have become crucial political agendas, influencing state policies, electoral outcomes, and inter-state relations. Political decisions regarding the Cauvery River can impact regional stability, economic development, and social harmony, making it a focal point of political discourse and governance in South India.

3.7. Economic significance

The economic significance of CRB is substantial, playing a pivotal role in the livelihoods and economic activities of the regions it traverses. Primarily an agricultural heartland, the basin supports the cultivation of a variety of crops including rice, sugarcane, cotton, and various fruits and vegetables. Agriculture here benefits from the river's waters through irrigation, enabling year-round farming and contributing significantly to the food supply chain of Karnataka and Tamil Nadu. Additionally, the basin's waters are harnessed for hydroelectric power generation, contributing to the region's energy needs. The river also facilitates inland navigation and transportation, supporting trade and commerce along its banks. Furthermore, the basin's diverse ecosystems and natural resources attract tourism, offering opportunities for recreational activities, eco-tourism, and wildlife conservation efforts.

Major economic activities are Agriculture, Horticulture, Poultry, Textile and paper industries, Fisheries are involved across the basin. Thanjavur and Kumbakonam are rich in history and generate economic activity through tourism. Tiruchirappalli and Coimbatore are industrialized cities which has boiler plant, information technology and BPO, home appliance industries (Fig. 12). However, the economic significance of CRB is not without challenges. Issues such as water management, equitable distribution of resources, environmental sustainability, and the impacts of climate change pose ongoing challenges that require careful planning and management to ensure long-term economic benefits while preserving the basin's ecological health.

Fig. 12. Industrial activities: (a) BHEL, (b) Tidel Park, (c) Salem Steel Plant, SAIL, and (d) Netaji Apparel Park

4. Biodiversity at a glance

4.1. Biodiversity hotspot

The basin supports a diverse range of plant and animal species. It is home to several endemic species and acts as a corridor for wildlife movement, especially in the Western Ghats, which is one of the world's biodiversity hotspots (Fig. 13). The river and its tributaries provide habitats for numerous fish species, some of which are endemic to the region. The river serves as a prime habitat for several species of amphibians, reptiles, birds and mammals comprising Tiger (Panthera tigris), Asian Elephant (Elephas maximus), Indian gaur (Bos gaurus), Sambar deer (Cervus unicolor), Spotted deer (Axis axis), Leopard (Panthera pardus), Wild dog (Cuon alpines), Sloth bear (Melurus ursinus), Smooth coated otter (Lutrogale perspicillata), Pangolin (Manis crassicaudata), Slender loris (Loris lardigradus) and Black naped hare (Lepus nigricollis), etc (https://wgbis.ces.iisc.ac.in/biodiversity/sahyadri_enews/newsletter/Issue85/article.html#annexure).

Fig. 13. Western Ghats biodiversity hotspots
(**Source:** https://www.worldatlas.com/articles/western-ghats-biodiversity-hotspot.html)

4.2. Wetlands and mangroves

The basin includes important wetlands like the Ranganathittu Bird Sanctuary, which serves as a breeding ground for a variety of migratory birds. These wetlands play a crucial role in water purification, flood control, and as habitats for aquatic life. In the delta region, the Cauvery supports mangrove forests that are vital for coastal protection, carbon sequestration, and as nurseries for marine life.

4.3. Forest ecosystems

The upper catchment area of the Cauvery lies in the Western Ghats, a region known for its dense forests and rich biodiversity (Fig. 14). These forests act as important carbon sinks and help in regulating the climate. The vegetation along the riverbanks helps in stabilizing the soil, reducing erosion, and maintaining water quality by filtering pollutants.

4.4. Hydrological functions

CRB provides a significant water source for domestic, agricultural, and industrial uses across Tamil Nadu, Karnataka, and parts of Kerala. The basin supports a large agriculture-based population heavily dependent on irrigation facilitated by groundwater. The CRB is integral in sustaining groundwater levels. Geospatial techniques applied in the basin reveal that areas with high lineament density and favourable geological formations (such as recent alluvium and Cretaceous limestone) exhibit excellent groundwater recharge potential. The natural flow regime of the Cauvery supports sediment transport, nutrient cycling, and the maintenance of riverine habitats. However, reservoirs and dams in the CRB significantly alter the natural flow regime, affecting water availability downstream. These structures impact sediment transport, groundwater recharge, and surface water interactions, thereby modifying overall hydrological functions.

Fig. 14. Nilgiris biosphere reserve in CRB
(**Source:** https://ar.inspiredpencil.com/pictures-2023/nilgiri-biosphere-reserves)

5. Current state of the basin and the river, including major tributaries

CRB faces significant challenges related to water availability and demand. Hydroclimate factors, influenced by the Western Ghats and monsoonal patterns, affect water availability. Despite projected increased monsoon rainfall, rising temperatures are expected to elevate evapotranspiration, potentially reducing runoff, and increasing drought risk, particularly in the eastern basin. Anthropogenic factors, including population growth and agricultural demands, exacerbate water stress. The basin supports critical agricultural activities, with Tamil Nadu heavily reliant on Cauvery water for paddy cultivation and Karnataka investing in irrigation projects, fuelling longstanding inter-state disputes. A comprehensive policy framework integrating hydrological and social research is essential for sustainable management of CRB's water resources, crucial for supporting agriculture, livelihoods, and economic stability across the region.

The Cauvery River, originating from the South Karnataka Plateau, is nourished by multiple tributaries. Positioned on its left bank are the Harangi, Hemavathi, Shimsha, and Arkavathi rivers, while the right bank is replenished by the Lakshmana Tirtha, Kabini, Suvarnavathi, Bhavani, Noyyal, and Amaravati rivers. Descending through the

Sivasamudram waterfalls, the river bifurcates into two branches, cascading over a 91m drop. Harnessing this energy is the hydroelectric power station at Shivanasamudram, after which the branches reconverge at Mekedatu Gorge. Extending 64 km, it delineates the Karnataka-Tamil Nadu border, veering south at Hogennekkal Falls before entering the Mettur Reservoir. Downstream, it merges with the Bhavani, Noyyal, and Amaravathi tributaries, broadening into the 'Akhanda Cauvery' riverbed. Near Tiruchirappalli, it splits into the Coleroon and Cauvery branches, initiating the Cauvery Delta. The Coleroon rejoins the primary branch at Srirangam Island, where the ancient Grand Anicut, attributed to a 1st century A.D. Chola King, regulates its flow. Below this point, the Cauvery further divides into the Cauvery and Vennar branches, intricately weaving through the fertile plains of the delta.

5.1. Major tributaries of the Cauvery River

a) Hemavathi River

It is an important tributary of the Cauvery River (Fig. 15). It rises from the Western Ghats at an elevation of about 1219 m near Ballalarayana Durga in the Chikkamagaluru district of Karnataka and flows through Chikkamagaluru, Hassan district, and Mysore district before joining the Cauvery near Krishnarajasagara. It is approximately 245 km long. A large reservoir has been built on the river at Gorur in the Hassan district.

b) Yagachi River

It is a major tributary of the Hemavathi River. Originating in the Baba Budan Hill Range near Chikkamagaluru, it flows through Belur Taluk in Hassan District before joining the Hemavathi River near Gorur. A minor tributary, known as Votehole (or Watehole), joins the river along its course. The Yagachi Dam was constructed across the river in 2001.

c) Harangi River

The Harangi River rises in the Pushpagiri hills of the Western Ghats in Kodagu district, Karnataka. The Harangi River flows for about 50 km from its source to its confluence with the Cauvery River, which occurs near Kudige, approximately 5 km north of Kushalnagar. It is impounded by the Harangi Reservoir, which supports irrigation and drinking water supply in southern Karnataka.

d) Lakshmana Tirtha River

It rises from the Irupu Falls (Iruppu Falls), located in the Brahmagiri Range in the Kodagu district of Karnataka, bordering the Wayanad district of Kerala. It then flows eastward and joins the Cauvery River in the Krishna Raja Sagara Lake. Ramathirtha is its major tributary.

e) Panamaram River

The Panamaram River originates in the Western Ghats of Wayanad district, Kerala, and flows eastward into Karnataka to join the Kabini River. It contributes significantly to the Kabini basin and supports agriculture in the Wayanad plateau.

f) Kabini River

Kabini (Kabani and Kapila) originates from Pakramthalam hills in Wayanad district of Kerala from the confluence of the Panamaram River and Mananthavady River. The backwaters of the Kabini reservoir are very rich in wildlife especially in summer when the water level recedes to form rich grassy meadows. After traversing two km from the confluence of the Panamaram river, Kabini forms an island called Kuruva Island, spreading over 520 acres with diverse flora and fauna.

g) Nugu River

Nugu River, a tributary of the Kabini River in the Cauvery basin, originates in the Western Ghats of Karnataka and drains forested and undulating terrain. Its flow is predominantly monsoon-driven and regulated by the Nugu Dam, contributing seasonal inflows to the Kabini-Cauvery river system.

h) Moyar River

Moyar River originates near the small settlement of Mayar, located off the Masinagudi-Ooty road. It forms a natural boundary between the states of Karnataka and Tamil Nadu and separates the forests of Bandipur National Park from the Mudumalai Wildlife Sanctuary to the south. The river ultimately joins the Bhavani River at the Bhavanisagar Reservoir on the plains of Tamil Nadu near Sathyamangalam.

i) Bhavani River

Bhavani River originates in the Nilgiri Hills of the Western Ghats, briefly flows through Silent Valley National Park in Kerala, and then re-enters Tamil Nadu. It is a perennial river with a total length of about 217 km, primarily fed by the southwest monsoon and supplemented by the northeast monsoon. It is regulated by the Bhavanisagar Dam and plays a crucial role in irrigation and hydropower generation.

j) Noyyal River

Its original name was Kanchinadi but changed later to the name of the place where it drains into the Cauvery River. It rises from the Vellingiri hills in the Western Ghats in Tamil Nadu and drains into the Cauvery River. Noyyal joins with the Cauvery River at Kodumudi in Erode district. The place is also called Noyyal. The 173 km long tributary of the Cauvery River filled 32 tanks. These interconnecting tanks held the water flowing from the Noyyal.

k) Amaravathi River

It is also known as Pournami, this 175 km long river begins at the Kerala/Tamil Nadu border at the bottom of Manjampatti Valley between the Annamalai Hills and the Palni hills in Indira Gandhi Wildlife Sanctuary and National Park. It descends in a northerly direction through Amaravathi Reservoir and Amaravathi Dam at Amaravathinagar. This river nourishes the agriculture of Erode district. The Amaravathi River and its basin, especially in the vicinity of Karur, are heavily used for industrial processing water and waste disposal and as a result, are severely polluted due to a large amount of textile dyeing and bleaching units.

l) Kodavanar River

Kodavanar River is a hill stream originating in the Palni Hills, Tamil Nadu, and forms an important tributary of the Amaravati River.

m) Santanavardhani River

Santanavardhani River is a tributary of the Amaravathi River in the Cauvery basin, draining semi-arid hard-rock terrain in central Tamil Nadu.

n) Kallar River

Kallar River is a tributary of the Cauvery River in Tamil Nadu, joining the main river in the lower reaches of the Cauvery basin. It originates from the eastern slopes of the Western Ghats and drains predominantly hard-rock terrain characterized by undulating to gently sloping topography.

o) Marudaiyar River

Marudaiyaru River (Marudaiyar or Marudaiyaru) is a minor but locally important river of Tamil Nadu, particularly within Perambalur and Ariyalur districts. It is part of the Kollidam river system and plays a role in local irrigation and water resources.

p) Aiyaru River

Aiyaru River flows through Namakkal district of Tamil Nadu. It is a seasonal river, supporting local irrigation and agriculture in the semi-arid regions it drains.

q) Thirumanimuthu River

Thirumanimutharu River rises from three reserved forests in the Eastern Ghats of the Shevaroy Hills in Salem district, Tamil Nadu. It flows for about 120 km through Namakkal district before finally joining the Cauvery River near Paramathi Velur at Nanjai Edayar village in Tamil Nadu.

r) Vrishabhavathi River

Vrishabhavathi River is a minor tributary of the Arkavathy River that flows through the southern part of Bengaluru, India. Once renowned for its pristine water-used for drinking and by the historic Gali Anjaneya Temple, the river is now heavily polluted due to untreated discharges from industrial, agricultural, and domestic sources.

s) Arkavathi River

This 161 km long river originates at Nandi Hills of Chikkaballapura district of Karnataka. It is a tributary of the Cauvery River, which it joins at Kanakapura, called Sangama in Kannada, after flowing through Kolar district and Bangalore Rural district. The river drains into the Chikkarayappanahalli Lake near Kanivenarayanapura. The picturesque Chunchi waterfall on the Arkavathi River at Sangama near Kanakapura attracts numerous tourists. The water is taken from two reservoirs built on the river, the Hesaraghatta (or Hesseraggatta), and the Tippagondanahalli Reservoir (or T G Halli).

t) Shimsha River

It originates at an altitude of 914 m from the Devarayanadurga hills in the Tumkur District of Karnataka. It is one of the tributaries of the river Cauvery. Maddur is a major town that lies on this river. Markonahalli Dam is a dam built across the river Shimsha in the Kunigal Taluk of Tumkur district. Shimsha has a waterfall at Shimshapura in Malavalli Taluk. This is also the location of the Shimsha Hydro Electric Project.

5.2. Major distributaries of the Cauvery River

a) Kollidam/Coleroon River

The Kollidam is a river in southeastern India (Fig. 15). The Kollidam is the northern distributary of the Cauvery River as it flows through the delta of Thanjavur. It splits from the main branch of the Cauvery River at the island of Srirangam and flows eastward into the Bay of Bengal. The distribution system in Kollidam lies at Lower Anaicut which is an island of river Kollidam. The town of Chidambaram lies on its banks.

b) Nandalar River

The Nandalar River is a small distributary of the Cauvery River flowing through parts of Thanjavur and Tiruvarur districts. It primarily supports irrigation in the central Cauvery delta through a network of canals and tanks.

c) Nattar River

The Nattar River is a minor river in the Cauvery basin, mainly functioning as an irrigation channel within the deltaic region. It contributes to agricultural water supply during monsoon and regulated releases.

d) Noolar River

The Noolar River is a small distributary in the Cauvery delta, carrying regulated flows from the main river system. It supports local irrigation and groundwater recharge in adjoining agricultural areas.

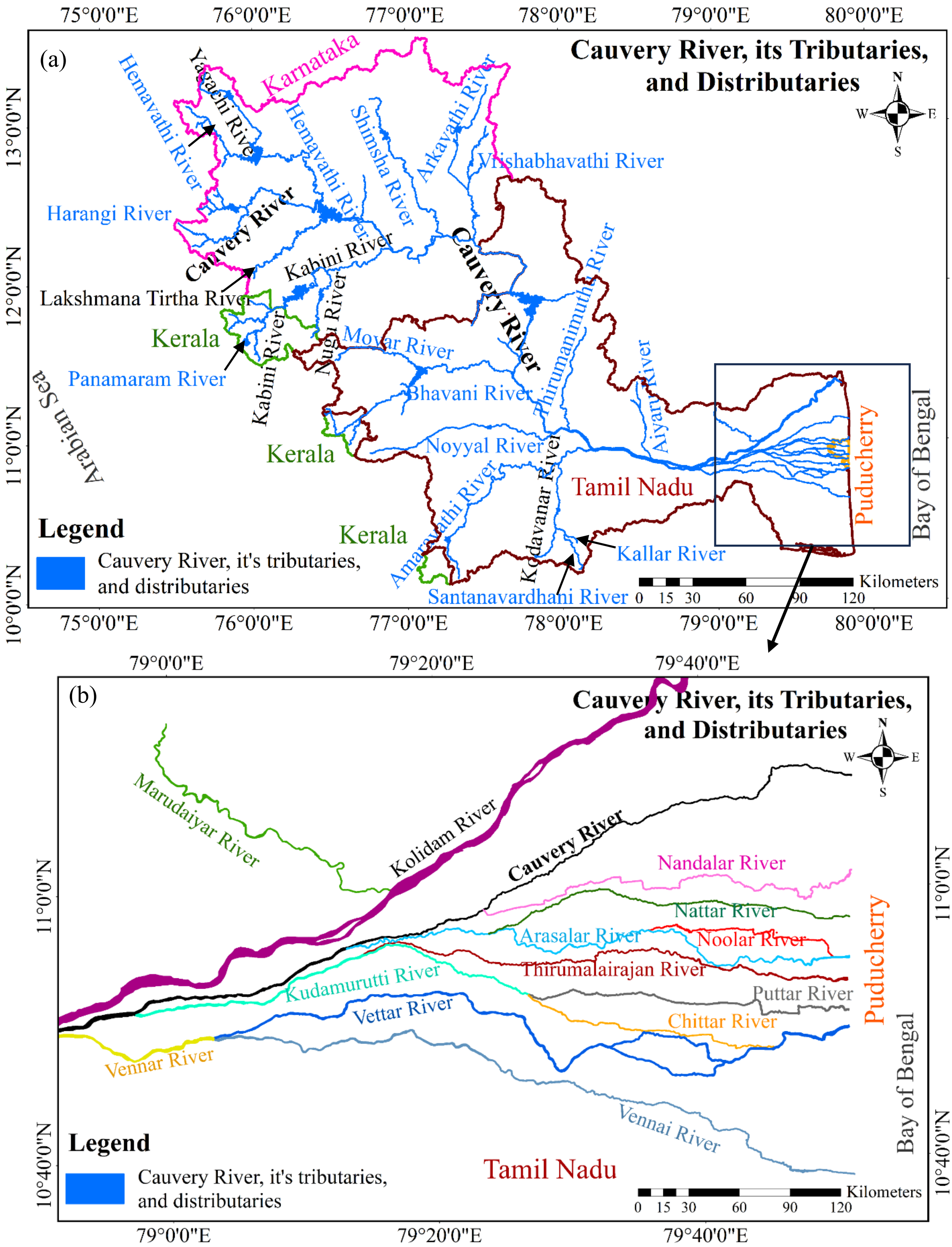


Fig. 15. Cauvery River and its major tributaries and distributaries, (a) basin-wide view of the entire CRB showing the boundaries of Karnataka, Tamil Nadu, Kerala, and Puducherry, (b) enlarged view of the Cauvery deltaic river network in Tamil Nadu

e) Arasalar River

The river Arasalar is a river that flows through Tamil Nadu and Pudducherry, and a distributary of Cauvery River which splits into 5 different rivers when it enters Thanjavur district from Trichy. The river takes is course from Thiruvaiyaru of Thanjavur where it branches from Cauvery and emptying itself into the sea of Bay of Bengal at Karaikal, east of Akalanganni. Karaikal once served as a river port till the 19th century where the yachts and Marakkalam ships of Karaikal Marakkayar harbored in and loaded and unloaded the goods towards exports and imports. The river is polluted by high concentrations of nitrate and chromium due to the mixing of sewage water into the river stream and industrial activities (https://lotusarise.com/cauvery-river-system/).

f) Thirumalairajan River

Thirumalairajan River is an important distributary of the Cauvery River flowing through Thanjavur and Tiruvarur districts. It plays a key role in irrigating deltaic farmlands and feeds several subsidiary channels and tanks.

g) Kudamurutti River

Kudamurutti River is a southern distributary of the Cauvery River, branching off near Thiruvaiyaru. It flows eastward through Thanjavur district and provides irrigation to extensive paddy-growing regions of the delta.

h) Puttar River

Puttar (or Puravadaiyanar) River is a minor distributary in the Cauvery delta. It mainly functions as an irrigation carrier, supplying water to agricultural lands and village tanks.

i) Chittar River

Chittar River is a small river within the Cauvery deltaic system, supporting irrigation and drainage. Seasonal flows contribute to soil moisture and groundwater replenishment.

j) Vennar/Vennaaru River

Vennar River or Vennaaru is a river and distributary of the Cauvery River in the Cauvery delta. It flows through the Thanjavur, Tiruvarur, and Nagapattinam districts of Tamil Nadu. The river begins at the Grand Anaicut at the eastern end of Srirangam Island, where it branches off from the Cauvery. After diverging from the Cauvery, the Vennar flows east. Northwest of Thennankudi, at the Thenperambur dam, the Vennar splits into a northern and southern branch. The northern branch becomes the Vettar River, while the southern branch continues east as the Vennar. Northwest of Needamangalam, there is another dam across the river, and the river splits again, into three branches. The Pamaniyar and Koraiyar Rivers begin as the two southern branches created by this divergence, while the Vennar continues through the northern branch.

k) Vettar River

Vettar River is a northern branch of the Vennar River formed near Thenperambur. It flows eastward through the Cauvery delta and is an important irrigation channel for surrounding agricultural lands.

l) Vennai River

Vennai River is a minor distributary within the Cauvery delta system. It supports localized irrigation and drainage, contributing to agricultural productivity in the deltaic plains.

6. Challenges faced by the river

6.1. Water scarcity and overexploitation

Excessive extraction for agriculture, domestic, and industrial use has led to significant groundwater depletion in the basin. Technical studies show declining water tables and aquifer levels (Ilamurugan et al., 2022; Prayag et al., 2023). Surface Water Overuse: The river's flow is heavily regulated with numerous dams and barrages. Overuse during dry seasons reduces the river's flow, affecting downstream users and ecosystems (Arulbalaji and Padmalal, 2020; Lalitha et al., 2021).

6.2. Water pollution

Water pollution in CRB is a significant environmental concern that affects the river's ecosystem, water quality, and the health of people who rely on it for drinking water and other purposes (Brema et al., 2021). The major water pollution sources can be described as:

- Industries along the riverbanks discharge effluents containing heavy metals, chemicals, and other pollutants, which contaminate the river water.
- Pesticides, fertilizers, and animal waste from agricultural fields enter the river through runoff, leading to water contamination and eutrophication.
- Untreated sewage from towns and cities along the riverbanks is a major source of water pollution, introducing pathogens and organic pollutants into the river.
- Sand mining and quarrying activities in the basin contribute to sedimentation and pollution of the river water.
- Deforestation and soil erosion in the basin's catchment area increase sedimentation in the river, reducing water quality and affecting aquatic life.
- Inadequate solid waste management practices contribute to the pollution of the river and its tributaries.

Efforts to address water pollution in CRB include the implementation of pollution control measures, such as the treatment of industrial effluents and sewage, enforcement of environmental regulations, promotion of sustainable agricultural practices, and awareness campaigns to educate communities about the importance of clean water and proper waste management. Collaboration among governments, industries, communities, and other stakeholders is essential to effectively tackle water pollution in the basin.

6.3. Over-extraction and flow regulation

Over-extraction and flow regulation are significant issues in CRB, affecting water availability, river health, and the livelihoods of communities dependent on the river. Rapid urbanization and agricultural expansion have led to the over-extraction of groundwater in the basin, especially in areas with intensive irrigation. Increased water demand for irrigation, domestic use, and industry has led to the over-extraction of surface water from the Cauvery River and its tributaries, particularly during dry seasons (Ekka et al., 2022). The construction of dams and reservoirs for irrigation, hydropower generation, and flood control has altered the natural flow regime of the Cauvery River, leading to reduced downstream flow, changes in sediment transport, and impacts on aquatic ecosystems. Water diversion projects that transfer water from CRB to other basins for irrigation or drinking water supply further reduce the flow available in the Cauvery River.

Reduced flow and altered flow patterns affect the river's ecosystem, including fish populations, aquatic vegetation, and habitats (Dutta et al., 2020). Reduced water availability affects agriculture, fisheries, and livelihoods of communities dependent on the river. It can also lead to conflicts over water allocation among riparian states. Implementing sustainable water management practices, such as water conservation, groundwater recharge, and efficient irrigation techniques, can help reduce over-extraction and improve water availability. Balancing the need for water storage and flow regulation with ecological and social considerations is essential. Adopting environmental flow assessments to determine minimum flow requirements for the river is one approach. Cooperation among basin states is crucial for equitable water sharing and sustainable management of CRB. Addressing over-extraction and flow regulation in CRB requires a holistic approach that considers the needs of all stakeholders and the long-term sustainability of the river ecosystem.

6.4. Interstate water disputes

Interstate water disputes in CRB have been a longstanding issue, primarily between the states of Karnataka and Tamil Nadu. The dispute revolves around the sharing of Cauvery River waters and has led to tensions, legal battles, and occasional outbreaks of violence. Both states have historical claims over the river's waters for agriculture and other purposes. The main point of contention is the sharing of water during the monsoon and non-monsoon seasons. Tamil Nadu argues that it requires a certain amount of water to irrigate its agriculture, especially in the Cauvery delta region. Karnataka, on the other hand, contends that it also needs water for its own agricultural needs and urban centres. The dispute has gone through various legal and political processes, including the involvement of tribunals and the Supreme Court of India. Several agreements and awards have been made to resolve the issue, but disagreements persist over the implementation and interpretation of these agreements.

The dispute has had significant socio-economic impacts on both states, affecting agriculture, livelihoods, and overall development. It has also strained relations between the two states and highlighted broader issues related to water management and governance. Efforts to resolve the dispute have included mediation, negotiations, and the formation of bodies like the Cauvery water management authority to oversee water sharing. However, a lasting solution that satisfies all stakeholders remains elusive. Sustainable management of CRB requires cooperation and dialogue among all basin states. This includes equitable sharing of water, sustainable use of resources, and mutual respect for each other's needs and rights. The Cauvery water dispute underscores the complexity of managing shared water resources, highlighting the need for integrated and inclusive approaches to water governance and management in river basins.

6.5. Climate change impacts

Climate change is having significant impacts on CRB, affecting its hydrology, agriculture, biodiversity, and the livelihoods of millions of people dependent on the river. It is altering the timing and distribution of rainfall in the basin, leading to changes in water availability and affecting agricultural productivity. The basin is experiencing more frequent and intense droughts and floods, which disrupt agriculture, infrastructure, and livelihoods. The rise in sea level is causing saltwater intrusion into coastal areas of the basin, affecting agriculture and freshwater availability.

Changes in temperature and rainfall patterns are affecting the basin's biodiversity, including fish populations, aquatic vegetation, and wildlife dependent on the river and its ecosystems. Climate change is exacerbating water scarcity in the basin, particularly during the dry season, leading to conflicts over water allocation among riparian states. It is posing challenges for adaptation in the basin, requiring innovative water management practices, agricultural techniques, and infrastructure development to cope with changing conditions. Addressing the impacts of climate change in CRB requires a multi-faceted approach, including sustainable water management practices, reforestation, watershed management, and community-based adaptation strategies. Collaboration among governments, stakeholders, and communities is crucial to build resilience and ensure the long-term sustainability of the basin's ecosystems and livelihoods.

6.6. Sedimentation and erosion

Deforestation, poor agricultural practices, and construction activities lead to increased soil erosion in the basin. This sediment is carried into the river, reducing the storage capacity of reservoirs, and affecting water quality (Arulbalaji and Padmalal, 2020; Gowri and Mujumdar, 2020). Sediment deposition in reservoirs reduces their capacity, affecting water storage, hydroelectric power generation, and flood control capabilities (Sreelash et al., 2020).

6.7. Biodiversity loss

Water diversion, pollution, and altered flow regimes degrade aquatic habitats. This threatens the biodiversity of the river, including several endemic and endangered species. Overfishing and habitat loss have led to a decline in fish populations, impacting local communities that rely on fishing for their livelihoods.

6.8. Agricultural challenges

Traditional flood irrigation methods lead to significant water wastage. Modern, efficient irrigation technologies like drip or sprinkler systems are not widely adopted (Jena et al., 2020; Keerthan et al., 2023). The cultivation of water-intensive crops (e.g., paddy, sugarcane) exacerbates water stress. There is a need to promote less water-intensive crops suitable for the local climate.

7. Mapping of disturbed areas based on population density, anthropogenic pollution, reservoir's siltation, land use, and soil erosion

7.1. Disturbed areas based on population density

The population density data for various districts within the CRB were sourced from the Census of India (Fig. 16). According to Fig. 16, Bengaluru Urban district has the highest population density, followed by Karaikal, Nagapattinam, Thiruvarur, Tiruchirappalli, and other districts. Based on these population density statistics, the districts were categorized into three classes: Bengaluru Urban and Karaikal as a highly disturbed district, Ramanagara, Mandya, Mysuru, Wayanad, Coimbatore, Tiruppur, Karur, Tiruchirappalli, Thanjavur, Thiruvarur, Nagapattinam, Ariyalur, Namakkal, Salem, and Erode as moderately disturbed areas, and the remaining districts as less disturbed areas (Fig. 17). High population density leads to an increased demand for resources, infrastructure, and services, thereby amplifying the vulnerability of these regions. Mining and other resource extraction activities in these districts degrade the environment, leading to soil erosion, deforestation, and loss of biodiversity. These activities disrupt the natural habitat and contribute to long-term ecological damage. In agricultural regions like Thanjavur and Namakkal, the extensive use of pesticides and fertilizers results in soil degradation and water pollution. These chemicals can contaminate groundwater and surface water, posing risks to human health and aquatic life. Over-extraction of water for irrigation, particularly in agriculturally intensive districts, depletes water resources and affects water availability for other uses. This unsustainable practice can lead to reduced groundwater levels and diminished surface water bodies, exacerbating water scarcity issues.

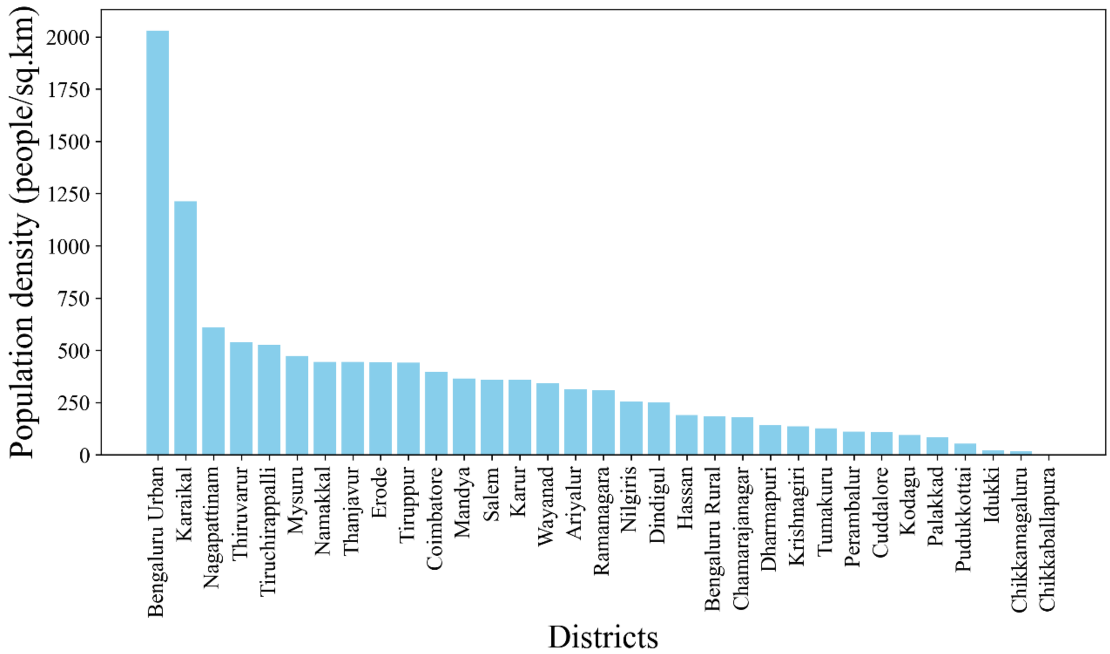


Fig. 16. Population density (people/sq. km) of each district lying within the CRB (**Source:** India Census, 2011)

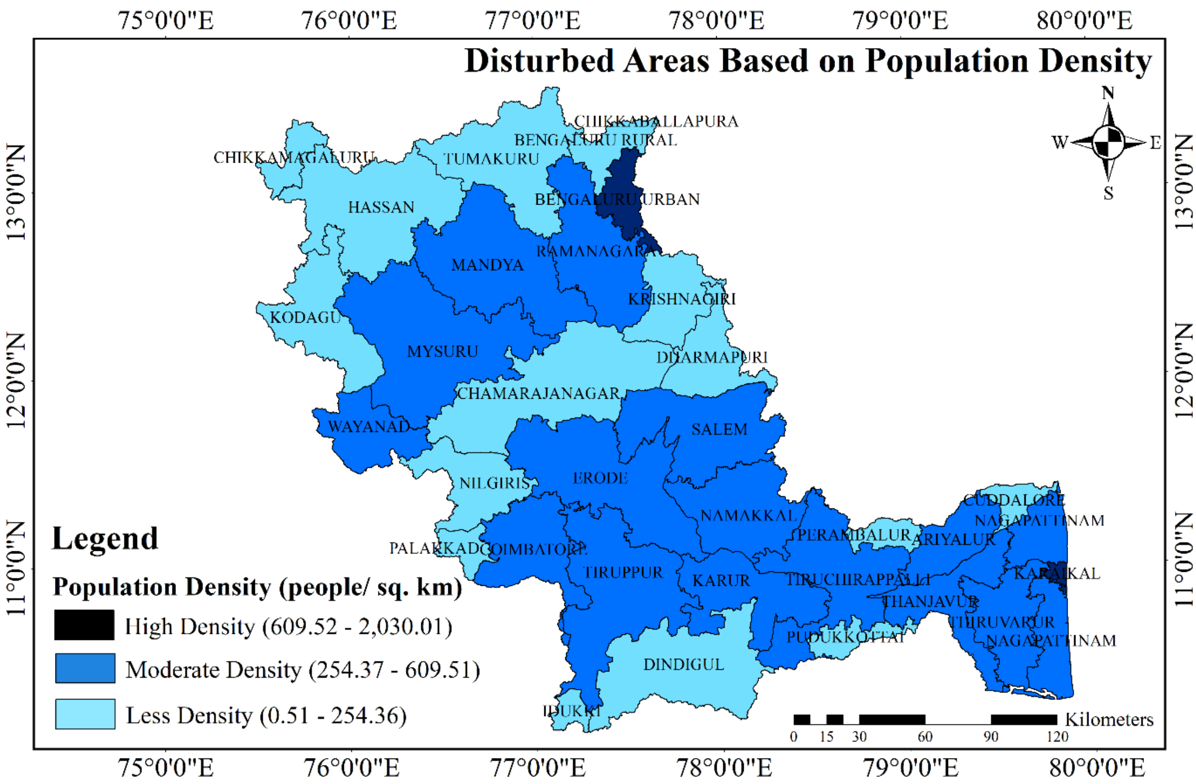


Fig. 17. Classification of disturbed areas based on population density for various districts within the CRB

(**NOTE:** In this analysis, district-wise data from the 2011 Census of India have been used, as it represents the most recent comprehensive census dataset available. However, the Mayiladuthurai district was formed in 2020, after the 2011 census. Consequently, census data for Mayiladuthurai are not available as a separate administrative unit in the 2011 census, and therefore it has not been included in the analysis.)

7.2. Disturbed areas based on anthropogenic pollution

7.2.1. Industrial activities

Bengaluru Urban and Bengaluru Rural districts, along with Coimbatore, experience significant anthropogenic pollution due to increased industrial activities, vehicular emissions, and inadequate waste management systems. The concentration of these factors contributes to elevated levels of air and water pollutants, impacting both environmental and human health.

Regions such as Salem, Tiruchchirappalli, and Karur are notable for their steel manufacturing, textile production, and chemical industries. These industrial activities discharge pollutants into the air and water, resulting in high levels of particulate matter, heavy metals, and toxic chemicals. This industrial pollution poses serious health risks to the local population and leads to the degradation of natural resources.

7.2.2. Mining and resource extraction

Districts like Chikkamagaluru, Hassan, Kolar, and Nilgiris are known for mining activities, including iron ore and bauxite extraction. Mining operations contribute to deforestation, soil erosion, and contamination of water bodies with heavy metals. These activities disrupt local ecosystems and lead to long-term environmental damage.

7.2.3. Coastal and marine pollution

Coastal districts such as Nagapattinam, Karaikal, and Cuddalore are vulnerable to marine pollution from both land-based sources and maritime activities. Industrial discharge, agricultural runoff, and untreated sewage flow into the coastal waters, affecting marine life and local fisheries. Coastal development and high fishing activity further exacerbate the pollution levels, leading to habitat destruction and biodiversity loss.

7.2.4. Air and water pollution in rural areas

Districts like Chamarajanagar, Perambalur, and the Nilgiris, although less urbanized, are still affected by anthropogenic pollution. The burning of biomass for cooking and heating, along with small-scale industries, contributes to air pollution. Additionally, inadequate sanitation and waste disposal practices lead to contamination of water sources, posing health risks to rural communities.

7.2.5. Agricultural pollution

Districts like Thanjavur, Namakkal, Thiruvarur, and Pudukkottai are major agricultural hubs. The extensive use of pesticides and fertilizers in these areas contributes to soil degradation and water pollution. Runoff from agricultural fields carries these chemicals into rivers and groundwater, contaminating drinking water sources and harming aquatic ecosystems.

7.3. Disturbed areas based on LULC

The categorization of LULC classes into different disturbance levels is detailed in Table 5. Based on this classification, a spatial distribution map depicting areas classified as highly disturbed, moderately disturbed, and less disturbed has been generated and is presented in Fig. 18. This map provides a visual representation of the varying levels of disturbance across the CRB, helping to identify and assess the extent of land use impact.

Table 5. Classification of LULC categories in highly, moderately, and less disturbed areas within CRB

S. No.	Disturbance levels	LULC class
1	Highly disturbed	Built up: Areas with significant human development such as cities, towns, and commercial areas. Crops: Agricultural areas extensively managed and altered by human activity. These may include former forest areas and floodplains that have been transformed into agricultural lands.
2	Moderately disturbed	Rangeland: Areas primarily used for grazing livestock, which may experience some disturbance but generally retain a natural state. Water: Natural bodies of water like lakes, rivers, and oceans, assuming minimal human intervention. These areas may experience direct human impact due to commercial activities like fishing, shipping, industrialization, and tourism, which can affect water quality. Bare ground: This class encompasses areas with little to no vegetation, which may result from human activities such as mining, quarrying, construction, or deforestation.
3	Less disturbed	Trees: Forested areas with minimal human disturbance. Flooded vegetation: Areas that may experience periodic disturbances due to water level changes but can still support vegetation.
4	Excluded category	Clouds: This class generally represents areas obscured from observation in satellite imagery and may not fit neatly into disturbance categories. It’s typically excluded from disturbance analysis.

The vulnerability of districts across Karnataka and Tamil Nadu is markedly influenced by specific land use practices. Rapid urbanization and industrialization in Bengaluru Urban, Bengaluru Rural, and Coimbatore have led to a significant environmental strain. Agricultural districts such as Mandya, Hassan, Mysuru, Erode, Thanjavur, Namakkal, Thiruvarur, and Perambalur encounter significant soil degradation and water scarcity issues due to intensive farming practices and excessive chemical use. In contrast, districts like Chamarajanagar, Chikkamagaluru, Nilgiris, and Pudukkottai face challenges related to deforestation and biodiversity loss because of extensive plantation activities and mining operations. Furthermore, mixed land use districts such as Tiruchirappalli and Karur experience environmental pressures from both industrial and agricultural activities, leading to pollution and resource strain. Addressing these vulnerabilities requires the implementation of effective sustainable land management practices and strategic urban planning to mitigate environmental degradation and ensure resource conservation.

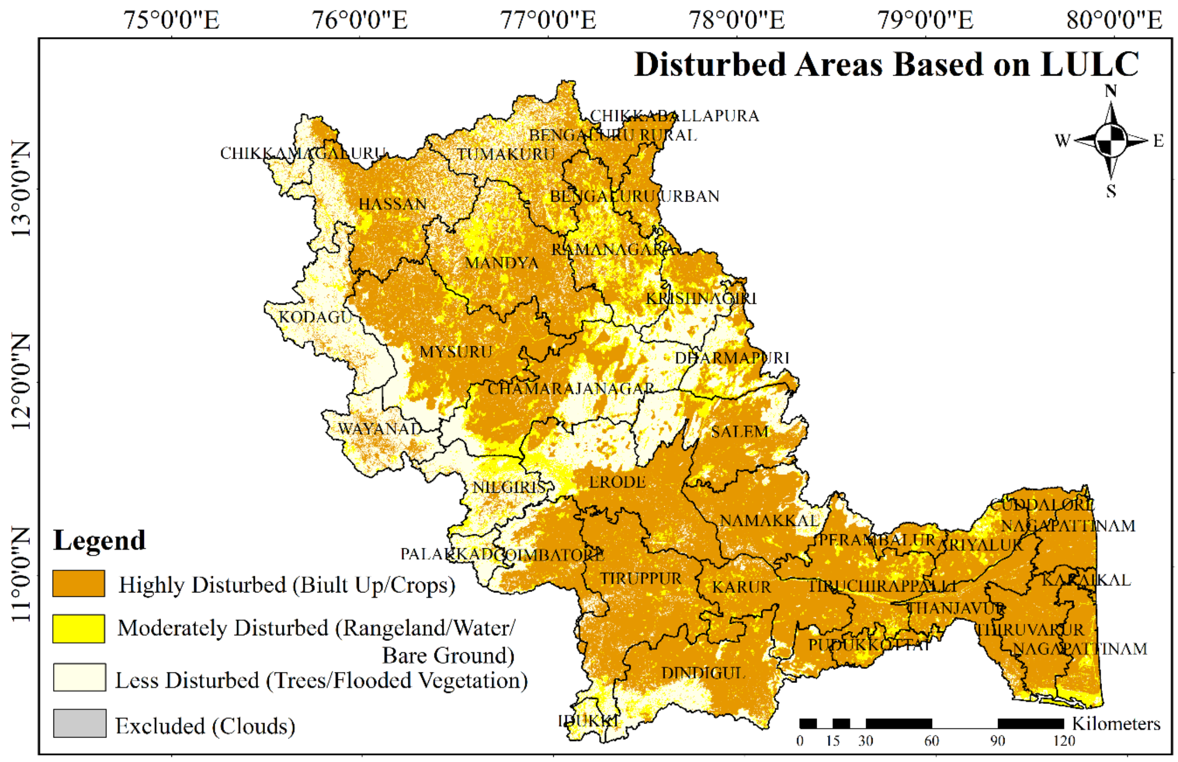


Fig. 18. Classification of disturbed areas based on LULC across various districts within the CRB

7.4. Disturbed areas based on reservoir's siltation

Within the CRB, siltation levels vary significantly across districts (Fig 19):

- **High siltation**
  Wayanad, particularly around the Karapuzha Reservoir, is highly susceptible to siltation, exhibiting the highest levels among the districts due to its challenging topography and land-use practices.
- **Moderate siltation**
  Kodagu: Siltation is notable around the Harangi Reservoir.

Mysuru: Moderate siltation is observed at several reservoirs, including Kabini, Nugu, and Upper Bhavani.

Nilgiris: Siltation is moderate at multiple reservoirs, including Maravakandy, Glennmorgan, Pykara, Mukurthy, Porthimund, Emerald, Avalanchi, Kundah Palam, Pillur, and Pegumbahalla. The region's siltation challenges are exacerbated by extensive plantation activities and rugged topography.

- **Low siltation**

  The remaining districts exhibit relatively lower siltation levels.

Effective soil conservation strategies and sustainable land management practices are crucial for addressing these siltation issues and protecting the health of the water bodies in these regions.

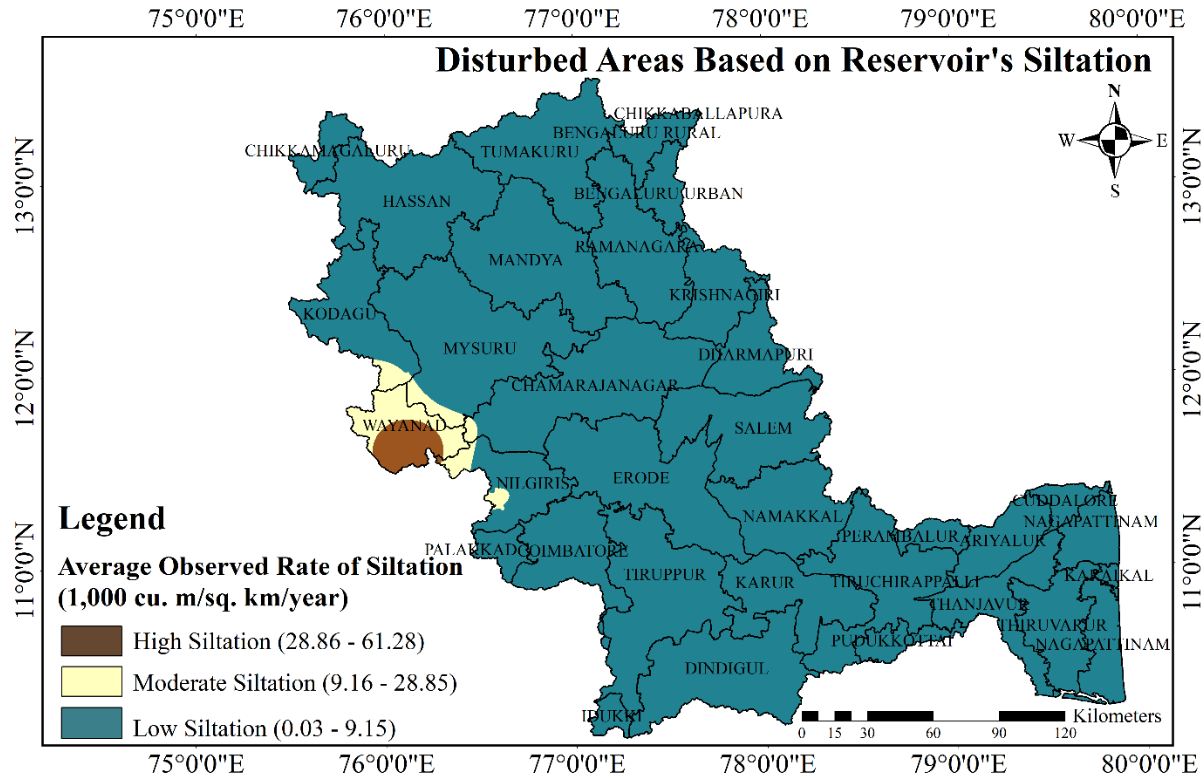


Fig. 19. Spatial distribution of disturbed areas based on average observed siltation rate of reservoirs (1,000 cu. m/sq. km/year) within the CRB

(**Source:** CWC, India WRIS)

7.5. Disturbed areas based on soil erosion

In districts such as Ramanagara, Erode, Mysuru, Chamarajanagar, Mandya, and Nilgiris, soil erosion is a critical issue (Fig. 20). The land use patterns in these areas contribute significantly to erosion problems. For instance:

- Ramanagara is characterized by a diverse mix of built-up areas, crops, rangeland, water bodies, and bare ground. This varied land use can lead to different degrees of soil disturbance and erosion depending on the specific combination of land features.

- Erode features a landscape dominated by crops, rangeland, and bare ground. The intensive agricultural practices and exposure of bare soil significantly contribute to erosion.
- Mysuru is largely used for agriculture, with extensive crop cultivation making the area particularly susceptible to soil erosion due to frequent soil disturbance from farming activities.
- Chamarajanagar is mainly covered by crops and rangeland, both of which contribute to soil instability.
- Mandya is predominantly agricultural, with extensive crop fields that contribute to significant soil erosion, particularly in areas where soil is left exposed.
- Nilgiris predominantly consists of trees with rugged topography this exacerbates erosion.

Similarly, significant erosion problems are observed in Palakkad, Dindigul, Hassan, Namakkal, and Coimbatore (Fig. 20). These issues are primarily due to a combination of intensive agricultural practices, deforestation, and challenging topography.

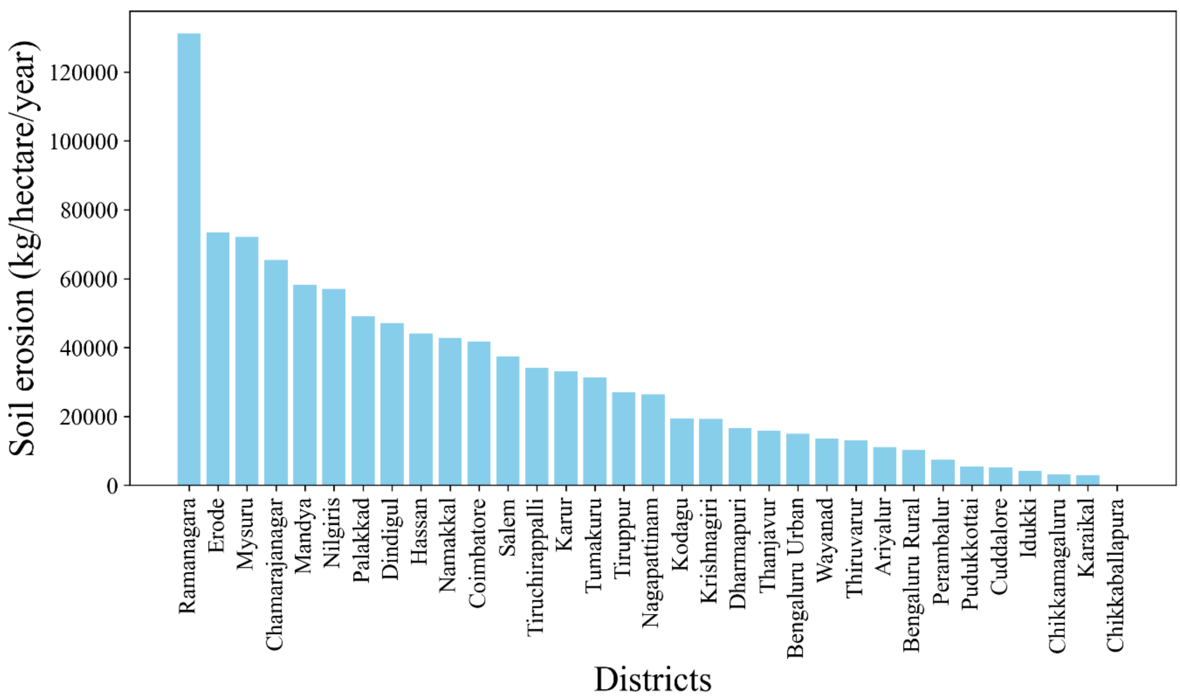


Fig. 20. Soil erosion values (kg/hectare/year) of each district lying within the CRB (**Source:** HydroSHEDS)

CRB's districts are classified into three categories based on the severity of soil erosion: highly eroded, moderately eroded, and less eroded (Fig. 21). According to the map, Ramanagara, Erode, Mysuru, Chamarajanagar, Mandya and Nilgiris fall into the highly eroded category due to the severe impact of their land use patterns on soil stability. Palakkad, Dindigul, Hassan, Namakkal, and Coimbatore are classified as moderately eroded, reflecting significant erosion but less severe than the highly eroded areas. The remaining districts are classified as less eroded, indicating lower levels of soil disturbance.

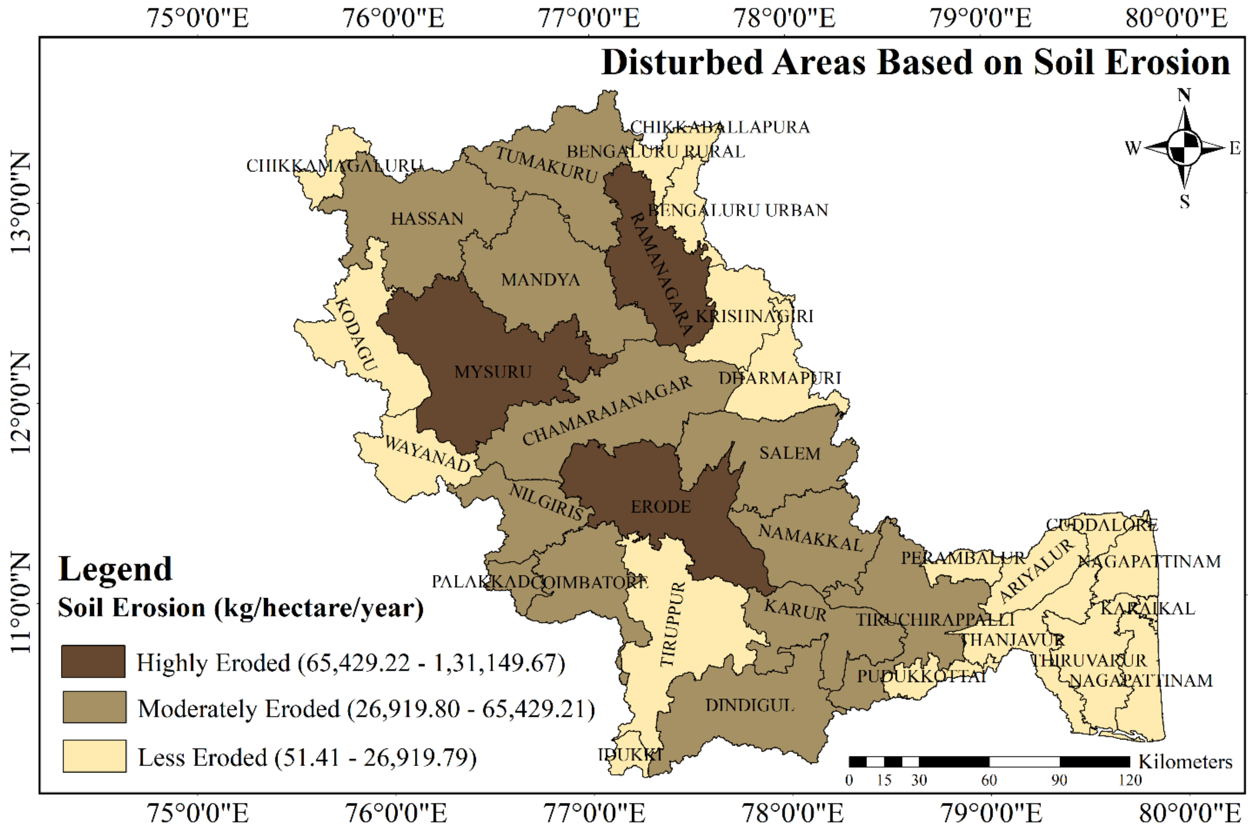


Fig. 21. Spatial distribution of disturbed districts of CRB based on soil erosion levels (kg/hectare/year) (**Source:** HydroSHEDS)

8. Classification of areas as less disturbed, moderately disturbed, and highly disturbed

A weighted overlay analysis was conducted to evaluate different disturbance levels in the CRB using layers for population density, LULC, soil erosion, and reservoir siltation, with respective weightings of 50%, 40%, 5%, and 5% (Fig. 22). The combined impact of these four layers enabled the following classifications:

- **Highly disturbed areas**
  Districts including Nagapattinam, Bengaluru Urban, and Karaikal were identified as highly disturbed based on the weighted overlay results.
- **Moderately disturbed areas**
  The analysis classified Ramanagara, Mandya, Mysuru, Wayanad, Coimbatore, Tiruppur, Karur, Tiruchirappalli, Namakkal, Salem, and Erode, as moderately disturbed.
- **Mixture of moderately and less disturbed areas**
  Bengaluru Rural, Chikkaballapura, Tumakuru, Hassan, Chikkamagaluru, Kodagu, Nilgiris, Palakkad, Idukki, Dindigul, Pudukkottai, Thanjavur, Thiruvarur, Cuddalore, Ariyalur, Perambalur, Dharmapuri, Krishnagiri, and Chamarajanagar exhibit a mixture of moderately and less disturbed conditions. Within these districts, some areas are moderately disturbed, while others are less disturbed, indicating variability in disturbance levels across different regions.

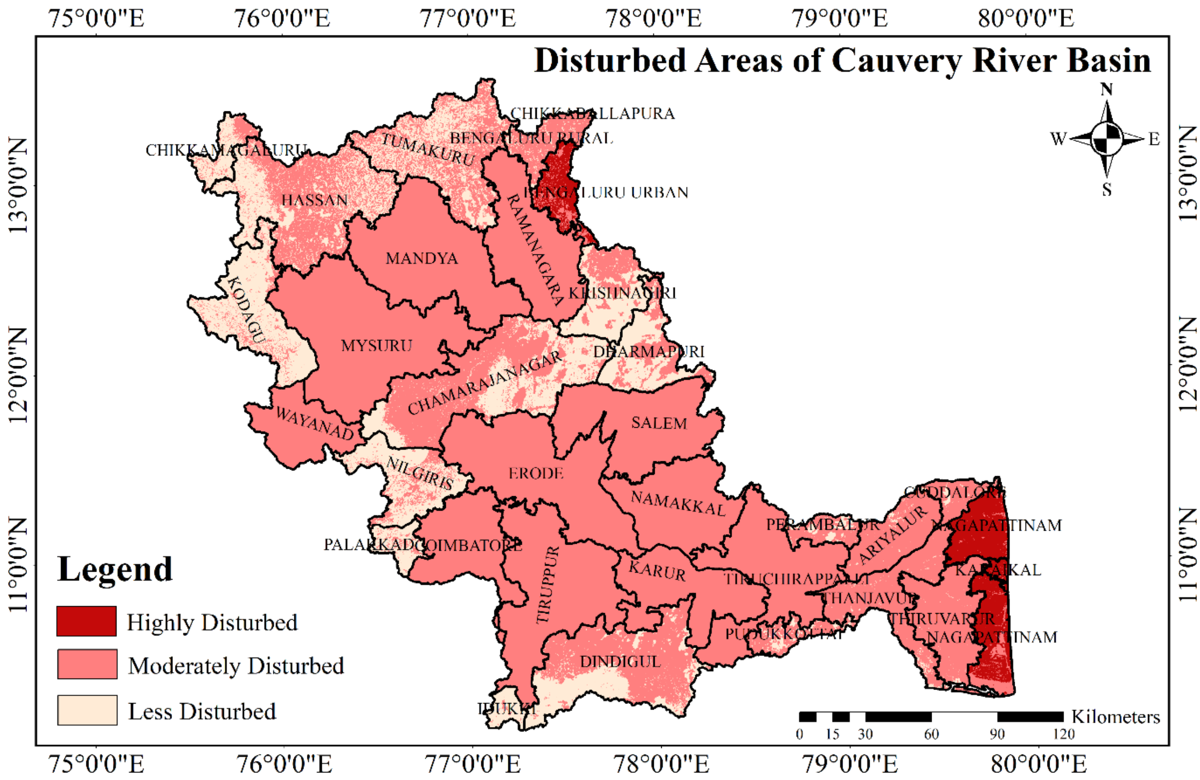


Fig. 22. Spatial distribution of highly disturbed, moderately disturbed, and less disturbed areas within the CRB

8.1. Less disturbed areas

a) Forest lands

Approximately 19.53% of the basin area is covered with forest. These regions generally include wildlife sanctuaries and national parks such as Nagarhole National Park, Talakaveri, Brahmagiri, and Pushpagiri Wildlife Sanctuaries, which are less influenced by human activities and provide habitats for various wildlife including otters, crocodiles, and approximately 1000 elephants (Chidambaram et al., 2018).

b) Headwater zones

These areas, especially around the origin of the river in the Brahmagiri hills of the Western Ghats, feature endangered fishes and high habitat heterogeneity (Chidambaram et al., 2018).

8.2. Moderately disturbed areas

a) Agricultural lands

More than 50% of the basin area is arable land, and agriculture is the predominant occupation in these rural regions. These areas experience moderate human intervention primarily due to agricultural activities (Chidambaram et al., 2018; Gowri et al., 2021).

b) River tributaries' catchment areas

Tributaries such as Hemavathi, Lakshmana Tirtha, Suvarnavathi, and Kabini show moderate tectonism and characterized by dendritic drainage patterns, indicating moderate disturbance levels (Chidambaram et al., 2018).

8.3. Highly disturbed areas

a) Urban and industrial zones

The urban population explosion and industrial activities, particularly in areas around Bangalore and Mysore, contribute significantly to high levels of disturbance. These regions face issues such as pollution from industrial effluents, municipal sewage, and the intrusion of saline water (Gowri et al., 2021).

b) Downstream areas

These areas face heavy pollution from various sources including agricultural runoff, waste from industries, and household sewage, particularly along the lower reaches of the river and its confluence with the sea (Arulbalaji and Padmalal, 2020; Chidambaram et al., 2018).

9. Factors responsible for these disturbances in segments of the basin and potential actions needed for restoration and conservation

Human disturbances in CRB stem from various interrelated factors, causing significant environmental and ecological impacts. Extensive agricultural activities involve substantial water withdrawal for irrigation, reducing river flow and affecting aquatic life. Additionally, runoff containing pesticides and fertilizers pollutes the water, while improper agricultural practices lead to soil erosion and increased sedimentation. Industrialization contributes to these disturbances through the discharge of untreated or partially treated effluents, introducing toxic substances and heavy metals into the river, along with thermal pollution from industries using water for cooling purposes. Urbanization exacerbates the situation, with untreated sewage, solid waste disposal, and construction activities along the riverbanks leading to habitat destruction and increased pollution.

Deforestation and land use changes further disrupt the river's natural flow. Clearing riparian vegetation for agriculture, urban development, or logging increases erosion and habitat loss, while converting forests and wetlands into agricultural or urban land introduces more pollutants and disrupts the ecosystem. Mining activities, particularly sand mining, alter river flow, increase erosion, and destroy habitats, while mineral extraction contaminates the river with heavy metals. Dam construction and water management practices, including the building of dams and barrages, alter the natural flow of the river, impacting aquatic habitats and sediment transport, and water diversion for irrigation, drinking, and industrial use leads to ecological imbalances.

Climate change compounds these issues by altering precipitation patterns, leading to droughts or floods, and increasing temperatures, which affect water temperature and aquatic life. Unsustainable fishing practices, such as overfishing and destructive methods like dynamite fishing, further disrupt the ecological balance and damage habitats. Tourism also contributes to disturbances through waste generation and littering, along with recreational activities that disturb wildlife and degrade natural habitats. Lastly, the introduction of invasive species disrupts local ecosystems, outcompeting native species and further straining the river's ecological balance. Mitigating these disturbances requires integrated water resource management, stringent pollution control measures, sustainable agricultural practices, afforestation, and active community participation in conservation initiatives.

Conservation and rejuvenation efforts in CRB are crucial to protect the river's ecosystems, improve water quality, and ensure sustainable water management. Several initiatives and strategies like afforestation, reforestation, watershed management, pollution control, community participation, regulatory measures, integrated water management, river rejuvenation programs have been implemented to address these goals. These conservation and rejuvenation efforts require coordinated action among governments, stakeholders, and communities to ensure the long-term health and sustainability of CRB.

9.1. Integrated river basin management

Integrated River Basin Management (IRBM) for CRB is a holistic approach that aims to manage water resources in a coordinated manner, considering the needs of all stakeholders, including environmental, social, and economic aspects. Implementing IRBM in CRB involves several key components (Fig. 23). It requires collaborative efforts from all stakeholders, supported by strong institutional frameworks, effective policies, and continuous monitoring and evaluation to ensure sustainable and equitable management of the river's resources.

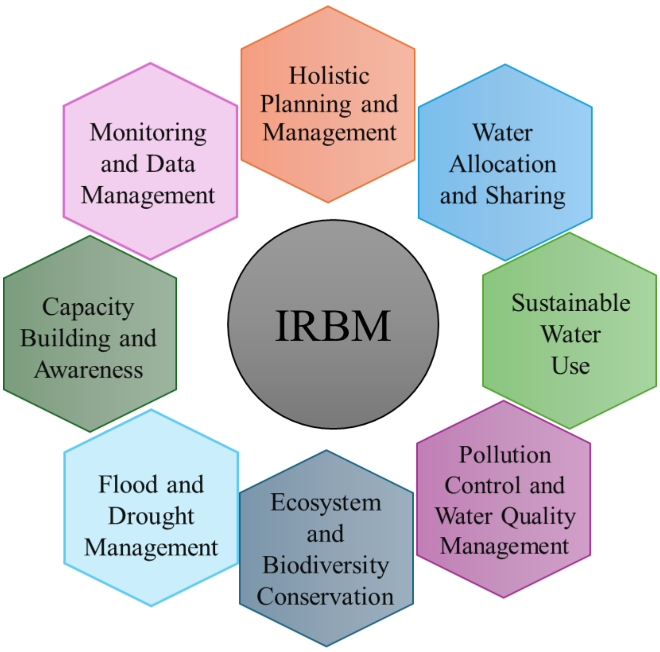


Fig. 23. Key components of integrated river basin management

9.2. Pollution control measures

CRB, stretching across Karnataka, Tamil Nadu, Kerala, and Puducherry, faces significant pollution challenges due to urbanization, industrialization, and agricultural runoff. Effective pollution control measures are crucial for restoring and maintaining the health of this vital water body (Fig. 24). Implementing these measures requires a coordinated effort from government authorities, industries, local communities, and environmental organizations. By taking a holistic and integrated approach, the health of CRB can be significantly improved, ensuring a sustainable and clean water source for future generations.

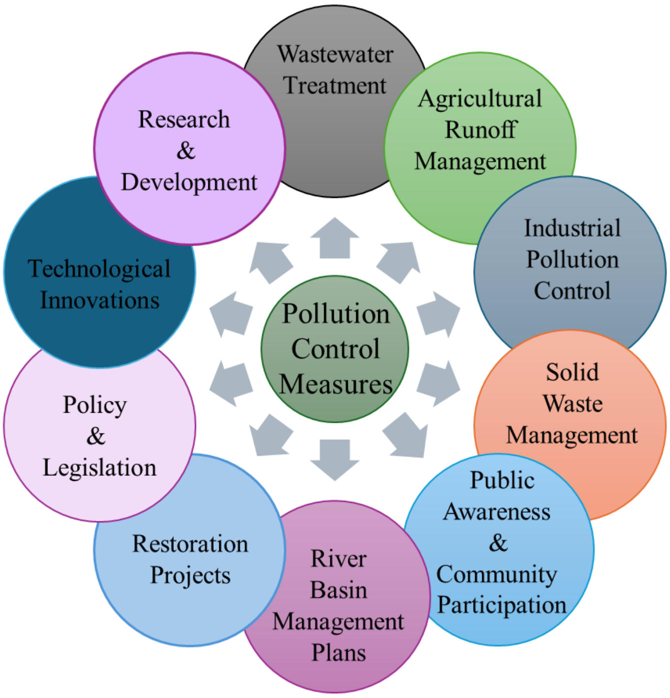


Fig. 24. Pollution control measures

9.3. Afforestation and riparian zone restoration

Afforestation and riparian zone restoration are crucial for enhancing the ecological health of CRB. These measures help stabilize the riverbanks, improve water quality, enhance biodiversity, and mitigate the impacts of floods and droughts. In afforestation, the first step involves strategic planning, which includes conducting surveys to identify degraded and deforested areas within the river basin that are suitable for afforestation. Selecting native tree species that are well-adapted to the local climate and soil conditions is essential. These species should also offer ecological and economic benefits for local communities. Engaging local communities is vital, as involving farmers and tribal groups in afforestation activities ensures broader participation and commitment. Providing training and incentives for tree planting and maintenance, along with conducting awareness campaigns about the benefits of afforestation, can significantly enhance public involvement. Promoting sustainable practices like agroforestry, which integrates tree planting with agricultural activities, offers additional income for farmers while improving soil health and water retention.

Implementing sustainable forest management practices ensures the long-term health and productivity of the newly planted forests.

For riparian zone restoration, establishing riparian buffer zones along the riverbanks by planting native vegetation such as trees, shrubs, and grasses is crucial. These buffers can filter pollutants, stabilize banks, and provide habitat for wildlife. Determining the appropriate width of these buffer zones based on factors such as slope, soil type, and land use is important. To control erosion, bioengineering techniques such as live staking, brush layering, and coir rolls can be used to prevent soil erosion and stabilize riverbanks. Planting deep-rooted vegetation anchors the soil and reduces the risk of bank erosion. Enhancing habitats by establishing biodiversity corridors along the river connects fragmented habitats, enhancing wildlife movement and genetic exchange. Restoring and creating wetlands within the riparian zone improves water filtration, provides habitat, and supports biodiversity. Regular monitoring of riparian zones to assess the health of vegetation, soil stability, and water quality is necessary, along with implementing measures to control invasive species that can outcompete native vegetation and disrupt the ecosystem.

The benefits of afforestation and riparian zone restoration include significant improvements in water quality, as riparian vegetation filters pollutants such as sediments, nutrients, and chemicals before they enter the river. These measures also mitigate floods by increasing the soil's infiltration capacity, reducing surface runoff. They create habitats for various plant and animal species, enhancing biodiversity and ecosystem resilience. Additionally, trees sequester carbon dioxide, contributing to climate change mitigation efforts. Sustainable afforestation and riparian restoration practices can also provide economic benefits to local communities through the provision of timber, non-timber forest products, and ecosystem services. Implementing afforestation and riparian zone restoration in CRB requires a coordinated effort from government agencies, NGOs, local communities, and other stakeholders. By taking a holistic and integrated approach, these measures can significantly improve the ecological health of the river basin, ensuring a sustainable and vibrant environment for future generations.

9.4. Water conservation techniques

Water conservation is essential for sustainable management of water resources, particularly in regions like CRB, which face significant water stress due to increasing demand and variable supply. Implementing effective water conservation techniques can ensure the availability of water for future generations, support agriculture, and maintain ecological balance. Implementing these water conservation techniques requires a coordinated effort from government agencies, local communities, industries, and individuals. By adopting a combination of these methods, it is possible to significantly reduce water consumption, enhance water availability, and ensure sustainable water management in CRB. Some key techniques for water conservation are described as:

9.4.1. Rainwater harvesting

Rainwater harvesting involves collecting and storing rainwater for reuse before it reaches the ground. This can be done through rooftop rainwater harvesting systems or by constructing check dams and percolation tanks to capture surface runoff. Rooftop systems direct rainwater into storage tanks, which can then be used for domestic purposes, irrigation, or groundwater recharge. Check dams and percolation tanks help to increase groundwater levels by allowing water to percolate into the soil, replenishing aquifers.

9.4.2. Drip irrigation

Drip irrigation is a highly efficient method of irrigation that delivers water directly to the plant roots through a network of tubes, valves, and emitters. This technique minimizes water loss due to evaporation and runoff, ensuring that plants receive the right amount of water. Drip irrigation systems can be automated to optimize water use based on soil moisture levels and plant needs, making it a sustainable option for agricultural water conservation.

9.4.3. Greywater recycling

Greywater recycling involves treating and reusing wastewater from household activities such as bathing, laundry, and dishwashing. This treated greywater can be used for non-potable purposes such as landscape irrigation, flushing toilets, and industrial processes. By reusing greywater, households and industries can significantly reduce their demand for fresh water, conserving valuable resources.

9.4.4. Mulching

Mulching is the practice of covering the soil surface with organic or inorganic materials such as straw, leaves, compost, or plastic sheeting. Mulching helps to retain soil moisture by reducing evaporation, suppressing weed growth, and moderating soil temperature. This technique is particularly beneficial in agricultural settings, where it can improve water use efficiency and enhance crop yields.

9.4.5. Efficient water uses appliances

Using water-efficient appliances and fixtures can significantly reduce water consumption in households and industries. Installing low-flow showerheads, faucets, and toilets, as well as water-efficient washing machines and dishwashers, can help to conserve water. Additionally, regular maintenance and prompt repair of leaks in plumbing systems can prevent water wastage.

9.4.6. Xeriscaping

Xeriscaping is a landscaping approach that uses drought-resistant plants and efficient irrigation techniques to reduce water use. By selecting native or adapted plants that require minimal watering and grouping plants with similar water needs together, xeriscaping creates attractive landscapes that conserve water. This technique is particularly useful in arid and semi-arid regions.

9.4.7. Water audits and leak detection

Conducting regular water audits in households, industries, and agricultural operations can identify areas where water use can be optimized, and wastage reduced. Implementing leak detection and repair programs can prevent significant water loss from leaking pipes, fixtures, and irrigation systems. Water audits also help to raise awareness about water conservation and encourage the adoption of best practices.

9.4.8. Community-based water management

Engaging local communities in water conservation efforts is crucial for long-term sustainability. Community-based water management involves organizing water user groups, conducting awareness campaigns, and promoting participatory decision-making. By involving communities in the planning, implementation, and monitoring of water conservation projects, a sense of ownership and responsibility is fostered, leading to more effective and sustainable outcomes.

9.4.9. Smart irrigation systems

Smart irrigation systems use advanced technologies such as soil moisture sensors, weather data, and automated controls to optimize water use in agriculture and landscaping. These systems can adjust irrigation schedules and amounts based on real-time data, ensuring that water is applied only when and where it is needed. This reduces water wastage and enhances crop productivity.

9.4.10. Groundwater recharge

Artificial groundwater recharge techniques involve methods such as constructing recharge wells, injection wells, and recharge trenches to augment natural groundwater replenishment. These structures help to capture and channel surface water into aquifers, increasing groundwater levels and ensuring a reliable water supply during dry periods.

9.4.11. Other suggestions

Given the richness of agricultural practices in CRB, there is a pressing need for the development of a corridor that connects the procurement of agricultural products from fields, provides storage facilities, and links agro industries to produce value-added goods. Establishing agro-industrial corridors can facilitate efficient logistics and connectivity between farms, storage facilities, and processing units. Enhancing storage infrastructure is essential to reduce post-harvest losses and ensure the quality of agricultural products. Furthermore, encouraging agro industries to focus on producing value-added products can enhance the economic returns for farmers.

10. Summary

The rejuvenation and conservation of CRB are imperative for ensuring the long-term sustainability of this vital water resource. Addressing the following key areas through a coordinated and integrated approach, the ecological health of CRB can be significantly improved, ensuring a sustainable and vibrant environment for future generations.

a) Effective mitigation of CRB's issues requires a holistic and integrated approach that considers all aspects of water management, including pollution control, afforestation, and sustainable agricultural practices.

b) Implementing wastewater treatment plants (STPs and ETPs), regulating, and monitoring industrial discharges, and managing agricultural runoff are critical to reducing pollution in CRB.

c) Strategic afforestation and riparian zone restoration can stabilize riverbanks, improve water quality, enhance biodiversity, and mitigate the impacts of floods and droughts.

d) Techniques such as rainwater harvesting, drip irrigation, greywater recycling, and mulching can significantly reduce water consumption and ensure sustainable water use in the basin.

e) Engaging local communities in conservation efforts through awareness programs, participatory decision-making, and community-based water management fosters a sense of ownership and responsibility, leading to more effective and sustainable outcomes.

f) Adopting advanced technologies like smart irrigation systems, real-time water quality monitoring, and bioengineering techniques for erosion control can optimize water use and enhance the overall health of the river basin.

g) Strengthening environmental laws, enforcing regulations, and providing incentives for conservation practices are essential for protecting CRB from further degradation.

h) Ongoing research to identify pollution sources, develop innovative pollution control technologies, and understand the basin's hydrology is crucial for informed decision-making and effective management strategies.

i) Undertaking projects to restore riparian zones, wetlands, and degraded forest areas can enhance the ecological balance and resilience of the river basin.

j) Coordinating efforts among government agencies, industries, NGOs, local communities, and other stakeholders is vital for implementing comprehensive and sustainable solutions for CRB.

References

1. Arulbalaji, P. and Padmalal, D., 2020. Sub-watershed prioritization based on drainage morphometric analysis: a case study of Cauvery River Basin in South India. Journal of the Geological Society of India, 95, pp.25-35.
2. Brema, J., Trivedi, S., Sherin, M., Dhotrad, D.S., Raj, K.G. and Samal, D., 2021. Urban Growth Impact on Cauvery River: A Geospatial Perspective. Geo-intelligence for Sustainable Development, pp.127-147.
3. Chidambaram, S., Ramanathan, A.L., Thilagavathi, R. and Ganesh, N., 2018. Cauvery River. The Indian Rivers: Scientific and socio-economic aspects, pp.353-366.
4. Dutta, V., Sharma, U. and Kumar, R., 2020. Restoring environmental flows for managing river ecosystems: global scenario with special reference to India. Environmental Concerns and Sustainable Development: Volume 1: Air, Water and Energy Resources, pp.163-183.
5. Ekka, A., Keshav, S., Pande, S., van der Zaag, P. and Jiang, Y., 2022. Dam-induced hydrological alterations in the upper Cauvery river basin, India. Journal of Hydrology: Regional Studies, 44, p.101231.
6. Gowri, R. and Mujumdar, P.P., 2020, June. Evaluation of geomorphologic similarity between the sub-catchments of Cauvery river basin. In IOP Conference Series: Earth and Environmental Science (Vol. 491, No. 1, p. 012015). IOP Publishing.
7. Gowri, R., Dey, P. and Mujumdar, P.P., 2021. A hydro-climatological outlook on the long-term availability of water resources in Cauvery river basin. Water Security, 14, p.100102.
8. Ilamurugan, O., Jothibasu, A. and Anbazhagan, S., 2022. Geospatial technology and modified DRASTIC model to assess the groundwater pollution vulnerability along a stretch of Cauvery River, South India. Environmental Earth Sciences, 81(3), p.85.
9. Jayakumar, R., Dhanakumar, S., Kalaiselvi, K. and Palanivel, M., 2015. Water pollution in the vicinity of stanley reservoir by point and non-point sources, Cauvery Basin, India. Environmental Management of River Basin Ecosystems, pp.491-505.
10. Jena, P., Kasiviswanathan, K.S. and Azad, S., 2020. Spatiotemporal characteristics of extreme droughts and their association with sea surface temperature over the Cauvery River basin, India. Natural Hazards, 104, pp.2239-2259.
11. Keerthan, L., RamyaPriya, R. and Elango, L., 2023. Geogenic and anthropogenic contamination in river water and groundwater of the lower Cauvery Basin, India. Frontiers in Environmental Science, 11, p.1001052.
12. Kishore, B.S.P.C., Kumar, A. and Saikia, P., 2024. Understanding the invasion potential of Chromolaena odorata and Lantana camara in the Western Ghats, India: An ecological niche modelling approach under current and future climatic scenarios. Ecological Informatics, 79, p.102425.

13. Koushlesh, S.M.N.S.K., Sajina, A.M. and Roshith, C.M., 2021. Ichthyofaunal diversity of the major Indian rivers: A review. J Inland Fish Soc India, 53(1&2), pp.22-35.

14. Kumar, G.P. and Nagayya, S., 2022. Invasive alien plant species of Hassan District, Karnataka, India. Journal of Threatened Taxa, 14(9), pp.21870-21890.

15. Lalitha, M., Dharumarajan, S., Kalaiselvi, B., Shivanand, K., Koyal, A., Kaliraj, S. and Hegde, R., 2021. Hydrochemical characterization and groundwater quality in Cauvery deltaic fluvial plains of Southern India. Environmental Science and Pollution Research, 28, pp.44861-44876.

16. Mageshkumar, P., Vennila, G. and Senthil, K.A., 2022. A multivariate statistical approach to pollution source identification in cauvery river, south India. Journal of Water Chemistry and Technology, 44(1), pp.62-71.

17. Pinder, A.C., Raghavan, R. and Britton, J.R., 2015. Eff icacy of angler catch data as a population and conservation monitoring tool for the f lagship Mahseer f ishes (Tor spp.) of Southern India. Aquatic Conservation: Marine and Freshwater Ecosystems, 25(6), pp.829-838.

18. Prayag, A.G., Zhou, Y., Srinivasan, V., Stigter, T. and Verzijl, A., 2023. Assessing the impact of groundwater abstractions on aquifer depletion in the Cauvery Delta, India. Agricultural Water Management, 279, p.108191.

19. RamyaPriya, R. and Elango, L., 2018. Evaluation of geogenic and anthropogenic impacts on spatio-temporal variation in quality of surface water and groundwater along Cauvery River, India. Environmental earth sciences, 77, pp.1-17.

20. Solaraj, G., Dhanakumar, S., Rutharvel Murthy, K. and Mohanraj, R., 2010. Water quality in select regions of Cauvery Delta River basin, southern India, with emphasis on monsoonal variation. Environmental monitoring and assessment, 166, pp.435-444.

21. Sreelash, K., Mathew, M.M., Nisha, N., Arulbalaji, P., Bindu, A.G. and Sharma, R.K., 2020. Changes in the Hydrological Characteristics of Cauvery River draining the eastern side of southern Western Ghats, India. International Journal of River Basin Management, 18(2), pp.153-166.

22. Sreenivasan, N., Mahesh, N. and Raghavan, R., 2021. Freshwater fishes of Cauvery Wildlife Sanctuary, Western Ghats of Karnataka, India. Journal of Threatened Taxa, 13(1), pp.17470-17476.

23. India Census, 2011. https://www.censusindia.gov.in/ (Accessed 15 June 2024)

24. India WRIS, 2014. https://indiawris.gov.in (Accessed 15 June 2024)

25. The Hindu, 2015. Aquarium fish invading waterbodies, ecosystems. Available at: https://www.thehindu.com/news/cities/Thiruvananthapuram/aquarium-fish-invading-waterbodies-ecosystems/article7067235.ece. (Accessed 15 June 2024)

26. https://wgbis.ces.iisc.ac.in/biodiversity/sahyadri_enews/newsletter/Issue85/article.html#annexure (Accessed 15 June 2024)

27. https://www.worldatlas.com/articles/western-ghats-biodiversity-hotspot.html (Accessed 17 June 2024)

28. https://lbb.in/chennai/pichavaram-mangrove-forest-cuddalore-chennai/ (Accessed 17 June 2024)

29. https://ar.inspiredpencil.com/pictures-2023/nilgiri-biosphere-reserves (Accessed 17 June 2024)

30. https://www.newsbricks.com/tamil-nadu/cauvery-delta-as-protected-agricultural-zone/84349 (Accessed 18 June 2024)

31. https://mssbg.mssrf.org/10-iucn-wg-plants/ (Accessed 18 June 2024)

32. https://lbb.in/chennai/pichavaram-mangrove-forest-cuddalore-chennai/ (Accessed 19 June 2024)

33. https://www.newsbricks.com/tamil-nadu/cauvery-delta-as-protected-agricultural-zone/84349 (Accessed 19 June 2024)

34. https://lotusarise.com/cauvery-river-system/ (Accessed 21 June 2024)

35. https://livingatlas.arcgis.com/landcoverexplorer (Accessed 21 June 2024)

36. https://www.tn.gov.in/district_view (Accessed 21 June 2024)

37. https://cpcb.nic.in/nwmp-monitoring-network/ (Accessed 21 June 2024)

38. https://www.cwc.gov.in/ (Accessed 21 June 2024)

Back cover page