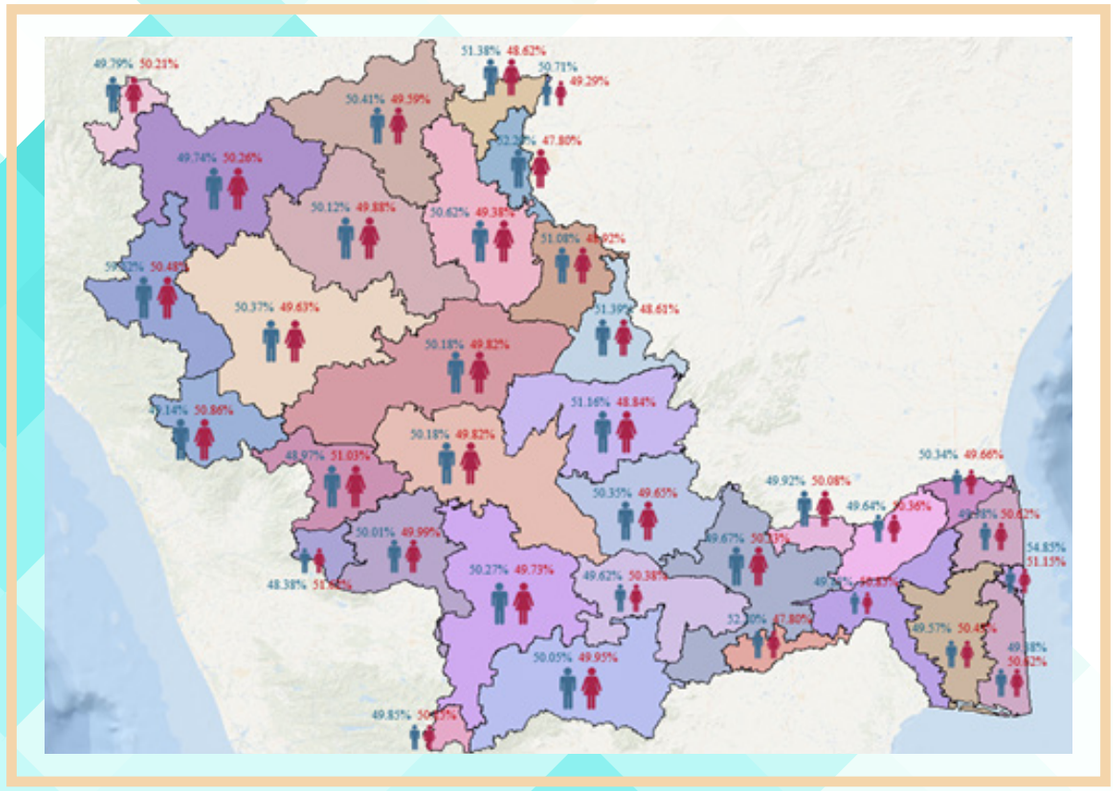
सत्यमेव जयते

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



DEMOGRAPHY OF CAUVERY RIVER BASIN

SEPTEMBER 2024

Centres for Cauvery River Basin Management Studies (cCauvery)

Centre for Ganga River Basin Management and Studies

DEMOGRAPHY OF CAUVERY RIVER BASIN

SEPTEMBER 2024

Centres for Cauvery River Basin Management Studies (cCauvery)

Centre for Ganga River Basin Management and Studies (cGanga)

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.

SUGGESTED CITATION

cCauvery and cGanga (2024), Demography of Cauvery River Basin, NRCD, DoWR, RD & GR, Ministry of Jal Shakti, Government of India

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Government of India

संदेश

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

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

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

सीआर पाटील

सत्यमेव जयते

जल शक्ति राज्य मंत्री
भारत सरकार, नई दिल्ली

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

संदेश

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

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

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

डा. राज भूषण चौधरी

PREFACE

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

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

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

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

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

cCauvery and cGanga

CONTENT

ABBREVIATIONS AND ACRONYMS

°	Degree
´	Minute
%	Percentage
₹	India Rupee
&	And
e.g.	For example
km	Kilometre
sq.	Square
CRB	Cauvery River Basin
GSDP	Gross State Domestic Product
HDI	Human Development Index
NLM	National Literacy Mission
NSDP	Net State Domestic Product
SSA	Sarva Shiksha Abhiyan
TWPR	Total Workforce Participation Ratio
UT	Union Territory

1. Basin Overview

The Cauvery River Basin (CRB) is a major river system in southern India, covering around 85,220.39 sq. km and extending across Karnataka, Tamil Nadu, Kerala, and Puducherry (Figure 1). It is geographically located between 75°27′ to 79°54′ east longitudes and 10°9′ to 13°30′ north latitudes, bordered by the Western Ghats to the west, the Eastern Ghats to the east and south, and ridges separating it from nearby basins in the north (Gowri et al., 2021; Ramkumar et al., 2019). The Cauvery River originates at Talakaveri in Karnataka's Western Ghats, flowing southeast through Karnataka and Tamil Nadu before emptying into the Bay of Bengal. The basin plays a crucial role in the region's ecology and socio-economic structure, supporting industrial, agricultural, and cultural activities. Rapid population growth in both rural and urban regions has increased pressure on natural resources, particularly forests, highlighting the need for sustainable land and forest management practices.

Industrially, the CRB is home to significant industries such as textiles, cement, and metal-based manufacturing, with major centres in Coimbatore, Mysuru, and Salem. The basin also plays a key role in agriculture, providing irrigation for crops such as rice, sugarcane, and coffee. Urban centres like Bengaluru, Mysuru, and Tiruchirappalli depend heavily on the Cauvery for their water needs. Culturally, the Cauvery River is revered, with numerous temples and pilgrimage sites lining its banks. Ecologically, it sustains a wide range of ecosystems, from the forests of the Western Ghats to the fertile agricultural plains in Tamil Nadu. Despite its importance, the basin faces significant environmental threats. Pollution from industrial waste, agricultural runoff, untreated sewage, and overuse of its water resources endangers both the river's health and its sustainability. Furthermore, water-sharing disputes between states, particularly Karnataka and Tamil Nadu, are frequent due to varying monsoon rainfall and growing demands on water resources (Chidambaram et al., 2018).

The CRB houses diverse flora and fauna, particularly in the biodiversity-rich Western Ghats. The river's tributaries, including the Hemavathi, Kabini, Bhavani, and Noyyal, contribute to maintaining ecological balance and support both terrestrial and aquatic life. However, these habitats are threatened by deforestation, excessive sand mining, and the construction of large dams like Mettur and Krishna Raja Sagara, which have altered natural flow regimes. Water quality in the CRB has deteriorated due to urbanization and industrialization (Chidambaram et al., 2018; Gowri et al., 2021; Panikkar et al., 2022). The presence of untreated sewage, industrial effluents, and agricultural chemicals has led to eutrophication, low oxygen levels, and the contamination of drinking water. This degradation affects human health and reduces biodiversity. The socio-economic and environmental challenges within the CRB are deeply connected. Interstate water disputes, over-extraction of groundwater, and the overuse of river water for agriculture have led to tensions and exacerbated environmental degradation. Groundwater depletion is particularly severe in areas where farmers depend heavily on it for irrigation.

To address these complex challenges, sustainable management of CRB is crucial. Key strategies include water conservation efforts, reforestation, eco-friendly agricultural practices, and enhanced governance for equitable water sharing. Advanced technologies like remote sensing and geographical information system can help monitor water usage and land management, while community-based approaches are essential for effective river restoration. The Cauvery River is not just a resource but a critical lifeline for millions of people. Its management is key to ensuring a sustainable future for both ecosystems and the communities that depend on it.

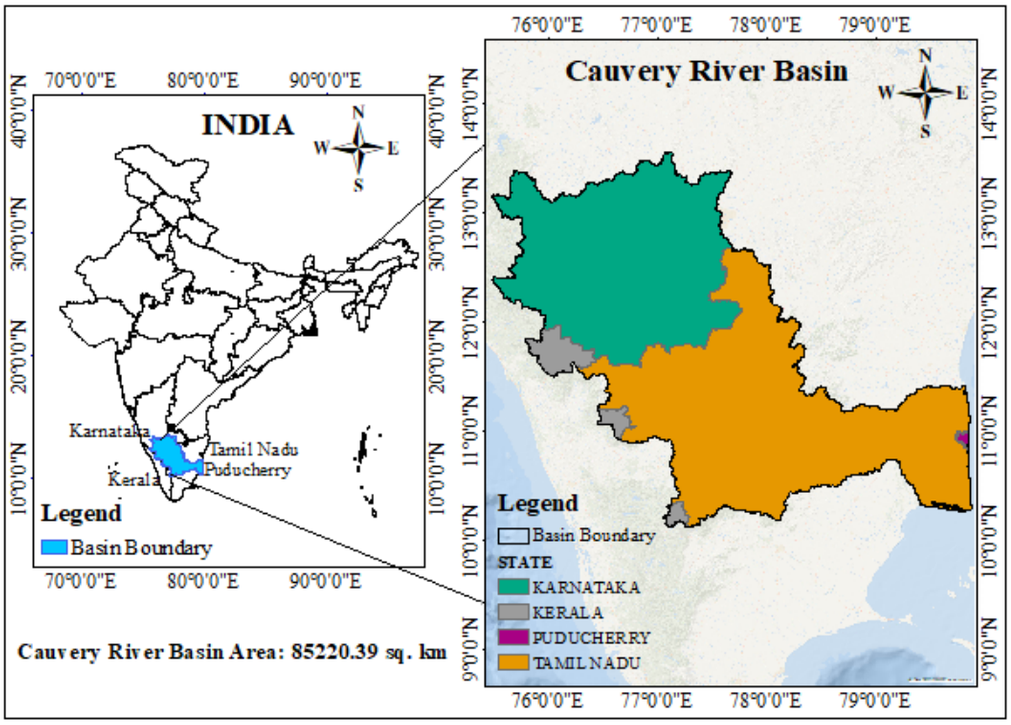

Figure 1. Spatial extent of the Cauvery River basin

2. Administrative Delineation at Various Levels within CRB

CRB, a significant water resource in southern India, spans multiple states and is characterized by its intricate network of administrative boundaries. Understanding these administrative delineations at various levels (e.g., state, district, tehsil, and village) is crucial for effective water resource management, inter-state collaboration, and regional development. Overview of the administrative delineation at various levels within CRB is given below.

2.1 State-Level Delineation

CRB spans two major Indian states (Figure 2), i.e., Karnataka (34987.99 sq. km) and Tamil Nadu (47162.62 sq. km), along with portions of Kerala (2913.40 sq. km) and the union territory of Puducherry (156.32 sq. km). Each state exercises governance over the parts of the basin within its boundaries, making state-level jurisdiction crucial for policies regarding water management, allocation, and dispute resolution.

a) **Karnataka**: The river originates in the Western Ghats in the Kodagu district of Karnataka, flowing eastward across the state.

b) **Tamil Nadu**: The river enters Tamil Nadu and flows through several districts before reaching the Bay of Bengal.

c) **Kerala**: Though Kerala is not a major stakeholder, parts of the basin, especially in the upper reaches, extend into the state.

d) **Puducherry**: The river basin extends to the Karaikal region of Puducherry, where the river finally drains into the sea.

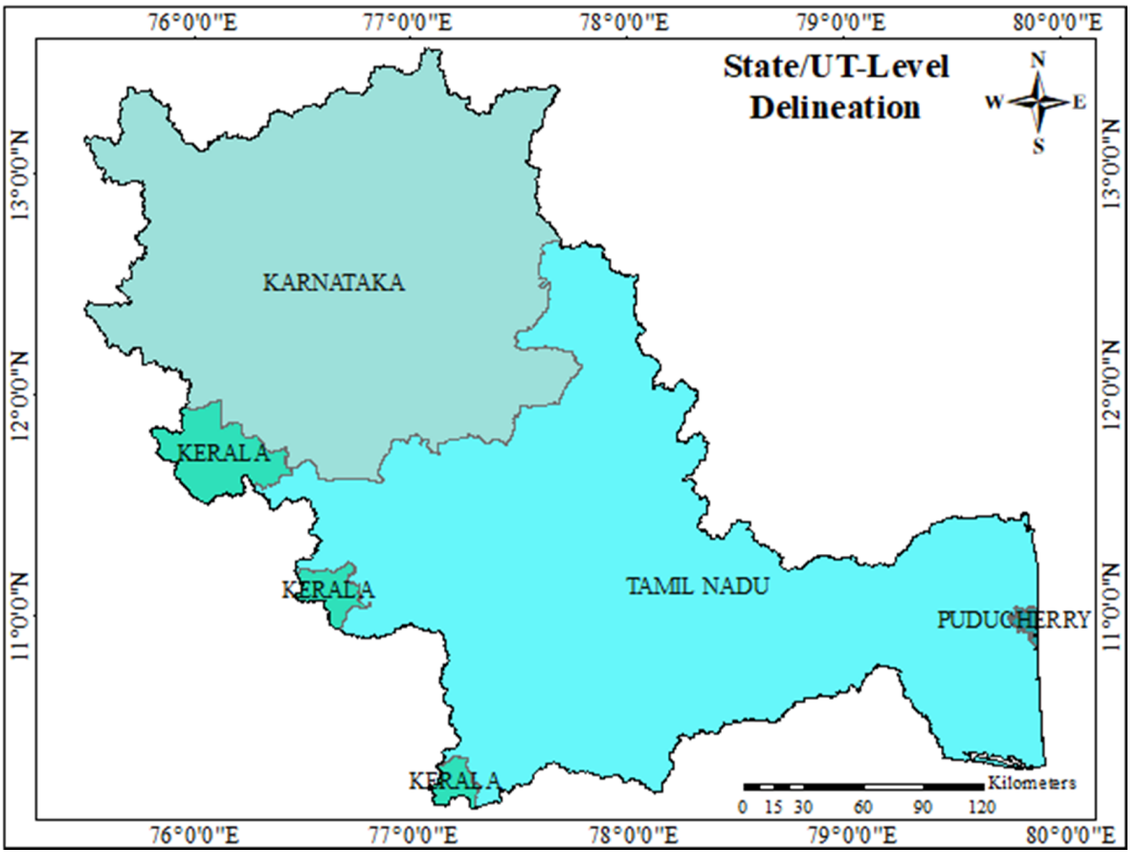

Figure 2. State-level delineation of the Cauvery River basin (Source: Survey of India)

2.2 District-Level Delineation

The districts within CRB are crucial administrative units responsible for implementing state policies and managing water resources at the ground level (Figure 3). In Karnataka, the river passes through districts such as Kodagu, Mysuru, Mandya, and Chamarajanagar. These districts are vital for irrigation projects and dam operations, such as the Krishna Raja Sagara (KRS) dam in Mandya. In Tamil Nadu, districts like Salem, Erode, Tiruchirappalli, Thanjavur, and Nagapattinam are key areas in the lower reaches of the Cauvery, forming the river's fertile delta. Districts such as Idukki, Wayanad and Palakkad in Kerala share small portions of the basin but are integral to forest and water conservation efforts. Moreover, the Karaikal district, in Puducherry, is where the river meets the Bay of Bengal, and the focus is on managing coastal and estuarine ecosystems.

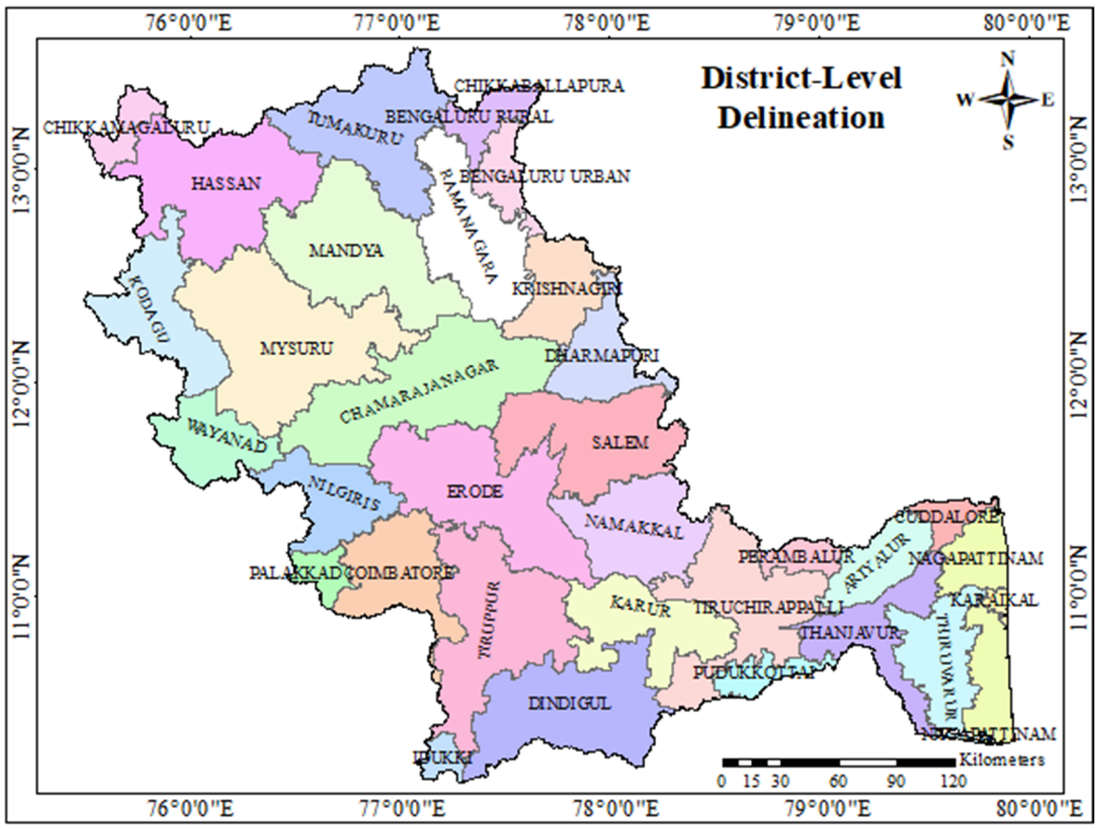

Figure 3. District-level delineation of the Cauvery River basin (Source: Survey of India)

2.3 Tehsil-Level Delineation

At the sub-district level, the administrative divisions include taluks in Karnataka and tehsils in Tamil Nadu (Figure 4). These are responsible for the day-to-day administration of local development programs, including agriculture and water resource management. In Karnataka, taluks such as Somwarpet, Virajpet (Kodagu), Srirangapatna (Mandya), and Tirumakudalu Narasipura (Mysuru) are important administrative centres overseeing agricultural activities, including the distribution of Cauvery water for irrigation. In Tamil Nadu, tehsils like Bhavani (Erode), Musiri (Tiruchirappalli), Kumbakonam (Thanjavur), and Mayiladuthurai (Nagapattinam) are central to managing local water supply and agricultural production, particularly for paddy cultivation. These sub-district divisions serve as the main points of interface between district-level authorities and the local population, playing a key role in land revenue administration, agriculture support, and local governance.

2.4 Village-Level Delineation

At the grassroots level, villages within CRB form the smallest administrative units (Figure 5). Village panchayats play a crucial role in managing local water resources, land use, and agricultural practices, which are essential for sustainable development in the region. In Karnataka, village panchayats in districts like Kodagu and Mandya actively engage in water conservation practices, including rainwater harvesting and small-scale irrigation projects. Moreover, in Tamil Nadu, villages in the Cauvery Delta are heavily dependent on irrigation canals fed by the river. They rely on local governance mechanisms like panchayats to address

issues related to water supply, drought management, and agricultural productivity. Villages also serve as the frontlines for community-led water management initiatives, such as tank irrigation systems, which have been historically significant in South Indian water governance.

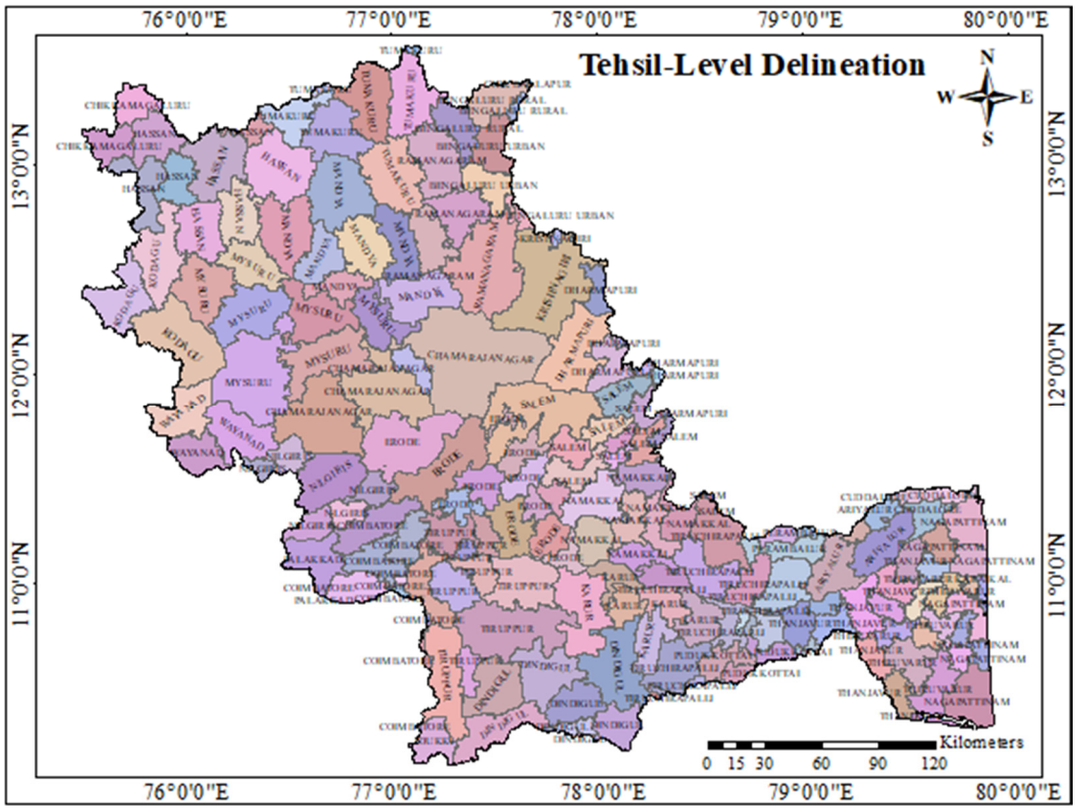

Figure 4. Tehsil-level delineation of the Cauvery River basin (Source: Survey of India)

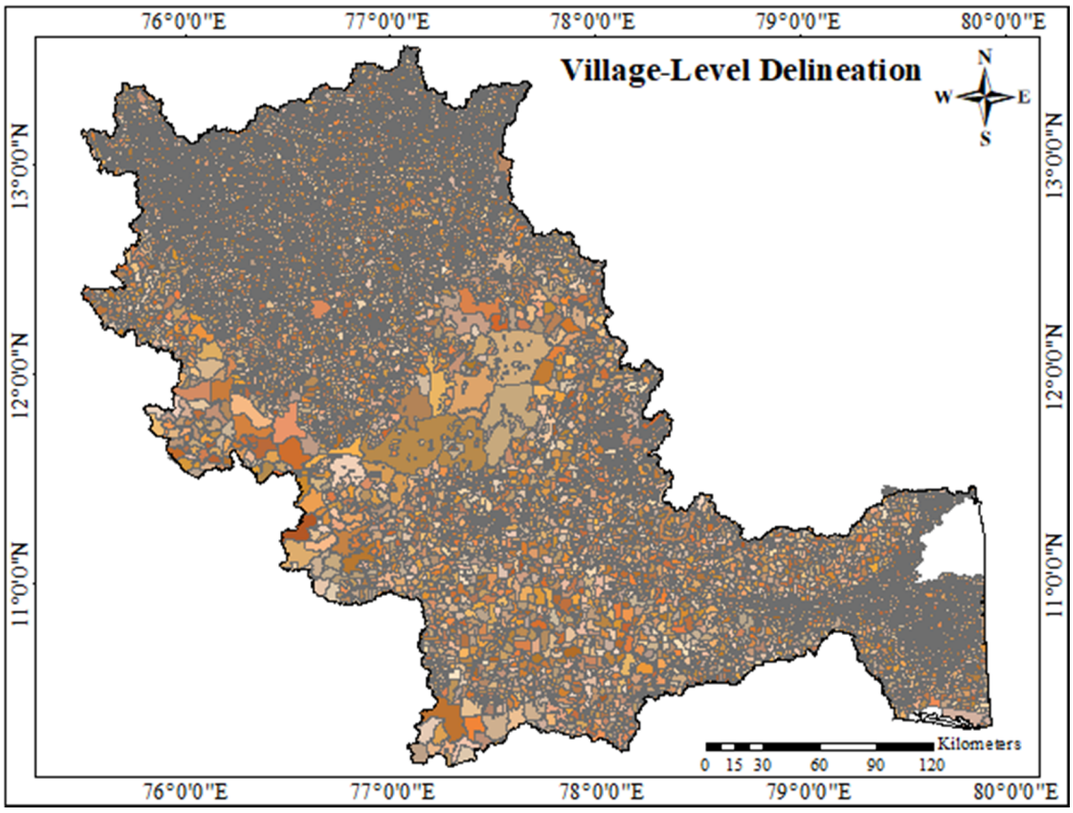

Figure 5. Village-level delineation of the Cauvery River basin (Source: Survey of India)

3. Distribution of Population in CRB

This analysis serves as a foundational understanding of the population distribution and population growth trends in CRB, which will help in devising long-term management strategies for the basin's sustainable development.

3.1 Total Population

Understanding the population distribution in CRB is critical for effective water resource management. Higher population, such as those found in Bengaluru Urban, exert greater pressure on water resources, necessitating efficient allocation and management strategies. Districts with smaller populations, while consuming less water, still contribute to the overall demand on the basin's water supply. A holistic approach is required to balance urban and rural water needs, particularly during periods of drought or water scarcity. Figure 6 includes the total population of each district in the Cauvery River Basin.

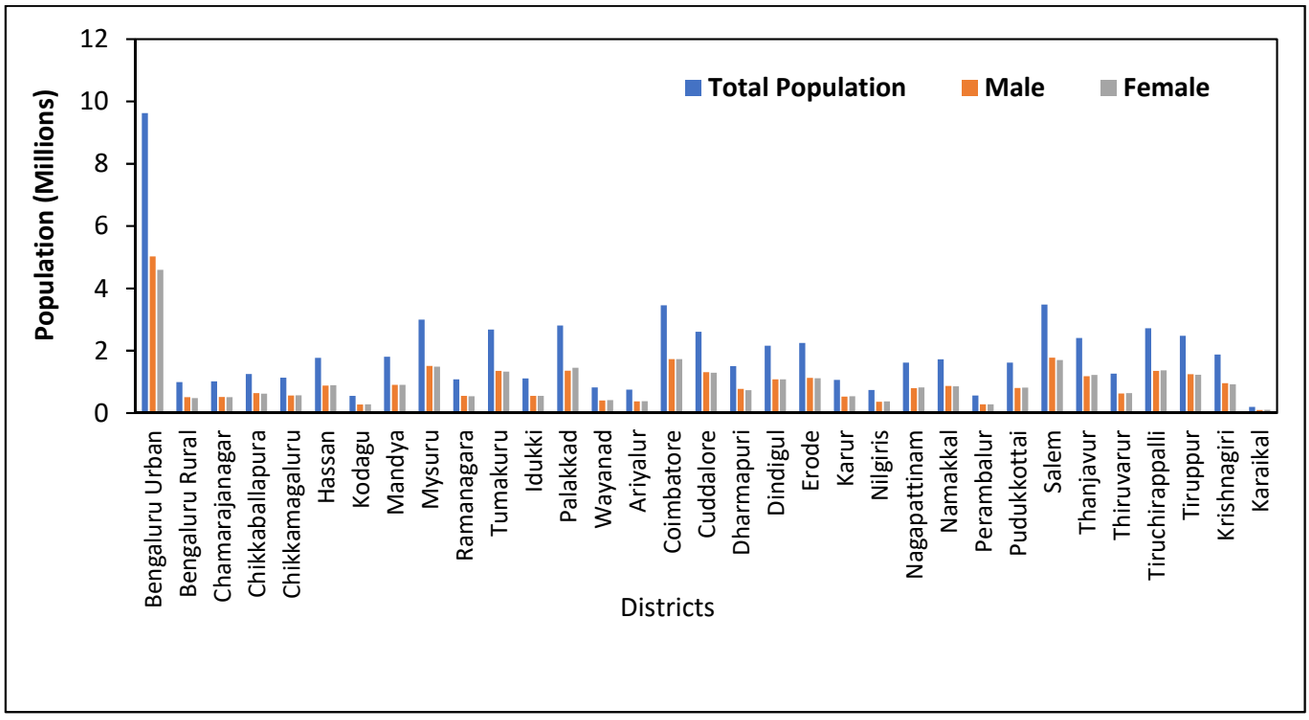

Figure 6. District-wise total population in the Cauvery River basin (Source: India Census, 2011)

3.2 Population Distribution

The population distribution across CRB shows distinct patterns in the four states, i.e. Karnataka, Tamil Nadu, Kerala and Puducherry (Figure 7). In Karnataka, the total population within the basin is approximately 24.9 million, with an almost equal split between urban (12.6 million) and rural (12.3 million) populations. This indicates a balanced demographic spread across both rural and urban areas. In contrast, Tamil Nadu, with a larger population of around 34.3 million in the basin, has a more significant rural demographic, accounting for nearly 20 million people, while its urban population stands at 14.3 million. Overall, CRB in Tamil Nadu exhibits a higher population density, especially in rural areas, compared to Karnataka.

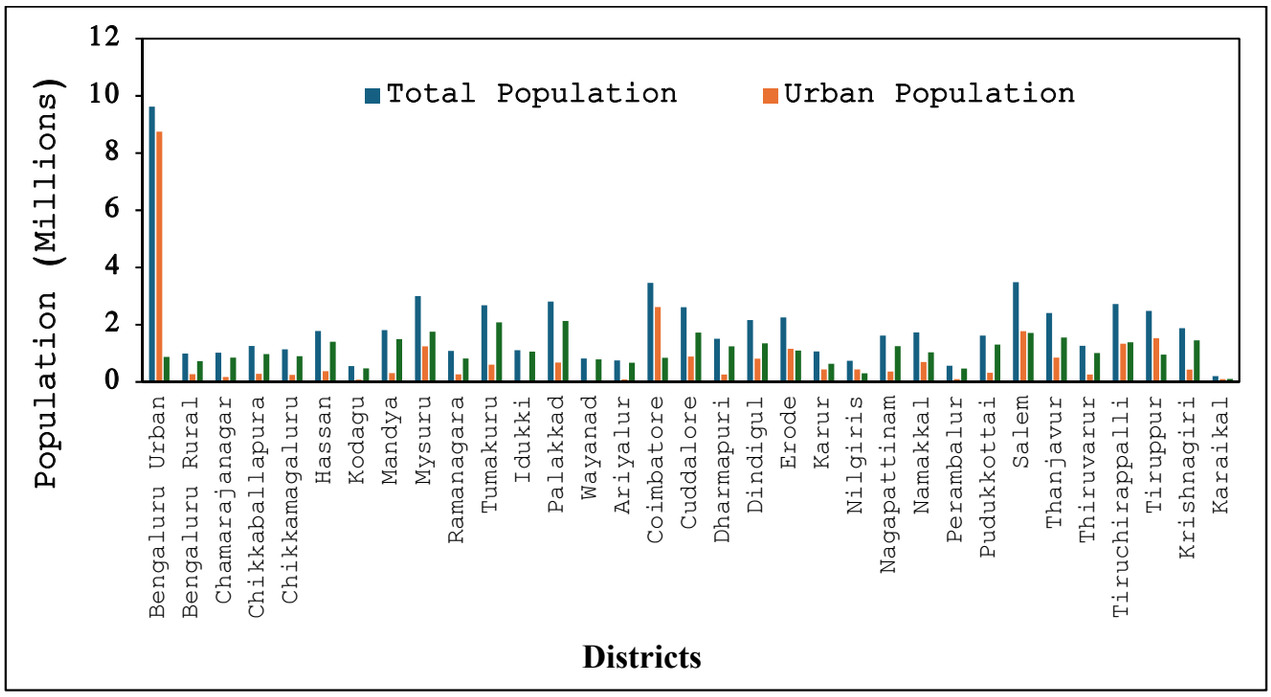

Figure 7. District-wise population distribution in the Cauvery River basin (Source: India Census, 2011)

3.3 Population Growth Trends

From 1991 to 2011, CRB witnessed significant demographic shifts across various districts (Figure 8). Urbanization played a major role in the growth of population, particularly in districts like Bengaluru Urban. Bengaluru Urban showed an increase from approximately 4.8 million in 1991 to over 9.6 million by 2011, driven by rapid urban expansion and economic opportunities. Conversely, districts like Bengaluru Rural displayed fluctuations, with population growth stagnating or declining in 2011 compared to previous years, potentially due to rural-to-urban migration. Coimbatore showed a significant population increase between 1991 and 2001. However, there was a notable decrease by 2011, which could be due to reclassification or migration. Cuddalore district saw a sharp decrease between 1991 and 2001 but had a slight recovery in population by 2011. The large drop might be due to administrative changes like splitting of districts. Dharmapuri experienced growth from 1991 to 2001, but there was a sharp decline in population by 2011. This could be linked to district bifurcation (Krishnagiri was carved out of Dharmapuri in 2004). In Dindigul, Steady and consistent growth over the two decades, reflecting typical population expansion. Erode experienced growth between 1991 and 2001 but saw a slight decline in 2011. This might be attributed to the creation of new districts or migration. Salem showed a slight dip between 1991 and 2001, but it recovered and grew by 2011. The dip might be related to the creation of Namakkal district from Salem in 1996. Like Salem, Tiruchirappalli saw a major decrease between 1991 and 2001 but recovered slightly by 2011. This could be linked to the formation of Perambalur and Karur districts in the 1990s. Pudukkottai shows a steady and stable population increase over the decades, indicating organic growth. In Thanjavur, a significant decline from 1991 to 2001 but a slight recovery by 2011. This decrease can likely be attributed

to the bifurcation into the Thiruvarur district. The data for Tiruppur is available only for 2011, likely due to it being a newly formed district. It shows a high population base, suggesting significant urban growth and industrialization.

Overall, the creation of new districts significantly impacted population trends from 1991 to 2011, particularly in regions such as Bengaluru Rural, Cuddalore, Dharmapuri, Salem, and Tiruchirappalli. While urbanization and industrialization drove population growth in some areas, particularly in districts near major urban centres, rural areas saw either slower growth or stabilization. The bifurcation of districts helped improve governance but also resulted in distinct demographic shifts across urban and rural regions.

3.4 Population Density

The population density (persons/sq. km) across different regions of CRB is illustrated in Figure 9. The darker shades represent areas of higher population density, while lighter shades indicate lower densities. This map reflects the concentration of people around urban centres, with rural and less developed regions having sparser populations. Bengaluru Urban (2021.52) has the highest population density in Karnataka. This is driven by its status as the capital city and a major IT hub, which attracts large numbers of people for employment and education. Bengaluru Rural (184.01) is significantly less dense, showing the contrast between the urban and rural areas despite their proximity. Other districts like Chamarajanagar (180.1) and Chikkamagaluru (16.6) have much lower population densities, likely due to their rural nature and economic activities focused on agriculture rather than industry or services. Tamil Nadu districts are likely to show more consistency in population density due to the relatively high level of urbanization and industrial development across the state. However, a small portion of Kerala lies under CRB, thus, districts such as Palakkad, Wayanad and Idukki are expected to have relatively low to moderate population densities in CRB. Karaikal district in Puducherry, is a small region with higher population density due to its urban characteristics, colonial history, and relatively small geographical area.

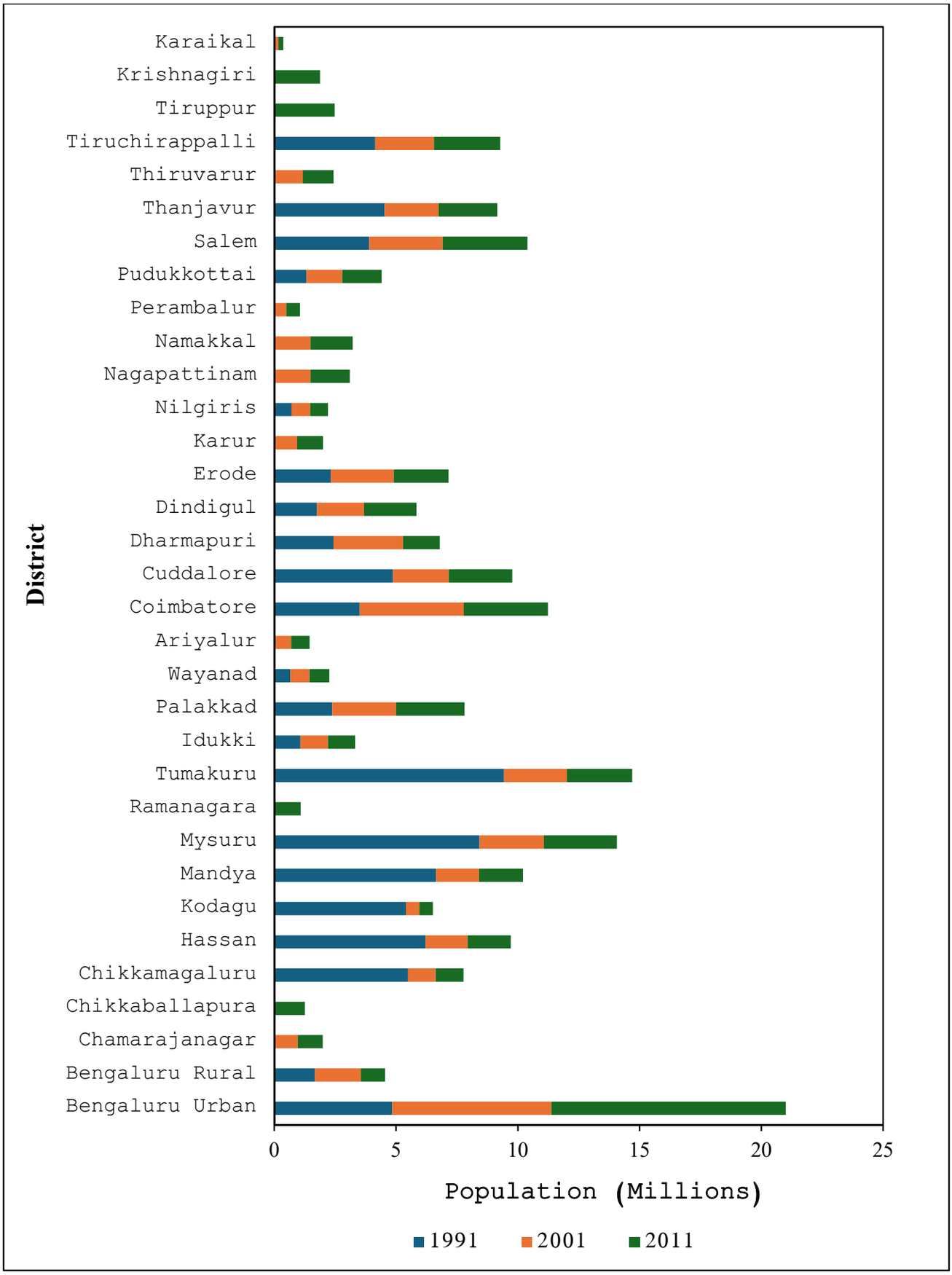

Figure 8. District-wise population growth trends in the Cauvery River basin (Source: India Census, 1991, 2001, 2011)

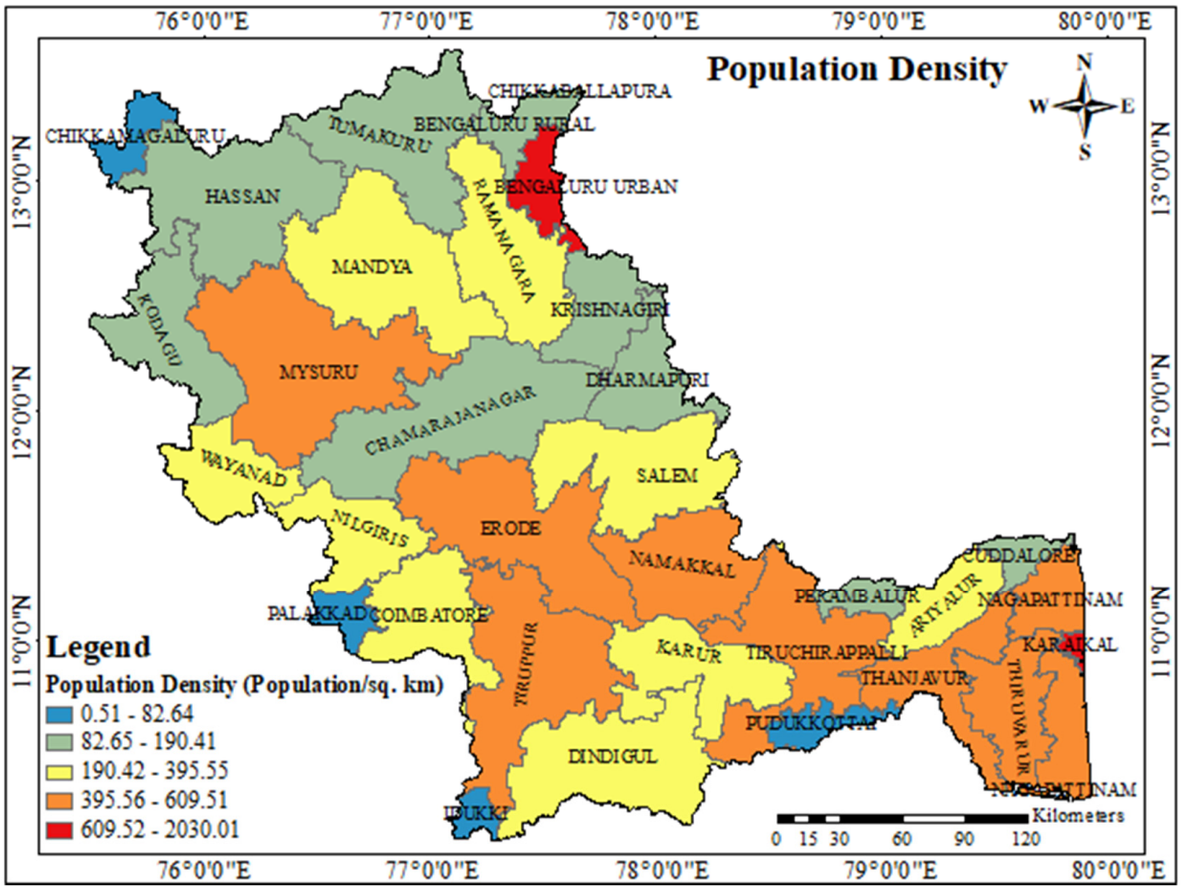

Figure 9. District-wise population density in the Cauvery River basin (Source: India Census, 2011)

4. Demographic Characteristics

4.1 Age Distribution

The bar chart (Figure 10) represents the population in the age group 0-6 years for different districts in CRB. The chart includes data for both total population and the breakdown by gender (male and female). Bengaluru rural and Bengaluru urban have the highest total population in the age group 0-6 years. Bengaluru urban has a slightly higher population of males compared to females in this age group. Chamarajanagar has the lowest total population in the age group 0-6 years. Karur has a very low child population, and the higher proportion of females compared to males in this age group. Ariyalur and Perambalur have relatively low child populations with balanced gender ratios. In contrast, Coimbatore, Tiruppur, and Salem have high child populations with varying gender distributions. Districts like Thanjavur, Tiruchirappalli, and Thiruvarur exhibit higher child populations with a predominance of female children. Namakkal and Dharmapuri have moderate child populations with slightly higher numbers of male children. The Nilgiris district, known for its hilly terrain, has a very low child population with a balanced gender ratio.

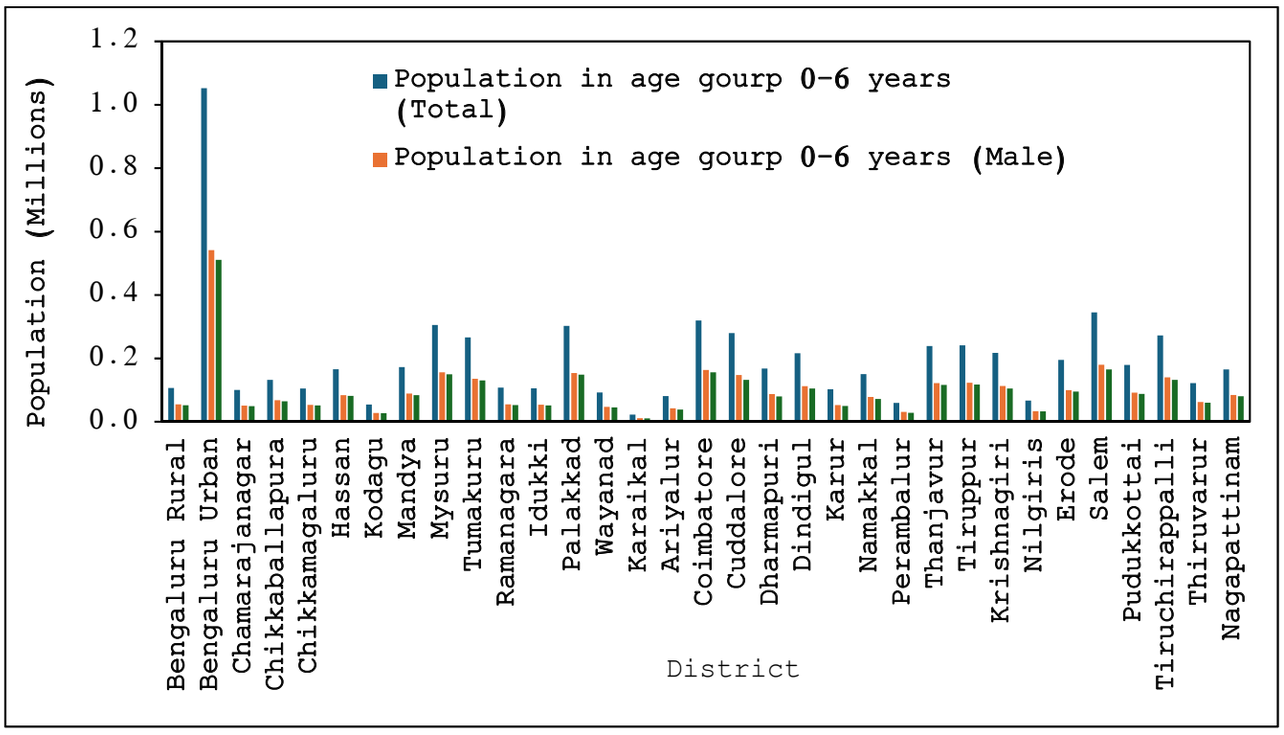

Figure 10. District-wise age distribution in the Cauvery River basin (Source: India Census, 2011)

4.2 Sex Distribution

The dataset contains information about the sex ratio in various regions of CRB, presented as the percentage of males and females (Figure 11) and sex ratio (Table 1) in each region. In CRB, the sex ratio varies across different districts and regions, indicating demographic trends influenced by factors such as migration, employment, health, and local cultural practices. The Bengaluru Urban region, known for being a metropolitan hub, has a male-dominated population with 52.2% males and 47.8% females. The male population surpasses the female population (sex ratio: 916), likely due to migration for employment in the urban sectors. A similar trend is observed in Bengaluru Rural, where 51.4% of the population are males, and 48.6% are females. Migration for labour opportunities in nearby urban centres could influence this slightly skewed ratio. Chamarajanagar district shows a more balanced sex ratio (993) with 50.2% males and 49.8% females. Being a more agrarian and rural district, it exhibits a closer parity between the sexes. With 50.7% males and 49.3% females, Chikkaballapura district has a slight male dominance. However, the difference is less pronounced compared to urban areas. Chikkamagaluru region, known for its agricultural and coffee plantations, has a more favourable sex ratio (1008) for females, with 49.8% males and 50.2% females, indicating better gender balance. Ariyalur, primarily an agricultural district, is known for its cement industries and limestone resources. The higher sex ratio (1015) indicates a relatively balanced gender distribution, possibly due to limited out-migration of males and better healthcare access, ensuring higher female survival rates. Coimbatore, an industrial hub known for its textile and engineering industries, shows a perfectly balanced sex ratio (1000). With 50% males and 50% females, the gender balance may be attributed to a well-developed socio-economic infrastructure, higher literacy rates, and employment opportunities for both men and women. Dharmapuri has the lowest sex ratio (946) in the dataset. The district is

economically less developed, with a significant rural population and agricultural dependence. The lower sex ratio could be influenced by a higher male population engaged in manual labour and possible gender biases in rural areas.

Dindigul, known for its agricultural products and thriving lock-making industry, shows a near-equal gender distribution. The balanced sex ratio (998) might be due to the lack of significant male migration and better healthcare services available in the district. Cuddalore, a coastal district with a mix of agriculture and small industries, has a slightly lower sex ratio (987). This could be due to out-migration of males to urban areas for employment or higher female infant mortality rates in rural regions. Typically, Thanjavur, Thiruvarur, Tiruchirappalli have a higher sex ratio, often >1000, indicating a favourable condition for females. These districts, like many in Tamil Nadu, show a higher-than-average sex ratio compared to other parts of India due to a combination of educational, economic, and social factors that promote gender equality and welfare.

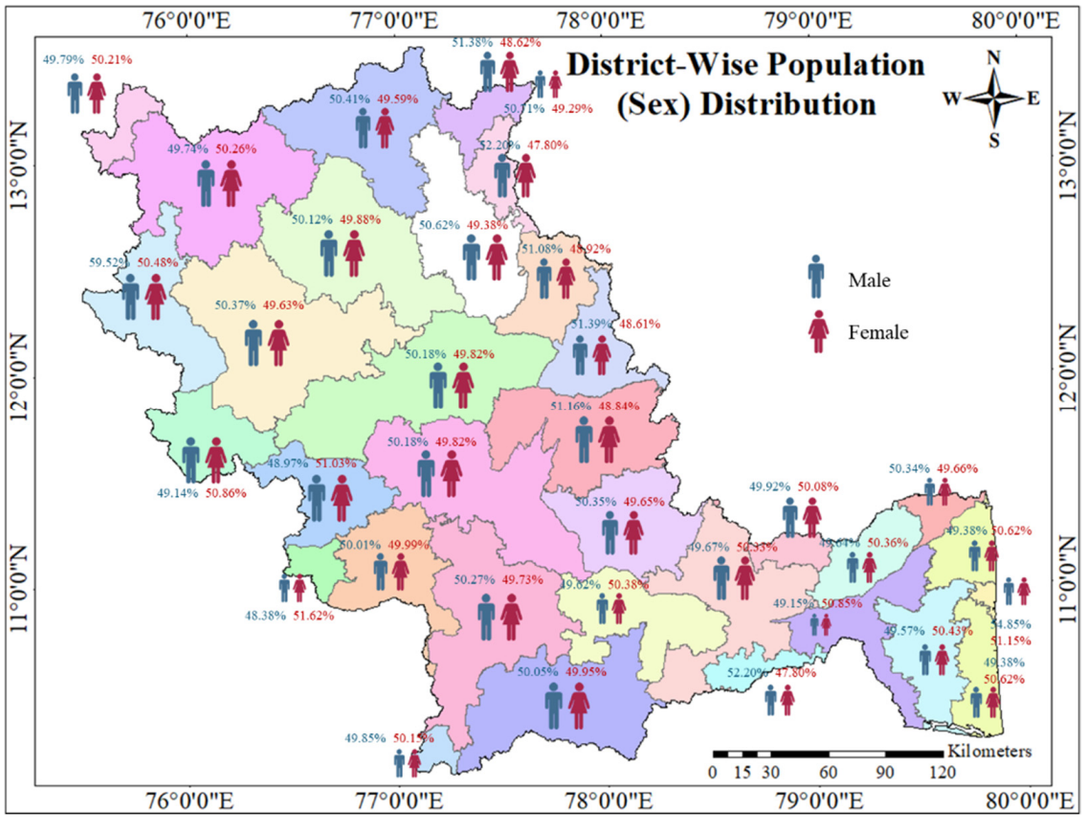

Figure 11. District-wise population (sex) distribution in the Cauvery River basin (Source: India Census, 2011)

The sex ratio varies significantly across different parts of CRB, reflecting regional economic activities, migration trends, and socio-cultural factors. Regions with a higher male population, particularly urban areas, may face challenges related to gender imbalance, such as disparities in marriage markets and potential issues with social cohesion. In contrast, more balanced rural regions may experience different challenges, such as equitable access to resources for women. By recognizing these trends, policymakers can address gender-specific needs, ensuring equitable development and resource distribution throughout the basin.

Table. 1. District-wise sex ratio in the Cauvery River basin (India Census, 2011)

State	District	Sex Ratio
Karnataka	Bengaluru Urban	916
	Bengaluru Rural	946
	Chamarajanagar	993
	Chikkaballapura	972
	Chikkamagaluru	1008
	Hassan	1010
	Kodagu	1019
	Mandya	995
	Mysuru	985
	Ramanagara	976
	Tumakuru	984
Kerala	Idukki	1006
	Palakkad	1067
	Wayanad	1035
Tamil Nadu	Ariyalur	1015
	Coimbatore	1000
	Cuddalore	987
	Dharmapuri	946
	Dindigul	998
	Erode	993
	Karur	1015
	Nilgiris	1042
	Nagapattinam	1025
	Namakkal	986
	Perambalur	1003
	Pudukkottai	1015
	Salem	954
	Thanjavur	1035
	Thiruvarur	1017
	Tiruchirappalli	1013
	Tiruppur	989
	Krishnagiri	958
Puducherry	Karaikal	1047

4.3 Household Statistics

The map shows the distribution of households based on the number of households in each district in CRB (Figure 12). Karnataka has the highest number in Bengaluru Urban with 2,393,845 households. Kerala is led by Palakkad with 6,37,220 households. Tamil Nadu's Coimbatore tops its list with 958,805 households. Puducherry's Karaikal brings up the rear with 49,705 households.

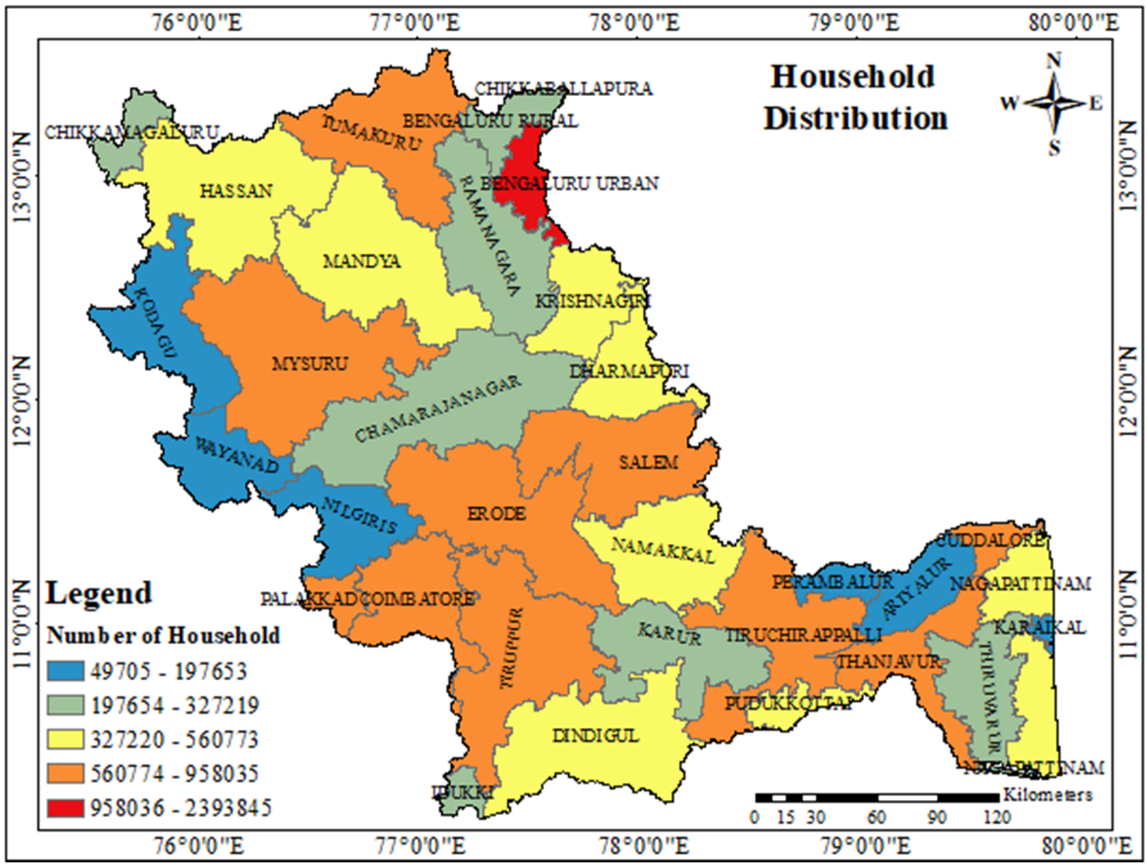

Figure 12. District-wise household distribution in the Cauvery River basin (Source: India Census, 2011)

5. Socio-Economic Characteristics

Socio-economic characteristics play a crucial role in river basin management, as they directly influence the sustainable use and conservation of water resources. Understanding the demographic composition, economic activities, land use patterns, and social behaviours of communities within a river basin allows for more effective management strategies. These characteristics determine the demand for water, the types of pollution sources, and the potential for community engagement in conservation efforts. By integrating socio-economic data, policymakers can design tailored solutions that balance ecological health with human needs, ensuring equitable access to water while promoting economic growth and environmental sustainability.

5.1 Population Health

5.1.1 Mortality Rate

Mortality rate is an important socio-health indicator in river basin management, as it reflects the well-being and health conditions of communities living within the basin (Figure 13). High mortality rates, especially those related to waterborne diseases, often indicate poor water quality and inadequate sanitation, pointing to environmental degradation and pollution in the river system. Understanding mortality trends helps river basin managers identify areas where water contamination poses serious public health risks, guiding efforts to improve water

treatment, sanitation infrastructure, and ecosystem health. Addressing such challenges not only enhances the health outcomes for communities but also supports sustainable water resource management and pollution control strategies in the river basin.

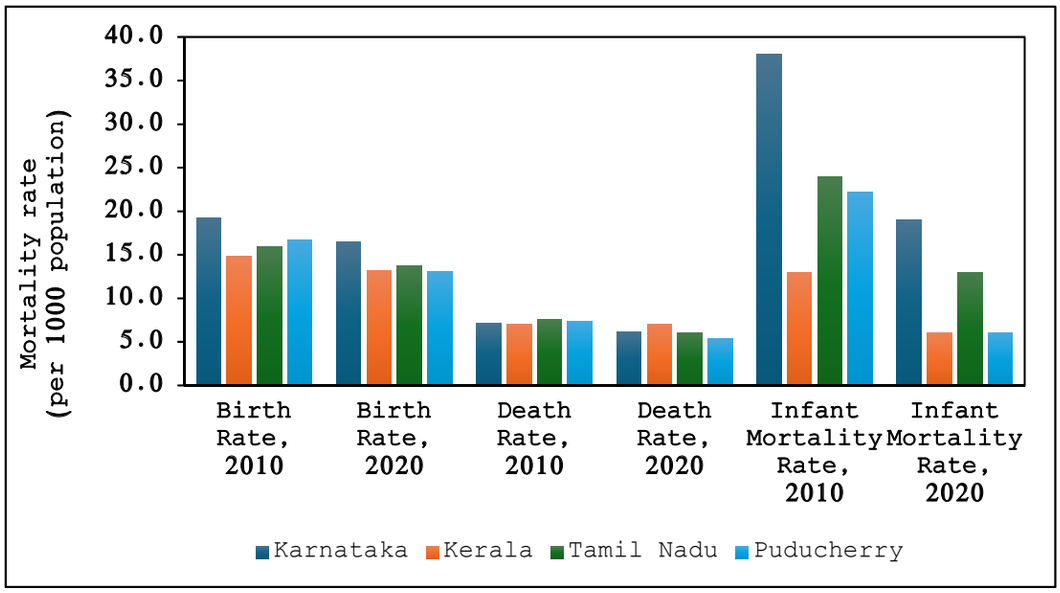

Figure 13. Mortality rate in the Cauvery River basin
(Source: Office of the Registrar General of India, Ministry of Home Affairs)

5.1.2 Life Expectancy

In India, life expectancy was 25.4 in the year 1800, and over the course of the next 220 years, it has increased to almost 70. Between 1800 and 1920, life expectancy in India remained in the mid to low twenties, with the largest declines coming in the 1870s and 1910s; this was because of the Great Famine of 1876-1878, and the Spanish Flu Pandemic of 1918-1919, both of which were responsible for the deaths of up to six and seventeen million Indians respectively; as well as the presence of other endemic diseases in the region, such as smallpox. From 1920 onwards, India's life expectancy has consistently increased, but it is still below the global average (https://www.statista.com/statistics/1041383/life-expectancy-india-all-time/).

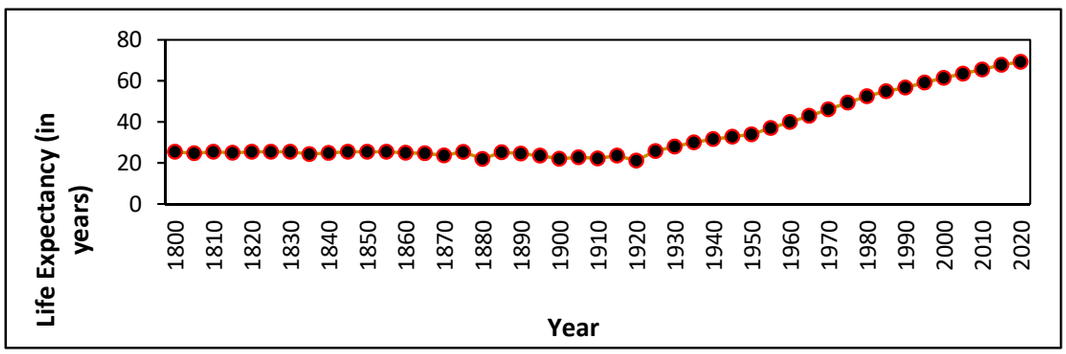

Figure 14. Life expectancy in the Cauvery River basin
(Source: https://www.statista.com/statistics/1041383/life-expectancy-india-all-time/)

5.2 Education Levels

CRB spans across various districts in southern India, with a range of literacy rates reflecting the socio-economic conditions of the region (Figure 15). For instance, Bengaluru Urban, being a major metropolitan area, has a notably high literacy rate of 78.08%, while districts like Chamarajanagar, predominantly rural and less developed, report lower literacy rates around 55.38%. Other districts, such as Chikkamagaluru and Bengaluru Rural, exhibit moderately high literacy rates of 71.91% and 69.51%, respectively. Districts like Coimbatore, Tiruppur, and Tiruchirappalli, which have higher literacy rates, are relatively more urbanized and industrialized. These regions have better infrastructure, more job opportunities, and access to educational institutions. The economic development in these areas, driven by industries such as textiles (Tiruppur) and manufacturing (Coimbatore), has likely spurred investments in education, leading to higher literacy rates. In contrast, districts like Dharmapuri and Ariyalur, which have lower literacy rates, are predominantly rural and agriculturally dependent. In these areas, the economy might not have provided sufficient incentives for educational growth, as many people may prioritize agricultural labour over schooling, especially in poorer families. Newer or less-developed districts like Perambalur and Krishnagiri may not have benefited from early investments in education and therefore have lower literacy rates. Geographical isolation may also play a role in districts like Nilgiris (which, despite a higher literacy rate, has historically faced challenges due to its hilly terrain) and Dharmapuri. Geographic isolation can hinder the establishment and accessibility of educational institutions, reducing the population's ability to attend school regularly. Poor transportation infrastructure in rural and geographically isolated areas exacerbates the issue.

Government programs like the Sarva Shiksha Abhiyan (SSA) and the National Literacy Mission (NLM) have had varying impacts across different districts. Urbanized areas and regions with better governance may have more efficiently implemented educational policies, benefiting from better school infrastructure, teacher training, and outreach programs. Districts with lower literacy rates may have faced challenges in the effective delivery of these programs, either due to administrative inefficiencies or socio-economic barriers. The disparities in literacy rates across districts in CRB are shaped by a complex interplay of factors such as economic development, urbanization, geographic isolation, historical educational investment, and socio-cultural norms. To improve literacy in lower-performing districts, targeted interventions focusing on school infrastructure, teacher quality, and addressing socio-economic barriers to education will be essential.

5.3 Migration

Population migration (Figure 16) is a complex phenomenon influenced by multiple socio-economic, environmental, and political factors, driving rural-to-urban migration. Major urban centres like Bengaluru Urban, Coimbatore, and Mysuru serve as hubs due to their economic opportunities, while rural areas often push migrants out due to a lack of infrastructure, jobs, and environmental stress. These migration flows are shaped by a combination of historical, economic, and social networks, underpinned by gender and labour market dynamics.

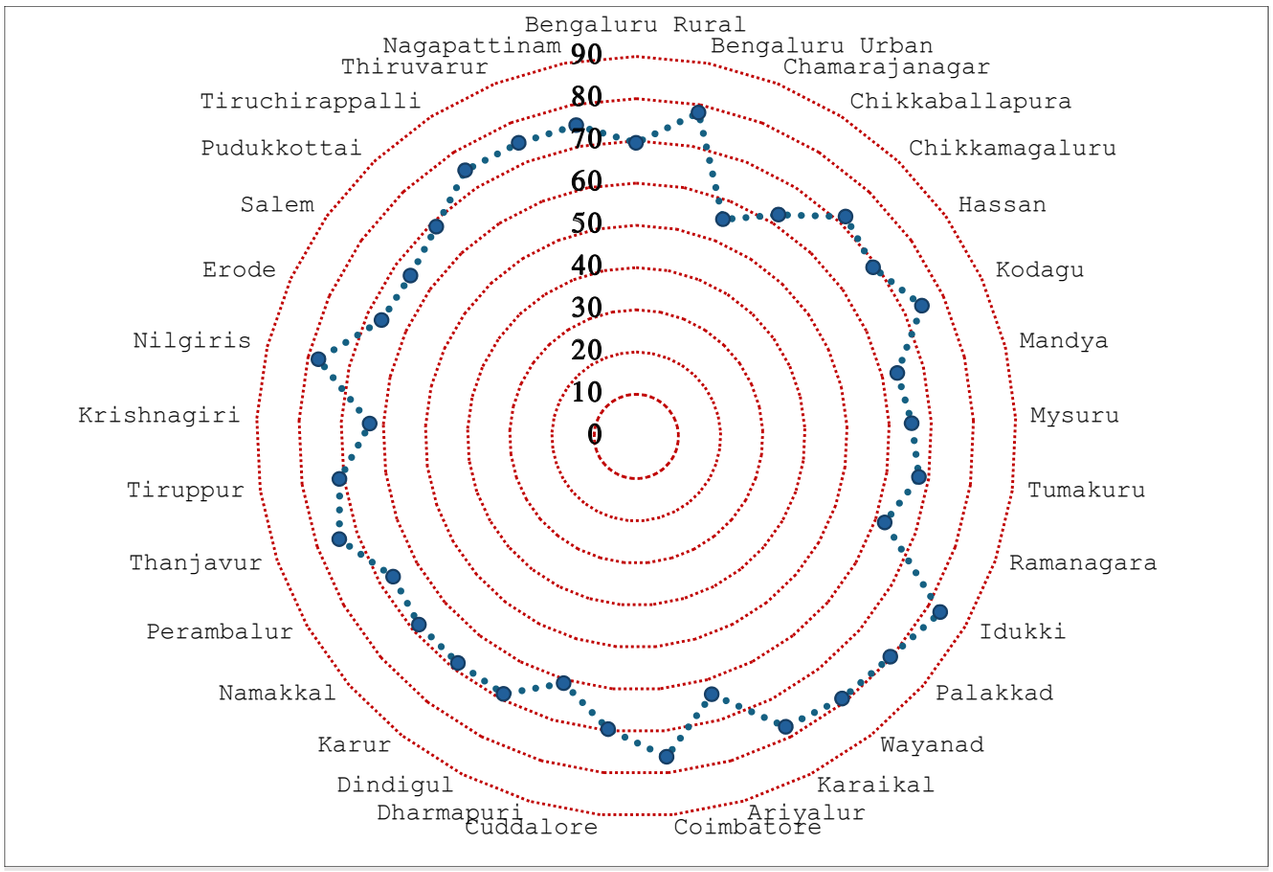

Figure 15. District-wise literacy rate (%) distribution in the Cauvery River basin (Source: India Census, 2011)

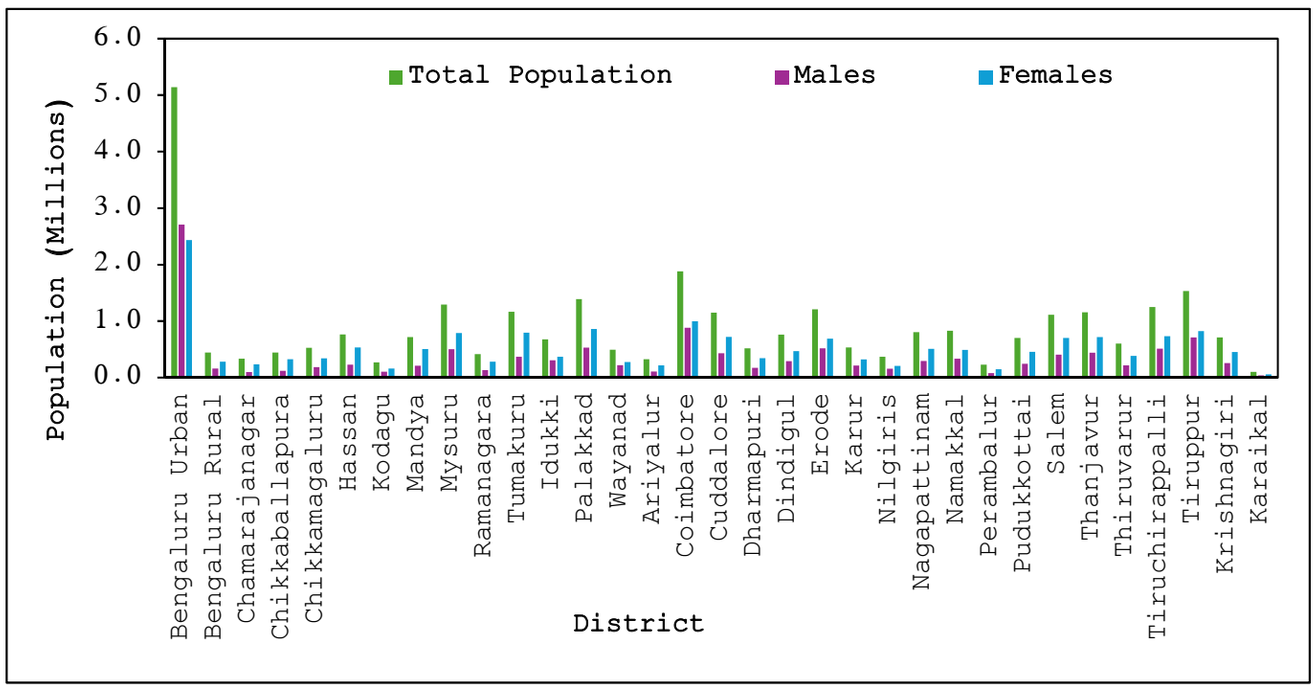

Figure 16. District-wise migration in the Cauvery River basin (Source: https://censusindia.gov.in/census.website/hi/data/census-tables)

5.4 Employment and Occupation

5.4.1 Total Working Population

The provided bar chart offers a comprehensive analysis of the total working population in CRB, with a detailed breakdown by gender and district (Figure 17). The data reveals significant disparities in the working population across the state. Bengaluru Urban and Rural stand out with the highest total working populations, followed by districts like Coimbatore, Mysuru, and Tiruppur. However, districts like Chamarajanagar, Ramanagaram, and Kodagu have the lowest total working populations. A significant gender gap is evident in most districts, with a higher proportion of male workers compared to female workers. This disparity is particularly pronounced in districts like Bengaluru Rural, Chamarajanagar, and Dharmapuri. In contrast, districts like Bengaluru Urban, Mysuru, and Tiruchirappalli show a slightly smaller gender gap.

Regional variations in the working population are also apparent. Districts in the southern and central parts of CRB tend to have higher working populations compared to those in the northern and western regions. This can be attributed to factors such as industrial development, urbanization, and agricultural practices. Overall, the chart highlights the uneven distribution of the working population across Karnataka. The gender gap and regional disparities underscore the need for policies and initiatives to promote gender equality and equitable economic development in the state. By addressing these issues, Karnataka can harness the full potential of its workforce and achieve sustainable economic growth.

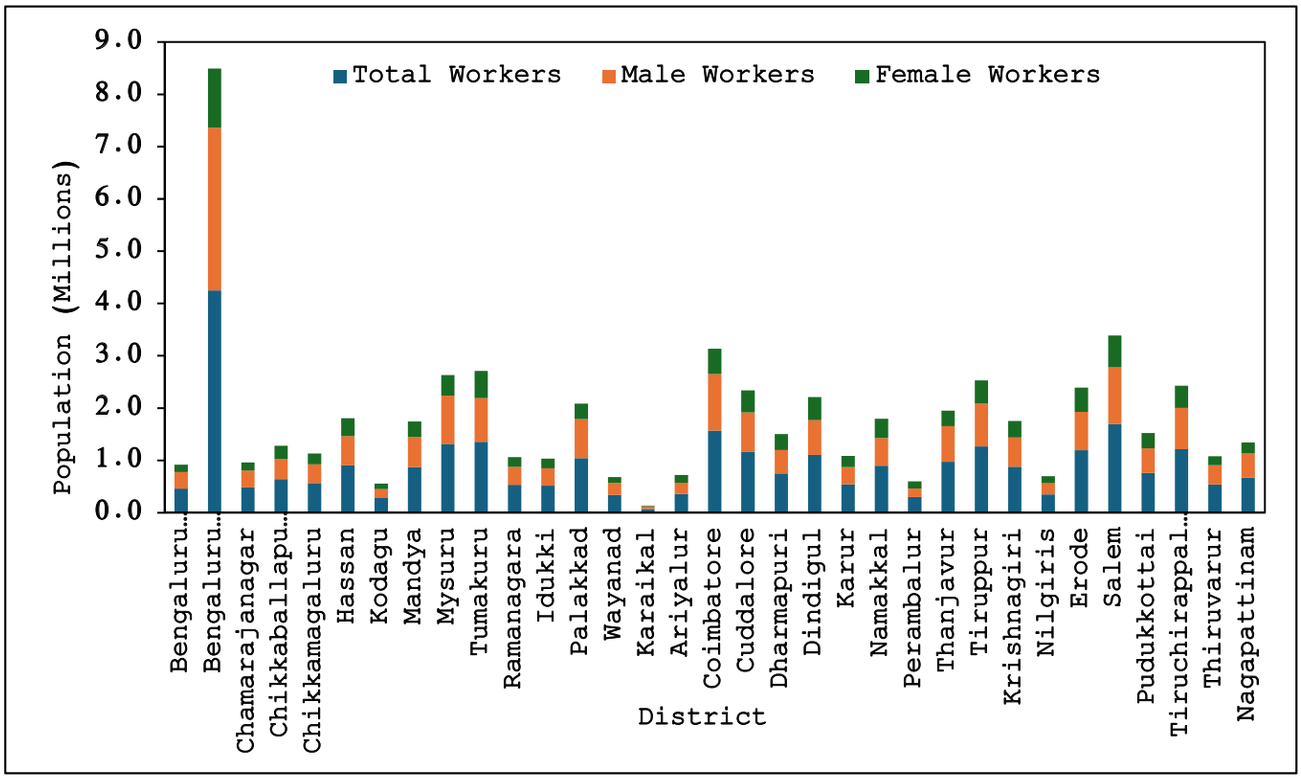

Figure 17. District-wise total working population in the Cauvery River basin (Source: India Census, 2011)

5.4.2 Total Workforce Participation Ratio

The total workforce participation ratio (TWPR) is an indicator that measures the proportion of the population engaged in economic activities (i.e., working or seeking work) to the total population of a specific area. It is typically expressed as a percentage (Figure 18). It plays a crucial role in river basin management as it reflects the level of economic activity and dependency on the basin's resources. A high TWPR in sectors such as agriculture or industry indicates significant water demand, making efficient management of water resources critical to sustaining livelihoods and economic productivity. Moreover, a low TWPR may highlight communities' vulnerability and reliance on natural resources from the basin for survival, emphasizing the need for sustainable resource use and diversified livelihoods. Understanding TWPR helps planners balance economic development with ecological conservation, ensuring that water resources are used efficiently without compromising the long-term health of the river basin.

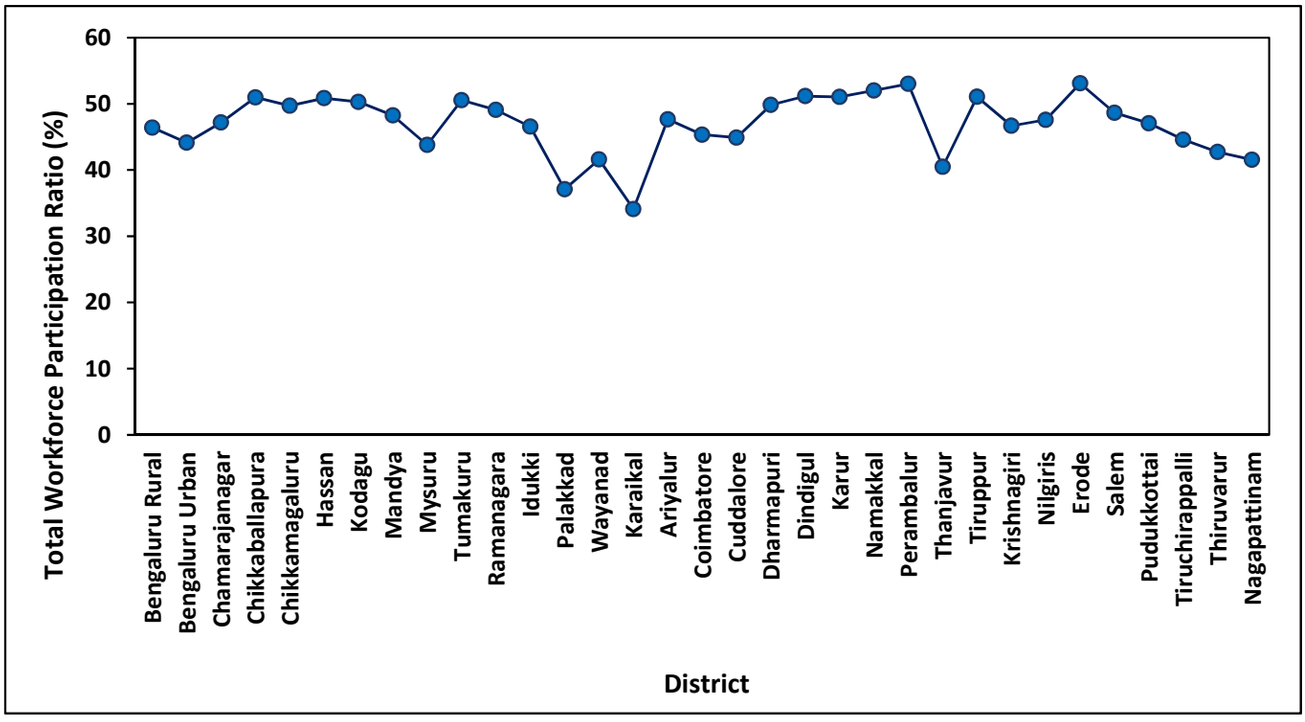

Figure 18. District-wise total work force participation ratio in the Cauvery River basin (Source: India Census, 2011)

5.4.3 Income Levels

The economic landscape of southern India is characterized by diverse income levels across the states of Karnataka, Tamil Nadu, Kerala, and the Union Territory of Puducherry. Gross State Domestic Product (GSDP) and Net State Domestic Product (NSDP) are key indicators of these regions' economic performance, reflecting the value of goods and services produced within a state. Understanding the GSDP and NSDP of these states provides insight into their economic strength, development trajectory, and comparative performance (Figs. 19 - 26) (https://rbi.org.in/Scripts/AnnualPublications.aspx?head=Handbook%20of%20Statistics%20on%20Indian%20States).

Karnataka is one of the fastest-growing economies in India, driven by its robust industrial base, especially in sectors like information technology, biotechnology, and manufacturing. In terms of GSDP, Karnataka consistently ranks among the top five states in India. As of the latest estimates, Karnataka's GSDP stands at approximately ₹18.85 lakh crore (at current prices), showing a significant growth over the years. The state's high-tech industry, cantered in Bengaluru, significantly contributes to this figure. When we consider the NSDP, which deducts depreciation from GSDP, Karnataka maintains its position as an economically advanced state, indicating efficient resource utilization and investment in durable goods. The state's per capita NSDP further illustrates a higher standard of living compared to the national average, attributed to its flourishing services sector and expanding industrial base.

Tamil Nadu is another economic powerhouse in the southern region, with a diverse industrial profile ranging from automobiles and textiles to IT and electronics. Its GSDP is estimated at around ₹24.85 lakh crore (at current prices), making it one of the largest economies in the country. Tamil Nadu's economic structure is well-balanced, with substantial contributions from agriculture, industry, and services sectors. The state's NSDP, when calculated, also reflects its robust economic health. Tamil Nadu's high per capita income level indicates widespread economic prosperity, driven by the state's focus on infrastructural development and industrial diversification. The state's urbanized nature and the presence of several industrial corridors have further accelerated its economic growth.

Kerala's economy is unique in the region, as it is heavily reliant on the services sector, particularly tourism, healthcare, and remittances from the expatriate community. Kerala's GSDP is estimated at approximately ₹9.8 lakh crore, which is lower than Karnataka and Tamil Nadu but reflects steady growth. The state's NSDP reveals an economy that, while smaller in size, has a high per capita income due to the lower population base and the high value of services offered. The state has invested significantly in social infrastructure, leading to high Human Development Index (HDI) scores, which sets it apart from other states in terms of quality of life.

Puducherry, as a Union Territory, has a much smaller economic footprint compared to the neighbouring states. Its GSDP is estimated to be around ₹40,000 crore, with a focus on services, tourism, and some manufacturing activities. Puducherry's NSDP is closely aligned with its GSDP due to minimal industrial depreciation and a relatively steady economic base. Despite its size, Puducherry enjoys a higher per capita income than the national average, owing to its compact and well-managed economy.

In summary, the income levels of Karnataka, Tamil Nadu, Kerala, and Puducherry vary significantly, with Karnataka and Tamil Nadu being the dominant players in terms of GSDP and NSDP, reflecting their industrial and technological strengths. Kerala and Puducherry, while smaller in economic size, display strong performance in per capita indicators and quality of life metrics.

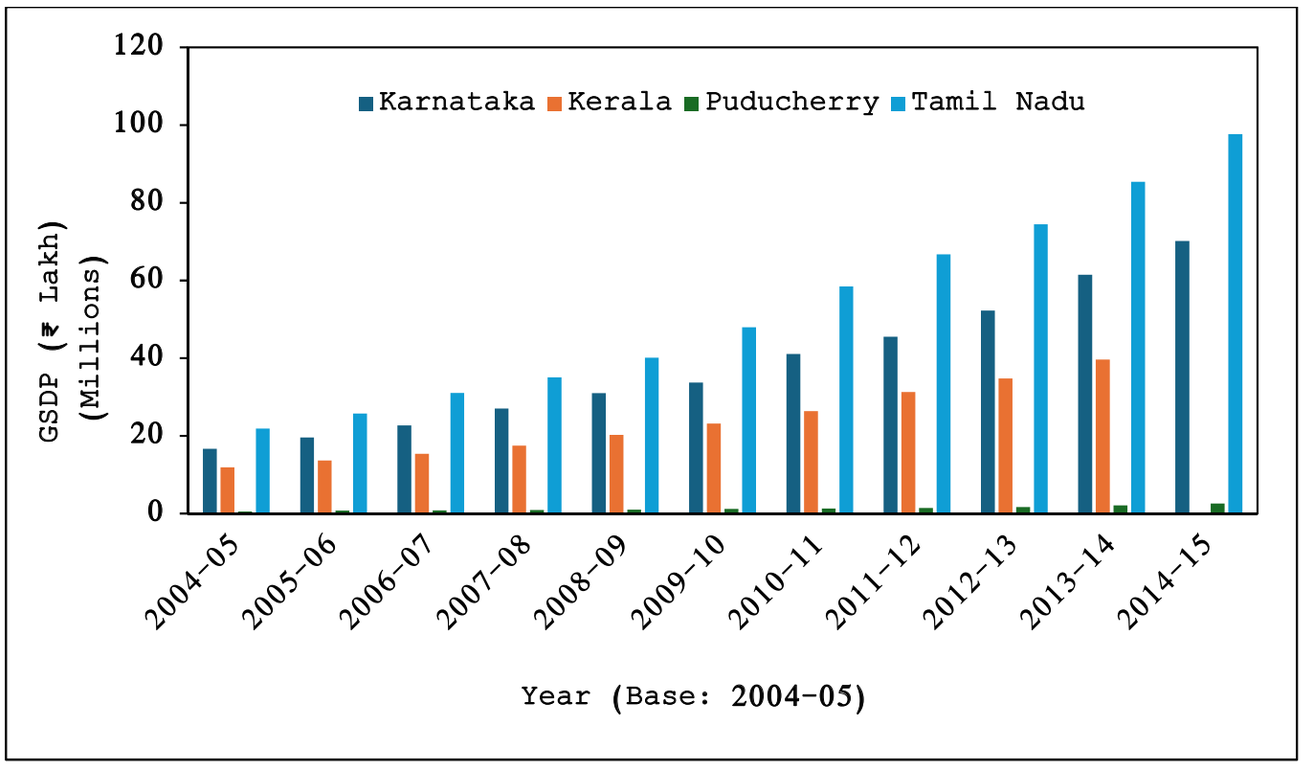

Figure 19. State-wise GSDP (Current Prices) in the Cauvery River basin (Base: 2004-05)

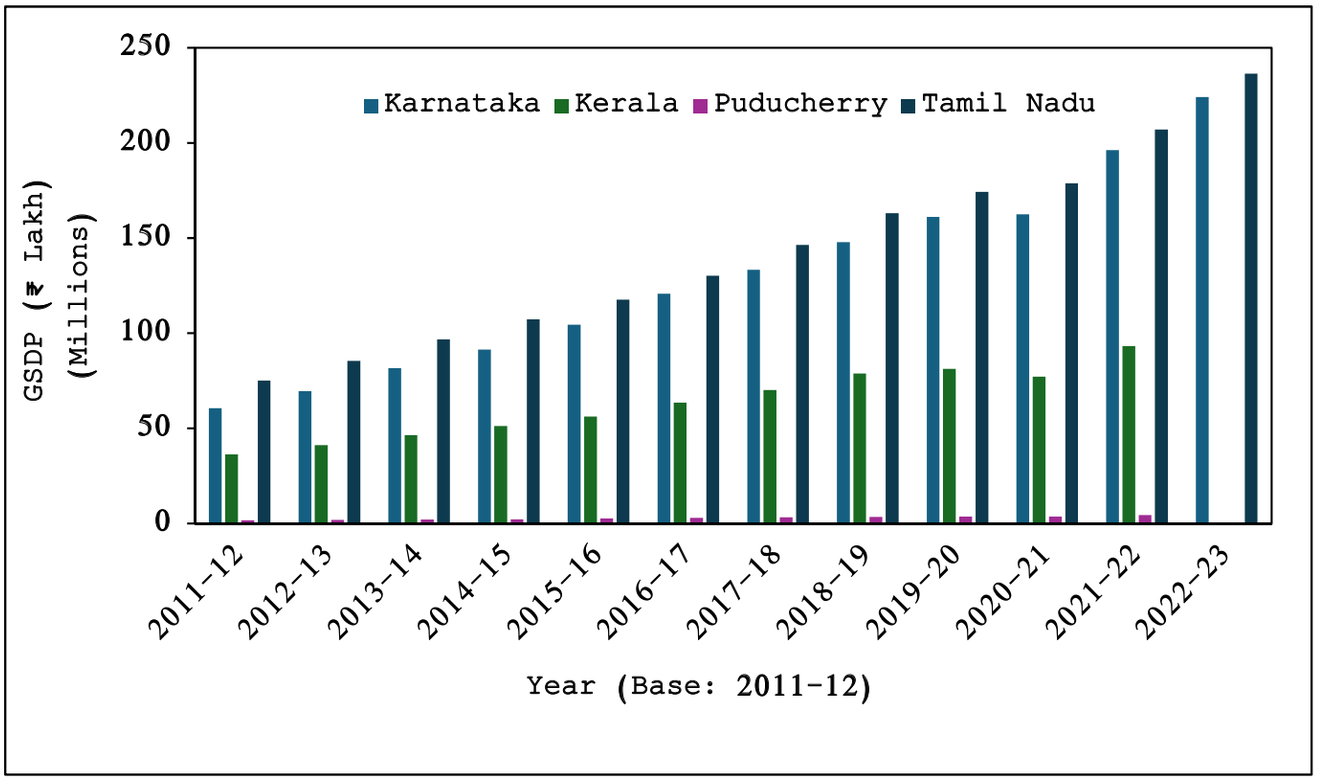

Figure 20. State-wise GSDP (Current Prices) in the Cauvery River basin (Base: 2011-12)

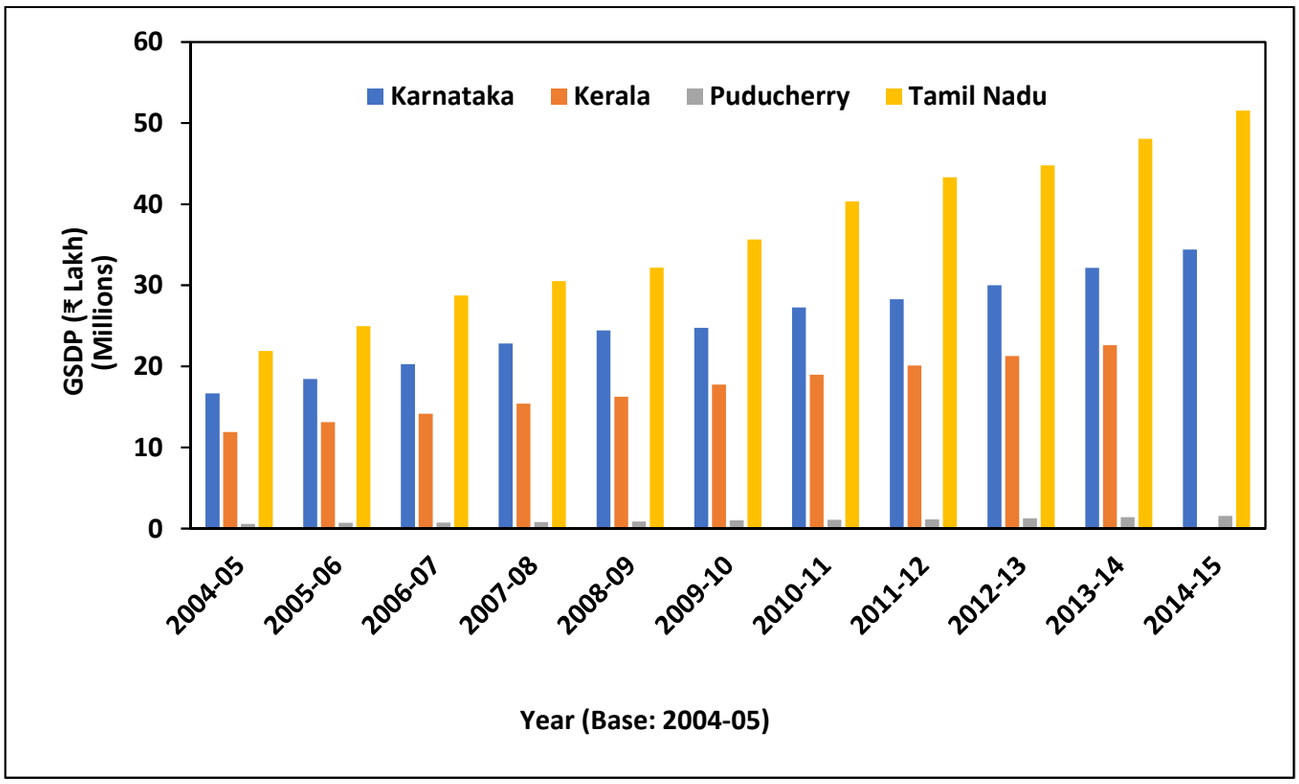

Figure 21. State-wise GSDP (Constant Prices) in the Cauvery River basin (Base: 2004-05)

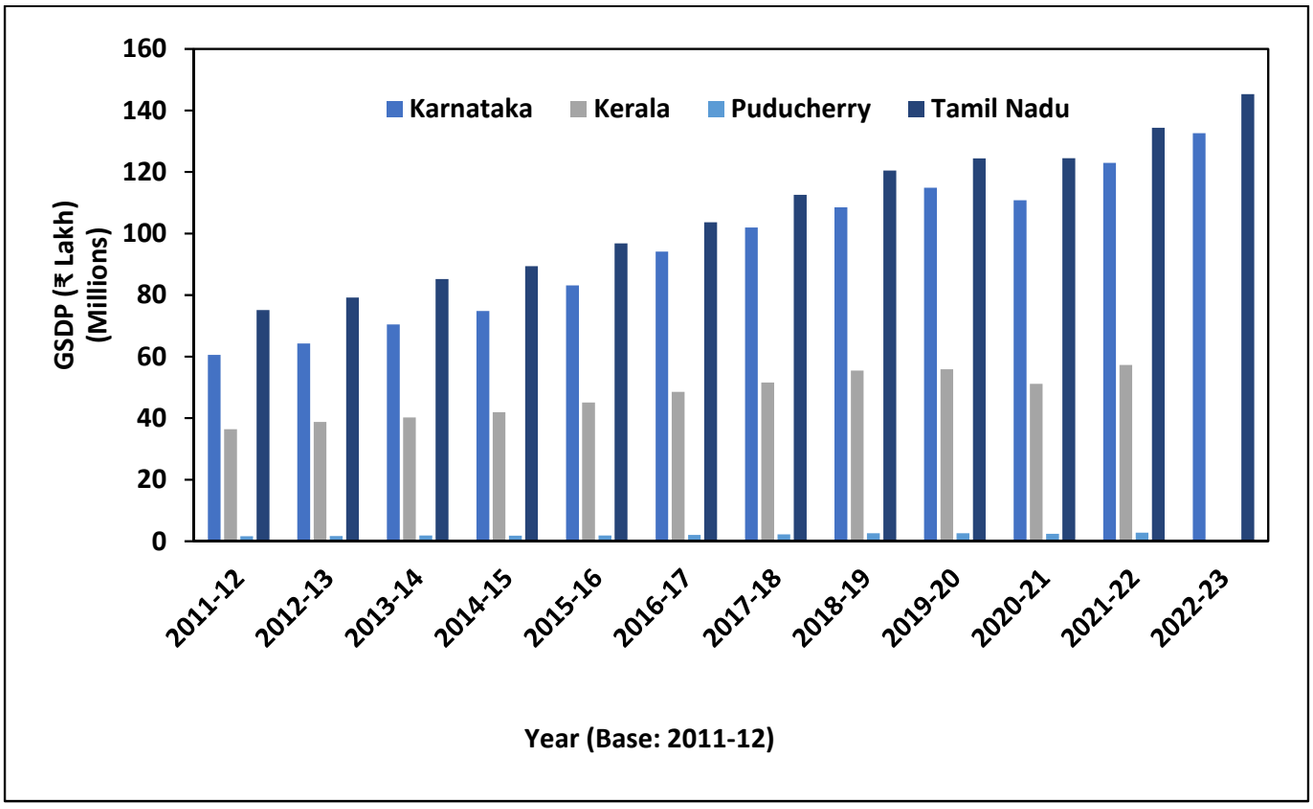

Figure 22. State-wise GSDP (Constant Prices) in the Cauvery River basin (Base: 2011-12)

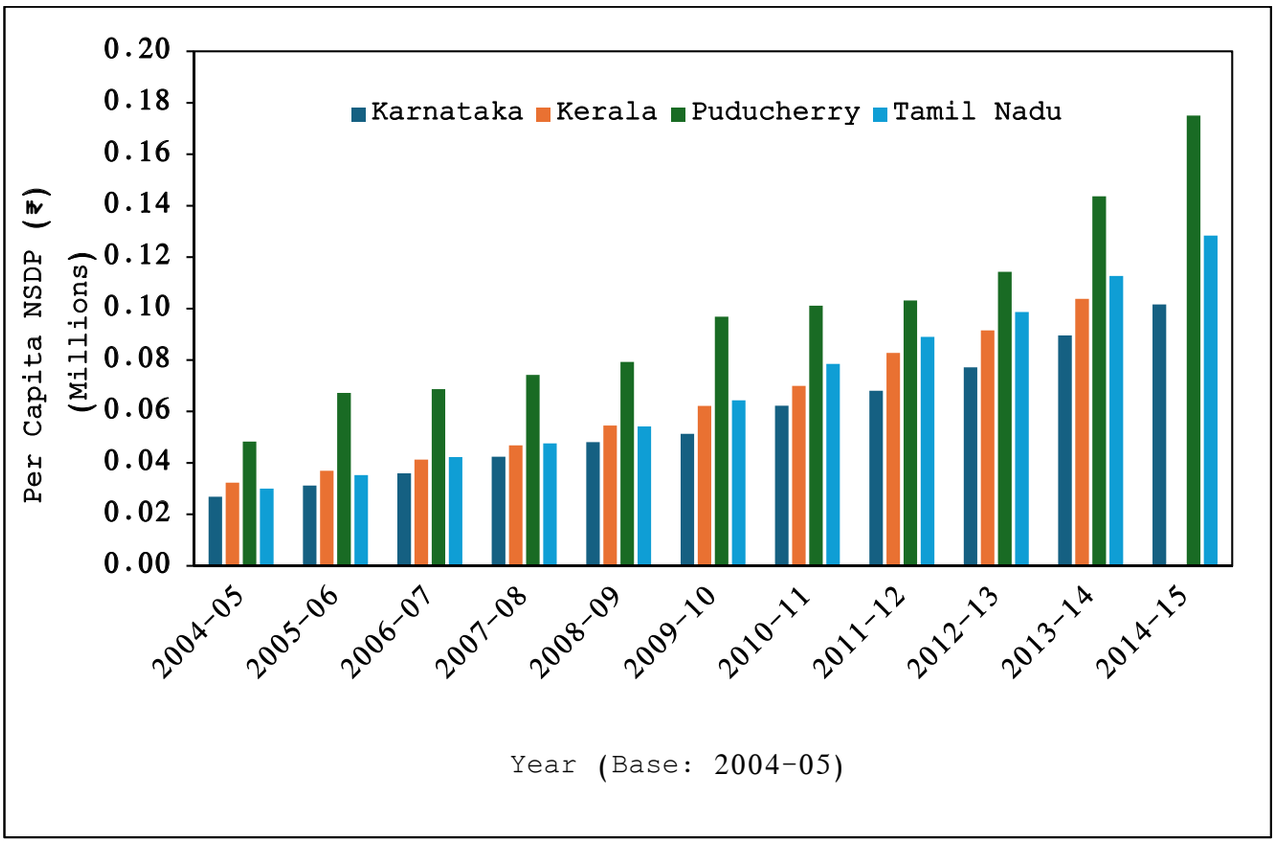

Figure 23. State-wise per capita NSDP (Current Prices) in the Cauvery River basin (Base: 2004-05)

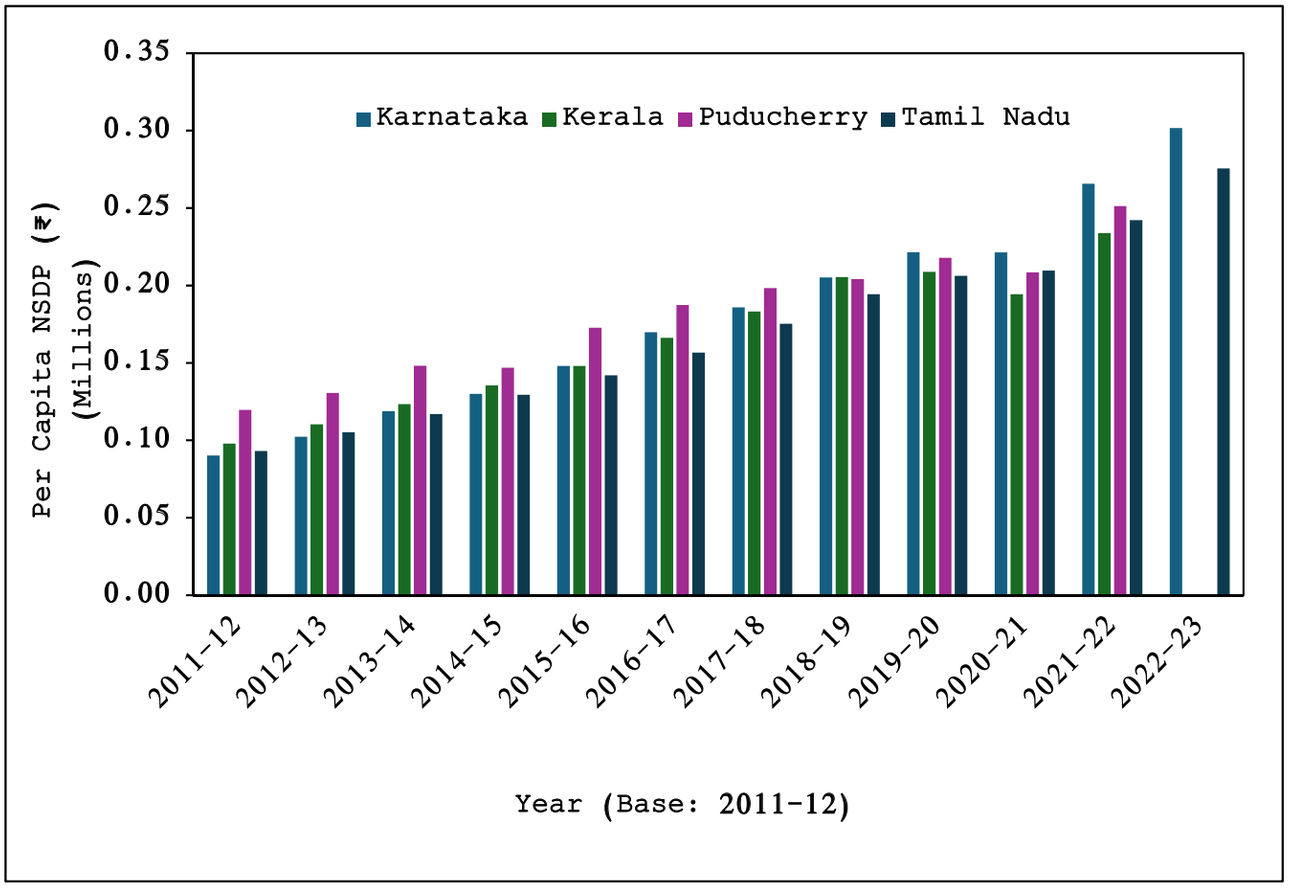

Figure 24. State-wise per capita NSDP (Current Prices) in the Cauvery River basin (Base: 2011-12)

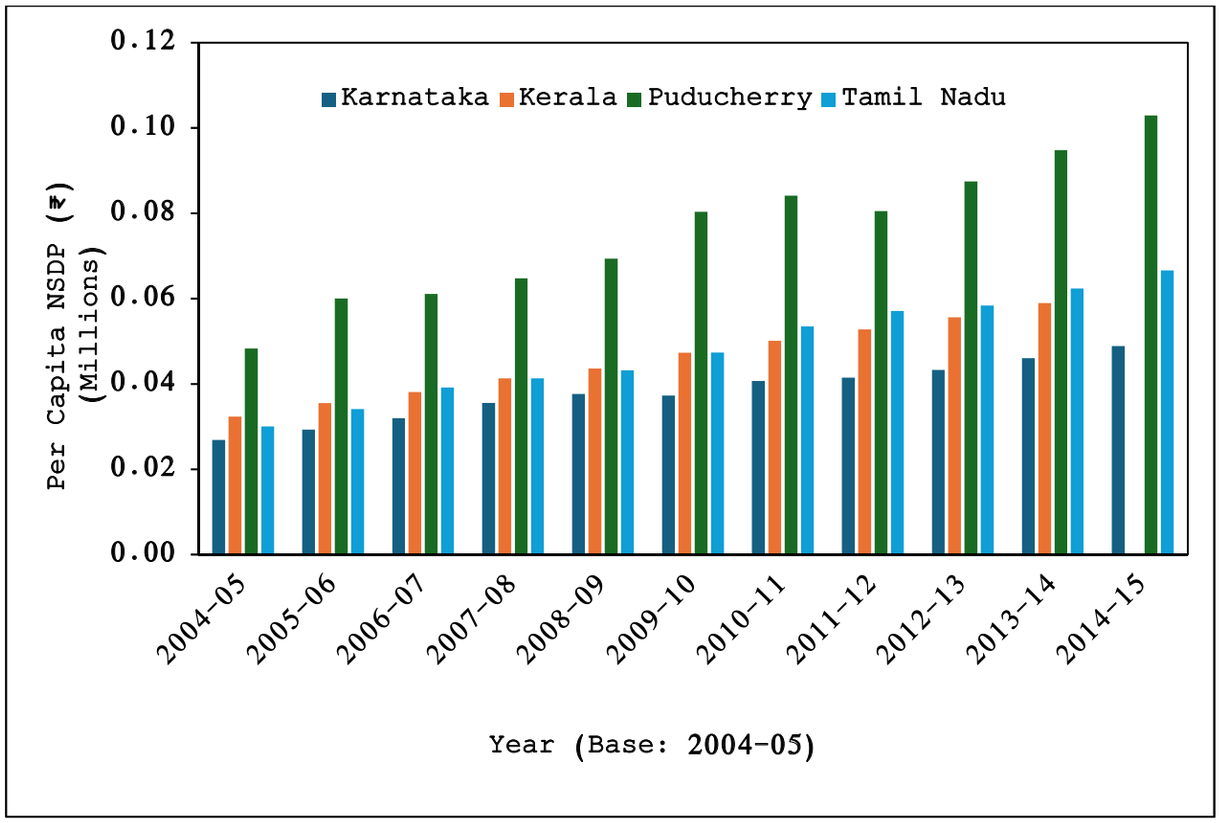

Figure 25. State-wise per capita NSDP (Constant Prices) in the Cauvery River basin (Base: 2004-05)

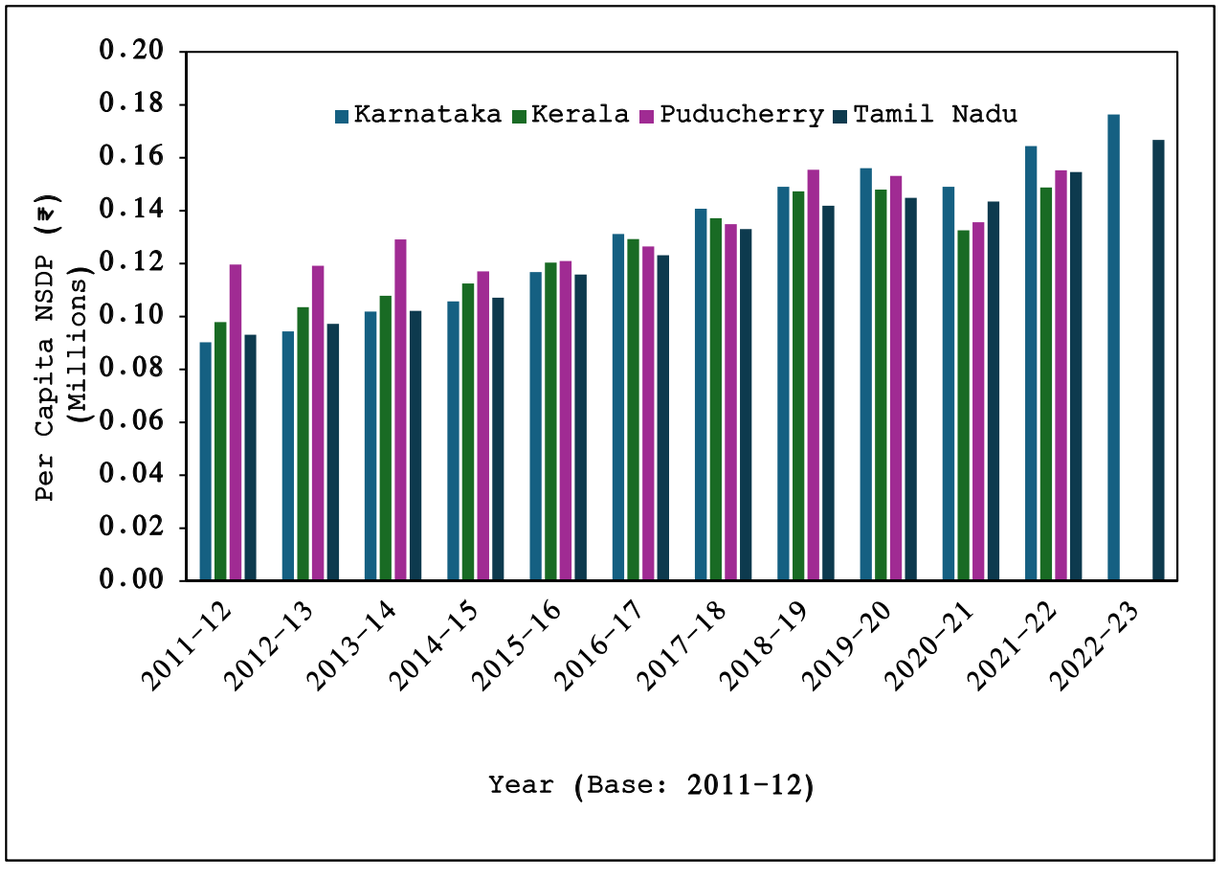

Figure 26. State-wise per capita NSDP (Constant Prices) in the Cauvery River basin (Base: 2011-12)

5.5 Demography of Notified Slums

The demography of notified slums is a crucial factor in river basin management due to the distinct socio-economic and environmental characteristics of these communities. Slum areas often exhibit high population densities, which impose significant pressure on water resources, both for domestic consumption and sanitation needs. Understanding these demographic patterns enables accurate estimation of water demand and helps assess resource stress. Furthermore, the lack of adequate sanitation and waste management infrastructure in slum areas can lead to contamination of nearby water bodies, adversely affecting the water quality of the entire basin. The demographic information of the notified slums is shown in Figure 27.

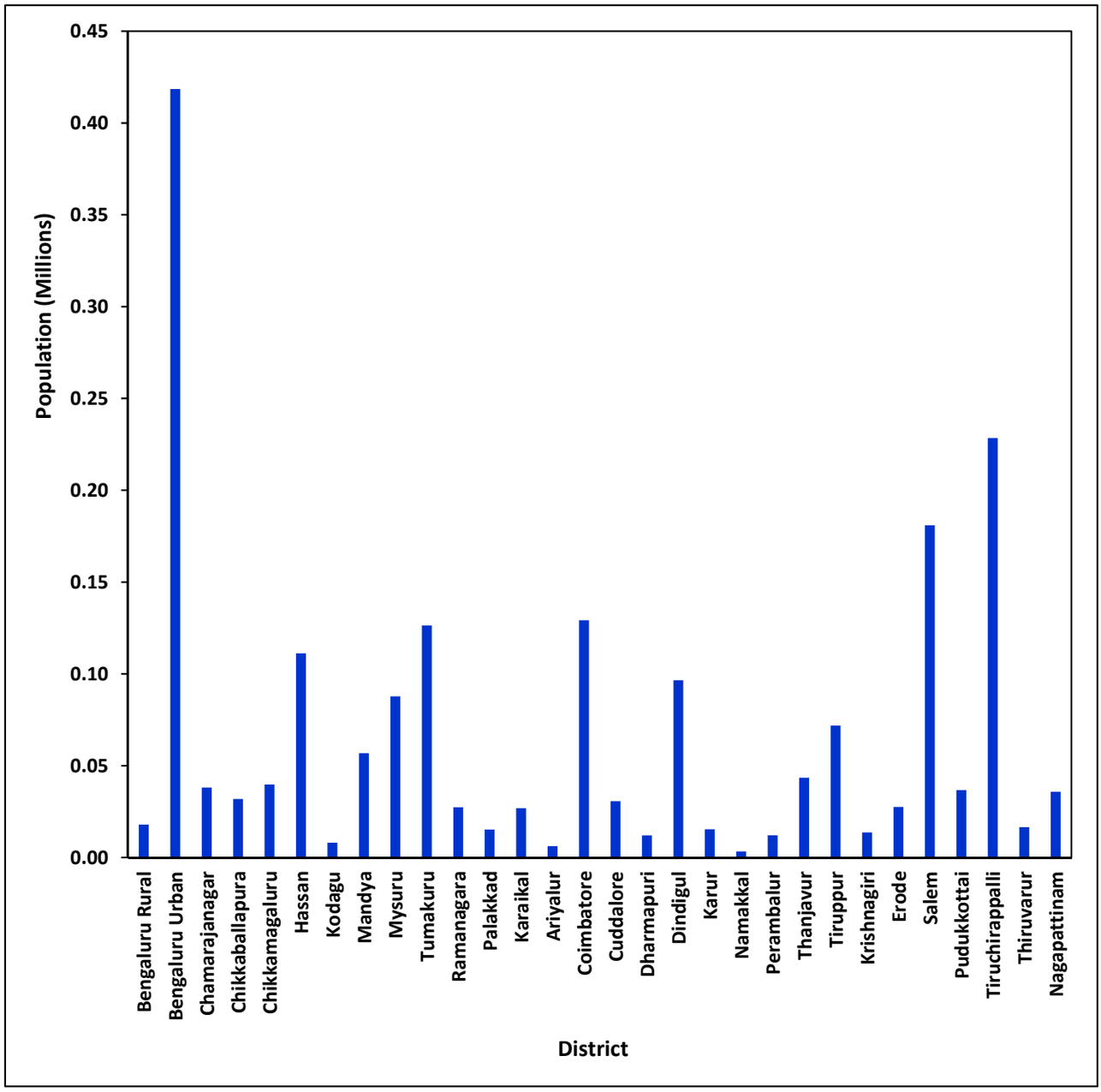

Figure 27. District-wise population distribution of notified slums in **the Cauvery River basin**
(**Sources:** https://www.census2011.co.in/slums.php,
https://ksdb.karnataka.gov.in/page/Slums/Abstract+Details+Of+Slums/en)

6. Future Projection and Scenarios

Future projections and scenarios of population are crucial in river basin management as they help anticipate and plan for changes that will affect water resources, ecosystem health, and socio-economic conditions (Quevauviller et al., 2012). The significance of future projections and scenarios of population can be described as:

6.1 Understanding Water Demand and Availability

Future population projections enable water resource managers to estimate future water demand in the basin. Population growth or decline directly impacts domestic, agricultural, and industrial water needs. By understanding future scenarios, water managers can make decisions regarding the allocation of water resources, ensuring equitable distribution among sectors.

6.2 Planning for Sustainable Development

Developing different population scenarios (e.g., high-growth, low-growth, urbanization trends) helps in creating robust management strategies that can adapt to various futures. Scenario planning aids in ensuring that future water demands are met without compromising the ecological integrity of the basin or the needs of future generations (Agarwal, 2000; Aryal, 2020).

6.3 Impact Assessment on Water Quality and Ecosystems

An increase in population typically results in more wastewater and agricultural runoff, affecting water quality. Future scenarios help anticipate these changes and develop mitigation measures. Projecting population changes helps assess potential impacts on ecosystems, such as changes in river flow regimes, habitat fragmentation, and biodiversity loss.

6.4 Infrastructure and Resource Management

Population projections inform the need for new infrastructure (e.g., dams, reservoirs, wastewater treatment plants) and maintenance of existing infrastructure. Planning for future scenarios ensures that the infrastructure can handle changes in water supply needs and provide protection against extreme weather events and flooding.

6.5 Addressing Socio-Economic Impacts

Population scenarios help predict future economic development and the demand for water in various economic activities. Ensuring that water management strategies account for population dynamics helps prevent conflicts over water use and ensures access to water for marginalized communities.

6.6 Climate Change Adaptation

Climate change and population growth are interconnected factors that influence water resources. Using population scenarios in conjunction with climate change models helps create

more comprehensive management strategies. Scenarios help prepare for uncertainties related to both climate and demographic shifts, allowing managers to adopt adaptive management approaches.

6.7 Policy and Decision-Making

Future projections provide a scientific basis for policy development, helping policymakers create regulations that account for long-term demographic changes. Scenarios can facilitate dialogue among stakeholders, helping them understand potential futures and collaborate on management strategies. Overall, incorporating future population projections and scenarios into river basin management allows for more informed, proactive, and adaptive decision-making, ensuring the sustainability and resilience of water resources in the face of changing demographic and environmental conditions.

In this report, future projected population is taken from a report on "Projection of district-level annual population by quinquennial age-group and sex from 2012 to 2031 in India" (Dhar, 2022), where ratio growth method (sub-national population projection method) is used for district-level population projection (Figure 27). The ratio method can be used for population projections of districts or tehsils, towns, or any smaller area. The only prerequisite for this method is that the population projections for larger areas should be available. So, generally, state-level projections are carried out with prior knowledge of the population projections of the country. District-level projections are carried out with prior knowledge of the state. In this method, the proportion of the population in a smaller area to the national population is calculated for past census years and changes in proportion are examined. The simplest method may be to assume the proportion observed in the latest census to hold for future dates also. Under this assumption, the population for a smaller area can be obtained by multiplying the national population already projected to the proportion for that area by the latest census. Such assumption implies that each sub-national area is growing with the same growth rate as that of the national population. This method may be quite useful in short-term projections. The formula used for the projection of the future population of area 'i' at any time 't' $\left(P_t^i\right)$ is as:

$$P_t^i = R_t^i \times P^t$$

Where; R_t^i = Ratio of future date population of an i^{th} area to the population of a larger area of which it is a part (this is calculated through the ratio of the population of a smaller area to the larger area at various points of time in the past). P^t = future population of the larger area. Moreover, variants of the ratio method are described in Table 2.

Table 2. Variants of the ratio method for population projection

Variants	Description
Ratio method 1	We assume that annual difference in the proportion observed during 2001-2011, will apply till 2021 (10 years) and the proportion will become constant thereafter.
Ratio method 2	We assume that annual difference in the proportion observed during 2001-2011, will apply till 2016 (5 years) and the proportion will become constant thereafter.
Ratio method 3	We assume that the proportion observed for the latest year (2011) will remain constant till the projection period (2012-2031).

There are 5 steps in projecting the districts population by applying one of the three variants of ratio method described above. These are as following:

- **a.** Obtaining district-wise population by sex for the latest two census years (2001 & 2011).
- **b.** Calculating population proportion of the district for both census years (2001 & 2011). For those districts, whose population is not available for the census 2001, we have taken the population proportion from the latest census report in which the same district was available.
- **c.** Calculating annual differences in the population proportion between the two census years
  (2001 & 2011).
- **d.** Assessing the population proportion of the districts for the projection period (2012-2031).
- **e.** Multiplying the population proportion of districts for the projection period (2012-2031) with the population of the corresponding State/UT for the respecting years to arrive at the projected population for the districts.

As far as the three variants of the ratio methods are concerned, first three steps and fifth step are same. The difference lies in the fourth step, i.e., assessing the population proportion of the districts for the projection period. The same has been described as following. In ratio method-1, we calculate the projected population proportion for the years 2012-2021 (10 years) by adding the annual difference observed during 2001-2011 and considered constant from 2021 to 2031. In ratio method-2, we calculate the projected population proportion for the years 2012-2016 (5 years) by adding the annual difference observed during 2001-2011 and considered constant from 2016 to 2031. In ratio method-3, we take the population proportion of the districts for the latest census (2011) and considered the same as constant throughout the projection period (2012-2031). Here, ratio method 1 for Karnataka, Kerala, and Puducherry, whereas ratio method 3 for Tamil Nadu was used for future projection of population (Dhar, 2022).

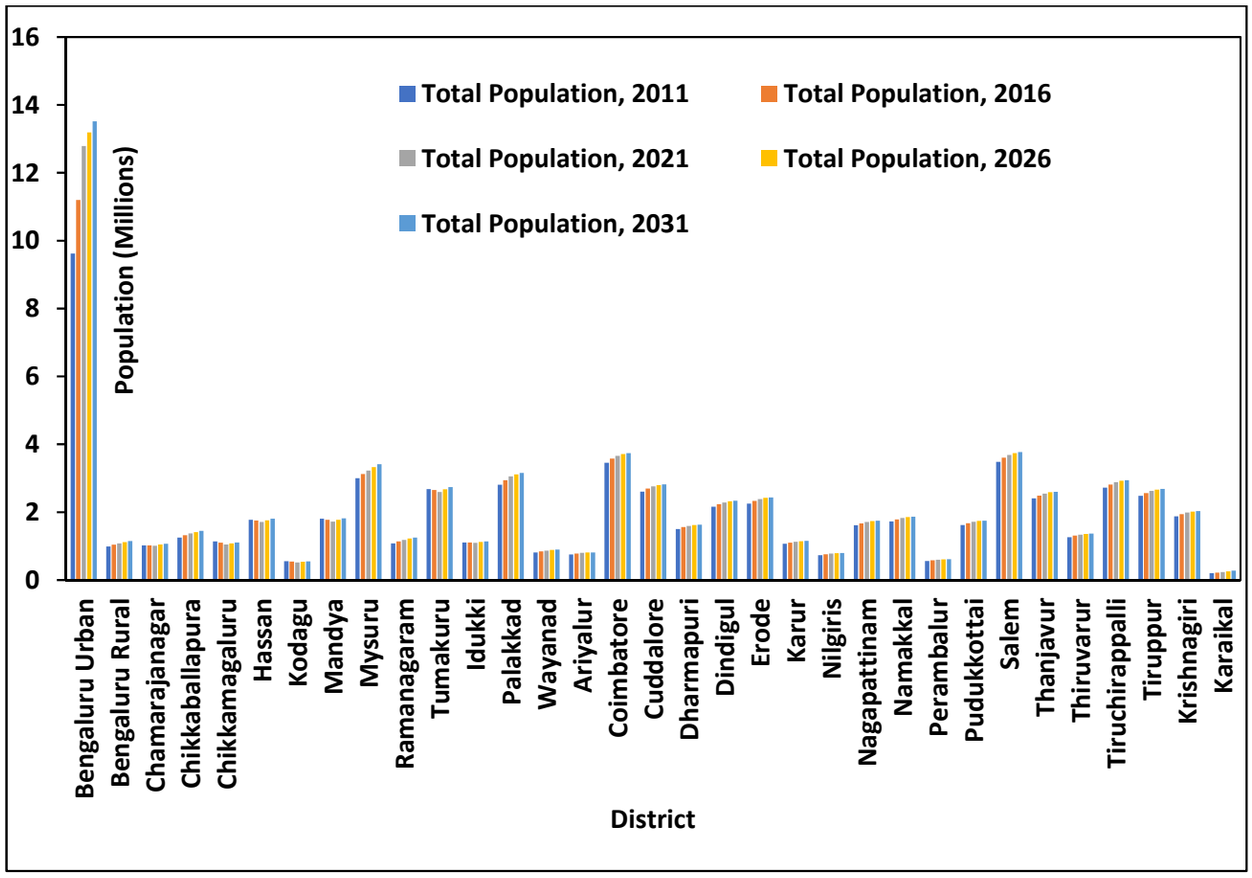

Figure 28. District-wise future population projection in the Cauvery River basin

7. Findings and Summary

Administrative delineation and granular demographic analysis across multiple administrative strata (State, District, Tehsil, and Village levels) within a river basin are pivotal for optimizing river basin management. These factors enable a nuanced understanding of population distribution, density gradients, and growth trajectories, as well as the socio-economic attributes of the inhabitants. Such comprehensive data sets facilitate the identification of zones with elevated population pressure, assessment of resource demand, and evaluation of anthropogenic impacts on hydrological systems. Detailed demographic parameters including age structure, sex ratio, household statistics, health indicators, educational attainment, and employment distribution offer critical insights into the community's resilience and capacity to implement water management strategies and adapt to environmental changes. Furthermore, metrics such as mortality rate, life expectancy, and migration trends are essential for forecasting population dynamics and future resource requirements. Projections and scenario-based analyses of these demographic variables are crucial for designing sustainable water use frameworks, planning infrastructure development, and informing policy-making processes. Integrating these demographic and administrative dimensions allows river basin managers to devise targeted strategies that ensure equitable resource allocation, mitigate conflicts, and support socio-economic development within the basin. The importance of this demography report in river basin management can be summarized as follows:

a) Administrative Delineation

- Provides a clear framework for managing resources across different administrative levels (e.g., state, district, tehsil, and village).
- Facilitates coordination and decision-making among multiple governance units within the river basin.

b) Distribution and Density of Population

- Helps identify areas with high population pressure and assess the demand for water resources.
- Guides resource allocation and management strategies to balance population growth with sustainable water use.

c) Population Growth Trends

- Allows for forecasting future water demand and planning infrastructure accordingly.
- Supports long-term management and policy development to accommodate demographic changes.

d) Demographic Characteristics

- Age distribution, sex distribution, and household statistics provide insights into population structure and resource needs.
- Helps determine community capacity to implement and adapt to water management strategies.

e) Socio-Economic Characteristics

- Information on employment, occupation, and income levels helps understand the socio-economic factors influencing water use and dependency.
- Supports equitable and targeted interventions for socio-economic development within the basin.

f) Population Health and Education

- Data on health (mortality rate, life expectancy) and education levels indicates community well-being and development needs.
- Informs the design of strategies to improve health and education, thereby enhancing community resilience to water-related challenges.

g) Migration Trends

- Analysing migration patterns helps anticipate changes in population distribution and potential impacts on water demand and availability.

- Enables proactive planning for resource management and infrastructure development in areas experiencing high migration.

h) Employment and Occupation

- Understanding employment patterns informs the assessment of water use in various economic sectors, such as agriculture and industry.
- Supports planning for economic growth without compromising water sustainability.

i) Future Projections and Scenarios

- Provides a basis for scenario analysis and forecasting to anticipate future water demand and challenges.
- Helps in developing adaptive management strategies that can accommodate various demographic and environmental scenarios.

j) Policy and Management Implications

- Facilitates evidence-based policy formulation and stakeholder engagement.
- Ensures the development of inclusive and sustainable water management strategies that consider demographic and socio-economic complexities.

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