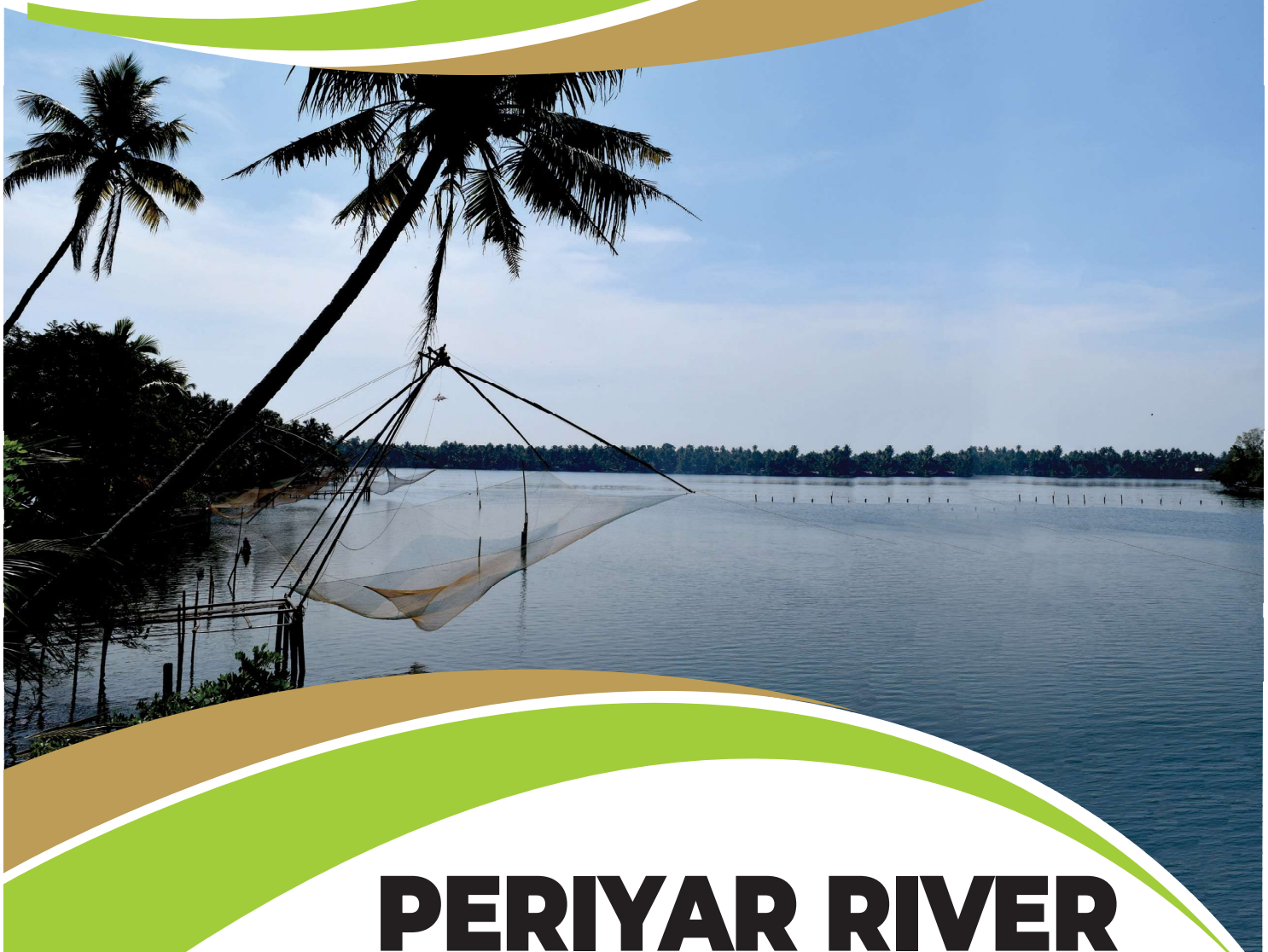
सत्यमेव जयते

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



PERIYAR RIVER AT A GLANCE

Version - 2

MARCH 2025

IIT PALAKKAD

cPeriyar

NATIONAL INSTITUTE OF TECHNOLOGY CALICUT

Centres for Periyar River Basin Management Studies

ganga

INDIAN INSTITUTE OF TECHNOLOGY KANPUR

Centre for Ganga River Basin Management and Studies

PERIYAR

RIVER AT A GLANCE

Version - 2

Centres for Periyar River Basin Management Studies

Centre for Ganga River Basin Management and Studies

National River Conservation Directorate (NRCD)

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

www.nrcd.nic.in

Centres for Periyar River Basin Management Studies (cPeriyar)

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

www.cPeriyar.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 IIT Palakkad (Lead Institute) and NIT Calicut(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

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

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सत्यमेव जयते

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Minister for Jal Shakti
Government of India

संदेश

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

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

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

सीआर पाटील

सत्यमेव जयते

जल शक्ति राज्य मंत्री
भारत सरकार, नई दिल्ली

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

संदेश

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

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

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

डा. राज भूषण चौधरी

PREFACE

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

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

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

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

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

cPeriyar and cGanga

CONTENTS

LIST OF ABBREVIATION

BDW	:	Biodegradable Domestic Waste
BPCL	:	Bharat Petroleum Corporation Limited
CAMP	:	Condition Assessment and Management Plan
CCT	:	Computer Compatible Tape
CESS	:	Centre for Earth Science Studies
CIAL	:	Cochin International Airport Limited
COD	:	Chemical Oxygen Demand
CORL	:	Collective for Right to Live
CWRDM	:	Centre for Water Resources Development and Management
ERE	:	Extreme Rainfall Event
IFM	:	Integrated Flood Management
IMD	:	Indian Meteorological Department
IRS	:	Indian Remote Sensing
ISMR	:	Indian Summer Monsoon Rainfall
KINFRA	:	Kerala Industrial Infrastructure Development Corporation
KLD	:	Kiloliters per Day
KSDMA	:	Kerala State Disaster Management Authority
KSEB	:	Kerala State Electricity Board
KSPCB	:	Kerala State Pollution Control Board
KWA	:	Kerala Water Authority

1. INTRODUCTION - PERIYAR

Periyar ('Peri' – Big, 'Aar' – River), is the longest river in Kerala with a length of 260.7 km and the second largest river basin in the state. The Periyar river basin has an area of 5216 km^2. The catchment area covers 5085 km^2 in Kerala and the remaining 131 km^2 in the Anamalai hills of Tamil Nadu. The Periyar River has the largest discharge capacity in Kerala (Kerala State Gazetter, 1986). It is one of the few perennial rivers in the area, providing drinking water to several populations. Periyar discharges its water into the Arabian Sea in Cochin, and is having a significant impact on Kerala's economic prospects. It provides a substantial portion of Kerala's electrical power through the Idukki Dam and flows through an area of industrial and commercial activity. It also provides domestic water supply, irrigation, tourism, industrial production, collection of various inorganic resources and fisheries.

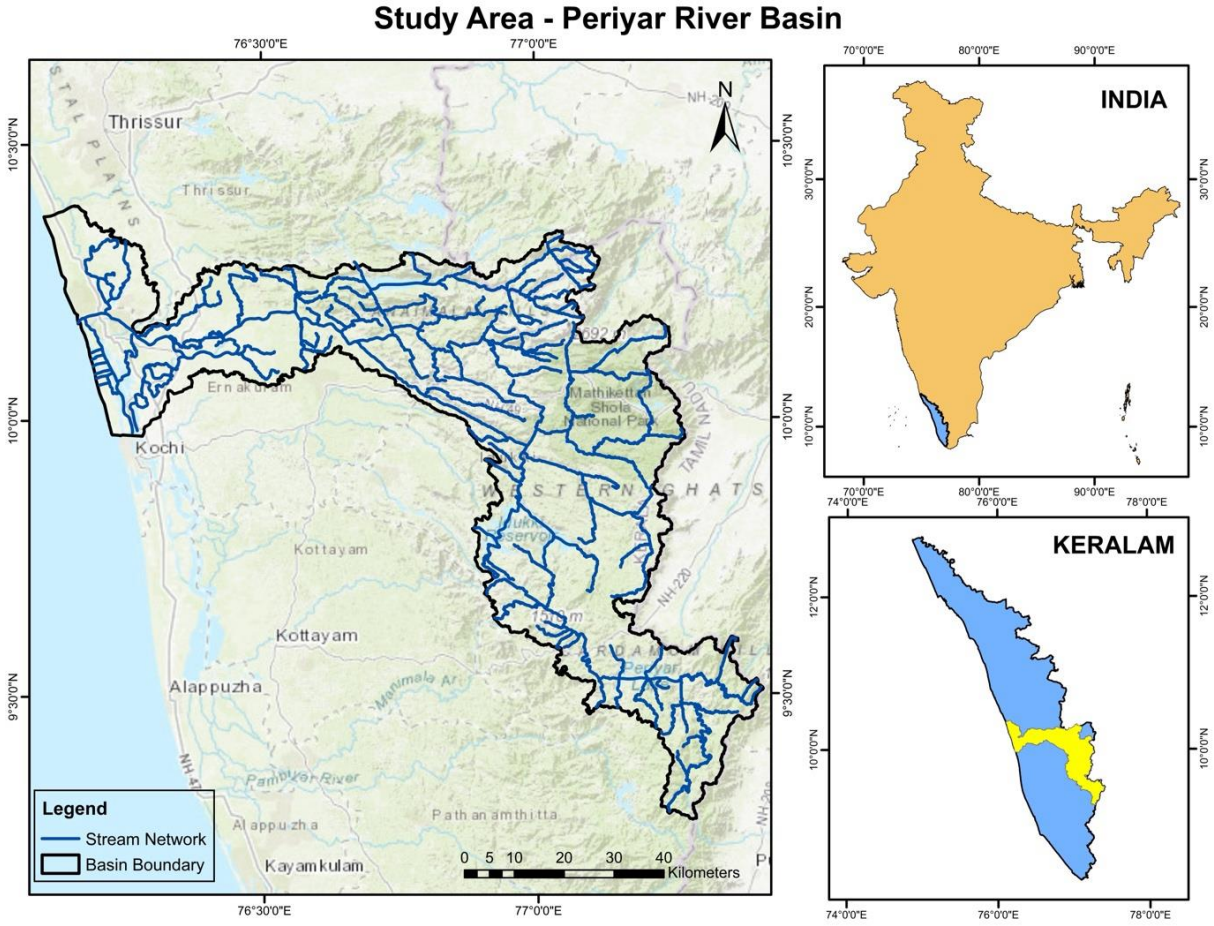

Fig. 1 Boundary of Periyar Basin

The Periyar is an eighth-order stream with a well-developed tributary network. The river flows from the Western Ghats, and the stream pattern and existence of structural troughs indicates tectonic activity in the region. The basin is environmentally vulnerable. Almost eighty percent of the total area in the high ranges is affected by erosion and mass movements (CESS Annual report, 2010). Anamudi, with an elevation of 2,695 m serves as the basin's highest point (Padmalal et al., 2008).

2. ORIGIN AND TRIBUTARIES

The Periyar originates from the serene forest of Periyar Tiger Reserve, known as the Sivagiri set of hills (Chokkampatti Malai), at an elevation of 1830 m from Mean Sea Level. After flowing approximately 53 km, the river is joined by its first tributary, the Mullayar River. The river continues to flow in the northerly direction and joins with the major tributary Muthirapuzha coming in the opposite direction. Later, Idamalayar joins Periyar near Neriamangalam. After Neriamangalam, the river flows towards the Bhoothathankettu Barrage. The reservoir at Bhoothathankettu is the source of irrigation under the Periyar Valley Irrigation Project. The river course in this part is mostly through forested areas. The river traverses the hilly terrains of Idukki district and, near Karimanal, passes the district boundary and enters Eranakulam District. The river then meanders through Malayattoor, and flows for about 23 km, passing through Kalady and Aluva. At Aluva, the river bifurcates into the Mangalapuzha branch and the Marthanada Varma branch. The stream network of Periyar River is shown in Fig. 2.

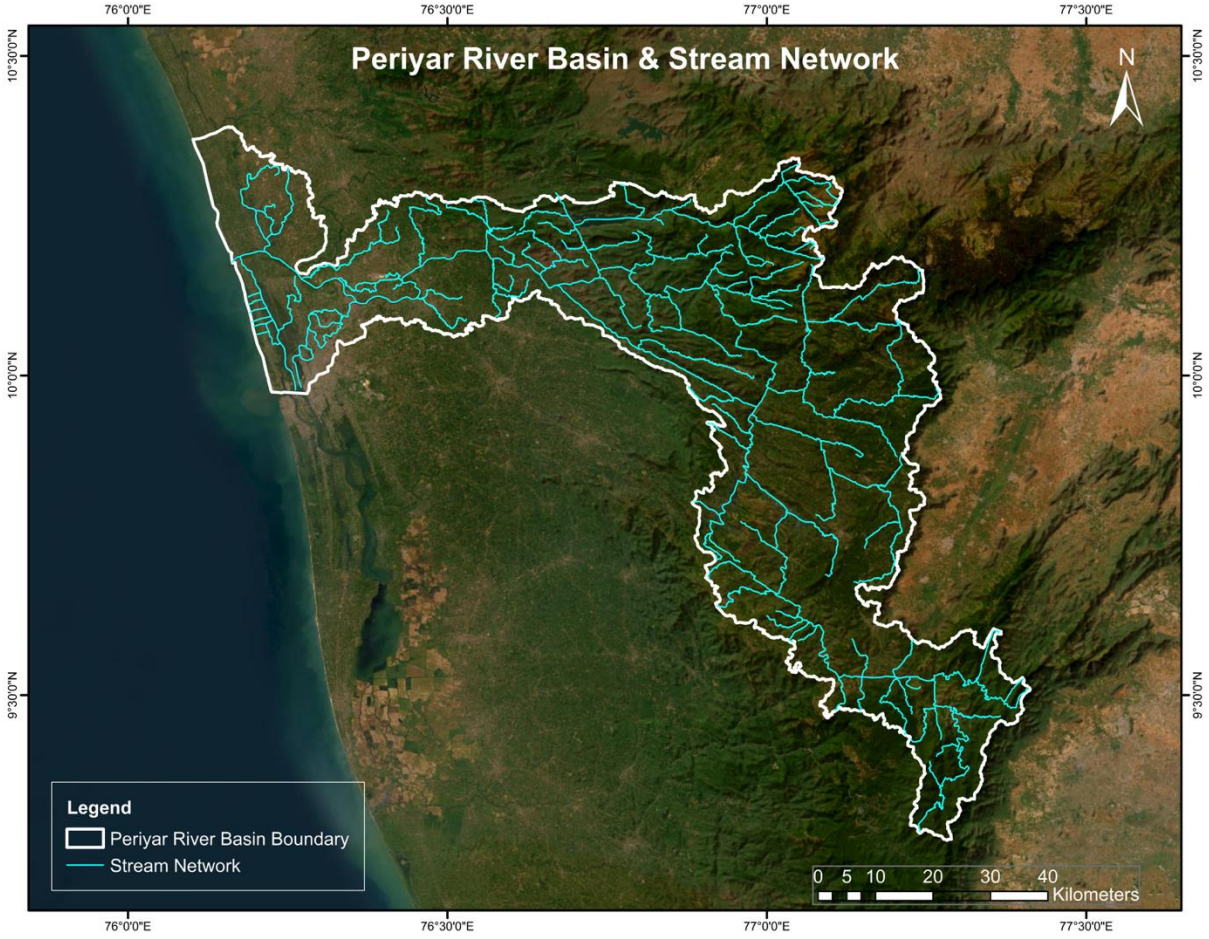

Fig. 2 Periyar Basin with stream network

The Mangalapuzha branch flows in the north-west direction and is joined by the Chalakudy River before finally draining into the Arabian Sea. The Marthanda Varma branch flows in the southern direction and divides into the Edamula branch and Eloor branch near the industrial belt at Eloor before discharging into the Vemabanad backwaters adjoining the Arabian Sea (KSPCB, 1981). Vembanad is the biggest wetlands system on India's west coast. After forming several islands, the

river finally flows into the Cochin estuary. The basin is inverted 'L' shaped, (Sudheer et al., 2019) with the intersection being its widest point. The river line diagram is shown in Fig. 3 & the details of the tributaries of Periyar is given in Table 1.

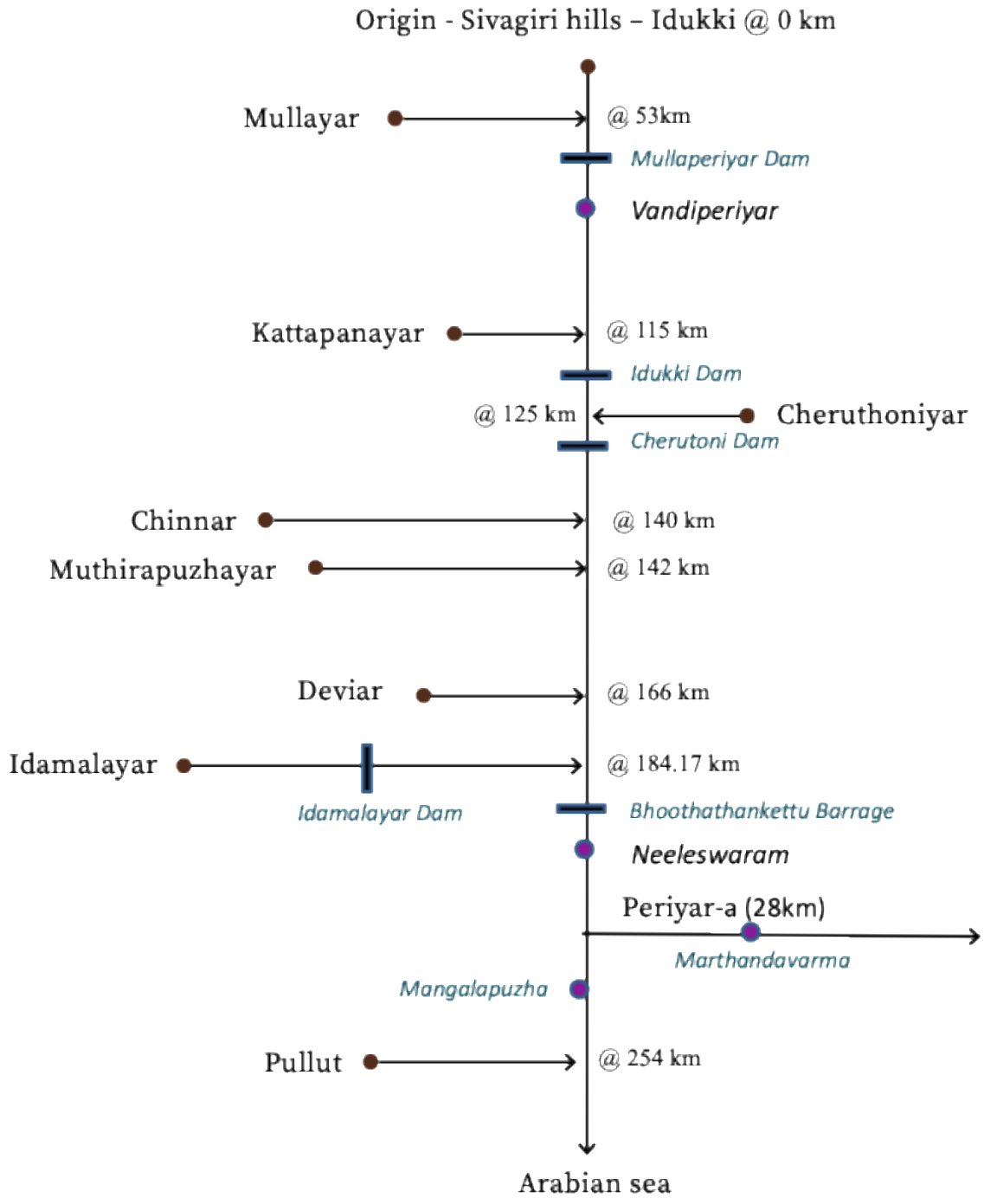

Fig. 3 River Line diagram – Periyar

Table 1 List of Tributaries of Periyar

No.	Name of River/Tributary	Place/District of origin	Place/district of confluence	Confluence into	Length (km)
1	Periyar	Sivagiri hills-Idukki	Munambam, Ernakulam	Arabian sea	244
2	Mullayar	Kottamalai peak (Periyar tiger reserve)- Idukki	Mullakudi- Idukki	Periyar	33.3
3	Kattapanayar	Cheyithanmala-Idukki	Anjuruli-Idukki	Periyar	20.56
4	Cheruthoniyar	Kottamala, Idukki	Vellakayam-Idukki	Periyar	26.78
5	Chinnar	Chakkupallam, Idukki	Periyar valley chappath, Idukki	Periyar	58.5
6	Muthirapuzhayar	Suriyanelli, Idukki	Panamkutty,Idukki	Periyar	57
7	Deviar	Western ghats, Adimali	u/s to Neriyamangalam, Idukki	Periyar	28.29
8	Idamalayar	Anamalai hills, Idukki	Bhoothathankettu, Ernakulam	Periyar	66.78
9	Pullut	Thrissur district	Kottappuram-Ernakulam district	Periyar	27.37

The Periyar river basin contains 17 dams, 15 of which are under the jurisdiction of KSEB and two of which are managed by the Irrigation Department. The important ones are Mullaperiyar, Idukki, Bhoothathankettu, and Edamalayar. The KSEB dams in the Periyar river basin, in addition to providing 1264.85 MW of power, also aid to manage river flow during dry seasons and prevent floods. The combined storage capacity of all dams on the Periyar River is 3278.70 Mm^3. Lift Irrigation Schemes features 136 lift irrigation systems, are the lifeline of agricultural activity in the Eranakulam district. These systems were designed to irrigate 58.78 km^2 of ayacut land. The largest dams are the Idukki-Cheruthoni-Kulamavu trio and the Idamalayar. The two largest irrigation projects in the watershed are the Periyar Valley Irrigation Project and the Idamalayar Irrigation Project. The major inter-basin water transfer from the basin occur through the Mullaperiyar Dam, which diverts water to the Vaigai River in Tamil Nadu. The tailrace discharge from the Idukki project is released into the Muvattupuzha River system. The major dams constructed on Periyar and their purposes are given in Table 2. The location of major dams within the basin are shown in Fig. 4. The RA Headworks and Mukkudil Dam are other minor dams in the basin.

Table 2 List of Major dams on Periyar River

Sl No.	Name	Length (m)	Purpose	Year of completion
1	Cheruthoni Dam	650.9	Hydro Power	1976
2	Kulamavu	385	Hydro Power	1977
3	Idamalayar	373	Hydro Power (Primary)	1987
4	Idukki dam	365.85	Hydro Power	1976
5	Mullaperiyar Dam	365.8	Hydro Power and irrigation	1895
6	Anayirankal	326.13	Hydro Power	1965
7	Ponmudy	288.8	Hydro Power	1965
8	Lower Periyar dam	284	Hydro Power	1998
9	Kundala	259.38	Hydro Power	1947
10	Mattupetty	237.74	Hydro Power	1956
11	Bhoothathankettu	210.92	Irrigation	1980
12	Kallarkutty	182.88	Hydro power	1961
13	Erattayar	146.30	Hydro Power	1975
14	Sengulam	143.26	Hydro Power	1957
15	Kallar	57.91	Hydro Power	1975

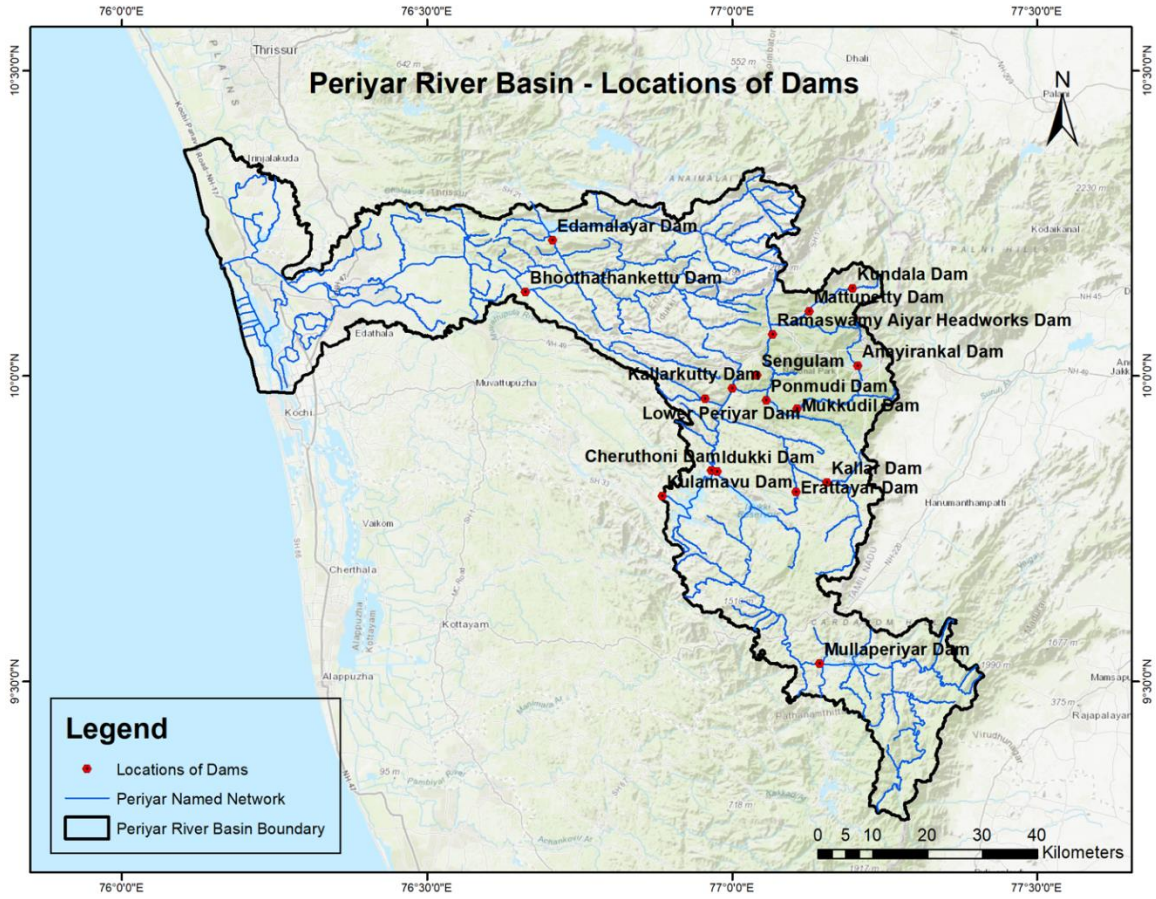

Fig. 4 Location of Major dams in the basin

The CWC has two discharge measuring locations in the basin, one located at Vandiperiyar & the other at Neeleswaram. The locations of these stations are shown in Fig 5. The water quality monitoring locations by the Central Pollution Control Board is given in Fig. 6. The station code and location of the CPCB water quality monitoring locations are given in Table 3.

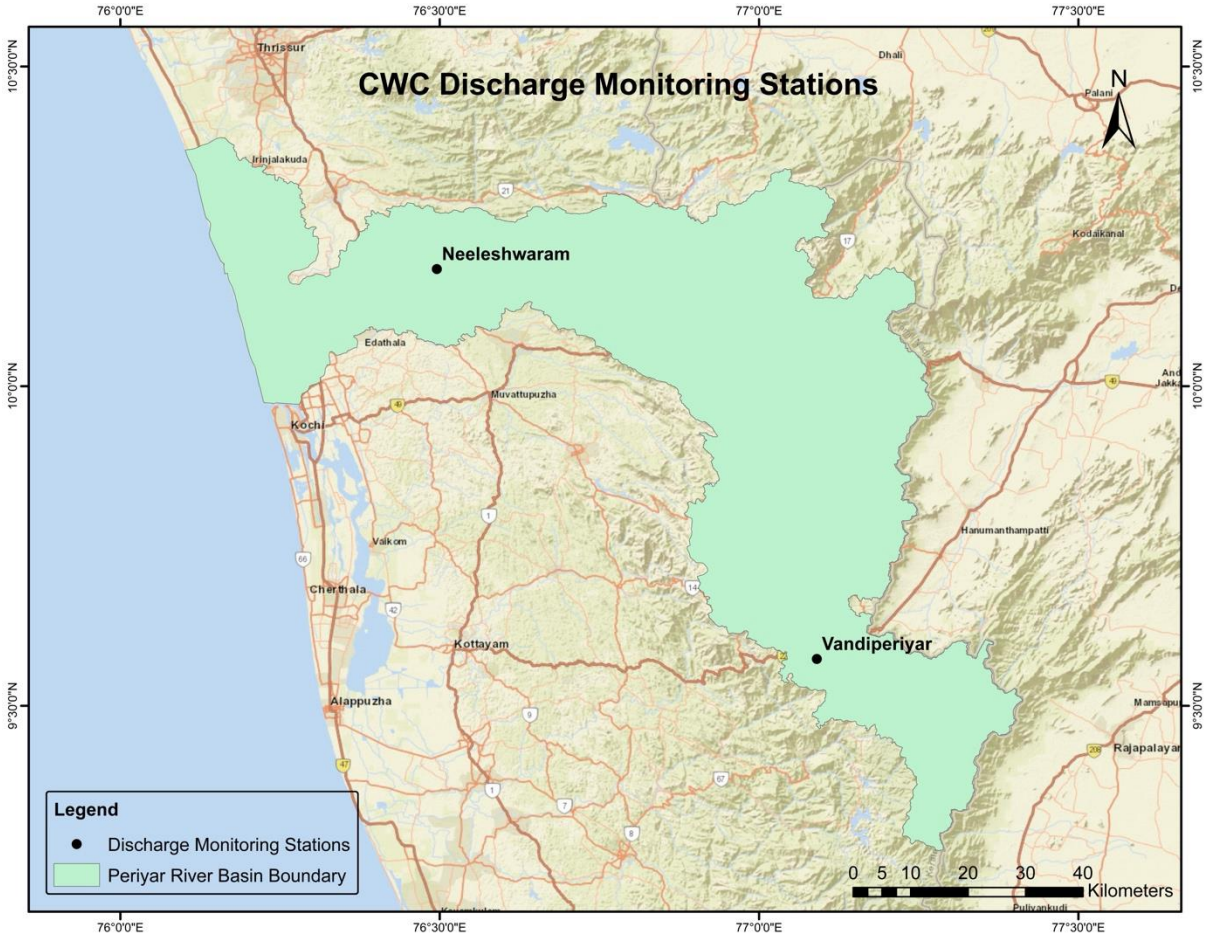

Fig.5 Location of CWC Monitoring stations

Table 3 CPCB Water Quality Monitoring locations in Periyar Basin

Label	Station	Label	Station
1	Aluva- Eloor	9	Pathalam(Vettukadavu)
2	Kalady	10	Kalamassery
3	SDP Aluva	11	Unthithodu at Eloor
4	Thekkady	12	Palakkatuthazhamthodu
5	Kodungalloor	13	Goshree bridge
6	Bhoothathankettu	14	Azhikode ferry, Kodungallur
7	Edamalayar	15	Kulamavu Resevoir
8	Muppathadam	16	Panamkutty bridge
		17	HMT colony

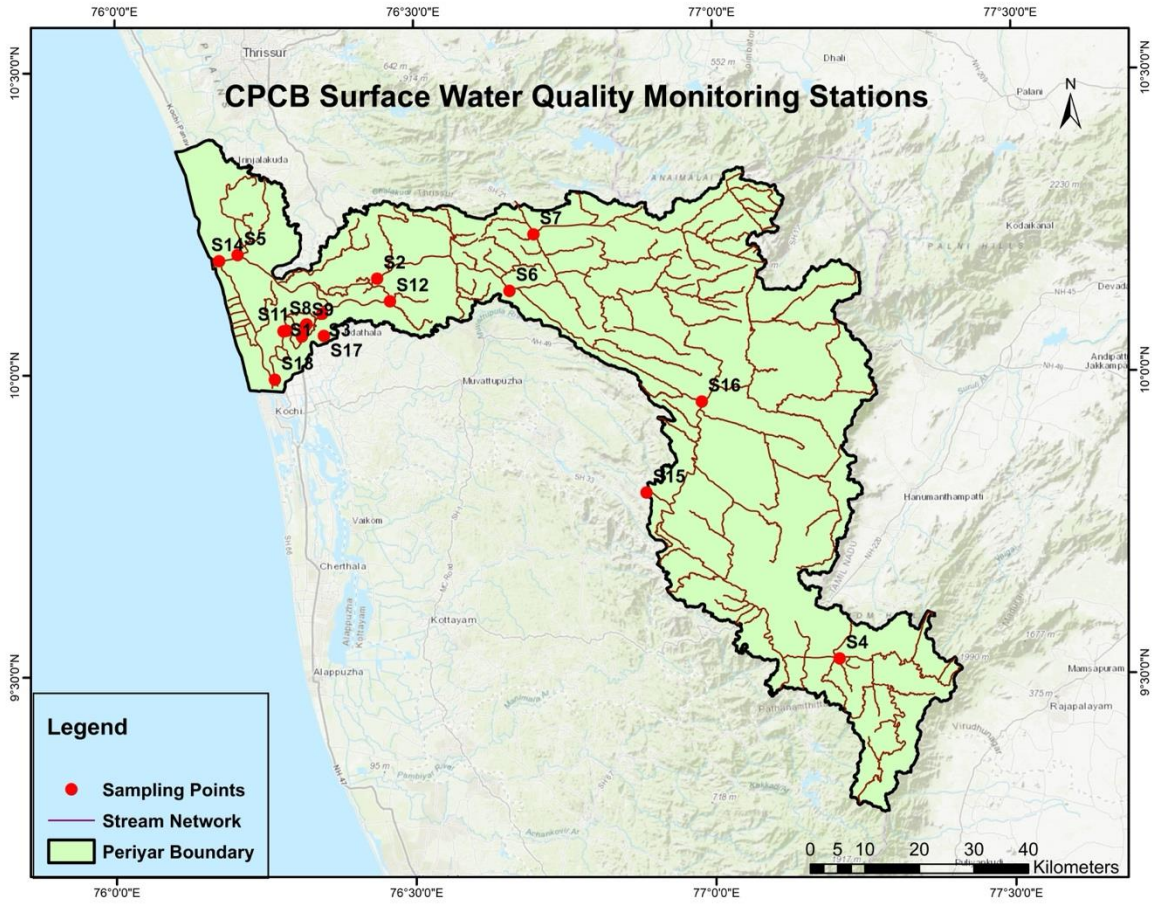

Fig.6 Location of CPCB Water Quality Monitoring stations

3. SOIL CHARACTERISTICS OF THE BASIN

The soils of the Periyar river basin are classified into six major types.

- Lateritic soil
- Hydromorphic soil
- Brown hydromorphic soil
- Riverine Alluvium
- Coastal alluvium
- Forest loam

Lateritic soils are the primary soil type in the midland area. Brown hydromorphic soil is usually found in valley bottoms with undulating terrain in the midland. They are produced by the deposition of material from surrounding hills and slopes. The majority of the upland is covered in forest loam, with an organic-rich top layer. Riverine alluvium is found mostly along river channels and tributaries. Coastal alluvium is thought to originate from marine and estuarine processes (Reconnaissance Survey Report, 2019). The soil map of the river basin is presented in Fig. 7.

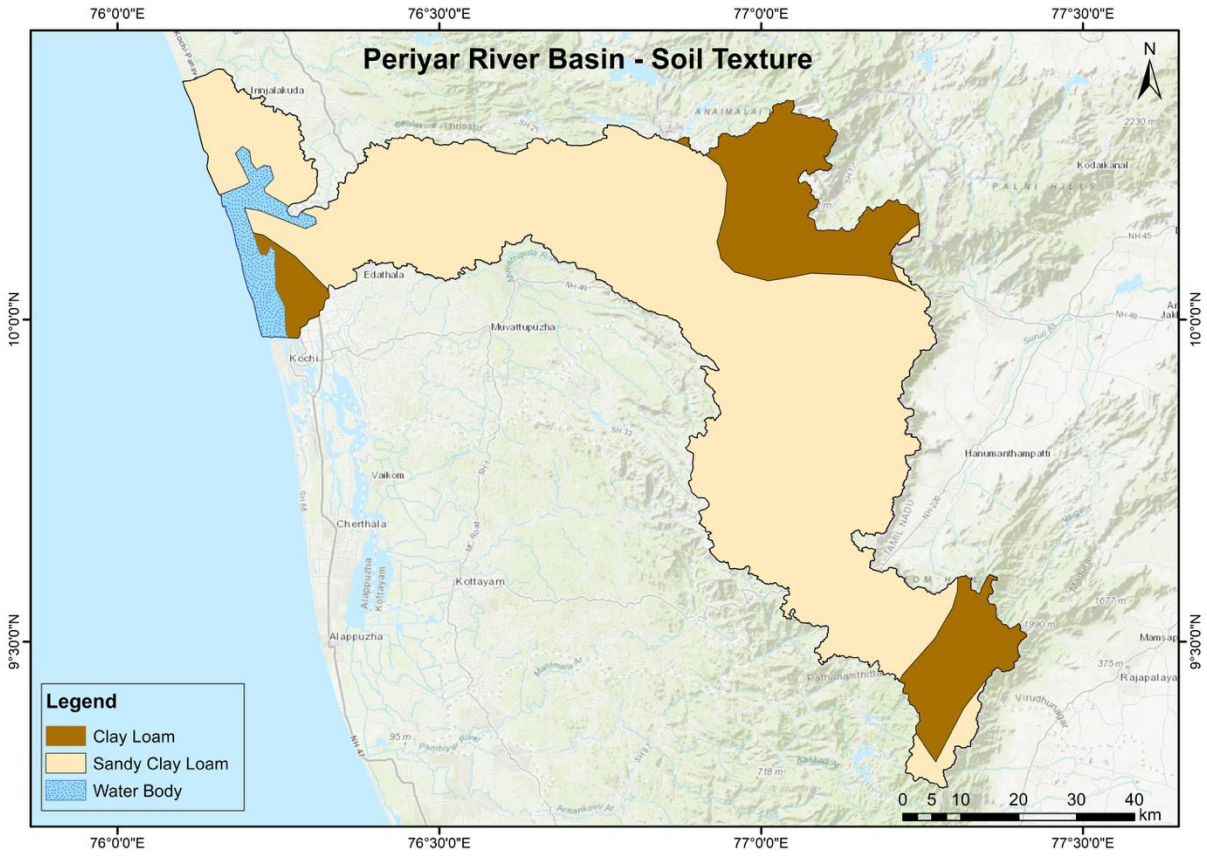

Fig. 7 Soil map of the basin

Sandy clay loam soils are dominant in the Periyar River Basin, covering about 80% of the area. These soils are primarily located in the central and north-western parts of the basin. Clay loam soils, which cover about 20% of the Periyar River Basin, are found in several key areas, including the north-eastern and south-western parts of the basin. The percentage distribution of various size fractions in clay loam indicate regions with a balanced mix of clay, silt, and sand, providing good drainage and nutrient retention. These soils are generally fertile and support a variety of crops, making these areas suitable for agriculture. With a higher proportion of sand compared to clay loam, it exhibits good drainage and has moderate water-holding capacity. These properties make it ideal for crops that require good aeration and do not need excessive moisture.

4. CLIMATE OF THE REGION

The Periyar basin has a typical tropical humid climate. The high altitude region of this basin has a moderate climate. Rainfall is received between two seasons of the South West and the North East Monsoons. The annual rainfall varies from less than 1000 mm to more than 5000 mm with an average of about 3000 mm. The South West Monsoon (June-August) accounts for 60% of rainfall in the basin, followed by the North East Monsoon (September-November) at 25%.

The period from March to May is the hottest with temperature reaching more than 32˚C and the lowest temperature are experienced during the months of December and January. Temperature is minimum in the month of July, when the State receives plenty of rainfall and the sky is cloudy.

Wind velocity, like rainfall, is monsoon-dependent. The North East and South West monsoons show unique patterns. During the SW monsoon, wind directions are stable from the North West quadrant, but unpredictable throughout the remainder of the time. During the South West monsoon, wind speeds range from 5 to 25 km/h, while the North East monsoon ranges from 5 to 18 km/h (Divya et al. 2021).

5. BASIN DEMOGRAPHY

The Periyar River Basin encompasses four districts - Thrissur, Ernakulam, Idukki in Kerala, and Coimbatore in Tamil Nadu. The basin has 81 villages, 75 towns, and 15 taluks. The sole municipal corporation in the basin is Kochi, located in Ernakulam district. According to the 2011 census, the Periyar River Basin has a total population of 3,716,550, consisting of 1,821,873, males and 1,898,497, females. The female population in the Periyar Basin is higher than the male population.

The basin encompasses of 15 taluks or sub-districts and the 2011 population data reveals that Paravur taluk in Ernakulam district has the highest population in the basin, with 6,61,766 people, accounting for 17.8% of the basin's total population. This high population density is largely due to Paravur's proximity to urban centres like Kochi, offering enhanced access to employment, education, healthcare, and developed infrastructure that attracts residents. Following Paravur, Kanayannur taluk in Ernakulam has a population of 4,75,808, making up 12.8% of the basin's population, and Aluva taluk, also in Ernakulam, hosts 4,68,408 people, representing 12.6% of the basin's population. Conversely, Chavakkad taluk in Thrissur district is the least populated sub-district in the basin, with only 54,643 people, contributing 1.4% to the total population.

6. LANDUSE OF THE BASIN

The largest portion of the basin includes vegetation comprising evergreen forest, deciduous forest, degraded forest and scrub. Approximately 72.8% of the total basin area (3796.81 km^2) comes under vegetation cover. The Periyar basin's forests are classified as wet-evergreen, semi-evergreen, moist-deciduous, dry-deciduous, and pure reed areas. According to the IRS (LISSII) CCT data, 30% of the area is dense in vegetation (more than 75% canopy coverage), 50% is medium (35-75%), and the remaining is low (CWRDM, 1993).

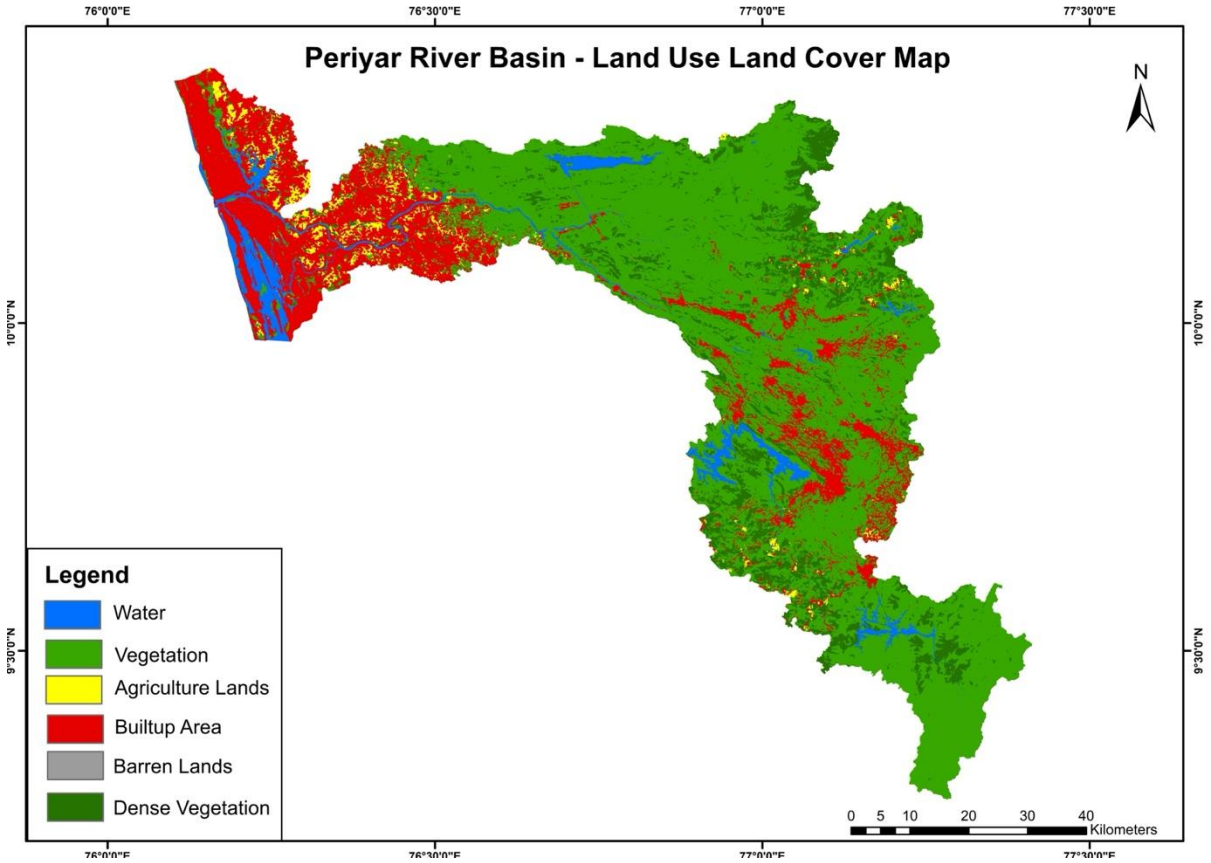

Fig. 8 LULC of the Periyar Basin (ESRI, 2023)

The upper reaches of the river basin (Udumpenchola, Peerumedu, and Devikulam) have been converted to plantations such as tea, coffee, cardamom, and rubber. This region contributes the majority of the state's cardamom and tea production. Rice, coconut, areca nut, banana, rubber, and vegetables are among the most often grown crops in the river basin. The built-up land covers 1057.78 km^2, comprising 20.28% of the total basin area. Water Bodies cover up 241.61 km^2 of the basin area and have a percentage share of 4.63% of the total basin area. Water bodies, residential units, and industrial sectors account for the majority of non-agricultural land use. The principal crops grown in the midland region are paddy on the flood plains, coconut, and other mixed crops in the valleys, and rubber on the mountains and hill slopes. The agricultural and cultivated area within the basin comprises 119.57 km^2 and covers 2.29% of the total basin area. The primary cultivation of the lowland region includes paddy, coconut, and other mixed crops (Balakrishnan, 2009).

7. INDUSTRIES

Angamaly to Kochi is the most industrialised area in the Periyar river basin. This region has about 50 large and medium industries, as well as 2500 small-scale industries. The point sources of pollution from industries and domestic waste dumps are shown in Fig. 9 (Room for River, 2022).

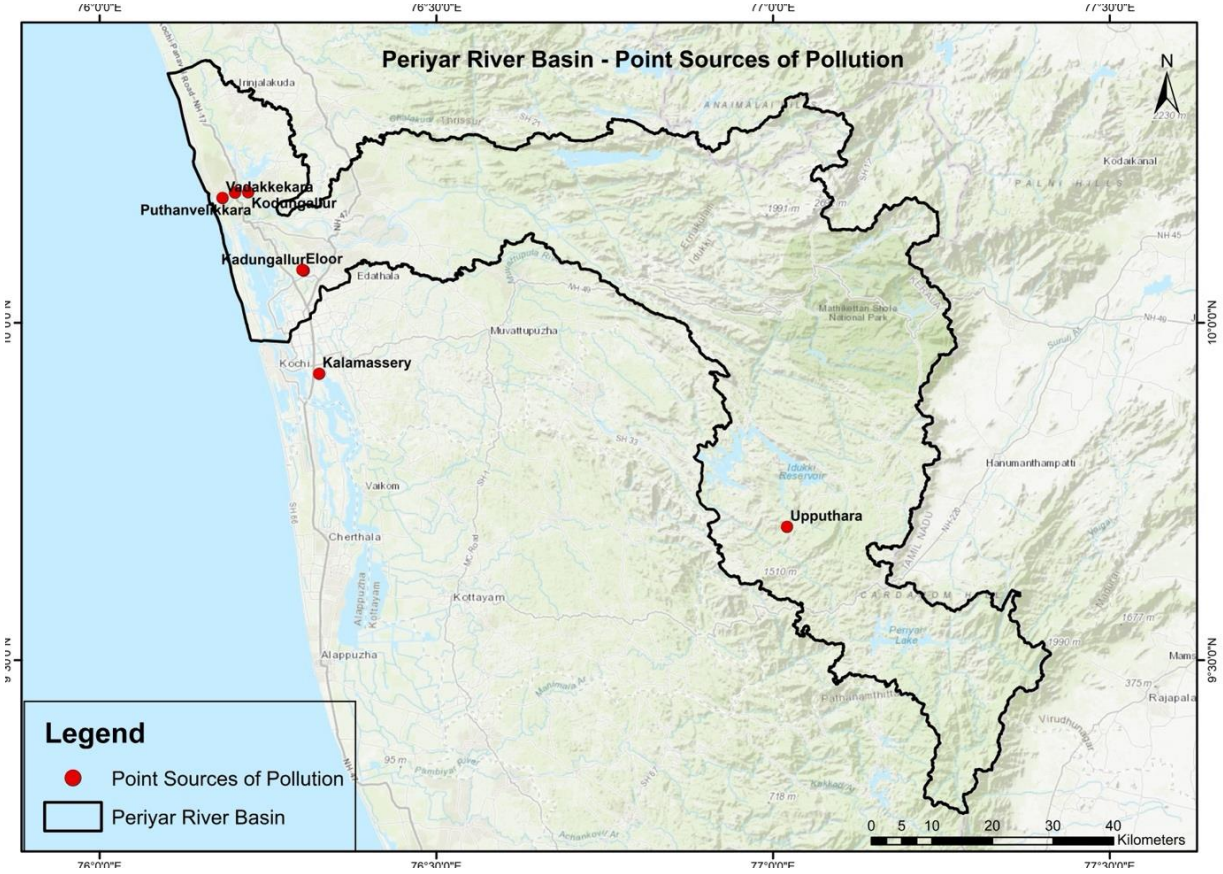

Fig. 9 Sources of Pollution in the Periyar Basin (Including domestic & industrial waste)

The major types of these industries are fertilisers, pesticides, chemicals and allied industries, petroleum refining, heavy metal processing, radioactive mineral processing, rubber processing units, animal bone processing units, battery manufacturers, mercury products, acid manufacturers, pigment, latex producers etc. The wide spectra of pollutants that adversely affect the natural environmental quality of the water of the river include toxic and hazardous materials such as heavy metals, phenolics, hydrocarbons, pesticides, radionuclides, ammonia, phosphates, domestic and untreated waste water etc.

8. HUMAN DEPENDENCY

The Periyar River basin is home to several indigenous tribal communities, including the Mannans, Palians, Uralis, Mala-arayas, and Malampandarams. These tribal groups have lived in the region for centuries, maintaining a close connection with the natural environment of the Periyar Tiger Reserve and surrounding areas. The six tribal communities are Mannan, Paliyans, Malayaryas, Uralis, Ulladan and Malampandarams. Indigenous groups (Mannans, Uralis, Paniyas, Malayar, and Malampandarams) rely on shifting agriculture, fishing, honey, and non-timber forest produce for survival. The tribal groups are found in Adimali, Bison Valley, Vellathuvel, Konnathadi, Munnar, Senapathi, Udumpanchola, Nedumkandam, Kanchiyar, Pampadumpara, Kattapana, Irattayar, Vazhathoppu, Vathikudi, Kanjikuzhi, Kumily, Ilamdesham, Azhutha, Upputhara, Velliyamattom, Vannapuram, Ayyapankovil, Vandanmedu, Peermade, Chakkupallam and Karimkunnam grama panchayaths of Idukki district.

Farmers in the midland belt grow paddy, coconut, and plantain, while those in the foothills cultivate rubber, coconut, and pepper. Riverside villages harvest high-value fin fish and shellfish. Artisanal fishing in the Periyar River leads to overfishing of fish species like Horabagrus brachysoma. The Vembanad lake at the river mouth is crucial for a vast population's survival and livelihood. Fisheries in this region provide a primary source of income for thousands of households. The Periyar River provides several benefits to the Idukki and Eranakulam districts of Kerala, including electricity generation, drinking water, agricultural and industrial growth, inland navigation, tourism promotion, and sand for construction. The Periyar River serves as the source of water supplies for significant towns such as Cochin, Aluva, Perumbavur and Parur. The river provides water to rural regions in Panchayats Maradu, Mulanthuruthy, Kadamakudy and Udayamperur. The residential supply serves a population of 32.27 lakhs with a daily consumption of 520 Million Litres (Latha & Vasudevan, 2016).

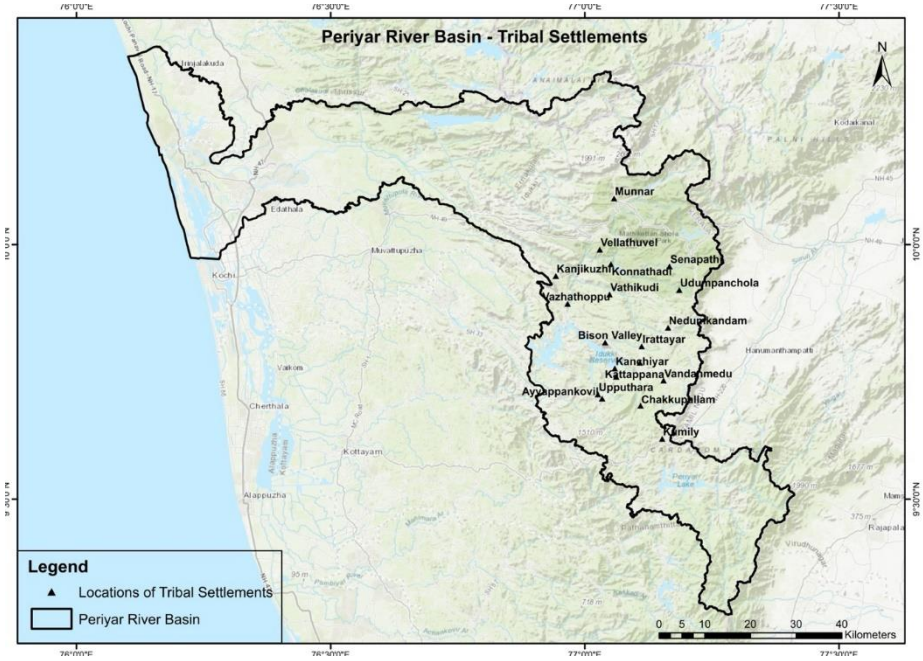

Fig. 10 Major tribal settlements within the basin

9. ECOLOGICAL SIGNIFICANCE & BIODIVERSITY

Wet evergreen woods dominate the Periyar Tiger Reserve (PTR), extending west into the Pamba valley and south into the forests of Achankovil Division. Within the Periyar Tiger Reserve, south of the Mullaperiyar reservoir and near the origin of the Periyar River, lies an uninterrupted tract of protected, untouched rainforests. The rainforests stretch west into the Pamba valley of the Gudarakal Forest Range and south to the Achankovil Division, covering approximately 600 to 700 km^2. The Periyar Tiger Reserve is one among the India's most environmentally significant locations. This region is a home to 1,966 of Kerala's estimated 3,800 angiosperm species (KWA, 2019). The reserve has an estimated 323 bird species, 38 fish species, and 44 reptiles. There were around 84 fish species found across the Periyar River. The ecologically significant areas within the basin is shown in Fig. 11. In the Shola grasslands of the river basin, endemics include the Nilgiri Tahr (Hemitragus bylocrius) and Habenaria periyarensis orchid. The Periyar lake-stream system supports endemic species. Native fish species such as Tor Khudree, Gonoproktopterus Curmuca, and Lepidopygopsis typus share a significant percentage of their food with invasive species like Tilapia (Oreochromis mossambicus) and Common carp (Cyprinus carpio).

Thattekad Species Sanctuary is an evergreen low-land forest located in the basin of Periyar River. It has been renowned since Salim Ali's time as a shelter for the Ceylon frogmouth, an endemic bird. The Ramsar Convention recognises the Vembanad lake, which drains into Periyar, as a wetland of worldwide importance for conservation and sustainable use. The Vembanad lake, has the third-largest population of waterfowls in India (Latha & Vasudevan, 2016).

Significant species within the Periyar River Basin

<table>
<tr>
<td> 
Nilgiri Tahr</td>
<td> 
Great Hornbill</td>
<td> 
Nilgiri Langur</td>
</tr>
<tr>
<td> 
Lion-tailed macaque</td>
<td> 
Bicoloured frog / Malabar Frog</td>
<td> 
Malabar flying frog</td>
</tr>
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Malabar glad-eye bushbrown

Strobilanthes kunthiana

Syzygium periyarensis

Source: wwwfindia.org, inaturalist.org, wikepedia.org

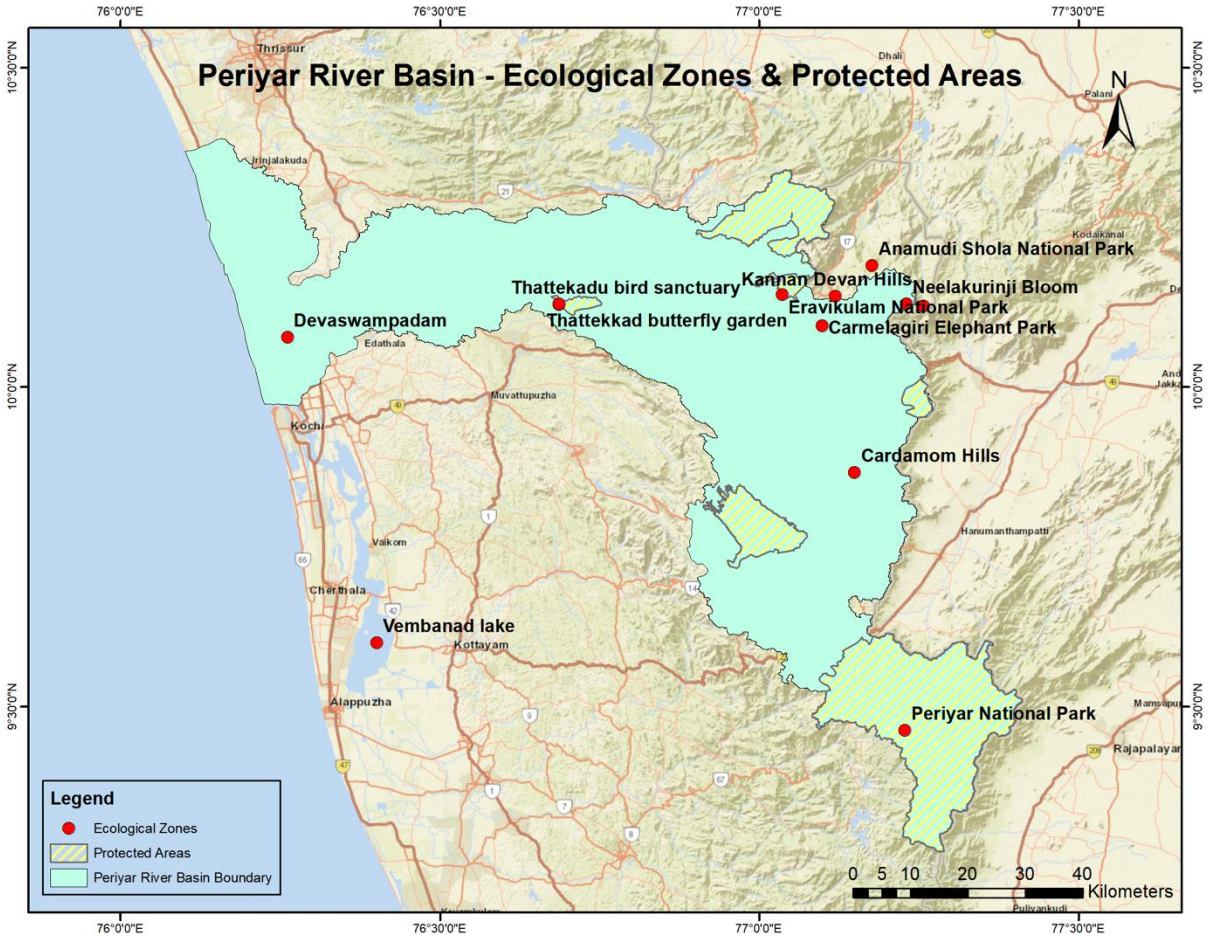

Fig. 11 Protected areas and ecologically significant locations within the Basin

9.1 Fish Diversity

Rivers are usually home to a diverse range of fish species. Chacko (1948) enlisted the fishes of Periyar Lake. A similar study (Arun, 1998) revealed the extinction of 16 fish species from the same aquatic system over a period of 50 years. Eels, catfish, goby, and cyprinids are among the species that have disappeared. According to Arun (1998), the presence of 56% of Kerala's endemic fishes in the Periyar lake and river system makes it a distinct and diversified ichthyofaunal habitat in

South India. Ponniah & Gopalakrishnan (2000) under the NBFGR, listed all 287 freshwater fish species present in the Western Ghats, including those in Periyar waters. After identifying several indigenous species, it was recommended to designate the upper reaches of Periyar as a potential fish sanctuary among other centres. The authors states that the restriction of Mullayar-Periyar streams by the dam's construction in 1895 may have halted the free upstream-downstream movements of many catadromous and anadromous fishes, including eels. Periyar's forest streams and reservoirs are home to many vulnerable or endemic fish species with high conservation status.

10. HISTORICAL AND CULTURAL SIGNIFICANCE

Historical records suggest that the Aluva Palace was once used as a residence by the royal family of Travancore. Situated along the banks of the Periyar River, it silently preserves a rich and eventful history. The palace is believed to have been constructed around the 1790, during the reign of the Chera kings of Travancore. Today, the palace is managed under the care of the Kerala state government since the passing of King Chithira Thirunal Balarama Varma in 1991. There are also mythological stories associated with the structures in the Periyar Basin. According to the stories, long ago demons attempted to drown the Trikkariyoor temple of Lord Shiva by damming the Periyar river and flooding the surrounding area. However, Lord Shiva sensed the deceit and wanted to test it. Thus, he created a sound similar to a rooster's crowing to indicate the impending dawn. Fearing the arrival of light, the devils abandoned their task. The "Old Bhoothathankettu" is said to be the result of the demons rolling massive stones onto the riverbank. The barrage called "Bhoothathankettu", means "Monster Fort" was believed to be built by 'Monsters'.

The banks of Periyar river are home to several places of historical and religious significance. Some of the other culturally significant locations within the basin are Aluva Manappuram, Chendamangalam Synagogue, Aluva Mahadeva Temple, Mangala Devi Temple, Sita Devi Lake. Kalady, a town located on the Periyar river banks, is the birthplace of Shri. Adishankara, the renowned Hindu philosopher who consolidated the principles of Advaita Vedanta. It was also the place where he first performed the Aarattu ritual (Bath of an idol), a ceremonial river bath for his ancestral deity, before installing it in its current location. Another significant site is the "Muthala Kadavu" or Crocodile Ghat, which is where Shankara's life took the path of sannyasa. The renowned Aluva Sivarathri festival is celebrated on the banks of the Periyar River in Aluva. This temple festival takes place annually on Sivarathri day in the month of Kumbham, according to the Malayalam calendar. One of the widely accepted theories relates to the Hindu god Shiva drinking the Kalakoodam poison to save the world. The town's famous Sivarathri festival honours Shiva. When the Jewish community in lived Cochin in the twentieth century, several of them had vacation homes at Aluva on the banks of the Periyar river. It is also known as the "gateway to the East". Prior to India's independence, Aluva was part of the Kingdom of Travancore and served as the official summer residence for the royal family. The Malayatoor church is located at the top of the Malayatoor Hill. The church is consecrated to St. Thomas, who is believed to have prayed there. It is one of the most important Christian pilgrimages in Kerala, it draws large numbers of devotees from Kerala and neighbouring states.

Historically & culturally significant locations within the basin

 Aluva Mahadeva Temple	 Alangad Jumma Masjid	 Chendamangalam Synagogue
 St Thomas Church Malayattoor	 Bhoothathankettu	 Kalady
 Thrikkariyoor Mahadeva Temple	 Sitha Devi Lake	 Muthala Kadavu

Source: kerala tourism.org, wikepedia.org

11. SOCIAL & ECONOMIC SIGNIFICANCE

Periyar is a popular tourist destination due to its mountain ranges, exquisite lakes, and dense forests with diverse wildlife. The boating facilities in Thekkady lake, Bhoothathan reservoir, and nearby wildlife sanctuary draw visitors from all over the world. Tourism enhances income, employment, and government revenue. Ecotourism is a relatively recent concept in tourism that was inspired by the desire to live in harmony with environment. Thekkady's Periyar Tiger Reserve is one of Kerala's most popular ecotourism locations. Since 1981, it has been recognised as Periyar National Park, and its ecotourism development project has been well-known since 1996. The location of socio-economic-cultural locations are shown in Fig.12.

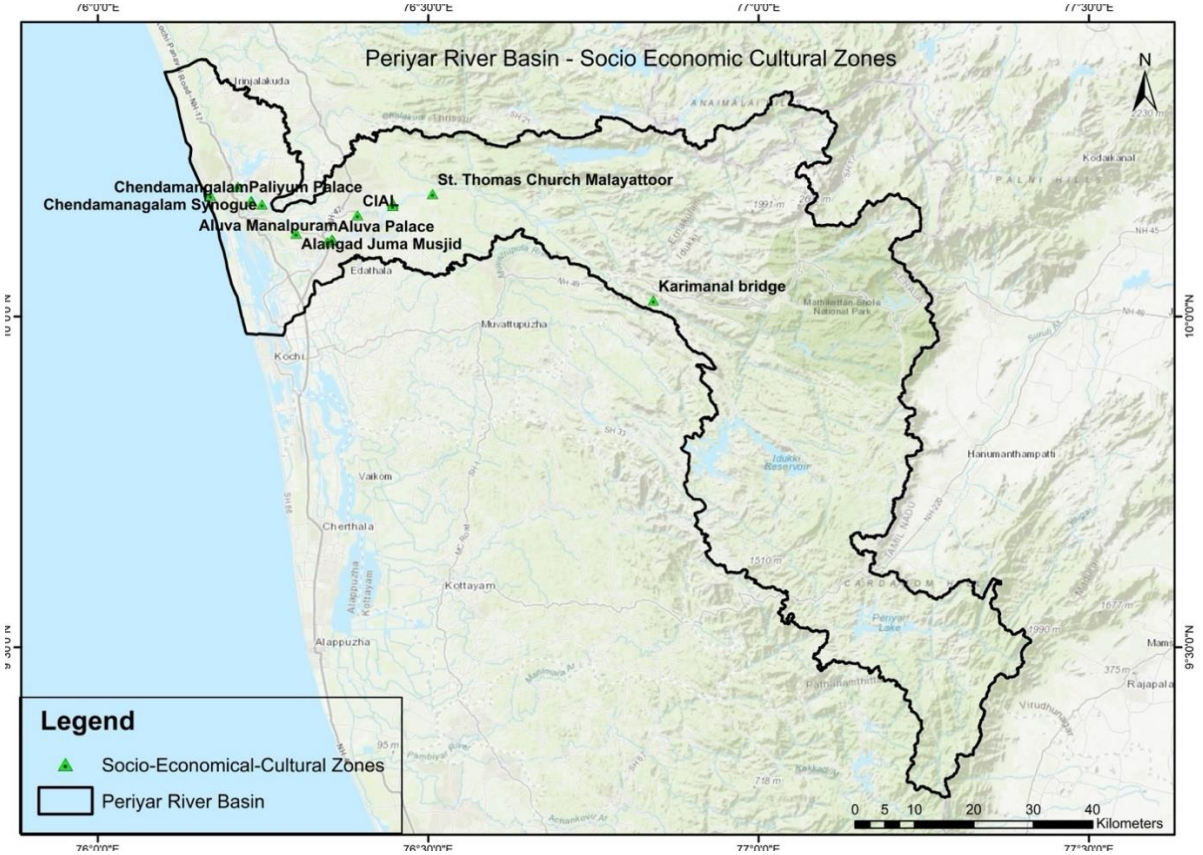

Fig. 12 Location of Socio-cultural and economic significance

Idukki Hydro Electric Project is the largest hydro-electric project in Kerala, with an Installed capacity of 780 MW. A significant portion of the electric power demands of the state is met from the Idukki Hydro Electric Project, in the Periyar Basin. The powerhouse has six generators of 130 MW capacity each. The Idukki reservoir with a capacity of 2 billion tons is formed by Periyar and its tributary, Cheruthoni. Water is held in the reservoir with the help of three dams – Idukki, Cheruthoni and Kulamavu. While the Idukki dam is meant for storing the water, Cheruthoni and Kulamavu, which are built at a lower portion of the reservoir, channel the water to the powerhouse. Power is generated at an underground station situated at Moolamattam.

The Cochin International Airport, Chendamangalam and Munambam Fish Harbour are locations of economic importance. These locations comes in the downstream side of the basin. Cochin International Airport, owned and operated by Cochin International Airport Limited (CIAL), is the first airport in India built under Public Private Partnership. It ranks as the third busiest for international passengers and seventh largest overall in India. As of 2022, Cochin Airport handles 61.8% of Kerala's total air passenger movement. The diverse investor base has played a crucial role in nurturing the airport, a significant undertaking materialized by the State Government, which remains the largest investor with a stake of approximately 34%. For the past four years, CIAL has been recognized as the "Best Airport" in the Asia-Pacific region by the Airports Council International with 5 to 15 million passengers. CIAL became the sole airport in the country during the post pandemic year to register a profit. In 2021-22, the company logged a profit of Rs.37.68 crore and in 2022-23 the profit increased to Rs.267 crores. In its 24 years of operational history, it handled 10 million passenger in a Calander year in 2023.

Socially & Economically significant locations within the basin

 Periyar National Park	 Idukki Arch Dam	 Cardamom Hills
 Munambam Fish Harbour	 CIAL	 Kochi Water Metro

Source: timesofindia.com, kerala tourism.org, wikepedia.org

Over 12 varieties of spices, including ginger, garlic, cardamom, vanilla, pepper, cinnamon, coffee, tea, clove and nutmeg are cultivated in Idukki and the surrounding areas of this district. The Cardamom Hills or Yela Mala are mountain range of southern India and part of the southern Western Ghats located in Idukki district. According to the Chief Secretary of the Government of Kerala, Cardamom Hill land is Government land under the control of the Revenue Department for more than a century. The total extent of the Cardamom Hill area was 1,072 km^2 of which 568 km^2 was assigned under various Land Assignment Rules. The balance of 504 km^2 is leased to farmers for cardamom cultivation The Cardamom Hills accounts for about 70% of the cardamom production of India. In the lower portions of the Periyar, inland navigation through the Cochin backwaters is the primary mode of transportation. Boats owned by government and commercial entities provide regular services. Compared to the busiest roads in Cochin, this route provides a smoother and more enjoyable travel. The fishing harbours in Kochi also contribute significantly to the economic aspects of the state.

12. BEHAVIOURAL & POLITICAL ASPECTS

With the increasing rate of growth of population, the human activities around the bank of rivers also increased, which results in contamination of water. Industrial waste, agricultural runoff, sewage, and household waste can introduce pollutants such as chemicals, heavy metals, and organic matter into the river. This can degrade water quality, harm aquatic life, and affect downstream ecosystems and human health. Unauthorized construction and urban development along the riverbanks also lead to habitat loss, increase pollution through sewage discharge and runoff that exacerbate flood risks. The direct discharge of waste into the rivers is a serious problem affecting the quality of the river water.

The Periyar River Action Plan has been drafted by the Kerala State Pollution Control Board (KSPCB) to address the persistent issue of the Kochi city's filthy drinking water source. The Pollution Control Board has sent notices to the companies with directives to install treatment plants or close down the factories. From the community level, different initiatives were taken to protect Periyar. Greenpeace International has appointed Mr. V.J Jose as the Periyar River Keeper to regularly monitor the quality of Periyar water. He has been trying to protect and save the Periyar from the clutches of pollution for the last 3 decades. In 1992, Prof. S. Sitaraman, an environmentalist started the Aluva Environmental Protection Forum and played an important role in the prevention of illegal sand mining and water pollution by afforestation programs. The different local authorities and communities with the help of student organizations conducted 'Punarjani' a cleaning process of the Periyar river and Tiger Reserves. 400 volunteers divided into six zones collected 700 bundles of waste.

In 2016 The Collective for Right to Live (CORL), a group of green activists, citizens and representatives of various political parties, launched the 'Save Periyar, Save Life' campaign in Kochi. The collective has been fighting against the discharge of untreated industrial effluents into Periyar, which is city's main source of water. With this, the campaigners intend to throw light on the inferior quality of potable water supplied in the city.

13. AGRICULTURAL STATISTICS OF THE BASIN

The Periyar River basin, plays a crucial role in Kerala's agriculture. It is known for producing cash crops such as cardamom, coffee, rubber, tapioca, coconut, and arecanut, as well as food crops like paddy, banana, and various vegetables. Other notable crops include pepper, ginger, turmeric, tamarind, clove, nutmeg, mango, pineapple, cashew, elephant foot yam, and vegetables like brinjal, chillies, cabbage, and tomato (Agricultural Statistics, 2023).

The Periyar basin encompasses three significant districts in Kerala's agricultural landscape: Idukki, Ernakulam, and Thrissur. In 2021-22, Idukki's net cultivated area was 256,149.29 hectares. The district is a leading producer of cardamom, accounting for nearly 90% of Kerala's production. Other significant crops include coffee (41.91% of the state's coffee area), pepper (13.91% of the state's

pepper area), and rubber (16.91% of the state's rubber area). However, paddy cultivation is minimal, covering only 488.29 hectares, or 0.25% of Kerala's paddy area.

Major crops in Ernakulam include paddy (4,723.13 hectares, 2.41% of the state's paddy area), tapioca (13,305.91 hectares, 13.91% of the state's tapioca area), coconut (10.87% of the state's coconut area), and banana (5.91% of the state's banana area). The district is a vital producer of tapioca, coconut, and bananas, with significant areas under vegetable and horticultural crops. The net area under cultivation in Thrissur district during 2021-22 was 167,135.33 hectares. Thrissur is a significant producer of paddy (23,658.66 hectares, 12.09% of the state's paddy area), coconut (10.87% of the state's coconut area), arecanut (13.91% of the state's arecanut area), and banana (5.91% of the state's banana area). The district has substantial areas under vegetables, spices, and other horticultural crops.

14. WATER SUPPLY & IRRIGATION

Water from the Periyar River is used for domestic and industrial purposes as well as for irrigation. The major water supply schemes include the following: Water Supply Scheme (WSS) for Cochin Corporation, WSS for Alwaye, WSS for Perumbavoor, WSS for North Paravoor, Rural water supply schemes for various Panchayats including Maradu, Mulanthuruthy, Kadamakudy, Udayamperur, Puthencruz etc. The water supply scheme for the Corporation of Cochin, started in 1914 and has two head works and treatment plants, one at Alwaye and the other at Chowara with a capacity of 48 MLD and 22.5 MLD respectively. Domestic water supply through these schemes cover a population of about 32.27 lakhs, the water requirement being about 520 MLD. Some of the major industrial and commercial consumers of water are listed in Table 4.

Table 4 Major industrial and commercial consumers of water

Sl. No.	Name of Industry/ Commercial Consumer	Water Consumption (KLD)	Intake point
1	M/s. Hindalco Industries Ltd., Eloor	1,017	Edamula
2	M/s. Travancore Cochin Chemicals, Udyogamandal	4,200	Edamula
3	M/s. Hindustan Insecticides Ltd., Eloor, Udyogamandal	550	Edamula
4	M/s. Fertilizers And Chemicals Travancore Limited, Eloor	14,297	Edamula
5	M/s. BPCL Kochi Refinery, Ambalamugal, Kochi	60,000	Edamula
6	M/s. Carborundum Universal Ltd., Kalamassery	1,175	Edamula
7	M/s. Amrita Viswa Vidyapeetham (Amrita Hospital), Kochi	97	Edamula
8	KINFRA	875	Edamula
9	Aluva Pump House	290	Aluva

The Periyar Valley Irrigation Project (PVIP) utilizes the tail race discharge from the Idamalayar hydel project and some other hydroelectric projects situated along the Periyar river, releases from the Idmalayar dam, and the run off from the uncontrolled/ independent catchment of the Periyar

River (about 938 km^2) located d/s of these projects, for irrigating about 32,800 ha of agricultural land located on the left bank of the Periyar, in Kothamangalam, Muvattupuzha, Kunnathunadu, Aluva, Paravoor and Kanayannoor Taluks through a network of canals and control structures. The scheme consists of the Periyar barrage at Bhoothathankettu with a catchment area of about 3,048 km^2. The Idamalayar Irrigation Project draws water from the Periyar Barrage through a canal system on its right bank and irrigates about 13, 209 ha of agricultural land. In addition to the above, there are a number of lift irrigation schemes. Out of the 136 lift irrigation schemes in Ernakulam District, 33 are located on the main Periyar River and 9 on the Mangalapuzha branch of the Periyar River. These schemes were envisaged to irrigate an ayacut of about 5878.50 ha.

15. SUB BASIN CLASSIFICATION OF THE RIVER BASIN AND RIVER SEGMENTATION

The salient features of each sub-basin based on the existence of hydro-power projects, historical and social importance, ecological significance, pollution and tribal settlements has been described in each classification. The sub-basin classification of Periyar River Basin is shown in Fig. 13.

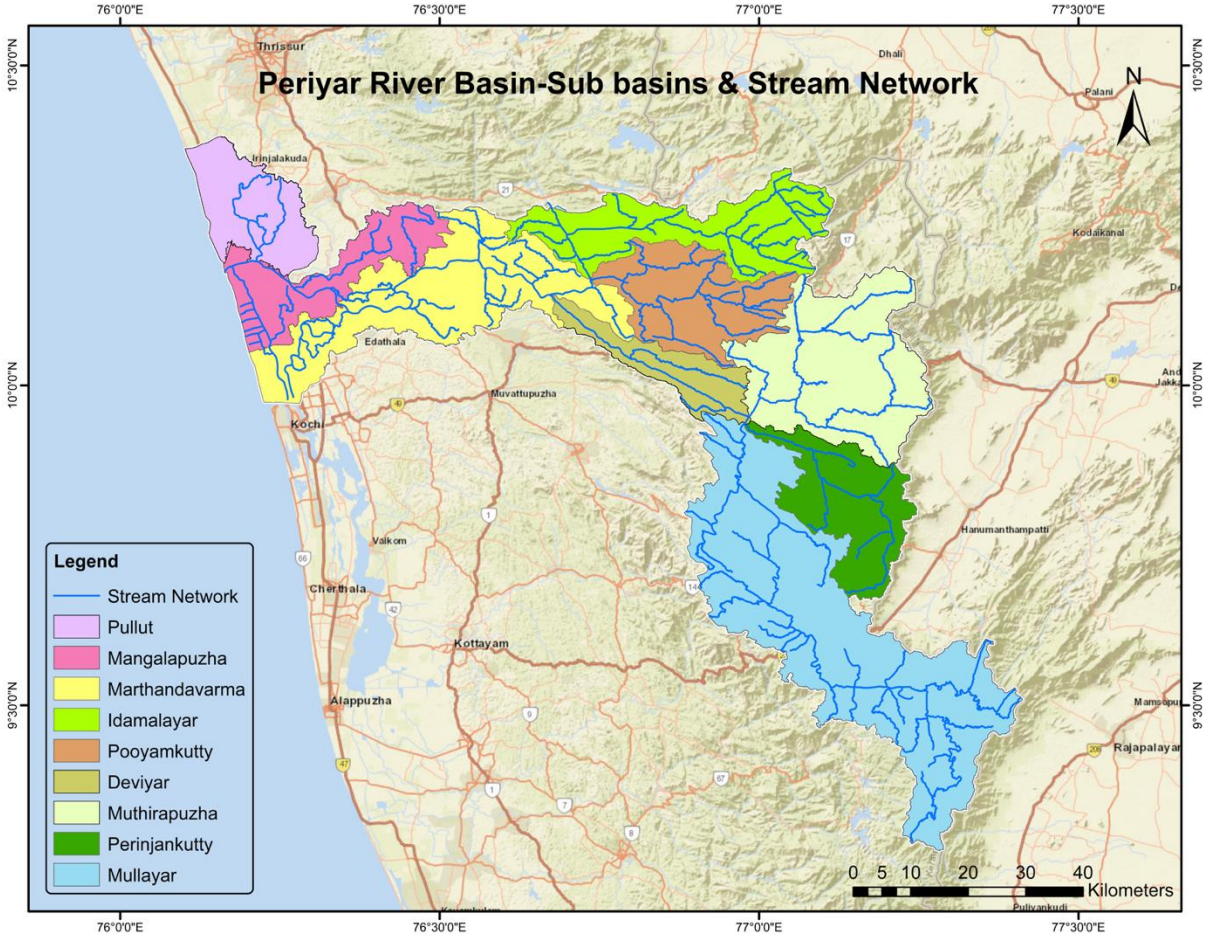

Fig. 13 Sub basin classification

The Periyar basin is divided into 9 Sub-basin, and they are listed as follows:

1. Mullayar Sub-basin with an area of 1446 km^2
2. Perinjankutty Sub-basin with an area of 406.24 km^2
3. Muthirapuzha Sub-basin with an area of 736.43 km^2
4. Deviar Sub-basin with an area of 216.84 km^2
5. Pooyamkutty Sub-basin with an area of 448.15 km^2
6. Idamalayar Sub-basin with an area of 516.72km^2
7. Marthandavarma Sub-basin with an area of 771.94 km^2
8. Mangalapuzha Sub-basin with an area of 362.80 km^2
9. Pullut Sub-basin with an area of 310.86 km^2

15.1 Mullayar Sub-basin

The elevation of the Mullayar Sub-basin varies from 1280 m to 385 m from the Mean Sea Level. The Periyar National Park belongs to this sub-basin. Periyar Tiger Reserve is one among the 27 tiger reserves of India. The Periyar National Park in Thekkady is enclosed by abundant evergreen forests. The forest area is a shelter for several bird species, elephants, tigers, sambars, gaurs, leopards, wild dogs, barking deer, mouse deer, monitor lizards, and various reptiles. The protected areas in the sub-basin account for 778.72 km^2, where a significant portion belongs to the Periyar Tiger Reserve. All the major dams within the Periyar basin come under this sub-basin. The major hydroelectric projects include Mullaperiyar Dam, Idukki Arch Dam and Cheruthoni Dam. The primary purpose of the Mullaperiyar Dam was to divert water from the Periyar River to the arid rainshadow regions of Tamil Nadu for irrigation via a tunnel. The dam has a height of 53.66 m with an installed capacity of 161MW. Idukki Arch Dam is meant for storing water. Cheruthoni and Kulamavu, which are built at a lower portion of the reservoir, channel the water to the powerhouse. Power is generated at an underground station situated at Moolamattam. Cheruthoni Dam has a height of 138.2 m and a power production capacity of 780MW.

Domestic Waste from houses and shops is directly dumped into the river basin at two points at Upputhara, the first site is near Upputhara Pump house, and the second is at the central Junction. The major tribal communities in this sub-basin are Muthavan, Mannan, Urali and Paliyan. The Mannan community mainly inhabits in the Kumily Panchayat, though their dwellings are also seen at Azhutha, Devikulam and Idukki block panchayats. The tribe has unique customs and rituals. Though they used to stay in remote forests, they were forced to migrate to plots allotted by the government at the outskirts of the Periyar Tiger Reserve a few decades back, following a government ban on deforestation in the preserved area. For a living, the Mannans cultivate some essential crops in the allotted farmland, collect forest produce from the non-restricted area and engage in manual labour or cattle breeding. The Paliyan community is another tribe found in Kumily panchayat. As they have very little farmland, they do very little agriculture. Their primary source of income is from manual labour and from the sale of things they have collected from the forest. The Urali community is also found in this area. Like the Palians, they have a deep connection with nature and engage in traditional occupations such as fishing and hunting.

The river segmentation for Mullayar is as follows:

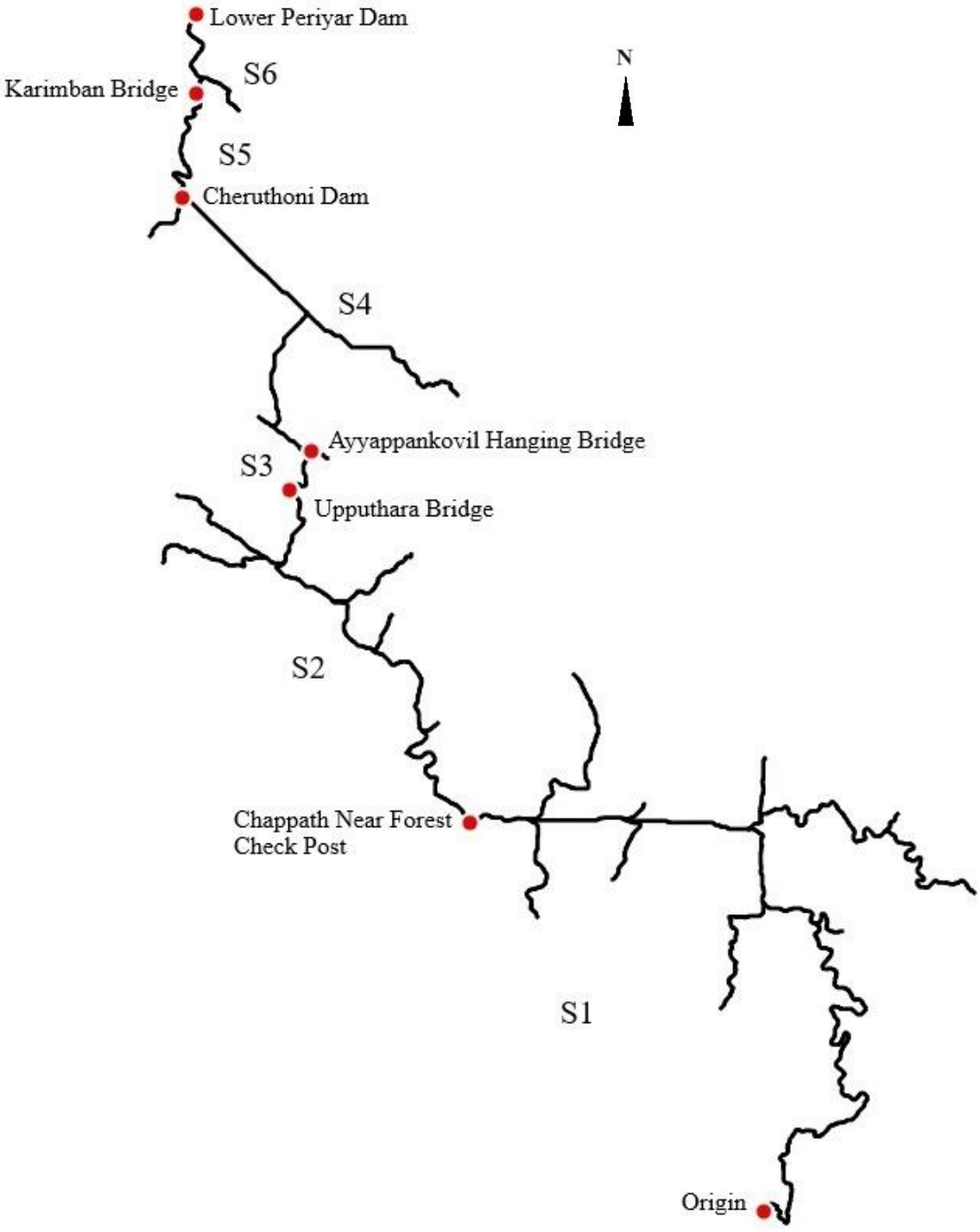

Fig. 13a River segmentation for Mullayar

Segment	Length (km)	Salient Features
Segment 1 Origin to Chappath near Forest Check Post	65.19	Characterised by near natural and pristine conditions, diverse ecosystems, thriving wildlife, lush vegetation and rugged terrain. Particularly in the area around Thekkady, is characterized by minimal human intervention. This region includes notable sites such as the KTDC lake palace, KTDC Periyar house, PWD resthouse, and Thekkady boat landing, etc, which have been developed for tourism. Apart from these specific locations, the area remains largely untouched by human activities, preserving its ecological integrity. Periyar Lake, located in the midst of the Periyar Tiger Reserve, is a reservoir created by the Mullaperiyar Dam on the Periyar River. It is encircled by the undulating hills and trees of Western Ghats. The surrounding Periyar Wildlife Sanctuary is home to diverse flora and fauna, including elephants, tigers, deer, and a variety of bird species.
Segment 2 Chappath near Forest Check Post to Upputhara Bridge	32.41	Starting from Chappath, the landscape is characterized by dense tropical forests that are part of the Periyar Tiger Reserve. As the river progresses towards the Upputhara bridge, the landscape shifts between forested zones and cultivated plots. Local communities practice agriculture and fishing in this area. The landscape includes tea and spice plantation. Upputhara and its nearby regions are inhabited by indigenous communities and showcase a deep cultural legacy. The village features temples, churches, and traditional Kerala architecture, which highlight its historical origins and cultural traditions. Slight pollution due to domestic and commercial establishments are noted in this area.
Segment 3 Upputhura Bridge to-Ayyappankovil Hanging Bridge	2.5	Bed of the river comprises of rock. Rivers flows through populated area. Mainly household and commercial wastes are discharged in the form of solid and liquid which results in degrading water quality and aquatic life. Two major tribal settlements are located near to this stretch- Upputhara & Ayyappakovil. Also, this stretch comprises of vegetation and human built structures.

Segment	Length (km)	Salient Features
Segment 4 Ayyappankovil Hanging Bridge to Cheruthoni Dam	19.4	Width of river increases as it reaches Cheruthoni Dam. Riverbed contains silt and rock. Sediment accumulation is found in the riverbed near to Idukki Dam portion. Major portion of this stretch flows through forest area so river is free from pollution. Banks of river contains forest loam soil. River basin is covered with natural vegetation. Idukki Arch dam is a major structure that comes in this stretch. Tribal settlement is observed at Bison Valley. Anchuruli Tunnel, Hill view park, Vysgali Caves are the major Tourist spots located near this stretch. Major portion of this stretch comes under protected area.
Segment 5 Cheruthoni Dam to Karimban Bridge	8.9	In this stretch the river bed narrows and widens. Riverbeds consist of rocks and Boulders. The river in this stretch is flowing through areas with dense population. So household and commercial wastes are discharged into the river mainly in the form of solid and liquid waste. Cheruthoni subemersible bridge, Thadiyambadu Chappath are the major structures come across this stretch. Tribal settlemet is observed at Vazhathoppu near this river stretch.
Segment 6 Karimban Bridge to Lower Periyar	10.8	The width of the river is changing across this stretch. The river bed consists of rocks and boulders of large size. Major portion of this stretch flows through hilly terrain and through forest area. River is free from pollution. Less human population is observed, and basin is covered with natural vegetation. Old chappathu Karimban, Bridge in Alappuzha-Madurai Road, Bridge at Periyar Valley are the major structures across the river in this stretch.

15.2 Perinjankutty Sub-basin

The elevation of this sub-basin varies from 1084 m to 363 m, approximately from the Mean Sea Level. The Cardamom Hills are the ecologically significant location within this sub-basin. The Cardamom Hills or 'Yela Mala' are a part of the southern Western Ghats in the Idukki District. Their name comes from the Cardamom grown in the higher elevations, along with pepper and coffee. The Cardamom Hill Reserve area in the Western Ghats has an area of 865 km^2 situated in the Taluks of Peerumedu and Udumbanchola in the Idukki District. The Western Ghats and the Cardamom Hills come under the UNESCO World Heritage Sites. The Cardamom Hill Reserve area falling under the Munnar Division bears tropical, wet, evergreen forests. The altitude varies from 900 to 1000 metres above MSL. It once connected Palani Hills to the Periyar Tiger Reserve

and forests of the South, forming a natural corridor for the passage of wildlife between these regions. Kallar and Erattayar are the two major dams that come under this sub-basin. Kallar Dam acts mainly as a diversion dam to supply water to the Idukki Dam. The water stored in the Kallar Dam reaches the Erattayar River through a tunnel. The dam has a height of 12.19 m and a capacity of 780MW. Erattayar Dam has a height of 19.81 m and an installed capacity of 780MW. The other prominent structure falling under this segment is the Chandravanam Bridge. Mannan and Paliyan are the two major tribal groups found in this segment. They are located in the Nedumkandam, Irattayar and Vandenmedu panchayats.

The river segmentation of Perinjankutty is as follows:

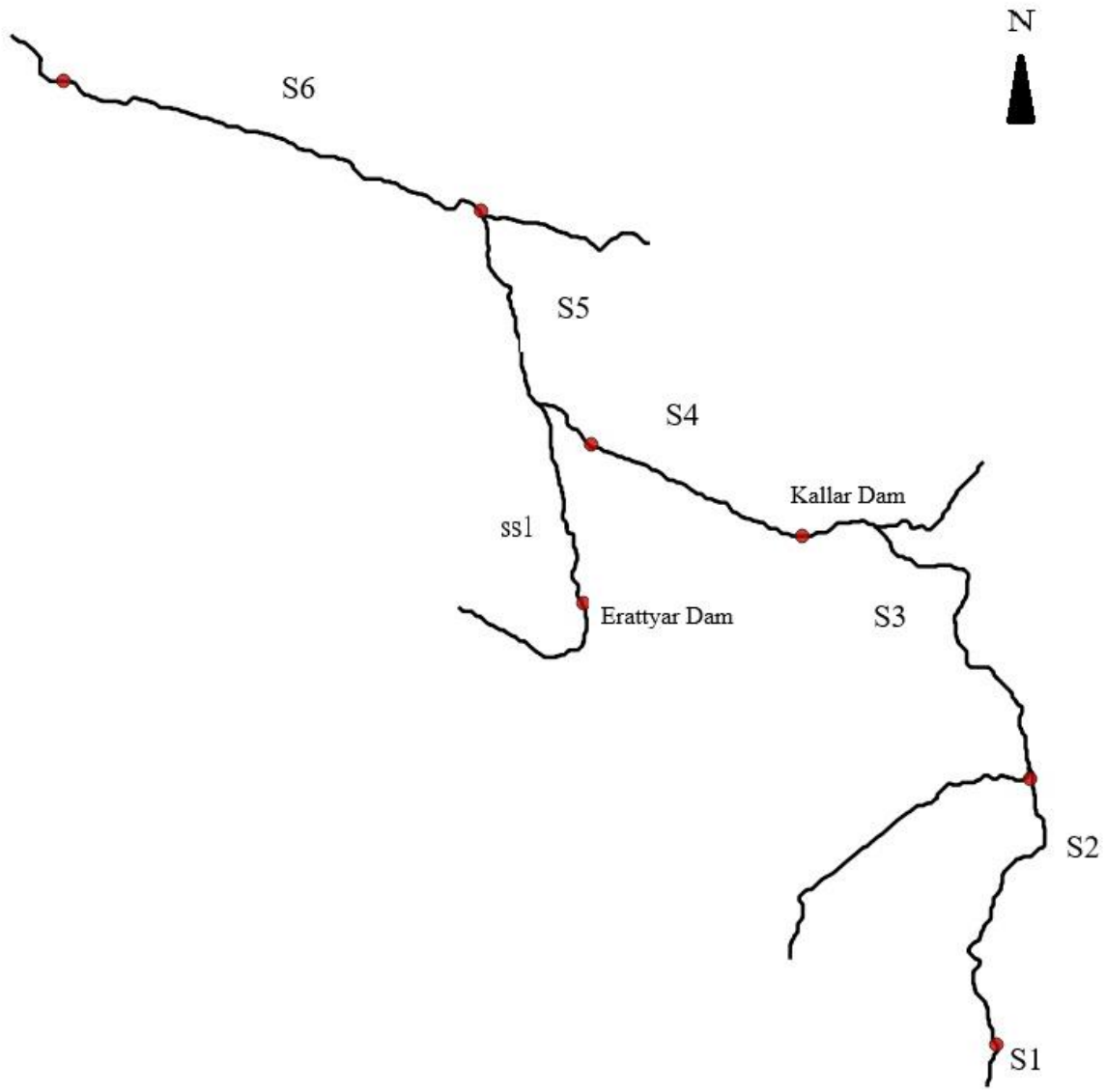

Fig. 13b River Segmentation for Perinjankutty

Segment	Length (km)	Salient Features
Segment 1 Nettithozhu to Kochra bridge	1.2	The river has agricultural fields on both sides. Tribal settlements are found in this area.
Segment 2 Kochara bridge Angekoottar confluence point	8	Tribal settlement is observed in this stretch. Type of soil in the bed is Rock. Major structures are keerikara bridge, chandravanam bridge. Ramakkalmedu tourist spot is found in this stretch. This segment has domestic and commercial activities.
Segment 3 Angekoottar Confluence Point to Kallar	10.1	The river in this stretch follows a highly curvy path along with lot of meandering
Segment 4 Kallar to Thovval	6	In this stretch there is a greater amount of human disturbance as the river passes through farm lands.
Segment 5 Perijamkutty Bridge to Mankuva Culvert	11.60	This stretch has tribal settlements. A southwest to northeast ridge called the Chekuthan Mala separates the Idukki Sub-plateau from the Peermade Plateau as well as the main mass of Cardamom Hills.

Sub-Segment

Sub-Segment 1 Erratayar dam to Kallarmekku	5.79	River meandering is found in this stretch

15.3 Muthirapuzha Sub-basin

The elevation of this sub-basin varies from 1749 m to 287 m, approximately from the Mean Sea Level. The ecologically significant locations that come under this segment are Carmelagiri Elephant Park and the location of Neelakurinji Bloom. Carmelagiri Elephant Park is a private park for elephant riding through the hilly paths of Munnar Forest. There are many green hills, lush valleys, misty cloud-covered forests and sprawling tea plantations around the park. Neelakurinji (*Strobilanthes kunthiana)* is found in the Shola forests of the Western Ghats. The purplish-blue flower blossoms only once in 12 years, giving the Nilgiri Mountain range its name. They grow at an altitude of 1300 m to 2400 m. The plant is usually 30 to 60 cm high. Kurinjimala Sanctuary protects the kurinji in approximately 32 km^2 core habitat in Kottakamboor and Vattavada villages in the Iduki district. The Save Kurinji Campaign Council organizes campaigns and, programs for conservation of the Kurinji plant and its habit. Kurinji Andavar Temple in Kodaikanal, dedicated to God Murugan, also preserves Strobilanthes plants. Botanists and nature lovers alike mark their calendars in anticipation of this event.

The major dams in this sub-basin include the Kundala Dam, Mattupetty Dam, Sengulam Dam, Kallarkutty Dam and Ponmudi Dam. The Kundala dam is a part of the Pallivasal Hydroelectric Project, the first hydroelectric Project in Kerala. The dam has a height of 46.93 m and a capacity of 37.5MW. The Mattupetty Dam, is built to conserve water for hydroelectricity. It has a height of 83.35 m with a capacity of 37.5MW. The water flowing from the Anayirankal dam reaches the Kuthungal and Ponmudi dams through the Panniyar River. Power is generated at Kuthungal and Panniyar powerhouses. It has a height of 34.14 m with a capacity of 32.4 MW. The Sengulam Dam is a part of Sengulam Hydro Electric Project. Water required for power generation is stored in a small reservoir created by constructing a dam across the Sengulam stream, a small tributary of the Muthirapuzha River. The Project utilizes the tailwater of Pallivasal Power House. The dam has a height of 26.84 m with a capacity of 51.25 MW. The Kallarkutty Dam is a part of the Neriamangalam Hydroelectric Project. It serves multiple purposes, including water storage, irrigation, and hydroelectric power generation. It has a height of 43 m with a capacity of 77.65 MW. The Ponmudy Dam is a part of Panniyar Hydro Electric project. The water from the Ponmudi reservoir is diverted through a water conductor system to the Panniyar Power station (32 MW) on the left bank of Muthirapuzha. It has a height of 57.6 m with a capacity of 32.4 MW.

The river segmentation for Muthirapuzha is as follows:

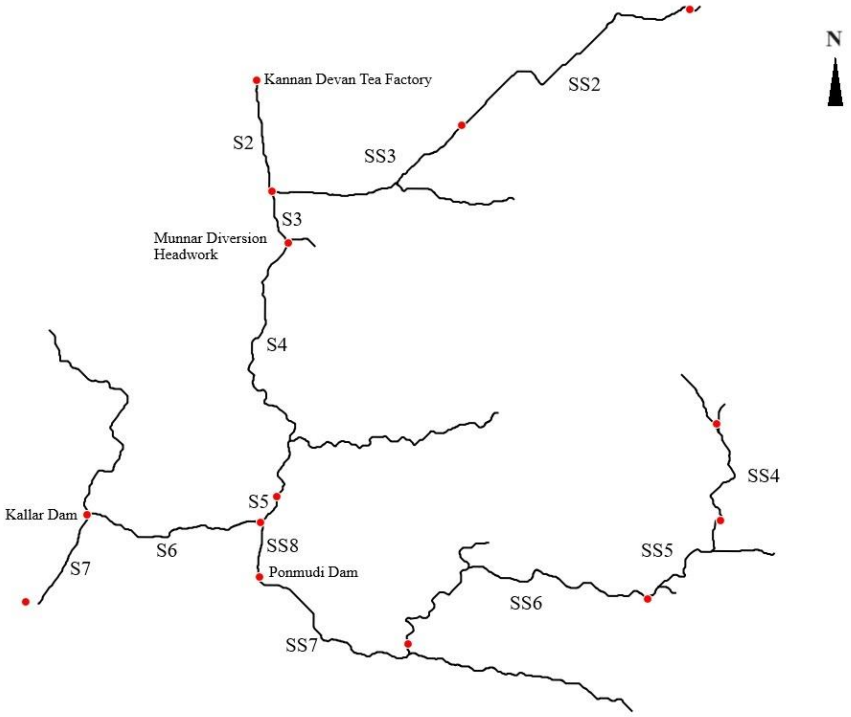

Fig. 13 c River segmentation for Muthirapuzha

Two major tribal groups, namely Muthuvan and Mannan, are found in this sub-basin. They are mainly settled in the Vellathuvel, Konnathadi, Munnar, Senapathi and Udumpanchola panchayats of the Idukki district. This sub-basin has a protected area of 28.64 km^2, which includes Eravikulam National Park and Mathikettan Shola National Park.

Segment	Length (km)	Salient Features
Segment 1 Origin to Structure near Kanan Devan tea factory	3.485	The river starts from Protected region of Annamudi and is free from any pollution. The terrain is rocky.
Segment 2 Structure near Kanan Devan tea factory to confluence point in Munnar	5.1	The river in this stretch is moving from ecologically undisturbed region to Munnar which has higher human intervention and increased chances of pollution. The river also shows meandering in this stretch.
Segment 3 From Confluence point in Munnar-to-Munnar Head work Dam	7.1	The river in this stretch has highest pollution - both solid and liquid waste are being dumped into the river. Also, smaller streams join the river in this stretch.

Segment	Length (km)	Salient Features
Segment 4 From Munnar Head work Dam to near Ripple Waterfalls	11.785	The initial part of the stretch has less human intervention and latter has resorts and other tourist activities. Significant waste disposal is found in this stretch. This segment is highly rocky.
Segment 5 From Near Ripple Water Falls Confluence point 2	1.31	The river meets the part from Ponmudi Dam. This stretch is similar to segment 4.
Segment 6 From Confluence Point 2 to Kallar Dam	6.84	The river here is passing through rocky terrain having large rocks and boulders. Here it passes through a tribal settlement of Vellathuvel. Human interventions are found in this stretch.
Segment 7 From Kallar Dam to Neerimangalam Power Station	4.17	The river meets Periyar river and flows towards lower Periyar dam

Sub-segment 1

Segment	Length (km)	Salient Features
SS 1 From Origin To Kundala Dam	2.86	The river flows through protected area and forest cover to join Kundala Reservoir
SS 2 Kundala Dam to Mattupetty Dam	14	The river continues to flow through Forest region and joins Mattupetty reservoir
SS 3 Mattupetty Dam to Confluence to Muthiranpuzha at Munnar	10	The River in this region flows through tea planation and no significant waste disposal is identified.

Sub-segment 2

Segment	Length (km)	Salient Features
SS 4 From Origin(Anayirankal Dam) to Poopara	4.9	The river flows through forest area and tea plantations
SS 5 From Poopara to Senapathi Bridge	5.8	Poopara is a densely populated area, hence waste disposal is found to be significant. The river follows a curved path along this stretch.
SS 6 From Senapathi Bridge to Kuthunkal Bridge	13.6	Meandering of the river is observed in this stretch. Rocks and boulders are found along the river path.
SS 7 From Kuthunkal Bridge to Ponmudi Dam	7.7	The river traverses through a rocky terrain in the beginning of this stretch and at latter stages follows a smoother path and then joins the Ponmudi reservoir
SS 8 From Ponmudi Dam to Confluence Point 2	9.4	The river flows through a rocky terrain. The river flows from Ponnmudi to Confluence Point where it meets Muthiranpuzha and flows towards Kallar Dam.

15.4 Deviar Sub-basin

The Deviar sub-basin of the Periyar River, extending from Panamkutty Bridge to Bhoothathankettu, is rich in biodiversity, this area is home to numerous endemic species of flora and fauna, including elephants, leopards, tigers, and various bird species, particularly within the Thattekkad Bird Sanctuary. Rare species such as *Macaws* and *Hornbills* also attract visitors. The lush vegetation and tropical monsoon climate contribute to its status as one of the wettest places in India, with heavy rainfall supporting dense forest cover and diverse agricultural practices. Historically, Neriamangalam and its surroundings are notable for landmarks such as the Neriamangalam Arch Bridge. Constructed between 1924 and 1935, the bridge was a crucial

development project initiated by Rani Sethu Lakshmi Bhai and opened by Sri Chithira Thirunal Ramavarma. This bridge, part of the Kochi-Madurai-Dhanushkodi NH-85, was essential for regional connectivity following the 1924 flood that necessitated an alternative route to Munnar from Ernakulam. The basin is vibrant, with ancient temples and the Kadamattom Church, one of India's oldest, attracting devotees and tourists. Traditional practices like bamboo crafts are integral to the local culture, with artisans producing eco-friendly products such as baskets, mats, and furniture.

The local communities maintain a strong connection to their land and traditions, primarily engaging in agriculture with many also involved in dairy farming. This lifestyle emphasizes sustainability and conservation, although wildlife poses challenges to profitable farming, particularly in hilly and forest regions. Politically, local governance and state policies influence the development projects, such as the construction of the Neriamangalam Arch Bridge and the establishment of the Neriamangalam Power Station. These initiatives focus on infrastructure improvement, agricultural support, and tourism promotion. Economically, the region thrives on agriculture, with rubber, coconut, and cocoa being main crops. The District Agricultural Farm in Neriamangalam provides resources and knowledge to local farmers. The Neriamangalam Power Station, with a capacity of 77.5 MW, meets the region's energy needs, utilizing water from the Muthirapuzha River Basin and the Kallarkutty Dam. The river segmentation for Deviar is as follows:

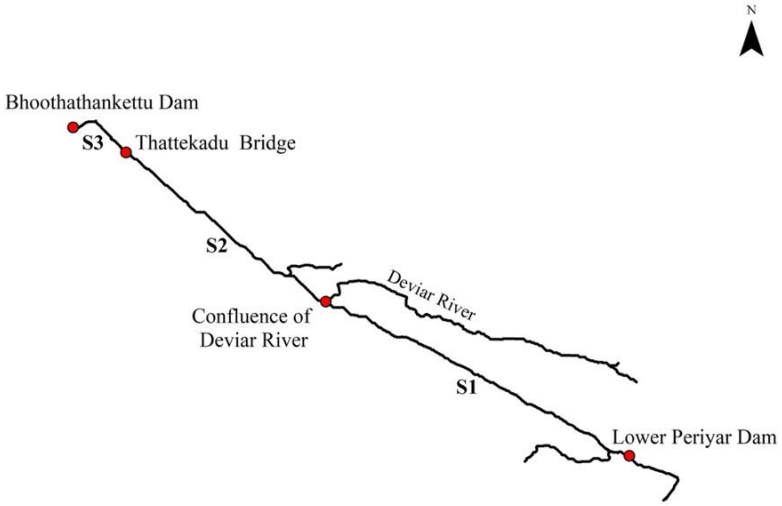

Fig. 13 d River Segmentation for Deviar

Segment	Length (km)	Salient Features
Segment1 Lower Periyar Dam to confluence of Deviar river	21.65	After the Lower Periyar Dam, the river flows almost in a straight course between two parallel hill ranges extending in the northwest direction. Downstream, reserve forests are present on both the left and right sides of the stream. This segment is characterized by settlements limited to the proximity of the river. It extends up to the confluence point of the Deviar River.

Segment	Length (km)	Salient Features
Segment 2 Confluence of Deviar river to Thattekkadu Bridge	15.43	From the confluence point of the Deviar River with the Periyar, the river flows through an area with denser settlements, including Neriamangalam, Injathotti, and Thattekkad. In this segment, settlements are interspersed with surrounding reserve forests. The river's course here is characterized by gentler slopes, in contrast to the steeper gradients observed in S1. This segment extends up to the Thattekkad Reserve Forest.
Segment 3 Thattekkadu Bridge to Bhoothathankettu Dam	4.15	The segment characterized by the presence of the Thattekkad Reserve Forest on both sides of the river is notable for its rich biodiversity and limited human settlement. The Thattekkad Bird Sanctuary, situated to the right side of the basin, is renowned for its diverse bird population. Following the confluence with the Kuttampuzha river, the river bends sharply to the left, leading to the Bhoothathankettu Barrage.

15.5 Pooyamkutty Sub-basin

The Pooyamkutty sub-basin, located in the foothills of the Western Ghats, is an area of significant ecological, cultural, historical, social, and economic importance. Agriculture is the primary economic activity, with rubber, coconut, pineapple, pepper, cocoa, coffee, and banana being the main crops. However, farmers in this region face substantial challenges due to crop destruction by wild animals such as elephants, monkeys, squirrels, and wild boars, which impacts the profitability of cultivation. Pooyamkutty sub-basin is enriched by the traditions and heritage of its diverse communities, including several Scheduled Tribe settlements. The tribal communities, such as the Mannan, Muthuvan, Ulladan, Malayarayan, Malayan, and Urali, maintain a lifestyle deeply connected to the natural environment. They live in huts within the dense forests of the Western Ghats, and their traditional practices, including bamboo crafts, contribute to the region’s cultural vibrancy. These artisans produce eco-friendly items like baskets, mats, and furniture, which are integral to the local economy and culture.

The sub-basin holds significance due to its ancient roots and natural landmarks. The region features numerous Muniyaras (ancient stone structures), offering a glimpse into its historical past. Additionally, natural attractions like the Elephant Pond (Anakulam), where large herds of elephants gather, and the longest suspension bridge in Kerala located in Inchathotty, underscore the historical and infrastructural importance of the area. The old Aluva-Munnar highway, which passes through the sub-basin, further highlights its historical relevance. Socially, the communities within the

Pooyamkutty sub-basin exhibit a strong connection to their land and traditions. The local population engages primarily in agriculture, supplemented by other activities like bamboo crafts and dairy farming. Despite the challenges posed by wildlife, the residents maintain sustainable agricultural practices and a close-knit community life, celebrating local festivals and upholding their cultural heritage. Pooyamkutty sub-basin falls under the Idukki parliamentary constituency and the Kothamangalam assembly constituency. The river segmentation for Pooyamkutty is as follows:

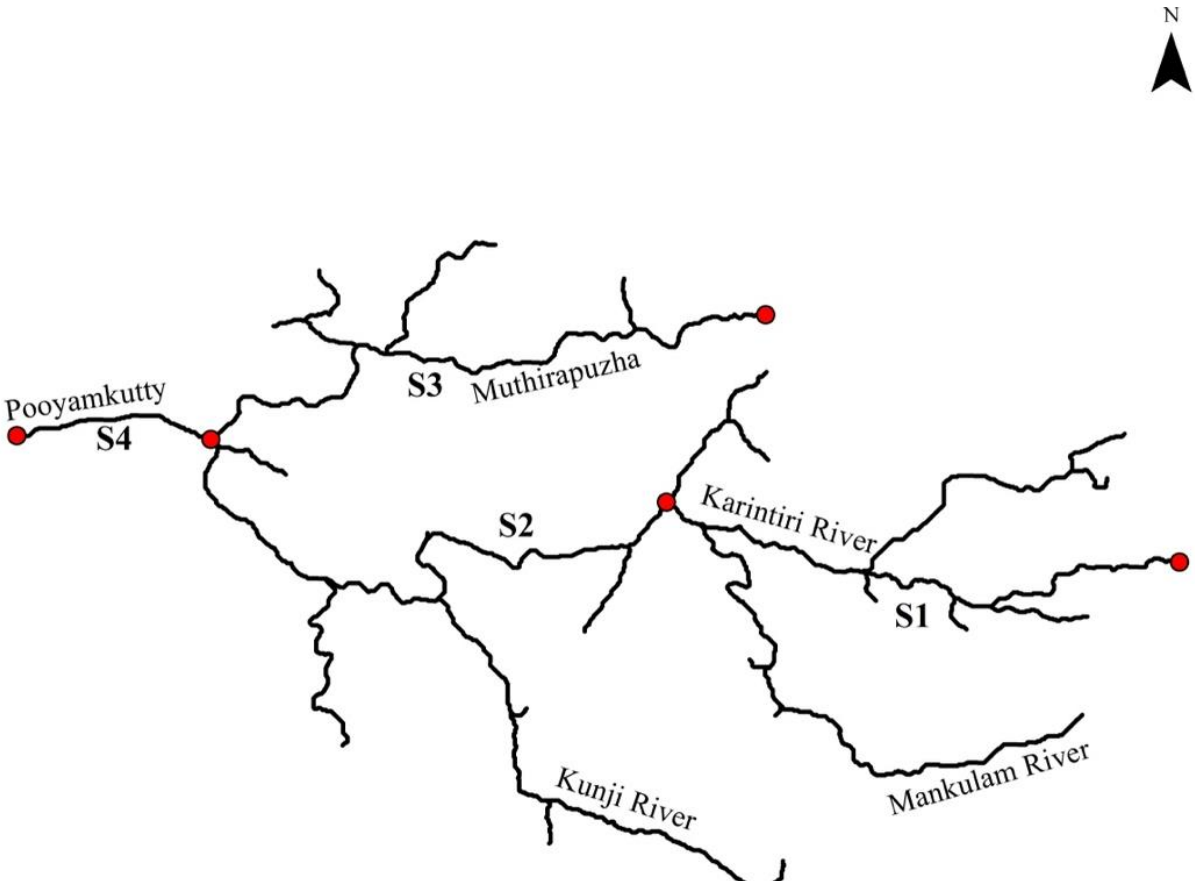

Fig. 13 e River Segmentation for Pooyamkutty

Segment	Length (km)	Salient Features
Segment 1 Origin of Karintiri river to Anakkulam-Mankulam Road	17.34	The Karinthiri River originates from the Kadalaar Tea plantation, and as it flows, it is joined by the Anamudi Aar from the Rajamalai Hills, followed by the Mankulam River. This segment is characterized by tea plantation estates and the associated settlements of workers. While the settlements are not densely packed, they are notably present in the areas of Kuwait, Valiyaparakkutty, and Anakulam.

Segment	Length (km)	Salient Features
Segment 2 Anakkulam-Mankulam Road to confluence of Muthirappuzha river	21.09	In this segment, the river flows through a dense mixed forest mainly consisting of bamboo. Settlements are very few, with various tribal communities located in provinces close to Muthirappuzha.
Segment 3 Origin of Muthirappuzha to confluence of Muthirappuzha river	20.48	Muthirapuzha flows through dense forest and joins the Pooyamkutty River approximately 650 meters downstream from the Pooyamkutty Bridge.
Segment 4 confluence of Muthirappuzha river to confluence of Idamalayar	5.82	The river drains through the villages of Pooyamkutty and Kuttampuzha, which are located on the left side of the river downstream, while the right side is completely covered by dense mixed jungle primarily consisting of bamboo.

15.6 Idamalayar Sub-basin

The Idamalayar sub-basin, a vital part of the Periyar River system, originates in the Anamalai hills of Idukki District. This region, characterized by its dense forests, fluvial landforms, and structural hills, is crucial for its ecological, social, economic, cultural, and historical significance. The riverbanks are composed of rock overburdens and hard soil strata, with primary soil types being clayey loam and sandy clay loam. The forests in this basin are rich in bamboo and various species of birds, including the Malabar grey hornbill, stork-billed kingfisher, and Oriental honey buzzard. This rich biodiversity underscores the ecological importance of the sub-basin. The Idamalayar sub-basin is home to several tribal communities, including the Muthuvans, who live in remote settlements like Idamalakkudy. These communities maintain a lifestyle deeply connected to the forest, relying on it for food, water, and materials. Socially, these tribes follow traditional practices and have a close-knit community structure, with leadership roles such as the chieftain (moopan) being pivotal in decision-making and community activities. Agriculture is the primary economic activity in the Idamalayar sub-basin, with most of the population engaged in farming. Key crops include honey, turmeric, and rubber. However, the tribal communities also engage in traditional crafts, such as bamboo mat weaving. The multipurpose Idamalayar Dam plays a significant role in irrigation and water management, contributing to the agricultural productivity of the region. The cultural fabric of the Idamalayar sub-basin is woven from the traditions and practices of its tribal communities. The Muthuvans, for instance, speak a dialect closely related to Tamil rather than Malayalam. Their cultural heritage includes traditional knowledge of forest resources, folklore, and practices related to sustainable living. Festivals and rituals are integral to their cultural identity,

reflecting a deep connection to nature and the environment. The river segmentation for Idamalayar is as follows:

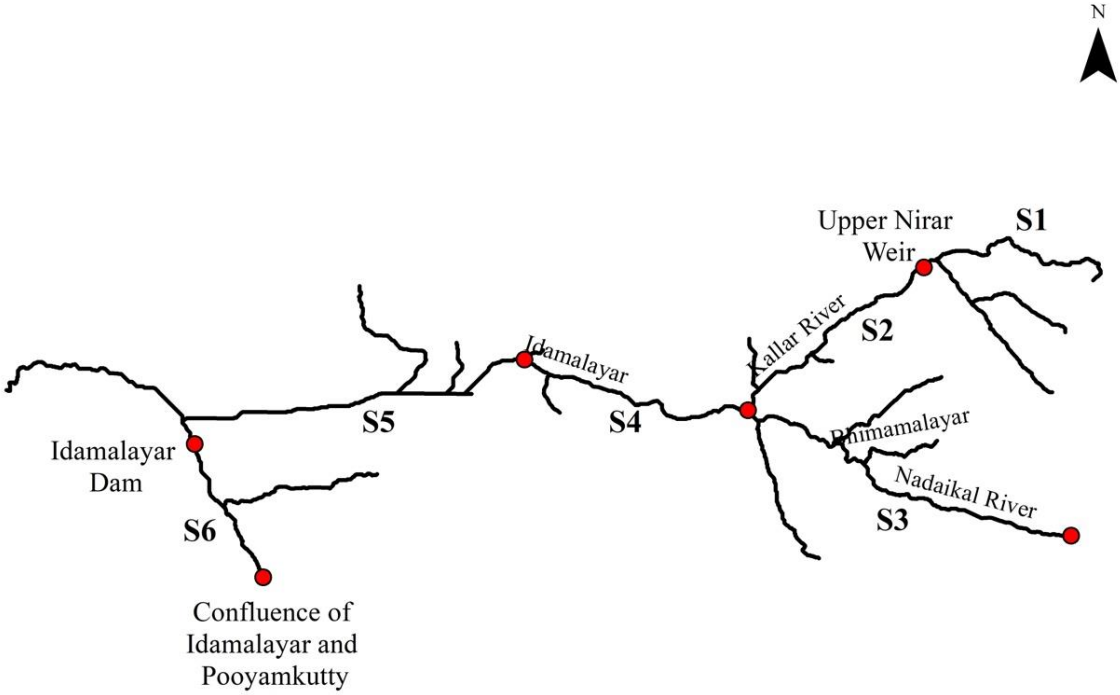

Fig. 13 f River Segmentation for Idamalayar

Segment	Length (km)	Salient Features
Segment 1 From origin of Nirar to Upper Nirar Wier	11.37	The Nirar originates as rivulets from the Kannan Devan Hills of Kerala and enters Tamil Nadu, where it meets at the Upper Nirar Weir at Chinna Kallar.
Segment 2 From Upper Nirar Wier to Confluence with Idamalayar	12.5	This segment lies entirely within the state of Tamil Nadu. Settlements are limited to those of plantation workers. The Lower Nirar Dam, part of the TNWRD-Parambikulam Aliyar Project, is also located in this segment.
Segment 3	18.66	The Nadaikal River originates from the valleys of Gundumalai in Eravikulam National Park, draining through various tribal

Segment	Length (km)	Salient Features
Origin of Nadaikal River to confluence of Kallar River		settlements on both sides of the river. From the downstream of Anamalai, the river acts as the boundary between Kerala and Tamil Nadu.
Segment 4 Confluence of Kallar to Idmalayar Reservoir	12.82	The river continues to serve as the boundary between Kerala and Tamil Nadu for 5.6 km and then enters Kerala. This segment is surrounded by dense mixed forest on both sides, with settlements associated with plantations also present in the vicinity.
Segment 5 Idamalayar Reservoir	18.65	This segment, in its entirety, represents the Idamalayar Reservoir. The reservoir is situated in the Ernakulam district of Kerala and plays a crucial role in irrigation, hydroelectric power generation, and flood control. The surrounding area is characterized by dense mixed forest, providing a habitat for diverse flora and fauna. The reservoir is a key water source for agricultural activities and supports various settlements in the region, including those associated with plantation estates.
Segment 6 Idamalayar Dam to confluence of Pooyamkutty river	8.03	The KSEB Idamalayar Power Station is situated 2 kilometers downstream from the Idamalayar Dam. The stretch of river in this area is densely forested and flows towards the Periyar River, joining it after merging with the Pooyamkutty River.

15.7 Marthandavarma Sub-basin

The Marthandavarma sub-basin is a historically and culturally rich area that includes various villages and towns, each contributing to its diverse character. Situated in the midlands of Ernakulam District, this sub-basin is traversed by the Periyar River, which splits into the Marthandavarma and Mangalapuzha branches near Aluva. The historical significance of the sub-basin is evident in places like Aluva, known for its ancient settlements dating back to 250 BC and its connection to the Kingdom of Travancore. The region is also marked by the historical presence of Jewish communities and the summer residence of the Travancore royal family. Aluva's rich history is complemented by the Advaita Ashram, founded by the social reformer Sree Narayana Guru, and the annual Sivarathri festival at Aluva Manappuram. Marthandavarma sub-basin encompasses a variety of landscapes, from the Western Ghats' foothills to the banks of the Periyar River. The area is home to several important ecological sites, such as the Abhayaranyam elephant park in Kodanad and the mangroves of Njarakkal and Puthuvype, which play crucial roles in stabilizing shorelines

and supporting local biodiversity. Villages like Malayattoor attract pilgrims to the international shrine, while Kalady is renowned as the birthplace of Adi Shankaracharya. The diverse population engages in various cultural practices, with festivals and traditional livelihoods deeply rooted in the local heritage.

Economically, the Marthandavarma sub-basin has seen a progressive shift from an agricultural to an industrial economy as one moves westward. Villages like Ayyampuzha and Kottappady rely primarily on agriculture, producing crops such as rubber, coconut, and paddy. However, in areas closer to Kochi, like Perumbavoor, Eloor, and Vazhakkulam, the economy is driven by industries, including plywood manufacturing, rice mills, and small-scale industries. Politically, the sub-basin encompasses parts of the Kochi municipality, including areas like Kalamassery and Aluva, which are experiencing rapid urbanization and development pressures. The growth of these areas brings both opportunities and challenges, such as increased flood risks and industrial pollution in places like Eloor. The river segmentation for Marthandavarma is as follows:

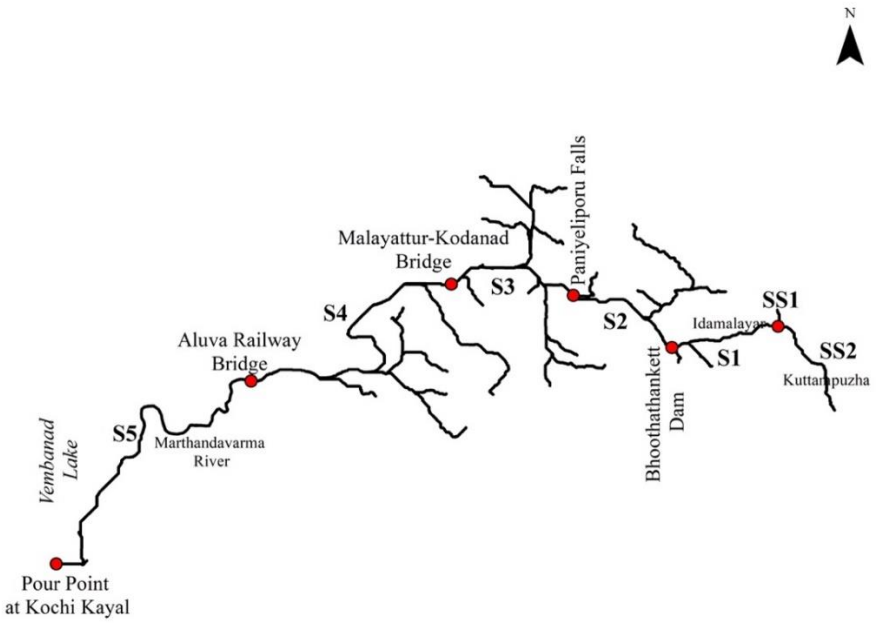

Fig. 13 g River Segmentation for Marthandavarma

Segment	Length (km)	Salient Features
Segment 1 Kuttampuzha Walking Bridge to Bhoothathankettu Dam	9.26	After collecting the Pooyamkutty and Idamalayar rivers, this stretch flows wide, passing beside the Thattekad Bird Sanctuary, and joins the Periyar River at the Bhoothathankettu Dam, where the Deviar sub-basin also converges.

Segment	Length (km)	Salient Features
Segment 2 Bhoothathankettu Dam to Paniyeliporu falls	10.03	This stretch of the Periyar River flows through a sparsely settled area that is rich in forests.
Segment 3 Paniyeliporu falls to Malayattur- Kodanad Bridge	10.64	From the Paniyeliporu Waterfalls onwards, settlements begin, and this stretch of the river flows entirely through a populated area on both sides.
Segment 4 Malayattur- Kodanad Bridge to Aluva Railway Bridge	27.02	This stretch of the river flows entirely through a densely populated area on both sides. It also passes through historically significant sites such as Malayattoor, with the river course meandering along the way and collecting water from several tributaries on both sides.
Segment 5 Aluva Railway Bridge to Pour Point at Kochi Kayal	30.52	This is the largest stretch in the sub-basin, beginning at Aluva. At the Aluva Railway Bridge, the river divides into two branches: Mangalappuzha and Marthandavarma. The Marthandavarma branch remains in this sub-basin and flows into the Kochi Kayal, while the Mangalappuzha branch forms another sub-basin.
Sub-Segment 1 Anakkayam to Kuttampuzha Walking Bridge	1.392	This stretch is the Idamalayar River, which receives the Pooyamkutty River and flows as the Idamalayar, eventually joining the Periyar River.
Sub-Segment S2 Origin of Kuttampuzha to Kuttampuzha Walking Bridge	9.36	This stretch is known as the Kuttampuzha River, which flows into the Idamalayar River, eventually joining the Periyar River. The area surrounding Kuttampuzha is renowned for its natural beauty, featuring lush forests, diverse wildlife, and scenic landscapes, making it a popular destination for nature enthusiasts and tourists.

15.8 Mangalappuzha Sub-basin

The Mangalappuzha sub-basin in Ernakulam District represents a diverse and dynamic region marked by its historical significance, cultural richness, and economic transformation. This sub-basin encompasses a range of villages, each contributing to the overall character of the area. Economically, the Mangalappuzha sub-basin displays a gradient of change from the east to the coastal areas. In the eastern regions, villages like Angamaly and Nedumbassery exhibit a robust industrial and trade-based economy. Angamaly, with its state-owned industrial estate and Cochin International Airport, serves as a significant economic hub, facilitating trade and commerce. As one moves westward, the economic landscape transitions towards agriculture and fishing. Villages like Thuravoor, Karukkutty, and Parakkadavu are predominantly agricultural, with extensive cultivation of rice, rubber, and other crops. The coastal areas, including villages such as Pallippuram, Vadakkekkara, and Kuzhippilly, rely heavily on fishing and aquaculture, particularly prawn farming and the traditional Pokkali farming method. This shift from industrial to agricultural and fishing economies underscores the region's adaptability and diverse economic base.

Paravur, with its historical boat races and cultural landmarks like the Jews Synagogue and Cherai Beach, reflects the region's vibrant traditions. Religious diversity is prominent, with significant Hindu, Christian, and Muslim places of worship spread across the villages. For instance, Angamaly hosts the St. George Basilica, Vembiliyam Mahadev temple, and several other important religious sites, making it a religious and cultural center. Chendamangalam, known for the Paliyam struggle and its role as the headquarters of the prime minister of the Kochi dynasty, is a testament to the area's historical importance. The presence of ancient ports, such as parts of the Muziris port in Moothakkunnam, further highlights the region's historical maritime significance. Socially, the sub-basin exhibits a mix of traditional and modern lifestyles. Villages like Manjapra, with a high literacy rate and a large number of professionals working abroad, showcase the blend of local and global influences. The region's social fabric is characterized by community cohesion, with agriculture, fishing, and trade forming the backbone of local livelihoods. The influence of nearby urban centres like Kochi cannot be overlooked. As a major city, Kochi drives economic growth and urbanization in the sub-basin. The city's infrastructure and connectivity facilitate the migration of the workforce from rural to urban areas, impacting traditional occupations. Kochi's proximity also enhances the economic prospects of the sub-basin, attracting investments and fostering development.

The river segmentation for Mangalappuzha is as follows:

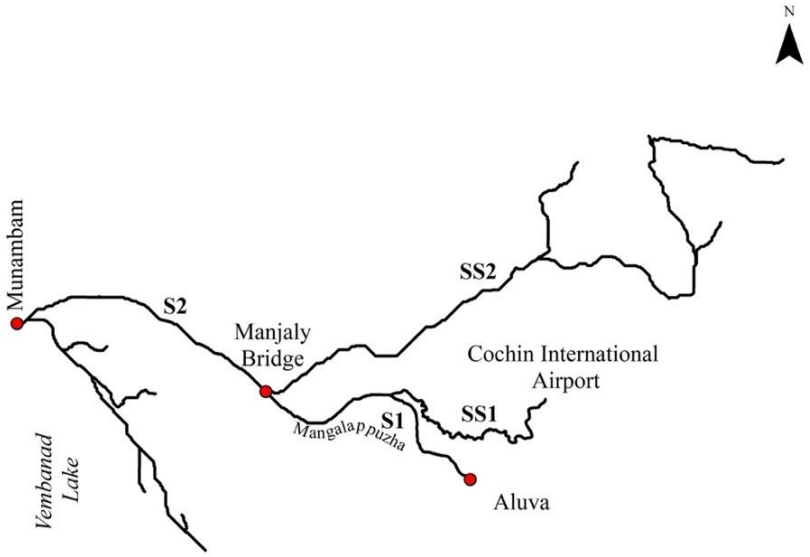

Fig. 13 h River Segmentation for Mangalapuzha

Segment	Length (km)	Salient Features
Segment 1 From Aluva Railway Bridge to Manjaly Bridge	13.47	The Mangalappuzha branch starts from Aluva and flows through a densely populated region that includes many industries.
Segment 2 Manjaly Bridge to Pour point at Munambam	14.49	Densely populated and heavily polluted stretch of the Periyar River. The Chalakudy River joins the Periyar in this stretch.
Sub- Segment 1 From CIA to Thadikkakadav Bridge	13.39	The river stretch starting from CIA joins the Periyar at Kozhikkakadav near the Thadikkakadav Bridge.
Sub- Segment 2 Origin of Manjaly Thod to Manjaly Bridge	41.02	The Mukkadi Thod and Thonnamakka Thod flows as it is for several kilometers and combine to form the Manjally Thod, which eventually joins the Mangalappuzha at the Manjaly Bridge.

15.9 Pullut Sub-basin

The Pullut sub-basin, located in the Ernakulam and Thrissur districts, presents a dynamic interplay of historical, cultural, socio-economic, and political aspects. Kodungallur stands out as a historically significant town within the Pullut River sub-basin. Known in ancient times as Mahodayapuram and Muziris, it was a major port city that facilitated extensive trade between Kerala and various parts of the world. Kodungallur, being a significant historical and trade center, played a crucial role in the political landscape of Kerala. The arrival of the Portuguese, followed by the Dutch and the British, left a lasting impact on the political and socio-economic fabric of the area. The ancient port of Muziris, located on the banks of the Periyar River, was a crucial center for spice trade, attracting traders from as far as Rome, Egypt, and the Middle East. The presence of the Kottappuram Fort, built by the Portuguese, and the Thiruvanchikulam Mahadeva Temple, one of the major Shiva temples in South India, underscores the historical richness of this area. These landmarks not only bear testimony to the region's past glory but also continue to attract tourists and historians alike.

The Pullut sub-basin is a cultural tapestry woven with threads of Hinduism, Christianity, and Islam. The region is dotted with numerous temples, churches, and mosques, each with its own unique history and significance. For instance, Puthenvelikkara houses several ancient churches like the St. Francis Assissi Church, established in AD 1531, and the St. Thomas Church Thuruthoor, making it a notable Christian pilgrimage centre. Similarly, the Malavana Shiva Temple, known as 'Thekkan Kasi,' attracts a large number of Hindu devotees, especially during the Karkidaka Vavu Bali. The co-existence of diverse religious communities living in harmony is a hallmark of the cultural fabric of this region.

The socio-economic landscape of the Pullut sub-basin is characterized by a mix of agricultural, fishing, and small-scale industrial activities. The presence of educational institutions and healthcare facilities further contributes to the socio-economic well-being of these communities. Fishing is a primary occupation in coastal villages like Azhikode and Methala, where traditional fishing methods and shrimp cultivation are prevalent. The region also has pockets of small-scale industries, such as the screw pine mat market in Edavilangu and the coir manufacturing units in Vallivattom. The transformation from an agriculture and fishing-dependent economy to one that includes small-scale industries and tourism reflects the region's adaptability and resilience.

The river segmentation for Pullut is as follows:

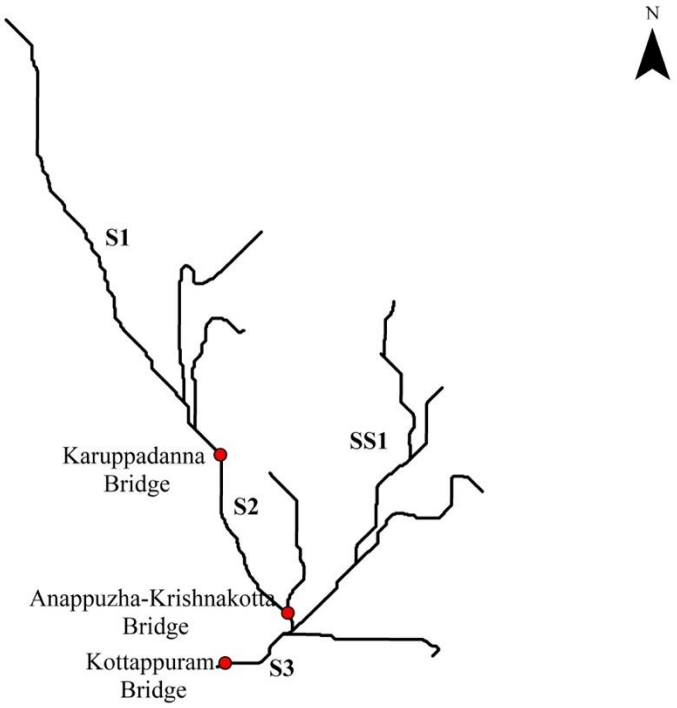

Fig. 13 i River Segmentation for Pullut

Segment	Length (km)	Salient Features
Segment 1 From origin to Karupadanna Bridge	17.15	From its origin to the Karupadanna Bridge, the river flows over wetland areas.
Segment 2 Karupadanna Bridge to Anappuzha-Krishnankotta Bridge	6.28	This stretch is known as the Pullut River, where cultivation and fish culture are promoted.
Segment 3 Anappuzha-Krishnankotta Bridge to Kottappuram Bridge	3.73	This stretch is wide, connects several tributaries, and is known for its historical significance, including the area of Muziris.
Sub-Segment 1 Puthenchira sub segment	13.17	This stretch of the river passes over wetlands and features numerous bridges.

16. MAJOR ISSUES REPORTED IN THE BASIN

16.1 Flooding in the Periyar Basin

In August 2018, Kerala state, experienced some of the most severe Extreme Rainfall Events (EREs). This resulted in extensive flooding and landslides across most districts of the state, causing severe damage to both the built and natural ecosystems. According to the India Meteorological Department (IMD), the occurrence of the EREs in August 2018 was mainly due to the formation of monsoon depressions over the Bay of Bengal and the west-north-westward movement of the depression over coastal Odisha and its neighbourhood. On an average, Kerala received significantly high Indian Summer Monsoon Rainfall (ISMR) from 1 June 2018 to 19 August 2018 (2346.6 mm), roughly 42% above the average rainfall for the same period. Among the different districts of the state, Idukki received the maximum rainfall, which was almost 100% excess compared to the average rainfall (Sudheer et al., 2019).

Due to the continuous rainfall from the first week of June to August, water levels were almost near the Full Reservoir Level. The storm of 15th to 17th of August 2018 was spread over the entire Kerala with eye centred at Peermade, a place between Periyar and Pamba sub-basins resulting in the massive flood throughout the state affecting 13 of the 14 districts. It resulted in the loss of over 400 lives, evacuation of about 3.4 million people to the 12,300 relief camps across the state making this the worst flood in the century. The storm was so severe that the gates of 35 dams were opened to release the flood runoff. All 5 overflow gates of the Idukki Dam were opened, for the first time in 26 years. The heavy rains along with the over-flooding of the Periyar River resulted in massive floods in Aluva region of Kerala's Ernakulam district. The Aluva's renowned Manappuram Sree Mahadeva Temple were submerged under water for days. All the operations in Cochin International Airport were suspended for two weeks until August 26 due to heavy damage inflicted upon by rising flood level damaging the periphery wall, runway and airport buildings. A number of water treatment plants were forced to cease pumping water, resulting in poor access to clean and potable water. 2018 Kerala flood caused extensive damage to the crops, building, and infrastructure. The associated aftermath of the flood resulted in a huge loss to states economic, social, and natural environment, accompanied by the 331 landslides across 10 districts (Parthasarathy et al. 2021).

Water level rises in Periyar & Muvattupuzhayar: Aluva Shiva Temple submerged.

The *Sunday Guardian* on 18th Aug 2018 "The mother nature's wake-up call"

Kochi airport suffers Rs 250 crore damage in Kerala floods, massive repair work on.

Published by: *India today* on Aug 22, 2018

"From the ruins, life begins anew in high ranges". Published by: *onmanorama* on September 8, 2018.
(Left) Cheruthoni river overflows when all the five shutters of the Cheruthoni dam were opened. (Right) The river is dried up, revealing collapsed bridge and damaged roads.

Sreekala et al. (2024) used geospatial technology utilising elevation, slope, aspect, flow direction, drainage density, and rainfall as input to create flood-prone areas. Various machine learning algorithms were developed and validated to identify flood-prone locations, showing evidence that geospatial technology is critical in disaster management. They identified different risk zones based on the risk factor (Sreelakshmi et al., 2021). The high flood risk zone covers 20.79%, the Moderate flood risk zone covers 71.35%, and the Low flood risk zone covers 7.86% of the study area. This

study has made it easy for policy makers to disaster preparedness, readiness, and responses. The state has also emphasised the importance of Integrated Flood Management (IFM) in efficiently utilising floodwaters while minimising the impact on communities and assets. Tidal floods have brought untold year-long misery to the residents of coastal areas and islands around Kochi.

16.2 Water Quality Issues Reported in the Periyar Basin

The Periyar River provides water for both residential and agricultural purposes. Jose & Ambili (2021) conducted physicochemical and bacteriological investigations on samples from various sites along the Pambar, Periyar, Muvattupuzha, Meenachil, and Thodupuzha rivers. The coliform count was found to be more prominent in the Periyar river. Since fecal contamination is primary source of coliform bacteria, the major reason for this is the rising population density in town areas. Higher COD levels in the site of Thekkady river indicates pollution from anthropogenic sources. The study by Subin & Husna (2013) found that garbage released from sites at Eloor, Kalamassery, and North Paravur had a significant impact on water quality in the Periyar river. The study found that contamination linked with physicochemical parameters is triggered by untreated or partially treated industrial waste, sewage waste, and unlawful solid waste disposal near rivers. Depending on the waste discharge and the flow of the river, the water quality may vary with season. Ashraf & Mukundan (2007) examined the quality of water at four locations along the Periyar River, with the intention of using them for drinking purposes. Mercury and lead were found in Kanakkankadavu water samples from January and March. During the summer, magnesium and calcium levels were significantly higher.

The primary reason for river pollution is the location of the Industrial Hub of Ernakulam District in the Periyar River basin. The chemical factories in the Eloor region, particularly, are responsible for a substantial portion of the pollution, making it one of the 35th most toxic hotspots in the world. Releasing industrial and municipal wastewater also leads to eutrophication, negatively affecting aquatic ecosystems (Joseph, 2004). The stretch from Angamaly to Kochi is the most industrialized zone of the Periyar River Basin. The industries located in Edayar – Eloor area consumes about 1,89,343 m^3 of water per day from the river and discharge about 75% of this as used water/ effluent along with a large quantity of pollutants. The types of industries include fertilizer and pesticide manufacturing industries, chemical and allied industries, petroleum refining and heavy metal processing industries, radioactive mineral processing industry, rubber processing units, animal bone processing units, battery manufacturers, mercury products and acid manufacturers, pigment and latex producers etc. Green Peace Reports (1999, 2003) describe Eloor industrial area as one of the most vulnerable industrially polluted “hot spots” in the world. High levels of Mercury (Hg), Copper (Cu), Zinc (Zn) and Cadmium (Cd) have been reported near the factory discharge points. As a part of the CAMP Project for the Periyar River, a river walk was carried out from Neriamangalam to the downstream and sampling points were identified.

Fig. 14 Sampling points identified during the river walk

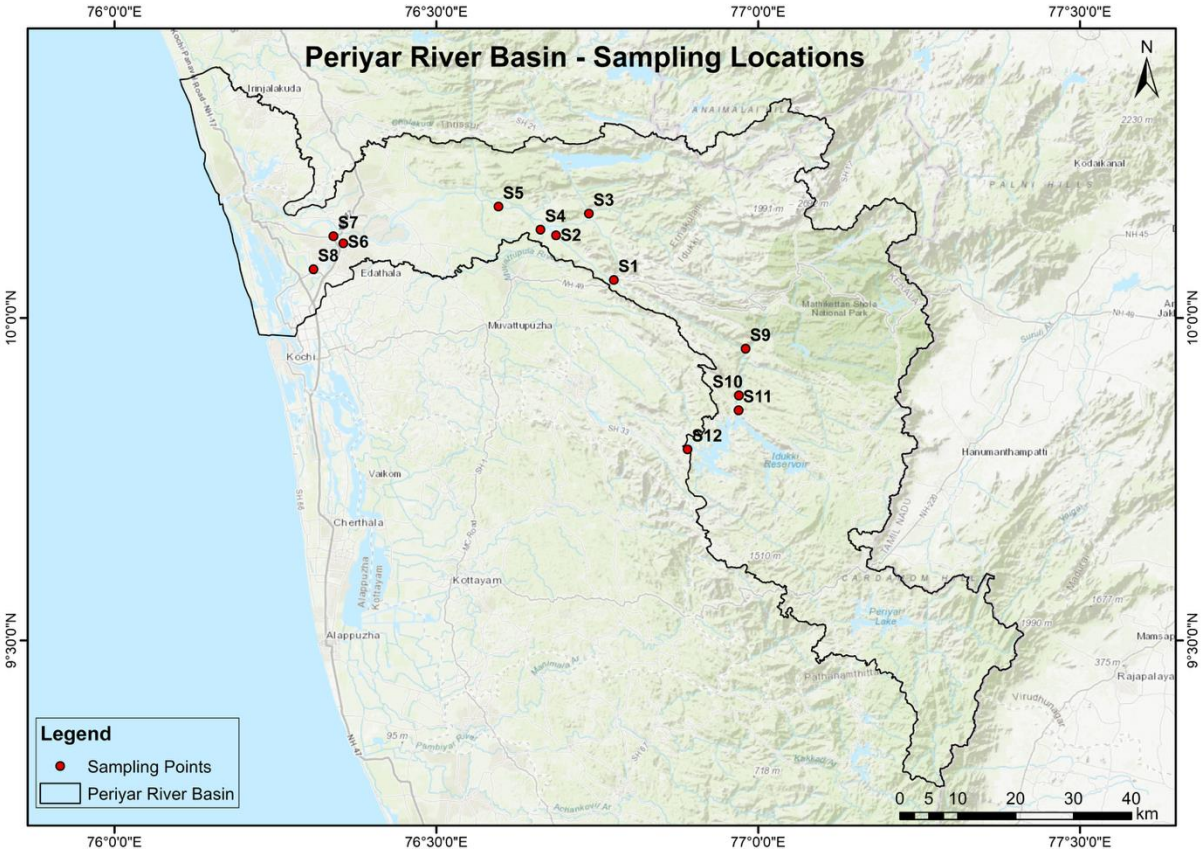

Fig. 14a Location of sampling points identified

16.3 Sand Mining and Rock Quarrying

Sand mining is a serious threat to most of the rivers in Kerala. Even though, the Govt. of Kerala had imposed controls on sand mining, since 2016, it remains a challenge to enforce these regulations due to various reasons. Additionally, sand mining has extensive adverse effects on the environment and socio-economic structures, causing river bank erosion, slumping, and channel widening, which undermines engineering structures. Excessive dredging has occurred at Neelesweram and Thannipuzha on the Periyar River, leading to water scarcity in wells and significant groundwater fluctuations near mining sites. A study by Subha Lekshmi (2021) showed that the river widened from 2008 to 2011, and its course changed due to bank erosion and sediment deposition. John (2016) reported that moderate levels of exploitation are observed in the highlands. The midlands face the most severe exploitation. This region shows the highest quantity of sand mined, with 3.616 MT/ year from the main channel and 1.68 MT/ year from the tributaries and distributaries. Additionally, the alluvial reaches of the midlands experience severe degradation compared to the highlands due to higher proportion of sand extracted from this region.

About 45 mining sites were observed in this region, reflecting a concentrated effort. The alluvial reaches of the lowlands also experience significant degradation, though less severe compared to the midlands. The study by John (2016) provides detailed data supporting these findings. The study revealed that sand and gravel are extracted not only from active channels (instream mining) but also significantly from overbank areas (floodplain mining). Two main types of instream mining were being practiced: pit excavation and bar skimming. These methods contribute to the environmental degradation observed in the region. In Periyar–Chalakudy basin, there are about 525 rock quarries. Out of these, 137 are active quarries, while 388 are abandoned ones. Mining activities are noticed even in ecologically sensitive zones (Vandana et al., 2019). They reported that nearly ten hard rock quarries in the Periyar River basin are directly contributing to changes in the drainage channels. It was also observed that a number of first order streams have either been blocked or have disappeared. Major impacts of excessive rock quarrying include lowering of the water table, modification or disappearance of natural drainages, degradation of the natural landscape, environmental pollution etc.

16.4 Landslides

The Periyar basin is subjected to frequent mass movements posing threats to communities and infrastructure. A recent incident of a major landslide event in this basin is the Pettimudi landslide that occurred in 2020 and took a toll of 66 lives in addition to considerable damages to property (Jain et al., 2021). According to the Kerala State Disaster Management Authority (KSDMA), 46.93% of landslides reported in Kerala during 2018 had occurred in Idukki District, a major part of which lies in the Periyar River Basin (Jones et al., 2021). Accumulated rainfall in short periods along with several geologic and topographic factors triggers these mass movements. The most common type of mass movement in this area are debris flow (Urul pottal) and landslips (Mannidichil).

16.5 Soil Erosion and Reservoir Sedimentation

As per the Integrated Hydrologic Data Book released by the CWC in 2015, the monsoon sediment load at Neeleswaram ranged from 0.049 to 0.146 million metric tonnes during the period 2002-2012 whereas the non-monsoon load ranged between 0.002 and 0.017 million metric tonnes. The maximum sediment load was observed in the year 2005-2006. As per a report of the Room for River for the Periyar River Project envisaged by the Government of Kerala, the reach from Marthandavarma Bridge to Vaduthala experiences the largest amount of sedimentation (about 49,90,580.53 m^3 of sediments). The reach from Karimanal Bridge to Bhoothathankettu Barrage experiences the least sedimentation with almost nil sedimentation in the main river channel. Muthirapuzha tributary has the largest sediment load (about 2,21,185 m^3) followed by Perinjamkutty Aar (51,117m^3) and Kallar Puzha (26,600m^3). Dwarakish et. al. (2009) reported that the net runoff and sediment load of the Periyar River Basin is reduced mainly due to impoundment in dams. They reported that the total amount of sediment trapped in all the reservoirs in Periyar River up to 2006 is about 225MT, which is approximately 30 times the total sediment load transported by Periyar towards Cochin coast during the period 1978-2002. Skariah & Suriyakala (2021) reported that the capacity of the Idukki Reservoir reduced by about 11.60% between 1976 and 2019. The original live storage capacity of the Idukki reservoir is reported to have reduced from 0.867 to 0.766 km^3. It has been reported in the Compendium on Sedimentation of Reservoirs in India (2020) published by the CWC that the average siltation rate of Idukki Reservoir is 1590 m^3/ km^2/ year whereas that of the Idmalayar reservoir is 2660 m^3/ km^2/ year.

16.6 Drought

Despite its typically humid tropical climate, the basin has experienced significant drought events, impacting water availability and socio-economic conditions. A reduction in rainfall of about 34% and 32% during the South-west monsoon and North-east monsoon respectively was recorded in the year 2016, an extreme drought year (Saranya et.al, 2020). After the extreme flood event in 2018, some regions in the basin experienced severe drought conditions. One particularly affected region is Cheranalloor, where all wells within a distance of 500 m from the river have dried up, causing critical water shortage issues. In 2024, drought has severely affected the cardamom farmers in Idukki District causing wilting of plants. Around 80% of the cardamom plants in Nedumkandam, Udumbanchola and Bison Valley Panchayats have wilted. Additionally, the drought has affected coffee, pepper, and nutmeg in the area (Manoj, 2024). Agricultural crops across 33,722 ha of farmlands in Idukki have been destroyed due to the prolonged dry spell, coupled with heat wave and soil warming, devastating the lives of 29,743 farmers. The prolonged drought has also resulted in the depletion of groundwater levels. A report on the issue of decreasing flows in Pamba and Periyar Rivers in Kerala reported that the Periyar River at Neeleswaram which was perennial till 2007-2008, had no flow on a number of occasions since 2008. In 2012-2013, the river had no flow for 119 days whereas in 2013-2014, it had no flow for 54 days.

16.7 Seawater Intrusion

The problem of salinization of coastal aquifers in Kerala has been mainly reported from Ernakulam, Thrissur, and Alleppey districts. Studies reveal that groundwater quality in Ernakulam District has deteriorated, particularly along the coastal areas due to salt water intrusion. Seawater intrusion is severe along the Chellanam and Vypin coasts. Groundwater samples collected at Njarakkal, Malipuam, Edacochin, Chellanam, Munambam and Pallipuram in the lowland area near the coast have shown values of Na/Cl less than 1 indicating that sea water intrusion has occured into the aquifer at these locations (Kumar et al., 2015). Sea Level Rise (SLR) is considered to be one of the consequences of climate change and can lead to/ aggravate sea water intrusion (SWI) into coastal aquifers, thereby contaminating groundwater and making it unfit for household and irrigation purposes (Sreekesh et al., 2018). A review of the situation in the coastal belt of the Periyar River Basin reveals that it is extremely important to investigate the problems of sea water intrusion, sea level rise and coastal flooding as these area are very densely populated.

16.8 Solid Waste Management

In 2021, the population of Cochin was about 31.93 lakhs and the amount of municipal solid waste (MSW) generated was about 326 MT/ day. The Health Department of the Cochin Corporation is responsible for the collection, transportation, and disposal of MSW, while the Engineering Department assists them in planning and formulation of programs, procurement of vehicles and equipment and development of the treatment/ disposal site. The biodegradable waste (BDW) fractions are being treated at the Brahmapuram plant (treatment capacity 220 MT/ day) by windrow composting, and the leachate from the windrows is being treated at the Corporation owned 0.1 MLD septage treatment plant in the vicinity. The non-biodegradable waste (NBDW) fraction is being dumped in the yard and later handled by the 3 material collection facilities of the Corporation and 1 resource recovery facility at Brahmapuram. The MSW management situation in the Periyar river basin is characterized by lack of primary collection, and transportation of the BDW fractions. Moreover, low capacity of community-level BDW treatment facilities, and lack of centralized processing and disposal facilities, force the residents to manage their BDW locally. Moreover, NBDW management services are also inadequate as they focus primarily on high value plastics, with intermittent collection (most of the collection is being done by the Haritha Karma Sena without formal contracts with the urban local bodies (ULBs), eventually resulting in a very low percentage (~3 percent) of NBDW collection.

Table 5 Details of dumping sites in Periyar basin

Sl. No.	Urban Local Body	Dumpsite	Location	Area (acres)
1	Kothamangalam	Kumbalathumury	10.078930° N & 76.647811° E	2.13
2	North Paravur	Vedimara	10.150518° N & 76.242212° E	1.25
3	Kalamassery	Kalamassery	10.065159° N & 76.327607E	0.02

17. SENSITIVE AREAS WITHIN THE BASIN

The Periyar Tiger Reserve falls under the category of protected areas, which can be categorized as undisturbed zones. No human interventions are noticed in this area. The point sources of pollution, with a buffer boundary of 5 km, are identified as vulnerable zones. The mapping of sensitive areas within the basin is shown in Fig. 15.

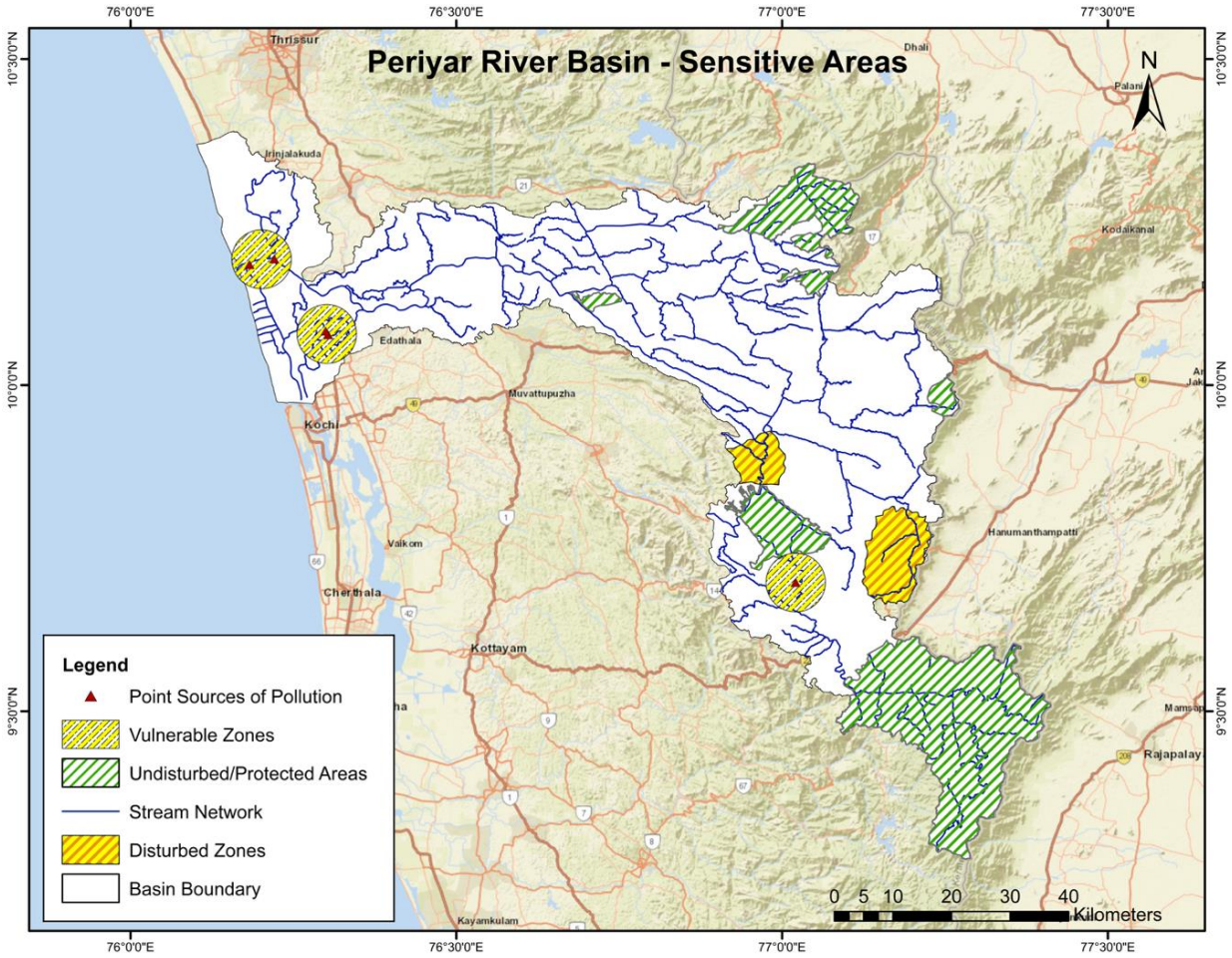

Fig. 15 Undisturbed, disturbed & vulnerable zones in the basin

Vadakkekara, Eloor, and Upputhara are some of the spots identified as sources of pollution in the basin. There are some locations within the basin where quarrying activities are found. These regions come under the disturbed zones within the basin.

18. POTENTIAL ACTIONS NEEDED FOR RESTORATION & CONSERVATION OF THE RIVER BASIN

The disturbances in the basin are mainly due to rock quarrying in the sensitive areas of the basin. Major impacts of excessive rock quarrying include lowering of the water table, modification or disappearance of natural drainages, degradation of the natural landscape, environmental pollution etc. The discharge of untreated waste water from industries and also direct discharge from households deplete the quality of the river water. The action plans for the restoration and conservation of river basin are listed below:

- Public shall be sensitized to treat the river as a living entity and treat it with utmost care and respect
- River Basin Management Authority shall be constituted with experts from all related disciplines and representatives of all stakeholders
- Land use planning has to be carried out scientifically with sustainability as the guiding principle. Such plans have to be properly implemented.
- The drainage network in the Kochi metropolitan area, as well as in other problem areas have to be critically reviewed and necessary modifications and interventions have to be made.
- The original river channels have to be re-established by removing all encroachments to enhance the capacity of the system to convey flood waters.
- Green infrastructure solutions such as permeable pavements, green buildings etc shall be adopted and implemented. This will help to enhance absorption and reduce flooding.
- Flood plain zoning and flood inundation mapping shall to be carried out and vulnerable areas shall be identified.
- Early warning system for floods and landslides to alert the public shall be developed and employed.
- An efficient model to forecast reservoir inflow and existing rule curve needs to be upgraded considering the present climate change scenario.
- Efficient irrigation methods to reduce the usage of water shall be adopted. Farmers shall be encouraged to cultivate drought resistant crops in drought prone areas. Agroforestry concept to reduce soil erosion and improve water retention shall be implemented.
- Greywater recycling for agricultural and industrial purposes should be adopted. Water conservation strategies shall be popularized and the public shall be encouraged to adopt it at the household level. This can be extended to industries and commercial buildings also.
- Soil erosion mapping shall be carried out to identify the areas vulnerable to erosion. Good agricultural practices and soil conservation strategies to reduce erosion shall be promoted.
- A detailed study needs to be carried out in the lower stretch of Periyar flowing through the industrial area to understand the actual pollution levels in the river.
- Illegal effluent discharge points shall be identified, and measures to prevent such discharges into the river shall be implemented.

- Regular monitoring of industrial discharges into rivers shall be carried out.
- Common effluent treatment plants shall be established in the industrial belt to minimize the pollution load from industries.
- In order to lower the harmful impact on health and the environment, it is necessary to adopt appropriate strategies to reduce waste generation, promote reuse and recycling of waste and ensure zero waste on ground. Dumping of solid wastes into the river and drainages shall be discouraged through awareness building and defaulters shall be penalized.
- Bins for segregation of wastes at the household and institutional level shall be provided and segregated collection, handling, and treatment of solid wastes shall be implemented.
- Mandatory segregation of waste at the source based on its characteristics will enhance recycling and reuse potential
- A large number of decentralised facilities for treating biodegradable domestic waste (BDW) at the community level shall be provided.
- Hazardous solid wastes generated in the industries needs to be handled properly so as to prevent nearby environment from getting contaminated
- Sand audit of rivers shall be carried out by adopting a rational and scientific approach.
- Limit mining only to the extent permissible based on the sand audit and other constraints such as environmental safeguards.
- Use of alternatives to river sand shall be explored and encouraged.
- Multidisciplinary studies on rivers aimed at providing adequate scientific information aiding river restoration and management activities shall be taken up.
- Abandoned pits shall be reclaimed.
- Use of groundwater shall be regulated in problem areas.
- Indiscriminate industrial and anthropogenic activities in the vicinity of the river shall be controlled as it can help to improve water quality and may prove cheaper and rational than incurring large expenditure for river restoration.

Role of the River at a Glance report in supporting stakeholders

River at a Glance – Periyar provides a concise overview of the Periyar River basin, making it a reference document for integrated river basin management. This report consolidates key information on the basin's physiography, demography, hydrological regime, land-use patterns, and ecological setting into a single, easy-to-interpret document. This enables a broad group of stakeholders including local bodies, NGOs, and community-based organisations to quickly understand the essential features and prevailing issues of the basin, even without technical expertise. The River at a Glance Report maps environmentally sensitive areas, disturbed zones, pollution hotspots, and protected areas. This spatial understanding helps authorities prioritise interventions with enhanced caution, ensuring that activities involving land modification are minimised in fragile regions. This report also provides a foundational data for research and academic work as it serves as a baseline dataset for students and researchers working on hydrology, ecology, climate and related studies within the Periyar Basin.

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