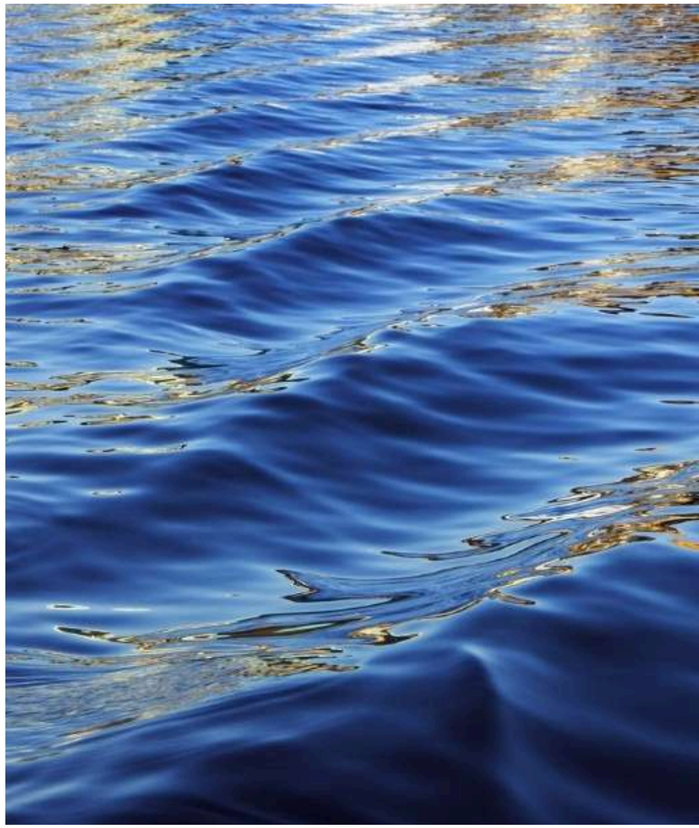
Relevance of IWRM in the Context of Humid Tropical Kerala

E J JAMES



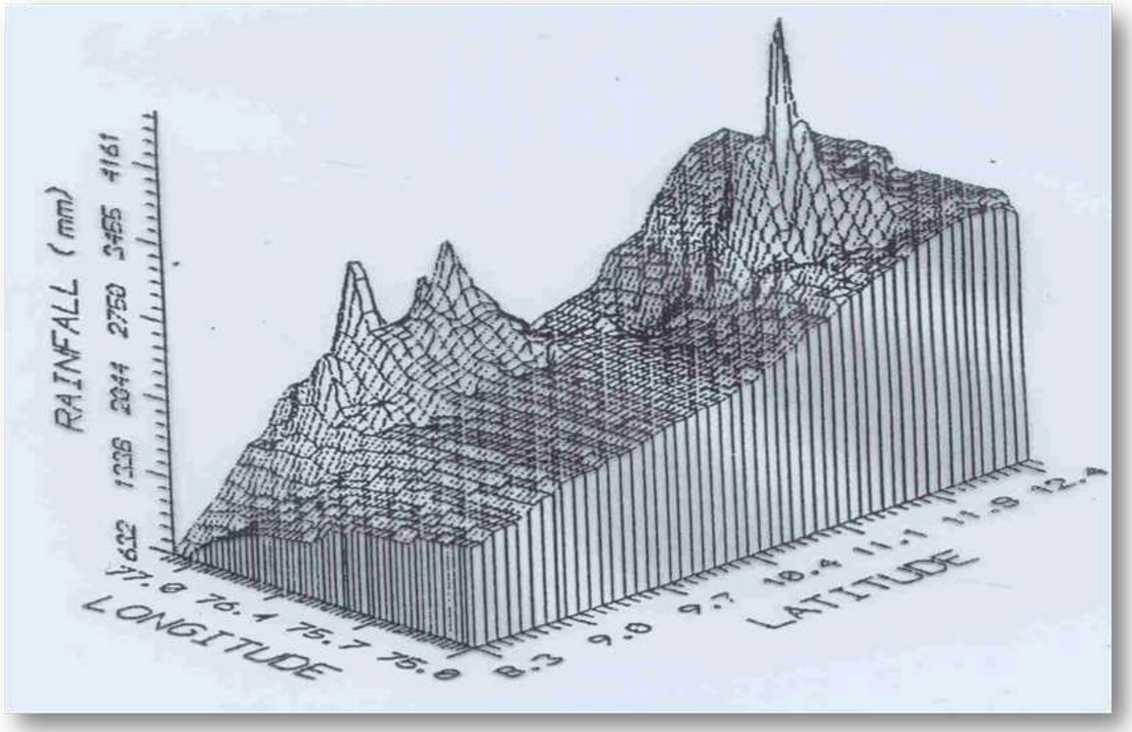
Four Relevant Questions Regarding Water Management in Kerala

1. What are the distinctive hydrologic, ecologic and socio-economic features of Kerala? Do they pose a challenge to water management? Is there a need for paradigm shift?
2. How do we approach the water management problem in the modern context in this wet, humid tropical zone?
3. Can we harness our remaining hydroelectric power? What are its advantages?
4. What is our Vision for 2031? Can we start implementing it from now onwards?

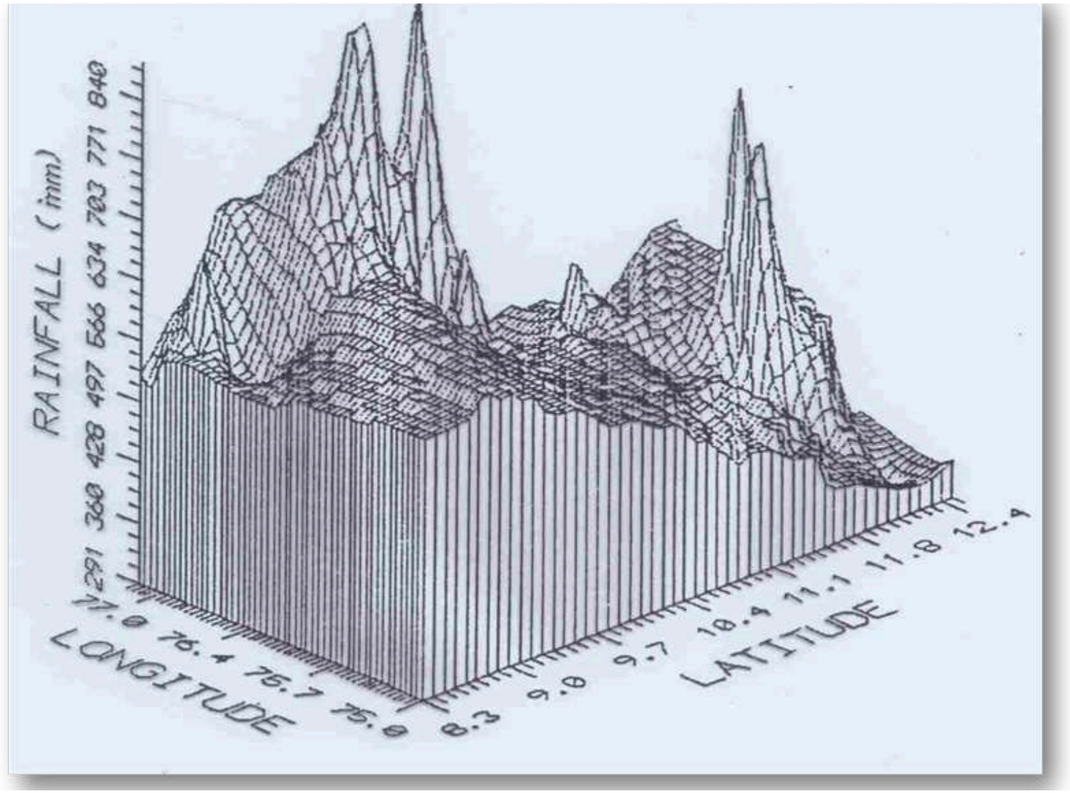
Unique Water Management Challenges of Kerala

Significant Spatial and Temporal Variation in Rainfall

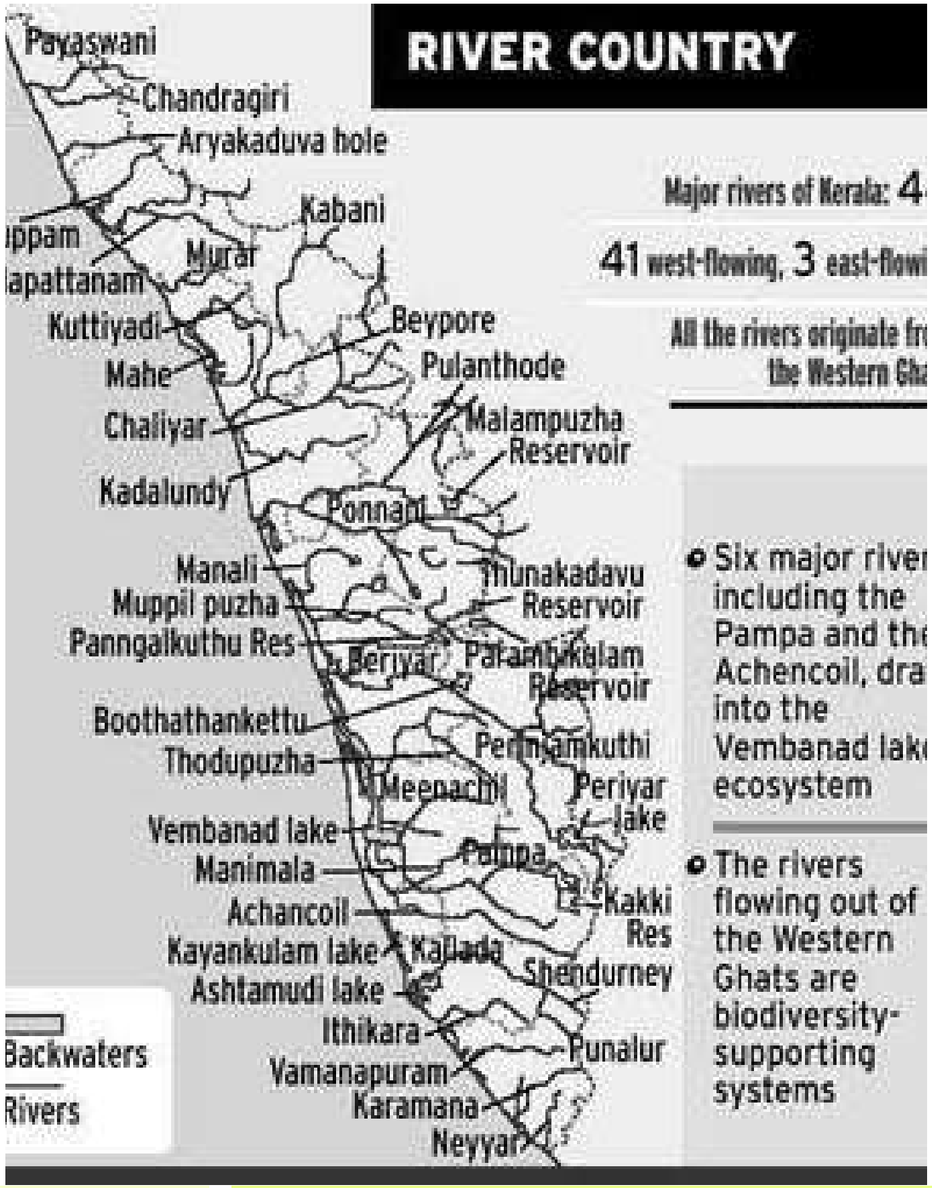
Southwest Monsoon

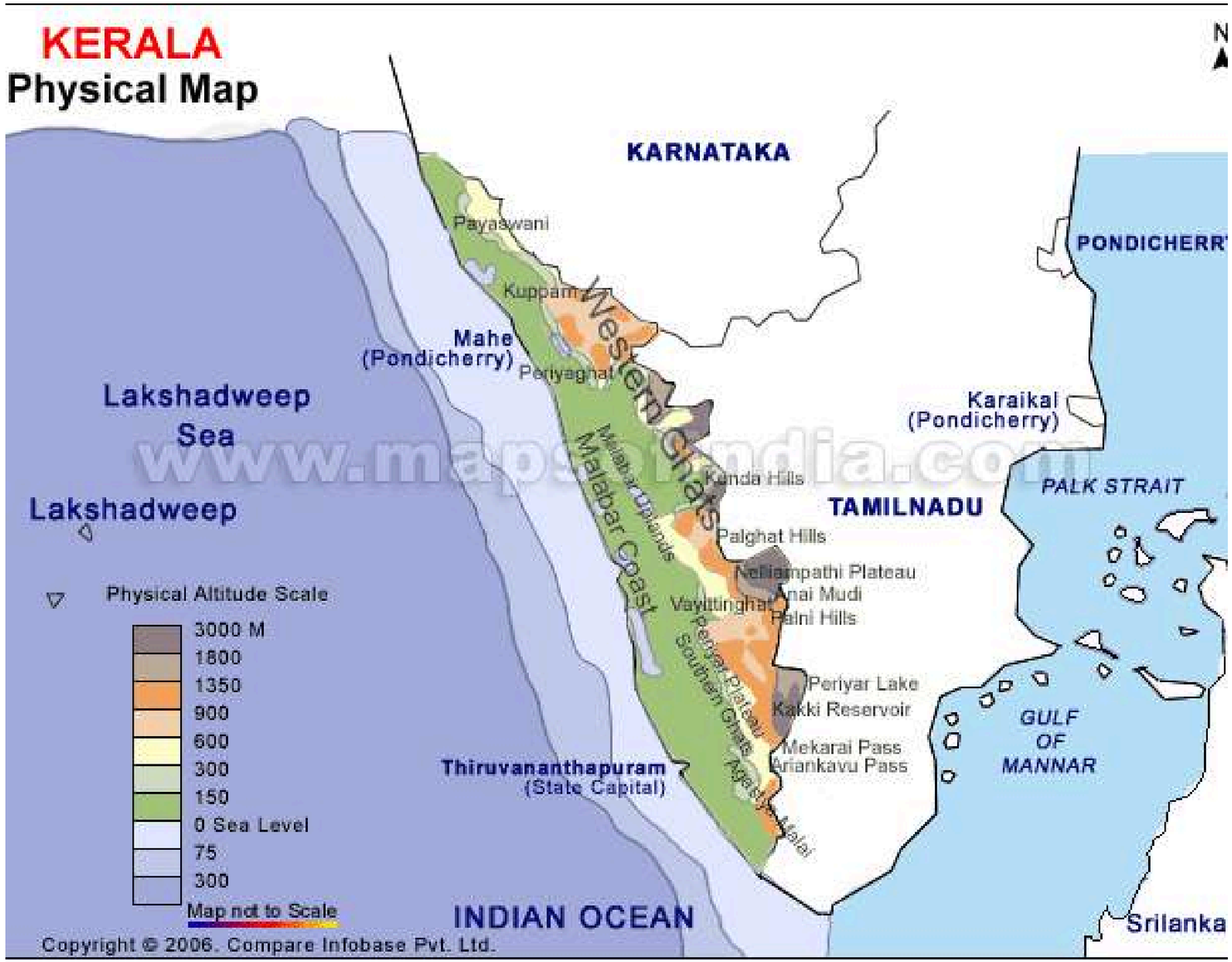


Northeast Monsoon

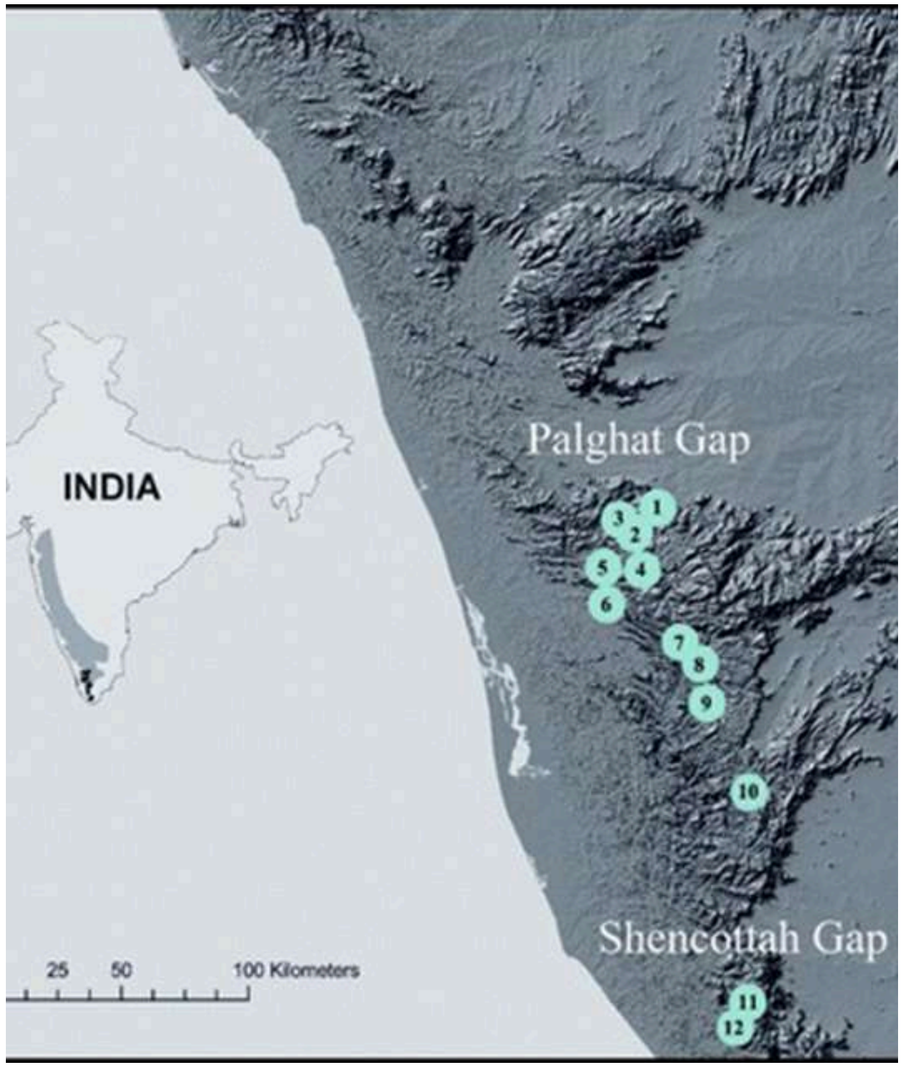


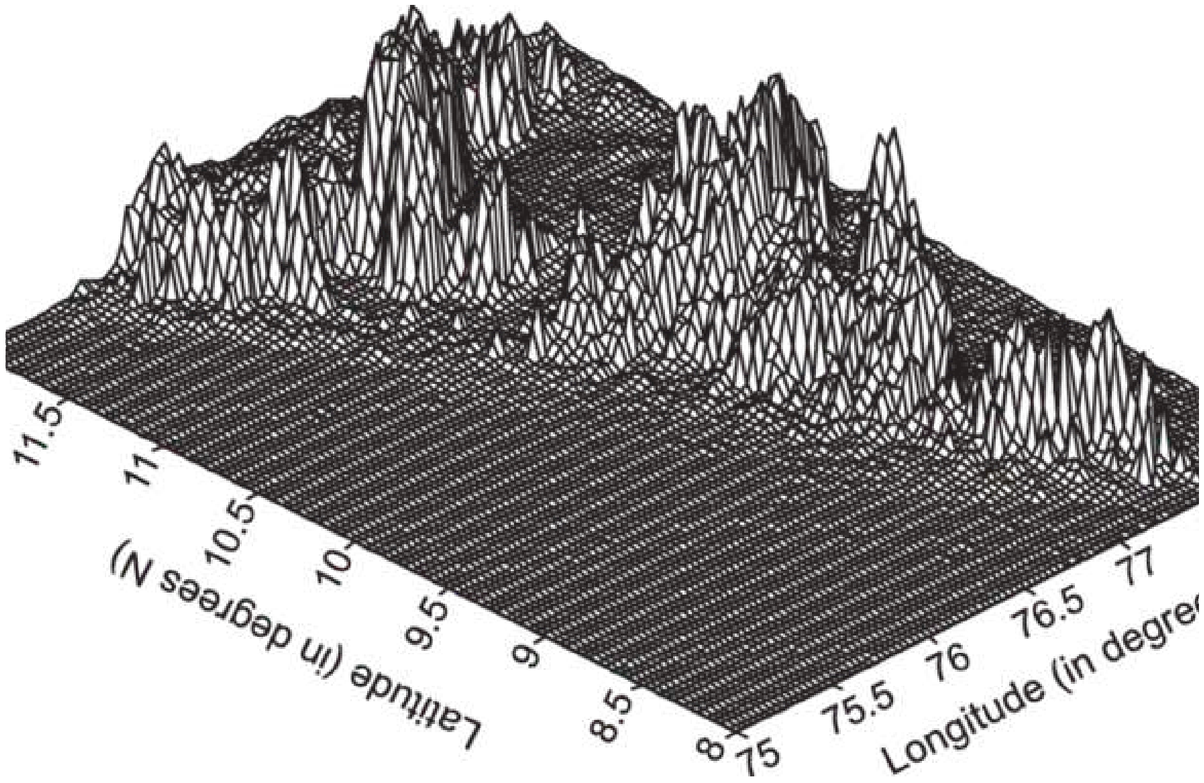
Short, Steep, Monsoon-fed Rivers



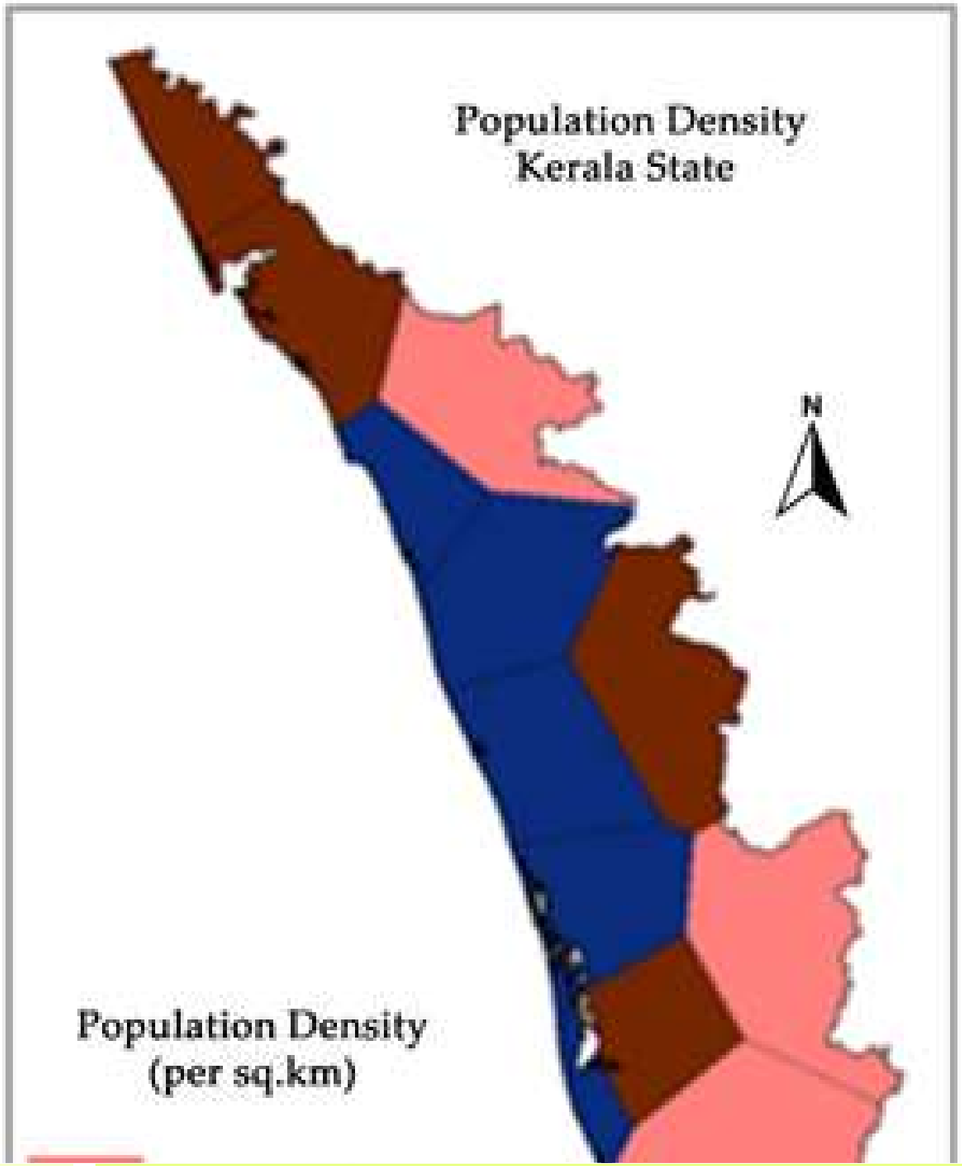


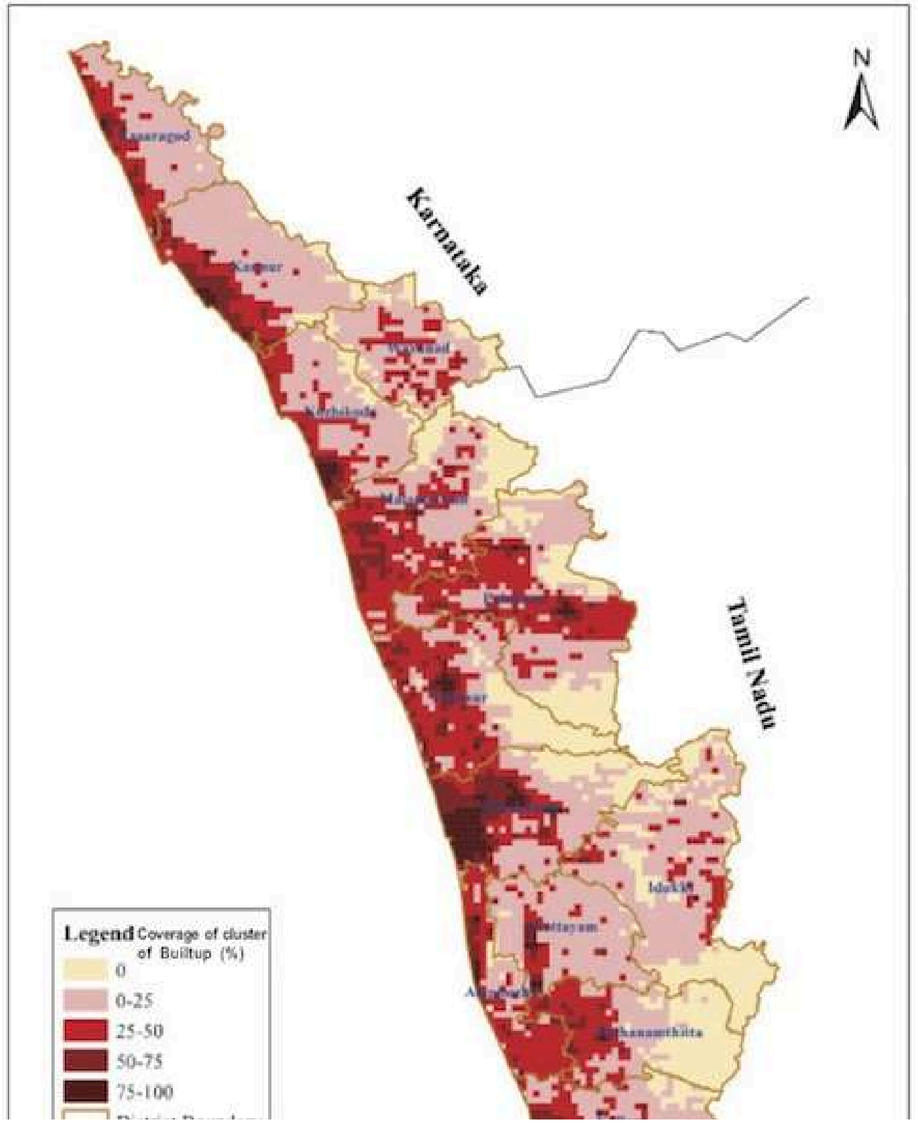
Undulating Topography



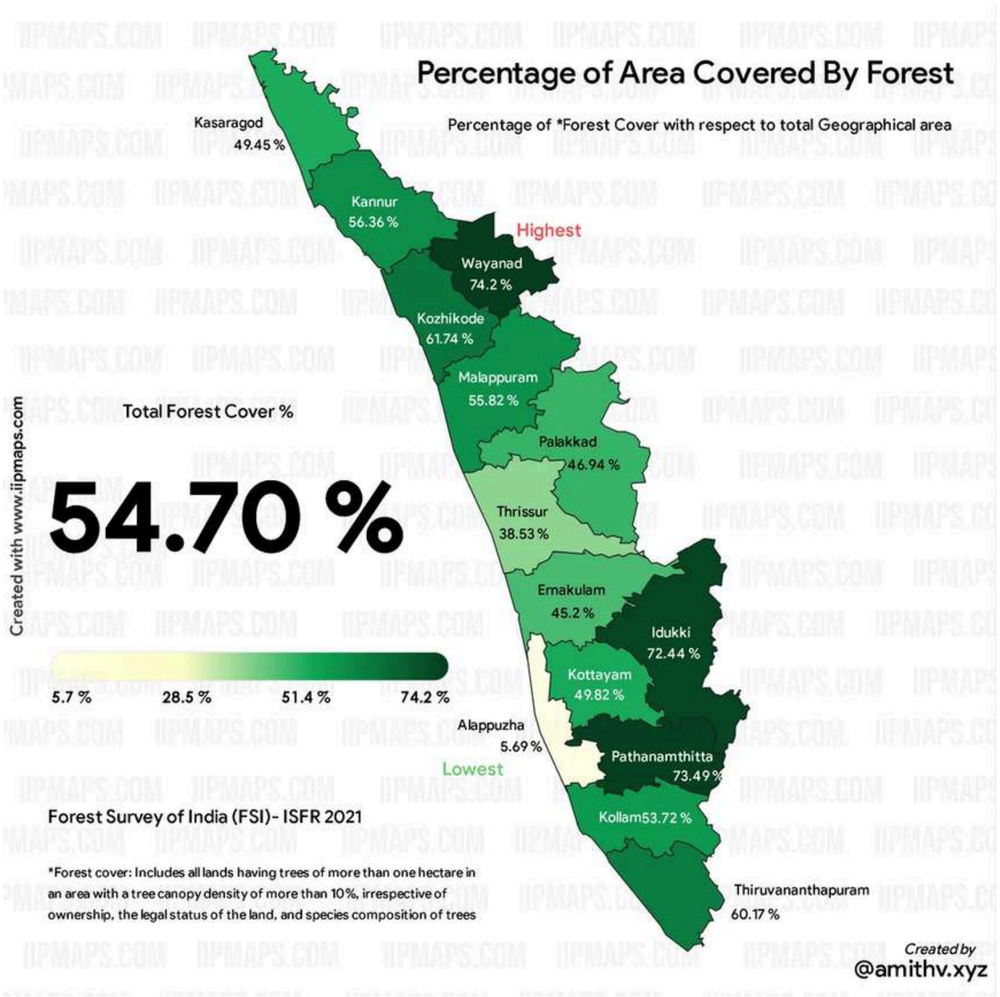


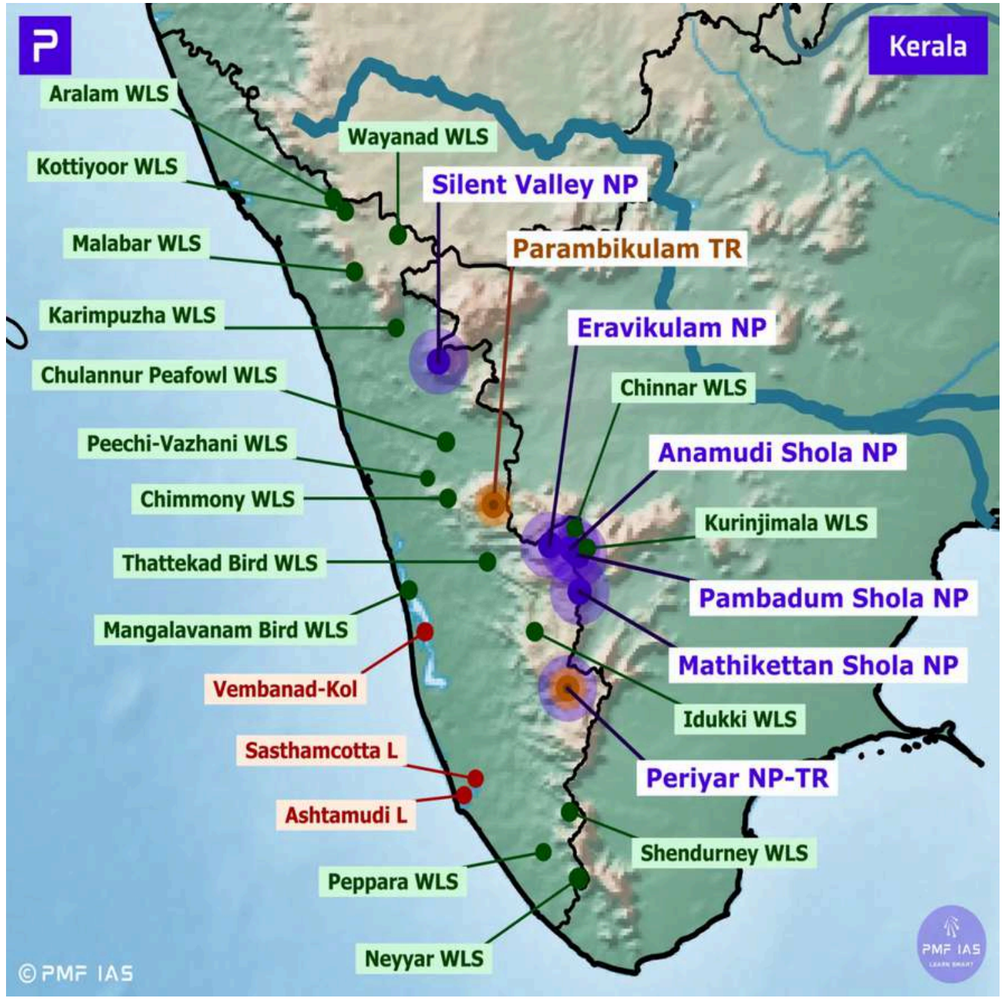
Dense Population and Urbanization Trends



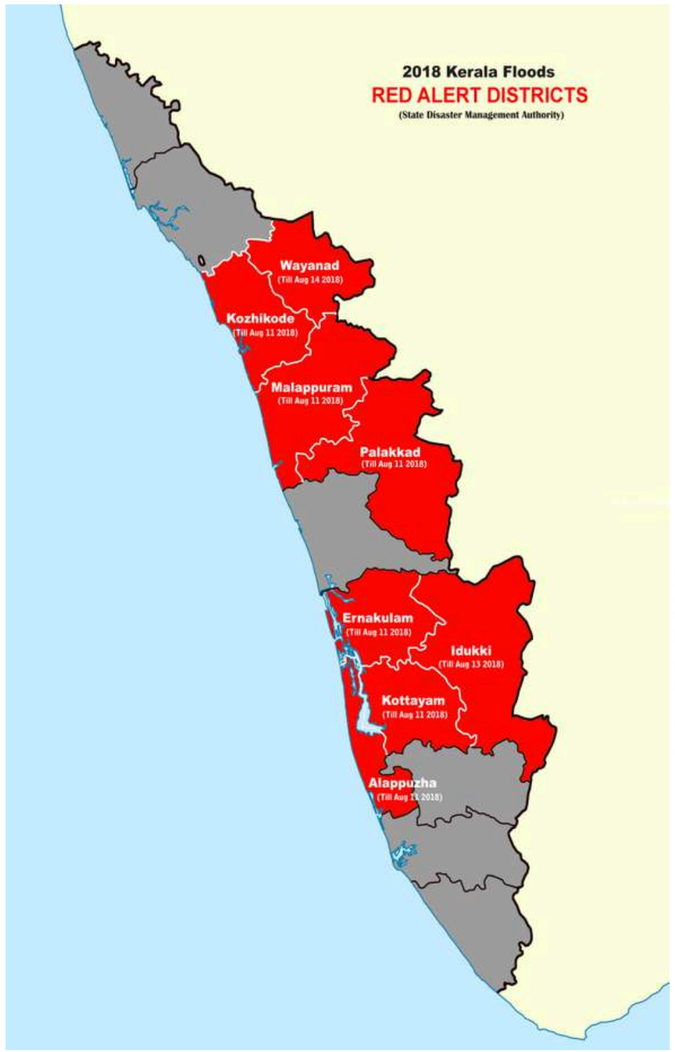


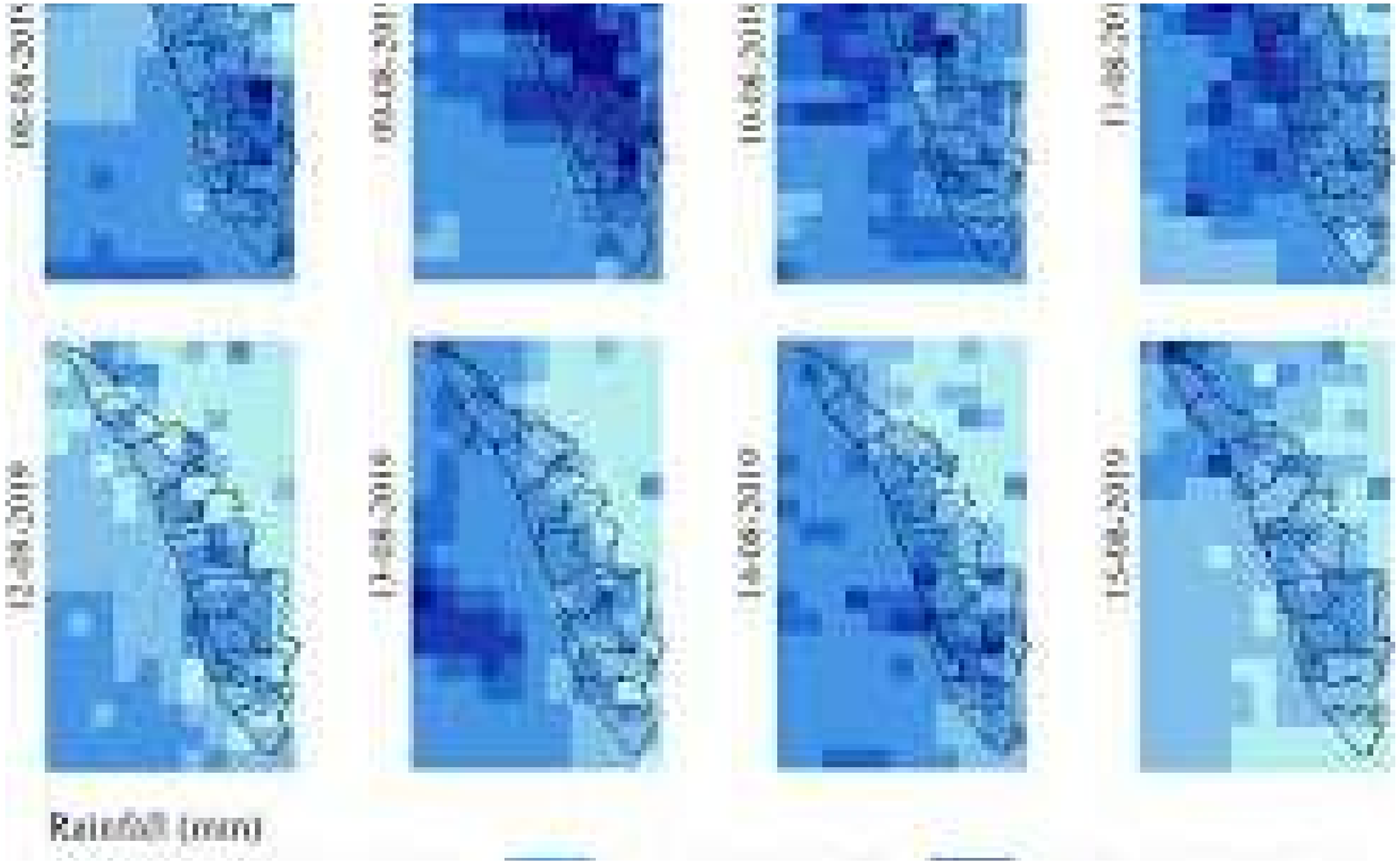
Significant Area Under Forests, Sanctuaries, Wetlands





Frequent Floods and Dry Periods Accelerated by Climate Change





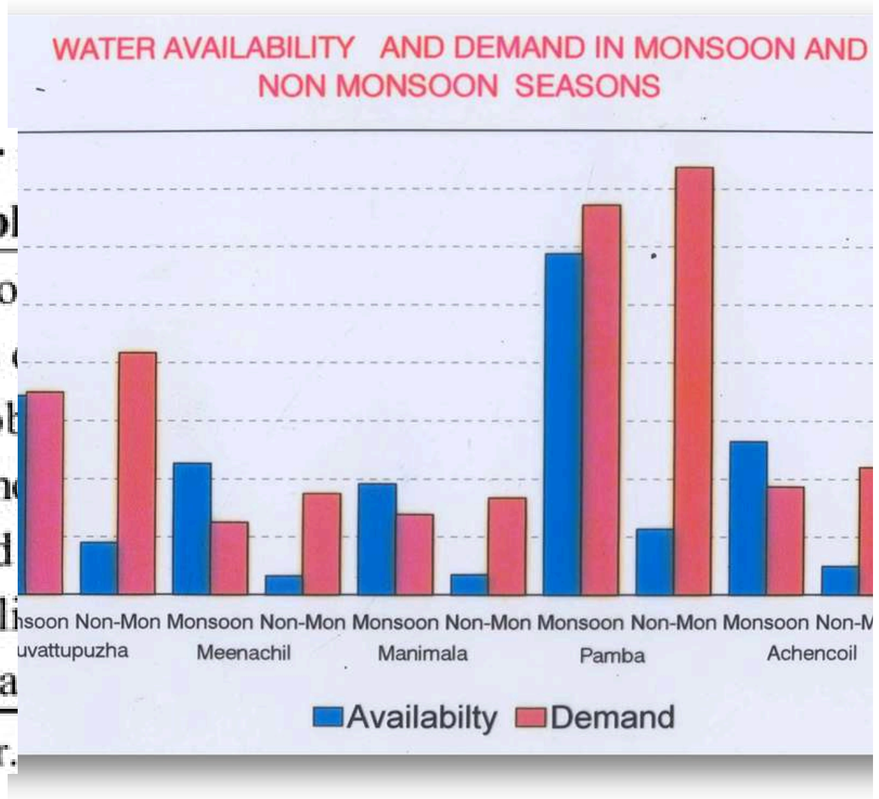
August 08-15, 2019

Water Scarcity, Water Stress, Temporal Flows

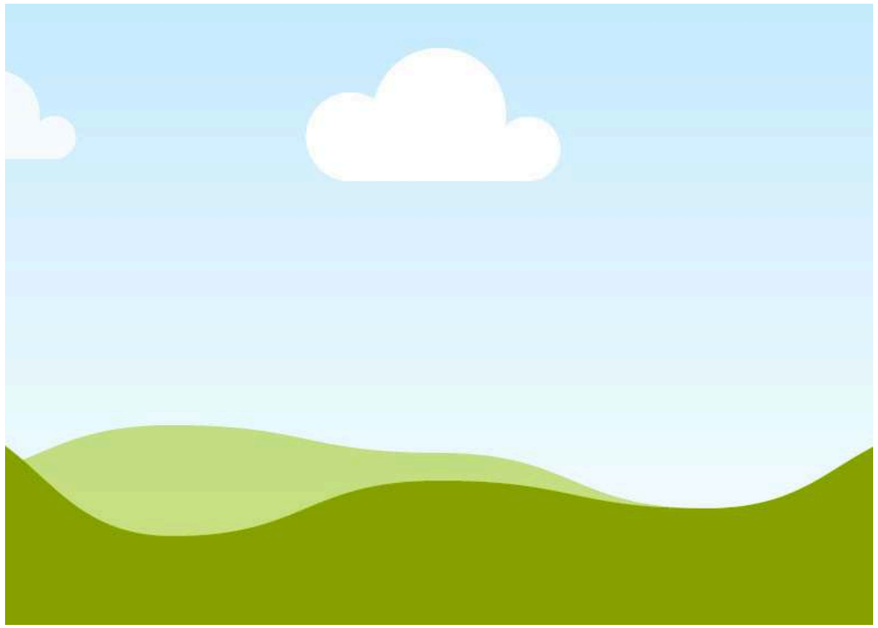
World Bank Classification of Scarcity and Stress

of water stress	Water probl
or local water stress	No or limited pro
lar water stress	Heavy pressures management prob
c water scarcity	Chronic water sh development and
te water scarcity	Beyond availabil of manageable ca

Note: [a] refers to renewable and usable water.

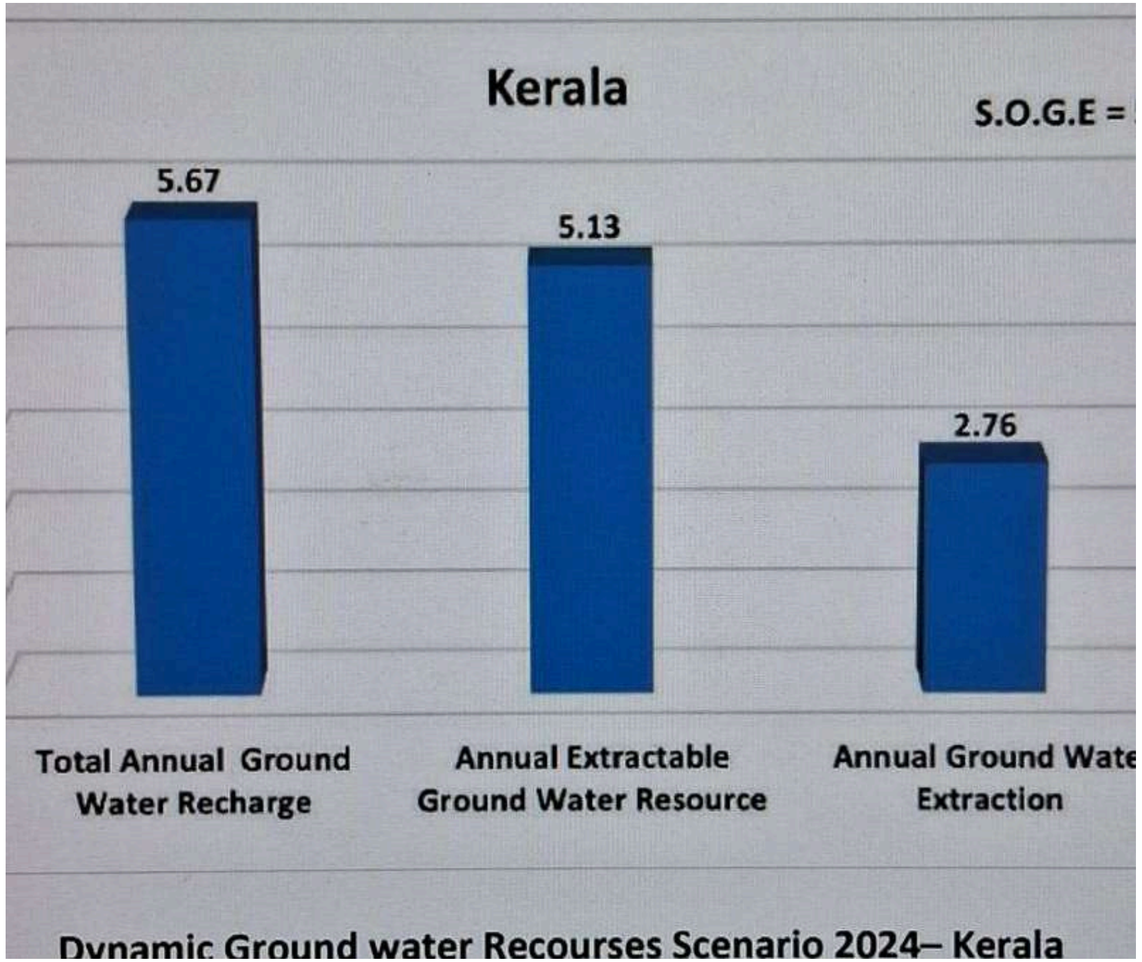


Temporal Flows - Mm^3 in the Chaliyar – Monsoon and Non-monsoon: 2006 - 2017



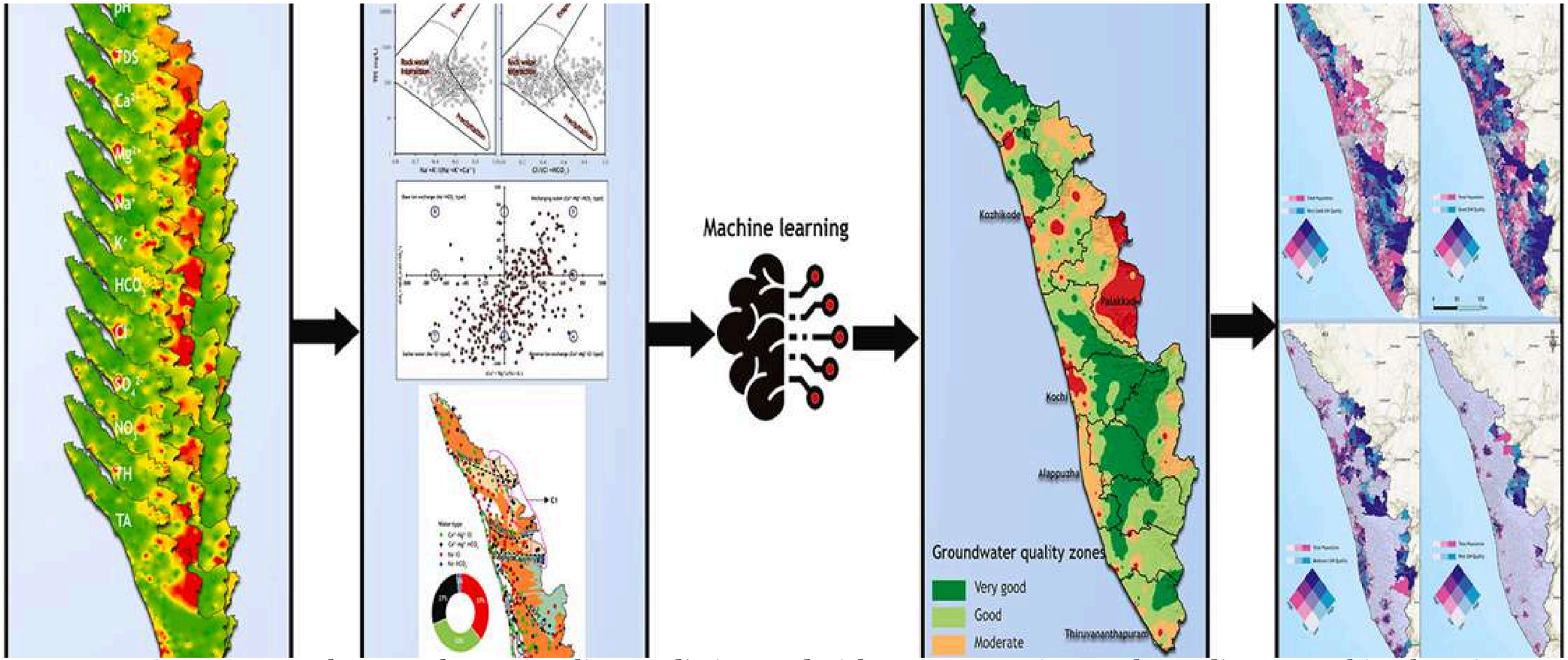
Unique Geological Formation and Hydrogeology

	Age	Formation	Lithology
Quaternary	Recent	Alluvium	sand and clays along the coast and flood plain deposits
	Sub-recent	Laterite	laterite capping over crystalline and sedimentary formations
Tertiary	Lower Miocene	Warkalai beds	sandstones and clays with thin bands of lignite
	Lower Miocene	Quilon beds	limestone and clay
	Oligocene to Eocene	Vaikom beds	sandstone, clay and thin bands of lignite
	Eocene	Alleppey beds	carbonaceous clay with minor lenses of fine sand
Unconformity			
	Archaean (crystalline formation)		charnockites, khondalites and granites



Source: *National Compilation on Dynamic Ground Water Resources of India 2024*

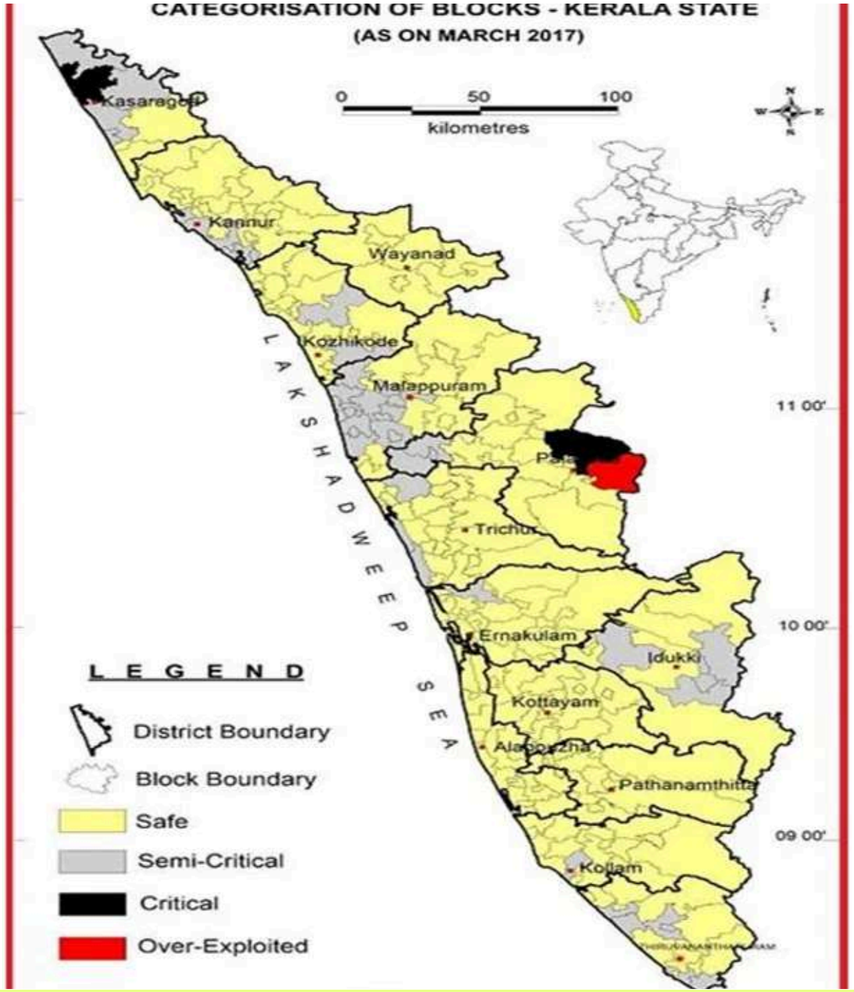
Groundwater Quality Prediction and Risk Assessment in Kerala – A Machine Learning Approach



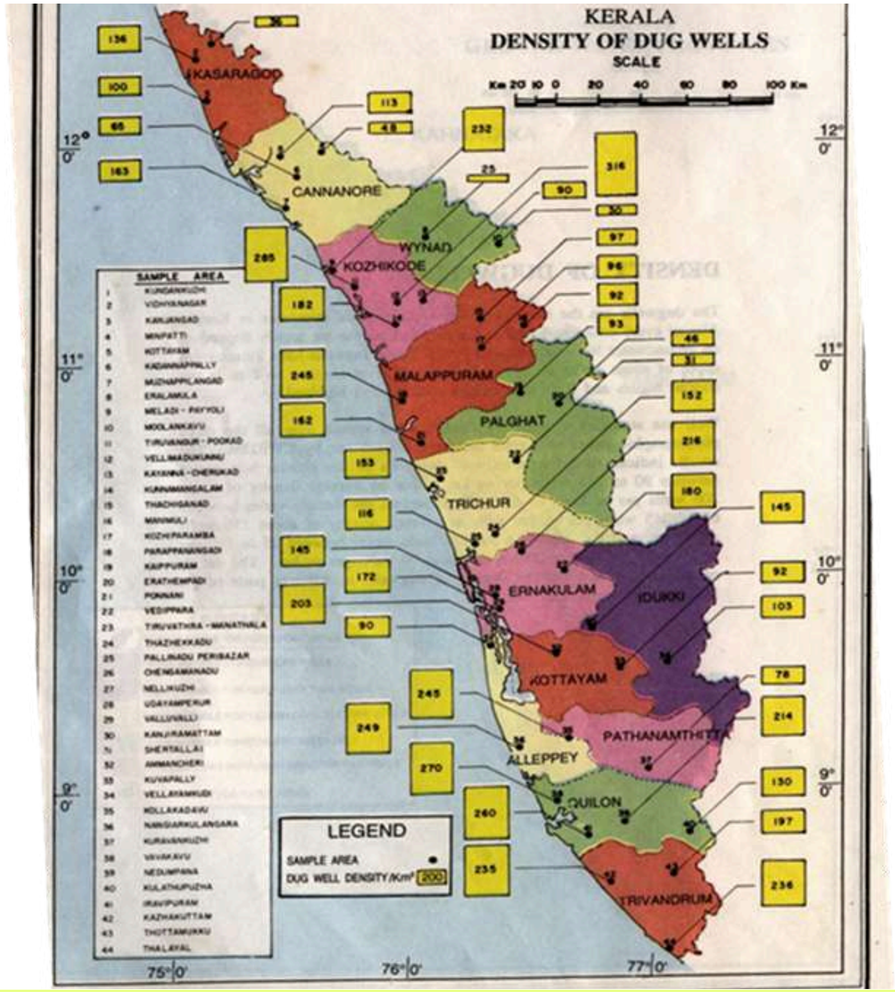
Source: Aju, C.D., et *al*, Groundwater quality prediction and risk assessment in Kerala, India: A machine-learning approach, *Journal of Environment Research, Elsevier*, vo. 370, November 2024.

Groundwater Exploitation and Density of Open Wells

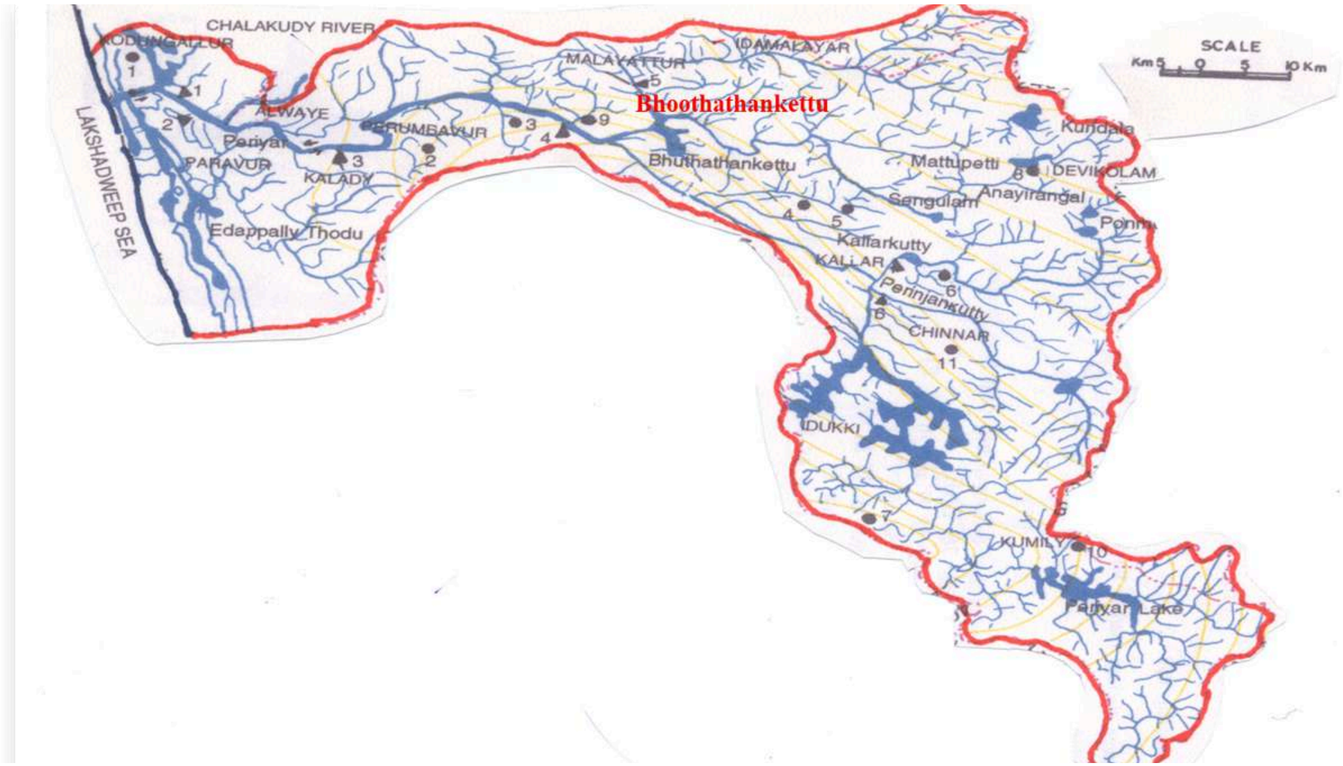
Groundwater Exploitation



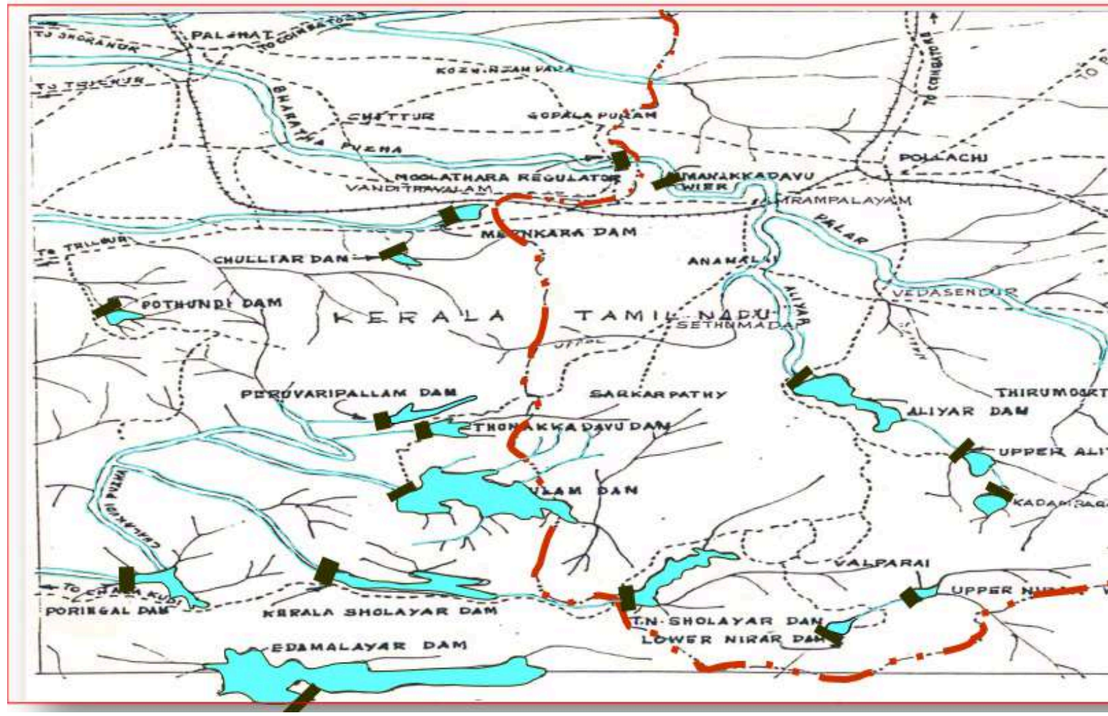
Density of Open Wells



Unplanned Water Transfers Affecting Upstream-Downstream Balance



Periyar



Parambikulam-Aliyar Project

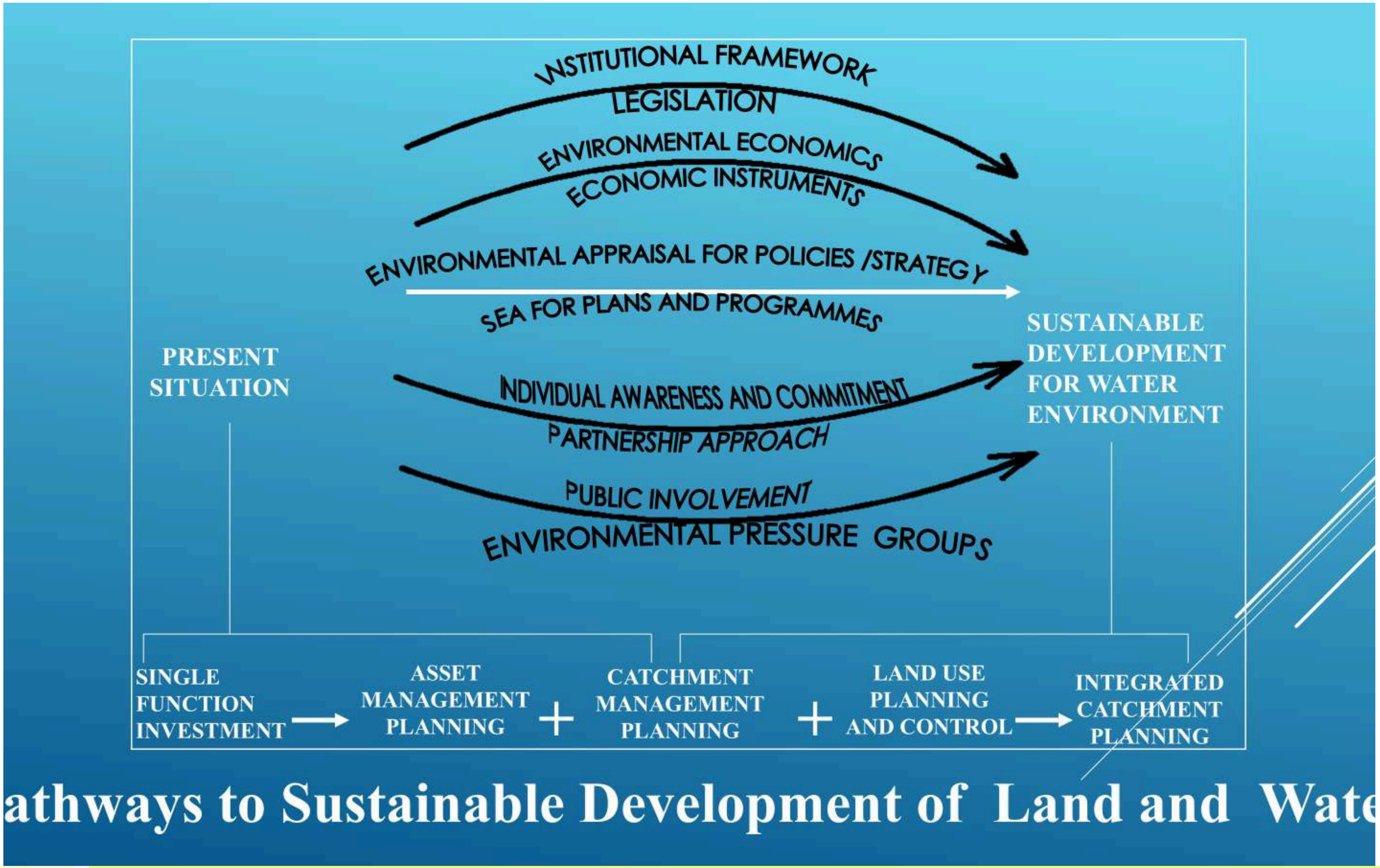
Unique Challenges in Water Management of Kerala

- Significant variation in spatial and temporal rainfall
- Short, steep, monsoon-fed rivers
- Undulating topography
- Dense population and related urbanization
- Forests and wetlands with rich biodiversity in the highland and coastal belt
- Geologic formations characterized by Precambrian crystalline rocks (Archaean), Tertiary sedimentary formations (Miocene – Pliocene), quaternary sediments (Recent), and laterites
- Large number of Open Wells
- Frequent floods and dry periods, accelerated by climate change
- A few river basins are close to ‘water scarcity’, and some are already under ‘water stress’
- Three administrative blocks each are classified under ‘critical’ and ‘sub-critical’ in the State

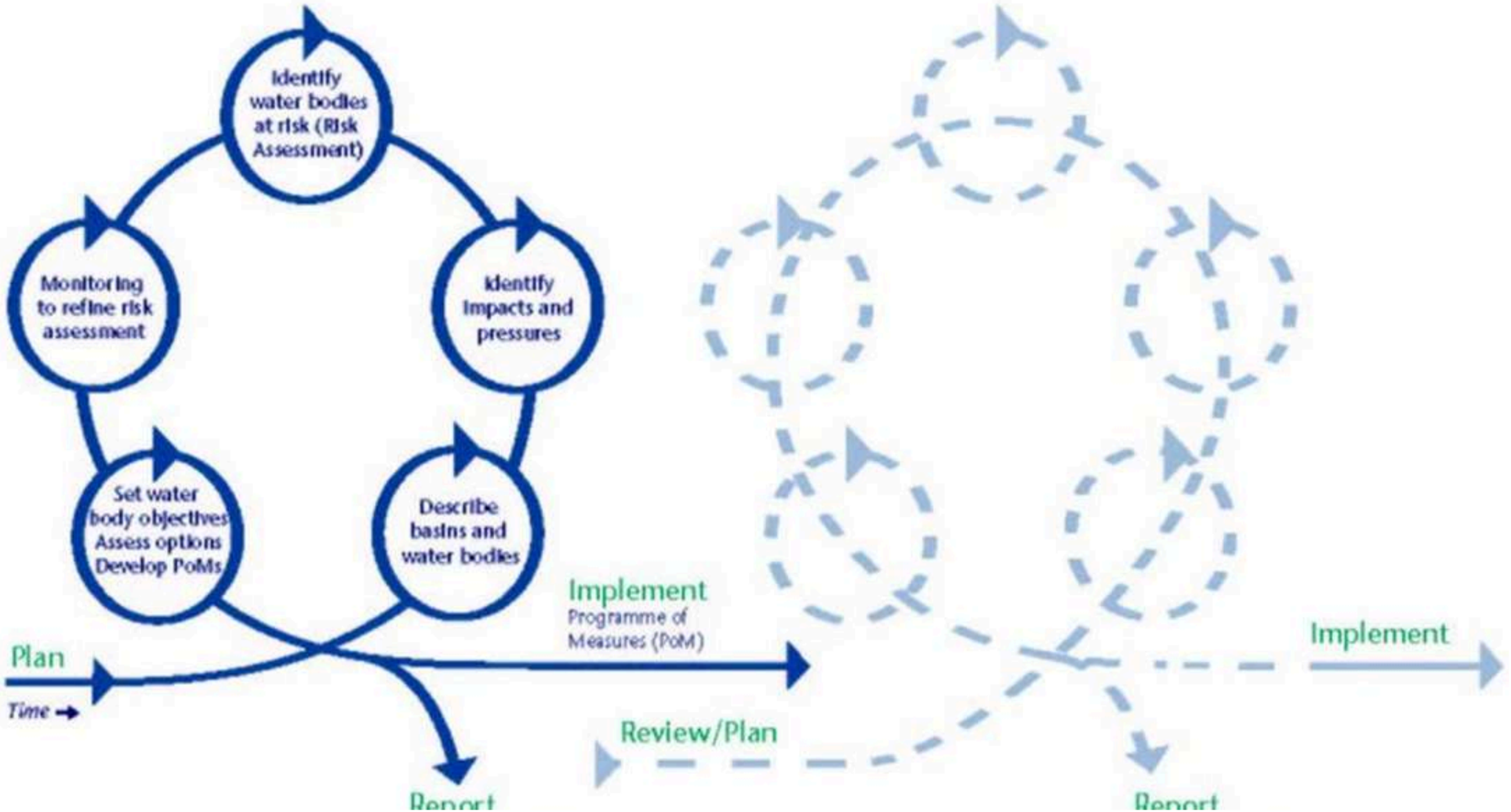
Methodologies to Adopt the Shifting Paradigms

Relevance of Integrated Water Resources Management (IWRM)

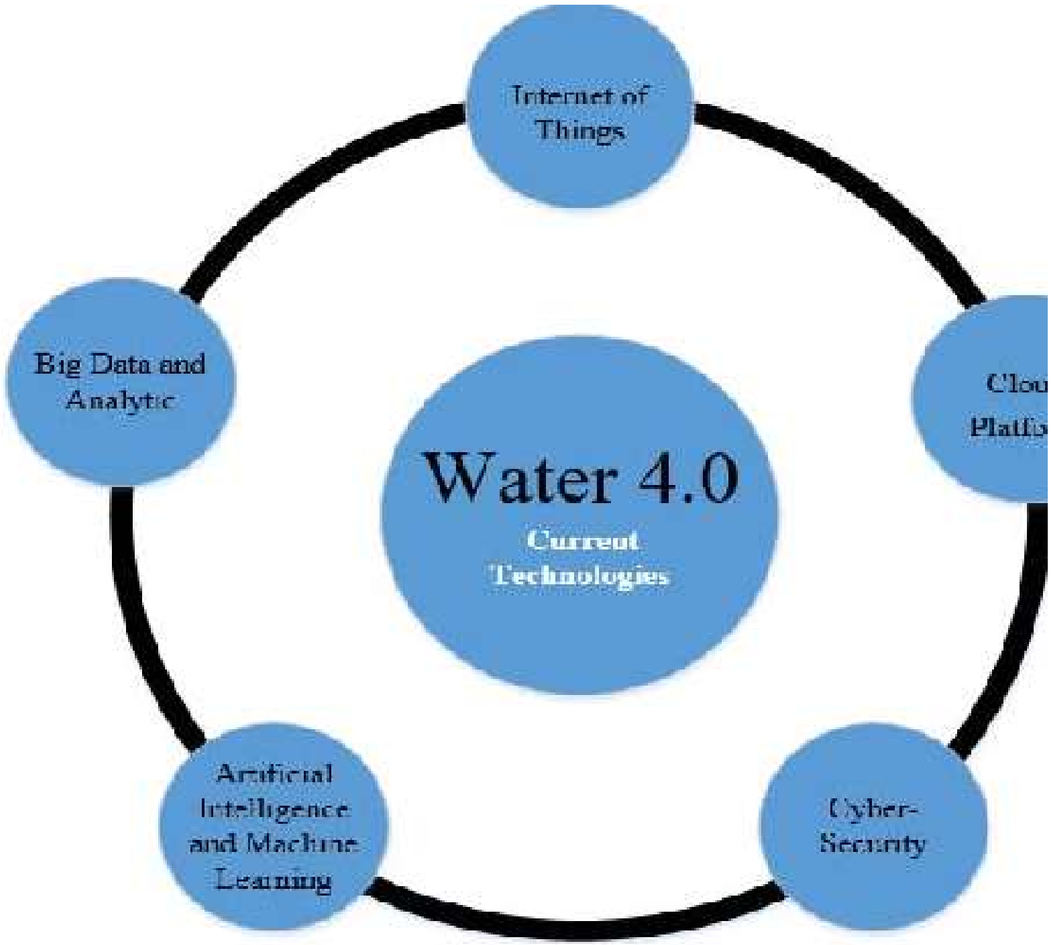
IWRM - Integrated Water Resources Management (IWRM) is a systematic process promoting the coordinated development and management of water, land, and other related resources. It aims to maximize social and economic welfare equitably without compromising the vital ecosystem sustainability. It replaces the fragmented, single-sector water management with a holistic, cross-sectoral approach.


INSTITUTIONAL FRAMEWORK
LEGISLATION
ENVIRONMENTAL ECONOMICS
ECONOMIC INSTRUMENTS
ENVIRONMENTAL APPRAISAL FOR POLICIES /STRATEGY
SEA FOR PLANS AND PROGRAMMES
PRESENT SITUATION
SUSTAINABLE DEVELOPMENT FOR WATER ENVIRONMENT
INDIVIDUAL AWARENESS AND COMMITMENT
PARTNERSHIP APPROACH
PUBLIC INVOLVEMENT
ENVIRONMENTAL PRESSURE GROUPS
SINGLE FUNCTION INVESTMENT
ASSET MANAGEMENT PLANNING
CATCHMENT MANAGEMENT PLANNING
LAND USE PLANNING AND CONTROL
INTEGRATED CATCHMENT PLANNING
athways to Sustainable Development of Land and Wate

Programme of Measures: Actions to Achieve River Basin Management Plan



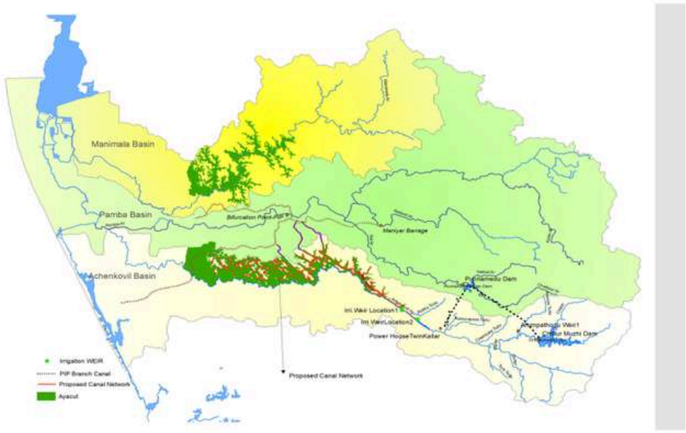
Application of Water 4.0 for Ease and Efficiency



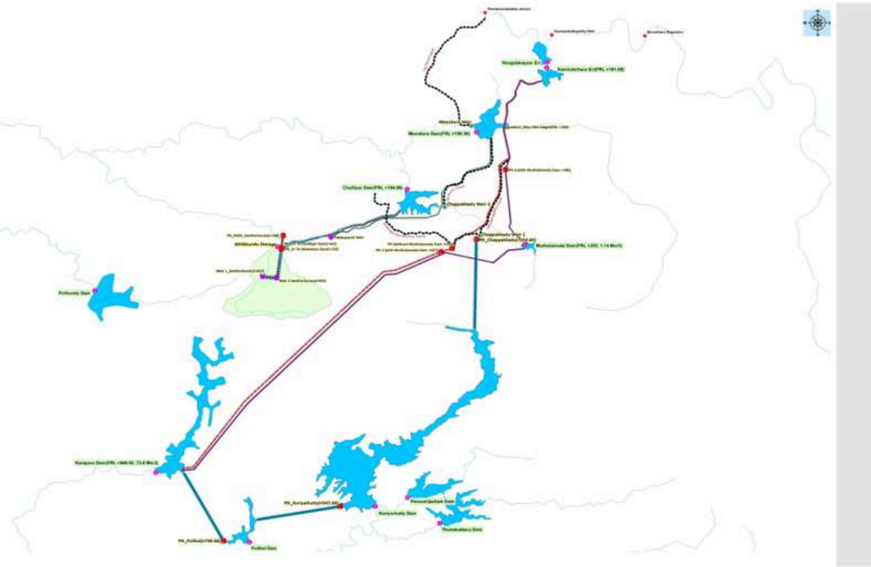
- **Smart Infrastructure & Leak Detection:** Industrial IoT (IIoT) sensors monitor water flow, pressure, and quality in real-time, allowing for rapid detection of leaks and blockages, which prevents significant water loss and infrastructure damage.
- **AI-Powered Optimization:** Artificial intelligence and machine learning (AI/ML) analyze vast datasets to predict future demand, optimize water distribution, and improve treatment processes.
- **Digital Twins:** Virtual replicas of water networks (digital twins) are used to simulate, monitor, and optimize physical infrastructure, enhancing operational efficiency.
- **Wastewater & Resource Management:** Automated systems manage sewage, wastewater treatment, and rainwater harvesting, treating and recycling water more efficiently.
- **Smart Metering:** IoT-enabled smart meters track consumption patterns in real time, reducing wastage and improving billing accuracy for municipalities and industries.
- **Flood Forecasting:** AI-based systems provide advanced flood predictions, allowing city officials to take proactive measures, minimizing damage and improving safety.
- **VR/AR:** Better and enhanced efficiency, safety, decision making, and training
- **Drones:** Providing high-resolution, real-time data for monitoring, mapping, and infrastructure inspection in water and farmng management

Intra-State River Basin Transfers

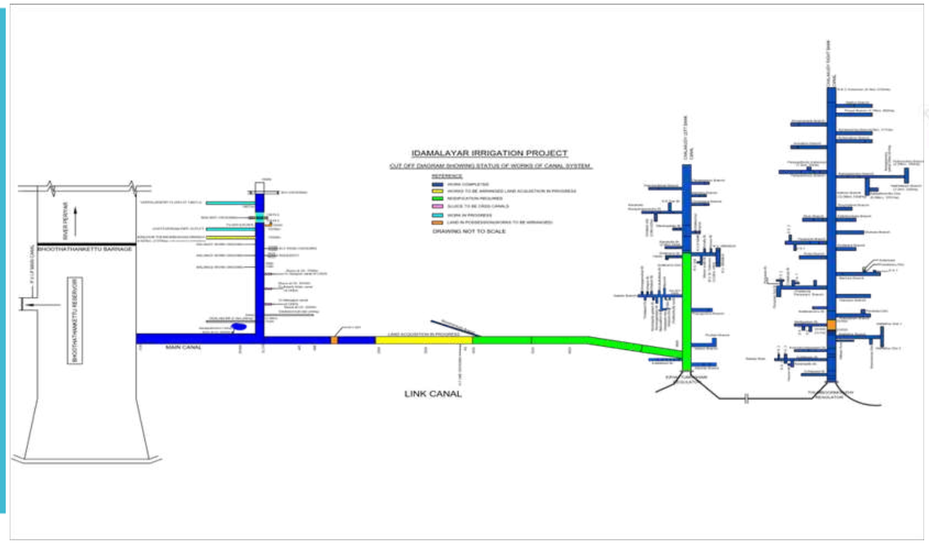
Twin Kallar Multi-purpose Project



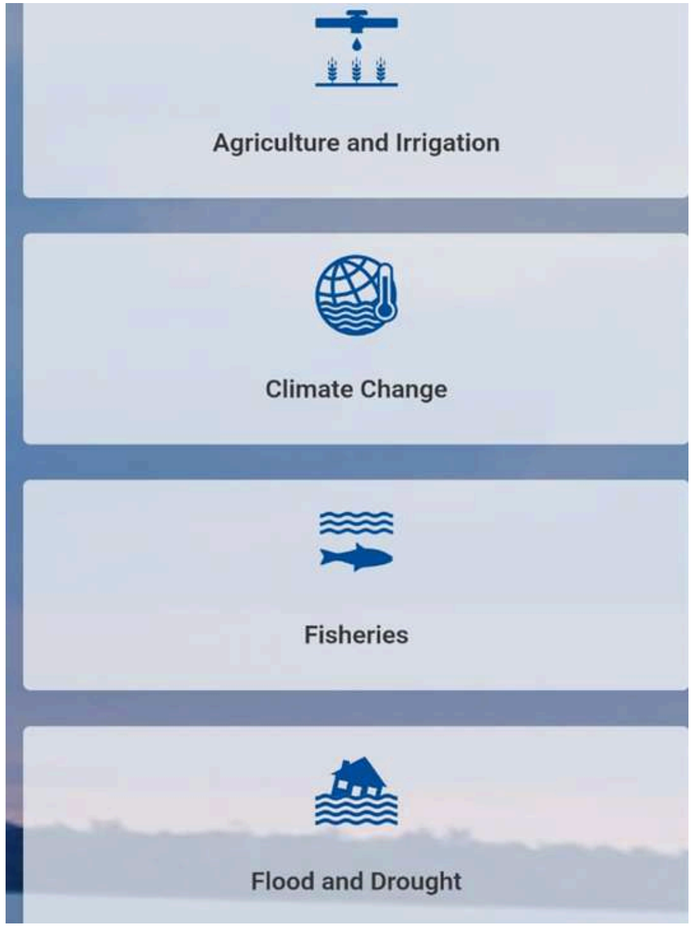
Alternative to Kuriarkutty-Karappara and Seethathodu Diversion

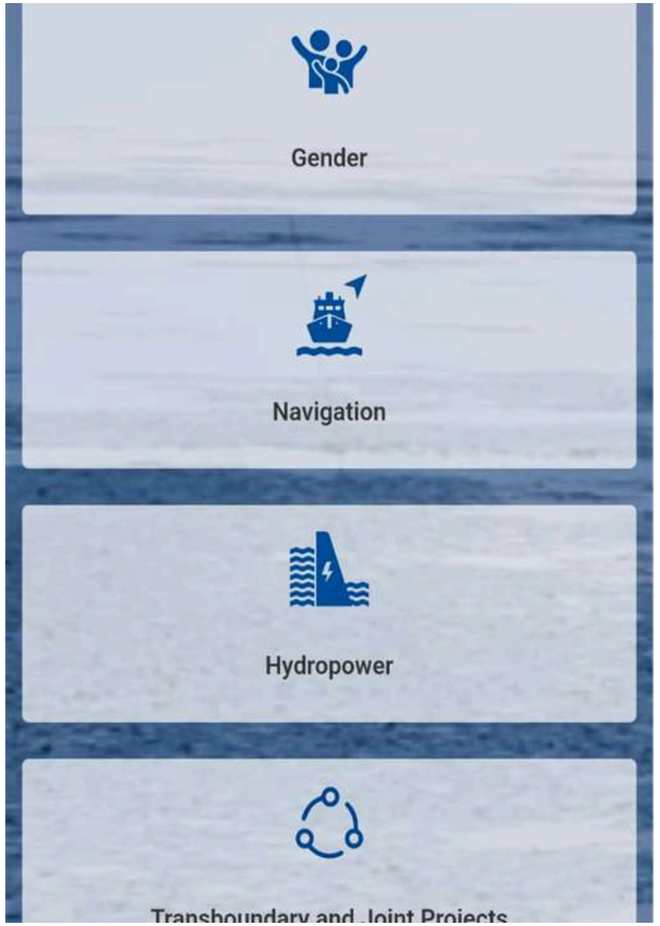


Periyar-Chalakudy Link for Irrigation



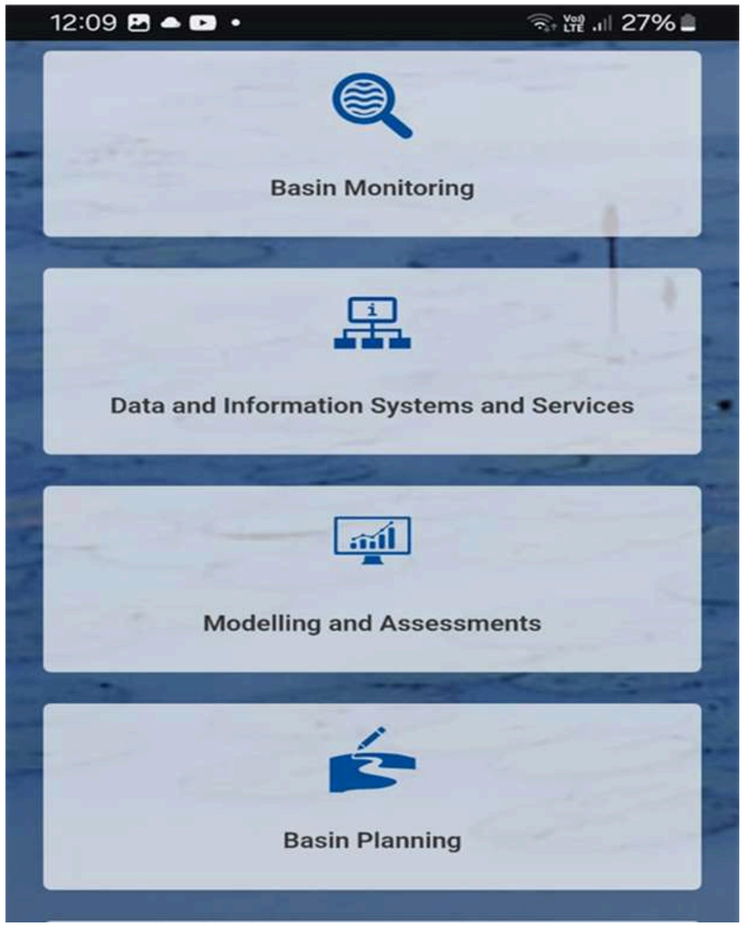
Mekong River Commission: Domains Covered
Recommended Model

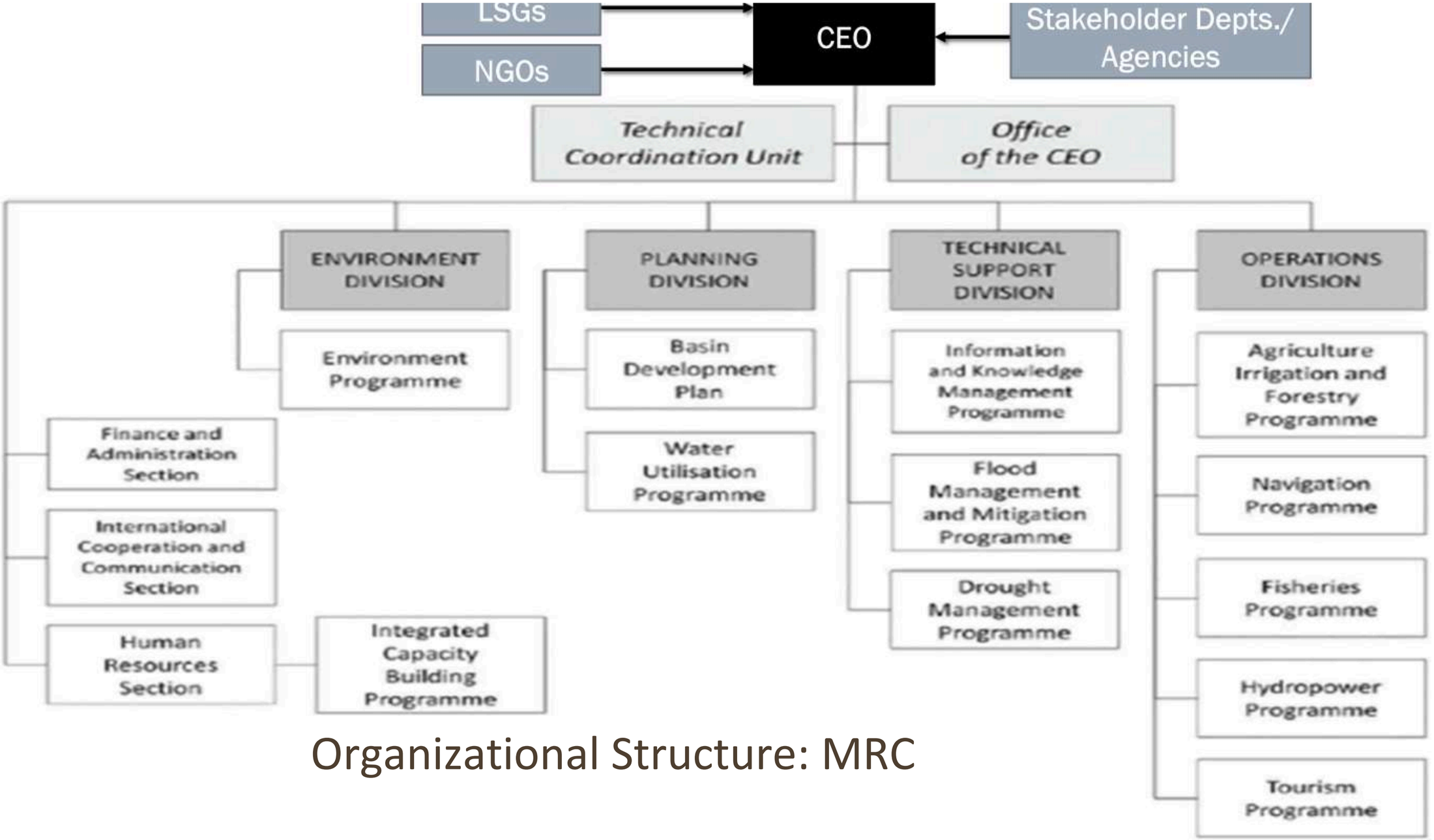




Mekong River Commission – Functions

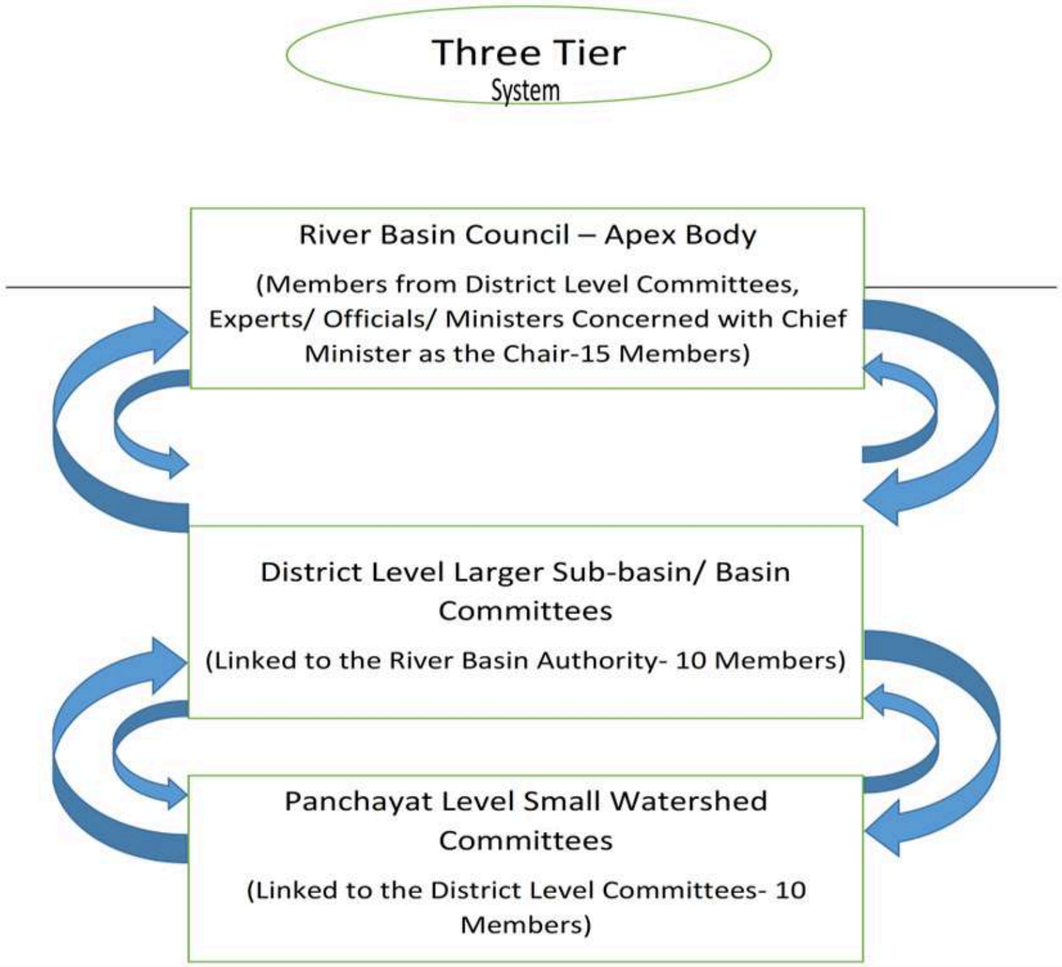
Recommended Model

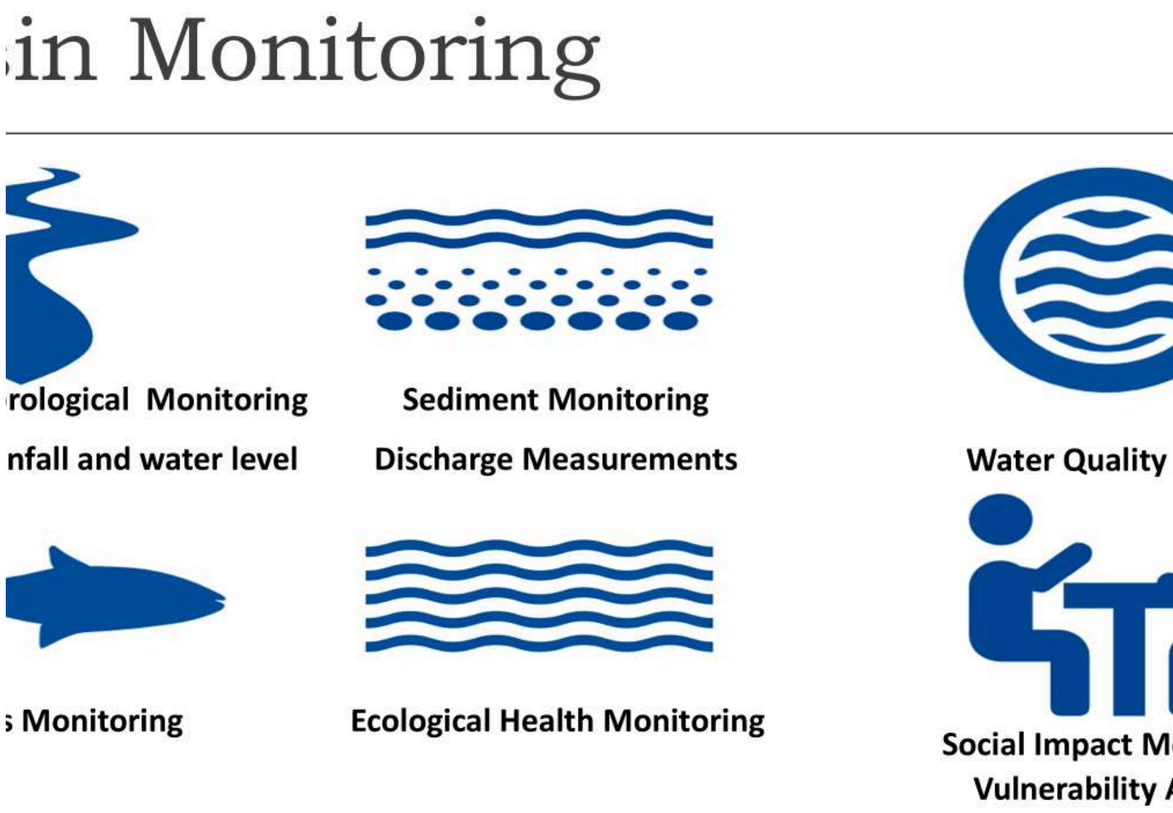




Organizational Structure: MRC

Proposed Three-Tier System and Basin Monitoring





Basin-wise Projects to be Implemented: 2026-2031

Methodology Followed: Technical Committee of PB

- Collection of hydrological and other related data from relevant Departments/Agencies
- Information on completed, ongoing, and proposed projects on irrigation, water supply, hydropower, and wetlands
- Hydrological, agronomic, and energy-related analysis
- IWRM and River Basin Approach and Planning
- Shortlisting the projects, considering preliminary analysis of environmental, social, and economic factors

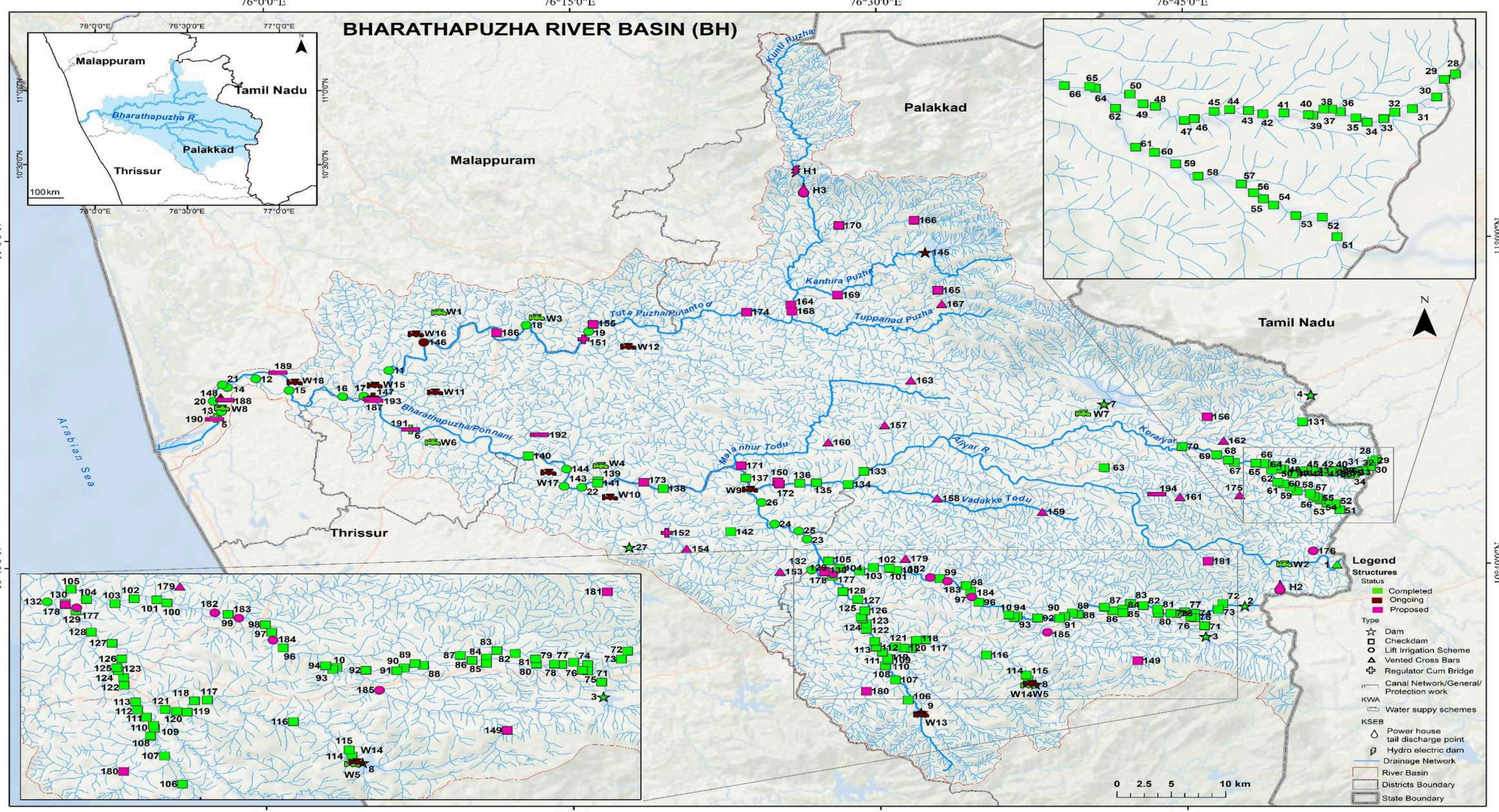
Multi-disciplinary and Multi-institutional Teams Involved in Basin Planning Task

SUMMARY OF BASINWISE PROPOSED IRRIGATION PROJECTS - MAJOR, MEDIUM AND MINOR*

Cluster	River Basin	Structure		Total Amount (Rs in lakh)			Total Ayacut (ha)			Balance Amount for Ongoing Projects (Rs in lakh)**	
		Type	Number	Structure-wise	Basin-wise	Cluster-wise	Structure-wise	Basin-wise	Cluster-wise	Basin-wise	Cluster-wise
Vembanad Wetland River Systems	**Muvattupuzha**	VCB	15	1279.65			2695			1374.82	1374.82
		Regulator	3	530			600				
		Pond	1	20			40				
		Micro Irrigation	1	170			20				
		Canal Network	19	8139.1			16417				
		LIS	1	41			5				
		Gen./Protection+	4	8867.22	19047		18397	38174			
	Meenachil	Check dams	7	5279			636			0	
		Canal Network	5	944			398				
		VCB	1	15			10				
		LIS	5	720			324				
		Pond	2	80			90				
		Gen./Protection+	3	74.8			0				
		Regulator	2	954	8066.8		178.3	1636.3			
	Manimala	Check dams	7	553			107			0	
		Gen./Protection+	6	368	921		0	107			
	Pamba	Check dams	1	200			200			0	
		VCB	1	200			50				
		Canal Network	1	21765			21135				
		Gen./Protection+	4	233.5	22398.5		0	21385			
	Achancoil	Check dams/ Tractor bridge	1	600			0			0	
		VCB	1	60	660	**51093.3**	40	40	**61342.3**		

Proposed Budget Phasing: 2026 - 2031

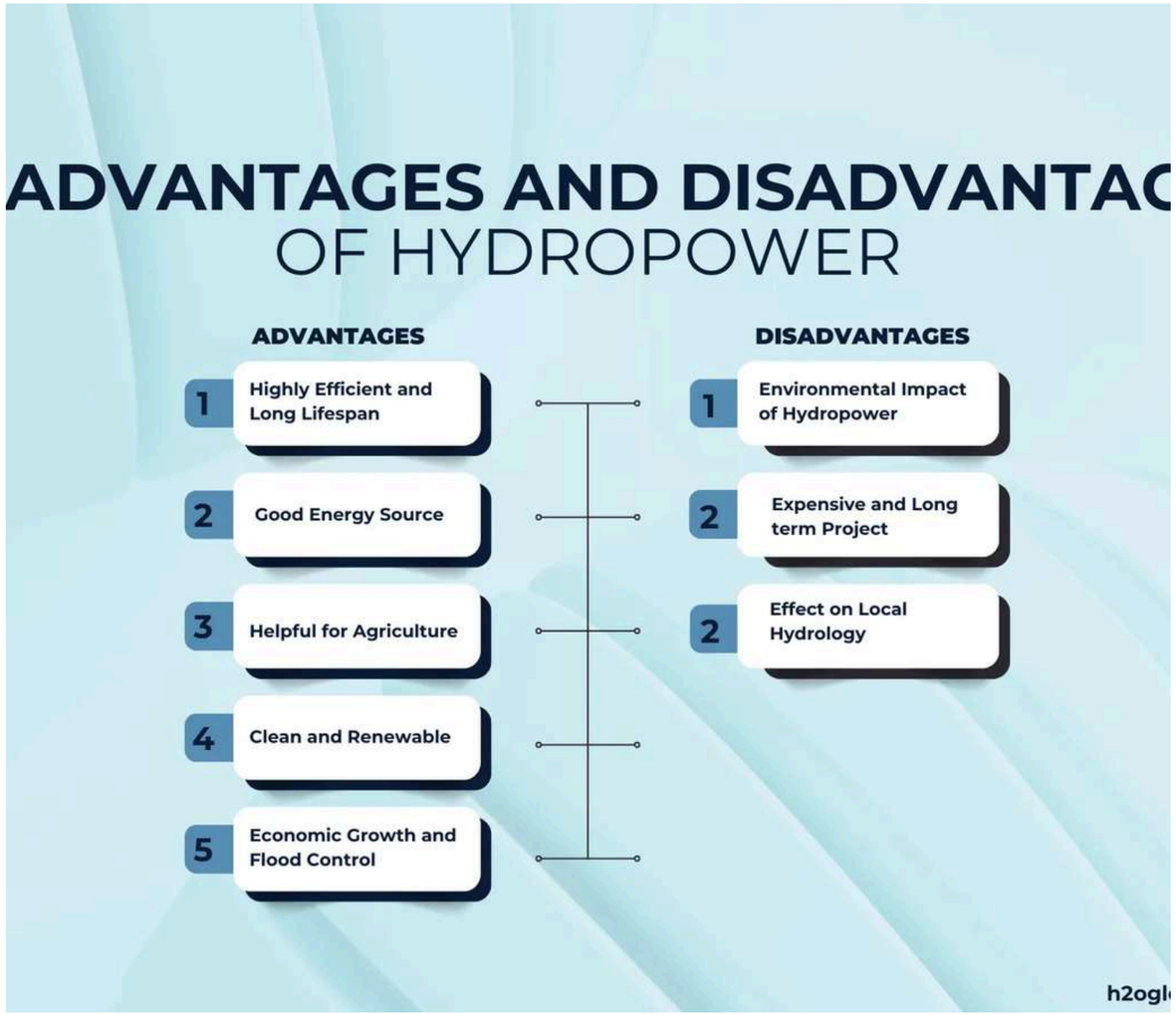
Sl. No.	River Cluster	Total Amount (Rs in lakh)	Phasing Amount (Rs in lakh)				
			2026-2027	2027-2028	2028-2029	2029-2030	2030-2031
1	Valapattanam and Northern River System	1,19,425	23,885	29,856	35,827	17,914	11,942
2	Chaliyar and adjacent river system	1,61,634	32,327	40,408	48,490	24,245	16,163
3	Bharathapuzha river systems	53,450	10,690	13,363	16,035	8,018	5,345
4	Kol Wetland River System	3,17,252	63,450	79,313	95,176	47,588	31,725
5	Vembanad Wetland River Systems	51,093	10,219	12,773	15,328	7,664	5,109
6	Kallada , Neyyar and Southern River system	1,22,141	24,428	30,535	36,642	18,321	12,214
7	Cauvery river systems	5,65,048	1,13,010	1,41,262	1,69,515	84,757	56,505
8	Wetland Projects	2,28,403	45,681	57,101	68,521	34,260	22,840
	TOTAL		3,23,689	4,04,611	4,85,534	2,42,767	1,61,845
		GRAND TOTAL	16,18,446				



Footnotes: 1) Only Canal Network and General/Protective works of rupees 50 million and above are demarcated.
2) Frames of reference missing for code BH95.

Advantages of Hydropower Projects

- NDC mentions utilizing environment-friendly hydropower potential to reduce emissions; it is also clean and renewable
- Flood mitigation and water conservation for dry periods
- Assured water downstream helps in drinking water and lift irrigation projects downstream, like Periyar, Chalakudy, and Muvattupuzha
- Tailrace water helps in maintaining the e-flows and subsequently conserving the wetland habitats and thereby the endogenous fish and biodiversity

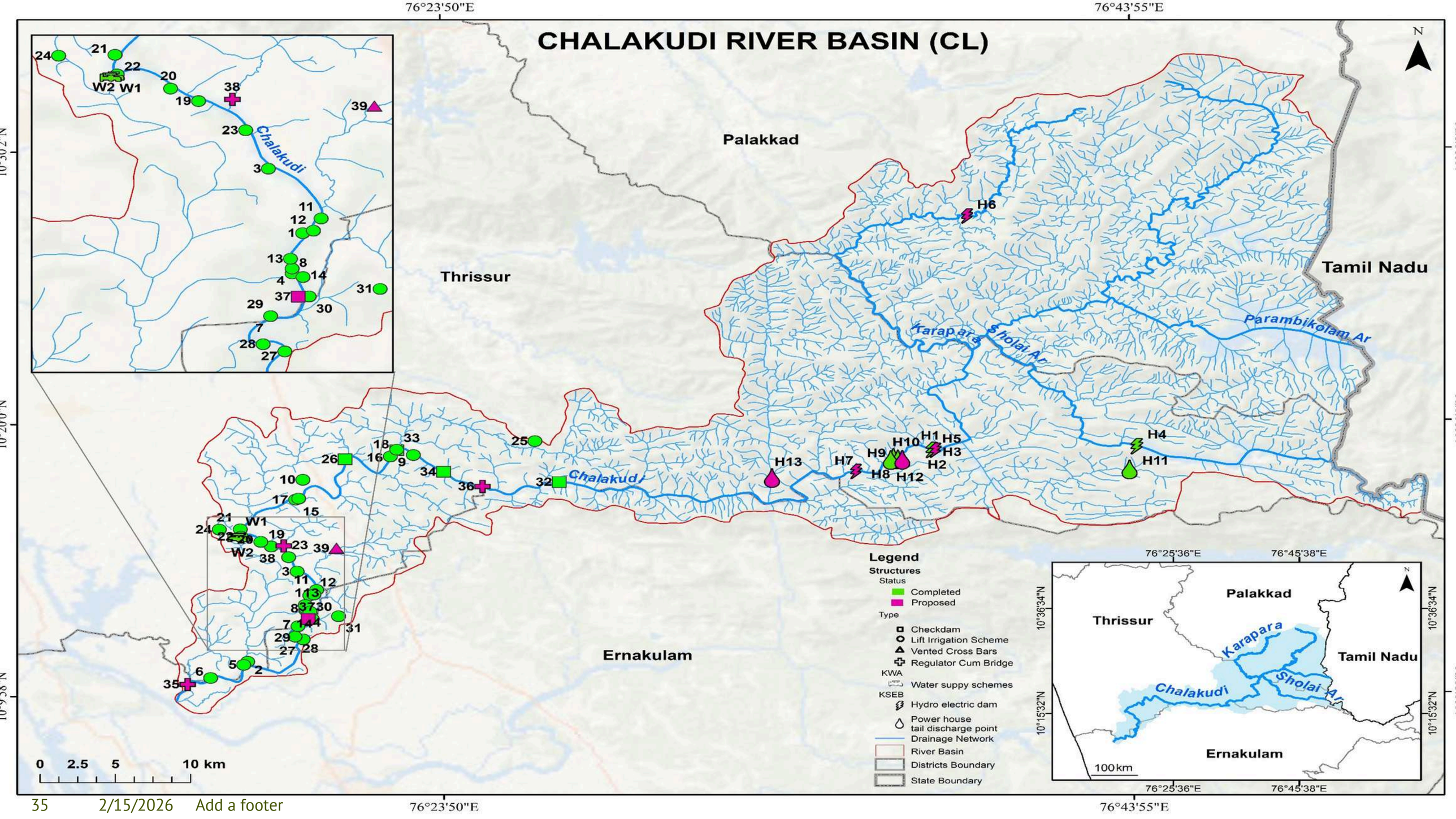


Proposed Hydroelectric Projects (Installed Capacity > 15MW)

Sl. No.	River Basin	Project / Scheme*	Location				Installed Capacity (MW)	Budget (Including IDC) (Rs in Lakh)	Cost in 2025 (Rs in Lakh)	Remarks
			Dam		Tail Race Exit					
			Latitude (N)	Longitude (E)	Latitude (N)	Longitude (E)				
		Prioritised Schemes								
1	Chalakudy	Poringalkuth Stage-II	10°18'56.90"	76°38'5.50"	10°18'35.40"	76°36'53.60"	24	8,070	9507.63	Awaiting EC & FC to proceeed
2	Periyar	Mankulam Stage-II (Rajamalayar)	10° 7'47.70"	76°58'27.60"	10° 7'29.80"	76°58'36.40"	40	40,000	40000.00	Intra-basin Diversion Investigation Stage
	Periyar	Mankulam Stage-II (Kadalar)	10° 7'29.80"	76°58'36.40"	10° 6'34.30"	76°55'52.70"				
3	Periyar	Idukki Extension	9°48'10.00"	76°53'10.50"	9°47'36.30"	76°50'40.70"	800	2,31,094	231094.00	Inter-basin Diversion, Awaiting Pre-DPR Clearances from CEA
4	Periyar	Letchmi Rajamala Diversion	10° 9'15.70"	77° 0'19.70"	10° 8'17.90"	77° 3'46.70"	240	1,63,000	193124.05	Intra-basin Diversion from Rajamlayar to Mudirapuzha, Investigation Stage, 90 MCM Storage
	Periyar	Letchmi Pumping Location	10° 4'17.10"	77° 3'43.50"	10°4’16.50”	77°02’59.00”				
	Periyar	Letchmi	10°4’16.50”	77°02’59.00”	10° 1'11.20"	77° 2'11.60"				
5	Periyar	Idamalayar Extension	10°13'19.20"	76°42'23.50"	10°12'21.30"	76°42'45.40"	80	80,000	80000.00	Investigation Stage
6	Pamba	Sabarigiri Extension	9°19'30.10"	77° 8'32.20"	9°18'33.30"	77° 4'24.70"	450	3,12,836	329121.14	Investigation Stage
7	Pambar	Pambar	10°15'14.50"	77°10'19.50"	10°17'41.70"	77°11'8.70"	40	22,540	61240.47	Investigation Stage

Sl. No.	River Basin	Project / Scheme*	Location				Installed Capacity (MW)	Budget (Including IDC)	Cost in 2025	Remarks
			Dam		Tail Race Exit					
			Latitude (N)	Longitude (E)	Latitude (N)	Longitude (E)		(Rs in Lakh)	(Rs in Lakh)	
8	Periyar	Deviyar	10°2'13.20"	76°50'48.00"	10°1' 29.30"	76°50'28.50"	24	6,616	10336.50	Extension of Thottiyar
9	Chaliyar	Kakkadampoyil 1	11° 20' 52"	76° 06' 36"	11°19'21.80"	76° 5'27.00"	21	9,905	32232.57	
10	Chalakudy	SAKKIP (Irrigation Dept.)	10°27'34.00"	76°39'9.50"	10°38'35.60"	76°49'34.30"	26	1,38,000	144307.08	Inter-basin Diversion
		Not prioritised								
11	Chalakudy	Athirappilly	10°18'9.70"	76°35'52.70"	10°17'56.40"	76°33'25.80"	163	99341	151996.41	Public Concerns
12	Chaliyar	Kanthanpara	11°31'31.30"	76° 9'8.00"	11°30'26.00"	76°11'28.00"	52	68521	106854.16	Forest Clearance required
13	Bharathapuzha	Pathrakadavu	11° 4'9.30"	76°26'2.40"	11° 3'0.00"	76°26'24.40"	70	43417	150449.34	Forest Clearance required
14	Kabani	Vythiri HEP Weir	11°34' 25.1"	76°01' 36	11°29'45.70"	75°59'35.40"	60	60018	115040.53	Inter-basin, Inter-state
15	Kabani	Mananthavady Multipurpose	11°46'54.80"	75°55'13.10"	11°52'56.60"	75°50'30.00"	240	323000	342338.85	Inter-basin, Inter-state
		Flood Control + Hydroelectric Power Generation								
16	Chalakudy	Upper Poringal (Flood Control)	10°19'38.70"	76°39'1.00"	10°19'21.70"	76°38'52.00"	20	48330	62432.37	Forest Submergence, Parambikulam Tiger Reserve Area 200 MCM Storage Capacity, Inception Stage

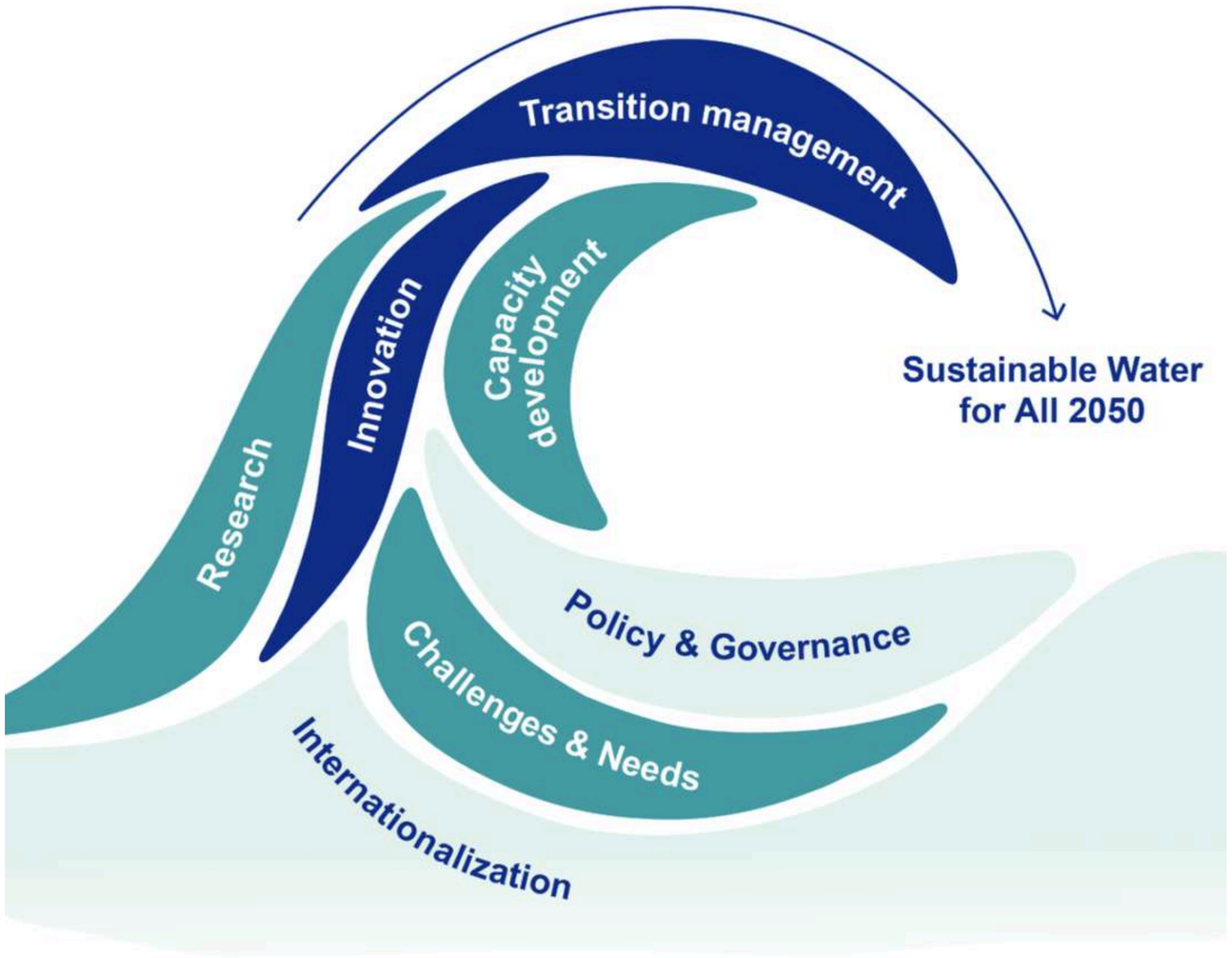
Sl. No.	River Basin	Project / Scheme*	Location				Installed Capacity (MW)	Budget (Including IDC)	Cost in 2025	Remarks
			Dam		Tail Race Exit					
			Latitude (N)	Longitude (E)	Latitude (N)	Longitude (E)		(Rs in Lakh)	(Rs in Lakh)	
17	Periyar	Puyankutty (Flood Control)	10° 7'41.20"	76°48'37.10"	10° 6'30.70"	76°46'30.50"	210	136743	368364.21	Forest Submergence 435 MCM Storage Capacity
18	Pamba & Achankovil	Twin Kallar (Flood Control)	9° 8'7.10" 9° 9'29.60" 9°13'34.90"	77° 8'10.80" 77° 6'7.00" 77° 0'53.10"	9° 9'24.30"	76°59'6.60"	60	141026	207658.13	Forest Submergence 296 MCM Storage Capacity
19	Periyar	Perinjankutty (Flood Control)	9°55'15.90"	77° 1'5.40"	9°57'5.50"	76°59'6.30"	270	5873	176588.67	Land Acquisition Procedures Dam Height 146m 1008 MCM Storage Capacity Own Basin inflow 264 MCM Balance through Diversion
	*Proposed projects are shown on the basin maps appended									
	Source: Kerala State Electricity Board Limited									


CHALAKUDI RIVER BASIN (CL)
76°23'50"E
76°43'55"E
10°30'2"N
10°20'0"N
10°9'58"N
N
Palakkad
Thrissur
Ernakulam
Tamil Nadu
Chalakudi
Karapara Sholai Ar
Parambikolam Ar
H1
H2
H3
H4
H5
H6
H7
H8
H9
H10
H11
H12
H13
W1
W2
0 2.5 5 10 km
Legend
Structures
Status
Completed
Proposed
Type
Checkdam
Lift Irrigation Scheme
Vented Cross Bars
Regulator Cum Bridge
KWA
Water suppy schemes
KSEB
Hydro electric dam
Power house
tail discharge point
Drainage Network
River Basin
Districts Boundary
State Boundary
76°25'36"E
76°45'38"E
10°36'34"N
10°15'32"N
100 km

Ongoing and Proposed Water Supply Schemes (Capacity > 15 MLD)

Sl. No.	River Basin / Source	WTP Location*	Installed Capacity (MLD)	Present Status / Remarks
Ongoing Projects				
1	Ithikkara river	Marankode	15	OnGoing
2	Vamanapuram river	Kailasathukunnu	15	OnGoing
3	Bharathapuzha	Kuthampully	15	OnGoing
4	Bharathapuzha	Mecherikkunnu	15	OnGoing
5	Muvattupuzha River	Nechoor	15.5	OnGoing
6	Neyyar River	Ponvila	16	OnGoing
7	Kallada river	Perinad	16	OnGoing
8	Kallada river	Ugrankunnu	16	OnGoing
9	Thootha Puzha	Manjaparakunnu	16	OnGoing
10	Kallada river	Chayalodu	17	OnGoing
11	Muvattupuzha River	Peringole	17	OnGoing
12	Periyar River	Angamaly	17	OnGoing
13	Vamanapuram river	Arattukadavu	18	OnGoing
14	Vamanapuram river	Kuttimoodu	18	OnGoing
15	Karuvannur Puzha	Mangadikkunnu	18	OnGoing
16	Periyar River	Chowara	20	OnGoing
17	Periyar River	malayikunnu	20	OnGoing
18	Manimala river	Morkulangara	22	OnGoing
19	Periyar River	Kumily Onnam Mile	22	OnGoing
20	Periyar River	Mattupetti	22	OnGoing
21	Periyar River	Nadukani	22	OnGoing
22	Thootha Puzha	Samiyarkunnu	22	OnGoing
23	Thootha Puzha	Irrigation Dam site Poonkavanam	22	OnGoing

50	Neyyar Dam	Kalippara	36	OnGoing
51	Bharathapuzha River	Annasseri	37	OnGoing
52	Manimala river	Koipuram	40	OnGoing
53	Bharathapuzha	Kondayur	40	OnGoing
54	Kallada river	Ambuvila	44	OnGoing
55	Malankara Dam (Intake inside Reservoir)	Neeloor	45	OnGoing
56	Kuttiyadi River	Koorangottukadavu	47	OnGoing
57	Bharathapuzha River	Kuttipuram	48	OnGoing
58	Arattupuzha	Pallisserikkunnu	100	OnGoing
59	Kuttiyadi River	Peruvannamuzhi Reservoir	100	OnGoing
60	Peruvannamuzhi Dam	Peruvannamuzhi	100	OnGoing
61	Chaliyar River	Koolimadu	100	OnGoing
Proposed Project				
1	Vellayani Lake	AUGMENTATION OF WSS to Vizhinjam and nearby coastal wards of Thiruvananthapuram Corporation Azhakulam - Harbour Road, directly in front of the existing 3 MLD WTP of KWA (The land identified for the construction of WTP belongs to Harbour Engineering Department)	15	Proposed - 48.81cr, present and future water demand, of the Vizhinjam region. Hence a water supply scheme is envisaged to meet the demand of potable water to the entire population and to meet the upcoming institutional demand in Vizhinjam Region.



From here, we move to 2031 to achieve sustainable development of water resources in Kerala…

Thank You