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GOVERNMENT OF TAMILNADU

PUBLIC WORKS DEPARTMENT

WATER RESOURCES DEPARTMENT

MICRO LEVEL REAPPRAISAL STUDY

PARAMBIKULAM ALIYAR PROJECT – BASIN

VOLUME - I

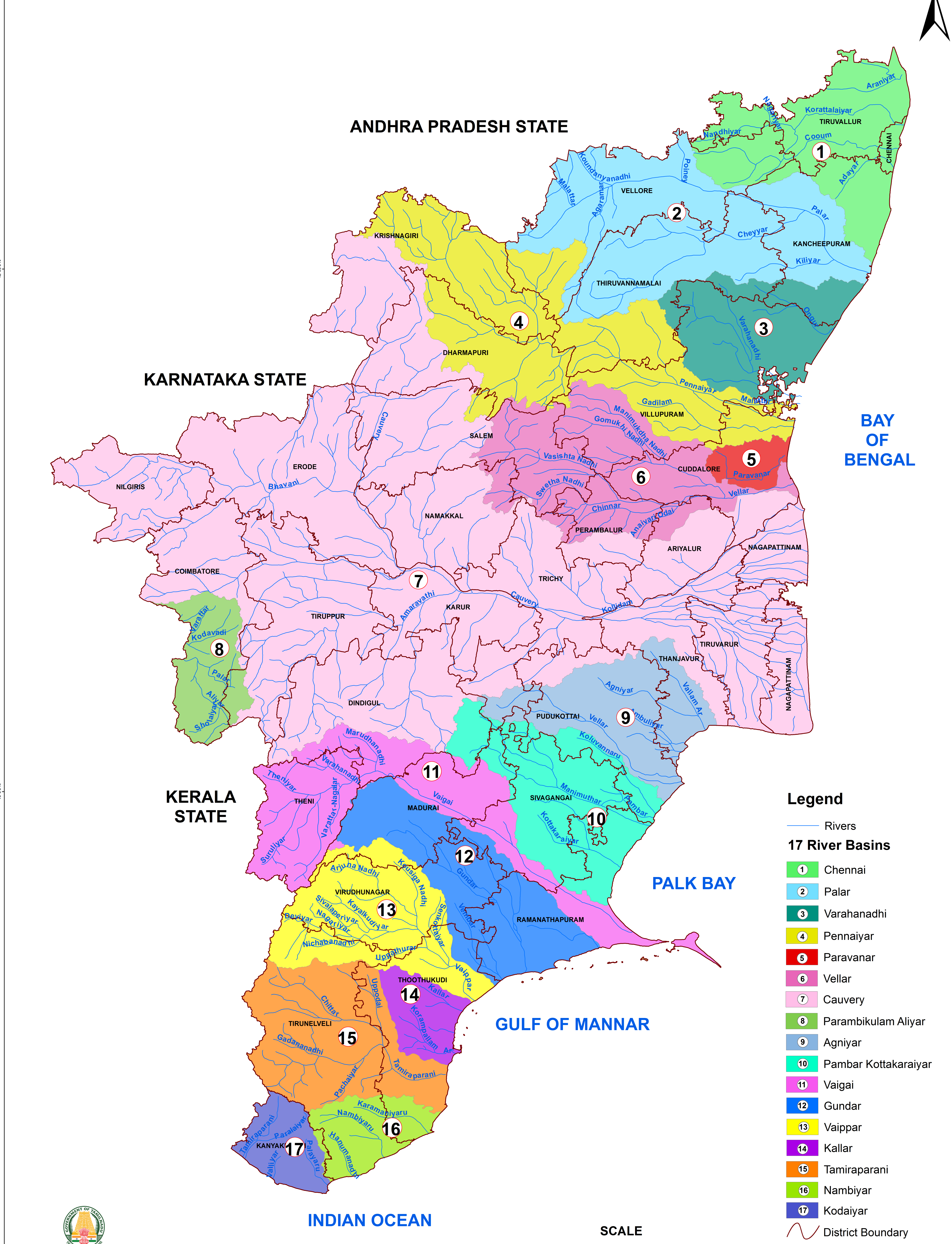
INSTITUTE FOR WATER STUDIES,

HYDROLOGY & QUALITY CONTROL,

TARAMANI, CHENNAI – 600113.

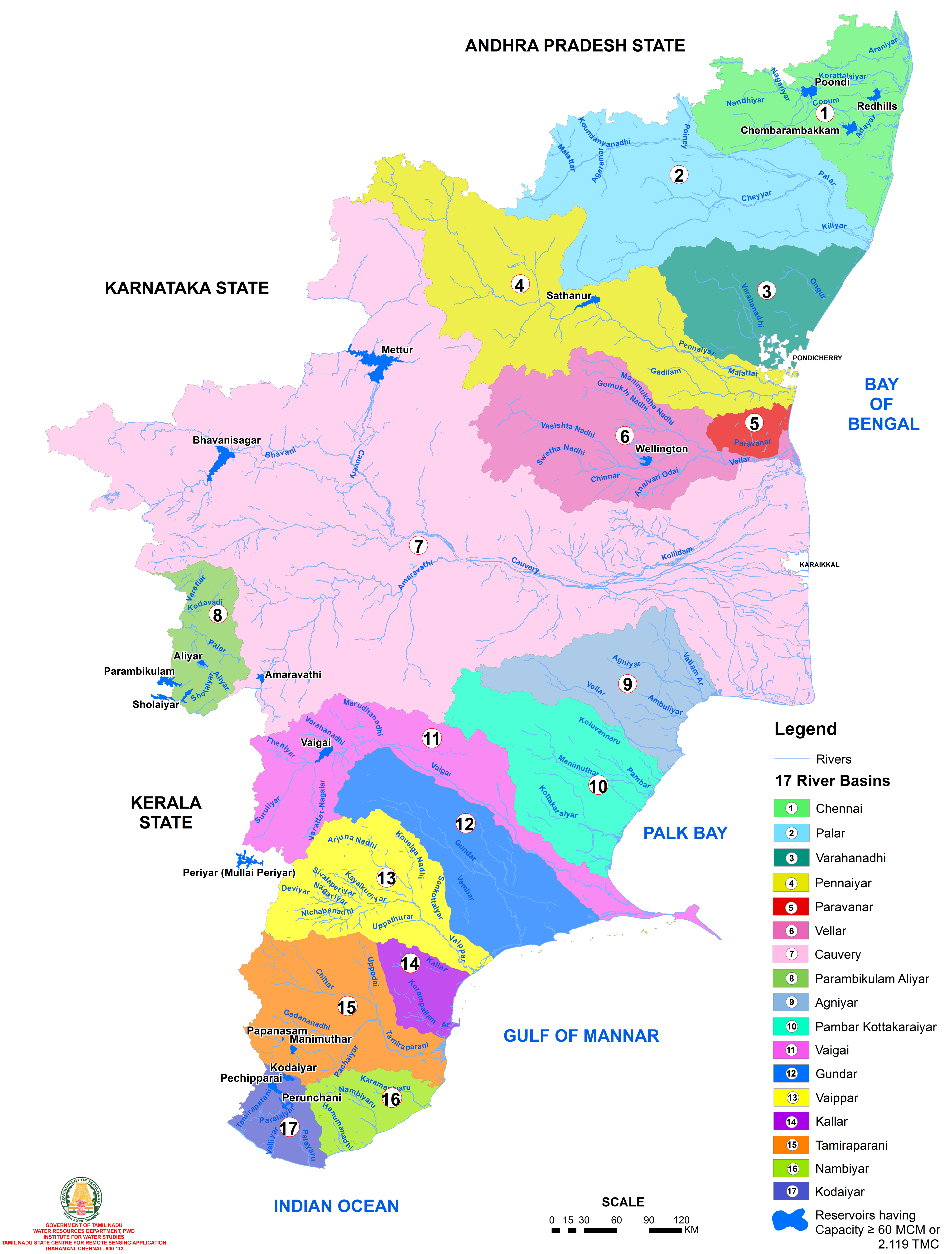
MARCH 2021

RIVER BASINS OF TAMIL NADU



GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI - 600 113

RESERVOIRS (Under WRD Control) OF TAMIL NADU
(CAPACITY ≥ 60 MCM or 2.119 TMC)



PREFACE

The Institute for Water Studies was established with an objective to assess, plan, and manage the Water Resources in Tamil Nadu in a scientific manner. This Institute carries out Multi-Disciplinary research activities in all the River Basins of Tamil Nadu for effective Water Resources Management. The Government ordered in G.O.(Ms) No.149 Public Works (F1) Department dated 08-06-2019 to change nomenclature of this Institute as Institute for Water Studies, Hydrology & Quality Control in June 2018 in addition to the regular research and water study activities and assigned the quality control work of Water Resources Department and Public Works Department to ensure effective quality control and monitoring of the works and to maintain uniformity in quality.

As a holistic river basin management guide, Micro level Study reports were prepared and completed for 16 River Basins except for Cauvery River basin. The Micro level Study reports were disseminated to the concerned offices of Water Resources Department and all other line departments connected with water resources for wider knowledge sharing and for better understanding of river basin.

As the time moves on, changes are inevitable and according to the requirement, preparation of Micro Level Study report had to be updated by incorporating changes taken place thereafter with regard to land use and water demand of various sectors. The River Basin boundaries were delineated recently in bigger scale, 1:50,000. The updated version of Micro level Reappraisal Study Report was prepared using latest analytical method and latest available software. The reappraisal studies for Kodaiyar, Vaippar, Vaigai, Vellar, Palar, Tamiraparani, Pennaiyar, Paravanar River , Varahanadhi and Pambar Kottakkaraiyar basins have been completed. The Micro level Reappraisal study of **Parambikulam Aliyar Basin** has been taken up for the year 2020 - 2021.

This Parambikulam Aliyar Project(PAP) Area is considered as “River basin” since the area falling under this scheme is surrounded by ridges and cannot be appended with the adjacent Cauvery river basin of Tamil Nadu. Micro level study for Parambikulam Aliyar Project had been carried out during 2005- 2006.

Subsequently, to assess the present water potential, demand and balance as per latest data availability upto the year 2019, the Micro level Reappraisal study of Parambikulam Aliyar Basin has been taken up in 2020-2021. With the advent of latest satellite imagery and remote sensing techniques various thematic maps of the **Parambikulam Aliyar Basin** are prepared. The hydro-meteorological data, groundwater & surface water potential, all sectoral demand (domestic, agriculture, industrial and livestock) are analysed with latest technique using latest version software to calculate the present water balance.

Eventually, some suggestions and strategic action plans are proposed in the Micro Level Reappraisal report for implementation for further better water management of water resources to benefit the basin society and Tamilnadu state.

Chief Engineer & Director, PWD,
Institute for Water Studies,
Hydrology & Quality Control.WRD.

ACKNOWLEDGEMENT

The officials of the Institute for Water Studies, Hydrology & Quality Control express their sincere thanks to the Principal Secretary to Government, Public Works Department for continuous advice and support in preparing the Micro level reappraisal study report of Parambikulam Aliyar Basin.

The officials of this Institute sincerely thank the Engineer-in-Chief, WRD, PWD for valuable contribution during course of preparation of Micro level reappraisal study report of Parambikulam Aliyar Basin.

The officials of this Institute whole heartily record their gratitude to Er.R.Subramanian, Chairman, Cauvery Technical Cell cum Inter State Waters Wing, Chennai for suggesting to prepare the report on Micro level reappraisal study of Parambikulam Aliyar Basin and our immense thanks to the Chairman for his valuable technical support and guidance bestowed in preparing this study report.

The officials of this Institute thank the Chief Engineer, WRD, Coimbatore Region, the Chief Engineer, WRD, State Ground & Surface Water Resources Data Center, Chennai for sharing hydrological, hydrometeorological and hydrogeological data respectively which are fundamental in carrying out the Micro level reappraisal study of Parambikulam Aliyar Basin.

The officials of this Institute also thank the Superintending Engineer, WRD, Parambikulam Aliyar Basin circle, the Executive Engineer, WRD, Parambikulam Division, Parambikulam, the Executive Engineer, WRD, Sholayar Basin Division, Valparai, the Executive Engineer, WRD, Thirumurthy Division, Udumalpet for their assistance and contributions for the preparation of this study report.

The officials of this Institute acknowledge and thank the Department of Agriculture, , Directorate of Census Operation, Tamil Nadu Water Supply and Drainage Board, Directorate of Public Health Preventive Medicine, Tamil Nadu Pollution Control Board, Directorate of Industries & Commerce, Department of Animal Husbandry & Veterinary Science, Department of Fisheries, Department of Statistics and Economics, Central Water Commission, Central Ground Water Board and Tamil Nadu Generation and Distribution Corporation for sharing and contributing the requisite data to carry out the Micro level reappraisal study of Parambikulam Aliyar Basin.

With earnest belief, I assure that the methodology and suggestions put forth in this report for Water Resources planning in Parambikulam Aliyar Basin will be effective and supportive to Water Resources Department and other line departments in taking necessary actions to improve the management of Water Resources in Parambikulam Aliyar Basin.

Chief Engineer & Director, PWD,
Institute for Water Studies,
Hydrology & Quality Control.WRD.

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PARAMBIKULAM ALIYAR RIVER BASIN
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ABBREVIATIONS

ADD	Acute Diarrhoea Disease
AED	Agricultural Engineering Department
AMSL	Above Mean Sea Level
ARS	Artificial Recharge Structures
BCM	Billion Cubic Meter
BCR	Benefit Cost Ratio
CCA	Culturable Command Area
CGWB	Central Ground Water Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
CROPWAT	Crop Water Requirement
CWC	Central Water Commission
DIC	District Industries Centre
DO	Dissolved Oxygen
DRIP	Dam Rehabilitation and Improvement Project
EFR	Environmental flow Requirement
ENE-WSW	East North East –West South West
ESP	Exchangeable Sodium Percentage
ETc	Evapo Transpiration of a crop
ETo	Evapo transpiration
EW	East West
FAO	Food and Agriculture Organisation
FCC	False Colour Composite
FRP	Fibre Reinforced Plastic
GIS	Geographic Information System

GOI	Government of India
GoTN	Government of Tamil Nadu
GPS	Global Positioning System
GSDP	Gross State Domestic Product
IAMWARM	Irrigated Agriculture Modernization and Water bodies Restoration and Management
IMD	Indian Meteorological Department
IMR	Infant Mortality Rate
IUD	Intra –Uterine Device
IRS	Indian Remote Sensing Satellite
Kc	Crop Coefficient
LISS	Linear Imaging Self Scanner
Mcum	Million Cubic Meters
MGD	Million gallons per day
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MMR	Maternal Mortality Rate
MRS	Monthly Run off Simulation
MSL	Mean sea level
MSME	Micro Small and Medium Enterprise
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
MT	Metric Tonnes
NADP	National Agricultural Development Program
NBSS	National Bureau of Soil Survey
NE-SE	North East –South East
NE-SW	North East –South West

NGO	Non Government Organization
NNE	North North East
NNE-NE	North North East- North East
NNE-SSW	North North East- South South West
NNW-SSE	North North West- South South East
NPK	Nitrogen, Phosphorous, Potassium
NWDA	National Water Development Agency
NW-SE	North West- South East
NWSW	North West South West
O & M	Operation and Maintenance
PA	Parambikulam Aliyar
PET	Potential Evapo Transpiration
PWD	Public Works Department
RRR	Repair Renovation Restoration
RWH	Rain Water Harvesting
SG &SWRDC	State Ground &Surface Water Resources Data Centre
SIPCOT	State Industries Promotion Corporation of Tamil Nadu
SPIC	Southern Petro Chemical Industries Corporation
SRI	System of Rice Intensification
SSI	Sustainable Sugarcane Initiative
SSW-SW	South South West-South West
SWP	State Water Plan
TACID	Tamil Nadu Corporation for Industrial Infrastructure Development
TANGEDCO	Tamil Nadu Generation and Distribution Corporation Limited.
TBL	Top Bund Level

TDS	Total Dissolved Solids
TH	Total hardness
TIDCO	Tamil Nadu Industrial Development Corporation
TIIC	Tamil Nadu Industrial Investment Corporation
TMC	Thousand Million Cubic feet
TNAU	Tamil Nadu Agricultural University
TNPCB	Tamil Nadu Pollution Control Board
TWADB	Tamil Nadu Water Supply and Drainage Board
UNDP	United Nations Development Programme
VES	Vertical Electrical Soundings
WNW-ESW	West North West – East South West
WRD	Water Resources Department
WRMS	Water Resources Management Studies
WUA	Water User Association
WAPCOS	Water and Power Consultancy Services

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List of the officers involved in the
Preparation of "Micro level Reappraisal study of Parambikulam Aliyar river basin"

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CHAPTER – 1

INTRODUCTION AND METHODOLOGY

CHAPTER - I

INTRODUCTION AND METHODOLOGY

The journey of evolution of life began in water and it is the major constituent of a human being. The culture, food, and life style of a place are closely knitted together and depend on climate and water is central to the climate of a place. Since the dawn of civilization, mankind has shown a preference to settle near rivers due to assured supply of water, facility of navigation, and fertility of river valleys. Therefore exploring the water resources in all areas in all directions is a must now a days.

1.1 RIVER BASIN CONCEPT

A river basin is an area of land drained by a river and its tributaries. The boundaries of river basins are divided from each other by topographic barriers called ridges / water divide. River basins are the main sources of fresh water.

The National as well as State Water Policy made it abundantly clear that water is a scarce and precious national resource to be planned, developed and conserved as such and on an integrated and environmentally sound basis. Article 3of this policy has categorically stressed that resource planning has to be done for a hydrological unit such as a drainage basin as a whole or a sub-basin.

Tamil Nadu is endowed with many rivers and 34 of them are classified as independent rivers which originates and confluence with sea independently. These 34 river are grouped into 17 major river basins (**Plate PA-1**). The 34 rivers and their basin group are shown in **Table 1.1.** The 17 river basins further sub divided into 127 sub basins **(Table 1.2)** for the purpose of precise water resources planning and management.

Due to various physical interactions within a river basin, it is the logical unit for water resources planning and management.

1.2. RIVER BASIN PLANNING

Basin planning is the process by which decisions are made over the competing uses and different demands for water resources and associated systems within a basin. Basin plans set objectives and measures for developing, protecting and harnessing the resources of the basin and health and safety of the river itself. In its most developed form, basin planning can bring together a range of different disciplines and themes, from hydrology and engineering to ecology and economics. There is no universally applicable template or roadmap for river basin planning. By nature, basin planning must reflect, consider and respond to the historical, physical, political, social, economic and institutional characteristics of the basin and country.

While approaches to basin planning have evolved over time and are adapted to the local circumstances within a basin, basin planning is ultimately the process of:

1. assessing and prioritizing issues of concern to be managed within a basin
2. deciding on the way in which these priorities should be managed to achieve social objectives over time
3. Specifying the way in which different competing purposes (such as abstraction, hydropower, flood control and navigation) may develop or use the basin water resources.

Basin planning has historically prompted by the need to manage the challenges associated with one or more of the fundamental basin-scale water-related issues:

1. Water allocation, reconciliation and utilization planning has tended to be the focus in more arid or seasonally variable basins where population and development has driven water demands.
2. Water quality planning has been the focus in highly developed urban, industrial or mining dominated basins, as well as those with intensive irrigation.
3. Flood risk management has tended to be the focus in higher rainfall basins, particularly where there is significant downstream development.

1.2.1. New Approaches in Basin Plan

Many basins and aquifers have become stressed as water has become insufficient to meet competing demands, the fitness of the water quality for use has declined and the modification of aquatic ecosystems has accelerated. Thus, as industrial, agricultural and urban demands for water have increased, the natural functioning and ability of these water resources to meet these economic, social and ecological needs has decreased. The challenges of reducing water use in over-allocated basins, decreasing waste loads from point and nonpoint sources in polluted rivers, and rehabilitating degraded river systems could not be resolved by the historical infrastructure-focused approaches to basin development.

The development of new approaches to basin planning was influenced by a number of emerging trends in the water and environmental sectors: The recognition of the importance of functioning aquatic ecosystems, and the rapid global decline in the health of freshwater ecosystems.

- ✓ The exhaustion of engineering solutions. For example, in some cases demand for more water supplies could not be met through new reservoirs because of the absence of suitable sites or because all run-off in a catchment was already being utilized.
- ✓ Steadily increasing costs of providing water services through engineering measures, such as increasing water treatment costs because of the pollution of water sources.
- ✓ The shift to decentralization and participatory governance of resources. This followed the recognition that there was a need for solutions that engaged with many individuals and groups through changes to development planning and natural resources management, and a stronger emphasis on demand management.

These trends led to new approaches to water resources management and basin planning that attempted to move beyond a narrow technical and engineering focus to address a wider range of issues and challenges. These new approaches are characterized by a focus on management at the basin scale, a recognition of the economic and developmental significance of water resources, a focus on the environmental and social importance of water, the participation of a wide range of groups in decision-making, and the attempt to manage the use of water as well as augment supply. The schematic diagram of water planning is given in **figure 1.1.**

1.2.2 Strategic Basin Planning

Strategic basin planning can be defined as a coherent multidisciplinary approach to managing the water resources, natural environment and human activities within a basin, in order to identify and satisfy social, economic and environmental priorities. Strategic basin planning therefore differs from water resources development planning in recognizing that water is a key element of the broader society and economy**. Table 1.3** attributes distinguishing water resources development planning and strategic basin planning.

Table 1.3 Comparison of Water Resources Development Planning and Strategic Basin Planning

	Water resources development planning	**Strategic basin planning**
Basin context	Basins with ‘spare’ water available for development and not facing significant environmental or flood risk pressures	Complex or water-stressed basins requiring difficult trade-offs between economic, social and ecological objectives
Purpose of basin planning	Reconciliation of water availability, quality or flood management with existing development goals: ‘water for the economy	Water planning as an integral part of development planning: ‘water in the economy’

Focus of attention	Engineering focused: water infrastructure systems	Society focused: economic, social and environmental systems supported by the river
Environmental requirements	Threshold levels, in particular water quality	Maintenance of ecosystem goods and services
Key skills in the planning process	Water planner led, with a focus on engineering skills	Cooperation between development, water and environment planners
Analysis techniques	Technical optimization: water resources infrastructure systems analysis, economic (cost–benefit) analysis, water quality assessment and future water use projections	Economic and environmental scenarios: integrated water resources systems analysis social/economic analysis of water strategic and environmental assessment scenario planning

The aim of strategic basin planning is not just to meet straightforward, externally set objectives, but to guide rational choices between a series of possible water management objectives that will best contribute to a range of competing economic, social and ecological goals. The followings are more strategic approach to basin plan;

- Understanding basin interactions
- High level objective - setting at different time frames
- Multidisciplinary teams
- Robust scenario-based analysis
- Reconciling and coordination of activities across all water sectors
- Prioritization
- Sophisticated environmental requirements
- Trade-offs between alternative economic, social and environmental objectives

1.2.3.Ten golden rules of basin planning

The following are the ten golden rules derived from the international lessons and experiences with basin planning over the past century.

- Develop a comprehensive understanding of the entire basin system
- Plan and act, even with part knowledge
- Prioritize issues for current attention, and adopt a phased and iterative approach to the achievement of long-term goals

- Recognize that basin planning is iterative and often chaotic
- Enable adaptation to changing circumstances
- Develop relevant and consistent thematic plans
- Address issues at the appropriate scale by nesting local plans under the basin plan
- Engage stakeholders with a view to strengthening institutional relationships
- Focus on implementation of the basin plan
- Select the planning approach and methods to suit the basin needs

1.3. RIVER BASIN MANAGEMENT

Sustainable River Basin Management (RBM), which is the basic objective, requires a sound understanding of water resources systems and their internal relations (groundwater, surface water; quantity and quality; biotic components; upstream and downstream interactions). The water systems should be studied and managed as part of the broader environment and in relation to socio-economic demands and potentials, with due influence of the political and cultural settings. The water itself should be seen as a social, environmental, and economic resource, and each of these three aspects must be recognized in the decision making process.

The concept of river basin management is widely accepted as a sound approach. But its application is not a wide because it requires a suitable institutional frame work, supported by appropriate laws and policies. Good governance exists where government agencies, NGOs responsible to allocate water effectively and manage water resources based on legitimate policies and laws are responsive to social and economic needs and, in long term, to the sustainability of the water resources in the state. To achieve good governance, itis necessary to create an enabling environment by encouraging and integrating private and public sector initiatives and to establish rules which allow clear transaction between stakeholders in a climate of trust. It is necessary to affix duties and responsibilities for management of rivers and aquifers because these affect large population and yet no one appear to be responsible for them.

The development planning utilization, preservation and management of most water resources project involve financial, political, and social objectives in addition to the specific objectives of the projects. All decisions on water resources projects are concerned with the quality of life, quantity and its distribution to the society now and in the near future. The river basin management must be ensured that all plans pass the following six feasibility criteria.

1. Technical feasibility	2. Economical feasibility	3. Financial feasibility
4. Political feasibility	5. Environmental feasibility	6. Social feasibility

1.4. OBJECTIVE OF THE REAPPRAISAL STUDY:

Micro level study for Parambikulam Aliyar Basin had been carried out during 2005-2006. The basin and sub basin boundaries and all other thematic layers were prepared under 1:250,000 scale. During the study, rainfall and water level data up to the year 2005 were used for analysis. For the climatological parameters such as temperature, humidity, evaporation, evapotranspiration, wind speed and sun shine hours, 2004 year data have been utilized. Water quality data of pre monsoon and post monsoon periods for the years 1985, 1995 and 2005 have been used to determine the basin groundwater quality.

The Satellite data of IRS-IC LISS III imageries of the year 1999 were used for the interpretation of Geomorphology, Lineament and Land use layers. The demographic analysis has been done by using 2001 census data. The block-wise groundwater assessment on 2003 has been used to derive sub basin wise groundwater potential.

The Micro level Reappraisal study of PAP basin is taken up now by updating the dynamic data such as spatial and temporal variations in rainfall, water level and water quality after a gap of nearly 14 years. The study on land use /land cover is done using high resolution IRS Resource Sat 2A LISS III Satellite data of the year 2018.

Similarly, updated methodologies for assessing the water resource potentials with upgraded / new software are used.

Hence reappraisal of the study is necessary to explore the current scenario of the basin and to recommend judicious management of water resources of the basin.

1.5. METHODOLOGY FOR THE STUDY

The methodology adopted for the Micro level Reappraisal study includes the analysis of spatial and non-spatial data collected to arrive,

- Influence of climatological parameters such as temperature, evaporation, evapotranspiration, wind speed and sun shine hours
- Mapping and generation of geo-database on geology, geomorphology, lineament, land use and soil characteristics.
- Sub basin wise drainage morphometric analysis carried out for qualitative potential assessment

- Geophysical Resistivity data obtained using Wenner Configuration method to determine the aquifer thickness. Spatial distribution and thickness of unconsolidated soil, weathered rock and fractured rock in the basin.
- Rainfall variation, distribution and evaluation of spatial rainfall dynamics. Season wise rainfall analysis was carried out and isohyets were generated using GIS software to explore the rainfall variation, pattern and influence in the study area.
- Ground water level distribution for evaluation of ground water regime. Groundwater level data for pre and post monsoon periods were analyzed to examine the spatial distribution of groundwater table and fluctuation in the basin.
- Evaluation of water quality of ground water and surface water: Selected parameters of water quality data for pre and post monsoon periods were analyzed using Water Quality Index (WQI) method and the spatial distribution of quality in the study area.
- Study on Land use and Land cover pattern and comparing for 2 periods ie. 1998 and 2018 to evaluate the change detection.
- For quantification of surface water potential, Monthly Runoff Simulation (MRS) model and National Water Development Agency (NWDA) method were used in general for estimating the sub basin wise surface water potential. Specifically in the context of Parambikulam Aliyar basin, the surface water potential is calculated as per actual measurement for Sholaiyar, Palar, Aliyar and Walayar due to the diversity in nature of the basin.
- Estimation of sectorial water demands.
- Arriving water balance based on available surface and ground water potential and demand.
- Assessing the environmental scenario of the basin.

Remote Sensing and GIS techniques were employed fully in this study wherever it requires. Both Visual and Machine interpretation of satellite data were done and the outputs were put in to GIS analysis. Aerial Photographs on 1:50000 scale were used for interpreting the geological structures such as lineaments. The IRS Resource Sat 2A LISS III data of December 2018data were used for interpretation of geomorphological features and lineaments. The digital satellite data was geo-rectified with ground control points (GCPs) from the rectified toposheets using Digital Image Processing software. Radiometric corrections such as filtering, edge enhancement, histogram and Principle

Component Analysis (PCA) were done to obtain better visual ability of the digital image before the image was taken for interpretation.

The coordinate system for all digital layers needs to be in appropriate units that represent the geographic features in their true shapes and sizes. The Survey of India graticule with 1:50,000 scale has been adopted for database. Transverse Mercator projection and WGS 1984 UTM projected coordinate system are adopted for database as per Government of Tamil Nadu policy, which represents the actual ground distance in meters.

1.6 DATA COLLECTION

For water resource planning and management, water related data either by way of direct or by indirect means, in the form of spatial and non-spatial formats are essential. The data such as physiography, drainage, geology, geomorphology, land use/land cover, lineament, soil, Digital Elevation Model, etc. have been collected from different sources. Similarly data on climate, rainfall, groundwater level, water quality, environment, socio-economic, health, agricultural, crop pattern population, livestock, industries, etc. are collected from the respective Government organizations. Data collected from various sources are given in the following **Table 1.4**.

Table 1.4 Data and their Source

Sl.No.	Data	Source
1.	Climatological Parameters - Temperature, Evaporation, Humidity, Wind Velocity Sunshine Hours	State Ground and Surface Water Resources Data Centre, WRD
2.	Rainfall	
3.	Water Level	
4.	Surface water and Groundwater Quality	
5.	Geophysical Resistivity Data	
6.	Aquifer Parameters	Central Ground Water Board, Chennai
7.	Geology	Geological Survey of India, Chennai

8.	Soil	Tamil Nadu Agricultural University, Coimbatore
9.	Agricultural details and cropping pattern	Tamil Nadu Agricultural Department and Agricultural Engineering Department
10.	Population and Household details	Census 2011
11.	Land utilization and socio-economic details	Statistical Department
12.	Live Stock	Animal Husbandry Department
13.	Domestic water supply	TWAD Board, Chennai
14.	Environmental details	Department of Environment and Forest
15.	Small, Medium and Large Industry details	Department of Industries

The following Satellite data were used for interpretation for this micro level study

1. IRS Resource Sat II, LISS III data of April, 2019
2. IRS Resource Sat II, LISS IV Mx of December, 2018
3. Shuttle Radar Topography Mission (SRTM) 30m DEM

1.6.1 Basin – Specific data:

For maintaining consistency and uniformity among different types of data, all the data collected need to be treated in the same way. For example, socio-economic, agricultural and livestock and other statistical data are available based on administrative units, which generally, do not coincide with river basin boundary. To evolve basin-specific data, one has to re-group and fit into river basins judiciously. Regrouping of data according to river basins is to be done systematically in order to strike consistency between basin and the administrative units of entire basin. With regard to administrative units, which are situated in two or more river basins, the value of the variables will have to be split between those basins in proportion to the area contained in the respective river basins.

1.6.2 Updates and Revisions:

The planning process is considered as a continuous effort. The assessment and planning process adopted in previous report is based on the scenario of 2006. According to the variations in results for the future-planning horizon based on the current scenario, the recommendations will have to be revised and updated. In the advent of continuous updation of theme database used need to be revised accordingly for an adjustable scientific assessment of water resources and of sectoral water demands of present and future, under different socio-economic development scenarios.

The process of the present planning study, which is proposed for its updating, is presented in **Figure 1.2.**

The present report is updated with latest data and analysed with modern tools available as on date. Remote Sensing and GIS technologies with latest tools were engaged to derive new thematic layers; few of them are not available in previous reports. Morphometric analysis and land use change detection analysis and rainfall co efficient of variation are appended in this report as a new attempt. Water level dynamics, Surface & groundwater quality analysis with Water Quality Index (WQI) and water balance are illustrated in the present study report which will reflect the exact current scenario. Recommendations on structural and non structural measures for the future planning were given in this report for implementation and hence the present report will be most useful for the field officers of WRD, line departments and all other stakeholders in the PAP basin jurisdiction.

FIG.1.1. SCHEMATIC DIAGRAM OF WATER PLANNING –RIVER BASIN PLAN

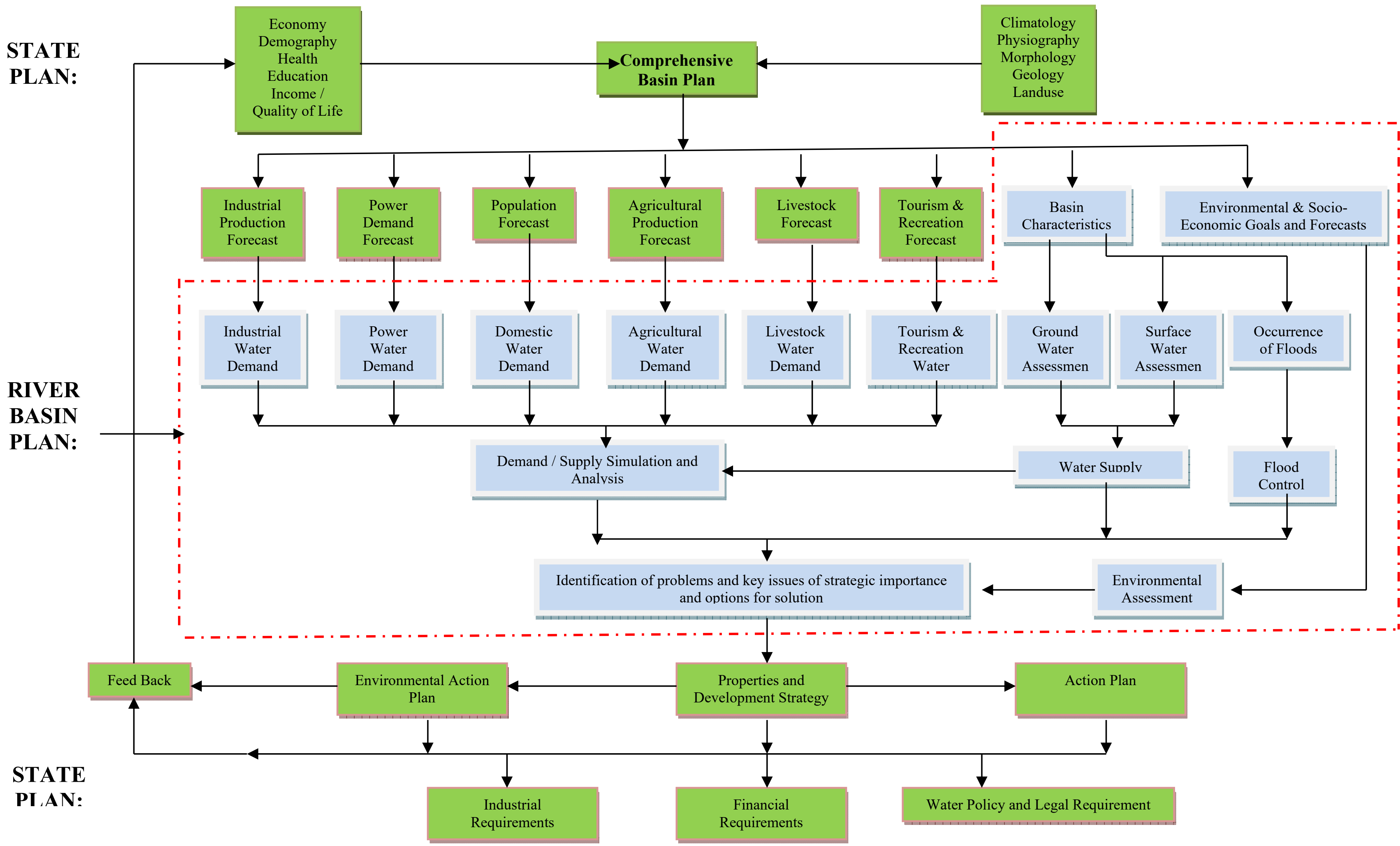
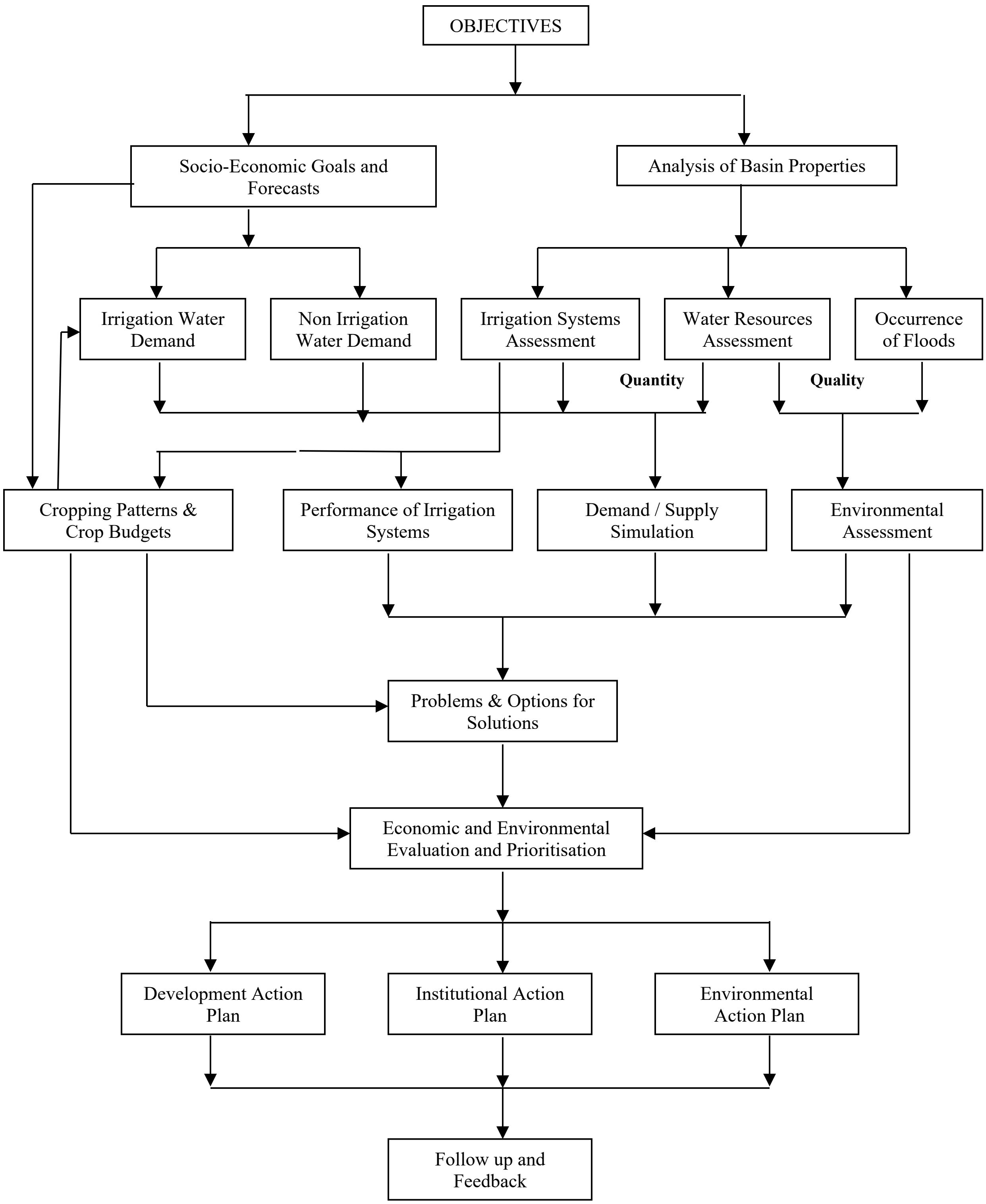
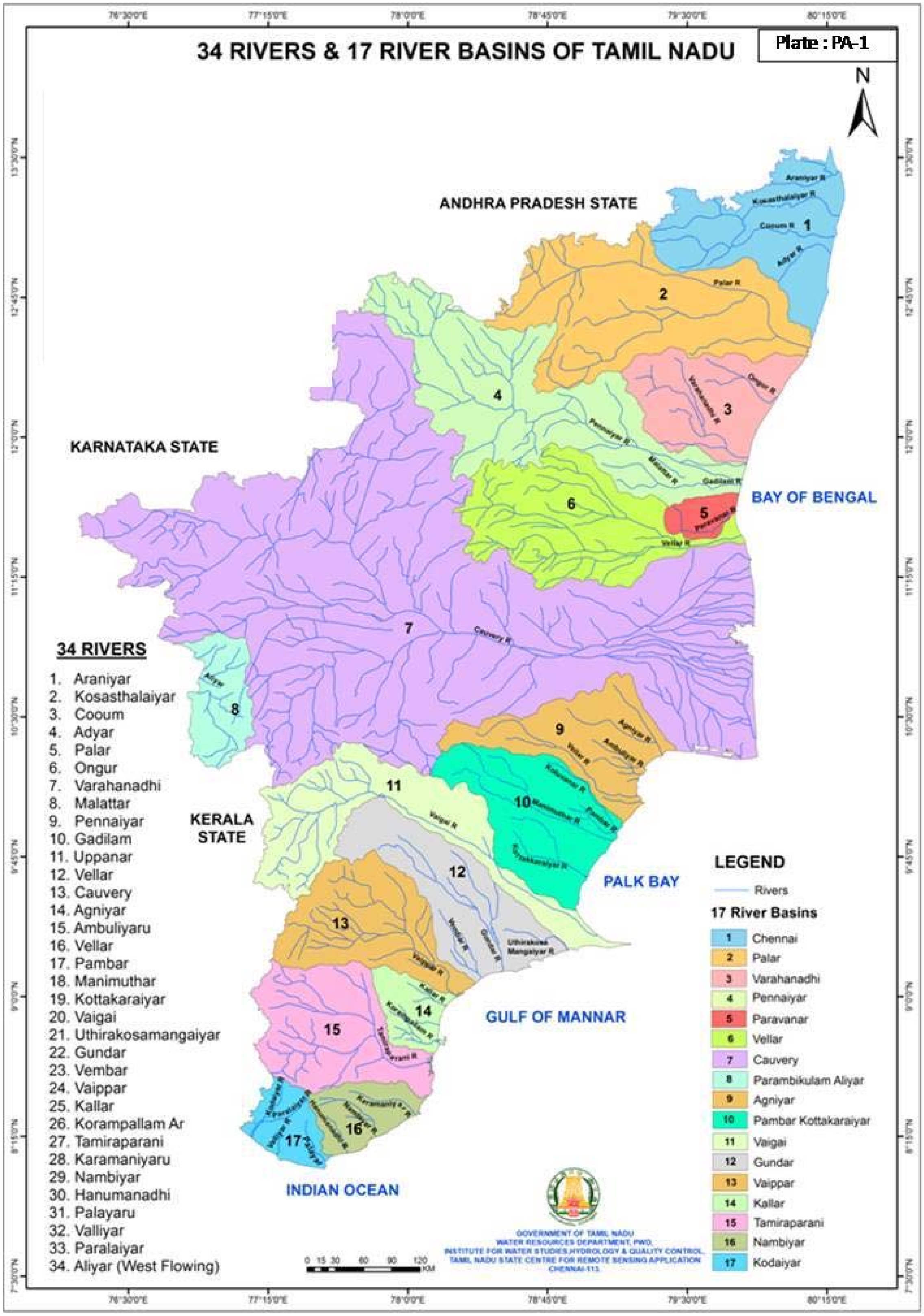


Fig. 1.2 FLOW CHART FOR PRESENT PLANNING STUDY





34 RIVERS & 17 RIVER BASINS OF TAMIL NADU
Plate : PA-1
N
ANDHRA PRADESH STATE
KARNATAKA STATE
KERALA STATE
BAY OF BENGAL
PALK BAY
GULF OF MANNAR
INDIAN OCEAN
34 RIVERS
1. Araniyar
2. Kosasthalaiyar
3. Cooum
4. Adyar
5. Palar
6. Ongur
7. Varahanadhi
8. Malattar
9. Pennaiyar
10. Gadilam
11. Uppanar
12. Vellar
13. Cauvery
14. Agniyar
15. Ambuliyaru
16. Vellar
17. Pambar
18. Manimuthar
19. Kottakaraiyar
20. Vaigai
21. Uthirakosamangaiyar
22. Gundar
23. Vembar
24. Vaippar
25. Kallar
26. Korampallam Ar
27. Tamiraparani
28. Karamaniyaru
29. Nambiyar
30. Hanumanadhi
31. Palayaru
32. Valliyar
33. Paralaiyar
34. Aliyar (West Flowing)
LEGEND
Rivers
17 River Basins
1 Chennai
2 Palar
3 Varahanadhi
4 Pennaiyar
5 Paravanar
6 Vellar
7 Cauvery
8 Parambikulam Aliyar
9 Agniyar
10 Pambar Kottakaraiyar
11 Vaigai
12 Gundar
13 Vaippar
14 Kallar
15 Tamiraparani
16 Nambiyar
17 Kodaiyar
0 15 30 60 90 120 KM
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD,
INSTITUTE FOR WATER STUDIES,HYDROLOGY & QUALITY CONTROL,
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
CHENNAI-113.

Table 1.1 : 34 Rivers and 17 Basins

Sl. No.	River Basin	Sl. No.	Rivers in the Basin
1	Chennai Basin	1	Araniyar
		2	Kosasthalaiyar
		3	Cooum
		4	Adyar
2	Palar	5	Palar
3	Varahanadhi	6	Varahanadhi
		7	Ongur
4	Pennaiyar	8	Malattar
		9	Pennaiyar
		10	Gadilam
5	Paravanar	11	Paravanar
6	Vellar	12	Vellar
7	Parambikulam Aliyar	13	Aliyar
8	Cauvery	14	Cuavery
9	Agniyar	15	Agniyar
		16	Ambuliyar
		17	Vellar
10	Pambar-Kottakkaraiyar	18	Pambar
		19	Manimuttar
		20	Kottakkaraiyar
11	Vaigai	21	Vaigai
12	Gundar	22	Uthirakosamangaiyar
		23	Gundar
		24	Vembar
13	Vaippar	25	Vaippar
14	Kallar	26	Kallar
		27	Korampallam Ar
15	Tamiraparani	28	Tamiraparani
16	Nambiyar	29	Karumeniyar
		30	Nambiyar
		31	Hanumanadhi
17	Kodaiyar	32	Pazhayar
		33	Valliyar
		34	Paralayar

Table 1.2 : List of Basins and Sub Basins

Basin Name	Sub basin.No.	Sub Basin Name
1. CHENNAI BASIN	1	Gummidipoondi
	2	Araniar
	3	Nagariyar
	4	Nandhiyar
	5	Kosasthaliyar
	6	Cooum River
	7	Adyar
	8	Kovalam
2. PALAR RIVER BASIN	9	Upper Palar
	10	Malattar
	11	Agramar
	12	Kavundinyanadhi
	13	Poiney River
	14	Vegavathi River
	15	Cheyyar
	16	Kiliyar
	17	Lower Palar
3. VARAHANADHI BASIN	18	Varahanadhi
	19	Nallavur River
	20	Ongur River
4. PENNAIYAR BASIN	21	1A Chinnar
	22	1 B Chinnar
	23	Markandanadhi
	24	Kambainallur River
	25	Pambar
	26	Vanniar
	27	Matturar
	28	Kottapattikallar (Kovilar)
	29	Valayar Odai
	30	Ramakal Odai
	31	Pambanar & Varattar
	32	Aliyar
	33	Musukundanadhi
	34	Thurinjalar
	35	Gadilam River
	36	Upto Krishnagri Reservoir
	37	Krishnagri to Pambar
	38	Lower Pennaiyar
	39	Pambar to Thirukovilur
5. PARAVANAR BASIN	40	Paravanar
	41	Uppanar

6. VELLAR BASIN	42	Upper Vellar
	43	Sweta Nadi
	44	Chinnar
	45	Anaivari Odai
	46	Gomukhi River
	47	Maniukdha Nadi
	48	Lower Vellar
7. CAUVERY RIVER BASIN	49	Chinnar
	50	Dodda Halla
	51	Mettur Reservoir to Noyel Confluence
	52	Palar Tatta Halla
	53	Moyar
	54	Upper Bhavani River
	55	Lower Bhavani River
	56	Noyyel River
	57	Tirumanimuttar
	58	Amaravathi River
	59	Karaipottanar
	60	Pungar (Upper Coleroon)
	61	Ayiaar
	62	Ponnaniyar
	63	Nandiyar-Kulaiyar
	64	Marudaiyar
	65	Lower Coleroon River
	66	Cauvery Delta
8. PARAMBIKULAM ALIYAR BASIN	67	Walayar
	68	Palar
	69	Aliyar
	70	Sholayar
9. AGNIYAR BASIN	71	Agniyar
	72	Ambuliar
	73	South Vellar
10. PAMABR KOTTAKARAIYAR BASIN	74	Manimuttar
	75	Pambar
	76	Kottakariyar
11. VAIGAI RIVER BASIN	77	Upper Vaigai River
	78	Suruliyar
	79	Theniyar
	80	Varattar-Nagalar
	81	Varahanadhi
	82	Manjalar
	83	Sirumalaiyar
	84	Sathaiyar
	85	Uppar
	86	Lower Vaigai River

12. GUNDAR BASIN	87	Upper Gundar
	88	Therkar
	89	Kanal Odai
	90	Gridhamalnadhi
	91	Paralaiyar
	92	Lower Gundar
	93	Uthirakosamangaiyar
	94	Palar
	95	Vembar
13. VAIPPAR BASIN	96	Nichabhanadhi
	97	Kalingalar
	98	Deviyar
	99	Nagariar
	100	Sevalaperiyar
	101	Kayalkudiar
	102	Vellampatti Odai
	103	Arjunanadhi
	104	Kousiganadhi
	105	Sindapalli Uppodai
	106	Uppathurar
	107	Sinkottaiyar
	108	Vaippar
14. KALLAR BASIN	109	Kallar
	110	Chalikulam River
	111	Korampallam River
15. TAMIRAPARANI RIVER BASIN	112	Upper Tamiraparani
	113	Manimuthar
	114	Gadana Nadhi
	115	Pachaiyar
	116	Chittar
	117	Uppodai
	118	Lower Tamiraparani River
16. NAMBIYAR BASIN	119	Karamaniyar
	120	Nambiyar
	121	Hanumanadhi
17. KODAIYAR BASIN	122	Pechiparai
	123	Chittar(Kodayar)
	124	Perunchani
	125	Kuzhithuraiyar
	126	Valliyar
	127	Pazhayar

CHAPTER – 2

DESCRIPTION OF THE BASIN

Chapter II
Description of the Basin

2.1 Parambikulam - Aliyar Project - (PAP)

Part of Coimbatore and Tiruppur districts of Tamil Nadu, lying on the leeward side of the Western Ghats is a dry and arid region with marginal rainfall and has no natural water resources sufficient for the vast stretch of parched soil. Hence the Government of Tamil Nadu decided upon the diversion of some of the west flowing rivers for the beneficial utilization of dry lands of then Coimbatore district. The Government of Tamil Nadu with the consent and co-operation of the Kerala Government executed the "**Parambikulam Aliyar Project (PAP)"** which is a multi-purpose and multi valley projects.

This multipurpose project has a long history dating back to 1921 which did not receive the consideration at that time and again revised in 1947 and shelved again. After an elaborate discussion with Kerala under the aegis of "Planning Commission" and "Central Water and Power Commission", the Project had been finalized and completed stage by stage from the year 1959 to 1984.

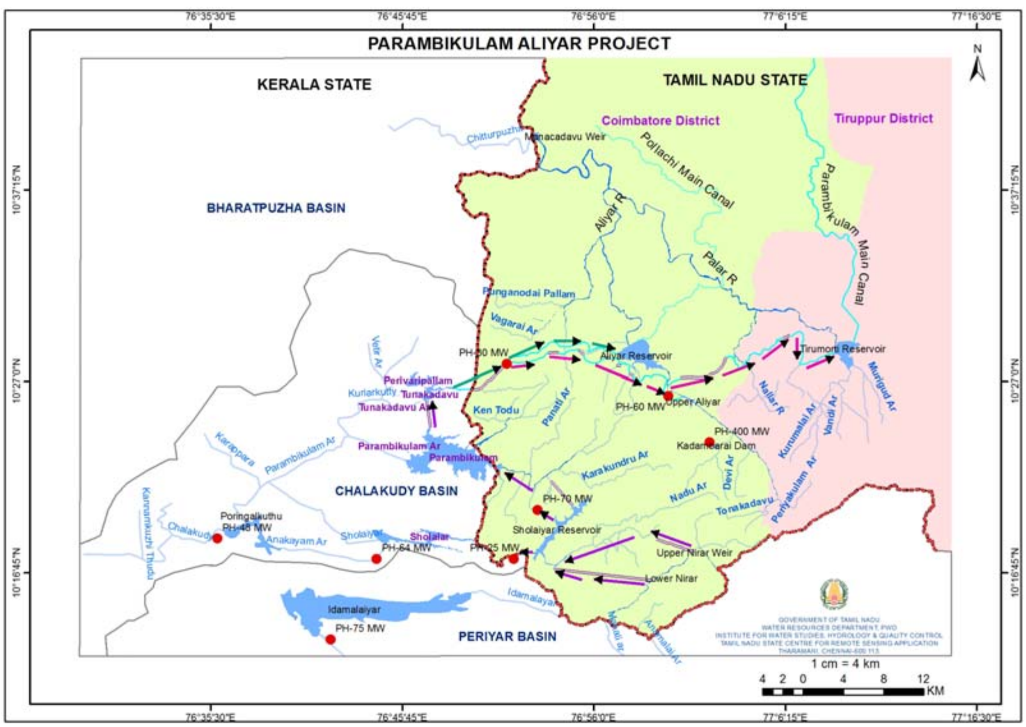


Fig. 2.1 Schematic Diagram of Parambikulam Aliyar Project

The project contemplated integration of seven rivers. Five rivers on the Anaimalai hills viz., Nirar, Sholaiyar, Parambikulam, Tunakadavu, Peruvaripallam, and two rivers in the plains viz., Aliyar and Palar. By constructing reservoirs across these rivers and inter-connecting them through tunnels **(Fig.2.1)** to divert the impounded waters of reservoirs to the plains of the Coimbatore and Tiruppur districts of Tamil Nadu State and Chittur area in Kerala State.

The surface water potential is mainly dependent on an inter-State Agreement (PAP Agreement) between Kerala and Tamil Nadu. An Agreement was entered into in 1970, with retrospective effect from 1958 was due for review on 09-11-1988 and thereafter once in 30 years. In the Inter-State Meeting of the Hon'ble Chief Ministers of Tamil Nadu and Kerala, it was decided in the meeting; both Tamil Nadu and Kerala Governments have constituted each, a five member Committee at the respective Secretary level PWD/WR for the review the Parambikulam Aliyar Project Agreement etc.

The basins of PAP system as per Agreement are Periyar, Chalakudi and Bharathapuzha basins which are inter-State basins. The sub basins of these basins which include the portion in Tamil Nadu are Nirar sub basin of Periyar basin, Sholaiyar and Parambikulam sub basins of Chalakudi basin and Aliyar and Palar sub-basins of Bharathapuzha basin. The Walayar sub basin is also part of Bharathapuzha basin though not covered in the PAP Agreement. The sub basins of Parambikulam Aliyar Basin as per IWS delineation, are listed as Sholaiyar, Walayar, Aliyar and Palar which is limited to the above mentioned inter State basins falling within the boundary of Tamil Nadu. The Sholaiyar sub basin thus mentioned includes the Parambikulam sub basins of Chalakudi basin and Nirar sub basin of Periyar basin.

Further, in the basin area covered in this study, there is inter basin transfer of water and water sharing which is governed by the PAP Agreement. This basin cannot be equated with any other basin and the study/analysis cannot be done in a routine manner. The Parambikulam Aliyar basin study done by IWS is confined to Tamil Nadu State limits. However, with reference to yield etc., the Inter State aspects are to be covered. For this the studies done by NWDA could be considered and referred.

Tamil Nadu is taking all the necessary measures to adhere to the terms of the PAP Agreement and sharing of water with Kerala. However, the quantity of water anticipated as the share of Tamil Nadu has not been practically realised in the PAP system over the years.

In this scenario, where the quantum of water sharing in an average year are as per the terms of the PAP Agreement which is due for review once in 30 years, the contents and quantities reported in this study are only to provide an insight and cannot be taken as absolute and shall not be misread with specific regard to the stipulations in the PAP Agreement.

2.1.1. Parambikulam - Aliyar River Basin

This Parambikulam Aliyar Project Area is considered as “River basin " since the area falling under this scheme is surrounded by ridges / water divide, and the rivers draining in this basin are west flowing, hence cannot be appended with the adjacent Cauvery river basin of Tamil Nadu. Thus it become one among the 17 river basins of Tamil Nadu and based on the geographical location from North, the Parambikulam - Aliyar basin is the eighth basin from Chennai basin. The basin is Inter State in nature. Total geographical area of the Parambikulam - Aliyar basin (Tamil Nadu part) is **2406.38 sq.km** and located in between N. Latitude 10° 12’ 50” - 10° 57’ 45” and E. Longitude 76° 42’ 30” - 77° 12’ 40”. The basin falls in Survey of India Topographic sheets " 58 / B9, B13, B14, B15, B16 and 58 / F1, F2, F3, F4 on 1:50,000 scale. Parambikulam - Aliyar basin is bounded by the Cauvery river basin in the east and north, Kerala State in the west and south **(Plate PA-2).**

The Parambikulam Aliyar basin is further delineated into four sub basins namely, Walayar, Palar, Aliyar and Sholaiyar. Walayar is the largest sub basin among the four sub basins with an area of 875.13 sq.km. The northern and eastern sides bounded by Cauvery basin and the western part bounded by Kerala State. The southern part bounded by Aliyar and Palar sub basins.

Palar sub basin having an area of 520.60 sq.km, which is bounded by Walayar sub basin in the north, Aliyar sub basin in the west and Cauvery basin in the east and south. The Aliyar sub basin is bounded by Walayar sub basin in the north, and Palar Sub basin in the east, Kerala State and Sholaiyar in south and Kerala State in the west. The total geographical area of the sub basin is 564.55 sq.km. Sholaiyar sub basin is the smallest among the four, having an aerial extent of 446.11sq.km which is bounded by Aliyar sub basin in the north, Kerala State in the east, west and in the south.

2.1.2 Administrative Setup

An area of 44.85 percent of Coimbatore district and 5.48 percent of Tiruppur district fall in the Parambikulam Aliyar basin. Podanur, Madukkarai, Anamalai, Valparai and Pollachi are the important towns located in the basin.

Eight taluks namely Perur, Madukkarai, Sulur, Kinathukadavu, Pollachi, Anaimalai, Valparai and Udumalaipet are spread over in this basin. There are eight blocks covered in this basin, out of which, Anamalai is the only full block and the remaining are part blocks **(Plate PA-3)**. Totally 19 Firkas are falling in this basin partially / fully **(Plate PA-4)**. The Parambikulam Aliyar basin has 247 Revenue villages, out of which, 226 villages are in Coimbatore district and 21 villages are in Tiruppur district. The details of districts and blocks falling in the basin are given in **Table 2.1** and the district and firka area details are given in **Table 2.2.** The sub basin wise Revenue villages and firka wise villages are furnished in Annexure 2.1 and 2.2 (Volume 2) respectively.

Table 2. 1 District and Block area of Parambikulam Aliyar Basin

District	Area of the District (Sq. Km)	District area falling in the Basin (Sq. Km)	% of District Area Falling in the Basin (in Percentage)	Block	Block area falling in the Basin (Sq. Km)
1	2	3	4	5	6
1) Coimbatore	4732	2122.33	44.85	1) Thondamuthur	67.40
				2) Madukkarai	220.87
				3) Sultanpet	36.90
				4) Kinathukadavu	313.55
				5) Pollachi North	241.80
				6) Pollachi South	185.64
				7) Anaimalai	1056.18
2) Tiruppur	5187	284.05	5.48	8) Udumalpet	284.04
TOTAL		**2406.38**	**TOTAL**		**2406.38**

Table 2.2 Firka wise area of Parambikulam Aliyar Basin

District		Area of the District (Sq. Km)	District area falling in the Basin (Sq. Km)	% of District Area Falling in the Basin (in Percentage)	Firka		Total Firka Area (Sq. Km)	Firka area falling in the Basin (Sq. Km)	% of the Firka falling in the Basin (in Percentage)
1		2	3	4	5		6	7	8
1)	Coimbatore	4732	2122.33	44.85	1	Alandurai	70.37	42.30	60.11
					2	Aanaimalai	122.04	122.04	100.00
					3	Kinathukadavu	113.86	113.86	100.00
					4	Kolarpatti	92.96	66.15	71.16
					5	Kottur	104.44	104.44	100.00
					6	Kovilpalayam	89.77	89.77	100.00
					7	Madukkarai	55.27	55.27	100.00
						Madukkarai RF & Reservoir area		82.15	
					8	Marchinaickenpalayam	118.53	118.53	100.00
					9	Ottakal Mandapam	101.25	87.31	86.23
					10	Periyanegamam	77.19	59.11	76.58
					11	Perur	33.03	21.24	64.31
					12	Pollachi (North)	72.57	72.57	100.00
					13	Pollachi (South)	114.99	114.99	100.00
					14	Ramapattinam	133.31	133.31	100.00
					15	Selakaraichal	136.78	36.9	26.98
					16	Vadachithur	126.22	104.75	82.99
					17	Valparai	249.3	249.3	100.00
						Valparai RF		448.33	
2)	Tiruppur	5187	284.05	5.48	18	Kurichikottai	113.14	20.14	17.80
						Kurichikottai RF		170.10	
					19	Periyavalavadi	116.57	93.8	80.47
						TOTAL		**2406.38**	

2.1.3 Transport Network

As far as the transport network is considered, the Parambikulam Aliyar basin area is well connected with roads and railway lines **(Plate PA-5).** All the towns and villages are connected with village roads, district roads, State Highways and National Highways. The National Highway - NH 49 is passing from Udumalaipet to Muthalamada and Challakudi of Kerala State through Anaimalai. National Highways - NH 544 is passing from Podanur to Palakkad. National Highways - NH 209 passes from Udumalaipet to Coimbatore via Pollachi. National Highways passing through this basin are inter connected with State highway SH 19 from Vadakkanchery, Pollachi and Palladam stretch. The State Highway - SH 78, from Pollachi to Valparai is a ghat road with 40 hair pin bends.

2.2 Physiography

Physiography (**Plate PA-6)** is the study of terrain morphology of an area which includes major hills and valleys, its elevation details such as contours, spot heights, slope, river systems and forest cover etc. These physiographic features are derived for Parambikulam Aliyar basin with the aid of Survey of India Toposheets, Digital Elevation Model (Shuttle Radar Topography Mission – SRTM 30 meter resolution) and satellite imageries etc. The salient physiographic features are described below.

The elevation ranges in between +2504 m AMSL and +155 m AMSL and the mean elevation is +1600 m AMSL. The highest elevation (+2504 m AMSL) is observed at Tanaka Malai in Anaimalai reserved forest. The lowest elevation (155 m AMSL) is observed at west of Ganapathypaalayam village (Marichinayakanpalayam Firka – Coimbatore District).

The basin area is covered by hills with reserved forests at the northwest and whole of southern portion. The reserved forests at the northwest are Boluvampatti and Shulakkarai where the elevation ranges from 200 m AMSL to 1308 m AMSL. The major portion of the area is covered by Anaimalai and Thunakadavu reserved forests at south and the elevation ranges between 300 m AMSL and 2504 m AMSL. Apart from this, the area has no significant hillocks.

The basin area is classified into 4 zones based on the elevation (**Plate PA** –7) to understand the distribution of the plain and highly elevated hilly areas. According to this,

- Zone I covers from 155 m AMSL (the minimum elevation of the basin) to 740 m AMSL and this zone covers 1695 Sq Km of the basin which is 70% of the total basin. Most of the plain areas along with the respective foot hills of Walayar, Palar and Aliyar sub basins and few parts of the plateau of Anaimalai Hills in Sholaiyar sub basin falls in this zone. The reservoirs viz., Walayar, Aliyar, Thirumurthy and Tamil Nadu part of Parambikulam are located in this zone.

- The zone II covers the elevation between 741 m AMSL and 1340 m AMSL with an area of 498 Sq. Km (20.69 % of the basin). Part of Shulakkarai Reserve forest and Anaimalai hills are in this zone. Tamil Nadu part of Sholaiyar, Upper Nirar, Lower Nirar, Upper Aliyar and Kadamparai reservoirs are located in this zone.
- Zone III (1341 to 1920 m AMSL) is found in the Anaimalai hills and it is spread out in Palar, Aliyar and Sholaiyar sub basins and covers an area of 158 Sq Km (6.56 %).
- Zone IV takes elevation from 1921 m AMSL to 2504 m AMSL (the highest elevation in the basin) and covers 55.4 Sq Km (2.3 %). This zone is located around the highest peak of Anaimalai in the South eastern part of the basin sharing Palar, Aliyar and Sholaiyar sub basins.

2.2.1 Topographical trend

The terrain trends from east to west where the plain area has maximum contour of 420 m and minimum of 180 m. Hence the rivers in the area are west flowing.

2.2.2 Gradient

Gradients for Parambikulam Aliyar Basin were calculated using US Geological Survey's Digital Elevation Model "Shuttle Radar Topographic Mapping (SRTM)", which was used to generate the drainage network and analysed in GIS software.

The Walayar sub basin has three major rivers viz., Kumattipatti Nadhi, Varattar and Koraiyar. The north most Kumattipatti Nadhi flows from the starting point to a distance of 2.22 Km in 1 to 1.62 m/km gradient and for the remaining distance the gradient is 1.62 – 2 m/Km. The Varattar river flows in a gradient of 1-1.39 m/Km for a distance of 5.32 Km and for a distance of 2.51 Km the gradient is 1.39 -2 m/Km. The southernmost river Koraiyar River flows in the gradient of 1-1.36, 1.36 – 1.84 and 1.84-3 m/Km before runs into Kerala State.

The Palar sub basin is drained by Palar River and its tributary Nallar River. The gradient of Nallar River is 1-1.48 and 1.48 – 2 m/Km. the Palar River flows in the highest gradient of 2-2.55 m/Km to 2.55-3 m/Km.

The Aliyar Sub Basin is drained by Aliyar River. The part of river before drains into the Aliyar Reservoir, flows in the gradient of 1- 2 m/Km. The Aliyar River flows in steepest gradient of 3-3.43 m/Km and at a gradient of 3.43-4 m/Km before flows out of the basin.

2.2.3 Hills and Reserve Forest:

The north western part of the Walayar sub basin is covered by Bolampatti Block II Reserved forest, Shulakkarai and small Shulakkarai Reserved forests. The Bolampatti RF comprises of hills namely Kuttadi Malai, Ayyaswami malai, Etti Malai and Dharmalingam Malai.

In Palar sub basin, the dense forests are noticed in the southern portion of the sub basin and are spread over the hills viz. Thadaganachi Malai, Kolikuttu Malai, Idi Malai, Bhahiravamalai, Kadattimalai, Ten malai, Pichchamalai, ChikkaMalai, Kochchaimalai, Kombumalai and Konimalai.

In Aliyar Sub basin, the Poonachi reserved forest and part of Anaimalai Reserved forest covers Tanaka Malai, Akka Malai, Tangachi malai, Kokkana malai, Pachchaipal Malai, Naivetti Malai and Munga Malai.

The Sholaiyar sub basin has many hills viz., Peraiyar malai, Samba Malai, Usi malai, Podu malai, Karu Malai, Periya Anai Malai, kannisholai Malai, Periya Tanaka Malai, Murukalli Malia, Koipuli Malai, Perumkundru Malai, Helepaarai Malai, Tekkanaparai Malai, Kunjaliparai Malia, Sholaiyar Malai, Sittikkal malai, Karuvaru Malai, tavittuoivu Malai, Olavara Malai, Nadu Malai, Korakkal Malia, Pamban Malai, Velli Malai and Umaya Malai and it contains a part of Anaimalai reserve forest.

Palakkad Gap, the most prominent discontinuity in the Western Ghats, is a low mountain pass in the Western Ghats between Coimbatore in Tamil Nadu and Palakkad in Kerala (**Figure 2.2**). It has an average elevation of 140 meters (460 ft) with a width of 24 –30 kilometres (14–18 mi). The pass is located between the Nilgiri Hills to the north and Anaimalai Hills to the south.

Fig. 2.2 Palghat / Palakkad Gap

2.3 Drainage

There are twenty six major rivers drain in this basin as detailed in the **Table 2.3** All the rivers in this basin are seasonal. Major rivers such as Nirar, also called as Kallar River, Sholaiyar, Tunakadavu are draining in hilly regions, where as Aliyar and Palar rivers are draining in the plain areas. The surplus from Parambikulam reservoir flows into Parambikulam River, which is in Kerala. Similarly, the surplus of Peruvaripallam reservoir flows into Pervaripallam River in Kerala. Nearly 35 tributaries to the main rivers are draining in the basin **(Table 2.3)**. Eight reservoirs located in Tamil Nadu and three located in Kerala, along with various canal systems for catering the need of Coimbatore and Tiruppur districts of Tamil Nadu.

Table 2.3 River and Tributory Particulars								
Sl. No.	**Main River**	**Tributory**		**Origin**	**Origin at Elevation in m**	**End with**	**Total Length_ Km**	**Sub Basin**
1	Valayar			Kerala		Valayar reservoir	17.7	Walayar
		Kummattipatti Nadi		Dharmalingam Malai	631	Valayar River	23.61	Walayar
2	Varattar			Palanikavumdanpudur	260	Kerala	7.83	Walayar
3	Kodavadi Ar/ Koraiyar R			Mandekavundanpudur tank	300	Kerala	52.32	Walayar
4	Aliyar R			Aliyar Reservoir	300	Kerala	43.75	Aliyar
		Palar		Tirumurti Reservoir	400	Aliyar	37.22	Palar
			Nallar	Verapatti Malai	1260	Palar	11.43	Palar
			Kottamadi Pallam	Lallikuttu Malai	1020	Nallar	3.34	Palar
			Pakka Pambar	Manga Malai	920	Nallar	8.71	Palar
		Pana Pallam		Kombanpatti Malai	580	Aliyar River	5.25	Aliyar
		Upper Aliyar					3.49	Aliyar
5	Murigud Ar			Arasiammal Malai	1580	Tirumurti Reservoir	7.09	Palar
		Vallaru Pallam		Kadamuruti Medu	1220	Murigud Ar	4.49	Palar
6	Panchalingam Ar			Bahirava Malai	1600	Tirumurti Reservoir	7.68	Palar
		Tattan Karunai Ar		Pambu Malai	1680	Tirumurti Reservoir	9.92	Palar
			Vandi Ar	Pichcha Malai	2820	Tottan Karunai Ar	3.93	Palar
		Kurumalai Ar		Bahirava Malai	1860	Panchalingam Ar	6.5	Palar
		Mangalamalai Pallam		Ten Malai	1280	Panchalingam Ar	1.73	Palar

Sl. No.	Main River	Tributory		Origin	Origin at Elevation in m	End with	Total Length_ Km	Sub Basin
7	Kottaiyar			Kadattimalai	2140	Tirumurti Reservoir	3.71	Palar
8	Devara Pallam			Ten Malai	1380	Tirumurti Reservoir	2.69	Palar
9	Kilavipatti Pallam			Panta Malai	1080	Tirumurti Reservoir	1.87	Palar
10	Mattala Pallam			Idi Malai	1220	Tirumurti Reservoir	4.82	Palar
11	Avaraikodi Pallam			Sindatumadu Malai	1040	Palar River	4.06	Palar
12	Torakadavu Ar			Tanaka Malai	2100	Upper Aliyar Reservoir	18.88	Aliyar
		Konalar Nadi		Podu Malai	1900	Torakadavu Ar	3.72	Aliyar
		Periyakulam Ar		Ponkatti Malai	2160	Torakadavu Ar	5.42	Aliyar
		Devi Ar		Tanaka Malai	2280	Torakadavu Ar	6.16	Aliyar
		Kadamparai Ar		Tavasi Malai	1600	Torakadavu Ar	5.5	Aliyar
			Pambai Ar	Koram Parai Hill	2380	Kadamparai Ar	8.01	Aliyar
13	Vellunipatti Pallam			Varaiyadu Malai	1620	Aliyar Reservoir	3.51	Aliyar
14	Kadukannai Pallam			Olakkaisattai Malai	1560	Aliyar Reservoir	7.03	Aliyar
15	Chinnar Ar			Ramar Malai	1420	Aliyar Reservoir	4.1	Aliyar
16	Uppar Pallam/Uppar R			Situlakkai Malai	1500	Aliyar River	18.3	Aliyar
17	Vagarai Ar			Tekkadi RF	980	Uppar River	14.64	Aliyar
		Punganodai Pallam		Kuchi Malai	1009	Vagarai Ar	9.18	Aliyar
18	Kolikamatti Pallam			Umaya Malai	1320	Tunakadavu Reservoir	8.07	Sholaiyar
19	Varigali Ar			Perumkundru Malai	1520	Parambikulam Reservoir	11.53	Sholaiyar
		Kurumpalli Pallam		Anamalai	1320	Varigali Ar	5.4	Sholaiyar
		Minimettu Pallam		Umaya Malai	1120	Varigali Ar	3.64	Sholaiyar
			Ken Todu	Pamban Malai	960	Minimettu Pallam	4.91	Sholaiyar

Sl. No.	Main River	Tributory		Origin	Origin at Elevation in m	End with	Total Length_ Km	Sub Basin
20	Parayankadavu Ar/ Periyar R			Tani Malai	1580	Parambikulam Reservoir	16.3	Sholaiyar
		Manampalli Ar	Parayankadavu Ar	Kunjaliparai Malai	2000	Parayankadavu Ar	3.18	Sholaiyar
			Anali Ar	Kunjaliparai Malai	1080	Manampalli Ar	1.66	Sholaiyar
		Karakundrau Ar/Kavurkal Pallam		Chinakattu Malai	1720	Parayankadavu Ar	14.37	Sholaiyar
		Talappaniyan Ar		Ramalakshmana Malai	1700	Parayankadavu Ar	7.31	Sholaiyar
		Urulikal Ar		Urulikal Malai	980	Periyar River	4.45	Sholaiyar
		Andimedu Ar		Urulikal Malai	1120	Periyar River	6.37	Sholaiyar
		Panati Ar		Koipull Malai	1700	Periyar River	10.94	Sholaiyar
21	Naikunnu Ar			Palagankundram	1060	Parambikulam Reservoir	3.18	Sholaiyar
22	Nadu Ar			Koram Parai	2240	Sholaiyar River	18.02	Sholaiyar
23	Sirukundru Ar			Kalliar Estate	1220	Sholaiyar River	6.37	Sholaiyar
		Nadu Ar		Karumalai	1120	Sirukundru Ar	6.36	Sholaiyar
24	Kallar River(Nirar)			Iravikulam Malai (Kerala)	2378	Idamala Ar	14.7	Sholaiyar
		Chinna Kallar Nadi		Mottakku Malai	2240	Kallar River	7.61	Sholaiyar
		Poiyar Nadi		Chinna Malai	1080	Kallar River	4.68	Sholaiyar
		Poiyar Nadi		Nadungkurukku Malai	1720	Kallar River	4.31	Sholaiyar
25	Idamala Ar			Kerala		Kerala	5.59	Sholaiyar
		Itili Ar		Samba Malai	1702	Idamala Ar	17.45	Sholaiyar
		Karinandu Todu		Anamalai RF	1260	Idamala Ar	4.36	Sholaiyar
26	Sholaiyar						15.29	Sholaiyar

There are 66 small to medium water bodies such as tanks, ponds and Ooranis exist in this basin. The drainage map based on Survey of India Topo sheets on 1:50,000 scale showing rivers, drainages, canals, channel and tanks is shown as **Plate PA-8.**

Walayar Sub Basin

Walayar river originates at an elevation of 1687 m MSL in Bolampatti Block II reserved forest in Kerala State and flows towards south east from the western boundary of the sub basin. The river feeds water into Walayar reservoir **(Plate PA-9),** after that the river continued in the name of Walayar along the State boundary and turns towards west near Kumandanparai and runs in to Kerala State. The total length of the Walayar river is 17.7 km. Kummattipatti Nadhi originates at an elevation of 631 m in Dharmalingammalai and runs through Madukkarai in the direction of south and afterward it turns to south west and finally it joins with Walayar river near Kummandanpatti. The total length of the river is 23.61 km.

The river Varattar having a length of 7.83 km originates at Palanikavundampudur at an elevation of 260 m MSL, runs towards south western direction and enters into Kerala near Anapur. Kodavadi river originates from Mandekavundanpudur tank at an elevation of 300 m MSL, runs towards south west direction and gain a name of Koraiyar river after the village Vadakkipalayam. After running 52.32 km, the river enters into Kerala State near Thavalam. A unnamed river running parallel to Koraiyar river joins as left arm near Pattikavundanur.

Five main canals distribute waters from Parambikulam Main Canal, among them Kovilpalayam lower canal (12.17 km) is the longest canal in this sub basin. There are 47 small to large sizes of water bodies such as tanks and ponds exist. The Walayar is the only reservoir in this sub basin.

Palar Sub Basin

There are fifteen rivers namely Palar, Devara Pallam, Kilavipatti Pallam, KottaiAr, Kottamadi Pallam, Kurumalai Ar, Mangalamalai Pallam, Mattala Pallam, Murigud Ar, Nallar, Pakka Pambar, Panchalingam Ar, Verapattimalai, Tattan Kanurai Ar, Vandi Ar and Vellaru Pallam drained in Palar sub basin **(Plate PA-10).** Palar river, a tributary of Aliyar river originates from the Tirumurti reservoir at an elevation of 400 m MSL and running towards north west direction in about 37.22 km and finally empties into Aliyar river near west of Agilandapuram. The Nallar river, a tributary of Palar river originates at an elevation of 1260 m MSL at Verapattimalai having a right arm called as Pakka Pambar originates at Mangamalai (8.71 km) and a left arm called as Kottamadipallam (3.31 km) originates at an elevation of 1020 m in Lallikattumalai joins with Palar river after travelling 11.43 km near south of Anthiyur village.

Murigud Ar originates at an elevation of 1580 m MSL in Arasiammalmalai and drains into Tirumurti reservoir after travelling a distance of 7.1 km. Vallaru Pallam a tributary of Murigud Ar originates at Kadamurutti Medu at an elevation of 1220 m MSL and joins with Murigud Ar. Tattankarunai Ar having a length of 9.92 km originates in Pambumalai at an elevation of 1680 m and empties into Tirumurti reservoir. At Pichchamalai, in the height of 2820 m, Vandiyar a tributory of Tattankarunai Ar originates and joins with the river after travelling a distance of 3.93 km. Panchalingam Ar originates Bhahiravamalai at the height of 1860 m MSL carrying waters of Mangamalai Pallam originates in the Tenmalai at an elevation of 1280 m MSL, Kottai Ar, Karumalai Ar, Devarapallam and Kilavipettaipallam into Titumurti reservoir. The river Mattanapallam originates in the Idi malai at an elevation of 1220 m MSL and empties water into Tirumurti reservoir after traveling a distance of 4.82 m. Avaraikodi Pallam originates at an elevation of 1040 m MSL at Sindatumadumalai and joins with Palar river after running a distance of 4.06 km. There are 9 small to large sizes of water bodies such as tanks and ponds available in this sub basin.

Aliyar Sub Basin

There are 16 rivers flowing in this sub basin **(Plate PA-11)** namely, Chinnar, Devi Ar, Kadambarai Ar, Kadukannai Pallam, Konalar Nadi, Kottai Ar, Kurumalai Ar, Pambai Ar, Pana Pallam, Periyakulam Ar, Punganodai Pallam, Tonakadavu, Ummattipatti Nadi, Uppar Pallam, Vagarai Ar and Vellunipatti Pallam.

Sholaiyar Sub Basin

Totally there are 18 rivers drain in this sub basin **(Plate PA-12)** namely, Anali Ar, Andimedu Ar, ChinnaKallar Nadi, Karakundru Ar, Karinandu Todu, Ken Todu, Kolikamatti Pallam, Kurumpalli Pallam, Manampalli Ar, Minmettu Pallam, Nadu Ar, Naikunnu Ar, Panati Ar, Poyar Nadhi, Sholai Ar, Sirukundru Ar, Talappaniyan Ar and Urulikal Ar.

2.4 Drainage Morphometry

Drainage morphometric analysis is the quantitative evaluation of characteristics of any landform unit. The term drainage in this analysis includes streams, channels, tributaries and rivers. This is the most common technique in basin analysis, as morphometry is an ideal interpretation and analysis, for any landforms to ascertain terrain characteristics. The composition of the stream system of a drainage basin is expressed quantitatively with stream order, drainage density, bifurcation ratio and stream length ratio (Horton,1945). It incorporates quantitative study of the various components such as, stream segments, basin length, basin parameters, basin area, slope, profiles of the land which indicates the nature of development of the basin.

Morphometric analyses require measurement of linear features, stream network and contributing ground slopes of the drainage basin. The morphometric analysis for individual sub basins of Parambikulam Aliyar basin has been done through measurements of linear, aerial and relief aspects of the basin and slope contribution.

The basin geomorphic characteristics have long been believed to be important indices of surface activities. These parameters have been used in various studies of geomorphology and surface-water hydrology, such as flood characteristics, sediment yield, and evolution of basin morphology. More recently, terrain characterization became an important part in modeling surface processes. The detailed analysis of morphometric and morphological characters indicate the role of the neo tectonics in shaping the drainage basin.

Remote Sensing and Geographical Information system (GIS) techniques are used as a convenient tool for morphometric analysis. Digital Elevation Model (DEM) of Shuttle Radar Topography Mission (SRTM) were also widely used in analysis to decipher the influence of rock types and structures in the development of drainage network in hard rock area in the basin, to discover holistic stream properties from the measurement of various stream attributes for the 4 drainage sub-basins of Parambikulam Aliyar basin. Also attempt has been made to find out the stages of geomorphic development with the help of different morphometric parameter viz., streams order, streams number, streams length, mean streams length, bifurcation ratios, elongation factor, circularity index, shape factor, drainage density, stream frequency, texture ratio, relief ratio, length of overland flow, constant channel maintenance and infiltration number.

Morphological characteristics of rivers are very important to study the behavior of a river, its aggradations / degradation, shifting of the river course, erosion of river bank etc. and to plan remedial measure for erosion and other related problems. Most of the streams appear to be in conformity with the geological and structural setup of the area.

For a detailed morphometric analysis of the Parambikulam Aliyar basin, drainages (streams) within the sub basins are delineated from the available Survey of

India topographic maps using GIS software in the scale of 1:50000 and assigning ‘stream order’ to all the segments following Horton's (1945) method modified by Strahler’s (1952). The sub basin wise morphometric analysis is carried out in following heads:

Linear Aspects	:	One dimension
Aerial Aspects	:	Two dimension
Relief Aspects	:	Three dimension

This analysis comprises a series of sequential steps. The drainage layer has been converted to digital format through on-screen digitization from topographic maps using GIS software and the attributes were assigned to create the geodatabase. All measurements were directly computed from the vector data that extracted from the topographic maps. The entire drainage segments were digitized as lines separately for each order (Strahler,1952).

The data in the first category includes maximum order of the streams, number of streams in each order, length, area, perimeter, relief for each of the basins. Those of the second category are the bifurcation ratios, elongation factor, circularity index, shape factor, drainage density, stream frequency, texture ratio, relief ratio, length of overland flow, constant channel maintenance and infiltration number.

Under GIS environment, linear, aerial and relief aspects for all four sub basins in Parambikulam Aliyar basin were arrived **(Table 2.4),** followed by linear regression analysis to check the mutual dependency of some variables viz., i) stream order vs. stream number, ii) stream order vs. stream length and iii) stream order vs. Mean stream length. From the attribute table of this polygon layer, the area between two contours within the basin are noted. Maximum height (H) is the difference between the maximum elevation and the minimum elevation and, are calculated by extrapolation. Mean elevation for each basin also calculated by dividing the sum of frequency of each pixel elevation by the total number of pixel in the basin. Details of the morphometric parameters are tabulated followed by analysis of the parameters through bivariate plots.

Table 2.4 Morphometric parameters

Aspect	Sl. No.	Parameter	Unit	Walayar Value	Palar Value	Aliyar Value	Sholaiyar Value
	1	Area (Sq.km)	A	875.13	520.6	564.54	446.11
	2	Perimeter (km)	P	165.22	121.75	165.09	117.06
	3	Basin Length (km)	L_b	53.28	37.22	51.15	33.68
Linear	4	Stream Order	(u)	5	6	5	6
	5	Stream Length of all order (km)	L_u	1242.52	1365.97	1411.5	1551.8
	6	Total number of stream segments in all order	N_u	1117	2189	2597	3357
	7	Mean stream length (Km)	$Lsm=L_u/N_u$	1.22	2.51	2.14	1.33
	8	Mean Bifurcation Ratio	$R_b=N_u/N_u+1$	7.58	4.67	9.29	12.9
Relief	9	Basin relief (m)	B_h	1472	1878	2349	1836
	10	Relief Ratio	R_h	27.63	50.46	45.92	54.51
	11	Ruggedness Number	Rn	2090.24	4920.36	5872.5	6389.28
Aerial	12	Total number of first order	N1	628	1240	1546	1840
	13	Drainage density(km/km2)	$D_d=L_u/A$	1.42	2.62	2.5	3.48
	14	Stream frequency	$F_s=N_u/A$	1.28	4.2	4.6	7.53
	15	Drainage texture	$R_t=N_u/P$	6.76	17.98	15.73	28.68
	16	Circularity ratio	$Rc=4\Pi A/P^2$	0.4	0.44	0.26	0.41
	17	Form factor ratio	$Rf=A/L_b^2$	0.31	0.38	0.22	0.39
	18	Constant channel maintenance	$C=1/D_d$	0.7	0.38	0.4	0.29
	19	Elongation ratio	$R_e=2((\sqrt{(A/\Pi)})/L_b$	0.63	0.69	0.52	0.71
	20	Texture ratio	T=N1/P	3.8	10.18	9.36	15.72
	21	Infiltration Number	If	1.82	11	11.5	26.2
	22	Length of overland flow	Lg	0.35	0.19	0.2	0.14

2.4.1 Linear Aspects of the Stream System

The drainages (streams) transport water and sediments of a basin through a single outlet, which is identified as the maximum order, and conventionally the highest order of the stream available in the basin, is taken as the basin order. The river size and basin varies greatly with the basin order. The results of the linear aspects of drainage network such as, stream order (Nu), bifurcation ratio (Rb), stream length (Lu) and mean stream length for four sub basins are summarized in **Table 2.5**

Table 2.5 Summary of drainage parameters

Sub Basin	Order	Number of Stream	Bifurcation Ratio	Mean Bifurcation Ratio	Stream Length (Km)	Mean Stream Length (Km)	Area (Sq.Km.)	Drainage Density (Km^{-1})	Drainage Frequency (Km^{-2})
Walayar	1	628		7.58	664.86	1.06	875.13	1.42	1.28
	2	317	1.98		288.32	0.91			
	3	144	2.20		187.44	1.30			
	4	46	3.13		100.62	2.19			
	5	2	23.00		1.28	0.64			
Palar	1	1240		4.67	901.48	0.73	520.6	2.62	4.2
	2	504	2.46		215.30	0.43			
	3	265	1.9		127.25	0.48			
	4	117	2.26		48.12	0.41			
	5	59	1.98		23.39	0.40			
	6	4	14.75		50.43	12.61			
Aliyar	1	1546		9.29	957.72	0.62	564.54	2.5	4.6
	2	618	2.501		221.86	0.36			
	3	275	2.247		124.31	0.45			
	4	153	1.7		63.41	0.41			
	5	5	30.6		44.21	8.84			
Sholaiyar	1	1840		12.9	1029.79	0.56	446.11	3.48	7.53
	2	773	2.38		249.40	0.32			
	3	441	1.75		138.28	0.31			
	4	248	1.78		89.40	0.36			
	5	54	4.59		39.21	0.73			
	6	1	54		5.72	5.72			

2.4.1.1 Stream Order (Nu)

Strahler's system, which is a slightly modified of Horton's system, has been followed for stream ordering because of its simplicity. The smallest, unbranched fingertip streams are marked as 1st order, the joining points of two 1st order streams give a 2nd order drainage segments, two 2nd order streams confluence to form a channel segment of 3rd order drainage(stream), and so on. When two channel of different order join then the higher order is considered. The trunk stream is the highest order of the stream segment.

From the drainage ordering system, It is noticed that Walayar and Aliyar sub basins have 5th order stream, Palar and Sholaiyar are 6th order sub basins (**Plate PA-13, PA-14, PA-15 & PA-16**).

The Walayar sub basin having an aerial extent of 875.13 Sq.Km is a 5th order drainage basin **(Plate PA-13).** A total of 1117 streams were counted in which 628 are 1st order, 317 are 2nd order, 144 are 3rd order, 46 are in 4th order and 2 are in 5th order. In this sub basin parallel and sub parallel drainage patterns have been observed. Parallel drainage patterns **(Fig.2.4)** form where there is a pronounced slope to the surface. A parallel pattern also develops in regions of parallel, elongated land forms like outcropping resistant rock bands. Tributary tend to stretch out in a parallel-like fashion following the slope of the surface. A parallel pattern sometimes indicates the presence of a major fault that cuts across an area of steeply folded bedrock. It may be pointed out that a sub-parallel pattern is, therefore, essentially an 'initial drainage pattern'**(Fig.2.5).** The sub parallel drainage patterns are observed in the upper part of the sub basin includes Chinnanpatti, Pudupatti, Pudur and Ettimadai.

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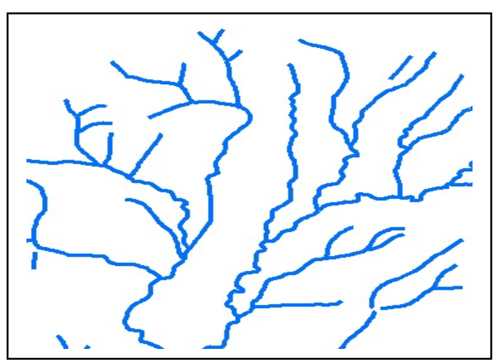


Fig. 2.3 Parallel drainage pattern in Walayar sub basin

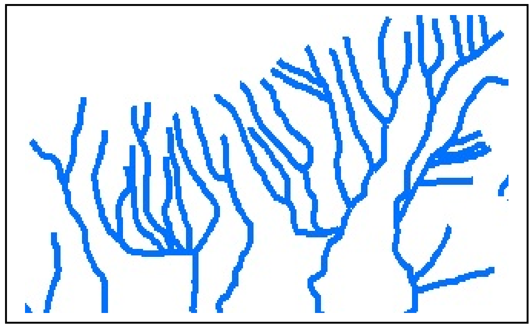


Fig. 2.4 Sub Parallel drainage pattern in Walayar sub basin

The Palar sub basin has a total stream of 2189 segments and is 6th order basin. The total geographical area of this sub basin is 520.60 Sq.Km. In this sub basin, 1st order stream count is 1240, 2nd order is 504 segments, 3rd order is 265, 4th order is 117, 5th order is 59 and 6th order is 4 segments **(Plate PA-14)**. Parallel drainage patterns **(Fig. 2.5)** are noticed in the north upper portion including Tippampatti, Pusaripatti, Kolarpatti, Kanjampatti, Tenkumarapalayam, Samattur and Tondamattur. Dentridic drainage patterns **(Fig. 2.6)** are noticed in the lower parts of the sub basin. Dendritic is a drainage pattern in which the streams branch randomly in all directions and at almost any angle, resembling in plan the branching habit of certain trees. It is produced where a consequent stream receives several tributaries which in turn are fed by smaller tributaries. It is an indicative of insequent streams flowing across horizontal and homogeneous strata or complex crystalline rocks offering uniform resistance to erosion. This pattern may form on top of the land surface or below the land surface in karst aquifers with forming the smaller tributaries.

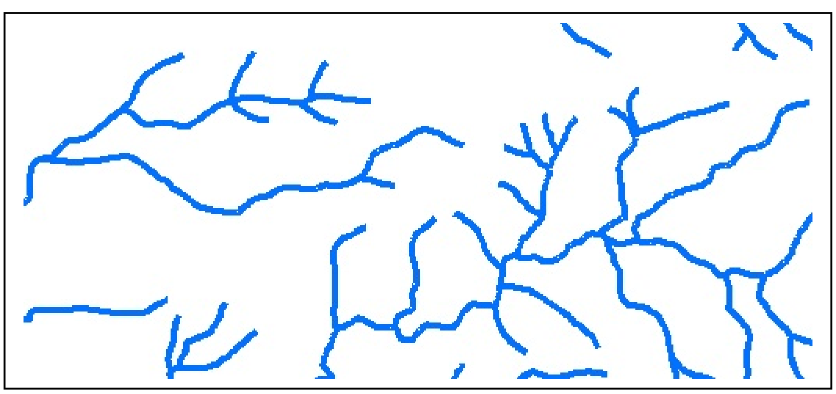


Fig. 2.5 Parallel drainage pattern in Palar sub basin

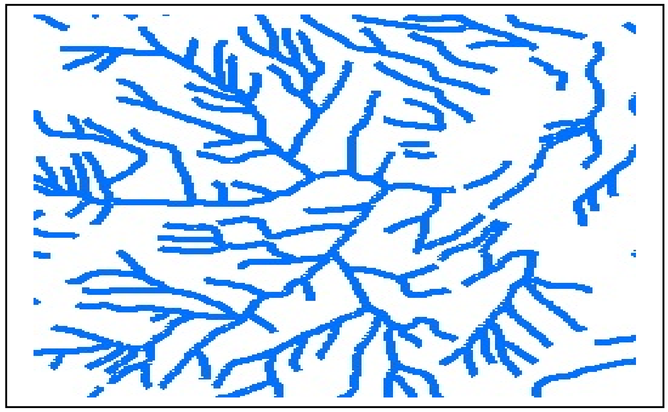


Fig. 2.6 Dentridic drainage pattern in Palar sub basin

Drainages (streams) in Aliyar sub basin forms a 5th order system. A total number of 2597 stream segments are identified in this sub basin **(Plate PA-15)**. The height order 5 has 5 segments, 4th order has153, 3rd order has 275, 2nd order has 618 and 1st order 1546 stream segments. In this sub basin also parallel drainage patterns are noticed in the north east and eastern of upper part and dendritic patterns are noticed in the north and north western of lower parts of the sub basin.

In Sholaiyar sub basin dendritic drainage systems form in V shaped valleys with impervious rock types in major portion. Parallel drainage patterns are noticed in few locations in the sub basin. Sholaiyar is the 6th order sub basin **(Plate PA-16)**. There are 1840 stream segments in the 1st order, 773 streams in 2nd order, 441 streams in 3rd order, 248 streams in 4th order, 54 streams in 5th order and only one stream in the 6th order. Totally 337 stream segments are encountered in the sub basin.

The total number of stream segments present in each order is the stream number (Nu). Nu is number of streams of order u. Horton's (1945) laws of stream numbers state that the number of stream segments of each order forms an inverse geometric sequence which when plotted against order, shows a linear relationship with small deviation from a straight line, for most of the drainage systems. The number of streams usually decreases in geometric progression as the stream order increases in all the sub basins **(Fig.2.7);** the variation in stream order and size of tributary basins is largely depends on physiographical, geomorphological and geological condition of the area.

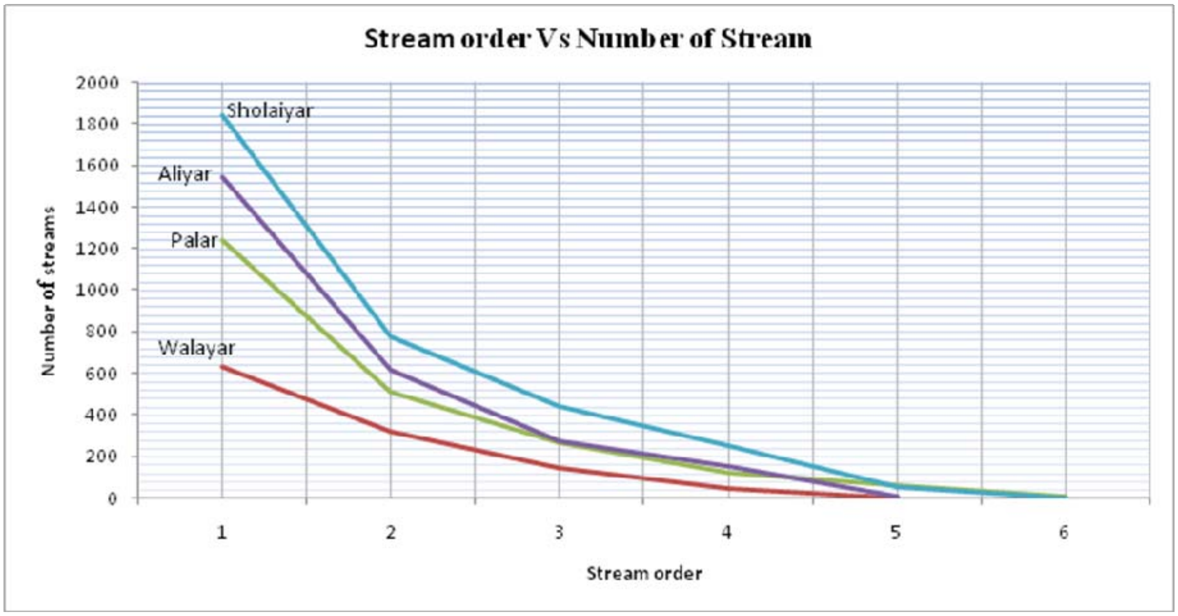


Fig. 2.7 Number of streams vs. Stream order

2.4.1.2 Stream Length (Lu)

According to Horton (1945), streams length delineate the total lengths of stream segment of each of the successive orders in a basin, tend to approximate a direct geometric series in which the first term is the average length of the stream of the first order. The stream length is a measure of the hydrological characteristics of the bedrock and the drainage extent. Wherever the bedrock and formation is permeable, only a small number of relatively longer streams are formed in a well-drained watershed, a large number of streams of smaller length are developed where the bedrocks and formations are less permeable. The number of streams of various orders in the sub basins is counted and their length are measured with the help of GIS software. The stream length in Walayar sub basin is 1242.52 Km, Palar is 1365.97 Km, Aliyar is 1411.5 Km and Sholiayar is 1551.8 Km. It is clearly identified that the cumulative stream length is higher in first-order streams and decreases as the stream order increases in all sub basins **(Fig. 2.8)**.

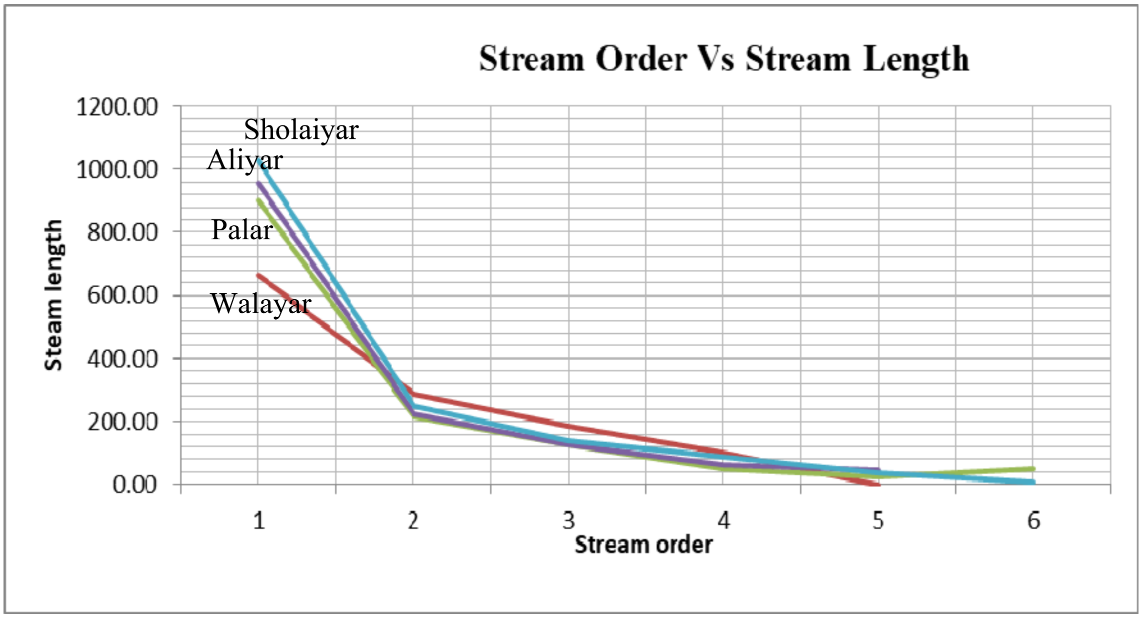


Fig. 2.8 Stream length vs. Stream order

2.4.1.3 Mean Stream Length (Lsm)

Mean stream length (Lsm) reveals the characteristic size of components of a drainage network and its contributing surfaces (Strahler 1964). It has been computed by dividing the total stream length of order 'u' by the number of stream segments in the order. The Lsm values for the Walayar sub basin ranges from 0.64 to 2.19 km (**Table 2.5**) with a mean Lsm value of 1.22 km. It is noted that Lsm value of any stream order is greater than that of the lower order and less than that of its next higher order in the basin. The Lsm values differ with respect to different basins, as it is directly proportional to the size and topography of the basin. Strahler (1964) indicated that the Lsm is a characteristic property related to the size of drainage network and its associated surfaces. The mean stream length (Lsm) of Palar sub basin ranges from 0.40 to 12.61 km and the mean Lsm value is 2.51 km. In the Aliyar sub basin, the Lsm value ranges from 0.36 to 8.84 km and the mean Lsm is 2.14 km. The Lsm value of Sholaiyar ranges in between 0.31 and 5.72 km and the mean Lsm value is 1.33 km.

2.4.1.4 Bifurcation Ratio (Rb)

The bifurcation ratio is of fundamental importance in drainage analysis as it is the foremost parameter that links the hydrological regime of a watershed under topological and climatic conditions (Raj et. al., 1999). It helps to have an idea about the shape of the basin as well as in deciphering the run off behavior. The bifurcation ratio will not be exactly same from one order to the next order because of possibility of the changes in the watershed geometry and lithology but will tend to be consistent throughout the series.

According to Schumn (1956), the term bifurcation ratio (Rb) may be defined as the ratio of the number of the stream segments of given order to the number of segments of the next higher orders. It is a dimensionless property and shows the degree of integration prevailing between streams of various orders in a drainage basin. Bifurcation ratio characteristically ranges between 3.0 and 5.0 for basins in which the geologic structures do not disturb the drainage pattern (Strahler, 1964).The mean bifurcation ratio (Rbm) may be defined as the average of bifurcation ratios of all order. The higher values of Rb indicate a strong structural control in the drainage pattern whereas the lower values indicate that the sub-basins are less affected by structural disturbances

In the Walayar sub basin, the Rb value increasing as the stream order increasing. The mean bifurcation ratio (Rbm) of Walayar sub basin is 7.58 (**Table 2.5**), which shows the sub basin is affected by geological structures. In Palar sub basin, the bifurcation ratio of all stream orders is less than 2.5 and the mean bifurcation ratio shows 4.67 and hence this sub basin has not disturbed by the geological formations. The mean bifurcation ratio (Rbm) of Aliyar sub basin is 9.29 and that of Sholaiyar sub basin is 12.9, which shows the two sub basins are under disturbance of geological features. The average mean bifurcation ratio of Parambikulam Aliyar basin is 8.6 which suggest that the basin area is tectonically active (Somashekar. et.al, 2011).

2.4.1.5 Basin Length

Basin length is the longest dimension of a basin to its principal drainage channel. Among the four sub basins, Walaiyar sub basin has the longest length of 53.28 km and area of 875.13 Sq.Km and Sholaiyar has the shortest basin length of 33.68 km with 446.11 Sq.Km area. as this sub basin. Basin length and the basin area of the alluvial river are maximum and in the dissected hill it is minimum. The basin length of Palar and Aliyar sub basins is 37.22 km and 51.15 km respectively.

2.4.2 Aerial Aspects of Drainage Basin

The aerial aspect is the two dimensional properties of a basin. It is possible to delineate the area of the basin which contributes water and acts as stream segment. The watershed can be delineated from where the stream has its confluence with the higher order stream along hillcrests to pass higher slope of the source and return to the junction. This line separates slopes which drain water towards the streams.

Area (A) and perimeter (P) are the important parameters in quantitative morphology. Perimeter is the length of the boundary of the drainage basin which can be delineated from topographical maps. Basin area is hydrologically important because it directly affects the size of the storm hydrograph and the magnitudes of peak and mean runoff. The aerial aspects of the drainage basin such as drainage density (D), stream frequency (Fs), texture ratio (T), elongation ratio (Re), circularity ratio (Rc) and form factor ratio (Rf) were calculated and results are given in **Table 2.5**.

2.4.2.1 Drainage Density (Dd)

Drainage density (Dd) is the expression of the closeness of spacing of channel within a basin as per Horton (1945). As it provides a numerical measurement of runoff potentiality and landscape dissection, Dd is the important indicator of landform element. Dd measures as the ratio of the total length of streams irrespective of stream order to the per unit area of the basin. Dd considers as an important parameter determining the travel time of water. The capability of any basin to drain is depended upon the drainage density of such area. Drainage density itself depends upon underlain geology, relief, geomorphology, climate, vegetation, etc. of that basin. Drainage density (Dd) is a measure the total stream length in a given basin to the total area of the basin. Walayar sub basin shows low drainage density 1.42 km/sq.km and Sholaiyar sub basin has high density of 3.48 km/sq.km (**Plate PA-17).** The drainage density (Dd) of Palar and Aliyar sub basins is 2.62 and 2.50 km/sq.km respectively.

The Walayar sub basin shows the lowest drainage density because the sub basin underlined by gneiss in major portion followed by pink migmatite and charnockite. Geomorphologically, buried pediment moderate is under lined in major part of the sub basin. The drainage density in Walayar sub basin is indicative of moderate relief and slope, high infiltration capacity and low water regimes throughout the basin.

Palar and Aliyar sub basins are covered by maximum of gneiss followed by granite and charnockite. Geomorphologically these sub basins are covered by buried pediment shallow and moderate and hence drainage density is lower in these sub basins compared to other sub basins. High drainage density in Sholaiyar sub basin indicates impermeable rock in bed surface, high slope and high water flow regimes. Thus, higher runoff with greater flow velocity results in potentiality of downstream flooding in the sub basin.

2.4.2.2 Stream Frequency (Fs)

Drainage frequency is directly related to the lithological characteristics. The total number of stream segments in all orders per unit area is termed as Stream Frequency or Channel Frequency (Horton, 1945). The stream frequency value of the Walayar, Palar, Aliyar and Sholaiyar sub basins is 1.28, 4.2, 4.6 and 7.53 respectively. It is noticed that, the stream frequency is increasing according to increase in the hilly terrain area in the respective sub basins. The stream frequency in Sholaiyar sub basin is very high as the sub basin is fully covered by structural hills. The value of stream frequency (Fs) for the Parambikulam Aliyar basin exhibits positive correlation with the drainage density value indicating the increase in stream population with respect to increase in drainage density.

The drainage study shows that the frequency of the drainage development is less in the lower part in Walayar sub basin (1.28 km^{-2}) and higher in Sholaiyar sub basin (7.53 km^{-2}) and hence it clearly reflects that the drainage development in the lower part especially in Aliyar and Sholaiyar sub basins of the Basin is high and the area is highly dissected.

2.4.2.3 Texture Ratio (T)

Texture ratio is defined as the ratio between total numbers of stream segments to the perimeter of the basin. Infiltration capacity is the single important factor influencing texture ratio recognised by Horton. It is also an important fluvial parameter which denotes the relative spacing of drainage network of any basin. Texture ratio depends upon numbers of natural factors like the amount of rainfall, density of vegetation, soil types, infiltration capacity, stages of geomorphic development and relief (Smith, 1950). Collectively drainage density and drainage frequency can be called drainage texture. Smith (1950) has classified drainage texture into 5 different classes i.e., very coarse (<2), coarse (2 to 4), moderate (4 to 6), fine (6 to 8) and very fine (>8). If the value of the drainage texture is more, then dissection will be more, which in turn leads to more erosion. Sholaiyar sub basin shows very fine texture of 15.72 with higher infiltration number of 26.2. These values indicate that more erosion including landslide will occur with high runoff. Palar and Aliyar sub basins also exhibit fine texture values of 10.18 and 9.36 with higher infiltration value of 11. Walayar sub basin shows the coarse texture ratio 3.8 and the lower infiltration of 1.8. Generally the Parambikulam Aliyar has fine drainage texture with high infiltration number which reflects that most part of the Parambikulam Aliyar basin is runoff zone.

2.4.2.4 Basin Shape

The shape of the basin mainly governs the rate at which the water is supplied to the main channel. The main indices used to analyse basin shape and relief are the elongation and relief ratios. The elongation ratio is calculated by dividing the diameter of a circle of the same area as drainage basin by maximum length of the basin, measured from its outlet to its boundary. Three parameters viz. Elongation Ratio (Re), Circulatory Ratio (Rc) and

Form Factor (Rf) are used for characterizing drainage basin shape, which is an important parameter from hydrological point of view.

2.4.2.5 Elongation Ratio (Re)

Elongation ratio (Re) is the ratio of the diameter of a circle having the same area as of basin to the maximum basin length (Schumm, 1956). It is also a significant index of basin shape. The value of Re varies from ‘0’ (maximum elongated) to near ‘1’ (maximum circularity). The Re values of near ‘1’ indicate that there are less geomorphological controls on river basin (Strahler, 1964). The mountain–plateau front humid environment river basin tends to form less elongated river basin than plateau–plain front river basin of sub-humid environment. It also helps to give the idea about hydrological character of a drainage basin. Thus higher the value of elongation ratio more will be the circular shape of the basin and vice-versa. Values near to 1.0 are typical of regions of very low relief, whereas that of 0.6 to 0.8 are usually associated with high relief and steep ground slope (Strahler, 1964). These values can be grouped as,

Elongation ratio	Shape of basin:
<0.7	Elongated
0.8-0.7	Less elongated
0.9-0.8	Oval
>0.9	Circular

The Re values of the Walaiyar, Palar and Aliyar sub basins are 0.63, 0.69, and 0.52 respectively and these values indicate the high relief with steep slope of the terrain that are elongated in shape. Sholaiyar sub basin has the ratio of 0.71 and shows less elongated in shape.

2.4.2.6 Circularity Ratio (Rc)

Circularity ratio (Rc) is defined as the ratio between the area of the basin to the area of a circle having the same perimeter (Strahler, 1964). Value of Rc varies from ‘0’ (minimum circularity) to ‘1’ (Maximum circularity). Cr values depend upon stream frequency, drainage density, climate, geological structure, slope, relief, etc. of any basin. The higher circular basin will affect by peak discharge in high rainfall season. It is an indicative value determined the geomorphological stages of development of any basin. The high, medium and low value of Rc is indicative of old, mature and young stages of geomorphological adjustment of any basin. Generally, the mountain–plain front river basin tends to form circular basin due to its young morphological adjustment, whereas plateau–plain front river basin forms elongated basin in response to mature morphological adjustment. Miller

(1953), described that the basin with the circularity ratio ranging from 0.4 to 0.5 indicates strongly elongated and highly impermeable homogenous rocks.

The Walayar, Palar and Sholaiyar sub basins having the circularity ratio values of 0.40, 0.44 and 0.41 respectively corroborate the Miller's ranges and they indicate that these sub basins are strongly elongated in shape, high discharge of runoff and also there is strong structural control on the drainage development. Higher the value represents more circularity in the shape of the basin and vice-versa. Naturally all sub basins have a tendency to become elongated to get the mature stage. The circularity ratio shows somewhat lower values for the Aliyar sub basin (0.26) with high elongation ratio (0.52), where there is a strong structural control on the drainage development. This complicated shape parameter is the result of the presence of a combination of lithological formations, leading to differential erosion and consequently to watershed displacement. It also refers to mature geomorphological adjustment and less peak flow characteristics. Therefore the structural control of drainage is probably responsible for the low values of circularity ratio.

2.4.2.7 Form Factor Ratio (Rf)

Form factor (Ff) is the ratio of the area of the basin to the square of basin length (Horton, 1932). The value of Ff is always less than 0.7854 (for a perfectly circular basin). Smaller the value of Ff, more elongated is the basin. The value '0' indicates elongated characteristics of basin and '1' indicates near-circular characteristics of basin with high peak flow. It indicates the flow characteristics of a basin. Higher the value of Ff, more circular is the basin which indicates high peak flow in shorter duration, whereas lower the value of Ff, more elongated is the basin which indicates low peak flow with longer duration. Flood flows of elongated basin can be easily managed than that of circular basin. Mountain–plain front river basin tends to form circular basin than plateau–plain front river basin.

The Ff values of Palar and Sholaiyar sub basins are 0.38 and 0.39, which indicates the basins are near-circular. It also indicates higher peak flow in limited times whereas the Ff values of Walayar and Aliyar sub basins are 0.31 and 0.22. These indicate their elongated shapes with less peak flow. The elongated basins with low form factors indicate that all the sub basins will have a flatter peak of flow for longer duration. Flood flows of such elongated basins are easier to manage than that of circular basin.

2.4.2.8 Infiltration Number (If)

The infiltration Number is defined as the product of Drainage Density (Dd) and drainage Frequency (Fs). The Sholaiyar sub basin shows very high infiltration number of 26.2. The Palar and Aliyar sub basins also show higher infiltration numbers of 11 and 11.5. The higher the infiltration number the lower will be the infiltration and consequently, higher will be the run off. This leads to the development of higher drainage density. It gives an idea about the infiltration characteristics of the basin which reveals impermeable lithology and higher relief. The Walayar sub basin shows lower infiltration number 1.82 and hence the sub basin has higher infiltration as most parts of the sub basins are underlined by soft rock.

2.4.2.9 Length of overland flow (Lg)

The term length of overland is used to describe the length of water over the ground before it becomes concentrated in definite stream channels. Horton (1945) expressed it as equal to half of the reciprocal of drainage density. It is one of the most important independent variables, which greatly affect the quantity of water required to exceed a certain threshold of erosion. This factor is related inversely to the average slope of the channel and is quiet synonymous with the length of sheet flow to a large degree. Smaller the value of overland flow the quicker surface runoff will enter the streams represents well developed drainage network with higher slope. In a relatively homogeneous area, therefore less rainfall is required to contribute a significant volume of surface runoff to stream discharge when the value of overland flow is smaller than when it is large**.**

The length of overland flow bears an effective relationship with the drainage density and constant channel maintenance. More the value represents long time of flow in the basin The Lg value of Sholaiyar sub basin is 0.14, which represents short time flow with quicker runoff in the basin. Palar and Aliyar sub basins show moderate Lg values of 0.19 and 0.20. These sub basins have also moderate run off zones. The Walayar sub basin shows the higher Lg values of 0.35 which shows long time of flow in the sub basin.

2.4.2.10 Constant of Channel Maintenance (C)

Constant of channel maintenance (C) is defined as the reciprocal of drainage density as property to define overland flow (Schumm, 1956). Indirectly, it can be expressed as a required minimum area for the maintenance and development of a channel (Dutta and Roy, 2012). Constant of channel maintenance is expressed in km2/km. The lower value of Constant of channel maintenance indicates higher flood potentiality and young geomorphological adjustment. Mountain environment generally has low Constant of channel maintenance values due to lower infiltration of bare soil and high overland flow.

On the other hand, plateau–plain environment tends to high Constant of channel maintenance value due to low drainage density and high infiltration in comparison to plateau–plain environment.

Sholaiyar sub basin has lowest constant of channel maintenance 0.29 km2/km with highest value of drainage density (3.48). It means that on an average of 0.29 sq.ft surface is needed in the sub basin for creation of one linear foot of the stream channel. It indicates less channel availability to drain out the excess amount of water and low infiltration capacity of soil. Palar and Aliyar sub basins show constant of channel maintenance values of 0.38 and 0.40 having high drainage density value of 2.62 and 2.5. All these ultimately indicate high flood potentiality. Higher value of constant channel maintenance (0.7) in Walayar sub basin which indicates high infiltration capacity, low drainage density and mature geomorphological adjustment.

2.4.3 Relief Aspects

Linear and areal features have been considered as the two dimensional aspect lie on a plan. The third dimension introduces the concept of relief. By measuring the vertical fall from the head of each stream segment to the point where it joins the higher order stream and dividing the total by the number of streams of that order, it is possible to obtain the average vertical fall.

2.4.3.1 Basin Relief (Bh)

Basin relief (R, H) includes absolute relief (R) and relative relief (H). The maximum relief of any basin and the maximum altitudinal difference is termed as absolute and relative relief, respectively. These are general morphometric parameters used to understand the morphological characteristics of basin. Basin relief depends upon the underlain geology, geomorphology and drainage characteristics of the region. It is the best indicator of erosional stages of any river basin. Normally, the mountain–plain front river basin has higher basin relief than plateau–plain front river basin.

Basin relief is the elevation difference of the highest and lowest point of the valley floor. Walayar sub basin relief ranges from 167 to 1639 m. The relief range of Palar sub basin is 226 to 2104 m, Aliyar sub basin relief ranges from 155 to 2504 m and the relief range of Sholaiyar sub basin is 546 to 2382 m.

2.4.3.2 Relief Ratio (Rh)

Relief ratio is defined as the ratio between the total relief of a basin i.e. elevation difference of lowest and highest points of a basin, and the longest dimension of the basin parallel to the principal drainage line (Schumn, 1956). This is a dimensionless height-length ratio and allows comparison of the relative relief of any basin regardless of difference in scale or topography. Relief ratio normally increases with decreasing drainage area and size of a given basin (Gottschalk, 1964). The relief ratios of sub basins Walayar, Palar, Aliyar and Sholaiyar are 27.63, 50.46, 45.92 and 54.51 respectively. The high values of relief ratio in Palar, Aliyar and Sholaiyar sub basins indicate the presence of highly resistant rocks granitic and gneiss. The high value indicates steep slope and high relief and vice-versa. Relief controls the rate of conversion of potential to kinetic energy of water draining through the basin.

2.4.3.3 Ruggedness Number (Rn)

Strahler (1968) describes ruggedness number is the product of maximum basin relief (H) and drainage density (Dd) and it usually combines steepness with its length. Extremely high values of ruggedness number occur when slopes of the basin are not only steeper but long, as well. The value of ruggedness number in Walayar, Palar, Aliyar and Sholaiyar sub basins is 2090.24, 4920.36, 5872.5 and 6389.28 respectively. The Sholaiyar sub basin is highly dissected as the high ruggedness number with higher drainage frequency lead more erosion and dissection. Sholaiyar sub basin, comparatively circular with low permeability with homogeneous lithology reflects the tectonic influence on the sub basin. The fine drainage texture with high relief and comparatively steep and long slopes leads to development of high drainage density though the area. Palar and Aliyar sub basins show higher ruggedness number and hence these sub basins have steep slopes, Drainage density map reflect the influence of structural disturbance on the three sub basins.

2.4.4 Inference from Drainage Morphometric Analysis

2.4.4.1 Walayar Sub Basin

The drainage density, stream frequency, relief ratio, ruggedness number are lower in Walayar sub basin. The elongated Walayar sub basin has long time of flow with high infiltration capacity and flood flows are easier to manage.

2.4.4.2 Palar Sub Basin

Palar Sub basin has steep slope and high relief with strongly elongated shape. It has high discharge of runoff and also there is strong structural control on the drainage development. The Palar has lower infiltration with higher run off. The sub basin is near-circular and has higher peak flow in limited times and hence lower infiltration rate. The high drainage density in the sub basin indicates high flood potentiality.

2.4.4.3 Aliyar Sub Basin

The drainage density in Aliyar is high and the area is highly dissected with steep slope. Aliyar sub basin is elongated in shape with less peak flow and has moderate run off zones. The drainage development is controlled by strong structures. The sub basin has low infiltration rate.

2.4.4.4 Sholaiyar Sub Basin

The stream frequency in Sholaiyar sub basin is very high as the sub basin is fully covered by structural hills. Sholaiyar sub basin is strongly elongated in shape, high discharge of runoff and also there is strong structural control on the drainage development. In Sholaiyar sub basin, more erosion including landslide will occur short time flow with high and quicker runoff. Sholaiyar sub basin indicates impermeable rock in bed surface, high slope and high water flow regimes. Thus, higher runoff with greater flow velocity results in potentiality of downstream flooding in the sub basin. Infiltration rate is very low in this sub basin.

The morphometric analysis of Parambikulam Aliyar basin basin reveals that,

1. Dendritic and parallel drainage systems prevail mostly in the Parambikulam Aliyar basin.
2. The average mean bifurcation ratio of Parambikulam Aliyar basin is 8.6 which reveal that the basin is tectonically active.
3. Generally the drainage density in the Parambikulam Aliyar basin is high due to the impermeable rock in bed surface, high slope and low water flow regimes. But in some parts of the basin, the drainage density is low due to the presence of certain geomorphologic landforms such as shallow and moderate pediments and high infiltration formation.
4. The drainage frequency in the upper part of the basin is lower and in the lower part of the basin higher. It clearly reflects that the drainage development in the area is highly dissected.
5. Generally the Parambikulam Aliyar basin has fine drainage texture with low infiltration rate which reflect that most part of the Parambikulam Aliyar basin is runoff zone. .
6. The Parambikulam Aliyar basin is elongated in shape. The elongated basins with low form factors indicate a flatter peak of flow for longer duration hence flood flows are easier to manage in the basin
7. The high values of relief ratio in Parambikulam Aliyar basin indicate the presence of highly resistant rocks. The high ruggedness number value indicates steep and

long slope and high relief experienced in the basin. Relief controls the rate of flow of water draining through the basin.

2.5 Geology

The study of Geology of the Parambikulam-Aliyar Basin is based on the District Resource maps published by the Geological Survey of India and the inferences derived from the lithology obtained through investigation borehole and water level observation well of SG&SWRDC. A Geological map (**Plate. PA-18)** was prepared, showing the surface geology of the basin. And also vertical cross section of selected borehole lithology is prepared for better understanding of various litho units of the basin. An attempt has been made to understand the hydro Geology of the basin.

The general geological sequence of the study area is given here under:

<table>
<tr><th>Era</th><th>Group</th><th>Age</th><th>Lithology</th></tr>
<tr><td rowspan="2">Cainozoic</td><td rowspan="2">-</td><td rowspan="2">Pleistocene - Recent</td><td>Fluvial sediments (Black cotton soil)</td></tr>
<tr><td>Laterite</td></tr>
<tr><td rowspan="3">Late Archaean - Proterozoic</td><td rowspan="3">Migmatite complex</td><td rowspan="3">2200-2550 Ma</td><td>Granite</td></tr>
<tr><td>Pink migmatite</td></tr>
<tr><td>Hornblende gneiss</td></tr>
<tr><td rowspan="5">Archaean</td><td rowspan="2">Charnockite Group</td><td rowspan="2">2600 Ma</td><td>Pyroxene granulite</td></tr>
<tr><td>Charnockite</td></tr>
<tr><td rowspan="3">Khondalite Group</td><td rowspan="3">2700 Ma</td><td>Calc granulite</td></tr>
<tr><td>Crystalline Limestone</td></tr>
<tr><td>Garnet sillimanite graphite gneiss</td></tr>
</table>

Parambikulam-Aliyar Basin is predominantly composed of weathered and fractured hard crystalline rock formations of Archean eon and sparsely by soft rock and unconsolidated sediment. Geologically, Charnockite group of rocks and Khondolite group of rocks makes the prominent lithology. The Khondolite group consists of migmatitic gneiss such as, garnetiferous sillimanite gneiss, calc granulite, crystalline limestone etc.

Charnockite group of rocks comprises of charnockite, pyroxene granulite, granite etc. Hornblende gneiss and pink migmatite represents migmatite complex in the study area. Major rock units are metamorphic in nature.

Gneiss is the most common rock type in the basin in which hornblende biotite gneiss is the predominant rock type which covers most of the basin area. Garnetiferous sillimanite gneiss is occupied in north northwest part of basin near to calc-granulite limestone area. Granites intruded into the older gneisses and charnockites, and have undergone metamorphism. They occupy mostly as small mounds in the southern reaches of the basin near Anamalai reserve forest area and linear domes in the eastern and western parts of the basin. Pink migmatite with granitic intrusion is found in north central area of the basin majorly in and around Kinathukadavu village. Charnockite is observed all over the study area, as linear stretches traversing the country rock in all directions. Pyroxene granulite is found as few linear intrusions in the eastern part of basin mainly in Kakkadavu village and Vaguthampalayam village. Notable deposits of calc-granulite crystalline limestone are found in Madukkarai village. Black cotton soil with gypsum is found in small patches along the eastern side boundary of the basin which is fluvial in origin. Laterite occupy in very small areal extend towards south of the basin near granitic mounds in Anamalai reserve forest.

Out of the total area of basin, hard rock type occupies 2383.67 sq.km and soft rock/unconsolidated sediments occupies minor area of 22.71 sq.km **(Fig. 2.9).** The minimum area of one particular litho unit is occupied by Pyroxene granulite with an area of 2.98 sq.km and maximum area of 2113.04 sq.km by Gneiss (**Fig. 2.10).** The percentage area in the basin comprised by hard rock is 99.06% and sedimentary formation is 0.94%.

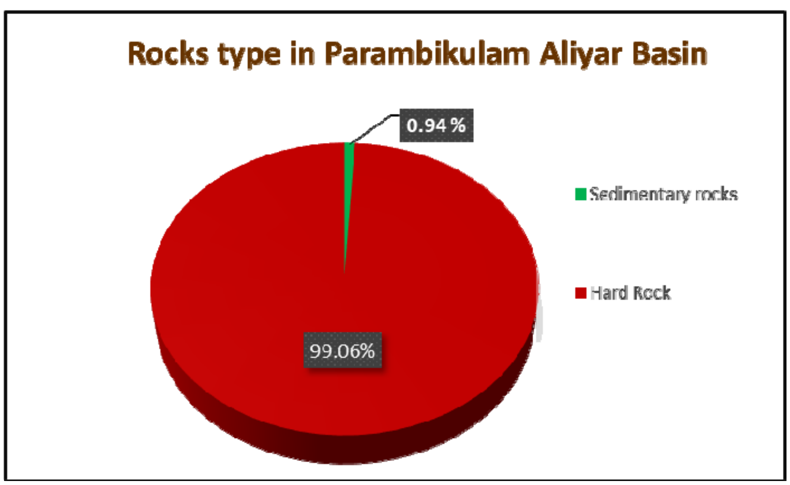


Fig.2.9 % of area occupy by hard rock and sedimentary rock

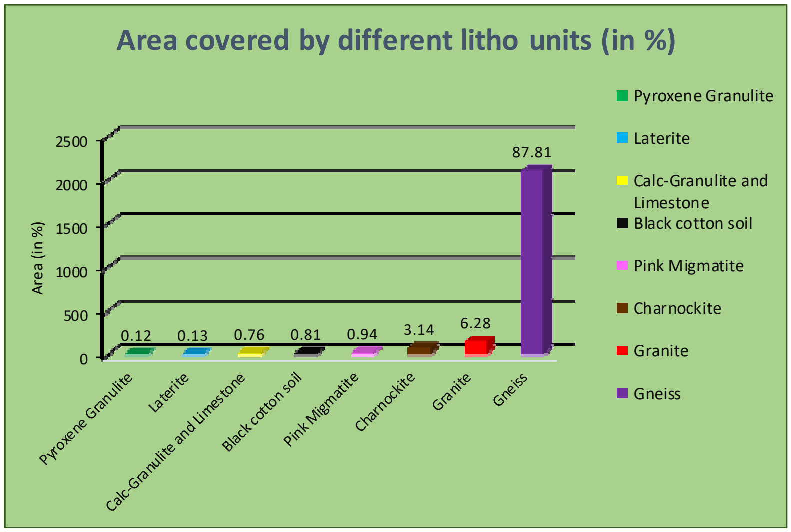
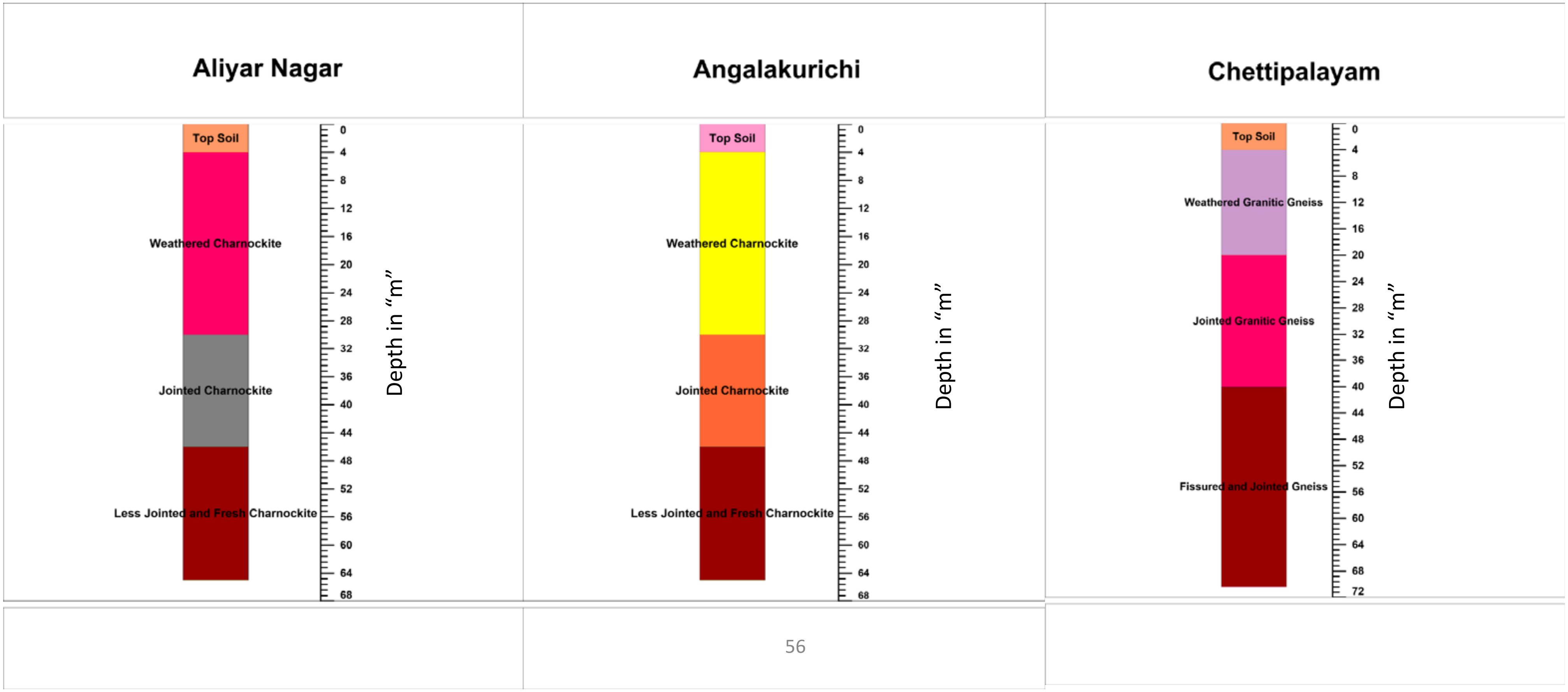


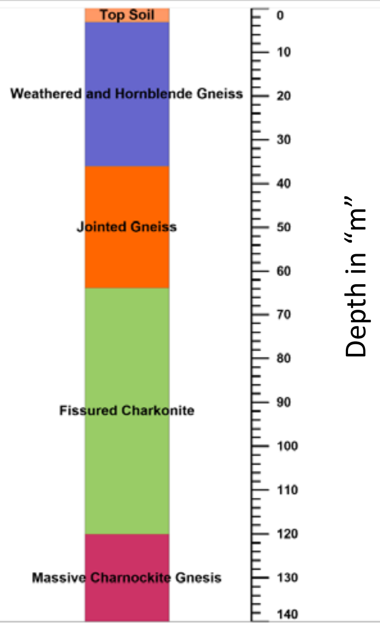
Fig. 2.10 % of area occupy by different litho units

Selected borehole vertical cross sections have been prepared to know the lithology of basin **(Fig. 2.11).**

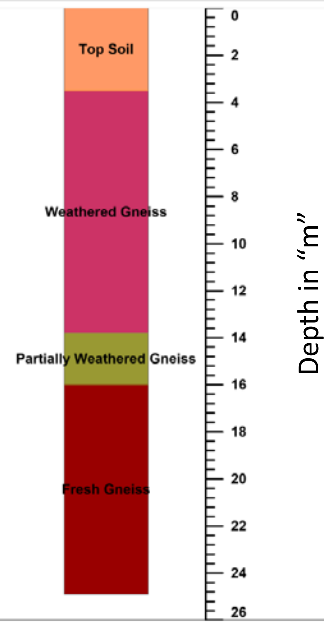
Figure. 2 .11 Vertical Cross section of selected Boreholes



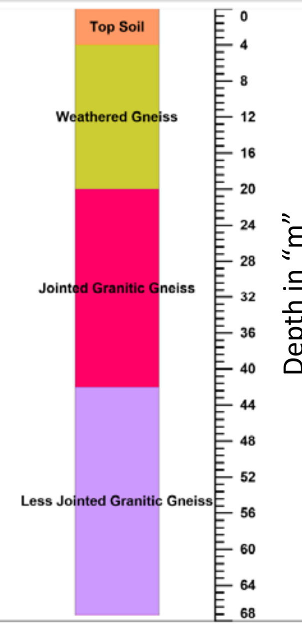
Bogampatti



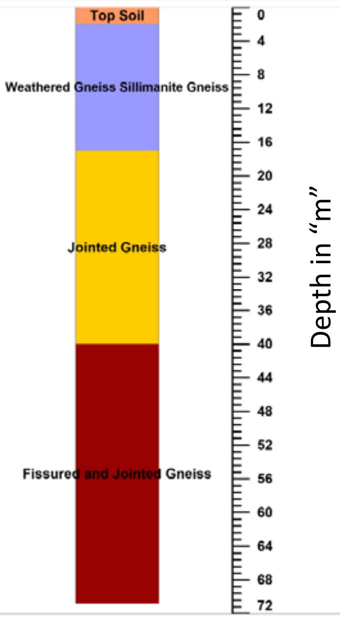
Ganapathipalayam



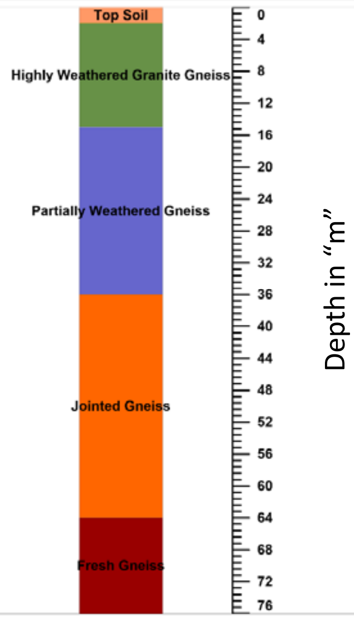
K.Mettupalayam



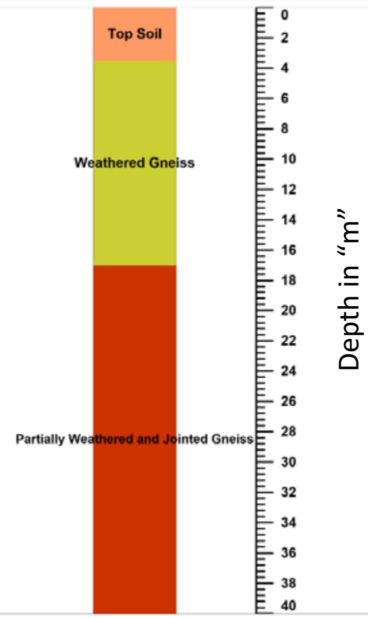
Kolarpatti



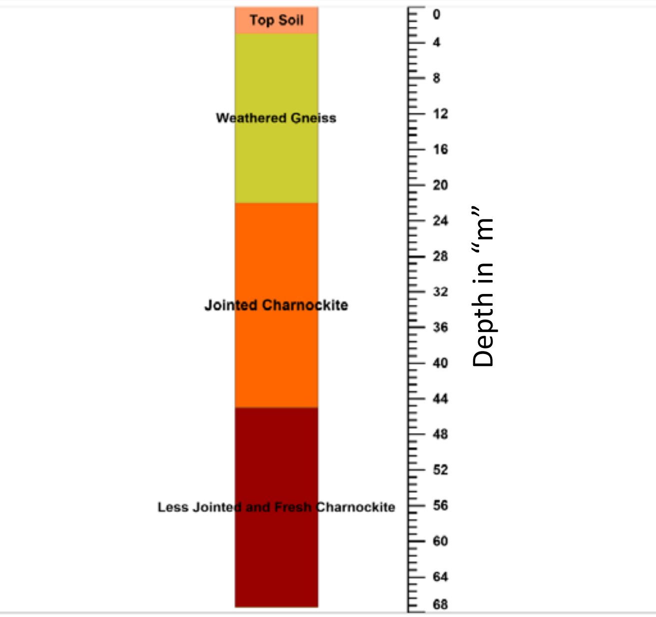
Kinathukadavu



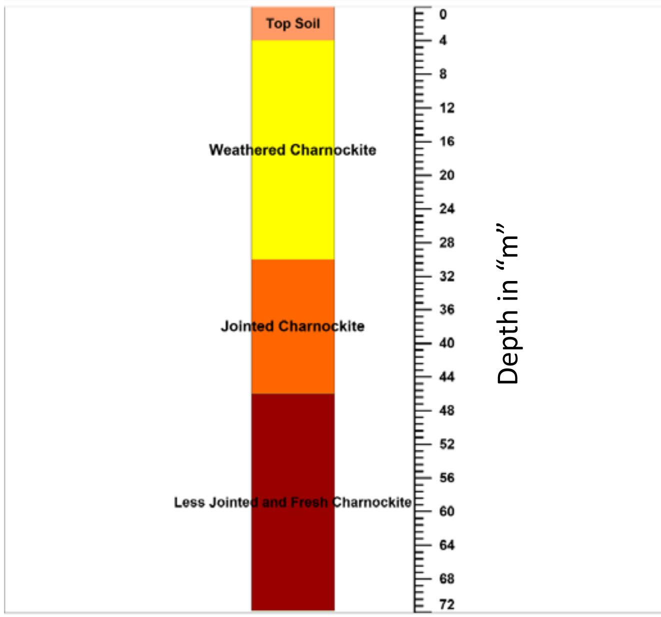
Natchipalayam



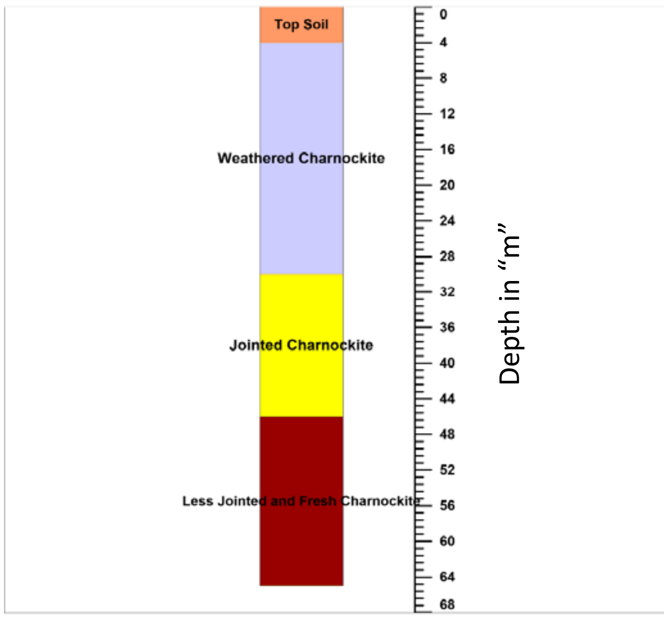
Samathur

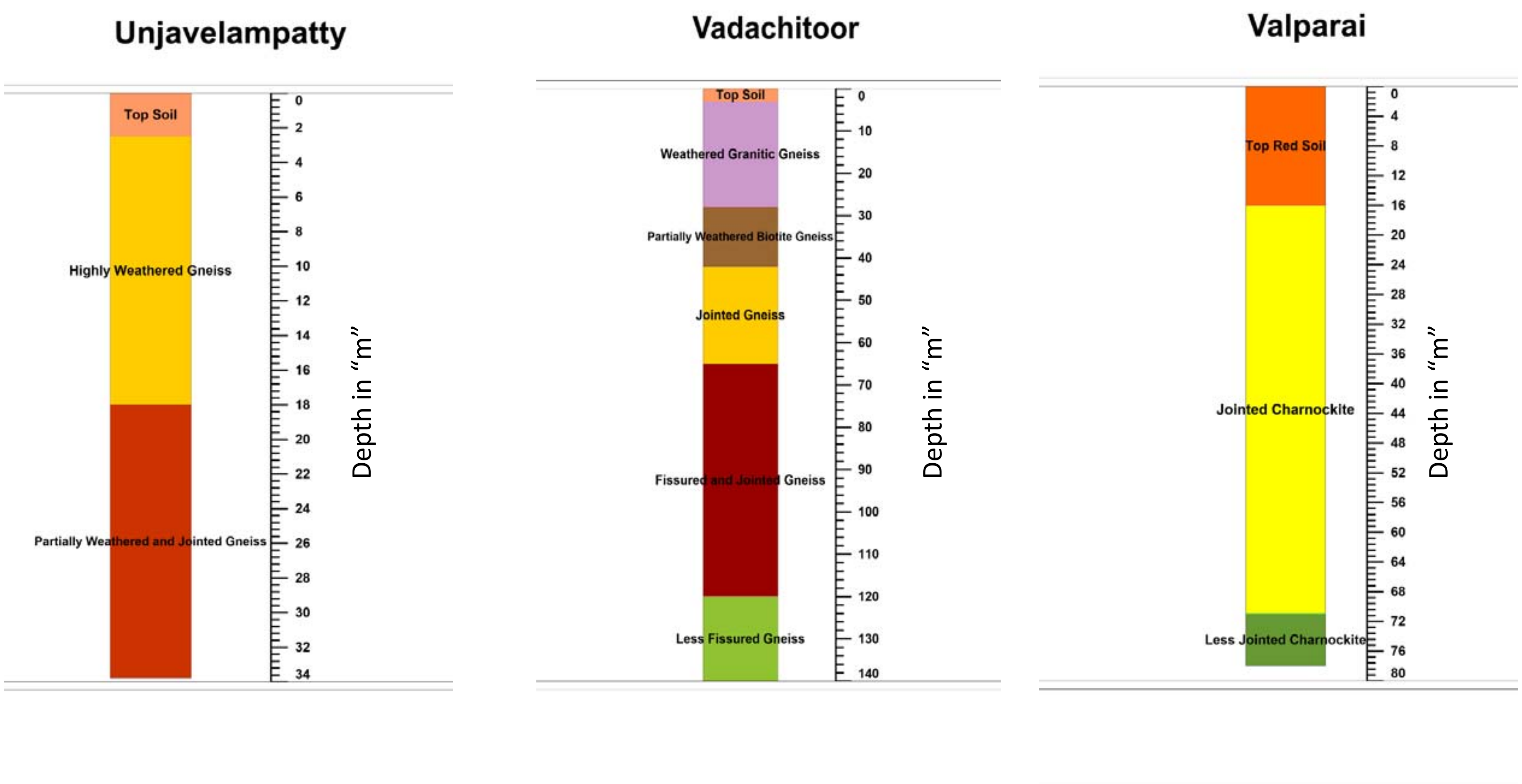


Sethumadai



Thondamuthur




Unjavelampatty
Top Soil
Highly Weathered Gneiss
Partially Weathered and Jointed Gneiss
0
2
4
6
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12
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18
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22
24
26
28
30
32
34
Depth in "m"
Vadachitoor
Top Soil
Weathered Granitic Gneiss
Partially Weathered Biotite Gneiss
Jointed Gneiss
Fissured and Jointed Gneiss
Less Fissured Gneiss
0
10
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40
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60
70
80
90
100
110
120
130
140
Depth in "m"
Valparai
Top Red Soil
Jointed Charnockite
Less Jointed Charnockite
0
4
8
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48
52
56
60
64
68
72
76
80
Depth in "m"

2.5.1 Hydrogeology

Hydrogeology is the area of geology that deals with the distribution and movement of groundwater in the rocks of the Earth's crust.

The important aquifer systems in the basin are constituted by weathered and fractured crystalline rocks. The hard crystalline rocks are comprised of weathered and fractured Gneisses, Granites, Charnockites and other associated rocks. The major geological formation which is forming an aquifer in Parambikulam-Aliyar Basin is metamorphic rocks, namely Gneiss, Calc granulite limestone, Pink migmatite and Pyroxene granulite, next come the igneous rocks like Charnockite and Granite. Generally, the aquifer is heterogeneous in nature. The lithology of geological formations generally varies significantly in both horizontal and vertical planes. Such a formation is called heterogeneous. In these hard rock formations, occurrence of ground water depends upon zone of weathering, fractures, joints etc. Due to heterogeneity nature, these fractures generally do not occur uniformly in depth. Ground water occurs under phreatic conditions in the weathered mantle of gneissic rocks and under semi-confined conditions in the fractured zones. The shallow weathered and fractured zone makes the potential aquifers that are better developed in hornblende biotite gneisses than in Charnockites and granites. Charnockite is massive rock and development of fractures is less in it compared to other rock types. In the study area, the yield of wells tapping in the gneissic areas is comparatively higher than in other rock type area.

Boreholes drilled in the basin were considered for hydro geological studies (Location of boreholes - **Plate PA-19**). In hard crystalline formation of the study area, the depths of boreholes ranging from 25 m to 140 m below ground level (bgl).

The range of aquifer parameters in hard crystalline rock region of the study area is as follows. The general well yield in crystalline formation is 9 to 135 litre/minute (lpm). and are able to sustain pumping for 2 to 4 hours per day in summer and 4 to 6 hours in winter. The general specific yield is 0.015%.The permeability is 0.25-26.75 m/day. The Transmissivity value in the region is 1.49 – 164.18 m^2/day (CGWB, Technical report-2008).

The highly weathered (30-40 m) and highly fractured (70-140 m) zones are located in and around Vadachitoor, Periyakuyilai and Bogampatti in the north western part of Walayar Sub basin (**Plate PA - 19).** Yield of the aquifer is 85 lpm.

Medium weathered (20-30 m) and highly fractured depths (70-140 m) are located around Ganeshapuram, Sundarapuram, Malumichampatti, Teganiand Thottipalayam. Yield of the aquifer is 50-85 lpm.

Highly weathered (30-40 m) and medium fractured (40-70 m) depths are located in Mamballi and Meenakshipuram. Yield of the aquifer is 85-130 lpm.

Medium weathered (20-30 m) and medium fractured (40-70 m) depths covers majority of the basin area in locations like Sethumadai, Samathur, Ganapathipalayam, Angalakurichi and Valparai. Yield of the aquifer is 9-135 lpm.

Medium weathered (20-30 m) and low fractured (30-40 m) depths are located in Upper Aliyar,Vellimudipatti, Thanakalpatti, Uramakundru, Kadambarai.Yield of the aquifer is 9-50 lpm.

Low weathered (10-20 m) and medium fractured (40-70 m) depths are located around Nallampalli, Alagapuri, Andiyur, Poosaripatti and Vanjipalayam. Yield of the aquifer is 50-135 lpm.

Low weathered (10-20 m) and low fractured (30-40 m) depths are located in Unjapalayam, Dhalavaipalayam, Kolarpatti, Chandrapuram, and Vellakavundanpudur. Yield of the aquifer is 50-100 litre/minute (lpm).

The general water level fluctuation is studied for the major formations of the basin for a period of 9 years. As shown in figure 2.12, in the gneissic terrain, water level fluctuation is high. This is attributed to the high grade of weathering, good percolation, porosity and occurrence of fractures in the formation. On the other hand, the bore well representing Charnockite shows less variation in water level fluctuation due to the low weathering thickness and less fractured and jointed zones.

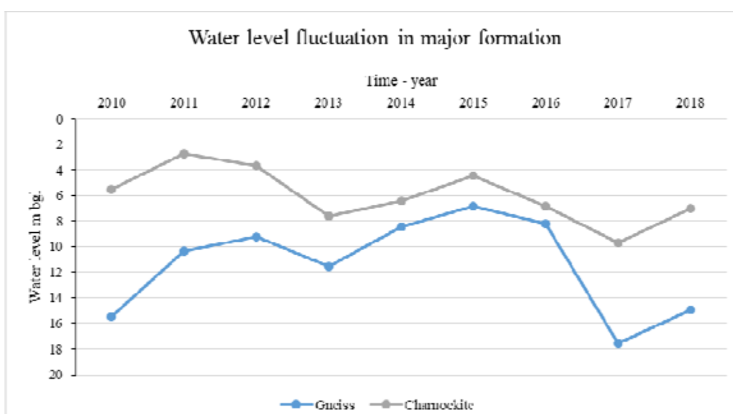


Fig. 2.12 Water Level fluctuation

Water observed in pre monsoon of 2018 shows the water level ranges between 6.9 to 21 m bgl **(Plate PA - 19).** The water level in shallow depth i. e zone I (6.9 to 10 m bgl) is observed in the north and middle portion of the basin where the rock types viz., Granite, Gneiss, Calc Granulite and limestone and charnockite are encountered. The Electrical Conductivity of groundwater in these area falls between 250 to 1000µS/cm.

The water level in Zone II and III (10 to 16 m bgl) is found in most part of Walayar sub basin and southern portion of the basin. Gneiss, Pink migmatite and granite are formations that form the aquifer here. The Electrical Conductivity of groundwater in these area falls between 250 to 1331 µS/cm.

The deeper water level zones, IV and V (16 to 19 m bgl) are seen in the south most part of the basin where the rock types viz., Granite and Gneiss are encountered. The Electrical Conductivity of groundwater in these area falls between 70 to 500 µS/cm.

Regarding the general water quality, ground water of the basin is colorless, odourless and alkaline in nature. The observed Electrical Conductivity values indicate that the quality of groundwater is good throughout the basin.

2.6. Geomorphology

Geomorphology is the study of landforms, their processes, and form at the surface of the Earth. In general geomorphology is the scientific study of the origin and evolution of topographic features. Geomorphological map help to identify the various geomorphic units in the earth surface. Depending on the morphology, a landform may act as a runoff, recharge or discharge zone.

I Landforms of Structural Origin

II Landforms of Denudation Origin

III Landforms of Fluvial Origin

The geomorphological study was carried out in the Parambikulam Aliyar basin by interpreting the satellite image LISS III with date of pass on 1 April 2019 by its characteristics such as tone, texture, shape, pattern and associated features etc. Geomorphologically, being a stable land mass, Tamil Nadu is characterized by the Western Ghats made up of Archaean Complex, comprising different types of metamorphosed gneisses and Charnockites in the west, with a central plain, Eastern Ghats and Coastal plain. The following three major landforms were identified in the Parambikulam Aliyar Basin, based on its genesis **(Plate PA-20).**

2.6.1 Landforms of Structural origin

The landforms of Structural origin include structural hills and other highly dissected hills. The structural hills are hills / mountain which exhibit geological structures such as folding, faulting, foliations trends etc. It is comprised of composite ridges and valleys traversed by above said structural features. Hydro geologically these are runoff zones with low infiltration rate (NRSC, ISRO & IRS, 2010). The relevence to groundwater prospects is moderate along its valleys ,subject to weathering.Structural hills are found in the southern part around Anaimalai Reserve forest hill range and in north western region of the basin near Boluvampatti. Maximum area of Sholaiyar sub basin is formed by Structural hill comprising of foliated ridges and valleys. In between the ridges steep valleys are developed to drain the numerous streams, which is covered by thick forests. Ground water potential of this landform is poor.

2.6.2 Landforms of Denudation origin

Denudational landforms covers majority of the basin area in the central and northern parts of the basin except the southern part which is occupied by structural landforms. The various geomorphic units in denudational landforms are pediment deep, pediment moderate, pediment shallow, inselberg and deflection slope. The denudation process is active in these landforms which lead to a reduction in elevation and in relief of landforms. Inselbergs are isolated steep conical hills that are surrounded by vast plain land. Inselbergs is located in isolated area in the north of Vettaikaranpudur, Odayakulam and Arivozhi Nagar and west of Dharamaraja colony . Generally these are landforms with varying hard rock lithology.Hydro geologically these are runoff zones with no infiltration chances .The groundwater prospects in inselberg is poor.

Pediment is gently sloping, smooth surface of erosional bed rock between hill and plain with thin layer of rock debris.The lithology is various hardrock formations.It forms around outcrops with or without soil cover. It occurs at the base of hill or as a plain having no associated hills.

Shallow Pediment is an intermediate zone between pediments and deep pediments. It is a flat and smooth surface, with shallow overburden. Weathered thickness of this landform is comparatively less. Moderate infiltration and moderate recharge rate are hydrogeological characteristics which is influenced by run off and rainfall. Ground water potential of this landform is moderate to poor. Shallow pediment covers most of the central part of the basin.

Moderate Pediment is shallow than deep pediment area and have high relief than shallow pediment with moderately thick over burden. Weathered thickness of this landform is appreciable. It will have good drainage network. Among denudational landforms in the basin, moderate pediment occupies major area. Likewise shallow pediment zone moderate infiltration and moderate recharge rate are hydrogeological characteristics. Ground water potential of this landform is moderate.

Deep Pediment have high relief than moderate pediment zone. It will have deep weathering with thick over burden and shallow soil cover and fracturing. Infiltration and recharge is moderate to good. Storage is complemented by secondary fractures. Ground water potential of this landform is good.

Shallow pediment and Moderate pediment landforms covers majority of the basin area in the central and northern parts of the basin except the southern part which is occupied by structural hills. These are found in and around Pollachi, Makkinampatti, Kodingiyam and Thalakkarai in the central part of the basin and Mettupalyam, Malumichampatty, Kinathukadavu and Panappatti etc in the northern part of the basin etc. Deep pediment is found near the western boundary of the basin in and around Aliyar and Meenakshipuram.

Deflection slope is found as a linear belt at the foot hills of the vast structural hills in the southern part of the basin. Steep escarpments are found along these foot hills. Deflection slope is found in the Palar and Aliyar sub basin.

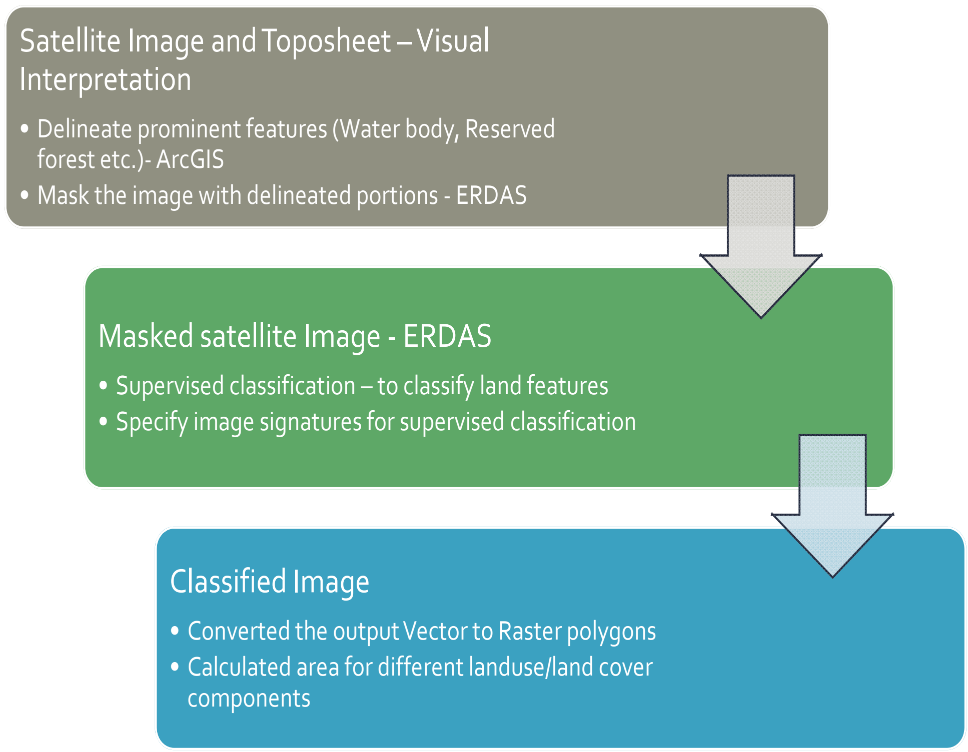
2.6.3 Landforms of Fluvial origin

Valley fills forms in the low lying valleys in the vicinity of hills. Valley fill is found towards south of Pollachi .It is highly permeable zone with good infiltration condition. Ground water potential of this zone is good.

2.7 Land use

The study of Land use/land cover and its changes over a period is essential for proper planning and utilization of natural resources and their management. Comparison of land use and land cover patterns of the same area in two different periods helps in understanding the variation in utilization and degradation of lands, deforestation in many areas. Remote Sensing and Geographical Information Systems (GIS) are powerful tools to derive accurate and timely information on the spatial distribution of land use/land cover changes over large areas. Processing and interpreting the satellite imageries of the study area is one of the best and ideal Remote Sensing ways to carry out land use study with less time and cost. This report on land use study is based on the interpretation of satellite imagery and serves as an indicator on basin's land use scenario.

For Parambikulam Aliyar Basin land use study, satellite imageries of LISS III acquired on January 1999 and of December 2018 have been interpreted. Land use maps were prepared and shown in **Plate PA-21 and Plate PA-22** respectively for the two periods. Visual interpretation and software aided digital interpretation using “unsupervised classification techniques", have been applied to derive the land use information of the basin. In order to prepare a complete land use / land cover mapping, Image processing coupled with GIS tools have been employed. The steps involved in the image interpretation for land use classification are shown as below:



Different land use categories with their extent of area, derived from satellite data by adopting level III classification for Parambikulam Aliyar Basin have been tabulated and shown in **Table 2.6 and 2.7** for the respective years. The land use pattern of the basin is discussed below.

2.7.1. Land use/ Land cover in 1999

In the Parambikulam Aliyar basin, the settlement area covers 0.95 %. Apart from dwelling area which is 19.92 sq. km, the factories and quarry land covers 3.05 sq. km of the Parambikulam Aliyar basin. Important urban settlements in this area are part of Coimbatore, Pollachi, Kinathukdavu and Metupalayam. Quarry land occupies 2.39 sq.km, which is 0.1 % of the total area. Most of the quarrying activities are witnessed in the northern portion of the study area where the Gneissic rocks are exploited for various purposes. Some of the locations are, east of Ramachandrapuram, east of Pudur and north of Poravipalayam and a quarry is located in the Boluvampatti Reserved forest.

The extent of agricultural land is 1512.69 sq.km, which is 63 % of the study area **(Table 2.6).** Fallow land covers much of the agricultural land followed by groves. Coconuts are predominantly raised in the area. Tea plantation in the hilly portion of Anaimalai consumes 5.8% of the total cultivated area of the basin.

Table 2.6 Land use pattern for the year 1999

Sl. No.	Land use Category			Area in 1999 sq.km	Percentage Area in 1999
	I Level	II Level	III Level		
1	Built up Land	Settlement and others	Dwelling	19.92	0.83
			Factory	0.66	0.03
			Quarry	2.39	0.10
2	Agriculture	Wet Crop / Irrigated Land / harvested area	Paddy, harvested Land	15.10	0.63
		Dry crop/Rainfed land	Groundnut, Grams, Millets	5.28	0.22
		Plantation	Tea	88.17	3.66
		Groves	Coconut	602.04	25.02
		Fallow	Current fallow	802.10	33.33
3	Barren/Waste Land	Reserved Forest	Reserved Forest	707.70	29.41
		Barren land	Barren land/ Rocky Outcrop	2.20	0.09
		Bushes	Shrubs	100.50	4.18
			Scrub	24.65	1.02
4	Water body	Water body	Tank	3.08	0.13
			Reservoir	17.59	0.73
			River	15.00	0.62
Total Area				2406.38	100.00

Most of the area is adapted for cultivation hence the barren land spread is only 2.2 sq. km. The reserved forests viz. Boluvampatti, Shulakkarai in North West and Anaimalai, Thunnakadavu and Poonachi in South spread over 707.7 sq. km and this is 29.41 % of the study area. Scrubs and shrubs are extended over 125.15 sq. km, distributed in the foot hills of Boluvampatti and in the Anaimalai.

Water bodies include rivers, 9 reservoirs (excluding Thunakadavu, Peruvaripallam and Kerala part of Walayar and Parambikulam) and tanks (5 WRD and 66 Panchayat Union) and they occupy 35.67 sq.km, which is 1.48% of the total study area.

2.7.2 Land use/ Land cover in 2018

Table 2.7 Land use pattern for the year 2018

Sl. No.	Land use Category			Area in 2018 sq.km	Percentage Area in 2018
	I Level	II Level	III Level		
1	Built up Land	Settlement and others	Dwelling	51.90	2.16
			Factory	1.50	0.06
			Quarry	9.55	0.40
2	Agriculture	Wet Crop / Irrigated Land / harvested area	Paddy and harvested Land	16.00	0.66
		Dry crop/Rainfed land	Groundnut, Grams, Millets	66.40	2.76
		Plantation	Tea	89.10	3.70
		Groves	Coconut	993.46	41.28
		Fallow	Current fallow	331.59	13.78
3	Barren/Waste Land	Reserved Forest / Hill	Reserved Forest / Hill	707.70	29.41
		Barren land	Barren land/ Rocky Outcrop	1.65	0.07
		Bushes	Shrubs	81.00	3.37
			Scrub	21.00	0.87
4	Water body	Water body	Tank	2.94	0.12
			Reservoir	17.59	0.73
			River	15.00	0.62
Total Area				2406.38	100.00

In 2018, majority of the area is covered by Grove **(Plate PA – 22)**. The total area of the agricultural land is 1496.55 sq.km, which is 62.2% in the total area **(Table 2.7).** Groves and fallow land, covers much of the agricultural land, followed by Tea plantations, dry crops and wet crop. The settlement area has been spread for 62.95 sq. km (2.65%).

Whereas the habitation is 51.9 sq. km and factory and Quarry are 1.5 sq. km and 9.5.5 sq. km respectively.

The area covered by reserved forest is 707.7 sq. km and that of the barren land portion is 1.65 sq. km. The shrubs and scrubs cover 102 sq. km and the water bodies such as rivers, reservoirs and tanks is about 35.53 sq.km. Over the time, 13 number of Panchayat Union tanks covered an area of 0.14 Sq Km have been vanished and the area is occupied for grove and some are left fallow.

2.7.3 Normalized Difference Vegetation Index (NDVI)

An attempt has been made to classify the vegetation cover by calculating Normalized Difference Vegetation Index (NDVI). NDVI is a measure of the state of plant health based on how the plant reflects light at certain frequencies based on absorption and reflection of waves (Near Infra-Red –NIR and Visible Red). It is calculated by the following formula:

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

Chlorophyll, a health indicator, strongly absorbs visible light, and the cellular structure of the leaves strongly reflect near-infrared light. When the plant becomes dehydrated, sick, afflicted with disease, etc., the spongy layer deteriorates, and the plant absorbs more of the near-infrared light, rather than reflecting it. Thus, observing how NIR changes compared to red light provides an accurate indication of the presence of chlorophyll, which correlates with plant health.

Hence, a healthy, young, dense vegetation cover has high NDVI value and an old, unhealthy, sparse vegetation have low NDVI value. The NDVI values for uncultivated area (Barren, fallow, settlements) will be 0.1 or less (minus values).

In order to understand the spread of crops, groves and shrubs, NDVI for the Parambikulam Aliyar basin has been calculated **(Plate PA-23**). The LISS III image (Date of pass December 2018) was used for this purpose using image processing system.

As per the NDVI classification, the range of indices falls in combination of wet crops dry crops, groves, shrubs, tea etc. The groves in the basin are in various levels viz. sparse, dense, healthy and unhealthy. Accordingly the area occupied by old, unhealthy grove is 192 sq. km and the respective NDVI range is 0.23 to 0.39. The densely spread and moderately healthy groves with NDVI value of 0.39 to 0.5 covers an area of 381 sq. km. Similarly, the moderately healthy groves with NDVI value 0.5 to 0.6 occupy an area of 318 sq. km with shrubs and healthy, young grove along with wet crop and tea plantation covers 376.3 sq. km whereas the NDVI value ranges between 0.6 to o.87 (maximum

NDVI for the basin). Due to the cumulative indices derived out of NDVI it was not helpful to indicate the type of crops of the area.

The above inferences are based on system based satellite analysis however it requires field corroboration.

2.7.4 Land Use/ Land cover comparison of 1999 and 2018

The comparison of changes in the settlement area for the two different periods **(Fig.2.13),** supports the increased spread of the habitation as well as factories and quarries in the Parambikulam Aliyar basin. All kind of settlements have doubled in extent. The major townships in the area have been enlarged. The quarry area have been expanded and new quarries are set up. The fallow and waste land then around Chettipalayam and west of Madukkarai are converted in to quarry now.

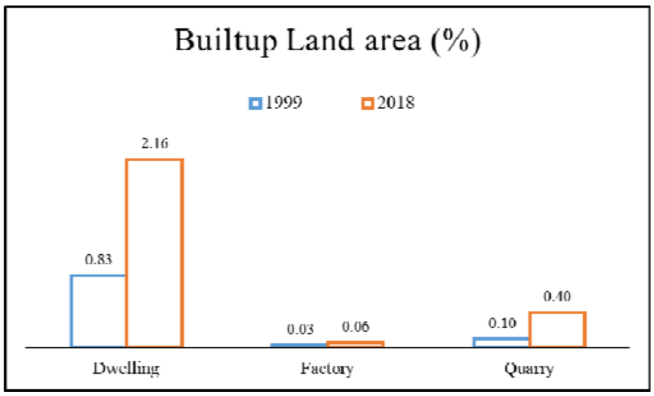


Fig. 2.13 Comparison of settlement area

The agricultural land has been reduced to 1496.4 sq. km from 1512.7 sq. km, which is only 0.7% variartion in the total of study area. The overall reduction in the cultivable area is attributed to the taken up of the agriculture land for quarrying and encroachment of the buildings. Many of the fallow land in 1999 have been adapted for quarrying in 2018 **(Fig.2.14).**

The spread of groves and dry crop / coconut sappling/nursery area have been increased and there is significant reduction in the fallow land over the course of time. Little increase in the wet crop portion and the tea estate area is not ignorable.

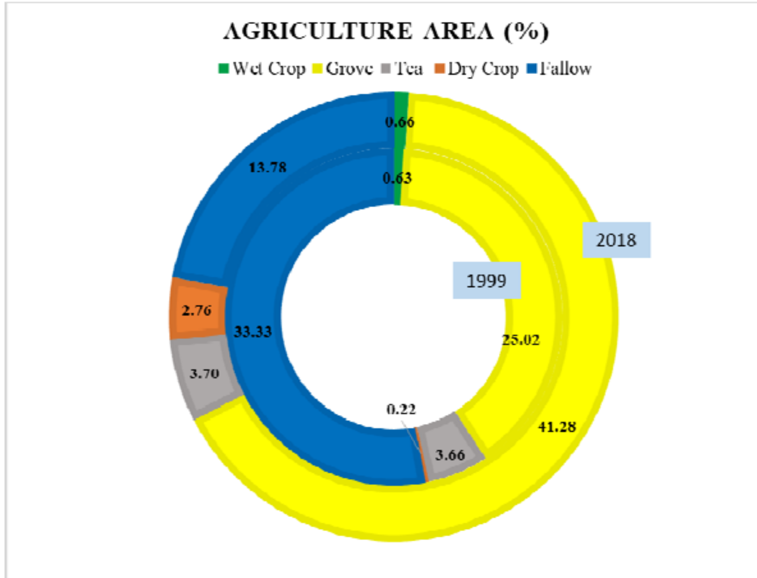


Fig. 2.14 Comparison of agriculture area

The overall variation in the wastelend is 23.7 sq. km. There is considerable reduction in the barren land, shrubs and scrubs area **(Fig. 2.15).** This is accosiated with the incease in quarries and factories in the area. The replacement of shrubs to tea plantaion in few parts of the Anaimalai RF is also a reason for the change.

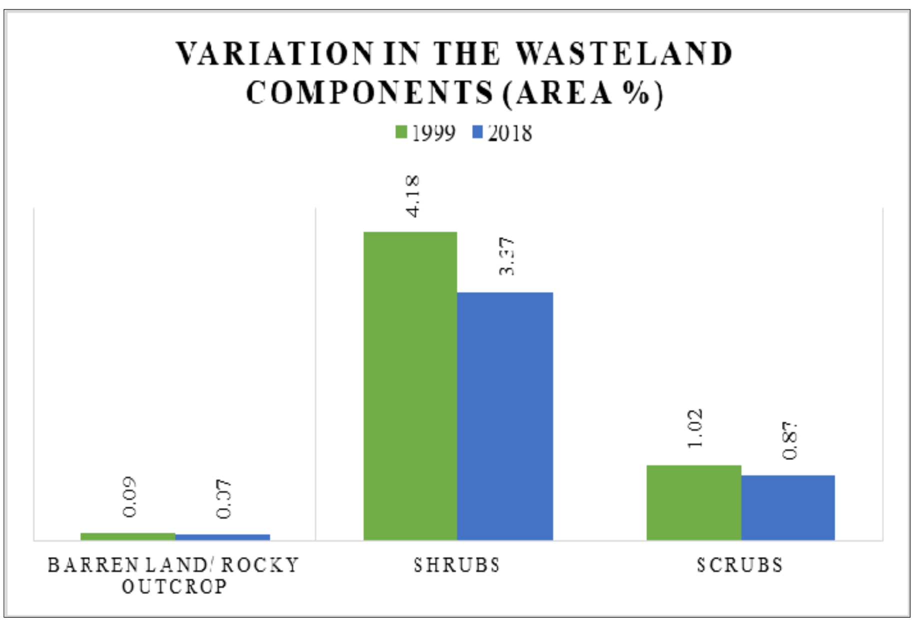


Fig. 2.15 Comparison of wasteland

Figure 2.16 shows the general alteration of land use/ land cover pattern in the study area over time. The increase in the settlement area is attributed to the changes in the agriculture land consumption, cultivation pattern and taken up of quarrying activities.

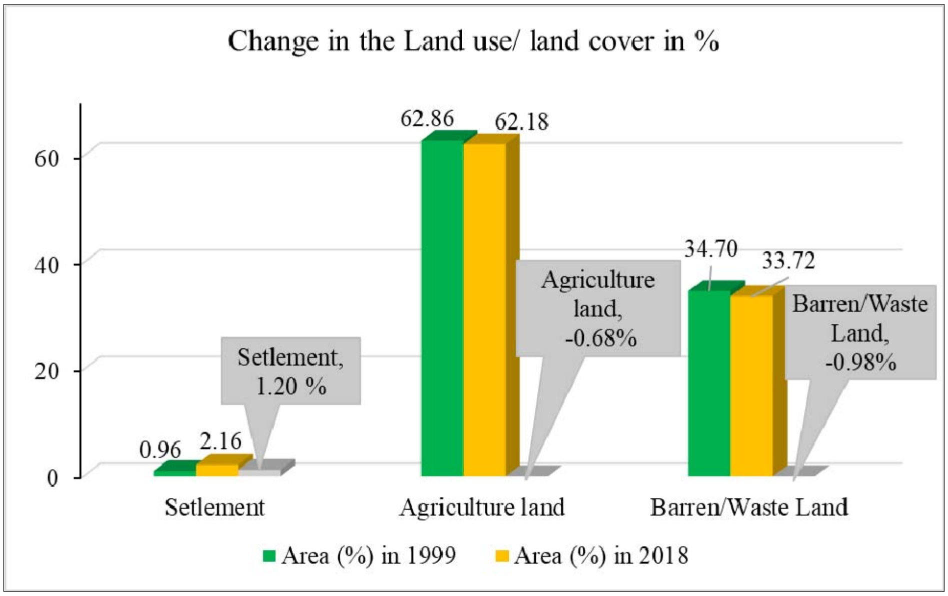


Fig. 2.16. Comparison of Land use/Land cover

2.8. Lineament

Introduction:

Numerous definitions of the term 'lineament' are given in the literature and various attributes are sometimes linked to the term, such as 'geologic lineament', 'tectonic lineament', 'photo lineament' or 'geophysical lineament' - either describing the assumed origin of the linear feature or sometimes the data source from which it has been derived. Some researchers also use the term 'fracture trace' or 'photo linear' as an alternative term.

In general, a lineament is a linear feature in a landscape which is an expression of an underlying geological structure such as a fault. Typically a lineament will appear as a fault-aligned valley, a series of fault or fold-aligned hills, a straight coastline or indeed a combination of these features.

2.8.1 Need for Lineament Mapping:

Mapping of lineaments is helpful for groundwater targeting and sustainable water resources management in hard rock hydro geological environment. Studies revealed a close relationship between lineaments and groundwater flow and yield (Mabee et al., 1994; Magowe and Carr, 1999; Fernandes and Rudolph, 2001). Generally lineaments are underlain by zones of localized weathering and increased permeability and porosity. Studies revealed relationships between groundwater productivity and the number of lineaments within specifically designated areas or lineament density rather than the lineament itself (Hardcastle, 1995). Therefore, mapping of lineaments closely related to groundwater occurrence and yield which lead to groundwater development and management.

2.8.2 Geomatics and Lineaments:

In the last two decades Remote Sensing and GIS have been widely used for preparation of different types of thematic layers and their integration for different purposes. In the event of insufficient data, maps of lineament and structural elements are important tools that may reveal points of groundwater recharge and discharge, flow and development. In particular, groundwater occurrences in hard formations are mainly controlled by the lineaments corresponding to fractures, joints and faults. Furthermore, the distribution of lineament is closely related to groundwater discharge points and their concentration. Remote sensing has proved to be a useful tool in lineament identification and mapping. This study demonstrates the application of remotely sensed data for lineament interpretation in a hard rock hydro geological environment.

2.8.3 Data used for interpretations:

Satellite Images of Indian Remote Sensing Satellite - R2A sensor LISS IV with date of pass on 26.Dec.2018 and sensor LISS III with date of pass on 1.Apr.2019. These data products are subjected to image enhancements techniques using image processing software followed by visual interpretation. Apart from this, Aerial Photographs on 1:50,000 scales were interpreted for deciphering the lineaments. Digital Elevation Model (DEM) - SRTM was also used as ancillary data for interpretation. This lineament analysis has been effectively done in GIS environment and finalised the interpretation.

2.8.4 Lineaments of Parambikulam Aliyar basin:

The lineament map of Parambikulam Aliyar basin is shown in **Plate PA – 24**. The Parambikulam Aliyar basin has numerous linear features which are probable fault or fractures. The length of the lineaments vary from 0.75 to 23 Km. Directions of lineaments are represented here under in the form of Rose Diagram.

2.8.5 Rose diagram:

Rose diagram has been prepared with the lineament data to understand the orientation of the linear features in the basin area **(Fig. 2.17).** It is a circular histogram plot which displays directional data and the frequency of each class.

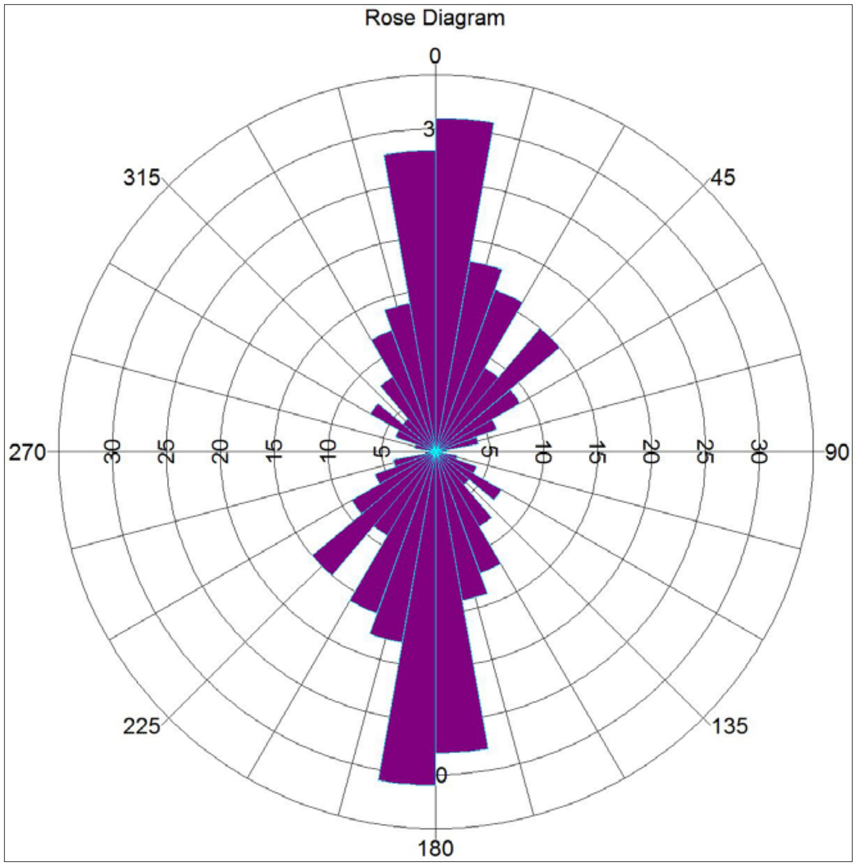


Fig. 2. 17 Rose diagram for lineaments

The rose diagram of the basin indicates that high frequency of lineaments is trending from NNE –SSW and NNW – SSE. This represents that most of the lineaments are vertical (perpendicular to the flow direction). The trend of the lineaments is in all directions. The lineaments are rarely in E-W direction.

2.8.6 Lineament Density:

A lineament density layer was generated using GIS which shows three classes such as low, medium and high lineament zones is given in **Plate PA – 25**. Regions with high lineament density indicate highly shattered ground which leads to highly weathered and fractured zone and thus have good groundwater prospects. In Sholaiyar Sub basin, most part of the upland on the structural hill (Anaimalai) has high lineament. Apart from this, the locations viz., Sethumadai, Aliyar, Navaramalai in Aliyar Sub basin, Servalkaranpalayam, Sattakal Pudur and North eastern part of Pollachi in Walayar Subbasin have high lineament density. Similarly in Palar Sub basin, the eastern part of Kodingiyam village has high lineament density zone.

Major portion of the basin has medium lineament density. Pollachi and Anaimalai towns are few of the locations that are falling in medium lineament density zone.

The locations with less lineament density are with less weathered and unconsolidated portion of rock. This in turn affects the groundwater prospects considerably. Malumichampatty, Panapatti, Periya Negamam, in Walayar Sub basin, Kodingiyam in Palar Sub basin, Meenakshipuram in Aliyar Sub basin and Periya Kallar in Sholaiyar Sub basin have less lineament bearing subsurface.

2.8.7 Lineament density vs Geophysical inferences:

Geophysical survey is helpful to confirm the presence of lineaments through Remote Sensing methodology. Intensity of weathering will be high in the lineament zones which resulting to possibility of groundwater occurrence. An attempt has been made through "overlay analysis" in GIS, using lineament density and thickness of weathered zone layers which delineated an area of probable groundwater potential / recharge zone and exhibited as **Plate PA-26**.

The combination of high and medium lineament intensity zones with weathered zone thickness of more than 30 m are considered as favourable for groundwater recharge and occurrence.

Accordingly, villages of Sattakkal Pudur, Thirumalayapalayam, Malumichampatti and Panappatti in Walayar Sub basin are falling in this zone.

2.8.8 Conclusion:

Remote Sensing technique is capable of extracting lineaments in an inaccessible tropical forest. The study has led to the delineation of areas of groundwater prospects which can be promising for sustainable supply. Further geophysical surveys can be concentrated in those areas. It is therefore suggested that the high lineament intersection and density should be combined with detailed geo-electrical surveys for quantitative evaluation of the groundwater resources of the study area. Properly sited wells along lineaments and intersection zones in drought-stricken areas could be helpful in meeting the ever rising demand for water.

2.9 Geophysical Inferences

Electrical Resistivity methods are widely used to delineate the subsurface formations including aquifer. This method involves measurement of resistances of different layers of subsurface by sending current into earth through metal electrodes using various methods of electrode configurations. This measurement of electrical resistivity of different layers of sub surface is called Vertical Electrical Sounding (VES). The results of Vertical Electrical Soundings (VES) conducted in this basin area are analysed and the resistance of the underground formation is calculated in ohms and used in order to have better interpolation. The VES together with borehole lithology forms the data base in determination of depth, thickness and spatial distribution of Top Soil, Weathered rock, Fractured and Jointed rocks.

2.9.1 Methodology

The predominant lithology of Parambikulam-Aliyar Basin is weathered and fractured hard crystalline rock formations and sparsely covered soft rock and unconsolidated sediment. Geologically, Charnockite group of rocks and Khondolite group of rocks makes the prominent lithology. The Khondolite group consists of migmatitic gneiss such as, garnetiferous sillimanite gneiss, calc granulite, crystalline limestone etc. Charnockite group of rocks comprises of charnockite, pyroxene granulite, granite etc. Hornblende gneiss and pink migmatite represents migmatite complex in the study area. Major rock units are metamorphic in nature.

The top soil and unconsolidated top layers are identified and demarcated by low resistivity zones. Similarly the thickness of weathered and fractured / jointed formations is demarcated by moderate and high resistivity values respectively. The details of 63 numbers of Vertical Electrical soundings are appropriately used with bore well lithological data and are simulated using GIS software for obtaining sub surface geometry of the basin. However, the information about subsurface lithology is restricted to depth of bore wells and depth of penetration of electrical resistivity measurements. The information thus obtained are used in the GIS environment for creation of thematic maps of top soil/unconsolidated formation, weathered rock and fractured / jointed rock layers of the basin **(Plate PA-27, Plate PA- 28 and Plate PA-29**).

The hard rock area of this basin is comprised mainly of Gneiss and Charnockite. The ohm value of 25 to 50 ohms indicates the top soil thickness. Resistance of 50 to 150 ohms indicates highly weathered formation and 150 to 200 ohms indicates partially weathered formation. Resistance of 200 to 400 ohms indicates jointed and fractured formation of gneissic formation and 400 to 500 ohms in fresh rock formation. Similarly in the Charnockite, Khondalite and other rock types ohm value of 80-100 indicate weathered formation and 100 -200 jointed and fractured formation. Resistance above 200 ohms indicates the fresh rock. As majority of Sholaiyar sub basin area is covered by structural hills and reserve forest, no resistivity data is available for subsurface interpretation.

2.9.2 Topsoil/ Unconsolidated Formation

Plate PA-27 represents spatial distribution, and depth of occurrence of topsoil in meter below ground level. Based on the depth of occurrence, these formations are classified further into four sub divisions namely **1.** Layers from 2-2.5 m below ground level, 2**.** Layers from 2.5-3 m bgl, 3**.** Layers from 3-3.5 m bgl, **4.** Layers from 3.5-4 m bgl.

In Parambikulam Aliyar basin topsoil layer is found in shallow depths. The shallow layer of 2-2.5 m bgl occurs sparsely in the western and north western part of the basin. In western part it occurs sparsely in and around Meenakshipuram and in north western part occurs around Sattakalpudur. The shallow layer of 2.5-3 m bgl covers majority of the basin. This layer is found in central region and along the western boundary of the basin. Small patch of this layer is also found in northern part of the basin. Another layer of 3-3.5 m bgl is second most observed formation and fully covers northern part of the basin and found towards the southern reaches of the basin which is covered by hills and reserve forest. Comparatively deeper layer of top soil formation which is 3.5-4 m bgl is observed in very limited area in the northern reaches of the basin near Boluvampatti reserve forest.

2.9.3 Weathered Formation

Spatial distribution and depth of occurrence of weathered formation is represented on **Plate PA-28**. This formation may form shallow aquifers on the basis of the depth of the formation. This formation is further subdivided into 4 sub layers based on depth of occurrence of layers in the basin. The shallow depth layer of weathered rock, which is 10-20 m bgl exists in limited area along the eastern boundary of the basin. Another weathered formation layer having moderate depth with 20-25 m bgl covers most of the basin in the central region and towards south of the basin. The deep weathered formation of 25-30 m bgl occurs mainly in the entire northern part of the basin. The deepest weathered depth of 30- >40 m bgl is found in very limited area in the northern and north western reaches of the basin. In general, based on the analysis of data, it is inferred that the weathered rock aquifer of this basin exists upto a depth of 15 to 40 m below ground level.

2.9.4 Fractured / Jointed Formations

Plate PA-29 represents spatial distribution and depth of occurrence of fractured/jointed formation. This zone underlies weathered formation and overlies the basement rocks forming the part of aquifer system. Based on depth of occurrence below ground level, this formation is further sub divided in to 5 sub layers. The layer of 30-40 m bgl is found very sparsely in central region of the basin. The intermediate depth zone of fractured formation of 40-50 m bgl covers majority of the basin which exists along the eastern boundary and extends from east towards the central part of the basin .Also found towards southern reaches also. The deep layer of 50-60 m bgl occurs along the western boundary of the basin. The deepest layers of fractured formation are 60-70 m bgl and 70-140 m bgl .The entire northern part of the basin is covered by this deepest layer. In general, it is inferred that the fractured rock aquifer in this basin exists to a depth of >40 - 140 m bgl.

2.9.5 Depth to Bed Rock

Generally bed rocks are observed below weathered or fractured formation in hard rock area. Hence, bottom of these formations are considered as depth of occurrence of bed rock. As per the classification of sub surface layers, it is observed that the bottom layer of fractured rock is mainly >40-70 m bgl in the study area which is considered as depth to bed rock. In limited area it is found in 70-140 m bgl. Generally the depth to bottom of aquifer (depth to bedrock) of this basin extends to deeper depths. The weathering / fracturing or both seems to be more in the gneissic region than charnockitic region, may be due to weak zones resulting from fault zone, shears zones, folds, lineaments etc.

In the regions where the depth to bedrock is shallow, dug well would be the better structure for augmenting groundwater especially in the hard rock regions. In the areas where the depth to bedrock is at moderate or at deeper depth, bore well would be the suitable structure for tapping groundwater.

2.10 Soils

Soil is one of the natural resources which has the major direct impact on agricultural production and in an agrarian state like Tamil Nadu, it is necessary to take steps for its proper conservation and management. Soil survey provides the nature of soils like texture, depth, their extent and physical and chemical characteristics which have greater impact on irrigability of the soil and there by on agricultural production.

The soil map of the Parambikulam Aliyar Basin has been shown in (**Plate PA -30 & Plate PA-31)**. The predominant soil order types found in this river basin are Inceptisols, Alfisol, Entisol and Vertisols. Due to different stage of weathering of parent material, the above soil types are met with in combination. The types of soils along with their sub groups are described below.

2.10.1 Soil Order

The soil order of the Parambikulam Aliyar Basin has been shown in **(Plate PA-30).** The major soil orders found in this basin are Inceptisols, Alfisols, Entisols and Vertisols to some minor extent.

Percentage of soil order in Parambikulam Aliyar basin

Sl.No	Order	Area(sq.km)	Percentage
1	Alfisols	259.62	10.79
2	Entisols	909.65	37.80
3	Vertisols	57.85	2.40
4	Inceptisols	419.29	17.42
5	Others	759.97	31.58
Total		**2406.38**	

Walayar Sub Basin			
Sl.No	**Order**	**Area(sq.km)**	**Percentage**
1	Inceptisols	334.82	38.29
2	Vertisols	49.44	5.65
3	Alfisols	228.96	26.19
4	Entisols	212.79	24.34
5	Others	48.36	5.53
Total		**874.37**	

Palar Sub Basin			
Sl.No	**Order**	**Area(sq.km)**	**Percentage**
1	Inceptisols	66.46	12.75
2	Vertisols	8.42	1.61
3	Alfisols	0.71	0.14
4	Entisols	246.24	47.25
5	Others	199.28	38.24
Total		**521.11**	

Aliyar Sub Basin			
Sl.No	**Order**	**Area(sq.km)**	**Percentage**
1	Inceptisols	18.01	3.19
3	Alfisols	29.95	5.30
4	Entisols	313.38	55.47
5	Others	203.62	36.04
Total		**564.96**	

Sholaiyar Sub Basin			
Sl.No	**Order**	**Area(sq.km)**	**Percentage**
1	Entisols	137.24	30.77
2	Others	308.70	69.22
Total		**445.94**	

i) Entisols

The predominant soil order of the basin is entisols. Major portion of the Aliyar sub basin and Palar sub basin belongs to this soil order and nearly one third of Walayar sub basin is composed of this soil order.

Characteristics of Entisols:

These soils show little or no evidence of development of pedogenic(diagnostic) horizons. Horizons have not been formed in these soils due to shortness of time for pedogenesis. Surface material is removed from the site as fast as or faster than most diagnostic horizons can form. They are found distributed on steep, actively eroding slopes and on flood plains which receive new deposits of alluvium. Erosion is active in these soils. Resistant nature of the parent material like quartzite, bed rock etc prolongs the period of undistinguished horizonation.

The followings are the 4 sub-groups identified under Entisols.

a) TypicUstorthents:

These are reddish brown to red, light to medium textured and mostly non calcarious soils. They are well drained and the permeability is moderate to rapid. Soil erosion is the major concern in these soils. Dry cultivation with millets, pulses and groundnut is quite common.

b) Lithic Ustorthents:

These soils resemble TypicUstorthents but their depth is within 50 cm followed by bedrock.

c) Typic Ustifluvents:

These soils are dark brown to dark grey soils of fluvial (alluvial) origin with rapid permeability and are well drained. Stratification of layers on account of fluvial deposition with irregular decrease in organic matter with depth is common.

These are confined to river systems. Intensive agriculture is being followed on these soils both irrigated and rainfed.

d) TypicUstipsamments:

These soils are very deep, freely drained and have low water holding capacity.

ii) Inceptisols

Predominantly found in the Walayar sub basin and in minor patches in Palar and Aliyar sub basin.

Characteristics of Inceptisols:

This comprises of immature soils having profile features more weakly expressed. All the pedogenic processes are active to some extent but none predominates in these soils. They are poorly drained to well drained with moderate to rapid permeability. Most of them are cultivated under irrigated or rainfed conditions.

iii) Alfisols

Alfisols is found mainly in Walayar sub basin and to some minor extent in Aliyar sub basin.

Characteristics of Alfisols:

This consists of deep to very deep matured soils with alluvial concentration of clay in the sub horizon. The surface horizon is massive and hard. Cultivation is extensive on these soils. They have moderate to high base saturation. Nine sub groups belonging to this category are described below.

a) TypicHaplustalfs:

This consists of reddish to brownish, deep to very deep, moderately drained to well drained, medium to heavy textured, moderately rapid to rapid permiability. Calcareousness in the form of calcic horizon or powdery lime is present, at moderate depth.

b) Udic Haplustalfs:

These soils are similar to TypicHaplustalfs except that they do not have calcic origin.

c) UlticHaplustalfs:

These resumbletypicHaplustalfs except that they have base saturation less than 75 % in the texterual horizon.

d) VerticHaplustalfs:

These are also like TypicHaplustalfs but are heavy textured and develop cracks.

e) TypicRhodustalfs:

These are comparatively dark red soils than TypicHalplustalfs and have secondary carbonates at moderate depth.

f) Udic Rhodustalfs:

These are like typicRhodustalfs but do not have secondary lime in the sub horizon and are non-calcareous.

g) Udic Paleustalfs:

The textural B horizon has a colour hue or Yellower in some part or has a value moist of 4 or more. They do not have secondary carbonates in the sub surface.

h) VerticNatrudalfs:

This consists of dark grayish brown, very deep, medium textured, calcareous and imperfectly drained soils. They are alkaline in nature and have sodium accumulation in the diagnestic horizon with exchangeable Sodium of 1.50 %.

i) Plinthustalfs:

Soils of this group are reddish, deep to very deep and well drained soils but have plinthite, humus, poor mixture of clay within 1.25 m of the soil surface.

iv) Vertisols

This soil order is found meagre in Walayar sub basin and in traces in Palar sub basin.

Soil Classification maps have been prepared in 1996 by National Bureau of Soil Survey and Land use Planning, Bangalore (NBSS) in co-operation with the Department of Agriculture, Tamil Nadu. The mapping unit for Parambikulam Aliyar basin is shown in **Plate PA 32** and list of mapping units falling in the Parambikulam Aliyar basin are given in **Table 2.8.**

Table 2.8 Tamil Nadu Soils- Parambikulam Aliyar River Basin

Mapping Unit	Description	Classification
13	Very deep, well drained, clayeysoils on gently sloping lands moderately eroded.	Fine, mixed,Rhodic Paleustalfs. Clayey skeletal, mixed, Rhodic Paleustalfs.
21	Shallow, Well drained; gravelly loamy soils on gently sloping lands, slightly eroded; Associated with; moderately shallow, well drained, calcarious, gravelly loamy soils.	Loamy skeletal, mixed, Typic Rhodustalfs. Loamy skeletal, mixed, Typic Ustrapepts.
24	Shallow, well drained gravelly loam soils on undulating lands, moderately eroded; associated with; moderately shallow, somewhat excessively drained, loamy soils on gently sloping lands with slight erosion.	Loamy skeletal, mixed, Typic Rhodustalfs. Fine- Loamy, mixed Typic Ustrapepts.
50	Very deep, somewhat excessively drained, clayey soils on very steeply sloping lands, low hills, severely eroded; associated with; moderately shallow, somewhat drained, loamy soils.	Fine mixed, Typic Haplustalfs. Fine Loamy mixed, Typic Ustrapepts.
58	Very shallow, somewhat excessively drained, loamy soils on undulating lands moderately eroded; associated with; shallow, well drained, gravelly loam soils on gently sloping lands with slight erosion.	Loamy, mixed, Ustorthents.. Loamy Skeletal, mixed , Typic Rhofustalfs.
62	Deep, somewhat excessively drained, clayey soils on moderately steeply sloping hill ranges, moderately eroded; associated with; deep, somewhat excessively drained, loamy soils.	Fine, mixed, Isothermic , Typic Humitropepts. Fine-loamy, mixed, Isothermic , Typic Humitropepts.
76	Shallow, moderately well drained, calcarious, gravelly loam soils on gently sloping low lands, slightly eroded; associated with ; very deep, well drained , calcarious, stratified loamy soils.	Loamy skeletal, mixed, Typic Ustrapepts. Coarse loamy over sandy, mixed, Typic Ustifluvents.
83	Deep, well drained, Loamy soils on gently	Coarse-loamy, mixed,

	sloping low lands, moderately eroded;	Typic Ustrapepts. Fine-loamy, mixed, Typic Rhodustalfs.
102	Deep, Somewhat excessively drained, Clayey soils on moderately steeply sloping, high hill ranges, severely eroded.	Fine, Mixed, Rhodic Ustrapepts.
111	Very shallow, somewhat excessively drained, gravelly loam soils on moderately sloping, isolated hillocks, severely eroded; associated with; moderately shallow, somewhat excessively drained, gravelly loam soils.	Loamy-skeletal, mixed, Lithic Ustrapepts. Loamy –skeletal, mixed, Typic Ustrapepts.
122	Deep, imperfectly drained, calcarious, cracking clay soils on nearly level low lands, slightly eroded; associated with; Very deep, imperfectly drained, calcarious, cracking clay soils.	Fine, montmorillonitic, Vertic Ustrapepts. Very fine, montmorillonitic, Udic Pellusterts.
129	Moderately shallow, well drained, clayey soils on moderately steeply sloping, high hill ranges, moderately eroded; associated with; moderately shallow, well drained, loamy soils.	Clayey, mixed, Isothermic, Typic Haplustalfs, Fine-loamy, mixed, Isothermic, Typic Dystropepts.
133	Rock Outcrops.	Rock lands.
150	Rock outcrops; associated with; moderately shallow excessively drained, gravelly loam soils on very steeply sloping escarpments and foot slopes, severely eroded.	Rock lands. Loamy skeletal, mixed, Typic Eutropepts.

The basin soil category and the corresponding soil unit numbers are given as below.

Sl No	Soil Category	Soil Unit Numbers
1	Entisol	58
2	Inceptisol	62, 76,83,102,111,122, 150.
3	Alfisol	13,21,24,50, 129.

Based on the accompanying NBSS Report on land use (Soil Resources of Tamil Nadu for Land-use Planning Executive Summary Report, NBSS Publication No.46 1997) and the corresponding soil classification, the irrigable soils of the Parambikulam Aliyar Basin were identified. The irrigable soils main properties are summarized in **Table 2.9.** and their interpretative classifications for land capability for crop production and irrigability are given in **Table 2.10.**

Table 2.9 Soil Major Properties

Type	Unit(*)	Drainage	Surface texture	Available water (mm/m) (**)	Depth (mm)	Slope (%)
I	24	Well	ls	50-150	1000-1500	1-3
	58	S.w.exc	ls	50-150	1000-1500	
	76	Mod Well	ls	50-100	500-1500	
	83	Well	ls	50-100	1000-1500	
	111	S.w.exc	ls	50-100	1000-1500	
II	13	Well	c	150-200	1000-1500	
	21	Well	ls	150-200	1000-1500	
	50	S.w.exc	c	150-200	1000-1500	
	62	S.w.exc	c	150-200	1000-1500	
	102	S.w.exc	c	150-200	1000-1500	
	129	Well	c	150-200	1000-1500	
	150	S.w.exc	ls	150-200	1000-1500	
III	122	Mod well	c	<50-150	1000->1500	1-3
IV	133	Poor	Rocky	150-200	>1500	

Drainage

Mod. = Moderately
S.w.exc = Some what excessive
Impr = Imperfect

Texture

ls = loamy soil

c = clay

(*) Soil association according to NBSS Publication No.46 1997
(**) Per 1 m of soil depth if the soil is shallower.

Table 2.10 Land capability for crop production and irrigability

Type	I					II							III	IV
Unit	24	58	76	83	111	13	21	50	62	102	129	150	122	133
Capability	II s	II s	II s	II es	II s	II s	II es	II s	II es	II s	II s	II es	III s	III s-II s
Irrigability	3s	3d	3d	3d	3d	2s	2d	2d	2d	2d	2d	2d	2s	3s-2d

The land capability classes II & III are good and moderately good cultivable respectively, and the corresponding s and e denote water holding capacity(fertility) and drainage predominant limitations for sustained use under irrigation respectively and the corresponding s and d denote the soil fertility and drainage predominant limitations. The crop suitability classes S1, S2 and S3 denote high, moderate and marginal suitability for the crop under consideration.

Based on the soil properties and their classification the Basin soils were grouped for irrigation planning purposes, into 5 major groups denoted Type-I to Type-V. The intention is to determine uniform cropping patterns which would be associated to the soil types, mainly for the assessment of future scenarios. The soil types are described as follows:

- <u>Type-I</u> soils. They are mostly with medium texture, well and moderately well drained, mostly moderately deep to deep, mostly with 1-3 % slope and with none to various degrees of erosion problems. The soils are irrigable and suitable for crops like groundnuts, cotton, pulses, millets, maize, sorghum, vegetables and tree crops.
- <u>Type-II</u> soils. They are of fine texture, imperfectly drained, moderately deep to deep, with 1-3% slope, with none to moderate erosion problems. In spite of the above mentioned NR classification for sugarcane it can be concluded that in the future with improved irrigation methods and systems, Type-II soils with lower slopes, could also be cultivated by sugarcane.
- <u>Type-III</u> soil. They are mostly of fine texture, mostly imperfectly drained, moderately deep to deep, mostly with 1-3 % slope, with none to moderate erosion problems. Type-III soils are irrigable and suitable to rice and sugarcane and also to relatively tolerant to imperfect drainage other crops such as cotton, sorghum and some fodder crops.
- <u>Type-IV</u> soils. They are similar to Type-III soils, however due to salinity and sodicity problems those soils could be sustainably irrigated if corrective measures to those problems would be taken.
- <u>Type-V</u> soils. Those soils include non-irrigable soils, such as rock outcrops, dunes, flooded areas, steep slopes, etc.

2.10.2 Soil Texture

The soil texture of the Parambikulam Aliyar Basin is shown in **(Plate No. PA 31)**. The texture types are described as below.

Sandy clay loam

Major part of Parambikulam Aliyar basin comprised of this soil type. This soil has visible particles of sand mixed into the soil. Sandy clay loam soils are dominated by sand particles, but contain enough clay and sediment to provide some structure and fertility.

When sandy loam soils are compressed they hold their shape but break apart easily. This is considered the most fertile soil type with combination of sand, clay and silt particles.

Clay

It is found in isolated parts of this basin. Clay soil is comprised of very fine mineral particles resulting in sticky nature. They remain wet and cold in winter and dry out in summer. They can hold more total water than most other soil types,but only about half of it is available for plants.

Clay loam

It is found in pockets of this basin comparatively in lesser proportion. This is a soil mixture that contains more clay than other types of rock or minerals.

Loamy sand

This type is found mainly in the Walayar sub basin and in isolated places of the other sub basins. It is a mixture of very fine sand, clay and silt. It contains more organic matter and good for cultivation.

Sandy clay

This type is found in meagre parts of the basin. They are with high proportion of sand and little clay characterized by quick water drainage and are easy to work with.

Sandy loam

This is found in all the sub basins next to sandy clay loam. They are dominated by sand particles mixed with soil particles. They are capable of quick drainage but cannot hold significant amount of water or nutrients for the plants and they need frequent irrigation. This soil is often deficient in specific micronutrients and requires additional fertilization to support plant growth.

Percentage of soil texture in Parambikulam Aliyar basin

Sl.No	Texture	Area(sq.km)	Percentage
1	Sandyclay	200.73	8.34
2	Sandyloam	266.98	11.09
3	Clay	186.77	7.76
4	Clayloam	273.48	11.36
5	Loamysand	116.87	4.86
6	Sandyclayloam	1220.51	50.72
7	Others	141.04	5.86
Total		**2406.38**	

Walayar Sub Basin			
Sl.No	Texture	Area(sq.km)	Percentage
1	Sandyclay	39.96	4.57
2	Sandyloam	142.80	16.32
3	Clay	70.70	8.08
4	Clayloam	183.44	20.97
5	Loamysand	87.21	9.97
6	Sandyclayloam	320.46	36.63
7	Others	30.32	3.47
Total		**874.90**	

Palar Sub Basin			
Sl.No	Texture	Area(sq.km)	Percentage
1	Sandyclay	32.77	6.29
2	Sandyloam	50.86	9.77
3	Clay	5.20	1.00
4	Clayloam	34.42	6.61
5	Loamysand	0.66	0.13
6	Sandyclayloam	367.71	70.63
7	Others	28.97	5.56
Total		**520.60**	

Aliyar Sub Basin			
Sl.No	Texture	Area(sq.km)	Percentage
1	Sandyclay	72.33	12.81
2	Sandyloam	37.58	6.66
3	Clay	53.60	9.50
4	Clayloam	55.62	9.85
5	Loamysand	28.28	5.01
6	Sandyclayloam	265.47	47.03
7	Others	51.55	9.13
Total		**564.43**	

Sholaiyar Sub Basin			
Sl.No	Texture	Area(sq.km)	Percentage
1	Sandyclay	55.67	12.47
2	Sandyloam	35.74	8.01
3	Clay	57.27	12.83
4	Loamysand	0.72	0.16
5	Sandyclayloam	266.86	59.77
6	Others	30.19	6.76
Total		**446.45**	

2.10.3 Soil Fertility & Nutrient Management

The land resources and their use are influenced by soil, rainfall and biotic factors. Analysis is done on various land use parameters region wise. The regression analysis indicated that the share of NSA (Net Sown area) in the total area is influenced by population density, share of rural population, grains available per capita and land available per capita.

Intervention strategies for efficient use of land and water resources for effective adoption of technology and institutions are suggested for decision at different planning. The strategies are presented with field examples in different region with the set of development related issues and problems for detailed comprehensive consideration and decision. More specifically land use problems are related to flood incidence, drainage, water logging and problem soil (acidic/alkaline).

It is viewed that nutrients are necessary for basic crop production. This includes Nitrogen, Phosphorous and Potash and micro nutrients such as Boron, Chlorine, Cobalt, Copper, Iron, Magnesium, Molybdenum, Sulphur and zinc. The soil organic matter that improves the structure of soil which has an impact on the water holding capacity. The soil pH in the range of 6.0 to 6.8 has a good soil structure which enables good drainage. The microorganisms present in the soil also influence the fertility of the soil. The soil fertility status of the basin is given in the Annexure 2.3 - 2.10 in annexure.

Nutrient Management

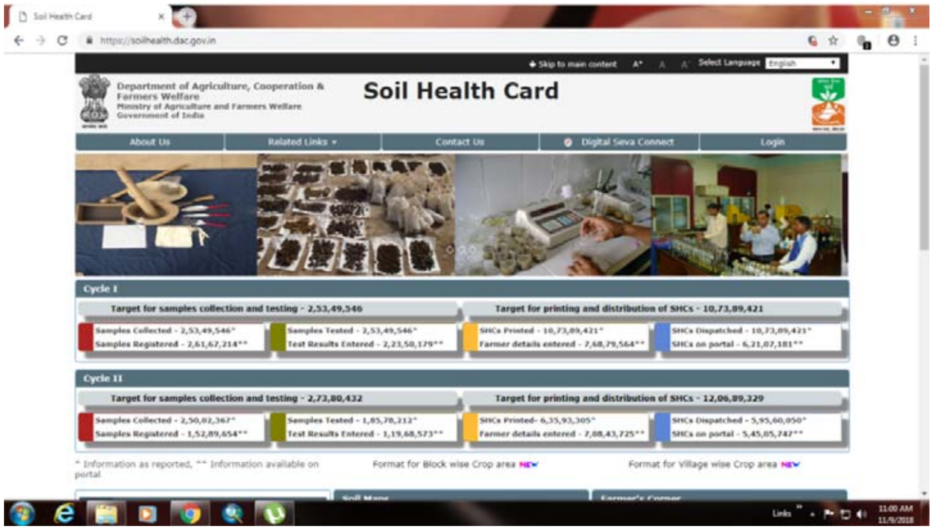
Role of organic matter in soil fertility includes the physical and structural condition of the soil maintained by the organic matter. Organic matter improves the soil to dissolve many insoluble soil minerals which are necessary for the plant growth.

Resource Management

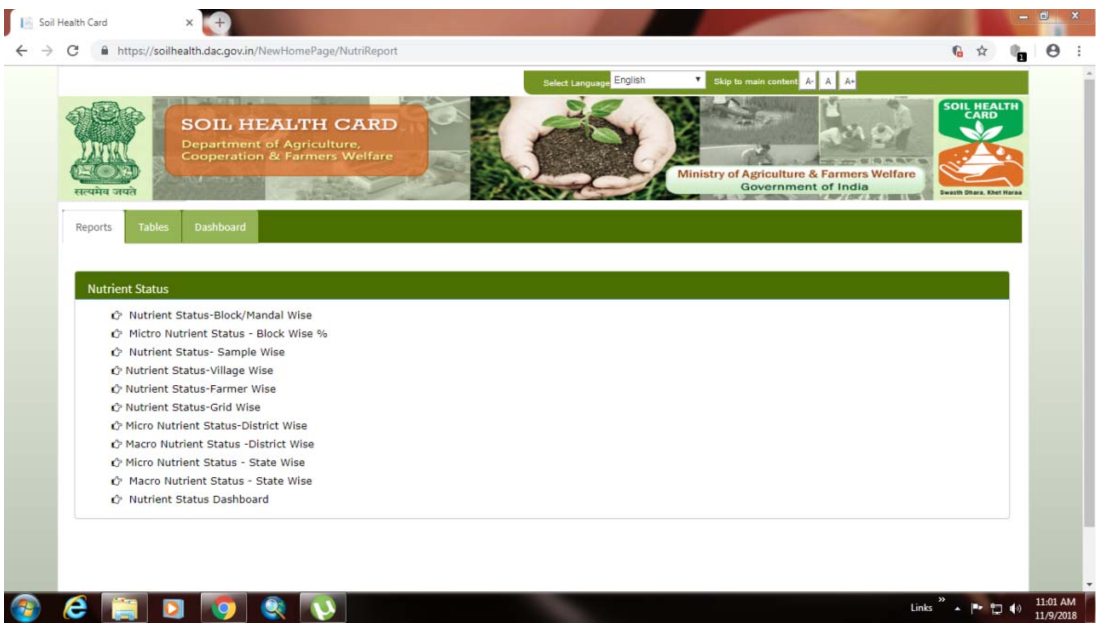
From the soil system, a considerable amount of nutrients are being removed through cultivation of crops, however, being replaced in the form of manure. Perhaps, leaching, erosion, volatilization etc., removes some nutrients from the soil. Soil fertility may be retained by soil testing and adding required organic matter so that the yield could be improved.

Guide to know the Soil Health - Village wise:

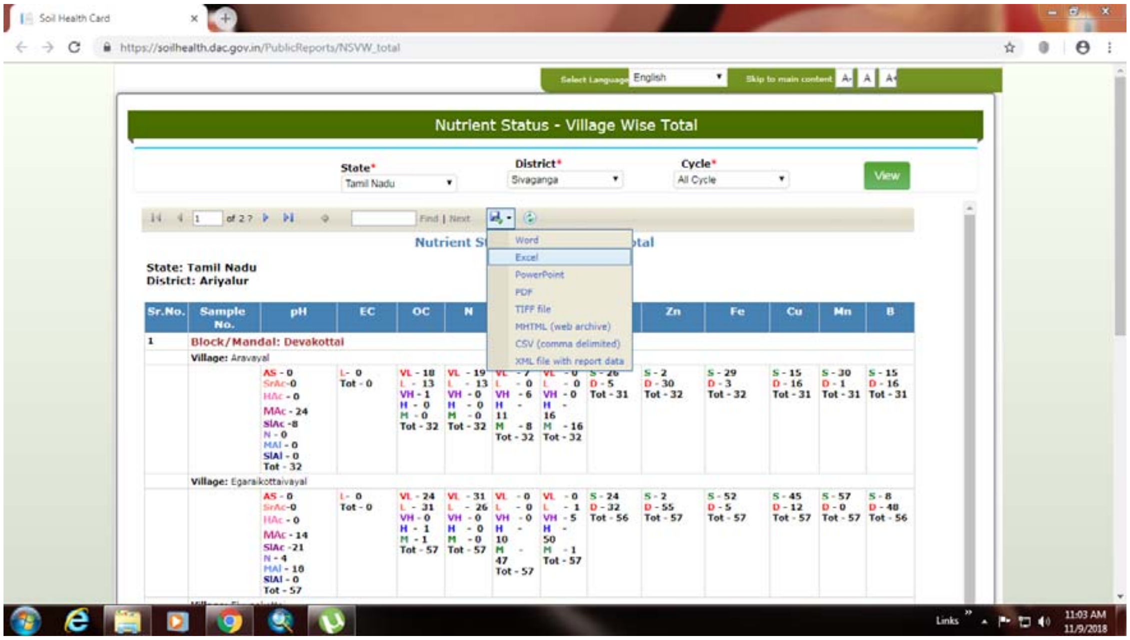
According to the soil health report the field specific nutrient management can be taken



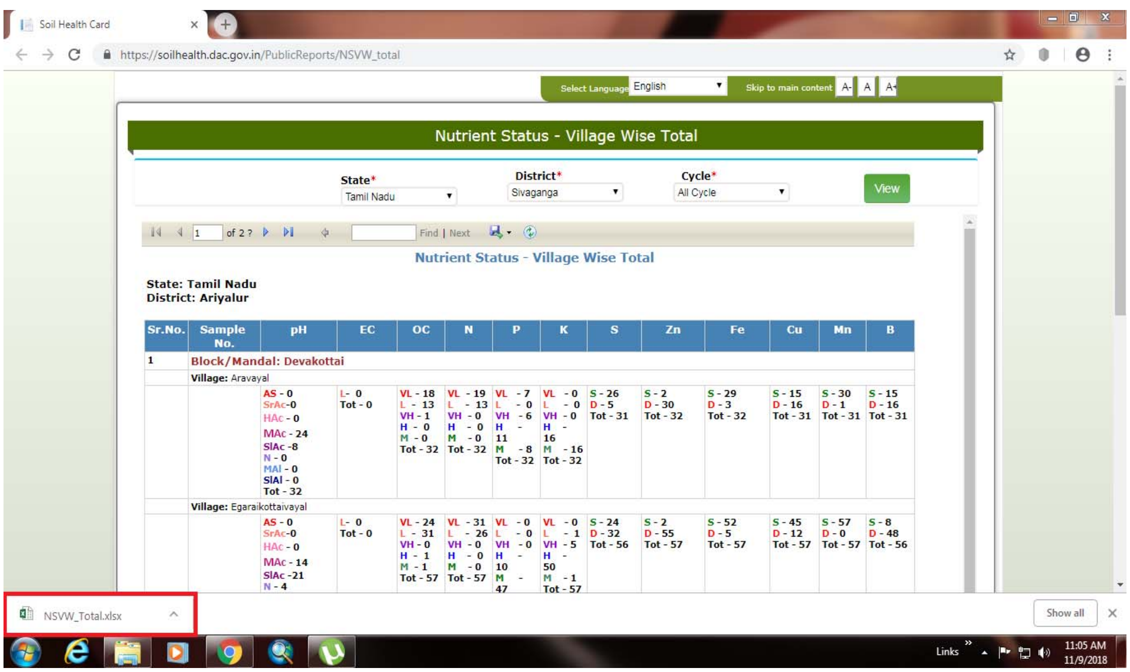
Step 1: Go to https://soilhealth.dac.gov.in
Step 2: Click the Soil health dashboard (A new tab appears)



Step 3: Click the Reports tab
Step 4: Click the Nutrient status/ Micro Nutrient status as per your need
Step 5: Fill the State,District, Cycle in the given boxes and Click view button (Now it will show the report in an excel file)



Step 6: To down load the report, click the Export drop down menu and select EXCEL.



Type of Soil Areas in Tamil Nadu	
Soil Type	***District Name***
Red Loam:	Krishnagiri, Thoothukudi, Virudhunagar, The Nilgirs,
	Dindigul, parts of Kancheepuram and Chengalpattu, Cuddalore, Salem,
	Dharmapuri, Coimbatore, Trichy, Thanjavur, Ramnad,
	Tirunelveli, Tenkasi and Sivagangai.
Red Sandy Loam :	Namakkal, Erode, Thiruppur and Karur.
Red Sandy Clay Loam :	Theni
Laterite Soil:	Parts of The Nilgirs
Black Soil :	Parts of Kancheepuram and Chengalpattu, Cuddalore, Vellore, Ranipet and Thipathur, Thiruvarur
	Tiruvannamalai, Salem, Dharmapuri, Madurai, Ramnad,
	Tirunelveli, Tenkasi, Sivagangai, Thoothukkudi, The Nilgiris,
	Virudhunagar, Dindigul, Perambalur and Ariyalur
Black Sandy Clay Loam:	Pudukkottai
Sandy Coastal Alluviam:	On the coasts in the districts of Ramnad, Thanjavur,
	Nagapattinam, Myiladudurai Cuddalore, Kancheepuram, Kanyakumari.
Red Sandy Soil :	Small patches in the districts of Coimbatore and The Nilgiris.

Source: Commissioner of Agriculture, Department of Agriculture, Chennai-600 005

2.11 Social and Demographic Characteristics

The development of a particular city, town or a region depends upon natural, physical and socio-economic factors. Among these factors the population assumes significance in determining the future pattern of progress and development.

Population trend and population dynamics are important indicators of the present and future water requirement in the River Basin. Also, the social characteristics of the population such as literacy level, level of housing, electrification, in house facilities, urbanization trend, have indirect bearing on water planning.

The Parambikulam Aliyar River Basin covers part of Coimbatore and Tiruppur districts. An analysis of Social and demographic characteristics of above two districts gives an idea about such characteristics in the Parambikulam Aliyar River Basin.

2.11.1 Population in Parambikulam Aliyar River Basin

44.85 % of total area of Coimbatore District (2122.33 sq.km out of 4732 sq.km) and 5.48 % of total area of Tiruppur District (284.05 sq.km out of 5187 sq.km), covers the Parambikulam Aliyar River Basin and population of districts covered in Parambikulam Aliyar River Basin within the Basin as per census 2011 is given below in **Table 2.11**

Table 2.11. District wise population details of Parambikulam Aliyar River Basin (in million)

Sl.No.	Name of the District	Population in 2011			Population during 2020		
		Rural	Urban	Total	Rural	Urban	Total
1	Coimbatore	0.474	0.556	1.030	0.518	0.608	1.126
2	Tiruppur	0.035	0.004	0.039	0.039	0.004	0.043
Total		0.509	0.560	1.069	0.557	0.612	1.169

There are 4 (four) sub Basins in Parambikulam Aliyar River Basin. The villages and towns falling under each sub basin are sorted out using GIS and its corresponding population is taken up from Census 2011. The village wise population details of each sub basin in Parambikulam Aliyar River Basin are given in **Appendix 2.11 to 2.14.** The Sub Basin wise population of Parambikulam Aliyar River Basin is given in the **Table 2.12**. The population of Parambikulam Aliyar River Basin is projected for the targeted years 2020, 2030, 2040 & 2050 which is detailed in Chapter 7.

Table 2.12 Sub Basin wise Population in Parambikulam Aliyar River Basin

S. No	Name of Sub basin	As per census 2011 (in million)			As projected to 2020 (in million)		
		Rural	**Urban**	**Total**	**Rural**	**Urban**	**Total**
1	Walayar	0.236	0.441	0.677	0.258	0.482	0.740
2	Palar	0.113	0.037	0.150	0.124	0.040	0.164
3	Aliyar	0.070	0.082	0.152	0.077	0.090	0.166
4	Sholaiyar	0.015	0.076	0.091	0.017	0.083	0.100
	Total	**0.434**	**0.636**	**1.070**	**0.475**	**0.696**	**1.170**

Source: Census 2011

2.11.2 Population Growth

Population growth (or decline) is influenced by many factors that fall into the broad realms of demographic characteristics, socioeconomic conditions.

In the micro level reappraisal study of the Parambikulam Aliyar River Basin, water demand for various sectors is arrived. The domestic water demand of the River Basin is ascertained by calculating the population within the River Basin. Since, the population data as per census 2011 only available, the present population, population expected in the targeted year shall be accomplished by projecting the population. The population of the Parambikulam Aliyar River Basin based on census 2011 is projected to the present year 2020. The average annual exponential growth rate is used to find out the growth of urban and rural population and projecting the population.

The exponential formula used for projecting the population is given below,

$$\mathbf{P_t = P_o (1+X)^t}$$

Where Pt = Population after ‘t’ years

Po = Population in the beginning years

X = Average Annual exponential growth rate and is calculated by

$$X = \{e^{(\ln (Yt/Yo)/t)} - 1\} \% 100$$

Where, X = Annual growth rate

Yo = Population in base year.

Yt = Population in t^{th} year.

t = Number of years (Current year – Base year)

t = Period in which year population is to be forecasted.

Development and population changes are complex that they have exhibited spatial variations in different time periods driven by different factors. The average annual exponential growth rate of rural and urban between census 1991 - 2001 and Census 2001-2011 are tabulated as below,

S.No	Census Period	Average Annual Exponential growth rate	
		Rural	Urban
1	**2001-2011**	**0.02%**	**0.04%**

Projections may be made with reference to the recent observed trend in growth. Hence, for this present forecast the growth rate may be adopted as 1% for Rural population and Urban Population. The projected population in Parambikulam Aliyar River Basin for 2020 is given below in **Table 2.13**

Table 2.13 Projected population in Parambikulam Aliyar River Basin for 2020

Sl. No	Name of Sub basin	Area in Sq.km	Total Rural Population in million		Total Urban Population in million		Total	
			2011	2020	2011	2020	2011	2020
1	Walayar	875.13	0.236	0.258	0.441	0.482	0.677	0.740
2	Palar	520.6	0.113	0.124	0.037	0.040	0.150	0.164
3	Aliyar	564.54	0.070	0.077	0.082	0.090	0.152	0.166
4	Sholaiyar	446.11	0.015	0.017	0.076	0.083	0.091	0.100
	Total	**2406.38**	**0.434**	**0.475**	**0.636**	**0.696**	**1.070**	**1.170**

Source: Census 2011

From the above table it is inferred that about 40.56% and 59.44% of people live in Rural and Urban area in this Parambikulam Aliyar River Basin.

2.11.3 Population Density

Population density is a measurement of population per unit area. The Sub Basin wise population density of Parambikulam Aliyar River Basin is given in Table **2.14.** The population density is higher in Walayar sub basin (773 persons per sq.km) and lower in Sholaiyar sub basin (204 Persons per sq.km).

Table 2.14 Sub basin wise Population density in Parambikulam Aliyar River Basin

Sl.No	Name of the sub Basin	Area (Sq.km)	Total population 2011	Density (Person/Sq.km)
1	Walayar	875.13	676675	773
2	Palar	520.6	150256	289
3	Aliyar	564.54	151810	269
4	Sholaiyar	446.11	91018	204
Total		**2406.38**	**1069759**	**445**

2.11.4 Population by Sex

The sex wise distribution of population in Parambikulam Aliyar River Basin as per census 2011 is given in **Table 2.15**

Table 2.15 District wise Population by sex in Parambikulam Aliyar River Basin

Sl. No	Name of the District	Area of the district in the Basin in Sq.km	Total Population (million)	Population of Male (million)	% Male	Population of Female (million)	% Female
1	Coimbatore	2122.33	1.030	0.513	49.81	0.517	50.19
2	Tiruppur	284.05	0.039	0.019	49.89	0.020	50.11
	Total	**2406.38**	**1.069**	**0.532**	**49.81**	**0.537**	**50.19**

2.11.5 Sex Ratio

Sex ratio is the demographic concept that measures the proportion of males to females in a given population. Changes in gender composition largely reflect the underlying social, economic and cultural patterns of the society in different ways.

Sex Ratio is expressed as number of females for every 1000 males. The sex wise distribution of population in all the sub basins of Parambikulam Aliyar River Basin is given below in **Table 2.16**

Table 2.16 Sex wise Population distribution in Parambikulam Aliyar River Basin

Sl. No	Name of the Sub Basin	Population(in million)			Male %	Female %	Total %	Sex Ratio
		Male	Female	Total				
1	Walayar	0.338	0.339	0.677	49.85	50.15	100	1006 females for 1000 males
2	Palar	0.074	0.076	0.150	49.33	50.67	100	1027 females for 1000 males
3	Aliyar	0.075	0.077	0.152	49.34	50.66	100	1027 females for 1000 males
4	Sholaiyar	0.045	0.046	0.091	49.45	50.55	100	1022 females for 1000 males
	Total	0.532	0.538	1.070	49.67	50.33	100	1013 females for 1000 males

2.11.6 Literacy Level

The literacy level of the population is also a vital social indicator of the standard of living and social status. The literacy rate of the Parambikulam Aliyar River basin is worked out sub basin wise and is given in **Table 2.17.** The overall literacy rate in Parambikulam Aliyar River Basin is found to be 65.98%.

Table 2.17 Details of Literacy level in Parambikulam Aliyar River Basin

Sl. No	Name of the Sub Basin	Literacy Population In million			Total Population In million			% Literacy of Population		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
1	Walayar	0.243	0.213	0.456	0.338	0.339	0.677	71.89	62.83	67.36
2	Palar	0.050	0.042	0.092	0.074	0.076	0.150	67.57	55.26	61.33
3	Aliyar	0.050	0.043	0.093	0.075	0.077	0.152	66.67	55.84	61.18
4	Sholaiyar	0.035	0.030	0.065	0.045	0.046	0.091	77.78	65.22	71.43
	Total	**0.378**	**0.328**	**0.706**	**0.532**	**0.538**	**1.070**	**71.05**	**60.97**	**65.98**

2.11.7 Population Dynamics

Population growth would be reflected on analyzing crucial parameters such as birth rate, death rate, Infant Mortality Rate (IMR), Maternal Mortality Rate (MMR) and life expectancy trends of the population. The details of registered births and deaths in Districts falling under Parambikulam Aliyar River Basin as per the Statistical Handbook of Tamil Nadu 2019 is given in **Table 2.18**

Table 2.18 Details of Births and Deaths Registered in Districts covered in Parambikulam Aliyar River Basin

Sl. No	Name of the District	Mid-Year Estimated Populaion for 2017 in Crore	As on Year 2017					
			Births	Deaths	Infant Deaths	Still Births	Maternal Deaths	Total Death
1	Coimbatore	3.894	45183	35554	712	360	46	36672
2	Tiruppur	2.923	22327	18645	70	154	1	18870

Source: Statistical Handbook 2019

2.11.8 Family Welfare & Impact of Family Planning

Tamil Nadu is pioneer in the implementation of Family Welfare Programme. It is being implemented in Tamil Nadu since 1956 purely on voluntary basis. It is viewed and implemented as a people's programme involving the active co-operation of many sectors and participation of the community at large.

The overall emphasis and priority given by the Government of India and Government of Tamil Nadu for family welfare and family planning has led to the establishment of institutions to promote family planning knowledge, at rural and urban areas. The Deputy Director of Medical and Rural Health Services and Family Welfare is the implementing authority of family welfare schemes. Family welfare Programme details for the districts covered by the Parambikulam Aliyar River Basin for the period of 2019-2020 is given in **Table 2.19**

Table 2.19 Details of Family Welfare Programme in Districts of Parambikulam Aliyar River Basin

Name of the District	2017-18			
	Sterilisation	IUCD	Oral Pill Users	Conventional Contraceptives Users
Coimbatore	11424	14978	3020	2511
Tiruppur	6741	9049	996	1604

Source: Statistical Handbook 2019

2.11.9 Level of Housing

The level of housing is an indicator of water requirement and of urbanization trend. Households that have electricity, water and toilet available within the premises would be using more water in comparison with those that do not have these facilities within the premises. The details of households in Parambikulam Aliyar River Basin are given in **Table 2.20.**

Table No 2.20 Number of Households in Parambikulam Aliyar River Basin (2011)

Sl.No	Name of the SubBasin	Total Population In million	Number of House Holds
1	Walayar	0.677	172251
2	Palar	0.150	41020
3	Aliyar	0.152	41444
4	Sholaiyar	0.091	22819
5	**Total**	**1.070**	**277534**

Source: Census of India 2011

2.11.10 Economic Profile and Employment Opportunities of the Districts covered in Parambikulam Aliyar River Basin

There are 906 small scale industries, 190 large & medium scale industries in Parambikulam Aliyar River Basin. The water requirement for the industrial purpose for large & medium and small scale industries are estimated as 1.834 Mcum and 4.756 Mcum respectively. The projected future water demand for large & medium scale industries for the targeted year 2020, 2030, 2040 & 2050 are estimated as 5.137 Mcum, 9.246 Mcum, 16.64 Mcum & 29.96 Mcum respectively. The projected future water demand for small scale industries for the targeted year 2020, 2030, 2040 & 2050 are estimated as 1.981 Mcum, 3.566 Mcum, 6.418 Mcum & 11.552 Mcum respectively.

Coimbatore District

This is an agrarian district and main activity for lively hood of the people is Agriculture. Crops cultivated are Paddy, Cumbu, Ragi, Red gram, Black gram, Green gram, Groundnut, Gingelly, Cotton and Sugarcane. The district is an important wholesale market for Onion and Groundnut. Oddanchathram is noted market centre for vegetables. It is also famous for the export of butter manufactured in the nearby villages using cream seperators. Batlagundu is an important market centre for Tomato. Nilakottai taluk is famous for the growing and marketing of flowers and grapes. Kodaikanal is famous for potato cultivation.

Tanneries are thickly situated in the district. The finished and semi finished leather and other leather products have a good export market .A large number of chamber brick units functions in this districts. Dindugul locks and iron safes are specially known for its quality. Handloom, Rice milling, Groundnut and Vermicilli are the other types of food based industries functioning in this district. This district is also known for the flourishing handloom industry at Chinnalapatti. Art - silk sarees and Sungudi sarees produced in the above place are in great demand throughout India.

Tiruppur District

The economy is primarily agrarian, supplemented by gradually growing industrial and service sectors. Of late, conscious initiative has been taken to launch rural-oriented projects, as the district offers scope in the field of readymade garments, dairying, floriculture, toy –making, brick kiln, coir and bakery units.

The district has a very few reputed organizations in the private sector like T.V.Sundaram Iyengar & sons, Madura coats, Fenner(I) Ltd, George oaks Ltd etc., which are engaged in the production of variety of goods like Tyres and Tubes, Machineries ,Textile, Conveyor belts etc., and also provided employment opportunities. There is also very good scope for food processing and agro basis industries. It generates revenue of approximately 2500 crore per annum in the rubber sector.

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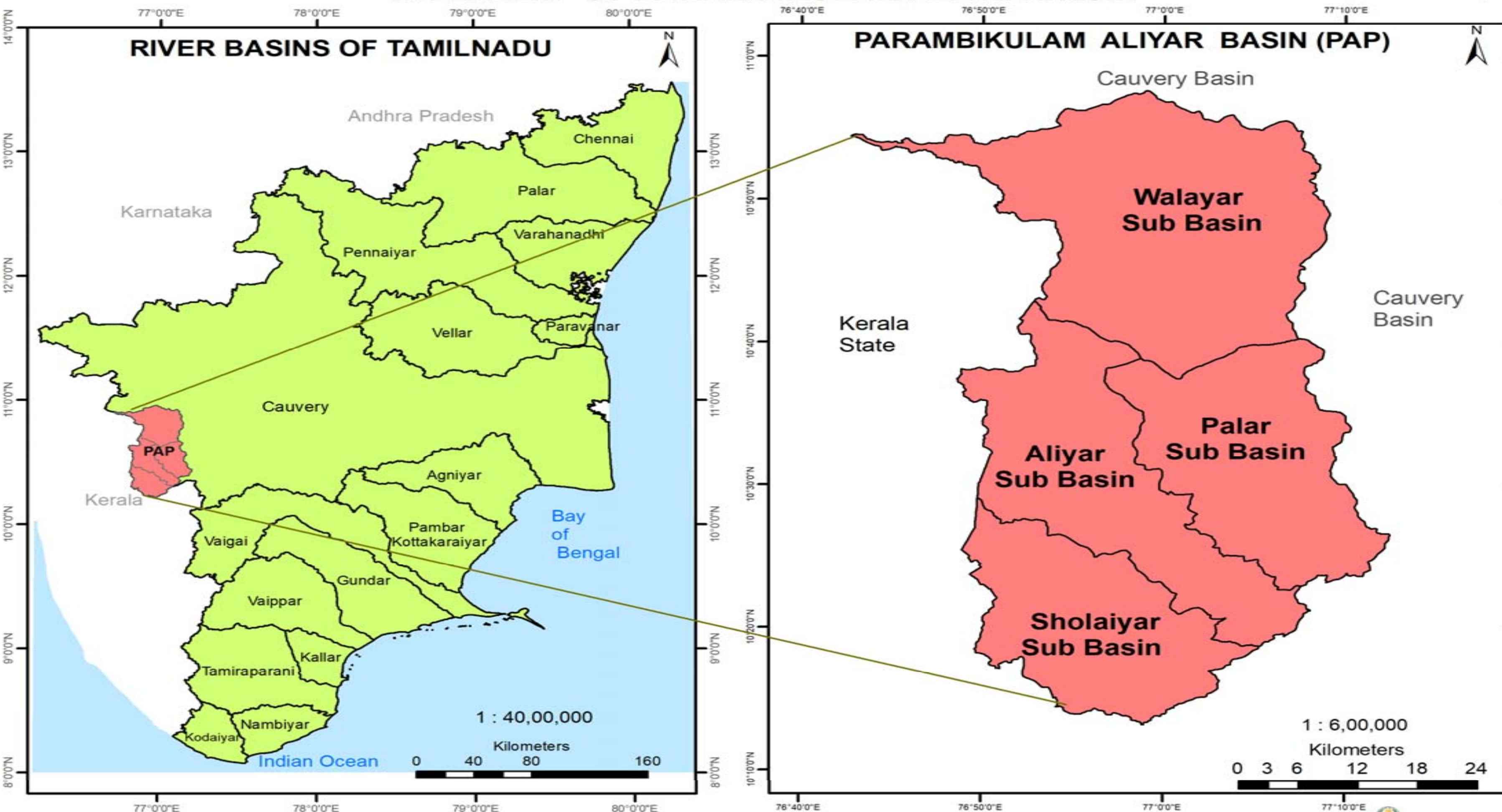
INDEX MAP OF PARAMBIKULAM ALIYAR BASIN

Plate PA -2



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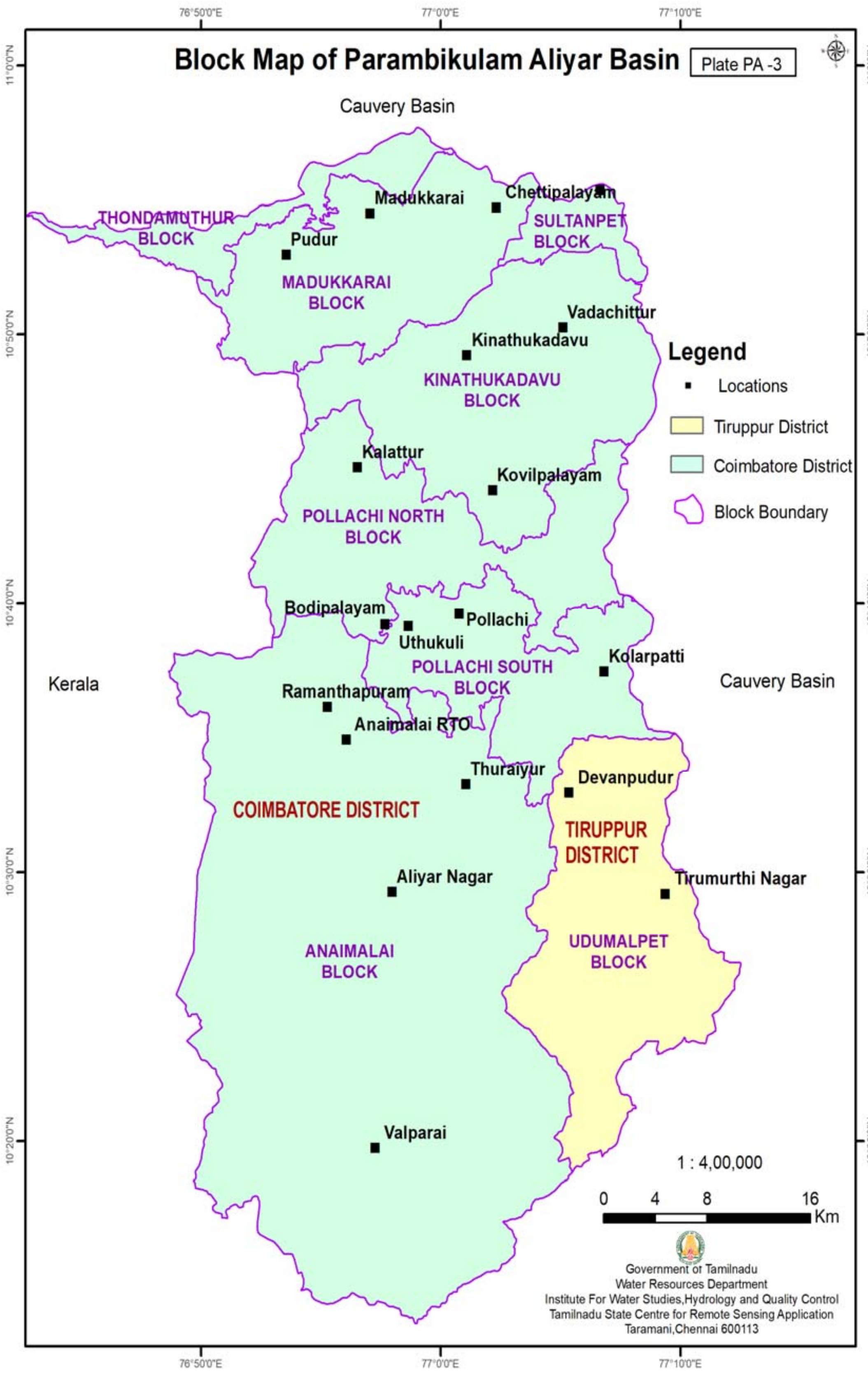
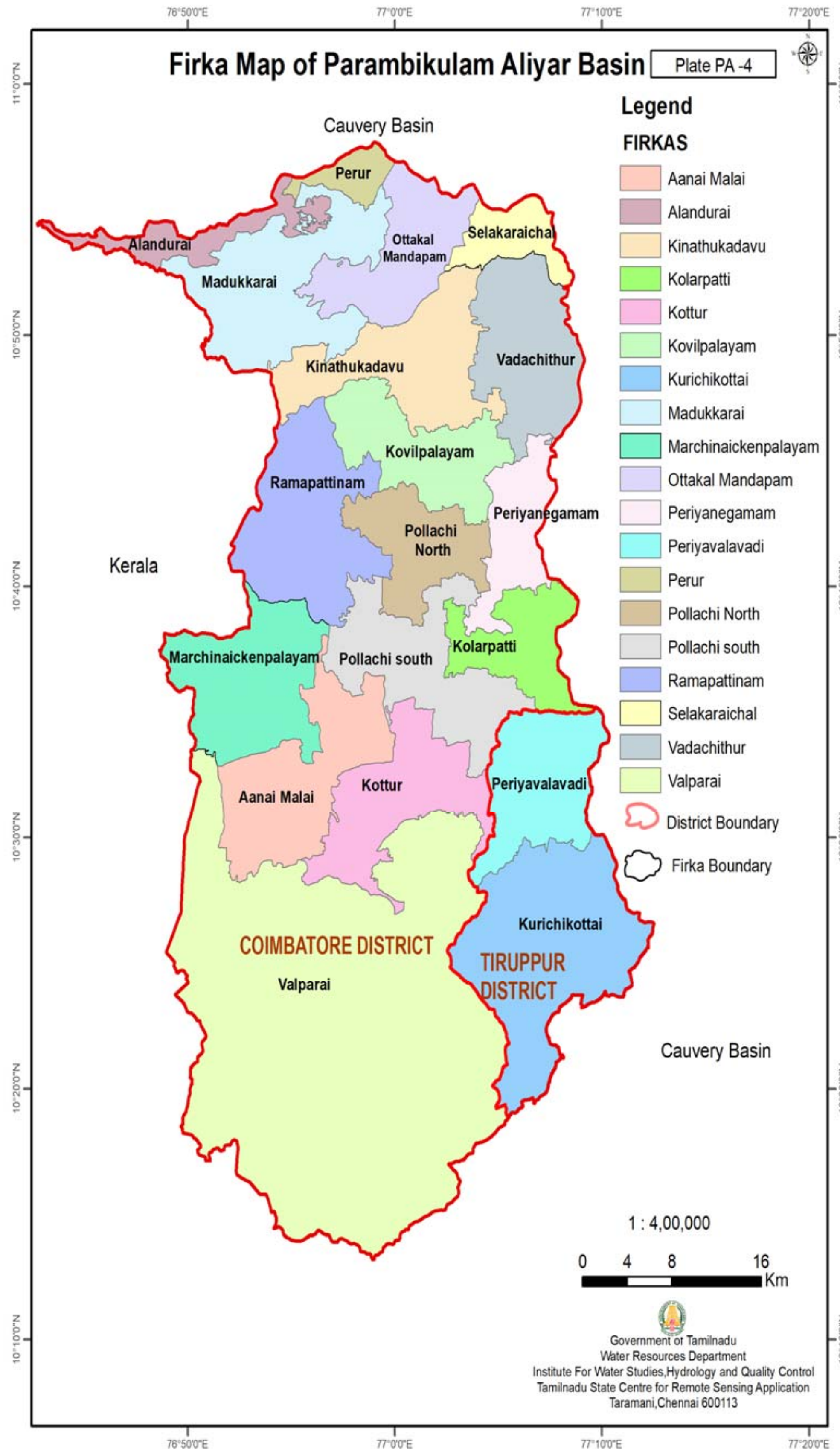
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113



Block Map of Parambikulam Aliyar Basin
Plate PA -3
Cauvery Basin
THONDAMUTHUR BLOCK
Madukkarai
Chettipalayam
SULTANPET BLOCK
Pudur
MADUKKARAI BLOCK
Vadachittur
Kinathukadavu
KINATHUKADAVU BLOCK
Kalattur
Kovilpalayam
POLLACHI NORTH BLOCK
Bodipalayam
Pollachi
Uthukuli
POLLACHI SOUTH BLOCK
Kolarpatti
Kerala
Cauvery Basin
Ramanthapuram
Anaimalai RTO
Thuraiyur
Devanpudur
COIMBATORE DISTRICT
TIRUPPUR DISTRICT
Aliyar Nagar
Tirumurthi Nagar
ANAIMALAI BLOCK
UDUMALPET BLOCK
Valparai
Legend
Locations
Tiruppur District
Coimbatore District
Block Boundary
1 : 4,00,000
0 4 8 16 Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113
76°50'0"E
77°0'0"E
77°10'0"E
11°0'0"N
10°50'0"N
10°40'0"N
10°30'0"N
10°20'0"N


76°50'0"E
77°0'0"E
77°10'0"E
77°20'0"E
11°0'0"N
10°50'0"N
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
Firka Map of Parambikulam Aliyar Basin
Plate PA -4
Legend
FIRKAS
Aanai Malai
Alandurai
Kinathukadavu
Kolarpatti
Kottur
Kovilpalayam
Kurichikottai
Madukkarai
Marchinaickenpalayam
Ottakal Mandapam
Periyanegamam
Periyavalavadi
Perur
Pollachi North
Pollachi south
Ramapattinam
Selakaraichal
Vadachithur
Valparai
District Boundary
Firka Boundary
Cauvery Basin
Perur
Alandurai
Madukkarai
Ottakal
Mandapam
Selakaraichal
Kinathukadavu
Vadachithur
Kovilpalayam
Ramapattinam
Pollachi
North
Periyanegamam
Kerala
Marchinaickenpalayam
Pollachi south
Kolarpatti
Aanai Malai
Kottur
Periyavalavadi
Kurichikottai
COIMBATORE DISTRICT
TIRUPPUR
DISTRICT
Valparai
Cauvery Basin
1 : 4,00,000
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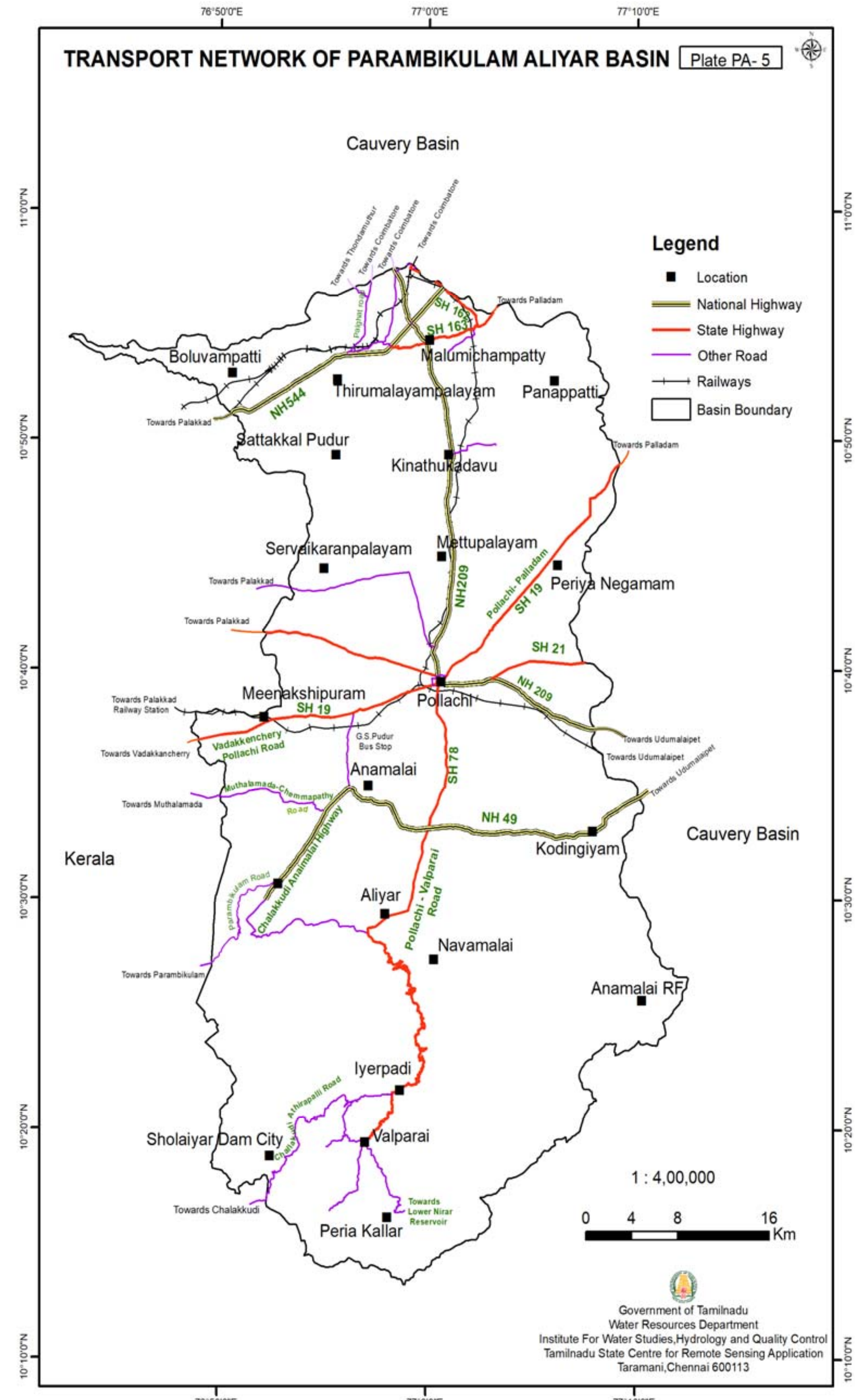
Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113


TRANSPORT NETWORK OF PARAMBIKULAM ALIYAR BASIN
Plate PA- 5
Cauvery Basin
Legend
Location
National Highway
State Highway
Other Road
Railways
Basin Boundary
Boluvampatti
Malumichampatty
Thirumalayampalayam
Panappatti
Sattakkal Pudur
Kinathukadavu
Servaikaranpalayam
Mettupalayam
Periya Negamam
Meenakshipuram
Pollachi
Anamalai
Kodingiyam
Cauvery Basin
Kerala
Aliyar
Navamalai
Anamalai RF
Iyerpadi
Sholaiyar Dam City
Valparai
Peria Kallar
NH544
NH209
NH 209
NH 49
SH 19
SH 21
SH 78
SH 163
Pollachi- Palladam
Vadakkenchery Pollachi Road
Muthalamada-Chemmapathy Road
Chalakkudi Anaimalai Highway
Pollachi - Valparai Road
Parambikulam Road
Towards Palladam
Towards Palakkad
Towards Palakkad Railway Station
Towards Vadakkancherry
Towards Muthalamada
Towards Parambikulam
Towards Chalakkudi
Towards Udumalaipet
Towards Lower Nirar Reservoir
G.S.Pudur Bus Stop
1 : 4,00,000
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Government of Tamilnadu
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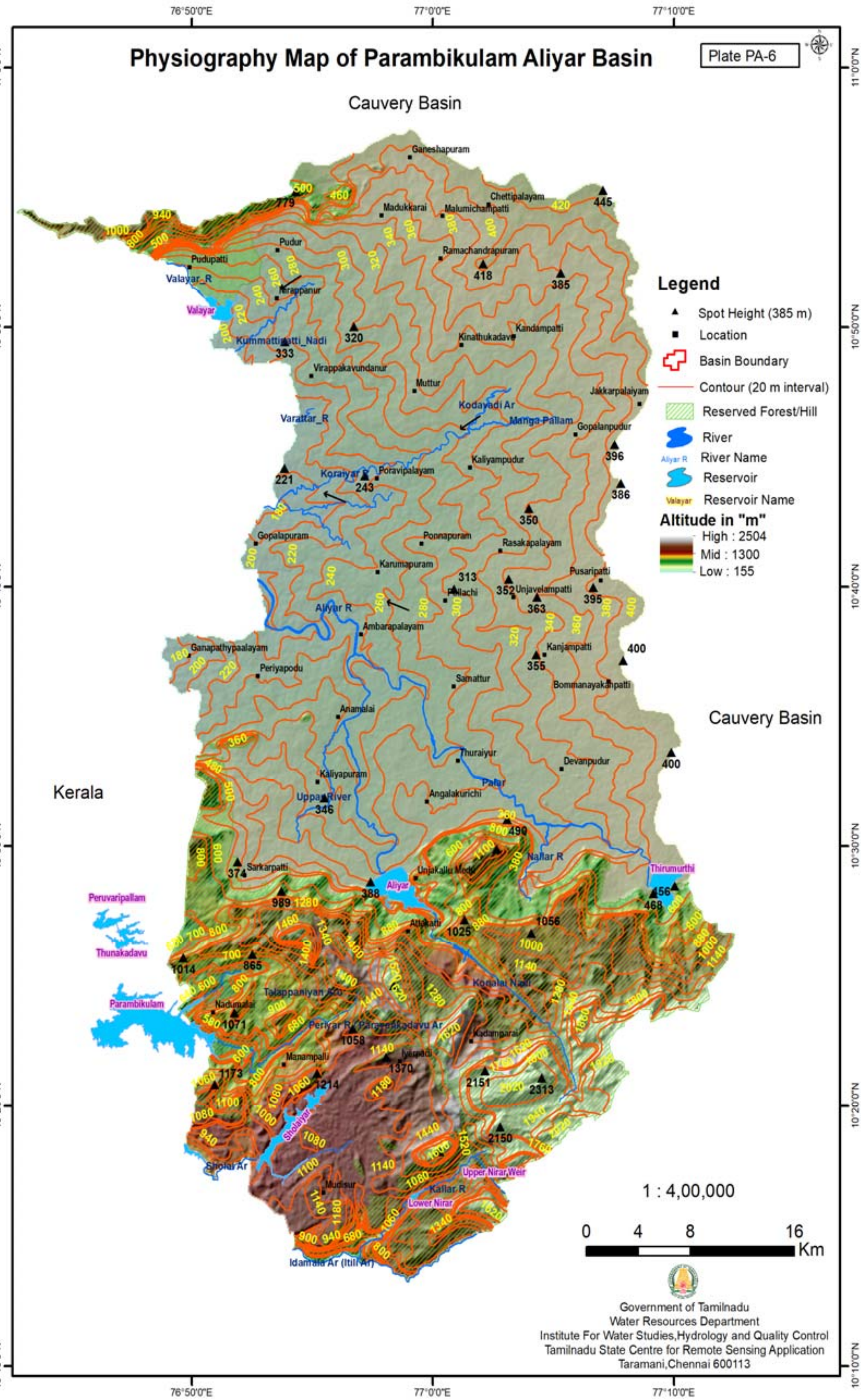
Physiography Map of Parambikulam Aliyar Basin
Plate PA-6
Cauvery Basin
Kerala
Legend
Spot Height (385 m)
Location
Basin Boundary
Contour (20 m interval)
Reserved Forest/Hill
River
River Name
Reservoir
Reservoir Name
Altitude in "m"
High : 2504
Mid : 1300
Low : 155
1 : 4,00,000
0 4 8 16 Km
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Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
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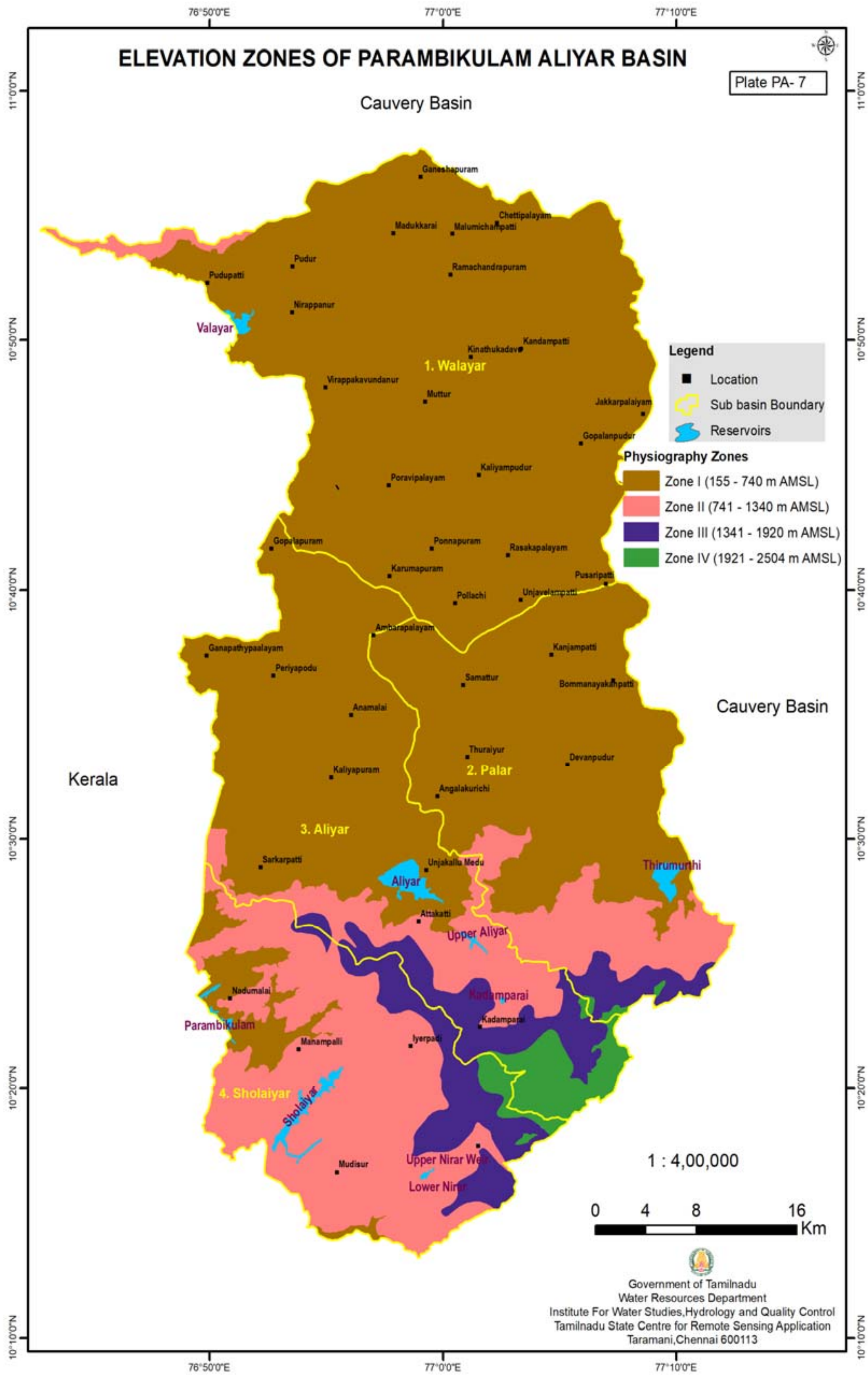
ELEVATION ZONES OF PARAMBIKULAM ALIYAR BASIN
Plate PA- 7
Cauvery Basin
Cauvery Basin
Kerala
1. Walayar
2. Palar
3. Aliyar
4. Sholaiyar
Valayar
Aliyar
Thirumurthi
Upper Aliyar
Kadamparai
Parambikulam
Sholaiyar
Upper Nirar Weir
Lower Nirar
Legend
Location
Sub basin Boundary
Reservoirs
Physiography Zones
Zone I (155 - 740 m AMSL)
Zone II (741 - 1340 m AMSL)
Zone III (1341 - 1920 m AMSL)
Zone IV (1921 - 2504 m AMSL)
1 : 4,00,000
0 4 8 16 Km
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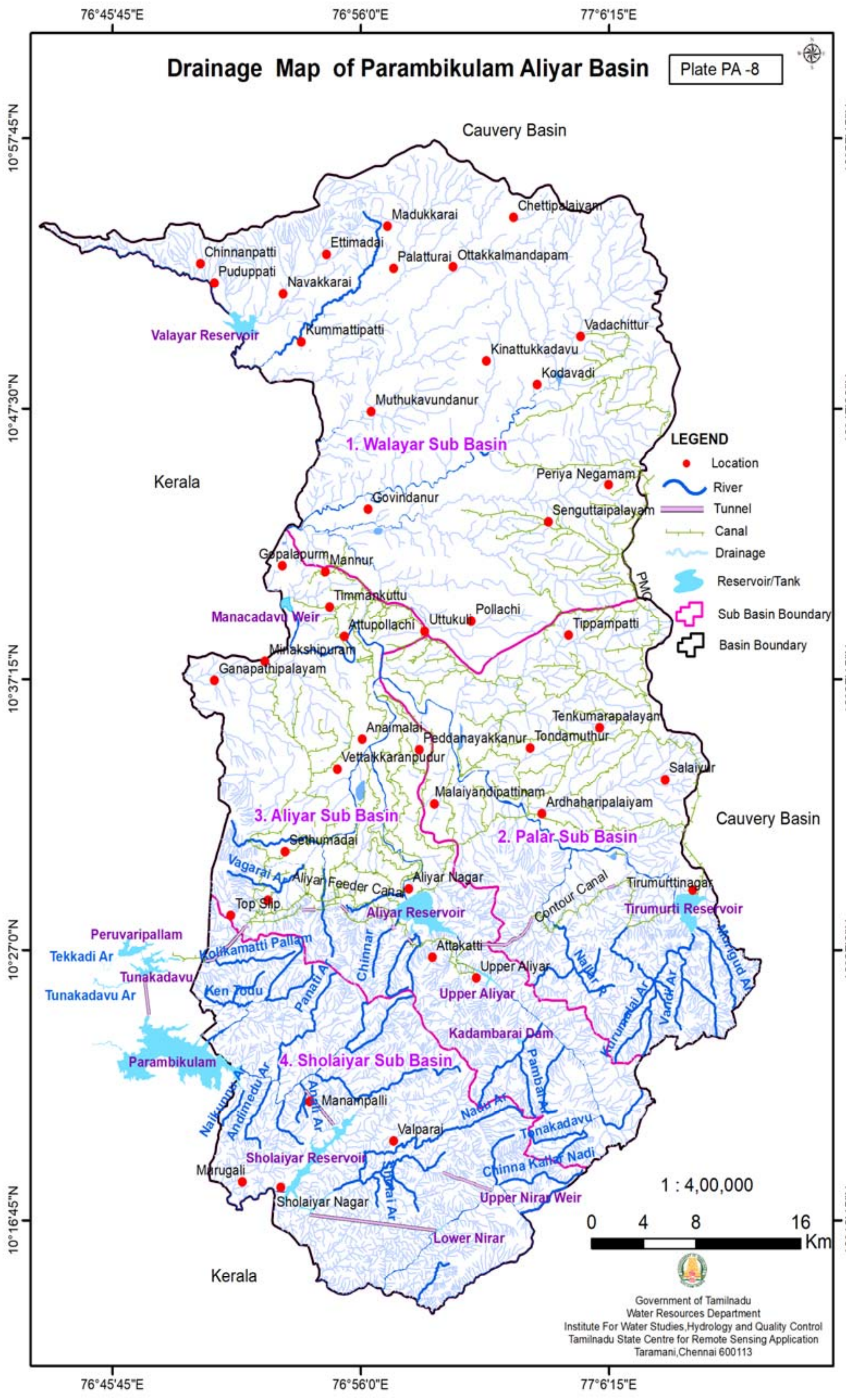

76°45'45"E
76°56'0"E
77°6'15"E
Drainage Map of Parambikulam Aliyar Basin
Plate PA -8
10°57'45"N
10°47'30"N
10°37'15"N
10°27'0"N
10°16'45"N
Cauvery Basin
Kerala
1. Walayar Sub Basin
2. Palar Sub Basin
3. Aliyar Sub Basin
4. Sholaiyar Sub Basin
Madukkarai
Chettipalaiyam
Ettimadai
Chinnanpatti
Puduppati
Palatturai
Ottakkalmandapam
Navakkarai
Valayar Reservoir
Kummattipatti
Vadachittur
Kinattukkadavu
Kodavadi
Muthukavundanur
Periya Negamam
Govindanur
Senguttaipalayam
Gopalapurm
Mannur
Timmankuttu
Manacadavu Weir
Attupollachi
Uttukuli
Pollachi
Tippampatti
Minakshipuram
Ganapathipalayam
PMC
Tenkumarapalayam
Anaimalai
Peddanayakkanur
Tondamuthur
Vettaikkaranpudur
Salaiyur
Malaiyandipattinam
Ardhaharipalaiyam
Sethumadai
Vagarai Ar
Aliyar Feeder Canal
Aliyar Nagar
Top Slip
Aliyar Reservoir
Contour Canal
Tirumurttinagar
Tirumurti Reservoir
Peruvaripallam
Tekkadi Ar
Tunakadavu
Tunakadavu Ar
Kolikamatti Pallam
Ken Todu
Panati Ar
Chinnar
Attakatti
Upper Aliyar
Nallar
Karumalai Ar
Vandi Ar
Uppar
Parambikulam
Kadambarai Dam
Pambar Ar
Nalkumudi Ar
Andimedu Ar
Manampalli
Nadu Ar
Tonakadavu
Valparai
Sholaiyar Reservoir
Chinna Kallar Nadi
Marugali
Sholaiyar Nagar
Upper Nirar Weir
Lower Nirar
LEGEND
Location
River
Tunnel
Canal
Drainage
Reservoir/Tank
Sub Basin Boundary
Basin Boundary
1 : 4,00,000
0 4 8 16
Km
Government of Tamilnadu
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Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
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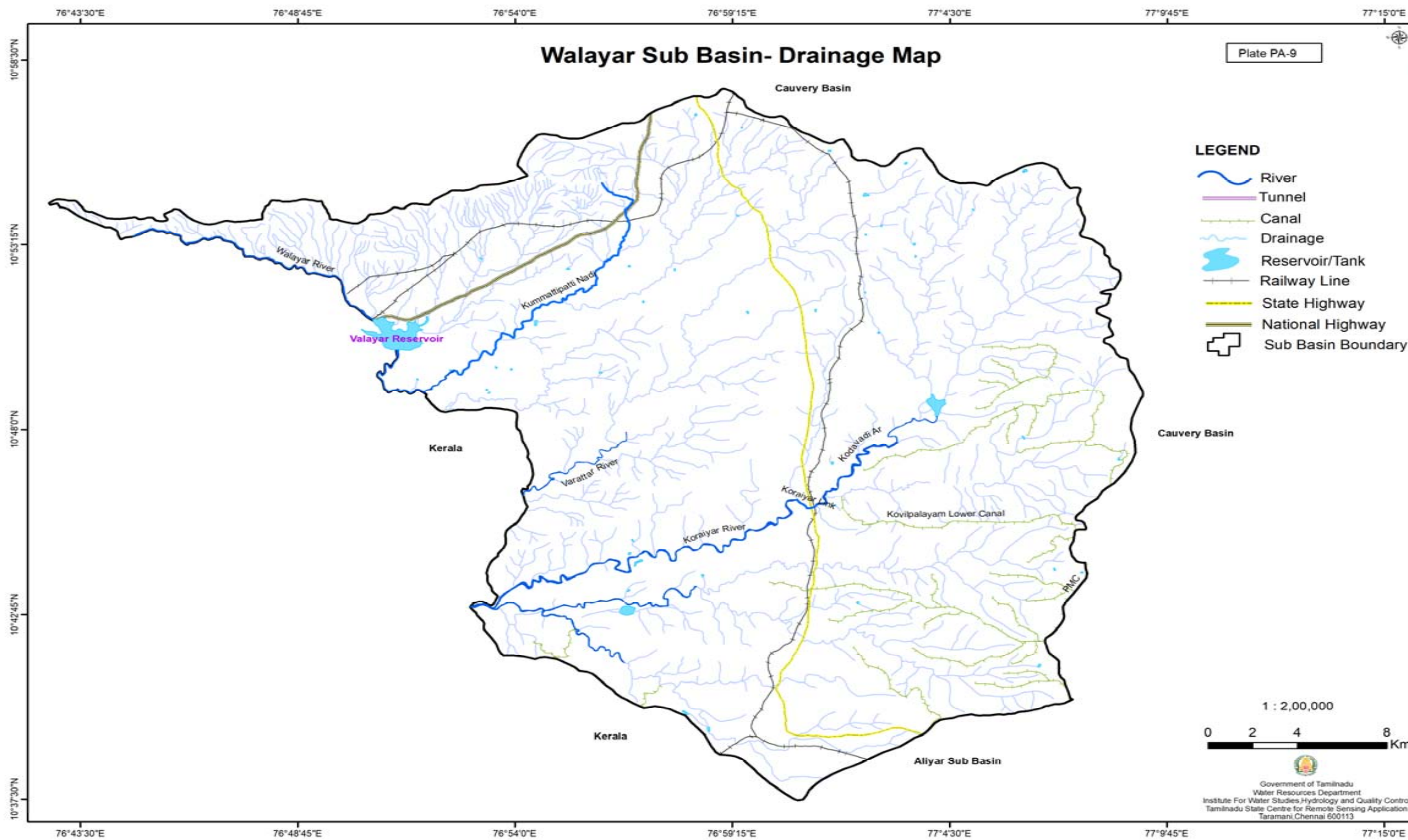
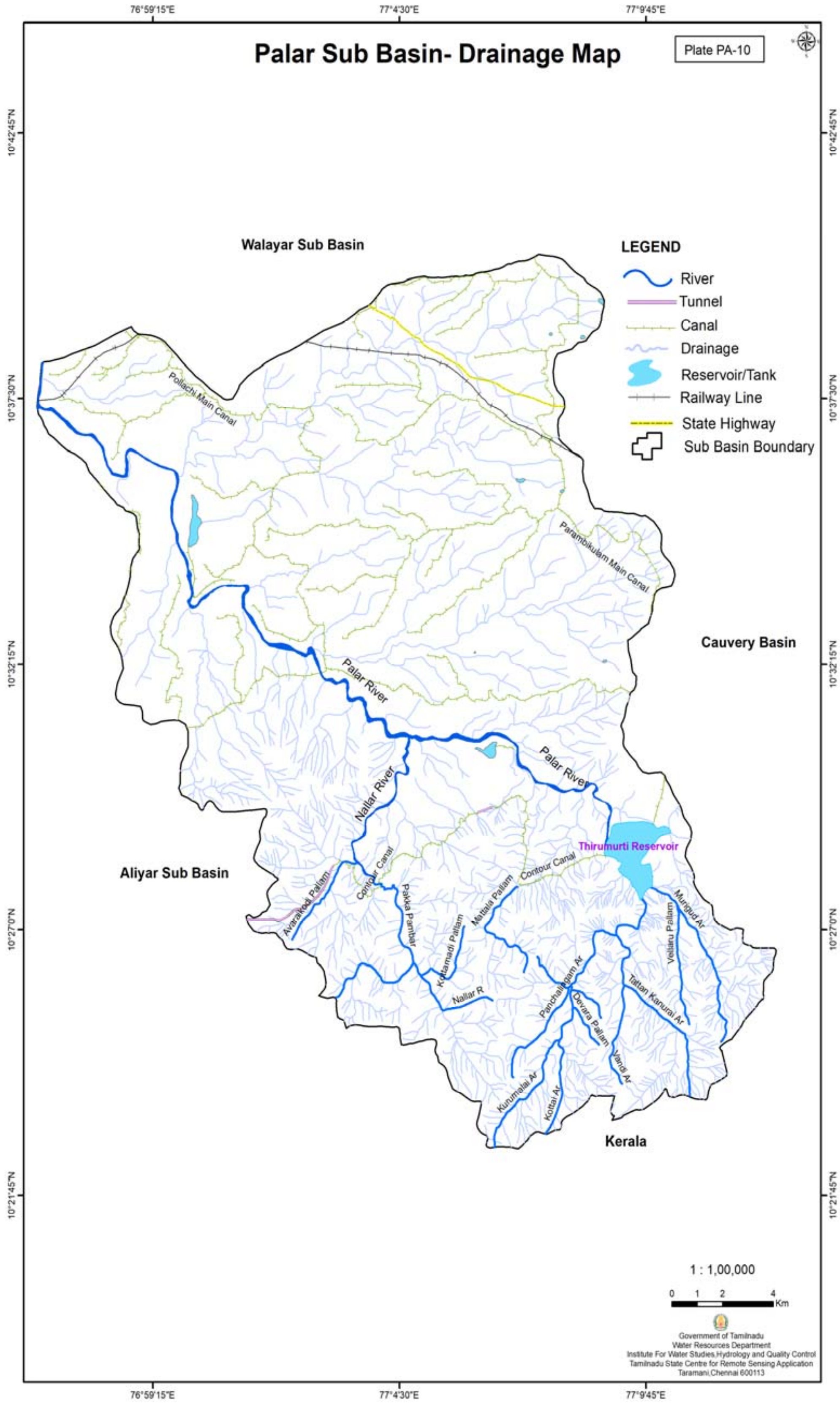
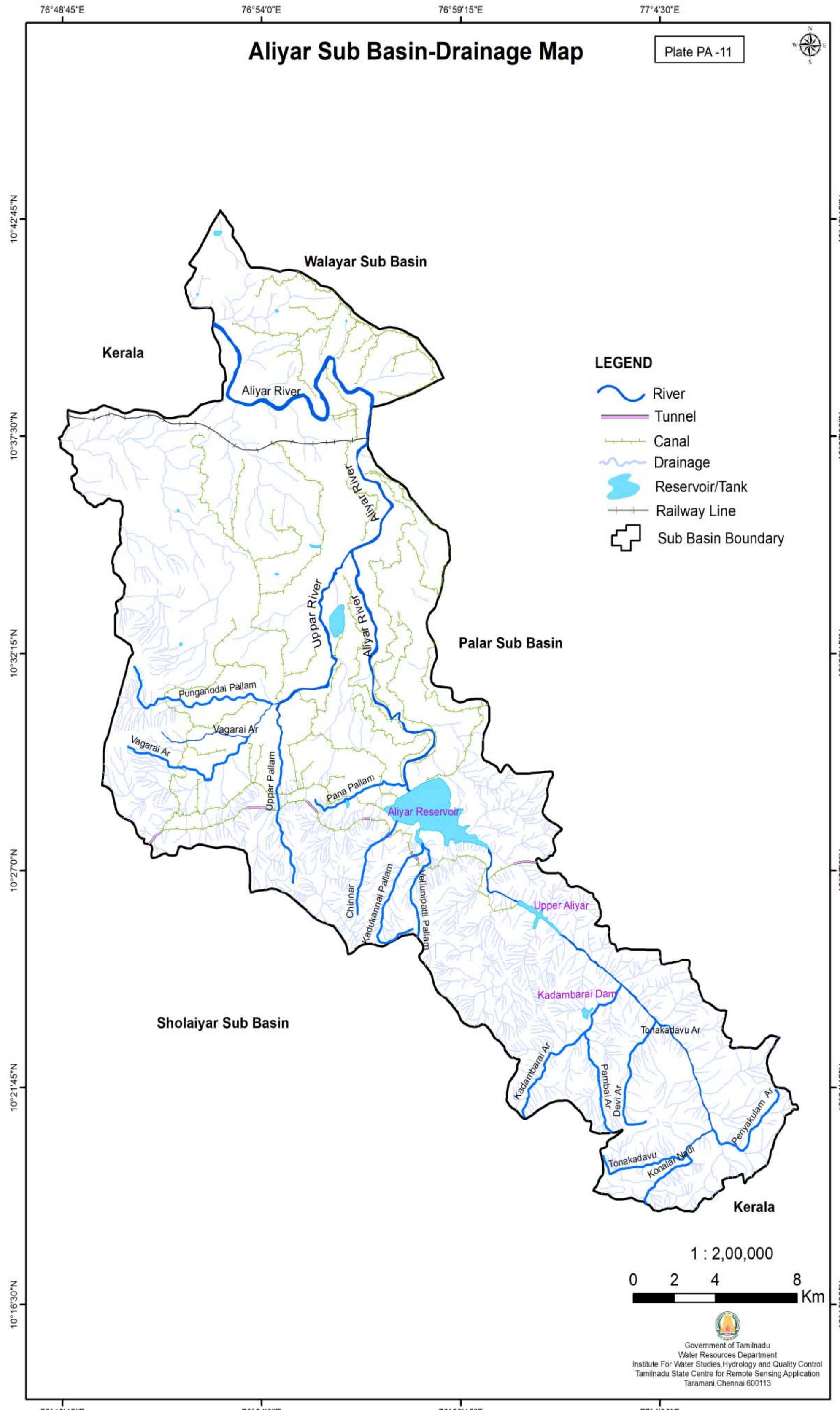

Walayar Sub Basin- Drainage Map
Plate PA-9
Cauvery Basin
LEGEND
River
Tunnel
Canal
Drainage
Reservoir/Tank
Railway Line
State Highway
National Highway
Sub Basin Boundary
Walayar River
Kummattipatti Nadi
Valayar Reservoir
Kerala
Varattar River
Koraiyar River
Kodavadi Ar
Kovilpalayam Lower Canal
PMC
Cauvery Basin
Kerala
Aliyar Sub Basin
1 : 2,00,000
0 2 4 8 Km
76°43'30"E
76°48'45"E
76°54'0"E
76°59'15"E
77°4'30"E
77°9'45"E
77°15'0"E
10°58'30"N
10°53'15"N
10°48'0"N
10°42'45"N
10°37'30"N
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113


Palar Sub Basin- Drainage Map
Plate PA-10
76°59'15"E
77°4'30"E
77°9'45"E
10°42'45"N
10°37'30"N
10°32'15"N
10°27'0"N
10°21'45"N
Walayar Sub Basin
LEGEND
River
Tunnel
Canal
Drainage
Reservoir/Tank
Railway Line
State Highway
Sub Basin Boundary
Pollachi Main Canal
Parambikulam Main Canal
Cauvery Basin
Palar River
Palar River
Nallar River
Thirumurti Reservoir
Contour Canal
Contour Canal
Aliyar Sub Basin
Avarankodi Pallam
Pakka Pambar
Mattala Pallam
Kottamadi Pallam
Nallar R
Panchalingam Ar
Devara Pallam
Vandi Ar
Tattan Kanurai Ar
Vellaru Pallam
Mungud Ar
Kurumalai Ar
Kottai Ar
Kerala
1 : 1,00,000
0 1 2 4 Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113


Aliyar Sub Basin-Drainage Map
Plate PA -11
76°48'45"E
76°54'0"E
76°59'15"E
77°4'30"E
10°42'45"N
10°37'30"N
10°32'15"N
10°27'0"N
10°21'45"N
10°16'30"N
Walayar Sub Basin
Kerala
Palar Sub Basin
Sholaiyar Sub Basin
Kerala
Aliyar River
Uppar River
Punganodai Pallam
Vagarai Ar
Vagarai Ar
Uppar Pallam
Pana Pallam
Aliyar Reservoir
Chinnar
Kadukammai Pallam
Nellunipatti Pallam
Upper Aliyar
Kadambarai Dam
Tonakadavu Ar
Kadambarai Ar
Pambai Ar
Devi Ar
Periyakulam Ar
Tonakadavu
Konalar Nadi
LEGEND
River
Tunnel
Canal
Drainage
Reservoir/Tank
Railway Line
Sub Basin Boundary
1 : 2,00,000
0 2 4 8
Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
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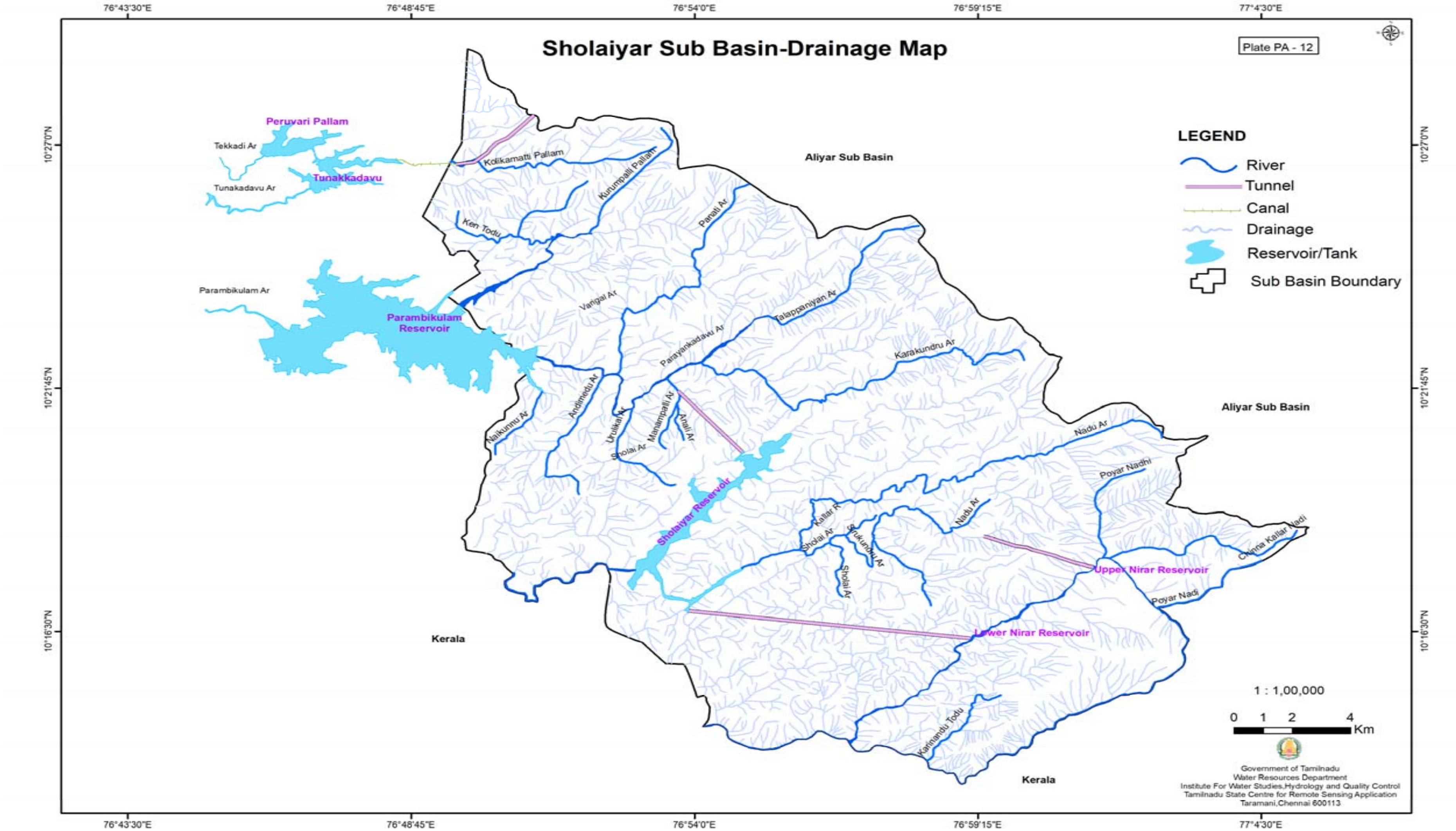
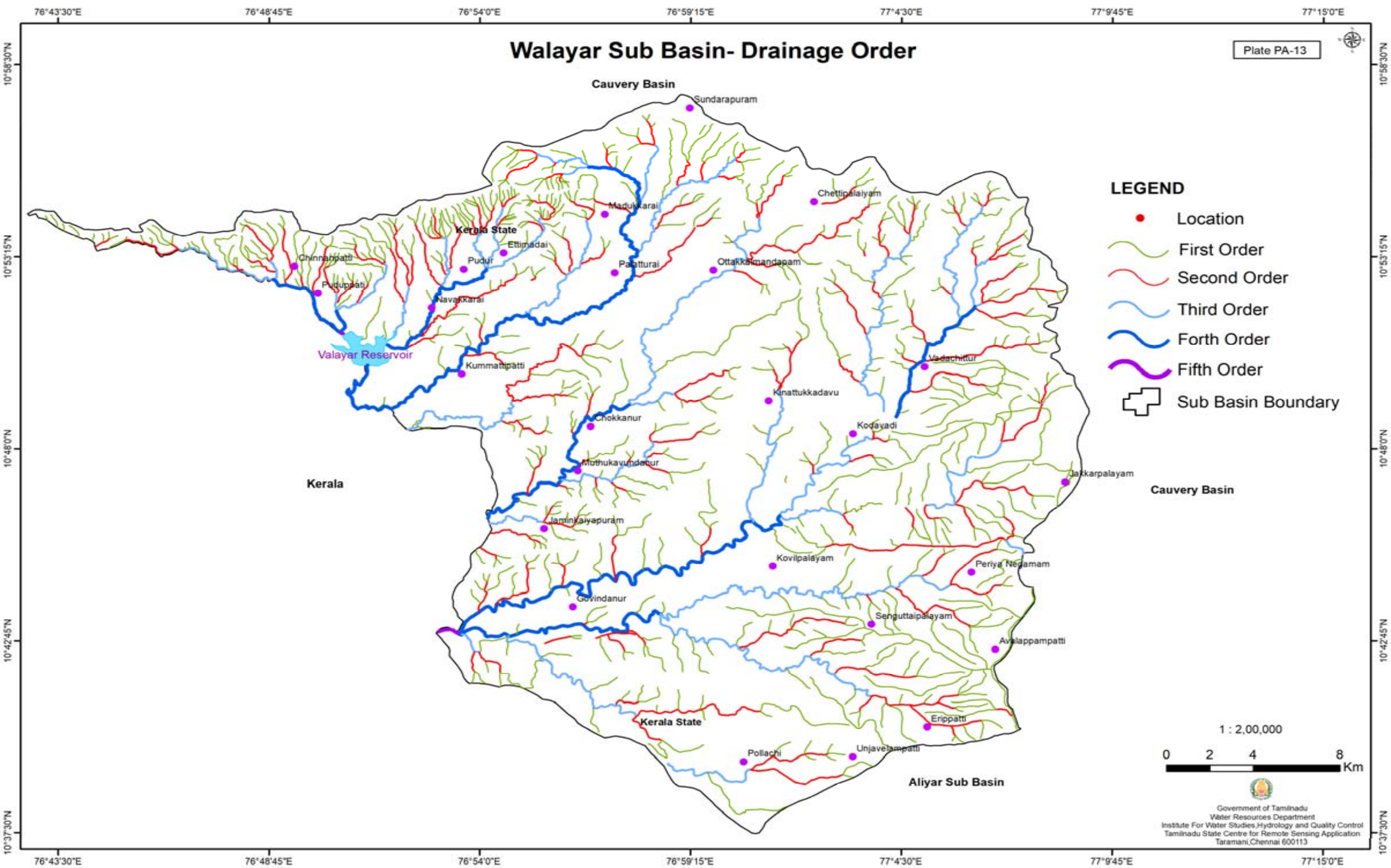
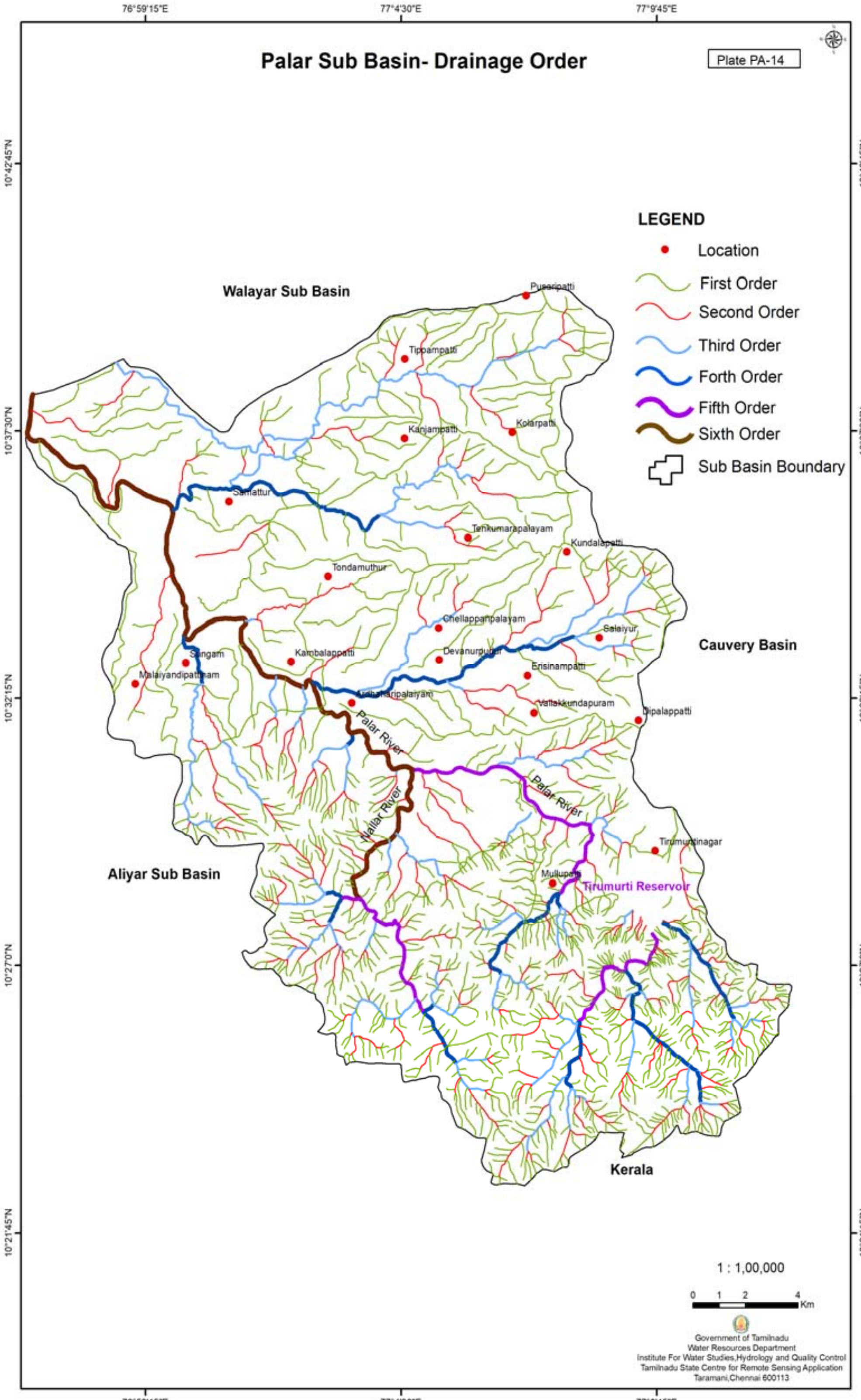
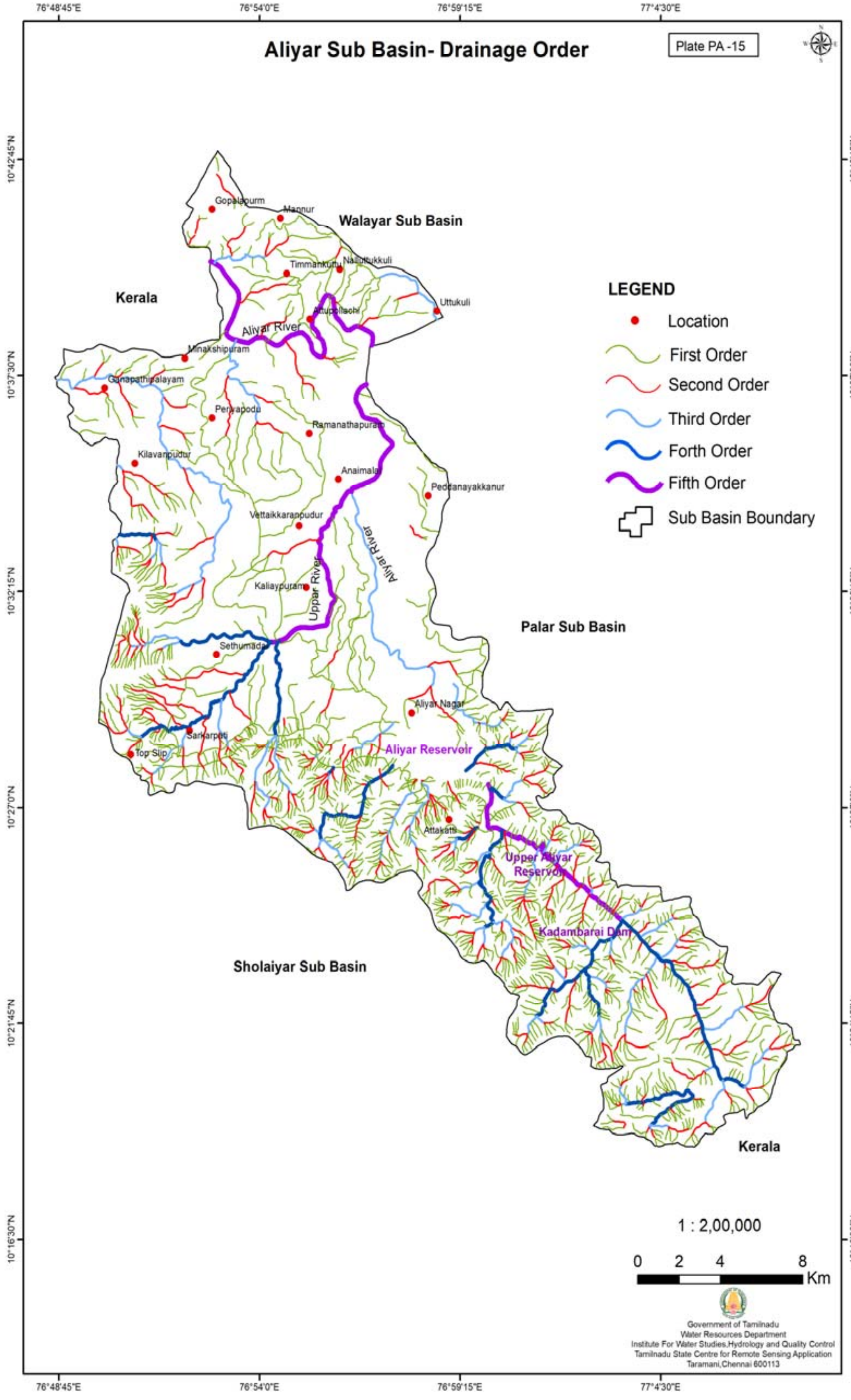


Sholaiyar Sub Basin-Drainage Map
Plate PA - 12
LEGEND
River
Tunnel
Canal
Drainage
Reservoir/Tank
Sub Basin Boundary
Aliyar Sub Basin
Aliyar Sub Basin
Kerala
Kerala
Peruvari Pallam
Tekkadi Ar
Tunakkadavu
Tunakadavu Ar
Parambikulam Ar
Parambikulam Reservoir
Kolikamatti Pallam
Kurumpalli Pallam
Ken Todu
Panali Ar
Varigal Ar
Talappaniyan Ar
Parayankadavu Ar
Karakundru Ar
Naikunnu Ar
Andimedu Ar
Urulikal Ar
Manampalli Ar
Anali Ar
Sholai Ar
Sholaiyar Reservoir
Nadu Ar
Poyar Nadhi
Kallar R
Sholai Ar
Sirukundru Ar
Sholai Ar
Nadu Ar
Chinna Kallar Nadi
Upper Nirar Reservoir
Poyar Nadi
Lower Nirar Reservoir
Karinandu Todu
1 : 1,00,000
0 1 2 4 Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113
76°43'30"E
76°48'45"E
76°54'0"E
76°59'15"E
77°4'30"E
10°27'0"N
10°21'45"N
10°16'30"N


Walayar Sub Basin- Drainage Order
Plate PA-13
Cauvery Basin
Sundarapuram
Chettipalaiyam
Madukkarai
Kerala State
Ettimadai
Pudur
Chinnampatti
Pudupati
Palatturai
Ottakkalmandapam
Navakkarai
Valayar Reservoir
Kummattipatti
Vadachittur
Kinattukkadavu
Chokkanur
Kodayadi
Muthukavundanur
Jakkarpalayam
Kerala
Cauvery Basin
Jaminkaliyapuram
Kovilpalayam
Periya Negamam
Govindanur
Senguttaipalayam
Avalappampatti
Kerala State
Erippatti
Pollachi
Unjavelampatti
Aliyar Sub Basin
LEGEND
Location
First Order
Second Order
Third Order
Forth Order
Fifth Order
Sub Basin Boundary
1 : 2,00,000
0 2 4 8 Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113
76°43'30"E
76°48'45"E
76°54'0"E
76°59'15"E
77°4'30"E
77°9'45"E
77°15'0"E
10°58'30"N
10°53'15"N
10°48'0"N
10°42'45"N
10°37'30"N


76°59'15"E
77°4'30"E
77°9'45"E
Palar Sub Basin- Drainage Order
Plate PA-14
10°42'45"N
10°37'30"N
10°32'15"N
10°27'0"N
10°21'45"N
LEGEND
Location
First Order
Second Order
Third Order
Forth Order
Fifth Order
Sixth Order
Sub Basin Boundary
Walayar Sub Basin
Cauvery Basin
Aliyar Sub Basin
Kerala
Pusaripatti
Tippampatti
Kanjampatti
Kolarpatti
Samattur
Tenkumarapalayam
Kundalapatti
Tondamuthur
Chellappanpalayam
Salaiyur
Sangam
Kambalappatti
Devanurpudur
Erisinampatti
Malaiyandipattinam
Vallakkundapuram
Dipalappatti
Palar River
Nallar River
Tirumurtinagar
Mullupadi
Tirumurti Reservoir
1 : 1,00,000
0 1 2 4 Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113



Aliyar Sub Basin- Drainage Order
Plate PA -15
76°48'45"E
76°54'0"E
76°59'15"E
77°4'30"E
10°42'45"N
10°37'30"N
10°32'15"N
10°27'0"N
10°21'45"N
10°16'30"N
Walayar Sub Basin
Kerala
Palar Sub Basin
Sholaiyar Sub Basin
Kerala
Gopalapurm
Mannur
Timmankuttu
Nallattukkuli
Uttukuli
Attupollachi
Aliyar River
Minakshipuram
Ganapathipalayam
Periyapodu
Ramanathapuram
Kilavanpudur
Anaimalai
Peddanayakkanur
Vettaikkaranpudur
Aliyar River
Upper River
Kaliaypuram
Sethumadai
Aliyar Nagar
Sarkarpoti
Top Slip
Aliyar Reservoir
Attakatti
Upper Aliyar Reservoir
Kadambarai Dam
LEGEND
Location
First Order
Second Order
Third Order
Forth Order
Fifth Order
Sub Basin Boundary
1 : 2,00,000
0 2 4 8
Km
Government of Tamilnadu
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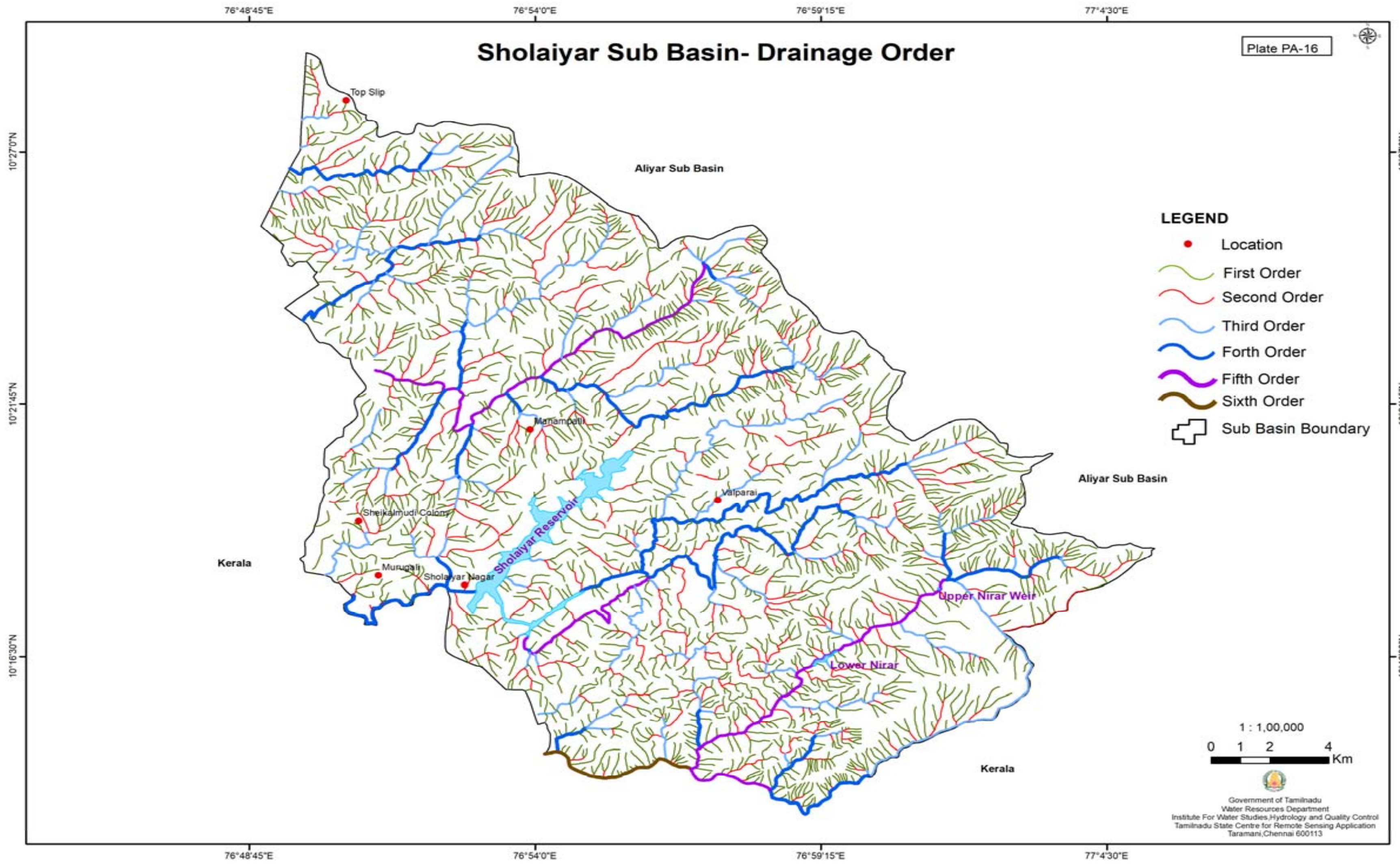
76°48'45"E
76°54'0"E
76°59'15"E
77°4'30"E
10°27'0"N
10°21'45"N
10°16'30"N
Sholaiyar Sub Basin- Drainage Order
Plate PA-16
Top Slip
Aliyar Sub Basin
Manampalli
Valparai
Sholaiyar Reservoir
Sholaiyar Nagar
Murugali
Sheikalmudi Colony
Kerala
Upper Nirar Weir
Lower Nirar
Aliyar Sub Basin
Kerala
LEGEND
Location
First Order
Second Order
Third Order
Forth Order
Fifth Order
Sixth Order
Sub Basin Boundary
1 : 1,00,000
0 1 2 4 Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
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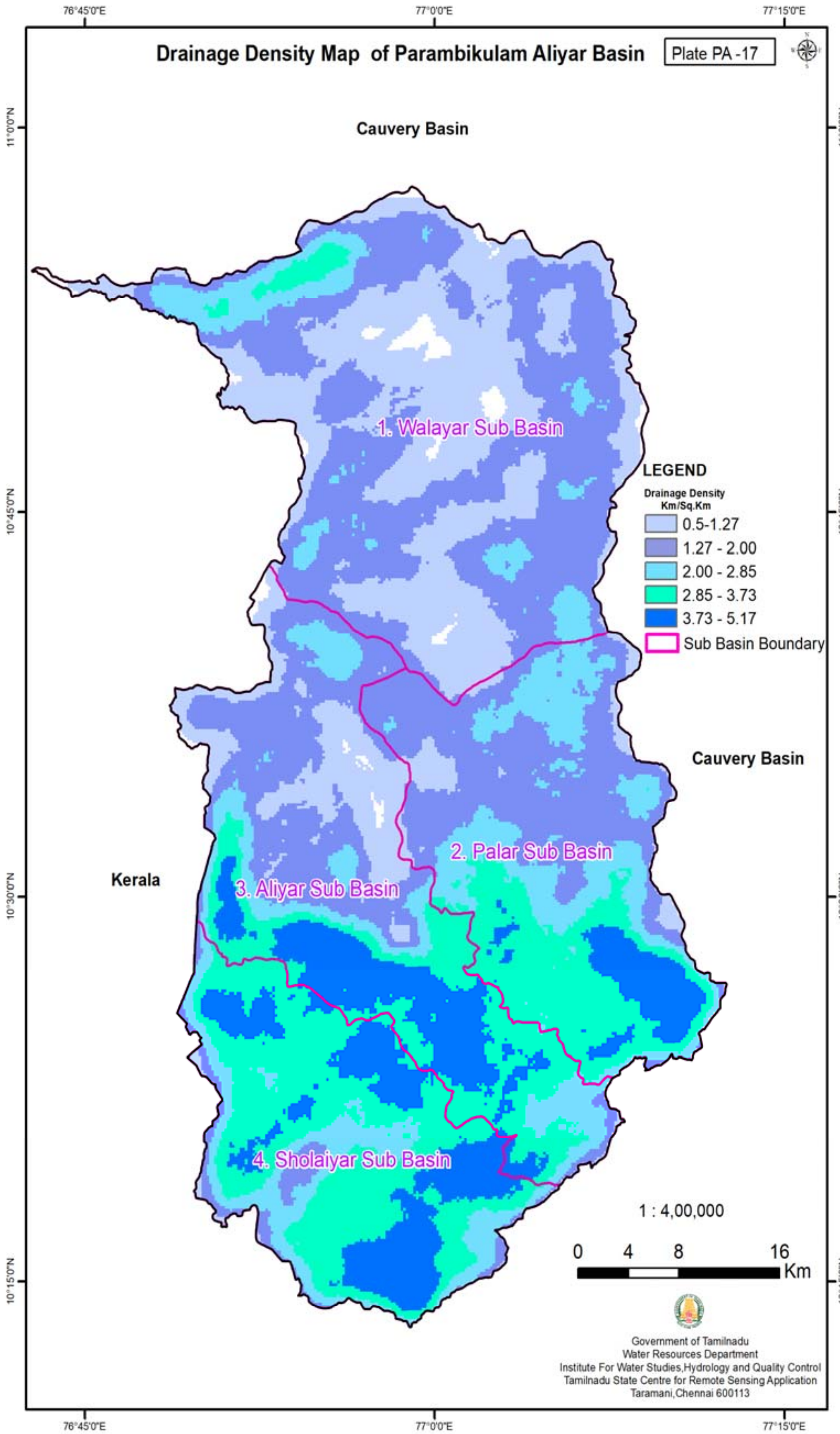

76°45'0"E
77°0'0"E
77°15'0"E
Drainage Density Map of Parambikulam Aliyar Basin
Plate PA -17
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N
Cauvery Basin
1. Walayar Sub Basin
LEGEND
Drainage Density
Km/Sq.Km
0.5-1.27
1.27 - 2.00
2.00 - 2.85
2.85 - 3.73
3.73 - 5.17
Sub Basin Boundary
Cauvery Basin
2. Palar Sub Basin
Kerala
3. Aliyar Sub Basin
4. Sholaiyar Sub Basin
1 : 4,00,000
0 4 8 16
Km
Government of Tamilnadu
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Taramani,Chennai 600113

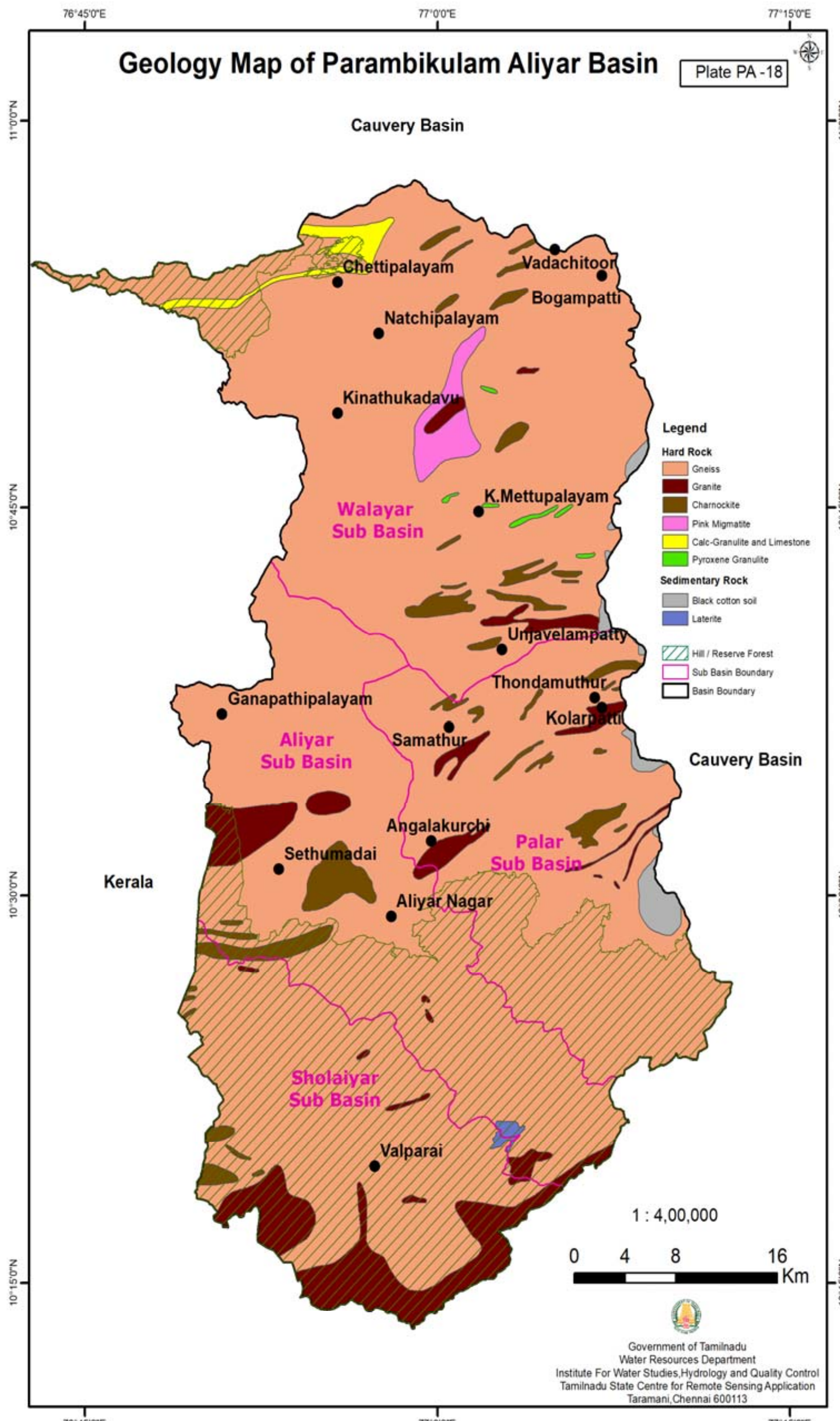
Geology Map of Parambikulam Aliyar Basin
Plate PA -18
Cauvery Basin
Chettipalayam
Vadachitoor
Bogampatti
Natchipalayam
Kinathukadavu
K.Mettupalayam
Walayar
Sub Basin
Unjavelampatty
Thondamuthur
Kolarpatti
Ganapathipalayam
Aliyar
Sub Basin
Samathur
Cauvery Basin
Angalakurchi
Sethumadai
Palar
Sub Basin
Kerala
Aliyar Nagar
Sholaiyar
Sub Basin
Valparai
Legend
Hard Rock
Gneiss
Granite
Charnockite
Pink Migmatite
Calc-Granulite and Limestone
Pyroxene Granulite
Sedimentary Rock
Black cotton soil
Laterite
Hill / Reserve Forest
Sub Basin Boundary
Basin Boundary
1 : 4,00,000
0 4 8 16 Km
76°45'0"E
77°0'0"E
77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N
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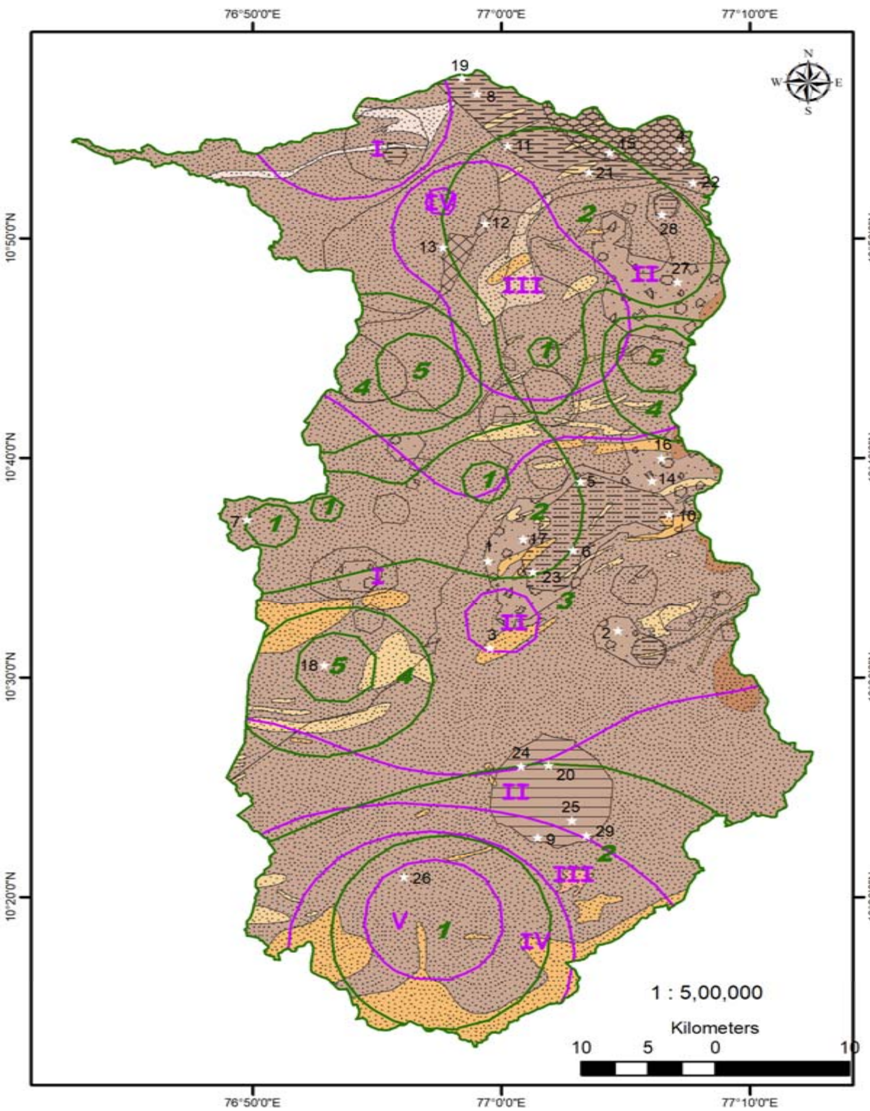
Plate PA-19

HYDRO GEOLOGY OF PARAMBIKULAM ALIYAR BASIN



Legend

Water Level in m - Pre Monsoon 2018

EC in µS/cm - Pre Monsson 2018

Geology

- Black cotton soil
- Calc-Granulite and Limestone
- Charnockite
- Gneiss
- Granite
- Laterite
- Pink Migmatite
- Pyroxene Granulite

Sl.No	Location	Yield in L/m	Recuperation in Hours
1	ALAGAPURI	100	6
2	ANDIYUR	135	6
3	ANGALAKKURICHI	100	6
4	BOGAMPATTI	85	10
5	CHANDRAPURAM	85	10
6	DHALAVAIPALAYAM	85	10
7	GANAPATHIPALAIYAM	100	6
8	GANASHAPURAM	85	10
9	KADAMPARAI	50	10
10	KOLARPATTI	85	10
11	MALUMACHCHAMPATTI	85	10
12	MAMBALLI	130	6
13	MINAKSHIPURAM	85	10
14	NALLAMPALLI	85	10
15	PERIYA KUYILAI	85	10
16	POOSARIPATTI	100	6
17	SAMATHUR	85	10
18	SETHUMADAI	85	10
19	SUNDARAPURAM	85	10
20	TANAKKALPATTI	9	15
21	TEGANI	85	10
22	TOTTIPALAIYAM	50	10
23	UNJAPALAIYAM	50	10
24	UPPER ALIYAR	9	15
25	URAMA KUNDRU	9	15
26	VALPARAI	9	15
27	VANJIPALAIYAM	85	10
28	VELLEKAVUNDANPUDUR	100	6
29	VELLIMUDIPATTI	9	15

Weathered - Fractured Zone

- HW-HF (30-140 m)
- HW-MF (30 -70 m)
- LW-LF (10-40 m)
- LW-MF (10- 70 m)
- MW-HF (20-140 m)
- MW-LF (20- 40 m)
- MW-MF (20 - 70 m)

Water level (m bgl)

I - 6.9 to 10
II - 11 to 13
III - 14 to 16
IV - 17 to 19
V - 20 to 21

Electrical Conductivity (µS/cm)

1 - 70 to 250
2 - 251 to 500
3 - 501 to 750
4 - 751 to 1000
5 - 1001 to 1331

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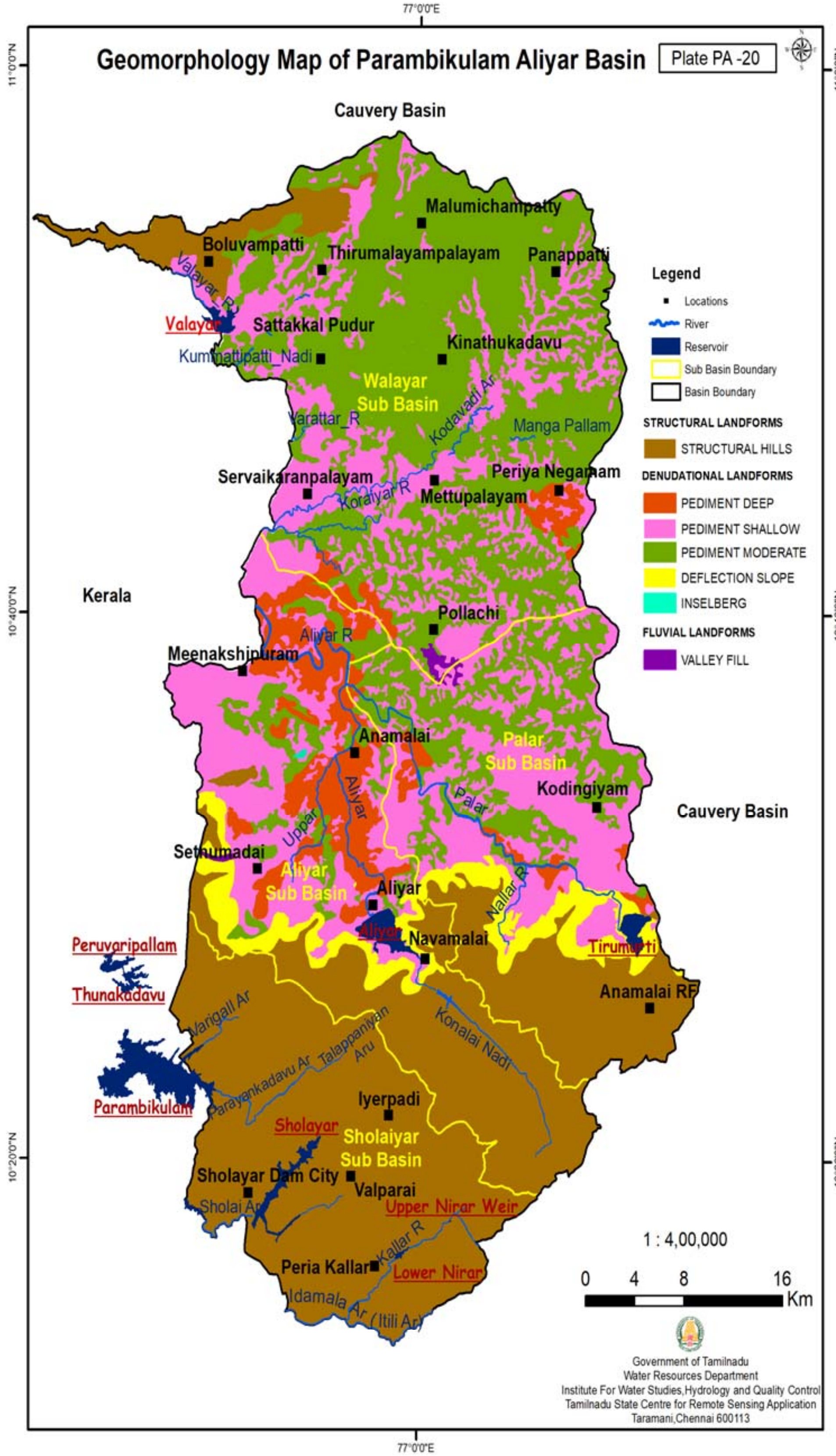
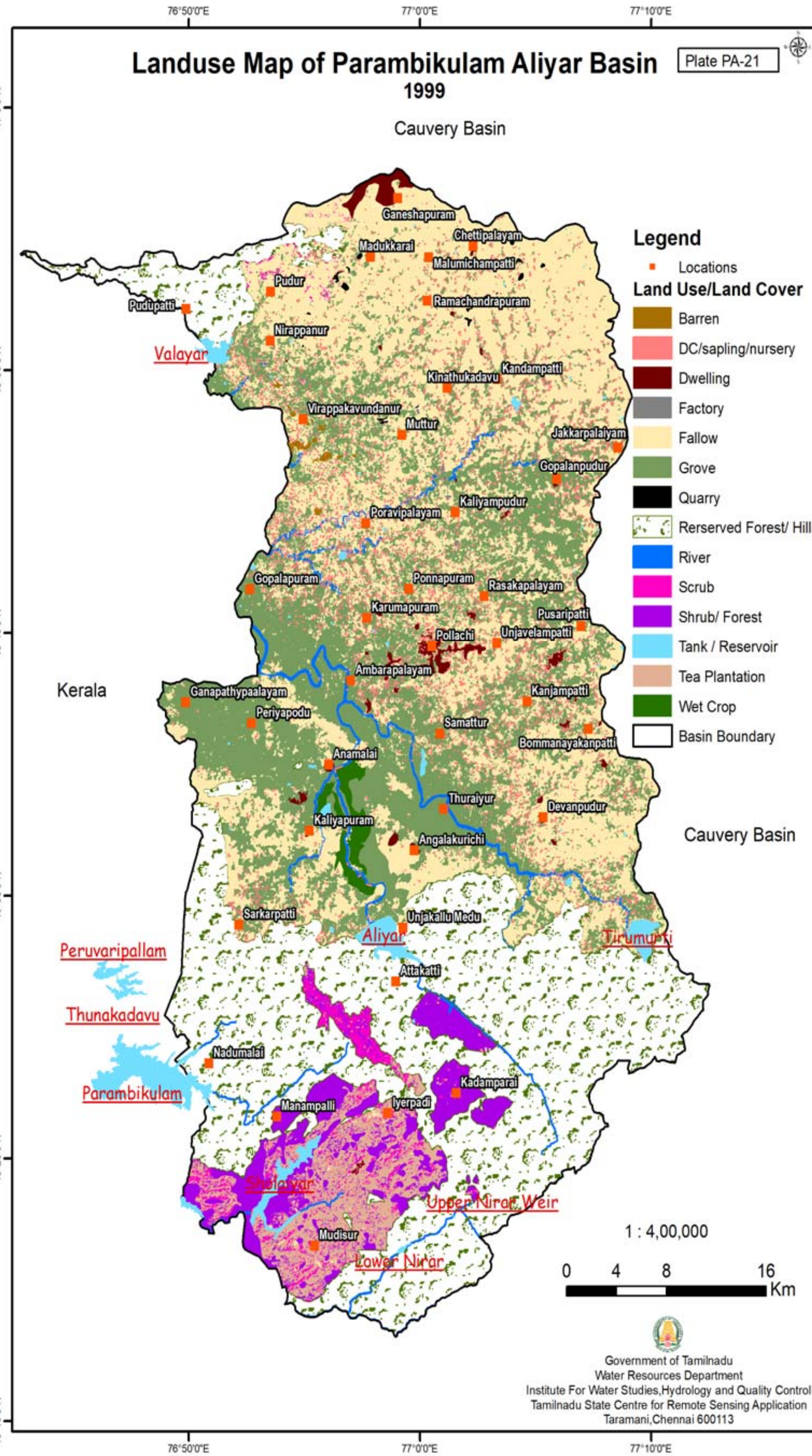

Geomorphology Map of Parambikulam Aliyar Basin
Plate PA -20
77°0'0"E
11°0'0"N
10°40'0"N
10°20'0"N
Cauvery Basin
Kerala
Cauvery Basin
Malumichampatty
Boluvampatti
Thirumalayampalayam
Panappatti
Valayar_R
Valayar
Sattakkal Pudur
Kumittipatti_Nadi
Kinathukadavu
Walayar
Sub Basin
Varattar_R
Kodavadi Ar
Manga Pallam
Servaikaranpalayam
Koraiyar R
Mettupalayam
Periya Negamam
Pollachi
Aliyar R
Meenakshipuram
Anamalai
Palar
Sub Basin
Aliyar
Uppar
Palar
Kodingiyam
Sethumadai
Aliyar
Sub Basin
Aliyar
Nallar R
Aliyar
Navamalai
Tirumurti
Peruvaripallam
Thunakadavu
Anamalai RF
Varigall Ar
Talappaniyan Aru
Konalai Nadi
Parayankadavu Ar
Parambikulam
Iyerpadi
Sholayar
Sholaiyar
Sub Basin
Sholayar Dam City
Valparai
Sholai Ar
Upper Nirar Weir
Kallar R
Peria Kallar
Lower Nirar
Idamala Ar (Itili Ar)
Legend
Locations
River
Reservoir
Sub Basin Boundary
Basin Boundary
STRUCTURAL LANDFORMS
STRUCTURAL HILLS
DENUDATIONAL LANDFORMS
PEDIMENT DEEP
PEDIMENT SHALLOW
PEDIMENT MODERATE
DEFLECTION SLOPE
INSELBERG
FLUVIAL LANDFORMS
VALLEY FILL
1 : 4,00,000
0 4 8 16
Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113


Landuse Map of Parambikulam Aliyar Basin
1999
Plate PA-21
Cauvery Basin
Kerala
Cauvery Basin
Legend
Locations
Land Use/Land Cover
Barren
DC/sapling/nursery
Dwelling
Factory
Fallow
Grove
Quarry
Rerserved Forest/ Hill
River
Scrub
Shrub/ Forest
Tank / Reservoir
Tea Plantation
Wet Crop
Basin Boundary
Ganeshapuram
Chettipalayam
Madukkarai
Malumichampatti
Pudur
Pudupatti
Ramachandrapuram
Nirappanur
Valayar
Kinathukadavu
Kandampatti
Virappakavundanur
Muttur
Jakkarpalaiyam
Gopalanpudur
Kaliyampudur
Poravipalayam
Gopalapuram
Ponnapuram
Rasakapalayam
Karumapuram
Pusaripatti
Pollachi
Unjavelampatti
Ambarapalayam
Ganapathypaalayam
Kanjampatti
Periyapodu
Samattur
Bommanayakanpatti
Anamalai
Thuraiyur
Devanpudur
Kaliyapuram
Angalakurichi
Sarkarpatti
Unjakallu Medu
Aliyar
Tirumurti
Peruvaripallam
Attakatti
Thunakadavu
Nadumalai
Kadamparai
Parambikulam
Manampalli
Iyerpadi
Sholayar
Upper Nirar Weir
Mudisur
Lower Nirar
1 : 4,00,000
0 4 8 16 Km
76°50'0"E
77°0'0"E
77°10'0"E
11°0'0"N
10°50'0"N
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
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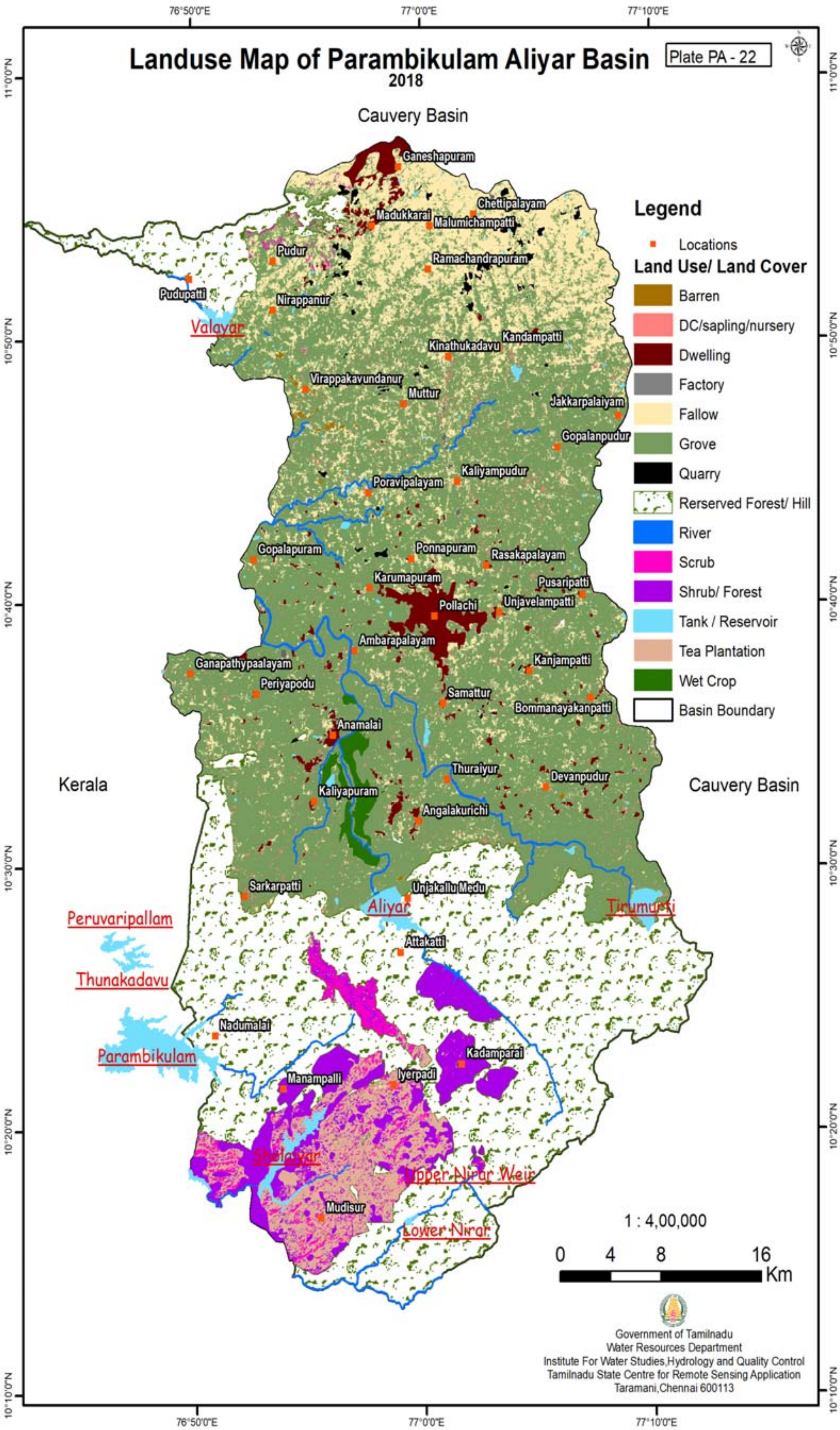
Landuse Map of Parambikulam Aliyar Basin
2018
Plate PA - 22
Cauvery Basin
Kerala
Cauvery Basin
Legend
Locations
Land Use/ Land Cover
Barren
DC/sapling/nursery
Dwelling
Factory
Fallow
Grove
Quarry
Rerserved Forest/ Hill
River
Scrub
Shrub/ Forest
Tank / Reservoir
Tea Plantation
Wet Crop
Basin Boundary
Ganeshapuram
Chettipalayam
Madukkarai
Malumichampatti
Pudur
Ramachandrapuram
Pudupatti
Nirappanur
Valayar
Kandampatti
Kinathukadavu
Virappakavundanur
Muttur
Jakkarpalaiyam
Gopalanpudur
Kaliyampudur
Poravipalayam
Gopalapuram
Ponnapuram
Rasakapalayam
Karumapuram
Pusaripatti
Pollachi
Unjavelampatti
Ambarapalayam
Ganapathypaalayam
Kanjampatti
Periyapodu
Samattur
Bommanayakanpatti
Anamalai
Thuraiyur
Devanpudur
Kaliyapuram
Angalakurichi
Sarkarpatti
Unjakallu Medu
Aliyar
Tirumurti
Peruvaripallam
Attakatti
Thunakadavu
Nadumalai
Parambikulam
Kadamparai
Manampalli
Iyerpadi
Sholayar
Upper Nirar Weir
Mudisur
Lower Nirar
1 : 4,00,000
0 4 8 16
Km
76°50'0"E
77°0'0"E
77°10'0"E
11°0'0"N
10°50'0"N
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
Government of Tamilnadu
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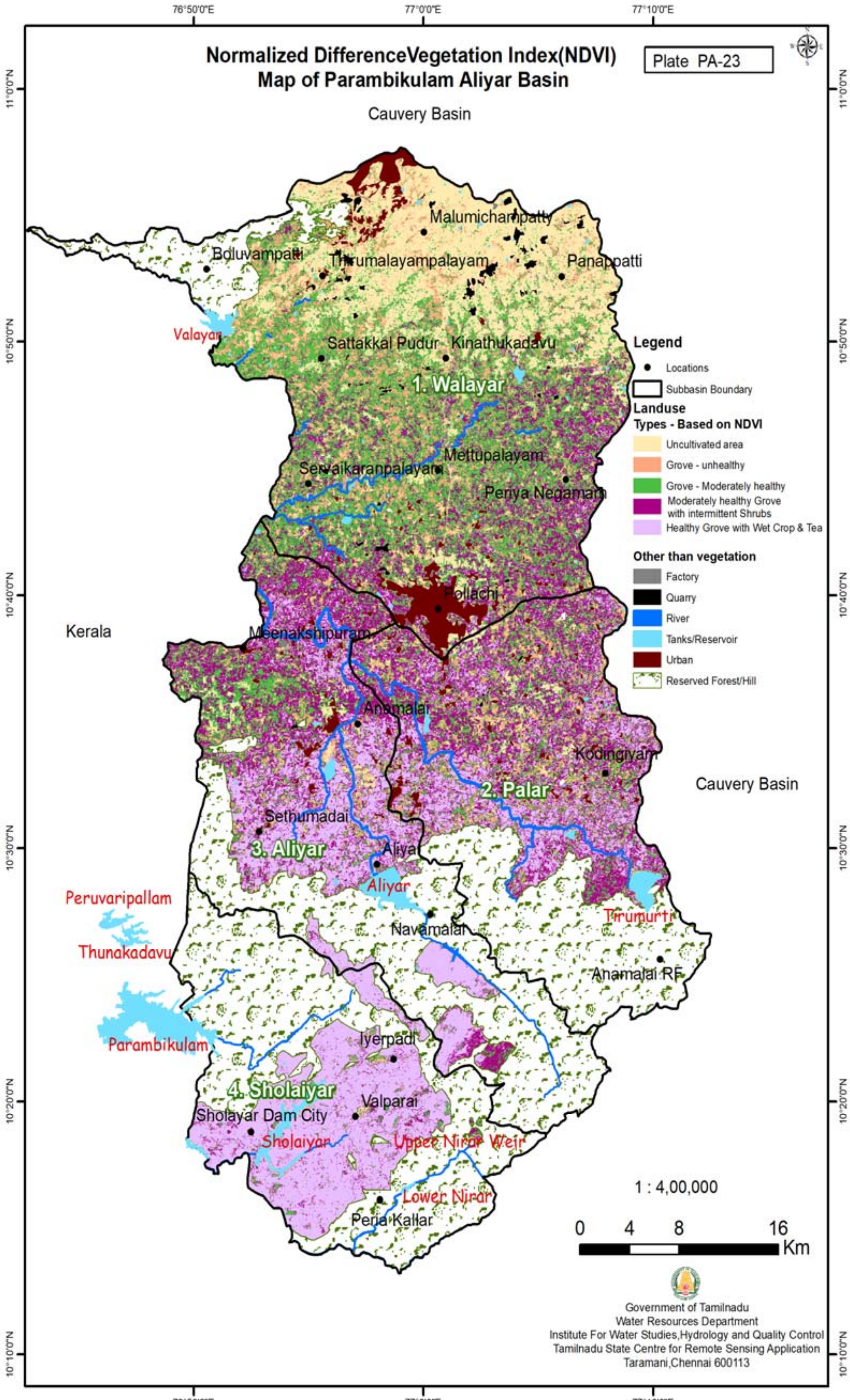
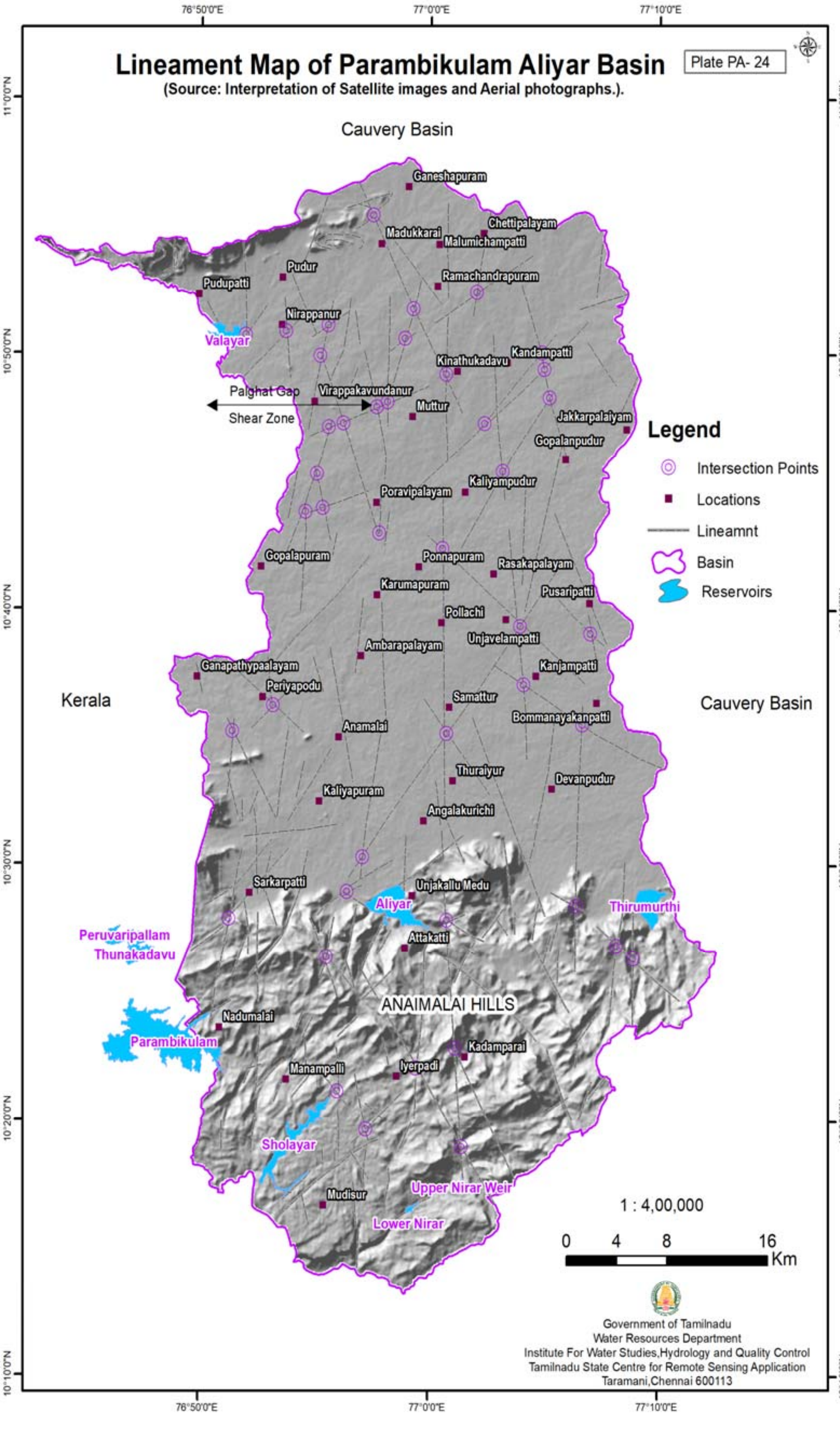
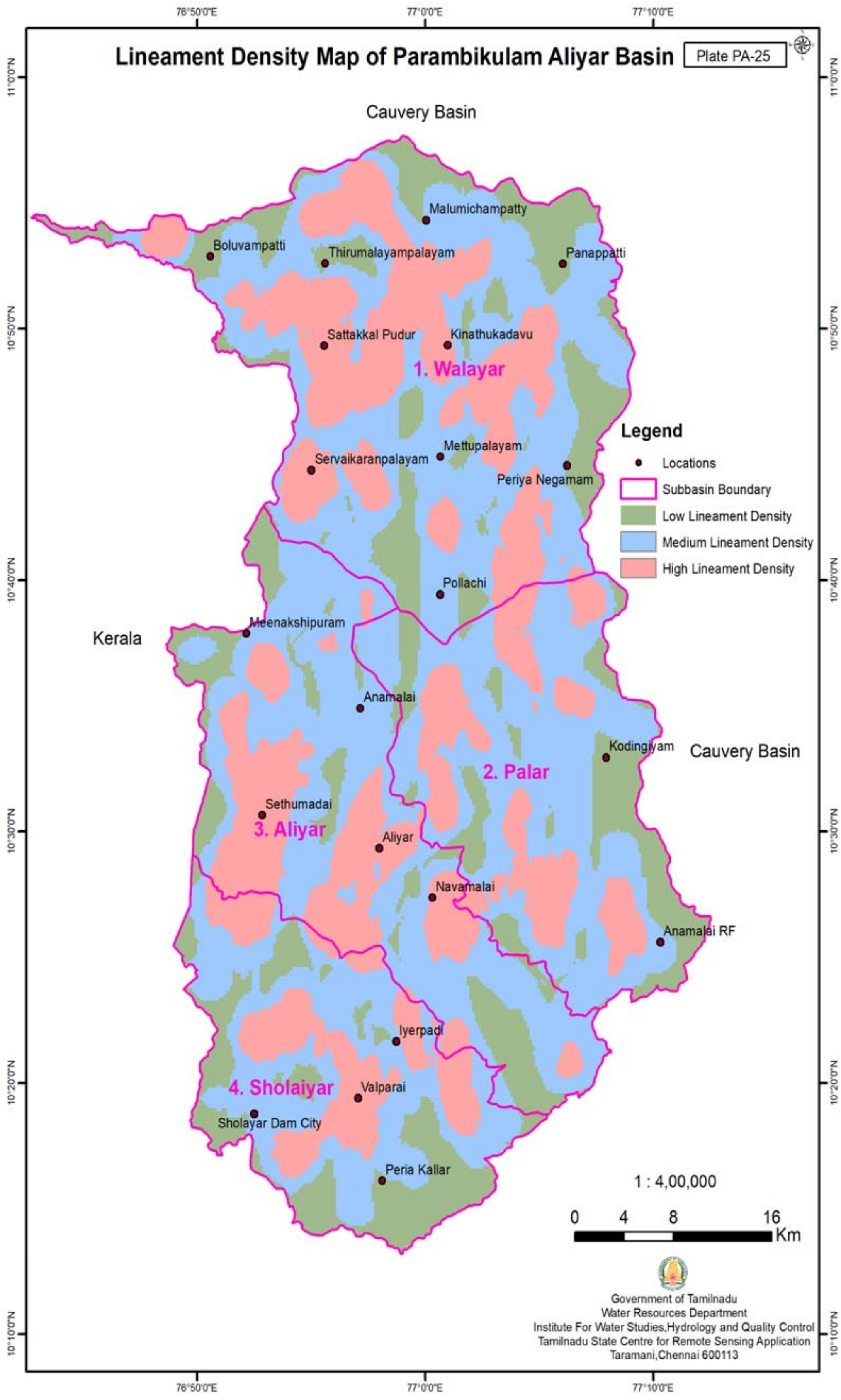

Normalized DifferenceVegetation Index(NDVI)
Map of Parambikulam Aliyar Basin
Plate PA-23
Cauvery Basin
Malumichampatty
Boluvampatti
Thirumalayampalayam
Panappatti
Valayar
Sattakkal Pudur
Kinathukadavu
1. Walayar
Mettupalayam
Servaikaranpalayam
Periya Negamam
Pollachi
Kerala
Meenakshipuram
Anamalai
Kodingiyam
2. Palar
Cauvery Basin
Sethumadai
3. Aliyar
Aliyar
Aliyar
Peruvaripallam
Tirumurti
Navamalai
Thunakadavu
Anamalai RF
Parambikulam
Iyerpadi
4. Sholaiyar
Sholayar Dam City
Valparai
Sholaiyar
Upper Nirar Weir
Lower Nirar
Peria Kallar
Legend
Locations
Subbasin Boundary
Landuse
Types - Based on NDVI
Uncultivated area
Grove - unhealthy
Grove - Moderately healthy
Moderately healthy Grove with intermittent Shrubs
Healthy Grove with Wet Crop & Tea
Other than vegetation
Factory
Quarry
River
Tanks/Reservoir
Urban
Reserved Forest/Hill
1 : 4,00,000
0 4 8 16 Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113
76°50'0"E
77°0'0"E
77°10'0"E
11°0'0"N
10°50'0"N
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N



Lineament Map of Parambikulam Aliyar Basin
Plate PA- 24
(Source: Interpretation of Satellite images and Aerial photographs.).
Cauvery Basin
Ganeshapuram
Chettipalayam
Madukkarai
Malumichampatti
Pudur
Pudupatti
Ramachandrapuram
Nirappanur
Valayar
Kinathukadavu
Kandampatti
Palghat Gap
Shear Zone
Virappakavundanur
Muttur
Jakkarpalaiyam
Gopalanpudur
Kaliyampudur
Poravipalayam
Gopalapuram
Ponnapuram
Rasakapalayam
Karumapuram
Pusaripatti
Pollachi
Unjavelampatti
Ambarapalayam
Ganapathypaalayam
Kanjampatti
Periyapodu
Samattur
Kerala
Cauvery Basin
Bommanayakanpatti
Anamalai
Thuraiyur
Devanpudur
Kaliyapuram
Angalakurichi
Sarkarpatti
Unjakallu Medu
Aliyar
Thirumurthi
Peruvaripallam
Thunakadavu
Attakatti
ANAIMALAI HILLS
Nadumalai
Parambikulam
Kadamparai
Manampalli
Iyerpadi
Sholayar
Upper Nirar Weir
Mudisur
Lower Nirar
Legend
Intersection Points
Locations
Lineamnt
Basin
Reservoirs
1 : 4,00,000
0 4 8 16
Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113
76°50'0"E
77°0'0"E
77°10'0"E
11°0'0"N
10°50'0"N
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N



76°50'0"E
77°0'0"E
77°10'0"E
Lineament Density Map of Parambikulam Aliyar Basin
Plate PA-25
11°0'0"N
10°50'0"N
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
Cauvery Basin
Malumichampatty
Boluvampatti
Thirumalayampalayam
Panappatti
Sattakkal Pudur
Kinathukadavu
1. Walayar
Servaikaranpalayam
Mettupalayam
Periya Negamam
Pollachi
Meenakshipuram
Kerala
Anamalai
Kodingiyam
Cauvery Basin
2. Palar
Sethumadai
3. Aliyar
Aliyar
Navamalai
Anamalai RF
Iyerpadi
4. Sholaiyar
Valparai
Sholayar Dam City
Peria Kallar
Legend
Locations
Subbasin Boundary
Low Lineament Density
Medium Lineament Density
High Lineament Density
1 : 4,00,000
0 4 8 16
Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
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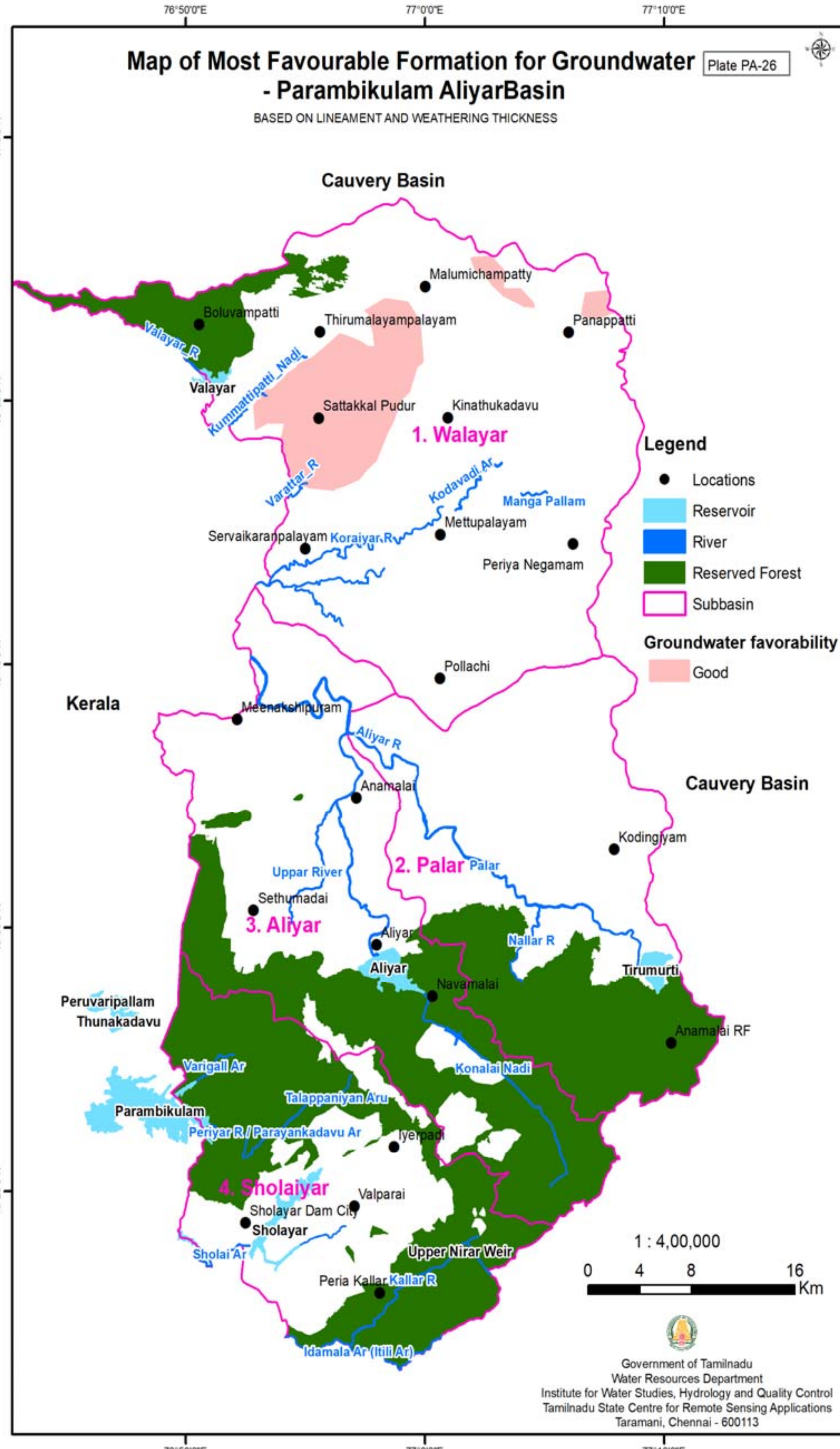
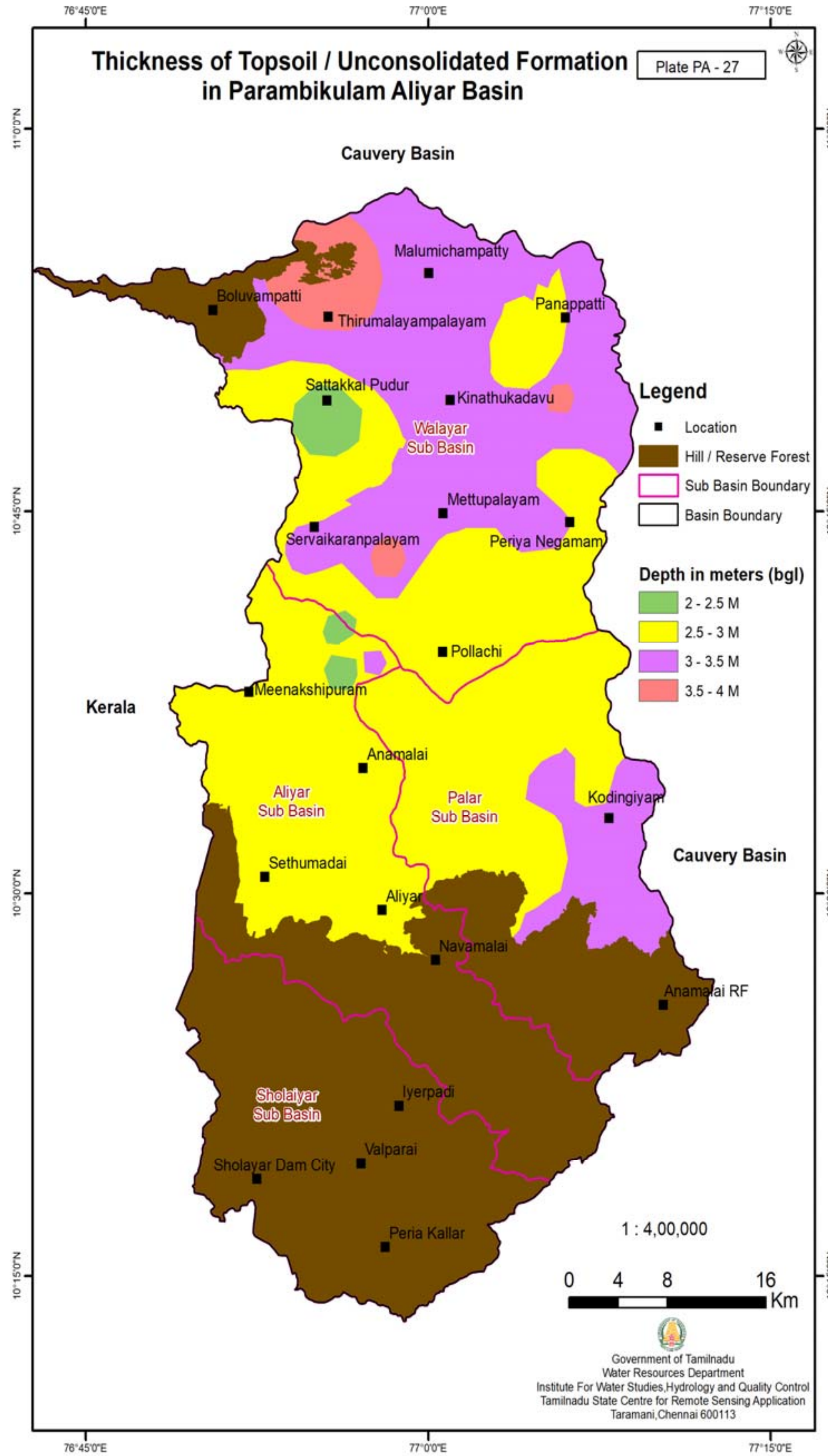
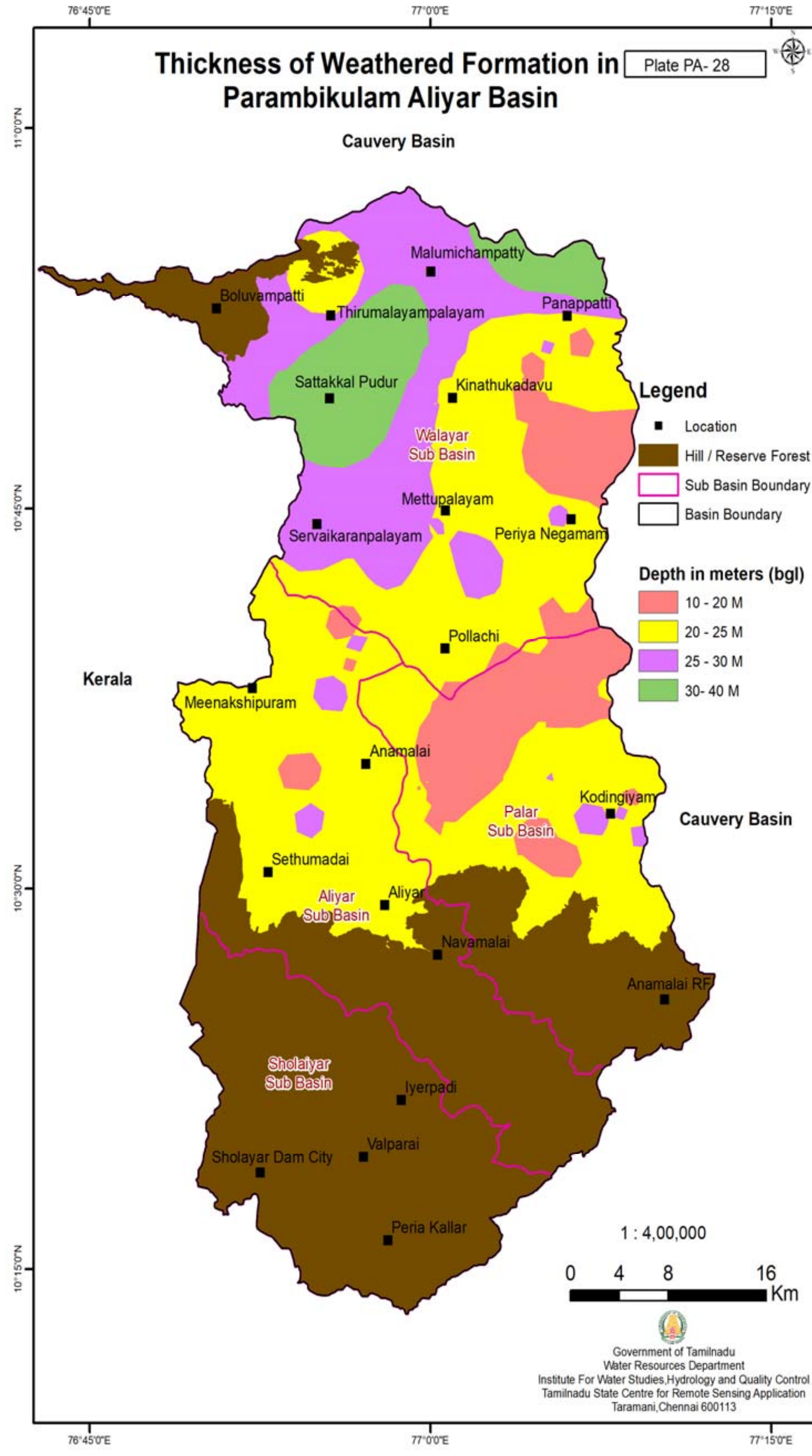

Map of Most Favourable Formation for Groundwater
- Parambikulam AliyarBasin
Plate PA-26
BASED ON LINEAMENT AND WEATHERING THICKNESS
Cauvery Basin
Malumichampatty
Boluvampatti
Thirumalayampalayam
Panappatti
Valayar_R
Valayar
Kummattipatti_Nadi
Sattakkal Pudur
Kinathukadavu
1. Walayar
Varattar_R
Kodavadi Ar
Manga Pallam
Servaikaranpalayam
Koraiyar R
Mettupalayam
Periya Negamam
Pollachi
Kerala
Meenakshipuram
Aliyar R
Anamalai
Cauvery Basin
Kodingiyam
Uppar River
2. Palar
Palar
Sethumadai
3. Aliyar
Aliyar
Nallar R
Tirumurti
Navamalai
Peruvaripallam
Thunakadavu
Anamalai RF
Varigall Ar
Konalai Nadi
Talappaniyan Aru
Parambikulam
Periyar R / Parayankadavu Ar
Iyerpadi
4. Sholaiyar
Valparai
Sholayar Dam City
Sholayar
Sholai Ar
Upper Nirar Weir
Peria Kallar
Kallar R
Idamala Ar (Itili Ar)
Legend
Locations
Reservoir
River
Reserved Forest
Subbasin
Groundwater favorability
Good
1 : 4,00,000
0 4 8 16
Km
Government of Tamilnadu
Water Resources Department
Institute for Water Studies, Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Applications
Taramani, Chennai - 600113
76°50'0"E
77°0'0"E
77°10'0"E
11°0'0"N
10°50'0"N
10°40'0"N
10°30'0"N
10°20'0"N


Thickness of Topsoil / Unconsolidated Formation
in Parambikulam Aliyar Basin
Plate PA - 27
76°45'0"E
77°0'0"E
77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N
Cauvery Basin
Malumichampatty
Boluvampatti
Thirumalayampalayam
Panappatti
Sattakkal Pudur
Kinathukadavu
Walayar
Sub Basin
Mettupalayam
Servaikaranpalayam
Periya Negamam
Pollachi
Meenakshipuram
Kerala
Anamalai
Aliyar
Sub Basin
Palar
Sub Basin
Kodingiyam
Cauvery Basin
Sethumadai
Aliyar
Navamalai
Anamalai RF
Sholaiyar
Sub Basin
Iyerpadi
Valparai
Sholayar Dam City
Peria Kallar
Legend
Location
Hill / Reserve Forest
Sub Basin Boundary
Basin Boundary
Depth in meters (bgl)
2 - 2.5 M
2.5 - 3 M
3 - 3.5 M
3.5 - 4 M
1 : 4,00,000
0 4 8 16
Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113


76°45'0"E
77°0'0"E
77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N
Thickness of Weathered Formation in
Parambikulam Aliyar Basin
Plate PA- 28
Cauvery Basin
Malumichampatty
Boluvampatti
Thirumalayampalayam
Panappatti
Sattakkal Pudur
Kinathukadavu
Walayar
Sub Basin
Mettupalayam
Servaikaranpalayam
Periya Negamam
Pollachi
Kerala
Meenakshipuram
Anamalai
Kodingiyam
Palar
Sub Basin
Cauvery Basin
Sethumadai
Aliyar
Aliyar
Sub Basin
Navamalai
Anamalai RF
Sholaiyar
Sub Basin
Iyerpadi
Valparai
Sholayar Dam City
Peria Kallar
Legend
Location
Hill / Reserve Forest
Sub Basin Boundary
Basin Boundary
Depth in meters (bgl)
10 - 20 M
20 - 25 M
25 - 30 M
30- 40 M
1 : 4,00,000
0 4 8 16
Km
Government of Tamilnadu
Water Resources Department
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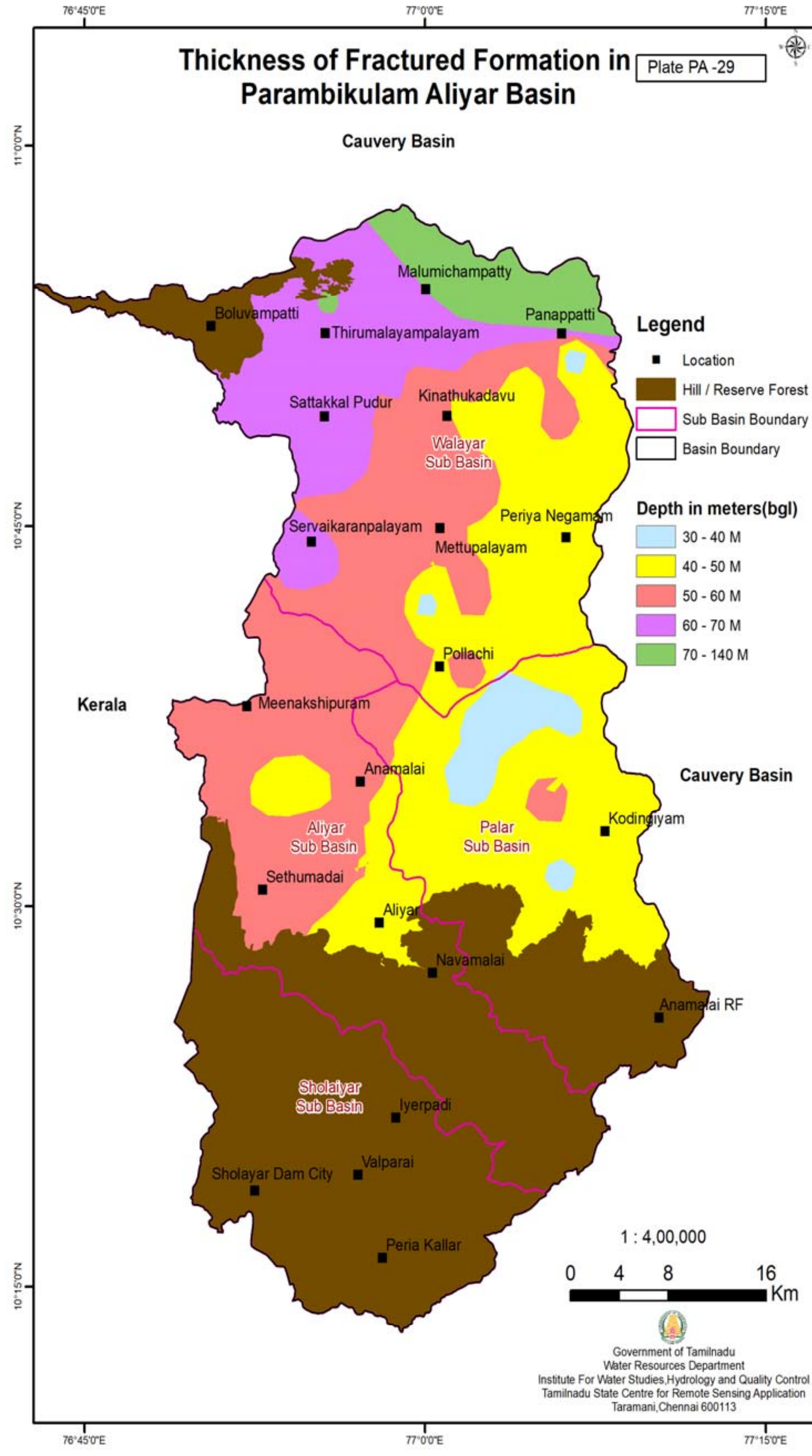

Thickness of Fractured Formation in Parambikulam Aliyar Basin
Plate PA -29
76°45'0"E
77°0'0"E
77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N
Cauvery Basin
Kerala
Cauvery Basin
Malumichampatty
Boluvampatti
Thirumalayampalayam
Panappatti
Sattakkal Pudur
Kinathukadavu
Walayar Sub Basin
Servaikaranpalayam
Mettupalayam
Periya Negamam
Pollachi
Meenakshipuram
Anamalai
Aliyar Sub Basin
Palar Sub Basin
Kodingiyam
Sethumadai
Aliyar
Navamalai
Anamalai RF
Sholaiyar Sub Basin
Iyerpadi
Valparai
Sholayar Dam City
Peria Kallar
Legend
Location
Hill / Reserve Forest
Sub Basin Boundary
Basin Boundary
Depth in meters(bgl)
30 - 40 M
40 - 50 M
50 - 60 M
60 - 70 M
70 - 140 M
1 : 4,00,000
0 4 8 16
Km
Government of Tamilnadu
Water Resources Department
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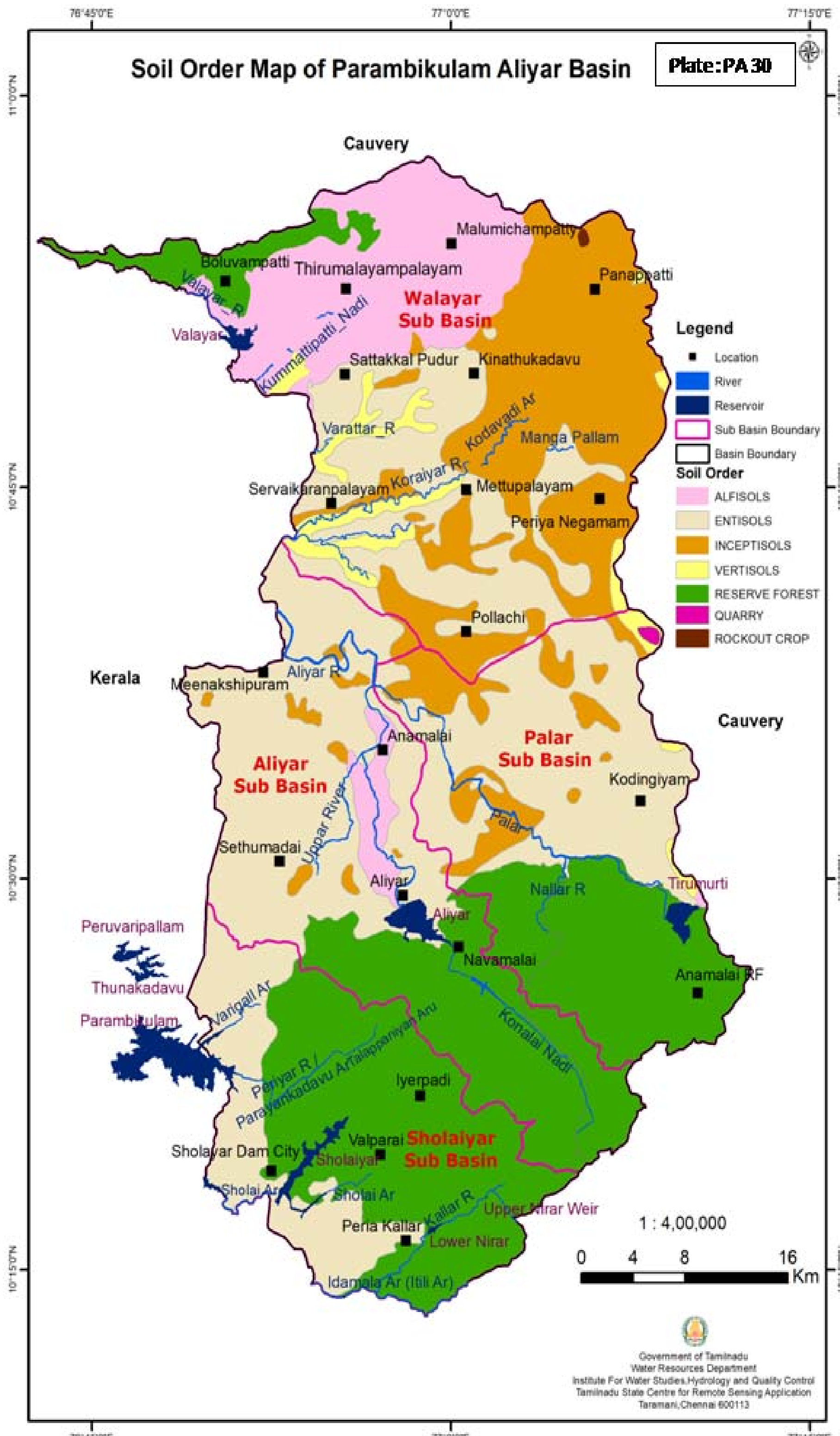
Soil Order Map of Parambikulam Aliyar Basin
Plate:PA 30
Cauvery
Malumichampatty
Boluvampatti
Thirumalayampalayam
Panappatti
Walayar Sub Basin
Valayar_R
Kummattipatti_Nadi
Valayar
Sattakkal Pudur
Kinathukadavu
Varattar_R
Kodavadi Ar
Manga Pallam
Servaikaranpalayam
Koraiyar R
Mettupalayam
Periya Negamam
Pollachi
Kerala
Meenakshipuram
Aliyar R
Cauvery
Anamalai
Palar Sub Basin
Aliyar Sub Basin
Kodingiyam
Upper River
Palar
Sethumadai
Aliyar
Tirumurti
Nallar R
Peruvaripallam
Aliyar
Navamalai
Thunakadavu
Anamalai RF
Parambikulam
Varigall Ar
Konalai Nadi
Periyar R / Parayankadavu Ar
Talappaniyan Aru
Iyerpadi
Sholaiyar Dam City
Valparai
Sholaiyar
Sholaiyar Sub Basin
Sholai Ar
Sholai Ar
Upper Nirar Weir
Peria Kallar
Kallar R
Lower Nirar
Idamala Ar (Itili Ar)
1 : 4,00,000
0 4 8 16
Km
Legend
Location
River
Reservoir
Sub Basin Boundary
Basin Boundary
Soil Order
ALFISOLS
ENTISOLS
INCEPTISOLS
VERTISOLS
RESERVE FOREST
QUARRY
ROCKOUT CROP
Government of Tamilnadu
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Tamilnadu State Centre for Remote Sensing Application
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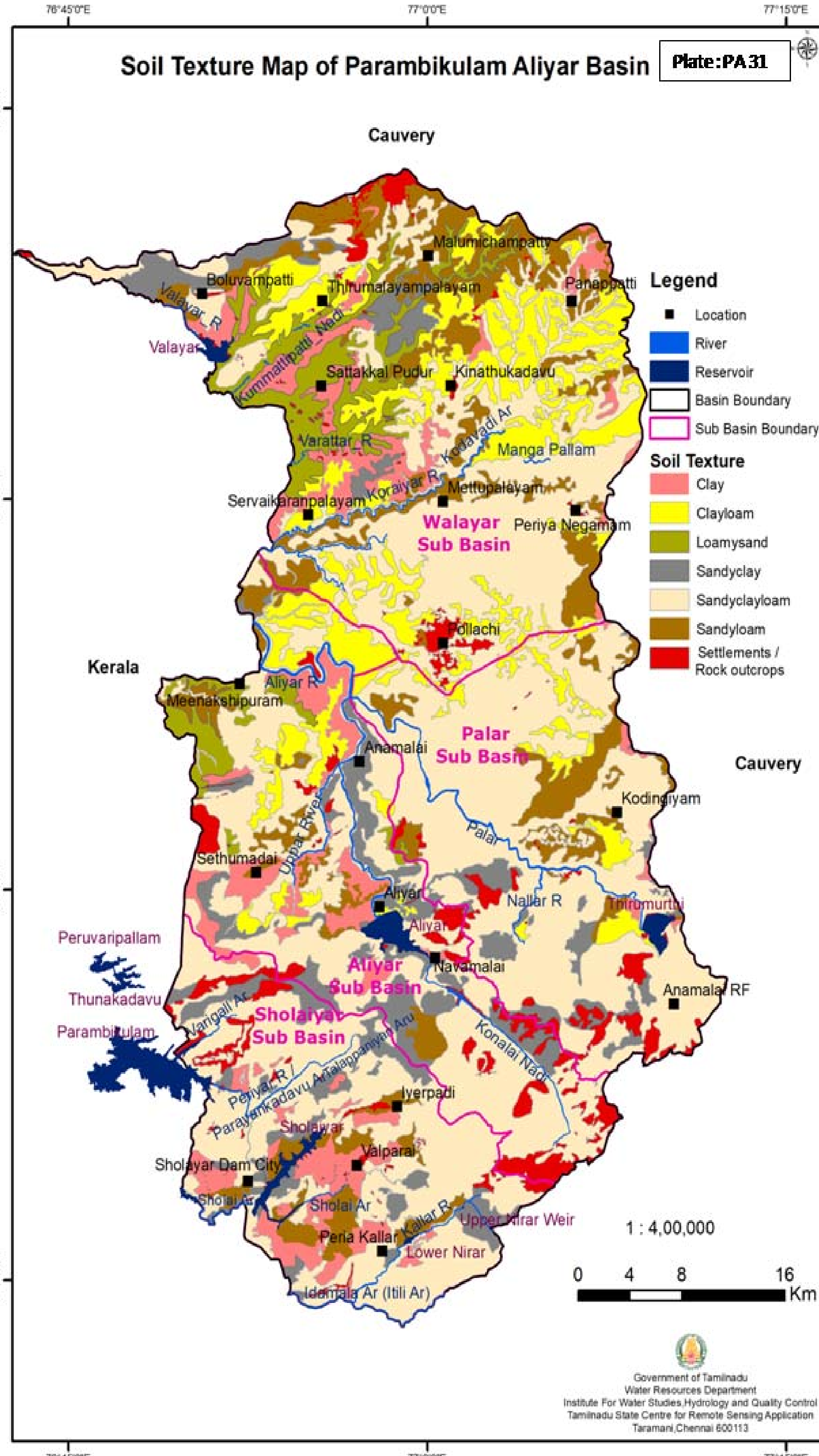
76°45'0"E
77°0'0"E
77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N



Soil Texture Map of Parambikulam Aliyar Basin
Plate:PA31
Cauvery
Kerala
Cauvery
Legend
Location
River
Reservoir
Basin Boundary
Sub Basin Boundary
Soil Texture
Clay
Clayloam
Loamysand
Sandyclay
Sandyclayloam
Sandyloam
Settlements / Rock outcrops
Walayar Sub Basin
Palar Sub Basin
Aliyar Sub Basin
Sholaiyar Sub Basin
Malumichampatty
Boluvampatti
Thirumalayampalayam
Panappatti
Valayar
Sattakkal Pudur
Kinathukadavu
Manga Pallam
Servaikaranpalayam
Mettupalayam
Periya Negamam
Pollachi
Meenakshipuram
Aliyar R
Anamalai
Kodingiyam
Sethumadai
Aliyar
Nallar R
Thirumurthi
Navamalai
Anamalai RF
Peruvaripallam
Thunakadavu
Parambikulam
Iyerpadi
Valparai
Sholayar Dam City
Sholai Ar
Upper Nirar Weir
Peria Kallar
Lower Nirar
Idamala Ar (Itili Ar)
Konalai Nadi
Palar
1 : 4,00,000
0 4 8 16 Km
76°45'0"E
77°0'0"E
77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
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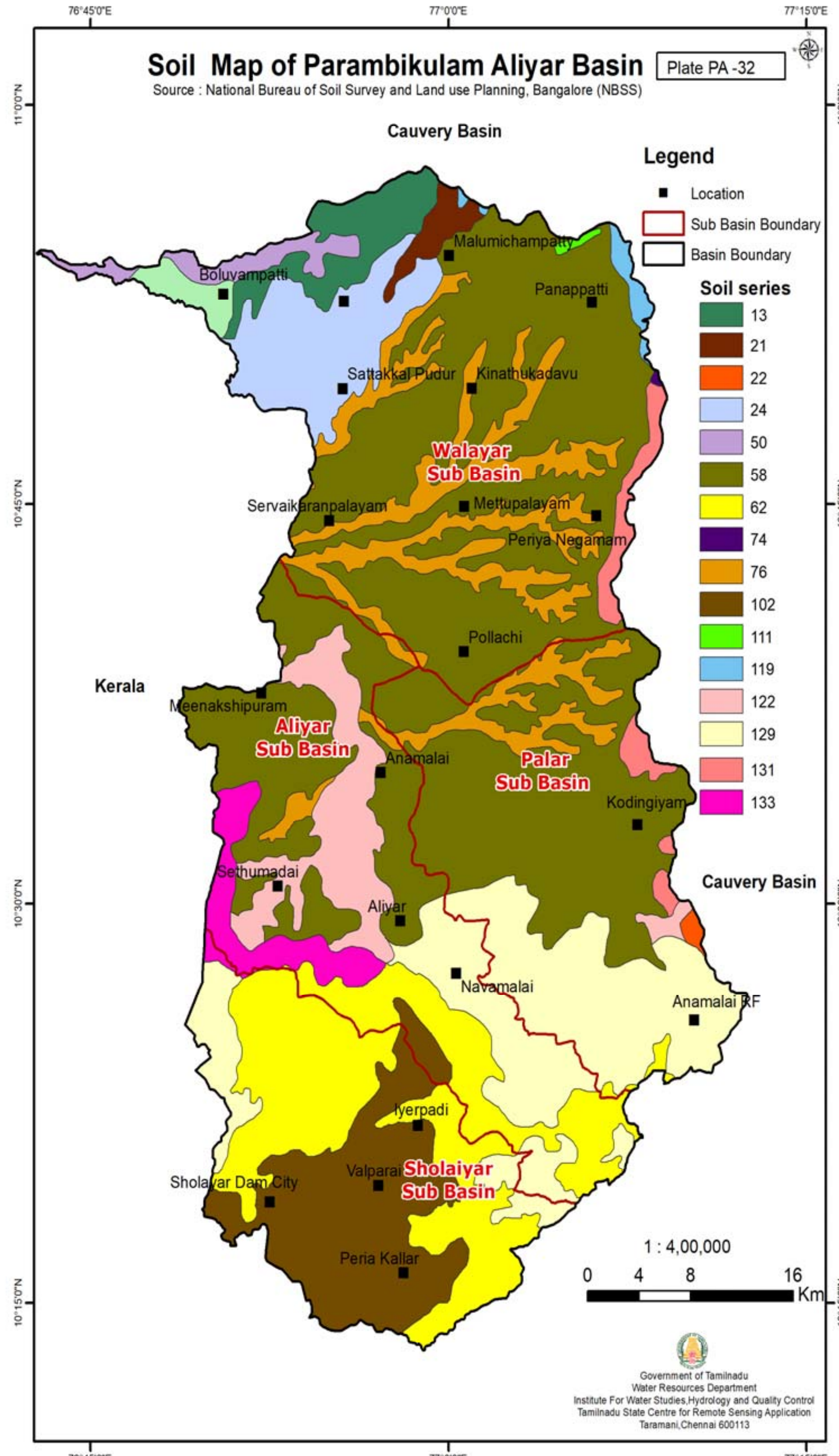

76°45'0"E
77°0'0"E
77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N
Soil Map of Parambikulam Aliyar Basin
Plate PA -32
Source : National Bureau of Soil Survey and Land use Planning, Bangalore (NBSS)
Cauvery Basin
Legend
Location
Sub Basin Boundary
Basin Boundary
Soil series
13
21
22
24
50
58
62
74
76
102
111
119
122
129
131
133
Malumichampatti
Boluvampatti
Panappatti
Sattakkal Pudur
Kinathukadavu
Walayar Sub Basin
Servaikaranpalayam
Mettupalayam
Periya Negamam
Pollachi
Kerala
Meenakshipuram
Aliyar Sub Basin
Anamalai
Palar Sub Basin
Kodingiyam
Sethumadai
Aliyar
Cauvery Basin
Navamalai
Anamalai RF
Iyerpadi
Valparai
Sholaiyar Sub Basin
Sholayar Dam City
Peria Kallar
1 : 4,00,000
0 4 8 16 Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113

CHAPTER - 3

HYDROMETEOROLOGICAL CHARACTERISTICS

CHAPTER - 3

HYDROMETEOROLOGICAL CHARACTERISTICS

3.1 General

Hydrometeorology is an interdisciplinary field of science that combines knowledge from the atmospheric sciences and hydrology to study the transfer and exchange of water and energy between land and the lower atmosphere. This field is the interface of two well-developed disciplines, meteorology and hydrology.

The scope of hydrometeorology includes analysis of the space-time properties of climatological parameters such as precipitation, minimum and maximum temperatures and sunshine and their influence on river systems and water bodies. In this regard, this field research is concerned with a broad understanding of the complex interactions between weather and the water resources of the earth.

Rainfall is a key factor determining the sustainability and conservation of living Species on the earth. In dry farming areas, where rainfall is the only source of water for crops, changes in both quantity and distribution of rainfall during the year could affect the economy of an area.

In this section, Parambikulam Aliyar Basin's climatological parameters are studied. The study made on the hydro-meteorological characteristics, includes analysis of rainfall, temperature, humidity, wind speed, sunshine and evaporation. Study has also been made on rainfall Pattern of the basin, which includes the spatial & temporal distribution and variability during different seasons, precipitation ratio and its dependability.

The Parambikulam Aliyar River Basin lies in the districts of Coimbatore, Tiruppur of Tamil Nadu State. A detailed study report on the hydro meteorological parameters for Parambikulam Aliyar River Basin is furnished below.

3.2 Rainfall

3.2.1 Rain gauge Stations

There are 24 rain gauge stations in and around the Basin. Considering the distribution of rain gauge stations and the stations having long term records, out of 24 rain gauge stations, only 15 rain gauge stations were selected for detailed analysis. The details of influencing and non-influencing rain gauge stations in Parambikulam Aliyar River basin are given in the **table 3.1 and 3.2**

Daily rainfall data for the period of 33years from 1986 to 2019 has been collected from State Ground & Surface Water Resources Data Centre(SG&SWRDC), PWD, Chennai. This data is used for Yearly, Monthly and Seasonal Rainfall Probability analysis. For the purpose of rainfall analysis, month is taken as a time step.

3.2.2 Monsoon and Non-monsoon periods

Geometrically, Tamil Nadu touches the acute southern tip of the Indian Peninsula. The climate of Tamil Nadu is generally wet subtropical climate and features fairly hot temperature over the year except during the monsoon season. The State has three distinct monsoon periods of rainfall. The south west monsoon spreads over the period from June to September with strong southwest winds. The north east monsoon spans from October to December with dominant northeast winds. Finally, dry season starts from January and ends at May. The monsoon period is hydrological significant for water resource analysis. Though the Monsoon is erratic and uneven, Tamil Nadu receives maximum Rainfall during North east monsoon Annual average rainfall of the State is 971.80mm, (Source: Statistical Hand Book TamilNadu-2017). Its distribution is, however, not uniform. There exists wide variation in rainfall from one part of the districts to the other.

The monthly and season-wise rainfalls for 15 rain gauge stations are given in the **Appendix 3.1**. The Rainfall of the basin is determined by Thiessen Polygon method. Thiessen Polygon of the basin with rain gauge station is prepared and furnished in the Plate **No: 33.** Dependable rainfall at 50% & 75% dependability and seasonwise average and annual rainfall for each of the sub basins have been analysed and tabulated in **Table 3.4 to 3.8**. The season wise Isohyets maps (**Plate Nos: 34 to 38)** are also presented.

. The sub basin wise influencing rain gauge stations, area of influence of each rain gauge station, area of the sub basin and percentage of weighted area of the influenced rain gauge station, the annual average rainfall and the annual average weighted rainfall for each sub basin are given in **Table 3.3.** The 33 years annual average rainfall of the basin is 1351.88 mm.

Table 3.1
Influencing Raingauge Stations of Parambikulam Aliyar River Basin

Sl.no	Station Code	Taluk	District	Lat	Long	Data Availability Period
1	ALIYAR_NGR	Pollachi	Coimbatore	10°29’11’’	76°58’02’’	1986-2019
2	ANAIMALAI	Valparai	Coimbatore	10°18’07’’	76°56’47’’	1986-2019
3	ATTAKATTI	Valparai	Coimbatore	10°27’13’’	76°58’46’’	1986-2019
4	IYERPADI	Coimbatore south	Coimbatore	10°21’38’’	76°58’47’’	1986-2019
5	NALLAR	Udumalpet	Tiruppur	10°29’43’’	77°10’12’’	1986-2019
6	PARAMBIKULAM	Pollachi	Coimbatore	10°23’34’’	76°46’38’’	1986-2019
7	POOLANKINARU	Udumalpet	Tiruppur	10°35’33’’	77°11’43’’	1986-2019
8	POTHANUR_RLY	Pothanur railway	Coimbatore	10°57’53’’	76°59’21’’	1986-2019
9	SHOLAIYAR	Udumalpet	Coimbatore	10°18’04’’	76°52’47’’	1986-2019
10	SULTANPET	Palladam	Coimbatore	10°52’31’’	77°11’47’’	1986-2019
11	THIRUMOORTHY ARG	Avinashi	Tiruppur	10°29’13’’	77°10’00’’	1986-2019
12	TOPSLIP	Valparai	Coimbatore	10°28’16’’	76°50’39’’	1986-2019
13	VALPARAI	Valparai	Coimbatore	10°20’04’’	76°57’45’’	1986-2019
14	VETTAIKAPUDR	Pollachi	Coimbatore	10°34’01’’	76°55’17’’	1986-2019
15	WEAVERLY	Udumalpet	Coimbatore	10°25’13’’	76°59’31’’	1986-2019

Table 3.2
Non - Influencing Raingauge Stations of Parambikulam Aliyar River Basin

Sl.no	Station Code	Taluk	District	Lat	Long	Data Availability Period
1	CITRACVD	Coimbatore South	Coimbatore	10°58’09’’	76°49’38’’	1997-2019
2	LOWRNIRAR	Valparai	Coimbatore	10°16’26’’	76°58’57’’	1992-2019
3	MANAKADVU_WR	Pollachi	Coimbatore	10°39’17’’	76°53’20’’	1988-2019
4	SETHUMADAI	Pollachi	Coimbatore	10°30’45’’	76°52’58’’	1993-1995, 1997-2019
5	THONDAMUTHUR	Coimbatore South	Coimbatore	10°59’18’’	76°50’35’’	1996-2019
6	THUNAKADAVU	Udumalpet	Coimbatore	10°26’00’’	76°46’52’’	1986-2019
7	UPPER NIRAR	Valparai	Coimbatore	10°17’53’’	77°01’14’’	1996-2019
8	VALPARAI SEC	Valparai	Coimbatore	10°20’04’’	76°56’45’’	2015-2019
9	VARATUPARI	Pollachi	Coimbatore	10°21’36’’	76°56’10’’	1996-2019

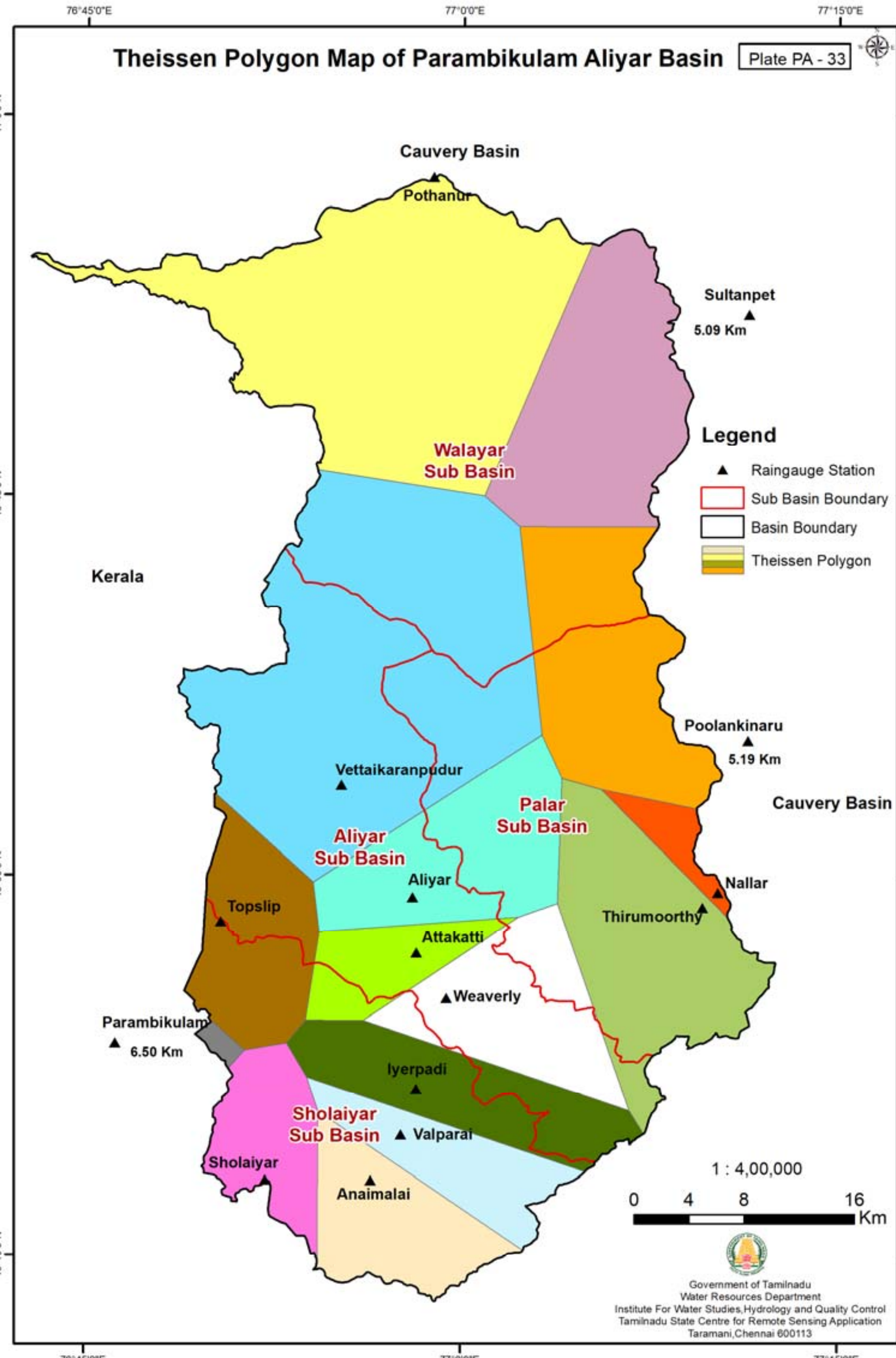

Theissen Polygon Map of Parambikulam Aliyar Basin
Plate PA - 33
Cauvery Basin
Pothanur
Sultanpet
5.09 Km
Walayar
Sub Basin
Legend
Raingauge Station
Sub Basin Boundary
Basin Boundary
Theissen Polygon
Kerala
Poolankinaru
5.19 Km
Vettaikaranpudur
Cauvery Basin
Palar
Sub Basin
Aliyar
Sub Basin
Aliyar
Nallar
Topslip
Thirumoorthy
Attakatti
Weaverly
Parambikulam
6.50 Km
Iyerpadi
Sholaiyar
Sub Basin
Valparai
Sholaiyar
Anaimalai
1 : 4,00,000
0 4 8 16
Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113
76°45'0"E
77°0'0"E
77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N

Table 3.3 Annual Average Weighted rainfall for the Basin

S.NO	SUB-BASIN	S.NO	Raingauge Station	RG Station Influencing Area in Sq.km	Sub basin Area in Sq.km	Weightage in %	Annual average weighted rainfall for the Stations in mm	Annual average weighted rainfall for the sub-basin in mm
1	**WALAYAR**	1	Sultanpet	206.5500	**875.13**	0.236	538.62	586.55
		2	Poolankinaru	65.1110		0.074	599.72	
		3	Pothanur	432.0020		0.494	545.49	
		4	Vettiakapudur	171.4620		0.196	742.76	
2	**PALAR**	1	Nallar	23.7431	**520.60**	0.046	844.30	789.68
		2	Thirumoorthy	185.0210		0.355	725.46	
		3	Vettiakapudur	74.7742		0.144	742.76	
		4	Weaverly	27.8901		0.054	1802.47	
		5	Attakatti	0.4048		0.001	1147.95	
		6	Aliyar	84.5008		0.162	899.81	
		7	Poolankinaru	124.2630		0.239	599.72	

3	**ALIYAR**	1	Vettiakapudur	247.0180	**564.55**	0.438	742.76	1170.51
		2	Topslip	54.4691		0.096	1383.12	
		3	Weaverly	95.9731		0.170	1802.47	
		4	Attakatti	46.5956		0.083	1147.95	
		5	Aliyar	68.0196		0.120	899.81	
		6	Iyerpadi	40.8439		0.072	2592.15	
		7	Thirumoorthy	11.6251		0.021	725.46	
4	**SHOLAIYAR**	1	Anaimalai	104.8830	**446.11**	0.235	3608.39	2860.80
		2	Iyerpadi	84.3351		0.189	2592.15	
		3	Sholaiyar	81.3624		0.182	3591.32	
		4	valparai	84.0718		0.188	3028.06	
		5	Attakatti	15.1068		0.034	1147.95	
		6	Weaverly	9.8963		0.022	1802.47	
		7	Topslip	61.0616		0.137	1383.12	
		8	parambikulam	5.3947		0.012	2364.99	
Basin Total Area				**2406.38**	**2406.38**			**1351.88**

Table 3.4 Walayar Sub Basin - Season wise - Dependable Rainfall (in mm)

Name of the Sub basin	Walayar		
Season	**50%**	**75%**	**Average**
SW	173.0	96.8	**168.4**
NE	305.7	158.1	**278.7**
Winter	3.1	0.0	**11.4**
Summer	125.5	81.7	**128.0**
Annual	624.6	517.8	**586.6**

Table 3.5 – Palar Sub Basin - Season wise - Dependable Rainfall (in mm)

Name of the Sub basin	Palar		
Season	**50%**	**75%**	**Average**
SW	271.2	187.3	**264.4**
NE	383.7	264.4	**377.8**
Winter	5.0	0.9	**14.5**
Summer	129.1	98.3	**133.0**
Annual	780.8	667.5	**789.7**

Table 3.6 - Aliyar Sub Basin - Season wise- Dependable Rainfall (in mm)

Name of the Sub basin	Aliyar		
Season	**50%**	**75%**	**Average**
SW	682.2	478.0	**648.2**
NE	341.4	242.4	**351.0**
Winter	4.9	0.2	**11.0**
Summer	154.8	113.6	**160.3**
Annual	1189.7	875.4	**1170.5**

Table 3.7–Sholaiyar Sub Basin - Season wise - Dependable Rainfall (in mm)

Name of the Sub basin	Sholaiyar		
Season	**50%**	**75%**	**Average**
SW	2021.2	1702.9	**2078.3**
NE	482.9	322.2	**466.3**
Winter	13.7	2.0	**17.3**
Summer	274.0	200.4	**298.9**
Annual	2816.0	2489.1	**2860.8**

3.2.3 Dependable Rainfall

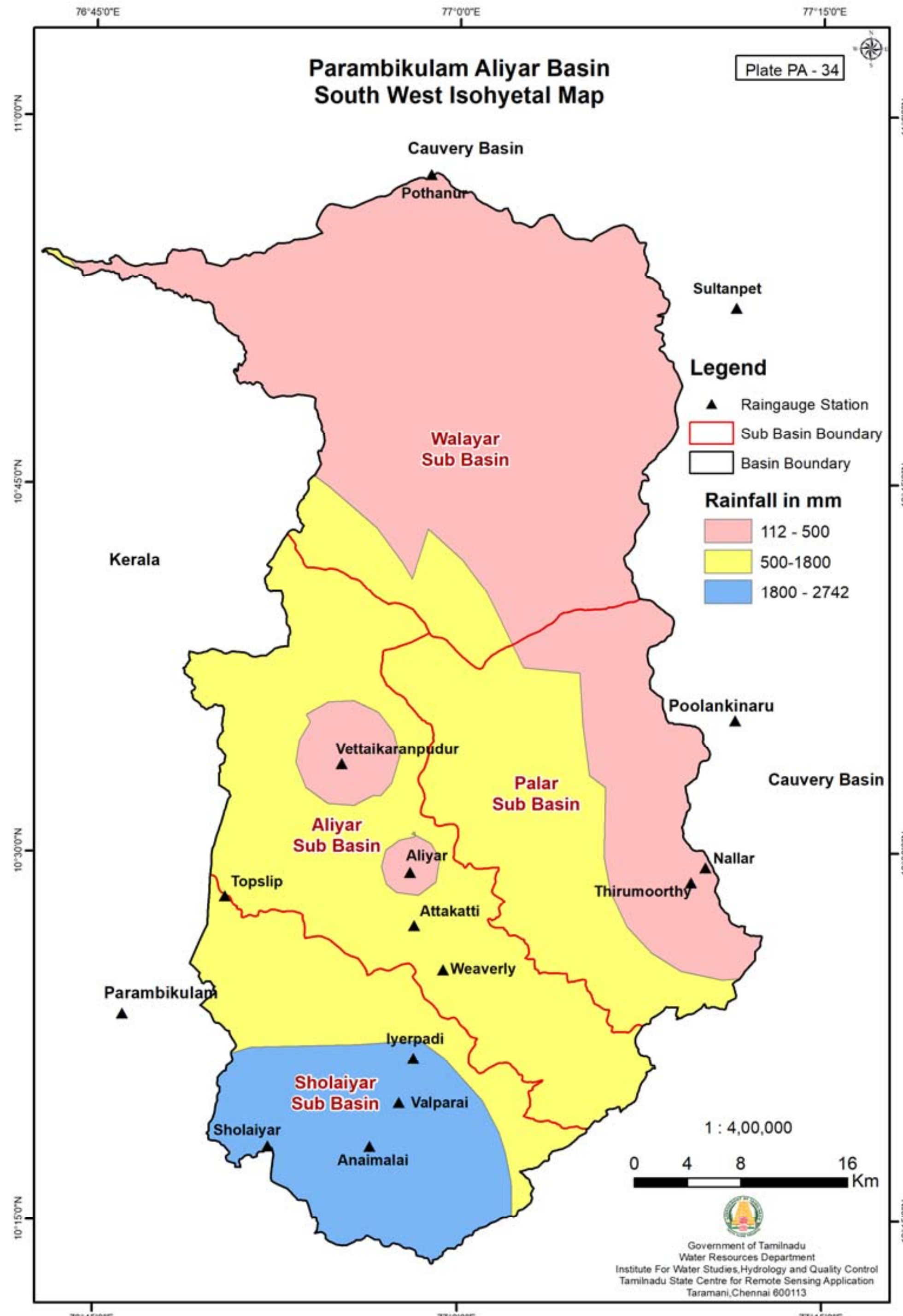
The 50% and 75% dependable rainfall for Parambikulam Aliyar River Basin are tabulated below in **Table 3.8**

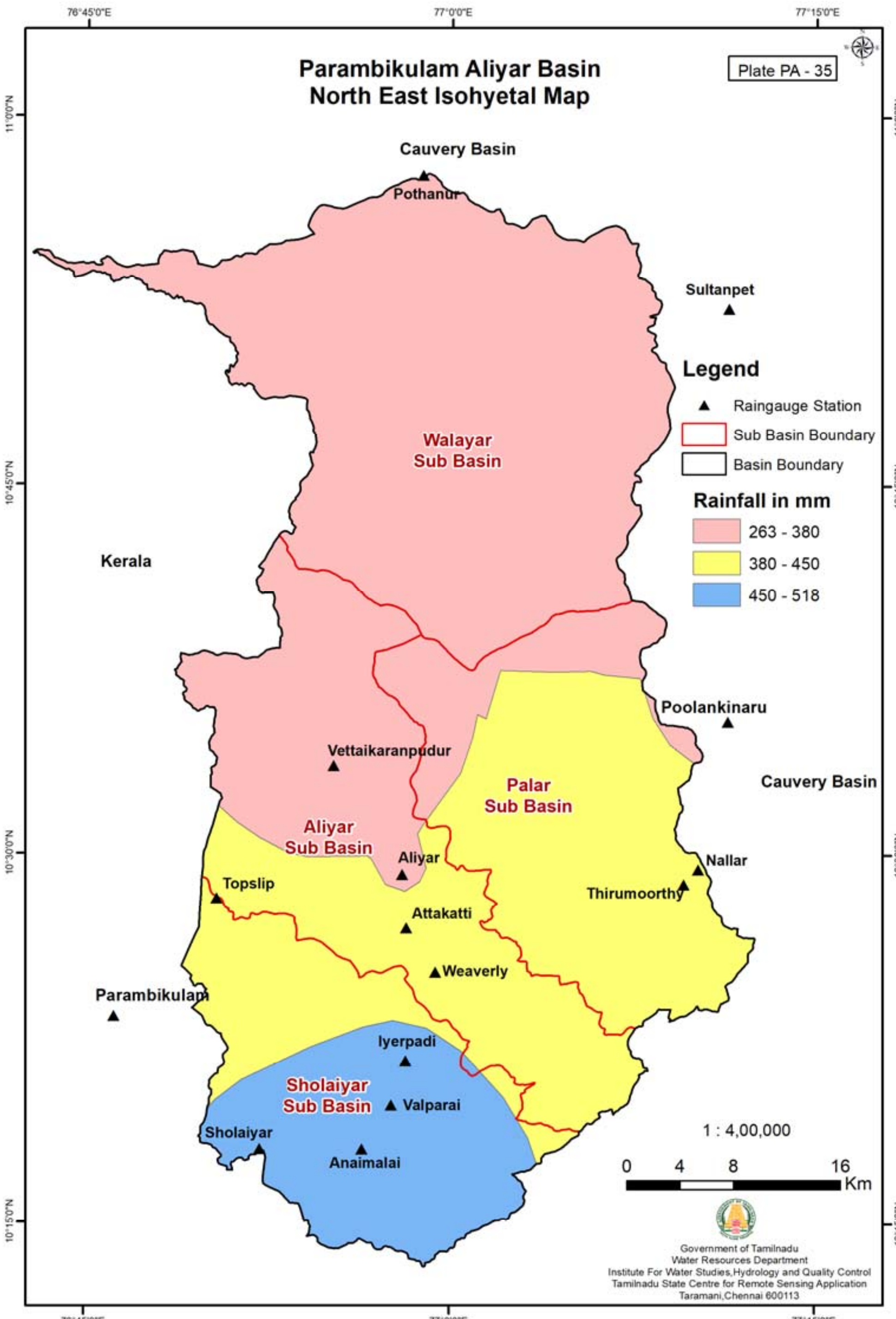
Table 3.8- Parambikulam Aliyar River Basin - Dependable Rainfall (inmm)

Name of the basin	Parambikulam Aliyar Basin	
Season	**Dependability**	
	50%	**75%**
SW	786.9	616.3
NE	378.4	246.8
Winter	6.7	0.8
Summer	170.9	123.5
Annual	1352.8	1137.5

3.2.4 Frequency Analysis

Frequency Analysis is used to predict how frequent certain parameter will occur and to assess the reliability of prediction. It is a tool for determining design rainfalls and design discharges for hydrology structures, in order to calculate the required hydraulic capacity. Frequency analysis is based on the past records over a long term. Rainfall data is random over the period and when arranged in a chronological order, it constitutes the time series data. From this time series data for each range of annual precipitation frequency in years have been determined and furnished in **Table 3.9** for each of the raingauge stations.




Parambikulam Aliyar Basin
North East Isohyetal Map
Plate PA - 35
76°45'0"E
77°0'0"E
77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N
Cauvery Basin
Pothanur
Sultanpet
Legend
Raingauge Station
Sub Basin Boundary
Basin Boundary
Rainfall in mm
263 - 380
380 - 450
450 - 518
Walayar
Sub Basin
Kerala
Poolankinaru
Cauvery Basin
Vettaikaranpudur
Palar
Sub Basin
Aliyar
Sub Basin
Aliyar
Nallar
Thirumoorthy
Topslip
Attakatti
Weaverly
Parambikulam
Iyerpadi
Sholaiyar
Sub Basin
Valparai
Sholaiyar
Anaimalai
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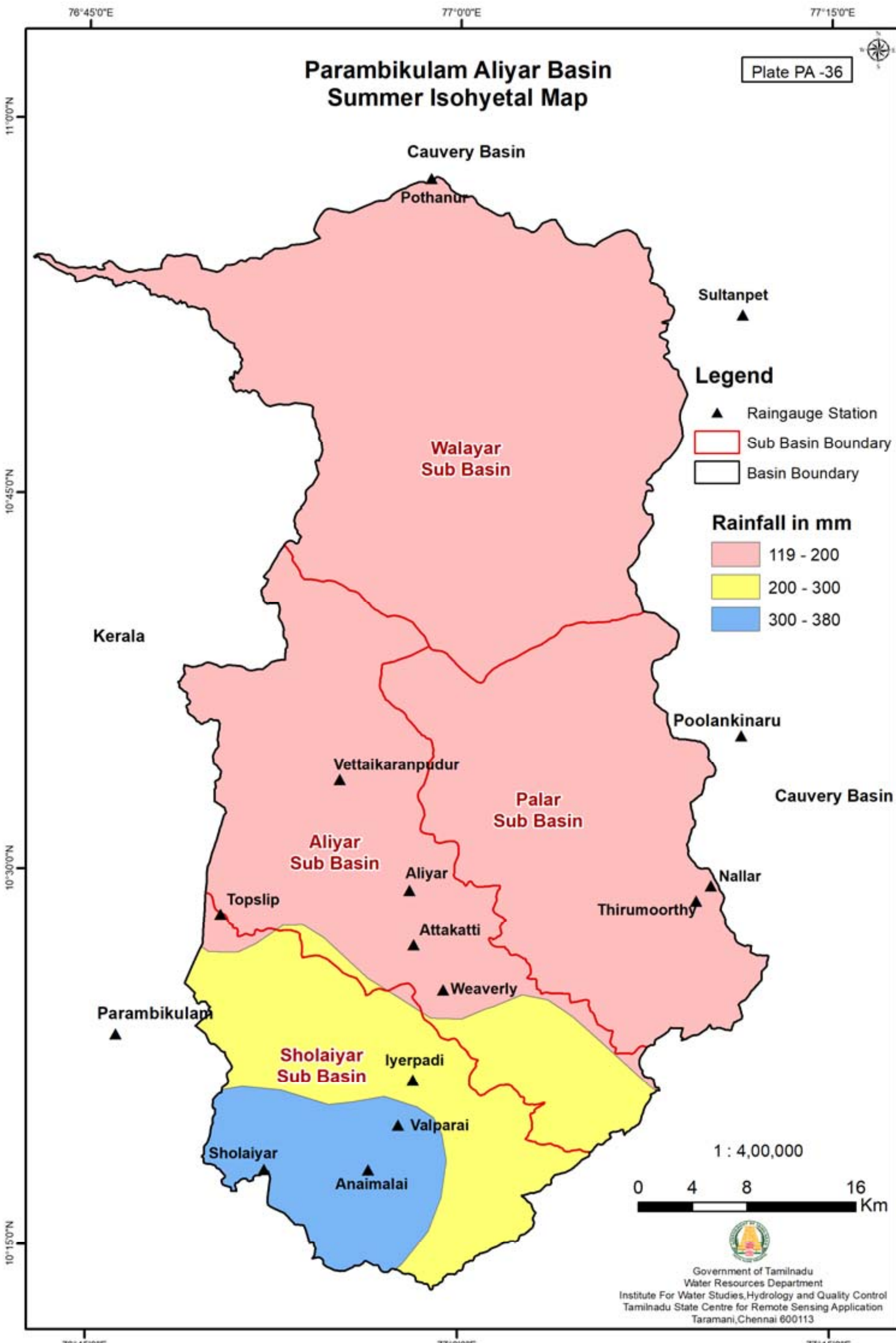
Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113


76°45'0"E
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77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N
Parambikulam Aliyar Basin
Summer Isohyetal Map
Plate PA -36
Cauvery Basin
Pothanur
Sultanpet
Legend
Raingauge Station
Sub Basin Boundary
Basin Boundary
Walayar
Sub Basin
Rainfall in mm
119 - 200
200 - 300
300 - 380
Kerala
Poolankinaru
Vettaikaranpudur
Cauvery Basin
Palar
Sub Basin
Aliyar
Sub Basin
Aliyar
Nallar
Thirumoorthy
Topslip
Attakatti
Weaverly
Parambikulam
Sholaiyar
Sub Basin
Iyerpadi
Valparai
Sholaiyar
Anaimalai
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Km
Government of Tamilnadu
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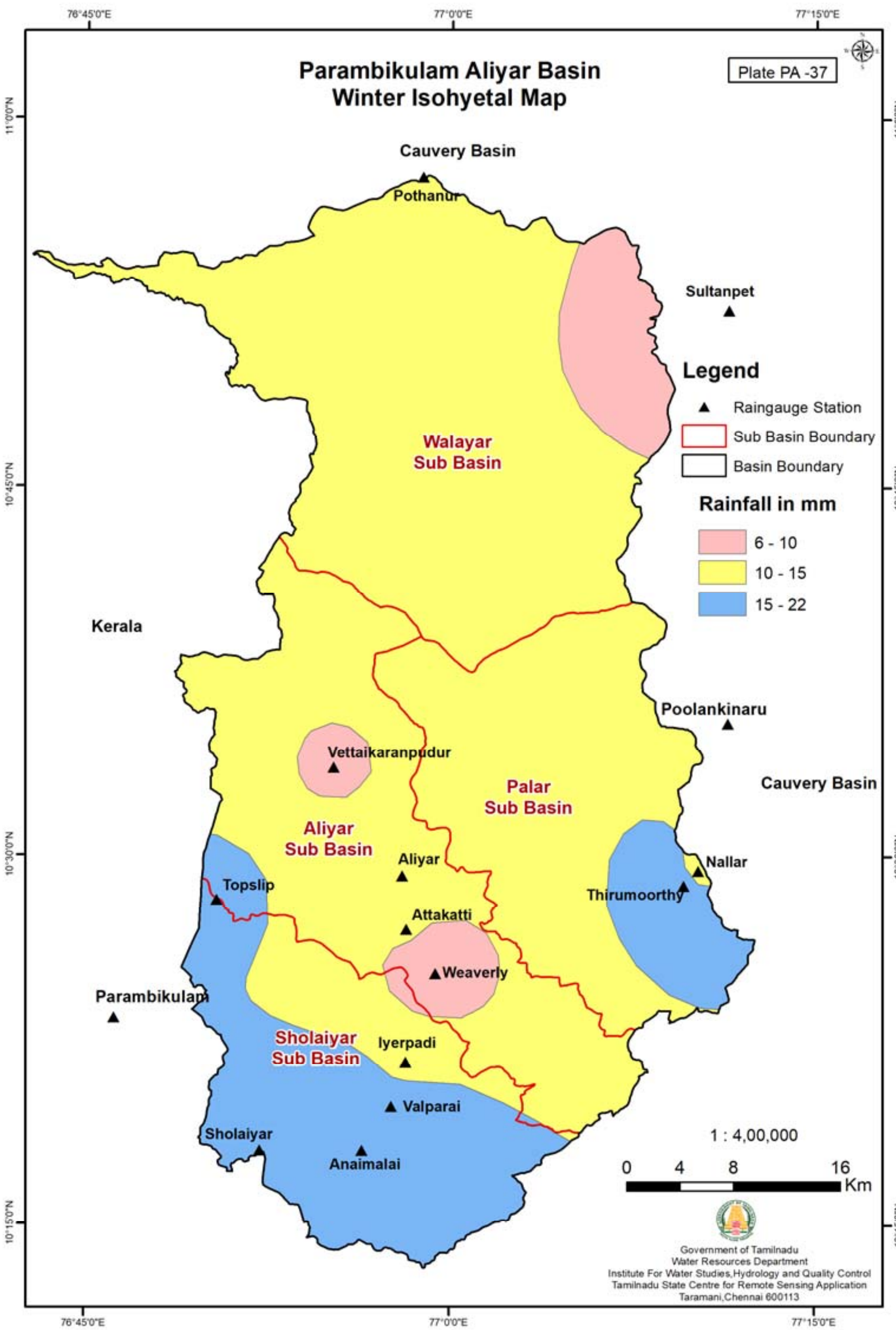
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113


76°45'0"E
77°0'0"E
77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N
Parambikulam Aliyar Basin
Winter Isohyetal Map
Plate PA -37
Cauvery Basin
Pothanur
Sultanpet
Legend
Raingauge Station
Sub Basin Boundary
Basin Boundary
Rainfall in mm
6 - 10
10 - 15
15 - 22
Walayar
Sub Basin
Kerala
Poolankinaru
Vettaikaranpudur
Palar
Sub Basin
Cauvery Basin
Aliyar
Sub Basin
Aliyar
Nallar
Topslip
Thirumoorthy
Attakatti
Weaverly
Parambikulam
Sholaiyar
Sub Basin
Iyerpadi
Valparai
Sholaiyar
Anaimalai
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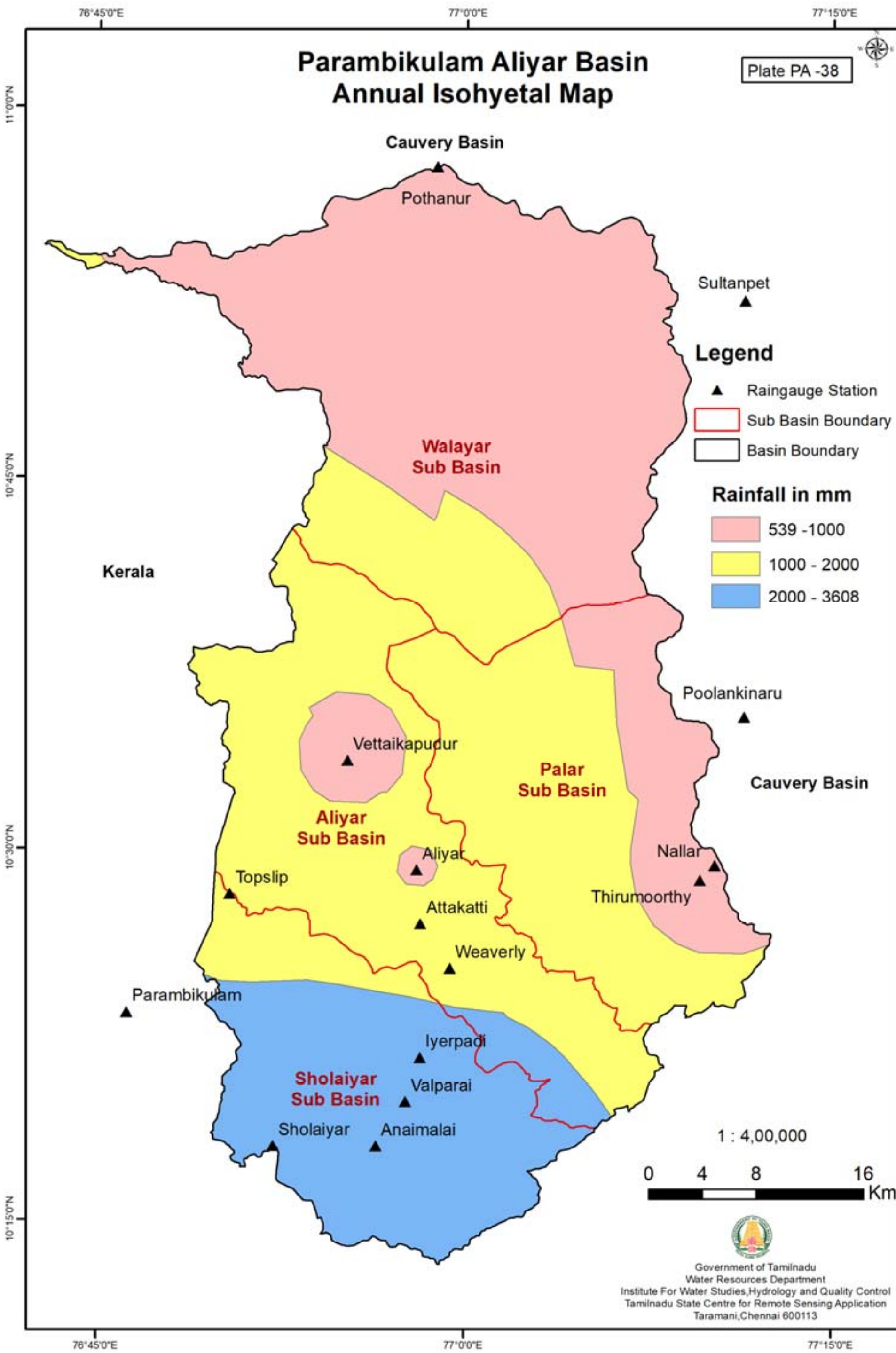
Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113


76°45'0"E
77°0'0"E
77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N
Parambikulam Aliyar Basin
Annual Isohyetal Map
Plate PA -38
Cauvery Basin
Pothanur
Sultanpet
Legend
Raingauge Station
Sub Basin Boundary
Basin Boundary
Rainfall in mm
539 -1000
1000 - 2000
2000 - 3608
Walayar
Sub Basin
Kerala
Poolankinaru
Vettaikapudur
Palar
Sub Basin
Cauvery Basin
Aliyar
Sub Basin
Aliyar
Nallar
Topslip
Thirumoorthy
Attakatti
Weaverly
Parambikulam
Iyerpadi
Sholaiyar
Sub Basin
Valparai
Sholaiyar
Anaimalai
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Km
Government of Tamilnadu
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Taramani,Chennai 600113

From the table it is noticed that rainfall exceeding 1000mm is maximum (100% of the study period (1986-2019) in Anaimalai, Sholaiyar, Parambikulam, Valaparai. Frequency of Rainfall in the range of 900-1000mm occurred nearly 15% and below of the study period in Aliyar, Vettaikapudur, Nallar, Sultanpet, Thirumoorthy, Topslip. Frequency of Rainfall in the range of 800-900mm occurred a maximum of 17 % in the study period in Thirumoorthy Frequency of Rainfall in the range 600 to 800mm rainfall occurred 10% to 26 % of the study period in most stations of the Basin. Frequency of Rainfall in the range 400 to 600mm rainfall occurred nearly 30% of the study period in Poolankinaru and Sultanpet. Frequency of Rainfall in the range 200 to 400mm rainfall occurred nearly 19% of the study period in Sultanpet. Less than 200 mm rainfall has not occurred in any of the stations considered.

Table 3.9 - Annual Rainfall Frequency Distribution

Sl.No.	Name of Stations	Study Period in Yrs	Exceeded 1000 mm	900 to 1000 mm	800 to 900 mm	600 to 800 mm	400 to 600 mm	200 to 400 mm	Less than 200 mm
1	Anaimalai	34	34	0	0	0	0	0	0
2	Pothanur	34	0	1	2	10	14	5	2
3	Sholaiyar	34	34	0	0	0	0	0	0
4	Aliyar	34	12	7	6	5	3	1	0
5	Attakatti	34	20	1	6	4	2	1	0
6	Iyerpadi	34	33	0	0	1	0	0	0
7	Nallar	34	13	3	5	5	6	2	0
8	Parambikulam	34	34	0	0	0	0	0	0
9	Poolankinaru	34	1	0	3	11	13	6	0
10	Sultanpet	34	0	3	0	9	13	9	0
11	Thirumoorthy	34	3	3	8	10	10	0	0
12	Topslip	34	28	3	0	2	1	0	0
13	Valparai	34	34	0	0	0	0	0	0
14	Vettaikapudur	34	3	5	5	12	8	1	0
15	Weaverly	34	26	1	1	1	1	1	3

3.2.5 Maximum, minimum and average rainfall

The maximum, minimum and average annual rainfall for the 15 rain gauge stations have been analysed and tabulated in Volume II **Appendix-3.1.1 to 3.1.15**

- Maximum Annual average Rainfall of this basin is 2860.8 mm [in Sholaiyar Sub basin]
- Minimum Annual average Rainfall of this basin is 586.6 mm [in Walayar Sub basin]
- Average annual rainfall of the Parambikulam Aliyar River Basin is 1351.88 mm

And each sub basin rainfall ranges are tabulated below **in Table 3.10**

Table 3.10 Rainfall ranges of the Parambikulam Aliyar Basin

Sl. No.	Name of the Sub-basin	No. of influencing Raingauage Staions	Rainfall range in mm(1986 - 2019)					Annual Average Rainfall in mm
			Annual	NE	SW	Winter	Summer	
1	Walayar	4	904.6 To 205.9	348.3 To 41.8	562.5 To 62.5	94.7 To 0.0	278.7 To 45.6	586.6
2	Palar	7	1139.2 To 450.4	532.8 To 74.3	728.7 To 96.6	145 To 0.0	302.1 To 50.4	789.7
3	Aliyar	7	1993.6 To 450	1434.8To 233.4	881.8 To 54.0	61.6 To 0.0	302.1To 7.1	1170.5
4	Sholaiyar	8	3975.0To 1736.6	3209.7To 1205.6	1133.5To 116.9	94.8 To 0.0	578.3To 95.3	2860.8

3.2.6 Moving Average

The 5 years moving average data for the four sub basins are given in the **Appendix 3.2.1 to 3.2.4**. The 5 years moving average graph for the annual rainfall has been drawn for the four sub basins. A linear fit has also been shown along with moving average curve. The details are given in fig 3.2.1 to 3.2.4 of volume II respectively.

- **The Walayar Sub Basin is showing the increasing trend**
- **The Palar Sub Basin is showing the slightly increasing trend**
- **The Aliyar Sub basin is showing the increasing trend**
- **The Sholaiyar Sub Basin is showing the slightly increasing trend**

3.2.7 Statistical Analysis

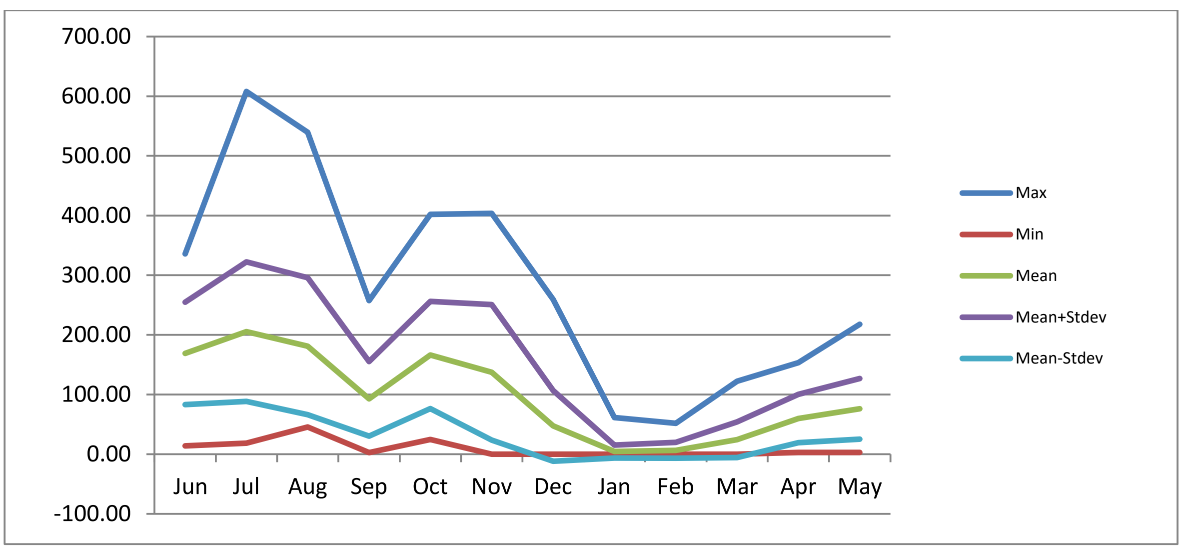
The statistical analysis for the rainfall data has been done for all the sub basins for the various seasons namely southwest, northeast, winter, summer and annual. The statistical results namely, Standard Deviation, Coefficient of variation, Skewness and Kurtosis have been analysed and tabulated in **Appendix 3.3**

The average value of the Aliyar Sub Basin statistical Parameters are

- Standard Deviation - 343.84
- Coefficient of variation - 0.29
- Skewness - 0.29
- Kurtosis - -0.17

The Statistical Parameters represents the rainfall distribution pattern with respect to the arithmetic mean of the rainfall data. Based on the Statistical data a model graph representing the rainfall details for Aliyar Sub-basin is given below in **Fig 3.1**

Fig.3.1 Statistical Parameters of Aliyar Sub-basin (1986 to 2019)



3.2.8 Deviation in Rainfall from Mean

The variability of rainfall may be defined as the deviation from the mean. The deficient or excess rainfall years are defined when rainfall of that year departs from the mean rainfall. The rainfall pattern over the basin for 33 years is found to be of alternating sequences of wet

(+ve- Deviation) and dry (-ve - Deviation) periods are given in **Table 3.11** as depicted from the **fig.3.2**

Fig.3.2 Deviation from mean South West monsoon Rainfall

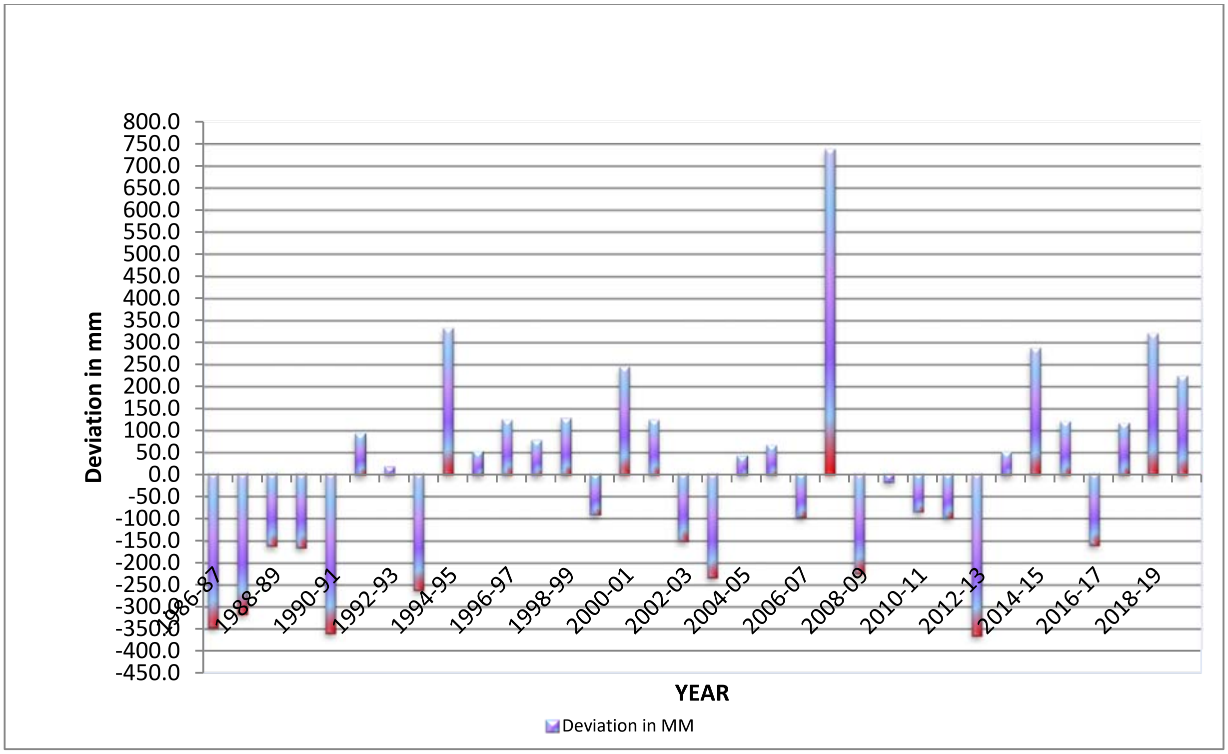


Table 3.11 – Details of deviation in South West monsoon Rainfall

Monsoon	Period of Years	No. of years	Deviation in mm	Deviation
South West Monsoon	1986-2019	16	51.07 to 414.86	Negative (-)
		18	30.64 to 789.58	Positive (+)

Table 3.12 – Details of deviation in North east monsoon Rainfall

Monsoon	Period of Years	No. of years	Deviation in mm	Deviation
North East Monsoon	1986-2019	19	2.76 to 297.05	Negative (-)
		15	9.15 to 530.79	Positive (+)

The North East monsoon and Annual Rainfall deviation from mean details are given in **Table 3.12& 3.13** as depicted from the **fig.3.3&3.4** respectively

Fig.3.3 Deviation from mean North East monsoon Rainfall

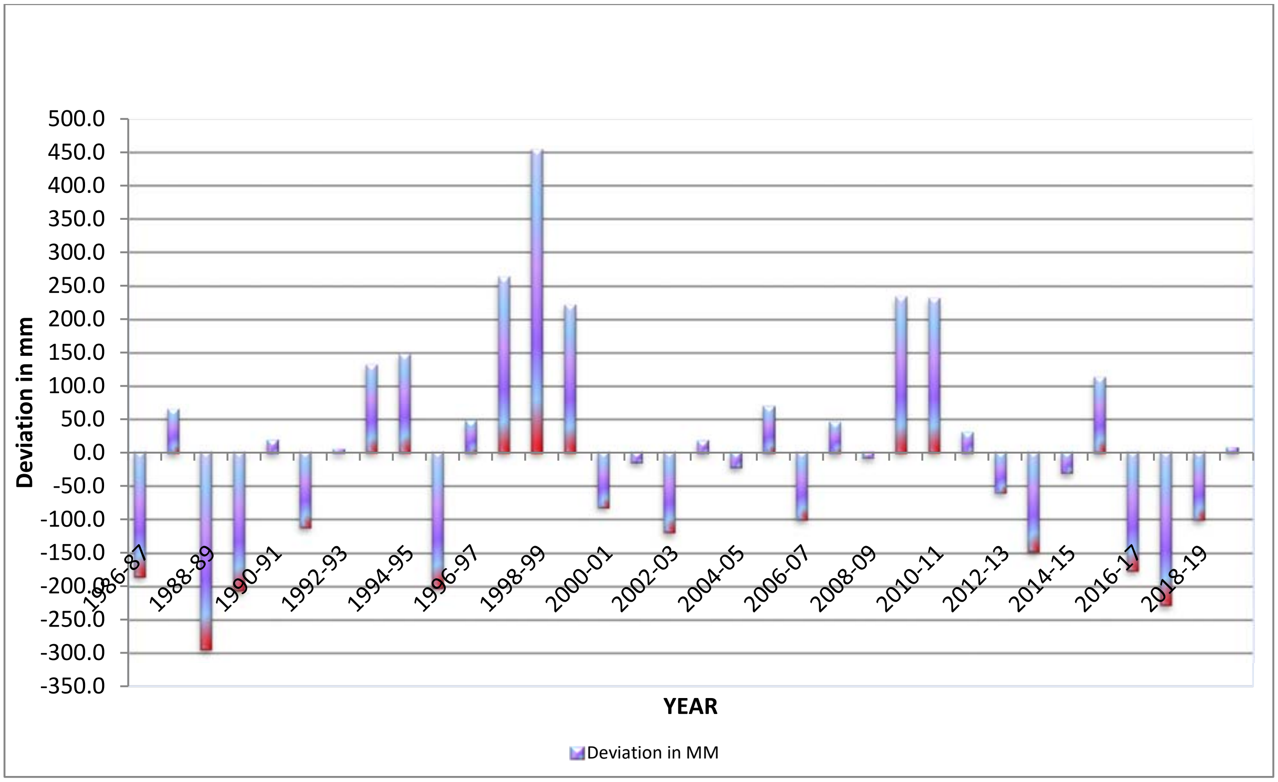


Fig.3.4 Deviation from mean - Annual rainfall

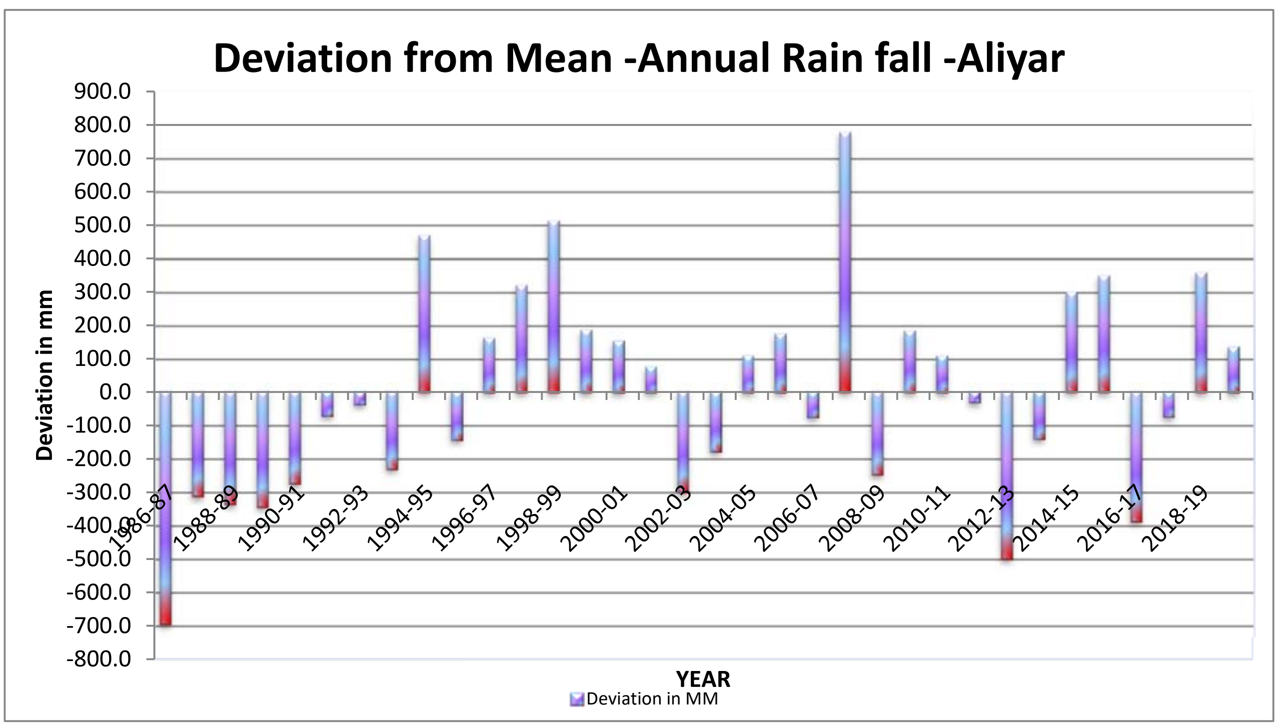


Table 3.13 – Details of deviation in Annual Rainfall

Monsoon	Period of Years	No. of years	Deviation in mm	Deviation
Annual Rainfall	1986-2019	17	22.37 to 720.49	Negative (-)
		17	19.15 to 823.07	Positive (+)

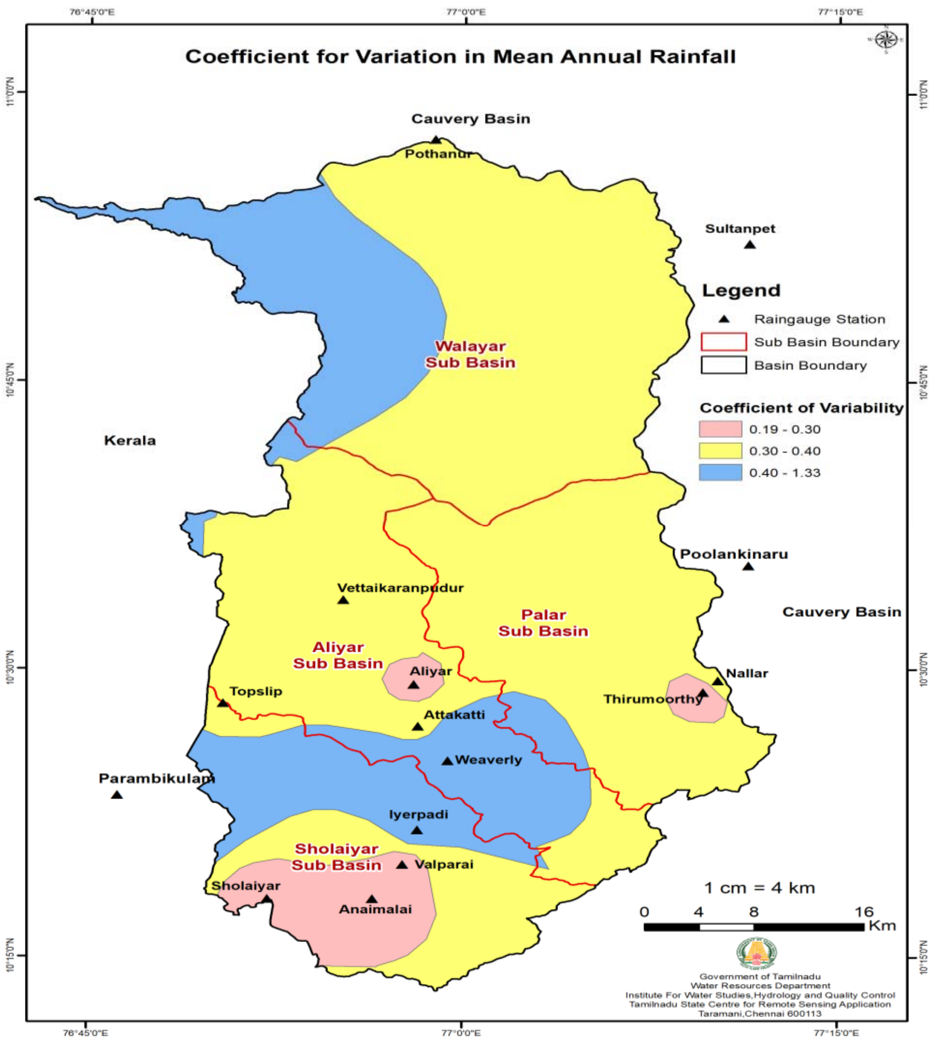
The above observations revealed the fact that the rainfall trend of south west monsoon is decreasing compare to that of north east monsoon over this basin. This trend influences on Annual rainfall pattern over this basin.

3.2.9 Coefficient of Variation deduced from Variability of Rainfall

An understanding of Spatial Variation in rainfall is an important requirement for the planning and management of Water Resources. **The Co-efficient of Variation (Cv)** is a measure of relative Variability. It is the ratio of the standard deviation to the mean (average) rainfall. It is generally expressed as a percentage. The higher value of Co-efficient of variation indicates greater level of deviation from the mean. The lower value of Co-efficient of variation indicates the level of deviation is close to the mean.

Based on the Variability data of 33 years from Raingauge location points, using an inverse distance weighted technique, the Co-efficient of variation for Parambikulam Aliyar basin for annual rainfall is determined. It ranges from 0.19 to 1.33(539mm to 3608mm) whereas the mean annual rainfall of the basin is 1351.88 mm. Cv value of the basin indicates the variation of annual rainfall is close to the mean.he annual Co-efficient of Variation for most part of the basin varies from 0.30 to 0.40.

Fig.3.5 Co-Efficient of Variation for mean - Annual rainfall



3.3 Climate

Mathematically climate is the statistics of weather over long periods of time. It is measured by assessing the patterns of variation in temperature, humidity, atmospheric pressure, wind, precipitation, atmospheric particle count and other meteorological variables in a given region over long periods of time. Climate differs from weather, that weather only describes the short-term conditions of these variables in a given region.

Aliyar Nagar and sethumadai weather station is situated inside Parambikulam Aliyar River Basin. Aliyar Nagar weather station data is taken for analysis, since it is the station having long term data records. The Location details of weather station considered for analysis are furnished in **Table 3.14** and its climatological Parameters are listed in **Table 3.15.**

Table-3.14-Weather Stations

SI.No	Name of the weather station	Block	Sub-basin	Maintained by
1	Aliyar Nagar	Pollachi	Aliyar	PWD

Table-3.15-Climatological Parameters

SI. No	Climatological Parameter (Annual Average)	Aliyar
1	Average monthly temperature Maximum in ^{0} Celsius	33.47
2	Average monthly temperature Minimum in ^{0} Celsius	23.97
3	Average mean temperature in ^{0} Celsius	28.72
4	Average relative humidity in %	80.67
5	Average wind velocity in km/hour	2.64
6	Average Sunshine hours / day	5.45
7	Average Pan Evaporation in mm/month	53.55

3.3.1 Temperature

The Climatological features of the basin have been studied from the data collected from weather station.Temperature is one of the basic factors under climatological features and it is one of the main parameter required to calculate the crop water requirement (i.e. reference crop evapo-transpiration). The maximum and minimum temperatures are observed in the Weather station.The monthly average Maximum and Minimum Temperature of the Aliyar station is 39.33^0 Celsius(April-2013),17.61^0 Celsius(Jan-2008)

The average monthly minimum and average monthly maximum temperature for the Aliyar station have been computed and tabulated in **Appendix 3.4.1 & 3.4.2**

3.3.2 Relative Humidity

Relative humidity is the ratio of the amount of atmospheric moisture present relative to the amount that would be present if the air was saturated. It is generally expressed in percentage. The relative humidity of air depends on temperature and the pressure of the system. The relative humidity of air depends on temperature and the pressure of the system. The monthly average relative humidity of the Aliyar station varies from 83.63 to 75.83. and tabulated in **Appendix-3.4.3**

3.3.3 Wind speed

Wind velocity is an important meteorological parameter which has considerable influence on evaporation and evapotranspiration phenomena. Wind has direct impact on climate & vegetation and is linked with the circulation pattern of the monsoon. The monthly average wind velocity of the Aliyar station varies from 0.86 km/hr to 5.18 km/hr and tabulated in **Appendix 3.4.4**

3.3.4. Sunshine

The monthly average sunshine hours of the Aliyar station varies from 7.45hrs/day to 3.56 hrs/day are tabulated and given in Appendix **3.4.5**

3.3.5 Evaporation

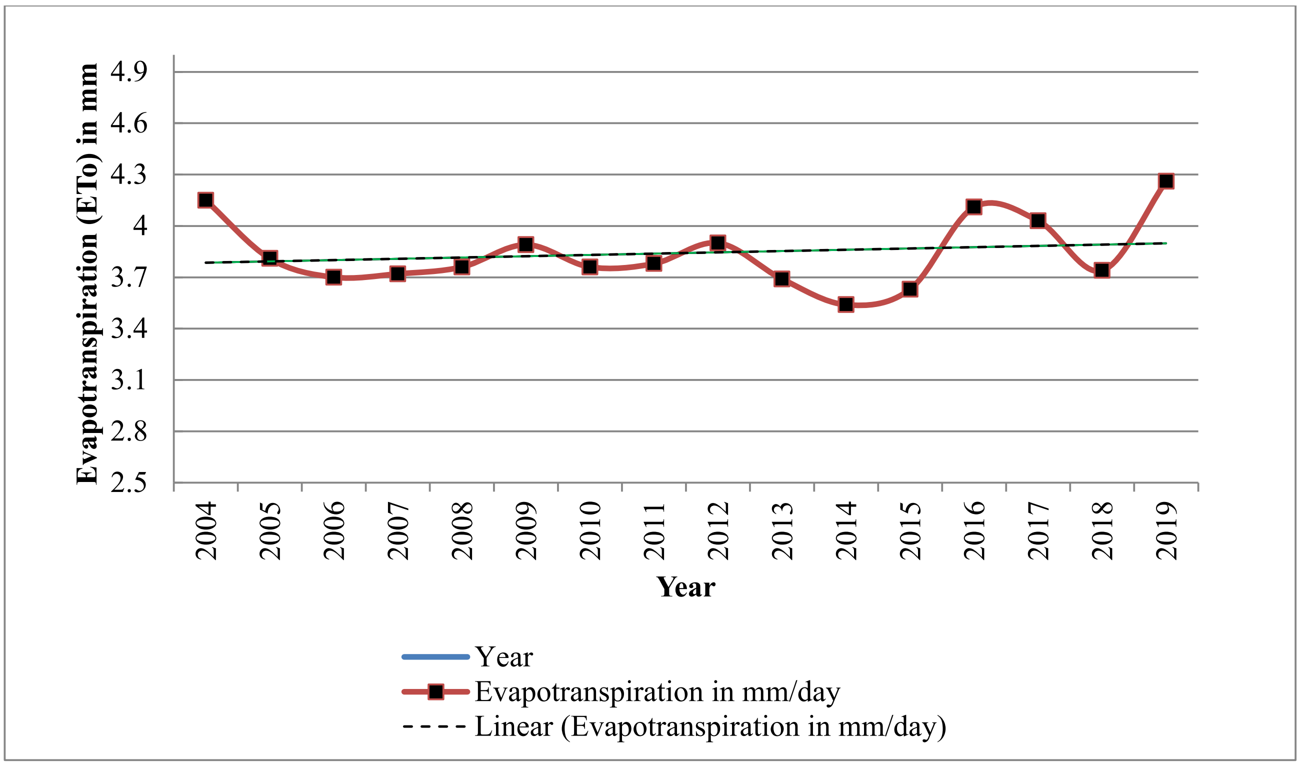
Evaporation is an essential part of the water cycle. The sun (solar energy) drives evaporation of water from oceans, lakes, moisture in the soil, and other sources of water.The estimation of evaporation in water body and transpiration from crop are important parameters to find out the crop water requirement of the crops in that area. The monthly average Pan Evaporation in mm for the Weather station is tabulated and given in **Appendix 3.4.6.**

Potential Evapotranspiration (PET)

In hydrology, evaporation and transpiration (which involves evaporation within plant stomata) are collectively termed as evapotranspiration.Potential Evapotranspiration is a measure of the ability of the atmosphere to remove water from the surface through the processes of evaporation and transpiration of greenery.

The monthly average Evapotranspiration in mm for the Aliyar Nagar weather station is estimated using Modified Penman Montieth Method. The estimated values for this basin are given in **Appendix 3.4.7**. The Annual PET for Aliyar weather station is arrived as 1388.08 mm. The PET for 15 years (2004 to 2019) of daily average for each year for Aliyar Nagar weather station is shown in **Fig 3.6** .The trend line for 15 years data of Potential Evapotranspiration is Slightly Increasing.

Fig.3.6 Evapotranspiration of weather Station in Aliyar Nagar



The results of Annual Rainfall, Rainy Days ,Maximum Temperature and Minimum Temperature of Aliyar Weather station are tabulated in **Appendix 3.4.8** and the graphical representation is shown in **Fig 3.7 to 3.10.**

The climatic change in Paramabikulam Aliyar river Basin,over 15years (2004-2019) based on the weather station in Aliyar is summarised below:

- The trend of annual rainfall is slightly decreasing.
- The trend of number of rainy days shows decreasing.

- There is a slight decrease in summer and winter maximum temperature trend.
- There is a increase in summer and winter minimum temperature trend.

Fig 3.7 Annual Rainfall

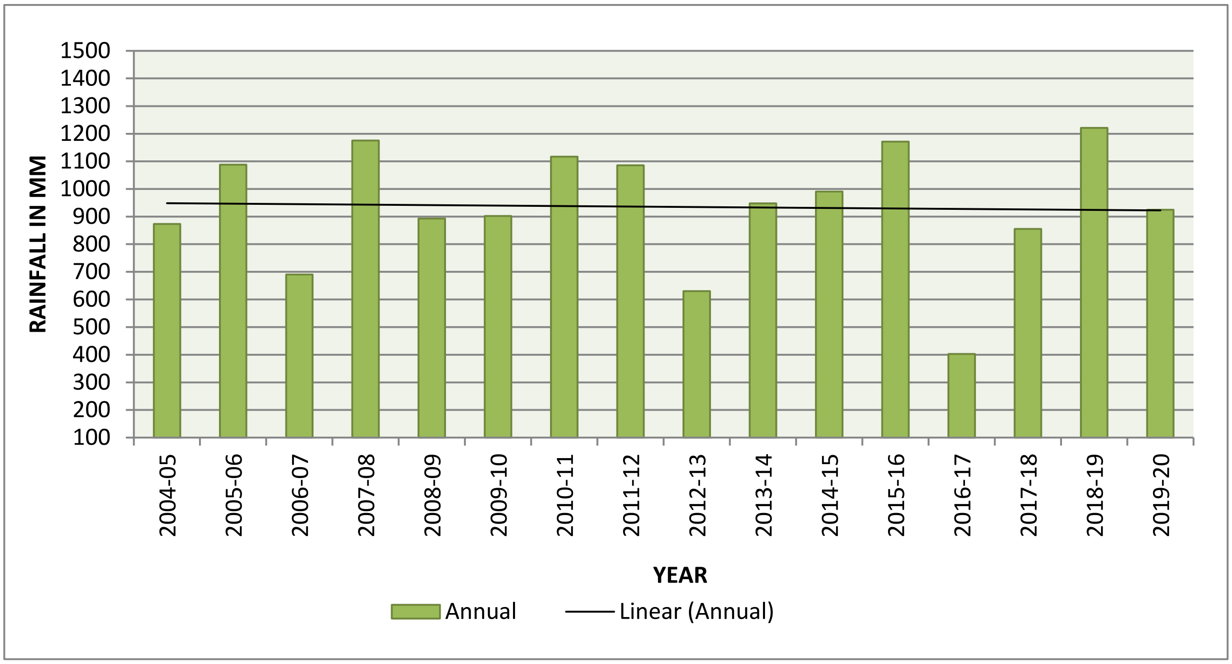


Fig 3.8 Rainy Days

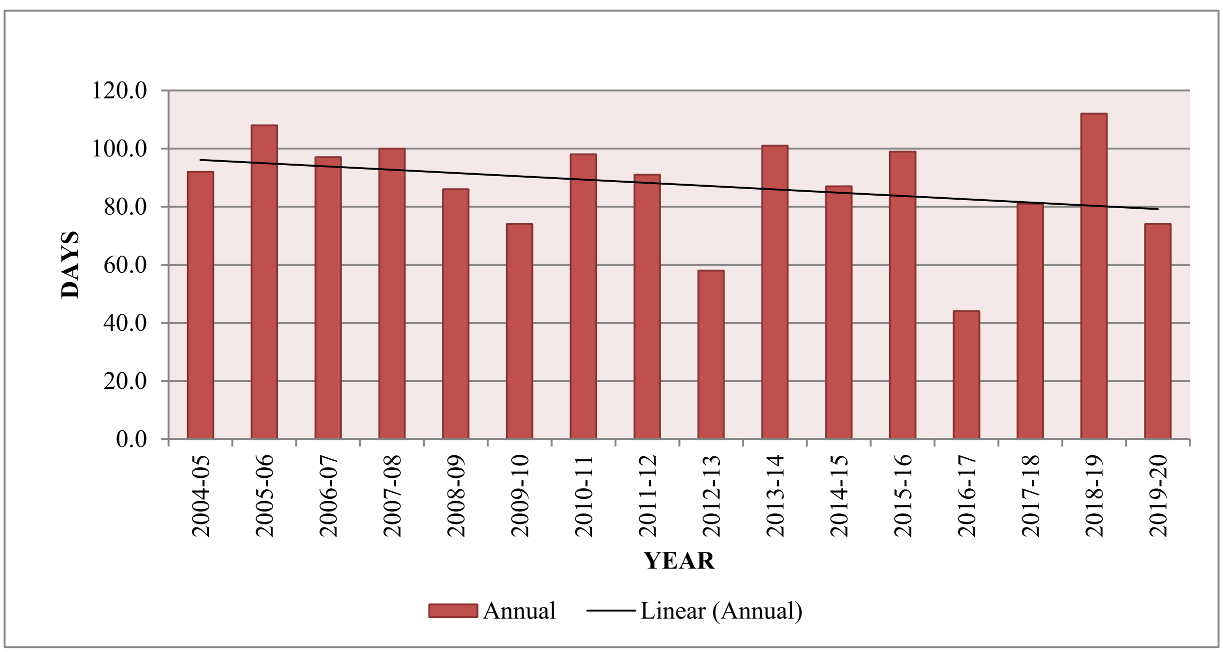


Fig 3.9 Maximum temperature

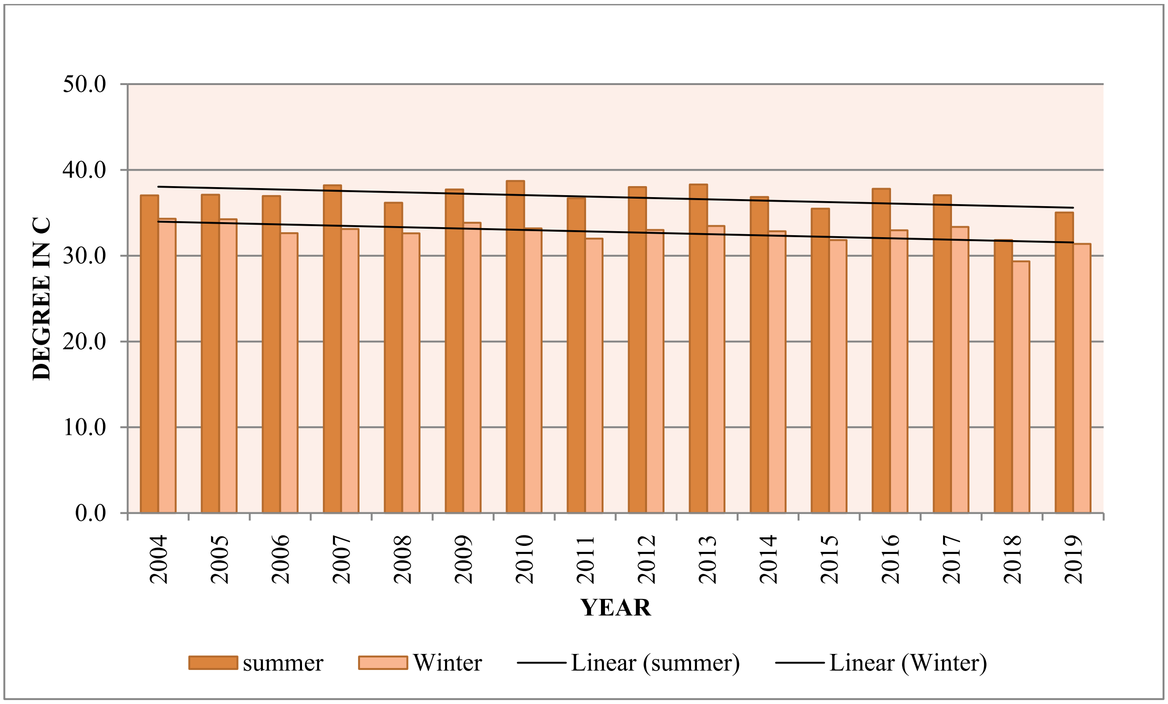
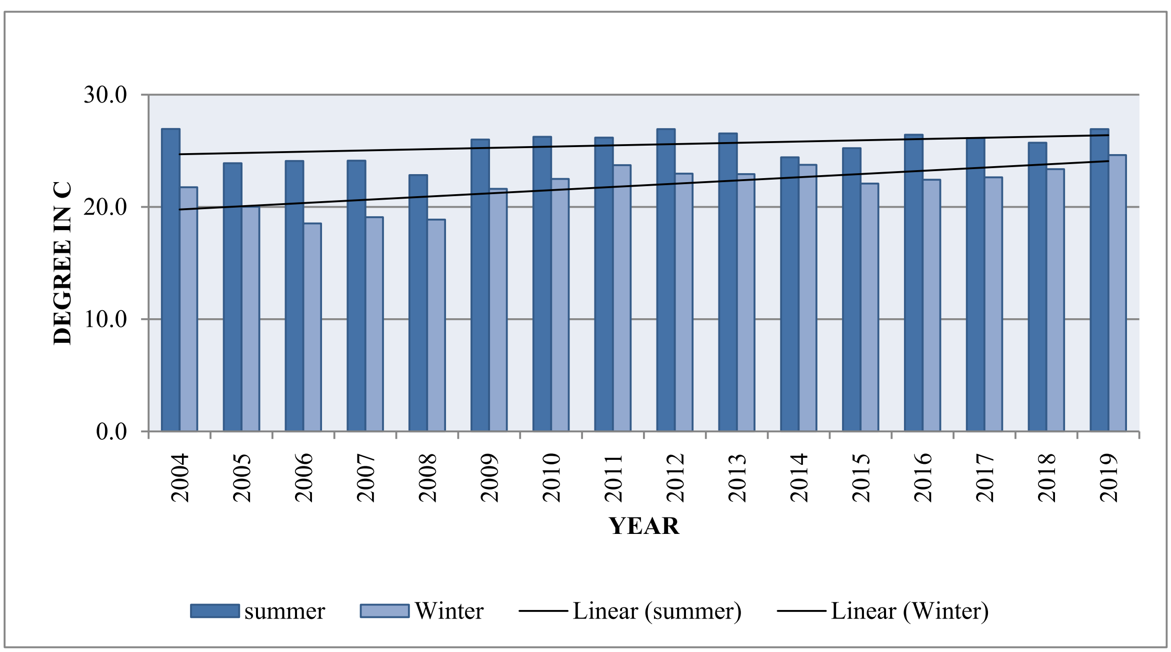


Fig 3.10 Minimum Temperature



3.3.6 Climatic Classification based on Moisture Index

Climate is the average atmospheric condition of a particular place or region, ranging from months to millions of years, 30 years being the classical period defined by the World Meteorological Organization (WMO). It represents different weather conditions prevailing at a site or region, considering the analysis of a large amount of data. Climatic classifications are broadly differentiated as either empiric or genetic methods. Empirical methods make use of actual observed environmental data, such as temperature, humidity, and precipitation, or simple quantities derived from them (such as evaporation) over a long period. In contrast, genetic methods classify climate on the basis of its relating elements, the activity and characteristics of all factors (circulation systems, fronts, jet streams, solar radiation, topography etc.) that give rise to the spatial and temporal patterns of climatic data.

In this Report, study has been made on the moisture factor existing in the basin area using climatic moisture index which was extensively used by C.W.Thornthwaite and others. Generally Moisture Index varies from -100% to +100%. The annual water surplus or the annual water deficit is the difference between the annual average rainfall and the potential evapotranspiration. The potential evapotranspiration is derived from Modified Penman Monteith method through CROPWAT model.

According to Thornthwaite's classification scheme,

Humidity Index $= I_h = \frac{100*s}{n}$, and Aridity Index $= I_a = \frac{100*d}{n}$,

Where

s = Monthly water surplus calculated as the sum of the monthly difference of precipitation and potential evapotranspiration when precipitation is greater than evapotranspiration (in mm)

d = Monthly water deficit calculated as sum of monthly difference of precipitation and potential evapotranspiration when precipitation is less than evapotranspiration (in mm)

n = Annual Water need (in mm) i.e PET

Thus Moisture Index is given by

$$\text{Moisture Index} = \frac{\text{Annual Water Surplus - Annual Water Deficit}}{\text{Annual Water need (i.e.) PET}} \times 100$$

(Source: Atmospheric Processes/ Climatic Classification By Dr. M.K.Nanda)

The classification climate according to Moisture Index is given in**Table 3.16**

Table 3.16 Moisture Index for Climatic Classification

Moisture Index (%)	Type of Climate
+100	Per humid
+100 to +20	Humid
+20 to 0	Moist sub-humid
0 to -33	Dry sub-humid
-33 to -66	Semi-arid
-66 to -80	Arid
-80 to -100	Extremely arid

The annual evapotranspiration (i.e. PET) of Aliyar (1388.08mm/year) weather Station isadopted for calculating moisture Index. The Moisture index (Im) and Climatic Classification for all the 15rain gauge stations and for all the sub basins has been worked out in **Table 3.17 and 3.18** respectively.

Table 3.17 - Moisture Index (Im) and Climatic Classification for Rainfall Station

Sl. No	RAINFALL STATION	Annual Avg Precipitation P mm	PET mm	Difference between P&PET mm	Humidity Index (Ih in %)	Aridity Index (Ia in %)	Moisture Index (Im=Ih-Ia) (%)	Classification
1	Anaimalai	3608.4	1388	2220.4	160.0	0.0	160.0	Humid
2	Pothanur	545.5	1388	842.5	0.0	60.7	0.0	Dry Sub-humid
3	Sholaiyar	3591.3	1388	2203.3	158.7	0.0	158.7	Humid
4	Aliyar	899.8	1388	488.2	0.0	35.2	0.0	Dry Sub-humid
5	Attakatti	1148.0	1388	240.1	0.0	17.3	0.0	Dry Sub-humid
6	Iyerpadi	2592.2	1388	1204.2	86.8	0.0	86.8	Humid
7	Nallar	844.3	1388	543.7	0.0	39.2	0.0	Dry Sub-humid
8	Parambikulam	2365.0	1388	977.0	70.4	0.0	70.4	Humid
9	Poolankinaru	599.7	1388	788.3	0.0	56.8	0.0	Dry Sub-humid
10	Sultanpet	538.6	1388	849.4	0.0	61.2	0.0	Dry Sub-humid
11	Thirumoorthy	725.5	1388	662.5	0.0	47.7	0.0	Dry Sub-humid
12	Topslip	1383.1	1388	4.9	0.0	0.4	0.0	Dry Sub-humid
13	Valparai	3028.1	1388	1640.1	118.2	0.0	118.2	Humid
14	Vettaikapudur	742.8	1388	645.2	0.0	46.5	0.0	Dry Sub-humid
15	Weaverly	1802.47	1388	414.5	29.9	0.0	29.9	Humid

Table 3.18 - Moisture Index (Im) and Climatic Classification for Sub basin

Sl. No	SUBBASIN NAME	Annual Ave. Rainfall P mm	PET mm	Difference between P&PET mm	Humidity Index (Ih in %)	Aridity Index (Ia in %)	Moisture Index (Im=Ih-Ia) (%)	Classification
1	Walayar	586.55	1388	801.5	0	57.7	-57.7	Semi-arid
2	Palar	789.68	1388	598.3	0	43.1	-43.1	Semi-arid
3	Aliyar	1170.51	1388	217.5	0	15.7	-15.7	Dry Sub-humid
4	Sholaiyar	2860.8	1388	1472.8	48.5	0.0	48.5	Humid

3.3.7 Meteorological Drought Assessment

Time series rainfall data analysis of a region helps in better understanding of its drought climatology. Identification of frequently drought affected regions plays an important role in drought management. Further, past performances provide indications on the future scenarios. Information on spatial and temporal dimensions of drought occurrence and its spread enables designing of more focused management tasks. Therefore, systematic understanding of drought climatology is indispensable for evolving efficient drought management strategies particularly in tropical regions like Tamil Nadu.

Long term rainfall data analysis is used for assessment of drought vulnerability. Study of droughts is also important for planning short-term operations, especially in connection with Irrigation scheduling.

Indian Meteorological Department method for drought assessment is simple and widely used. In this method, drought is assessed on the basis of percentage of deviation of rainfall from the long-term annual mean rainfall. The percentage deviation (Di) is given by

$$\mathbf{Di} = \frac{\mathbf{Pi} - \overline{\mathbf{P}}}{\overline{P}}$$

Where Pi is the annual rainfall in the year i and $\overline{P}$ is the long-term annual mean rainfall in mm. The percentage deviation of rainfall Di and the category of drought assessment as per IMD are given below in **Table 3.19**

Table-3.19 Drought Assessment

Sl. No	Range of Di	Classification of drought	Category
1.	> 0	M0	No drought
2.	0 to - 25	M1	Mild drought
3.	-25 to -50	M2	Moderate drought
4.	< - 50	M3	Severe drought

Drought assessment has been carried out for last 15 years for the area represented by the rain gauge stations in this basin. The classification of no. of years in each category of drought such as no, mild, moderate and severe drought and is given in the **Table 3.20**. It is observed from the **Table 3.20** that for maximum No. of years the area represented by the most of these stations have been classified as Mo (No drought) a few area have greater years in M1 Classification. This basin is not frequently drought prone.

Table 3.20 - Abstract of Drought Assessment (From 2001-02 to 2019-20)

Sl.No.	STATION NAME	SUB-BASIN	M0	M1	M2	M3
1	Pothanur	WALAYAR	10	7	1	2
2	Sultanpet		13	2	3	2
3	Nallar	PALAR	10	7	3	0
4	Poolankinaru		8	9	2	1
5	Thirumoorthy		8	6	6	0
6	Aliyar	ALIYAR	11	6	2	1
7	Attakatti		12	5	3	0
8	Topslip		9	6	3	2
9	Vettaikapudur		9	7	4	0
10	Weaverly		10	7	1	2
11	Anaimalai	SHOLAIYAR	8	9	3	0
12	Iyerpadi		7	8	5	0
13	Parambikulam		14	3	2	1
14	Valparai		9	8	3	0
15	Sholaiyar		6	12	2	0

3.4 Summary

Among the climatic elements the rainfall is the first index to agriculture ever thought by farmers and climatic analyzers as it is the most important factor which determines the cropping pattern of an area in general and the type of crop to be cultivated and its success or failure in particular. Therefore, the above study deals with the rainfall characteristics of the Parambikulam Aliyar River Basin such as the spatial and temporal distribution and variability through different seasons, precipitation ratio and frequency occurrences.

The rainfall measurements are used as the major input in water balance studies, such as assessment of water potential. In regional water resources management, rainfall studies provide the simplest guide for distribution of water over an area. However, the records need careful analysis, linked with an understanding of the effect of topography and aspect on rainfall distribution.

In general, Parambikulam Aliyar basin receives more rainfall in South West monsoon than North East monsoon. The highest rainfall of 2860.8 mm was recorded in Sholaiyar sub basin. Similarly lowest rainfall of 586.55 mm was recorded in Aliyar sub basin .The 33 years annual average rainfall of the basin is 1351.88 mm.

On viewing the climatic pattern, it is observed that there is decrease in number of rainy days, further, trend line of annual rainfall shows marginal declination, a slight decrease in summer and winter maximum temperature trend, a marginal increase in summer and reasonable increase in winter minimum temperature trend.

CHAPTER 4

IRRIGATION AND AGRICULTURE

CHAPTER – 4

IRRIGATION AND AGRICULTURE

4.1 Introduction

Tamil Nadu covers 4 percent of the geographical area (13.01 Million ha) and caters to 5.96 percent of the population of the country. More than 95 percent of the surface water potential and 80 percent of groundwater potential have been put into use. The total water potential of the State including ground water is 47,125 Mcum and the total surface water potential of the State is 24,160 Mcum including the contribution (7,391 Mcum) from the neighbouring States, viz., Kerala, Karnataka and Andhra Pradesh. The annual per capita water availability in India is about 2200 M^3whereas it is about 750 M^3 in Tamil Nadu.There are 85 dams and 4 reservoirs in the State with a combined storage capacity of 238.58 TMCft.The State's irrigation potential in per capita terms is 0.08 ha when compared to the all-India average of 0.15 ha. There are about 41,127 tanks, 2,239 irrigation main canals and 18.26 lakh irrigation wells in the state. (Source: State Planning Commission Report, 12^{th} five year plan (2012-17).

Irrigation is the artificial application of water to the land in order to fulfil the water requirements of the crops throughout the crop period for the full nourishment of crops.The State has a net irrigated area of 26.27 lakh hectares as per the season and crop report 2017-18. About 56.62% of the net area sown is benefitted by irrigation.The total Gross Irrigated area of ParambikulamAliyar Basin is 98,048 Ha as per the season and crop report 2017-18year crop area. The main crops cultivated in ParambikulamAliyar Basin are Coconut, Paddy, Sugarcane, Cholam, Maize and Pulses in addition to Fruits and Vegetables.

PAP – A Unique Project - The flows in the rivers of the PAP system are regulated and diverted by the storage / diversion structures which have been constructed with the intention to serve the drought prone areas in the Cauvery basin also. Part of the area irrigated by the PAP system fed by the canals taking off from the Thirumurthy Reservoir viz., Parambikulam Main Canal, Udumalpet Canal and the High level Canal falls in the Cauvery basin. The total command area spread over in Coimbatore, Erode and Tiruppur districts of Tamil Nadu lies both in "Parambikulam Aliyar basin" and Cauvery basin. The command area of the Parambikulam Main Canal system has been grouped into four near equal zones in a manner convenient for facilitating the supply by rotation. The extent of command area, under PMC fed by Thirumurthy reservoir, under the four zones are 98,558 acres, 98,418 acres, 94,024 acres, 86,152 acres respectively, totalling to 3,77,152 acres. This is a unique project in the sense that farmers get water once in two years for their ayacut for 41/2 months. The Palar sub basin irrigated area is fed by Thirumurthy Reservoir. The command area of 44378 acres in Aliyar sub basin has been divided into two near equal zones. In a normal year about 2.35 Lakh acres are expected to be irrigated by the PAP system.

Soils

Soil is the most important aspect in successful agriculture and is the original source of the nutrients.As per Technical Report Series of District Ground Water Brochure issued by Government of India, Ministry of Water Resources, the major types of the soilsfound in the Districts covering ParambikulamAliyar Basin are as follows:

The soil types found in the Coimbatore District are Red calcareous soil,Red non calcareous soil,Black soil andAlluvial Soil. About 60% of the district is covered by red soil of which the red calcareous soil is predominant, Forest soils are found in the reserve forest areas and Alluvial soils are found in small patches along the Noyil River.The soils found in Thiruppur district Udumalpet block are mainly Red calcareous and Red Non calcareous in limited area.

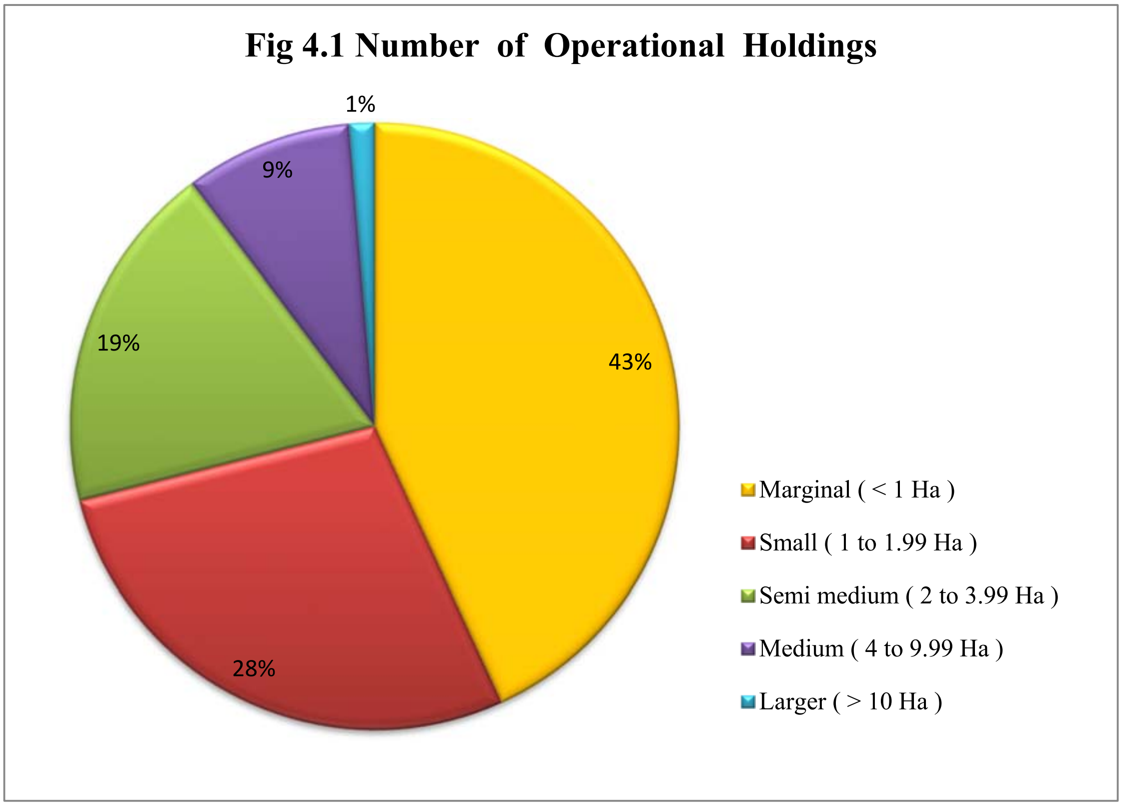
4.2 Land Holdings

A combination of factors such as increasing industrialization, urbanization, housing activities and infrastructure development triggered the conversion of agricultural land into non agricultural uses. This has resulted in a declination of area under cultivation. The scope for the expansion of area available for cultivation is also very limited.

As per the latest Agricultural Census 2017-18, the State had 79.38lakh holdings with an operating area of 59.70 lakh Ha. The category of agriculturists/farmers in ParambikulamAliyar Basin on the land holding size is given in **Table 4.1.**Marginal farmers accounts for 43.14%, Small farmers -27.90%, Semi medium farmers-18.69%, Medium farmers-8.91% and Large Farmers- 1.36% in ParambikulamAliyarBasin. (Source: Agriculture census 2015-16, Blockwise Number of Operational Holding and Area in Ha).**Fig 4.1** explains the different category of farmers in ParambikulamAliyar Basin.

Table -4.1 Sub Basin wise Number of Operational Holding

Social Group	Walaiyar	Palar	Aliyar	Sholaiyar	Total	Total in %
Marginal (< 1 Ha)	8757	12668	9052	14	30492	43.14
Small (1 to 1.99 Ha)	4988	8669	6062	2	19721	27.90
Semi medium (2 to 3.99 Ha)	3281	5898	4024	5	13208	18.69
Medium (4 to 9.99 Ha)	1550	2766	1958	21	6294	8.91
Larger (>10 Ha)	209	357	299	95	959	1.36
Total	**18785**	**30358**	**21394**	**137**	**70674**	**100.00**



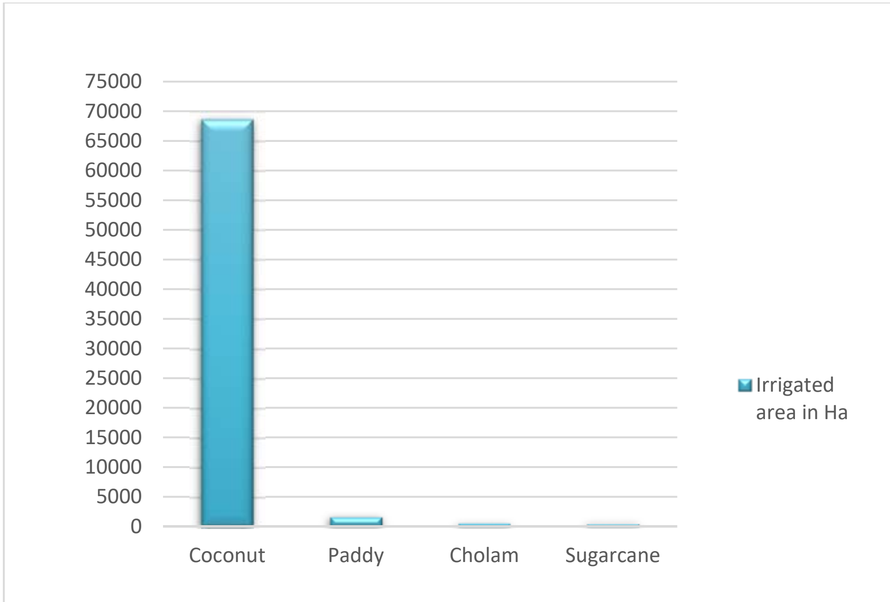
4.3 Irrigation Water Demand Calculation

Major crops and Irrigated area

Irrigated area details for various crops were collected from the Agricultural Department. Irrigated area data for the year 2019-20 was taken for computing Irrigation water demand. The block wise crop area cultivated during 2019-20 was transformed into sub basin area by its block area proportion. Present Sub basin wiseirrigated area of crops in ParambikulamAliyar Basin is shown in **Table 4.2**. For the irrigation demand calculation, a simplification of crop data was considered by uniform crop plant date and duration of crop growth period in different sub-basins.

For the year 2019-20, gross irrigated area in the basin under different crop is 71,735 Ha. Under irrigated conditions, Coconut (68,620Ha) is the main crop in this basin, followed by Paddy (1,579Ha), Cholam(549Ha) and Sugarcane (493Ha). Irrigated area of major crops is given in **Fig 4.2.**

Figure 4.2 Irrigated area of Major crops (Ha) in ParambikulamAliyar Basin



The total irrigated area in Walaiyar Sub Basin is 10,950Ha which accounts for 15% of basin area,Palar Sub Basin is 14,211Ha which occupies 20%, Aliyar Sub Basin is 22,372 Ha which occupies 31%and Sholaiyar Sub Basin is 24,201Ha which occupies 34% of the total Basin area.

Figure 4.3 Sub basin wise Irrigated area of crops in Parambikulam Aliyar Basin

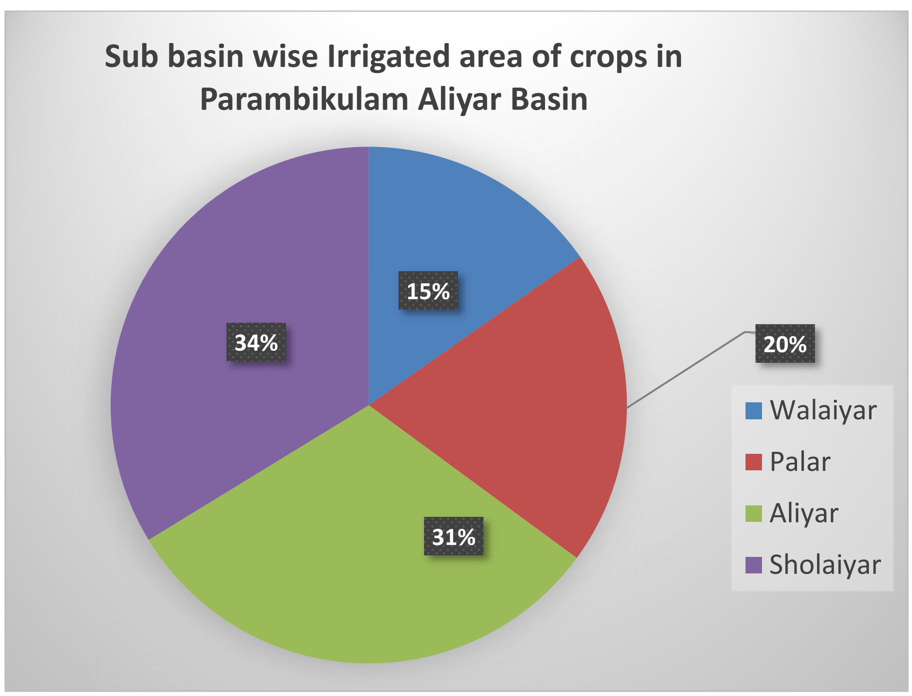
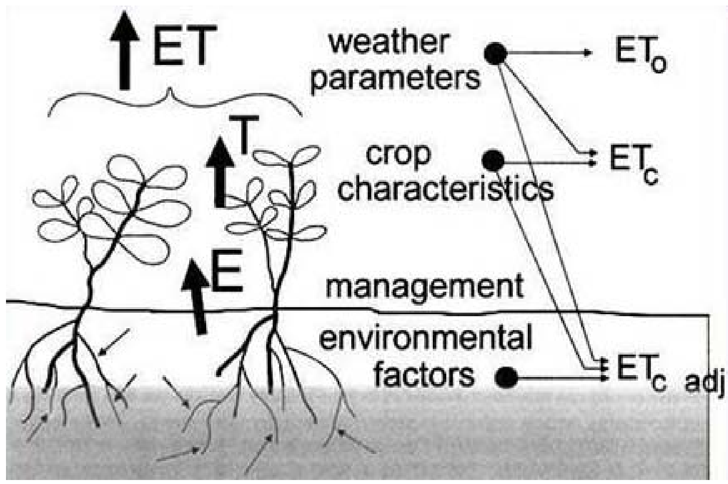


Table 4.2
Sub Basinwise Irrigated Area (Ha) of different crops in ParambikulamAliyar Basin

Crop	Walaiyar	Palar	Aliyar	Sholaiyar	Total
Coconut – Per - Jan	10779	12906	21484	23451	**68620**
Paddy I - June	10	182	477	516	**1184**
Paddy II - Oct	3	61	159	172	**395**
Cholam - Aug	0	473	76	0	**549**
Cumbu - Mar	0	4	1	0	**4**
Ragi - July	0	0	0	0	**0**
Maize - May	118	55	27	1	**201**
Red Gram - June	1	0	1	1	**3**
Black Gram - June	7	166	31	5	**210**
Green Gram - June	4	3	0	0	**8**
Other Cereals - July	0	0	0	0	**0**
Chillies - Feb	0	0	0	0	**0**
Onion-Apr	0	0	0	0	**0**
Fodder - Mar	0	0	0	0	**0**
Condiments -Sep	0	0	0	0	**0**
Sugarcane - Jan	13	323	106	52	**493**
Banana - Apr	0	0	0	0	**0**
Groundnut - Nov	9	24	8	3	**44**
Cotton - Jan	7	15	2	0	**24**
Gingelly - Feb	0	0	0	0	**0**
Fruits & Vegetables - July	0	0	0	0	**0**
Flowers - Per - June	0	0	0	0	**0**
Turmeric - Sep	0	0	0	0	**0**
Total	**10950**	**14211**	**22372**	**24201**	**71735**

4.4 Crop Water Requirement

Crop water requirement *(*CWR*)* is defined as the depth of water [mm] needed to meet the water consumedthrough evapotranspiration ET_c, by a disease-free crop for the complete crop period, growing in large fields under non-restricting soil conditions including soil water and fertility, and achieving full production potential under the given growing environment. The crop water need mainly depends on climate, crop type and growth stage of the crop.



Computational procedure for irrigated crop water under consideration involves simulation of monthly water balance within the effective root zone of the crop. A simplified balance equation presents the basic concept as follows:

STt=STt-1+ERt+TIRt+RIRt-ETAt, where:

t - month.

ST - Root zone storage level between the soil field capacity and wilting point over the effective root depth, mm.

ER - Effective rainfall (total rainfall less surface runoff if exists).

TIR - Technical irrigation, such as pre sowing, germination, or leaching irrigation, net, mm.

RIR - Regular irrigation, replenishing the net crop requirements, mm.

ETA- Actual crop evapotranspiration, a product of ETo and Kc, mm.

Kc - Crop coefficient, a function of crop type and its stage of development, ratio.

ETo - Reference crop evapotranspiration.

Simulation starts with an initial condition describing the state of the root zone soil water just before sowing, i.e. available moisture from previous period.

Basic water need is termed as Technical irrigation. Regular irrigation is applied within the "t" period whenever the root zone moisture level falls below a specified allowable depletion threshold. The allowable depletion is the fraction of the soil storage, which can be depleted from the root zone before moisture stress occurs. The allowable depletion is a characteristic of the crop, and is given as a percentage of the root zone to full soil storage.

The depth of regular irrigation, when applied, is determined so as to replenish the full deficit between the current storage level and the field capacity. In the last month of the irrigation period, if regular irrigation is applied, replenishment occurs only up to the allowable depletion level.

The simulation model distinguishes between two layers within the root zone storage. The upper layer consists of the current root depth and the lower one is the difference between the current root depth and the full root depth. The current root depth in each "t" period is linearly interpolated between zero at the start of the simulation and the full depth attained at a specified date. After that date, the upper layer remains at full depth level till the end of the simulation and the lower one is zero.

The irrigation balance is simulated in the upper layer. Excess moisture in the upper layer as a result of rainfall or technical irrigation, spills to the lower layer and then percolates below the root zone. Similarly, excess moisture from the lower layer, percolates below the root zone.

The net irrigation requirements include technical irrigation (TIR), regular irrigation (RIR) and leaching irrigation requirement (LIR) as described above.

The gross irrigation requirement (GIR) is obtained by applying efficiency factor EF, as follows: GIR = (TIR+RIR+LIR)/EF.

Hence, it is important to indicate that field percolation losses as a result of excess rainfall, technical irrigation and infiltration from the paddy fields are taken into account by the simulation model. On-farm and off-farm conveyance, runoff, deep percolation other than direct field percolation and operational losses are taken into consideration.

Factors influencing crop water requirements for irrigation

The following features which mainly influence the crop water requirement are:

1) Crop factors - a) Variety b) Growth stages c) Duration d) Plant population e) Crop growing season
2) Soil factors - a) Structure b) Texture c) Depth d) Topography e) Soil chemical composition
3) Climatic factors - a) Temperature b) Sunshine hours c) Relative humidity d) Wind velocity e) Rainfall

4) Agronomic management factors - a) Irrigation methods used b) Frequency of irrigation and its efficiency c) Tillage and other cultural operations like weeding, mulching etc / intercropping.

Input Data and Parameters

The required inputs for the crop irrigation requirement model include the following data and parameter sets:

Rainfall

Monthly rainfall distributions for four rainfall dependability ie 50% and 75% for the weighted rainfall in accordance with the discussion in section 3.2 were used.

Reference Crop Evapotranspiration (ETo)

ETo values calculated for the Aliyar station as discussed is section 3.3of Chapter 3 were used in all the cases.

Crop Parameters

The crop parameters used in the model are presented in **Table-4.3**.The Kc stages and coefficients were adopted from FAO irrigation Paper No. 56 (Ref: Evapotranspiration - Guidelines for computing crop water requirements). The Kc stages and coefficients for the permanent crops were adjusted to approximate the Kc variation of these crops for the entire year. The growth stage of a crop as in **Fig. 4.4** profoundly influences Kc values. The crop growing period can be divided into four distinct growth stages:

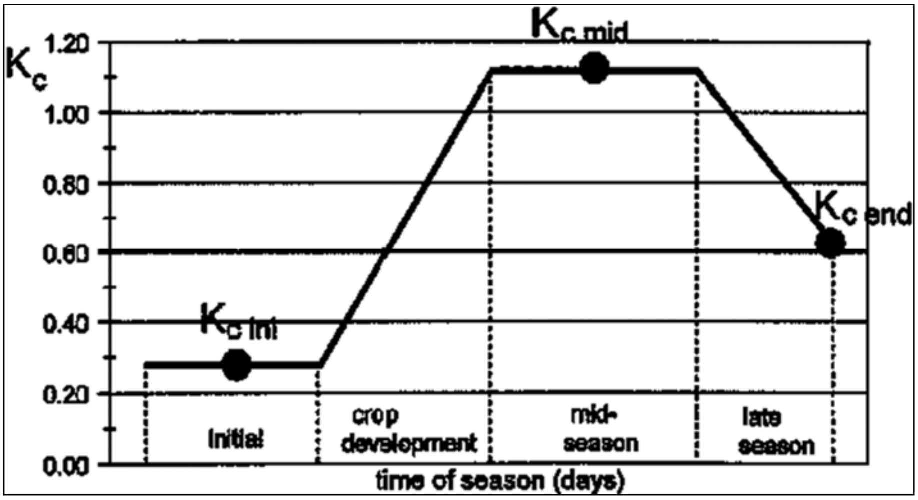
(i) The initial stage (from sowing to about 10% ground cover),

(ii) Crop development stage (from 10% to about 70% ground cover),

(iii) Mid-season stage (including flowering and grain setting and yield formation stage),

(iv) Late season stage (including ripening and harvest).

Figure 4.4 Growth Stage of a Crop



In general, out of the four growth stages, the mid-season stage is the most sensitive to water shortages, as it is the period of the highest crop water need. Water shortage during the mid-season will reduce crop yields substantially.

Soil Parameters

The field capacity and the wilting point of the soil were taken as 30% and 15% respectively for all cases. These values give soil water capacity of 150 mm/m, which could be considered as representative for the majority of the situations in all soils of the basin. Initial water storage condition was taken as dry root zone for all the crops except the coconut, and the fruit crops. For them dry soil layer of 15 cm was taken as initial condition.

Technical Irrigation Data

A planting (pre-sowing) application of 50 mm depth (net), named as technical irrigation was prescribed for all the crops except the coconut. For the paddy, technical irrigation depth is worked out from following data:

Nursery – ETA requirements and infiltration of 2 mm / day during the nursery period for the 8% of the area.

Land preparation - 200 mm

Paddy initial filling - 50 mm

Infiltration of 2 mm /day during the irrigation period.

The crop parameters and technical irrigation for crops for Parambikulam Aliyar Basin is given in **Table 4.3 & Table 4.4.**

4.5 Basin Net Irrigation Water Demand – Present situation

Though water from the Parambikulam Aliyar basin irrigates ayacut in Cauvery basin, the Irrigation demand is limited to the ayacut falling within the Parambikulam Aliyar basin.

The monthly crop irrigation requirements as discussed above were applied to the crop areas of the 4 sub basins for the three state of dependable rainfall. The irrigation demand calculated is the balance of the rainfall, the crop actual evapotranspiration, crop change of storage and the technical irrigation requirements and also include direct field deep percolation resulting from excessive technical irrigation and paddy infiltration.

Fig.4.5 explains about the methodology adopted in the calculation of Irrigation Demand. The net Irrigation Water Requirement at 50% and 75% Dependable Rainfall of sub basins in Parambikulam Aliyar Basin is given in **Vol-II Appendix 4.10, 4.11, 4.12 and 4.13.**On the same line, Irrigation water demand for 50% and 75% dependable rainfall of the four sub basins were calculated and given in **Tables 4.5 and 4.6** respectively.

Figure 4.5 Methodology for calculating Irrigation Demand – ParambikulamAliyar River Basin

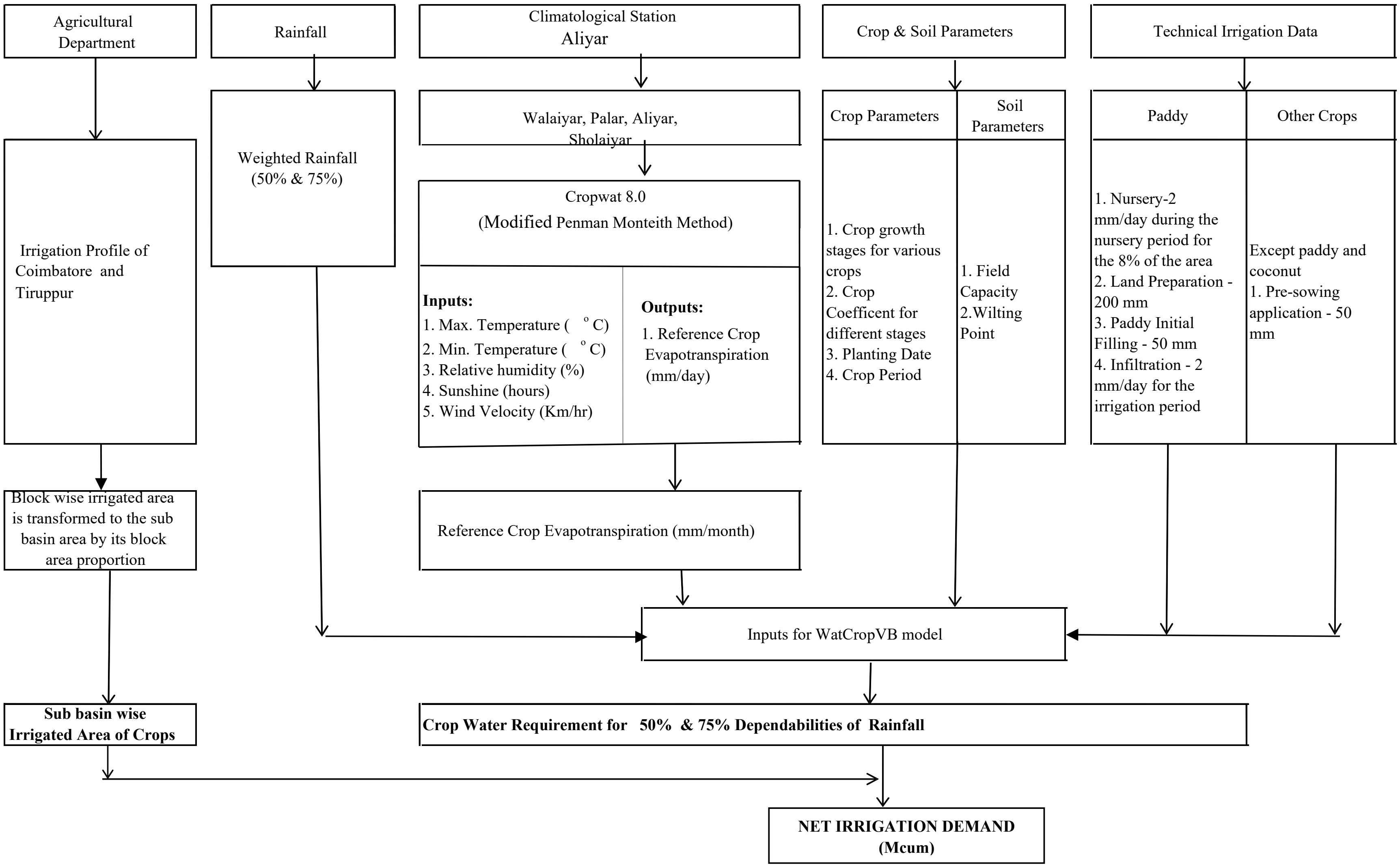


Table 4.3 Crop Parameters in Parambikulam Aliyar River Basin

Crop No.	Crop Name	Planting Date		Crop period	Kc Stages				Data for Kc calculations			Effective root		Allow-Able deplet-Ion
					Stage-1	Stage-2	Stage-3	Stage-4	Wetting interval	Kc mid season (Period-3)	Kc at harvest	Full depth	Time to Full depth	
		Month	Day	(days)	(days)	(days)	(days)	(days)	(days)			(cm)		(%)
1	Coconut- Per-Jan	1	1	365	25	100	100	140	10	1.00	1.00	150	150	40
2	Paddy I-June	6	5	115	30	40	30	15	5	1.10	0.90	15	20	33
3	Paddy- II -Oct	10	20	90	25	35	15	15	5	1.10	0.90	15	20	33
4	Cholam-Mar	3	25	90	20	25	25	20	8	1.00	0.35	125	40	50
5	Cumbu - July	7	15	80	15	25	25	15	8	1.00	0.35	125	35	50
6	Ragi-Feb	2	1	90	20	25	25	20	8	1.06	0.55	125	40	55
7	Maize-Feb	2	25	85	15	25	30	15	10	1.00	0.35	125	40	55
8	Red gram - June	6	10	130	20	40	40	30	10	1.00	0.35	80	30	50
9	Blackgram-June	6	15	70	20	15	20	15	10	1.00	0.35	80	30	50
10	Other Cereals-July	7	15	85	15	25	30	15	10	1.00	0.35	80	30	33
11	Chillies-Sep	9	1	180	30	55	65	30	7	1.05	0.90	75	70	70
12	Onion-Feb	2	1	80	15	25	25	15	5	1.05	0.90	50	35	30
13	Fodder-Mar	3	20	90	20	25	25	20	5	1.00	0.35	125	35	40
14	Condiments-Sep	9	25	100	25	35	20	20	5	1.00	0.35	80	30	50
15	Sugarcane-Jan	1	10	320	30	90	150	50	8	1.25	0.75	150	100	65
16	Greengram - June	6	10	70	20	15	20	15	10	1.00	0.35	80	30	50
17	Banana- Jan	1	1	365	30	100	185	50	7	1.10	1.00	75	100	35
18	Groundnut-Jan	1	5	105	25	35	25	20	10	1.15	0.60	70	45	40
19	Cotton - Feb	2	1	140	30	30	50	30	10	1.15	0.60	140	45	65
20	Gingelly-Dec	12	15	80	15	25	25	15	7	1.15	0.60	125	60	40
21	Fruits & Veg-Per July	7	10	365	25	100	100	140	5	1.05	0.90	100	35	30
22	Flowers-Per-Sep	9	20	365	20	125	125	95	4	0.95	0.85	100	50	20

Table 4.4 Technical Irrigation (Pre Sowing Basic Water Need)for Crops in Parambikulam Aliyar River Basin

Crop No.	Crop Name	Field application efficiency	Technical Irrigation											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		(%)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
1	Coconut- Per-Jan	60												
2	Paddy-First crop-June	60						319.2	112	162	54			
3	Paddy-Second crop-Oct	60	34									290	110	162
4	Cholam-Mar	60			50									
5	Cumbu– July	60							50					
6	Ragi-Feb	60		50										
7	Maize-Feb	60		50										
8	Red gram – June	60						50						
9	Blackgram-June	60						50						
10	Other Cereals-July	60							50					
11	Chillies-Sep	60									50			
12	Onion-Feb	60		50										
13	Fodder-Mar	60			50									
14	Condiments-Sep	60									50			
15	Sugarcane-Jan	60	50											
16	Greengram– June	60						50						
17	Banana- Jan	60	50											
18	Groundnut-Jan	60	50											
19	Cotton – Feb	60		50										
20	Gingelly-Dec	60												50
21	Fruits & Veg-Per July	60							50					
22	Flowers-Per-Sep	60									50			

Table 4.5 Net Irrigation Water Demand (Mcm) at 50% Dependable Rainfall in Parambikulam Aliyar River Basin

Sl.No	Sub Basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	Walaiyar	6.78	6.44	9.92	7.76	9.38	0.07	15.06	0.05	15.80	0.01	0.00	0.01	**71.28**
2	Palar	8.34	7.96	12.65	10.93	0.00	0.73	10.07	10.44	0.55	10.51	0.07	0.14	**72.39**
3	Aliyar	13.70	12.78	19.95	18.51	0.00	1.51	0.53	0.77	0.26	16.49	0.17	18.07	**102.76**
4	Sholaiyar	14.78	13.88	0.00	14.29	0.00	1.62	0.58	0.84	0.28	0.50	0.19	0.36	**47.31**
	TOTAL	**43.60**	**41.07**	**42.53**	**51.48**	**9.38**	**3.95**	**26.24**	**12.09**	**16.88**	**27.50**	**0.43**	**18.57**	**293.74**

Table 4.6 Net Irrigation Water Demand (Mcm) at 75% Dependable Rainfall in Parambikulam Aliyar River Basin

Sl.No	Sub Basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	Walaiyar	6.78	0.07	9.21	6.23	7.83	0.04	10.03	8.88	8.91	0.01	0.01	13.82	**71.81**
2	Palar	6.30	7.93	7.17	10.17	0.00	17.58	0.32	17.27	0.20	0.17	0.07	11.70	**78.88**
3	Aliyar	13.20	10.87	16.56	16.19	0.00	1.51	0.53	0.77	18.08	0.46	0.17	23.39	**101.74**
4	Sholaiyar	14.91	13.19	21.52	0.00	31.08	1.62	0.58	0.84	0.28	0.50	21.02	21.42	**126.96**
	TOTAL	**41.20**	**32.06**	**54.46**	**32.59**	**38.91**	**20.76**	**11.46**	**27.75**	**27.47**	**1.14**	**21.26**	**70.34**	**379.40**

The above table 4.6 shows the water requirement for the total crop cultivated during 2019-2020. When considering the maximum ayacut area of one year (88,751 ha), there is a balance area of 17,016 ha.

Adding the water requirement of 90.00 MCM for the balance area, the total water requirement for Parambikulam Aliyar Basin is 469.40 MCM (Calculation of water requirement for ayacut area given in **Vol II Appendix 4.14**).

4.6 Future Net Irrigation Water Demand-Lower Limit Scenario

This scenario is based on the identification of changes in the present cropping or cultivation pattern, which would result in, some reasonable lower limit for the future demand of irrigation water in the basin.

In Parambikulam Aliyar River Basin nearly 96% of the coconut area is raised only under irrigated condition. Considering this facts, the lower limit for the future irrigation demand is determined taking into consideration the cultivation of Coconut using DRIPirrigation method than the conventional method. If the objective of better yield for a drop of water is to be achieved, then comparatively less water consuming practices of cultivation are to be considered for future planning purposes. Lower Limit Scenario of sub basin wise irrigated area of crops in Parambikulam Aliyar River Basin are tabulated in **Table 4.7** and net irrigation Water Demand at 50% & 75% dependable Rainfall of Lower Limit Scenario are tabulated in **Tables 4.8 and 4.9**. Savings in demand in implementing lower limit scenario pattern of crops in Parambikulam Aliyar River Basin is listed in **Table 4.10.**

Table 4.7 Sub Basin wise Irrigated Area of Crops (Ha.) in Parambikulam Aliyar Basin Lower Limit Scenario

Crop	Walaiyar	Palar	Aliyar	Sholaiyar	Total
Coconut- Per - Jan	2156	2581	4297	4690	**13724**
DRIP - Coconut - Jan	8623	10325	17187	18761	**54897**
Paddy I - June	10	182	477	516	**1184**
Paddy II - Oct	3	61	159	172	**395**
Cholam - Feb	0	473	76	0	**549**
Cumbu - Mar	0	4	1	0	**4**
Ragi– Jan	0	0	0	0	**0**
Maize - Jul	118	55	27	1	**201**
Red Gram - June	1	0	1	1	**3**
Black Gram - Jan	7	166	31	5	**210**
Green Gram - Jan	4	3	0	0	**8**
Other Cereals - July	0	0	0	0	**0**
Chillies - Jan	0	0	0	0	**0**
Onion-June	0	0	0	0	**0**
Fodder - Mar	0	0	0	0	**0**
Condiments -Sep	0	0	0	0	**0**
Sugarcane - Dec	13	323	106	52	**493**
Banana - Dec	0	0	0	0	**0**
Groundnut - Dec	9	24	8	3	**44**
Cotton - Feb	7	15	2	0	**24**
Gingelly - Feb	0	0	0	0	**0**
Fruits & Vegetables - June	0	0	0	0	**0**
Flowers - Per - June	0	0	0	0	**0**
Turmeric - June	0	0	0	0	**0**
TOTAL	**10950**	**14212**	**22372**	**24201**	**71735**

Lower Limit Scenerio

Table 4.8 Net Irrigation Water Demand (Mcm) at 50% Dependable Rainfall in Parambikulam Aliyar River Basin

Sl.No	Sub Basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	Walaiyar	6.78	6.44	9.92	7.76	9.38	0.07	15.06	0.05	15.80	0.01	0.00	0.01	**35.72**
2	Palar	4.25	4.13	6.68	5.88	0.00	0.73	5.35	5.40	0.55	5.31	0.07	0.14	**38.49**
3	Aliyar	6.90	6.40	10.01	9.31	0.00	1.51	0.53	0.77	0.26	8.47	0.17	9.16	**53.51**
4	Sholaiyar	7.43	6.91	0.00	7.13	0.00	1.62	0.58	0.84	0.28	0.50	0.19	0.36	**25.83**
	TOTAL	**25.36**	**23.88**	**26.61**	**30.08**	**9.38**	**3.95**	**21.52**	**7.06**	**16.88**	**14.29**	**0.43**	**9.66**	**153.55**

Table 4.9 Net Irrigation Water Demand (Mcm) at 75% Dependable Rainfall in Parambikulam Aliyar River Basin

Sl.No	Sub Basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	Walaiyar	3.37	0.07	4.64	3.17	3.90	0.04	4.99	4.42	4.44	0.01	0.01	6.86	**35.91**
2	Palar	3.24	4.10	3.87	5.44	0.00	9.61	0.32	9.11	0.20	0.17	0.07	5.88	**42.01**
3	Aliyar	6.65	5.44	8.32	8.15	0.00	1.51	0.53	0.77	9.35	0.46	0.17	11.80	**53.16**
4	Sholaiyar	7.49	6.57	10.71	0.00	15.47	1.62	0.58	0.84	0.28	0.50	10.58	10.85	**65.48**
	TOTAL	**20.75**	**16.18**	**27.54**	**16.77**	**19.37**	**12.80**	**6.42**	**15.14**	**14.26**	**1.14**	**10.82**	**35.39**	**196.57**

Table – 4.10 Net Irrigation Water Demand at 75 % Dependable Rainfall in Parambikulam Aliyar River Basin

Sl. No.	Sub Basin	Present Irrigation Demand (Mcm)	Lower Limit Irrigation Demand (Mcm)	% of Savings in Demand
1	Walaiyar	71.81	35.91	49.99
2	Palar	78.88	42.01	46.74
3	Aliyar	101.74	53.16	47.75
4	Sholaiyar	126.96	65.48	48.42
	Total	**379.40**	**196.57**	**48.19**

4.7 Cropping Pattern

From time immemorial due to the good soil health and plentiful water availability, farmers have a set of cropping pattern in command areas of tanks and rivers, which predominantly coconut, paddy, sugarcane, cholam and other hydrophilic crops. Due to the changing rainfall pattern over the years, ground water depletion, lack of flows in the rivers, uncontrolled extraction of ground water, scarcity of labour and hike in wages, the existing cropping pattern has ceased to be economically viable. Hence, it is the time to design a new alternate-cropping pattern based on the agro-climatic zone. This must be demonstrated in the farmer's holdings by a massive research cum extension programmes in order to effectively utilize the natural resources and also to stabilize productivity and profitability. The irrigated area of four major crops for past 4 years is shown in **Fig 4.6.**The irrigated area(in Ha) of four major crops grown in the Parambikulam Aliyar basin and its crop water requirement is presented in the **Table 4.11**.

Fig 4.6 Irrigated area of various crops for past 6 years

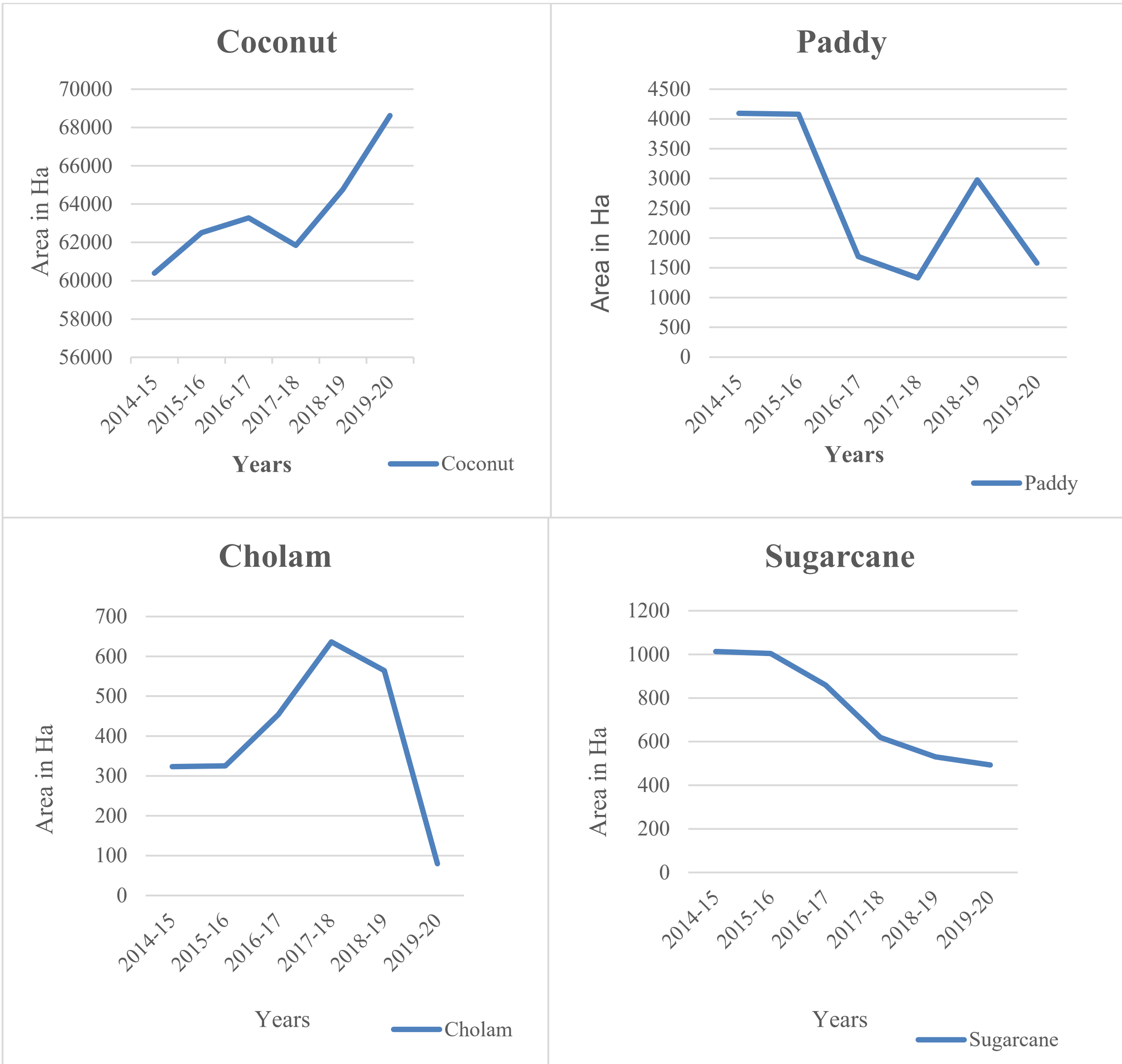


Table 4.11 Irrigated area (in Ha) of four major crops grown in the ParambikulamAliyar basin and its crop water requirement

Coconut				
Year	Crop area in Ha	Crop water reqd. in MCM	Yield rate Kg/Ha	Production in thous. Qtl
2014-15	60397.67	320.80	10135	6121.15
2015-16	62506.72	331.43	15274	9547.53
2016-17	63278.17	263.02	7366	4661.34
2017-18	61845.26	326.86	8513	5264.61

Paddy				
Year	Crop area in Ha	Crop water reqd. in MCM	Yield rate Kg/Ha	Production in thous. Qtl
2014-15	4096.96	29.51	4737	19.41
2015-16	4078.80	29.57	3977	16.22
2016-17	1492.22	12.15	4003	5.97
2017-18	1330.24	9.90	3680	4.89

Cholam				
Year	Crop area in Ha	Crop water reqd. in MCM	Yield rate Kg/Ha	Production in thous. Qtl
2014-15	323.04	0.55	1196	3864.31
2015-16	325.20	0.56	1647	5355.66
2016-17	454.09	0.78	507	2303.85
2017-18	636.37	1.09	610	3881.75

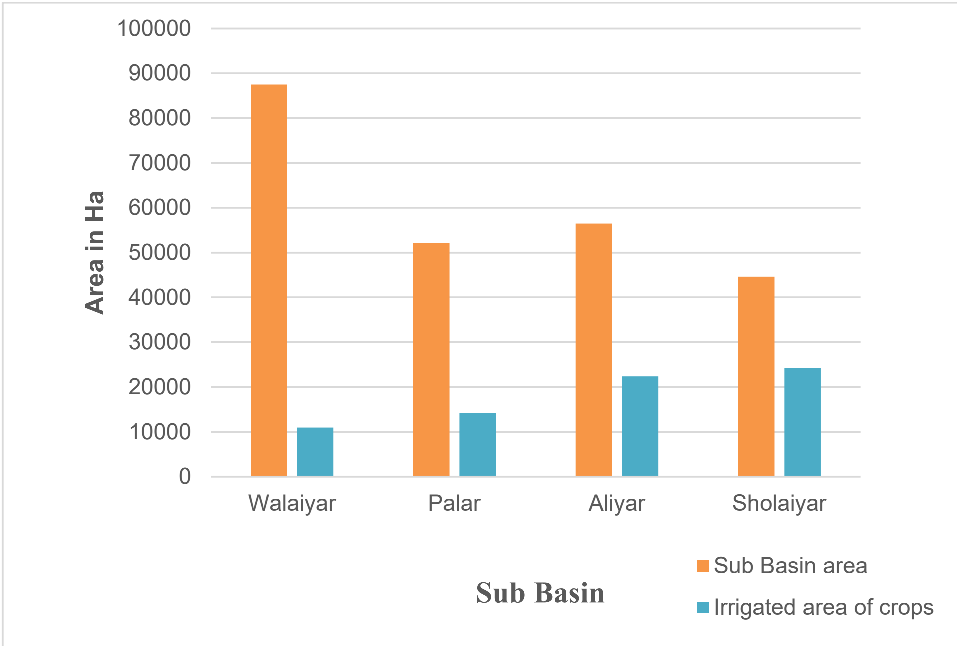
Sugarcane				
Year	Crop area in Ha	Crop water reqd. in MCM	Yield rate Kg/Ha	Production in thous. Qtl
2014-15	1013.14	6.31	107	1.08
2015-16	1003.77	6.26	104	1.04
2016-17	938.23	5.10	83	0.78
2017-18	618.73	3.80	100	0.62

It is observed from the table, that crop water requirement varies directly proportion to the crop area, Yield rate is taken from season and crop report of Tamilnadu for the year 2014-15, 2015-16, 2016-17, 2017-18. Yield rate for the crops may vary with the type of agriculture practices adopted by the farmers.

Existing & Suggested Cropping Pattern in Parambikulam Aliyar River Basin

The major crops cultivated in Parambikulam Aliyar Basin are Coconut, Paddy, Cholam, and Sugarcane. The irrigated area for the year 2019-20 in Parambikulam Aliyar Basin under different crops is 71,735Ha. Coconut is cultivated in 68,620Ha, in the balance area, other crops are cultivated. A bar chart showing the irrigated area (Ha) and the total sub basin area (Ha) for all four sub basins of Parambikulam Aliyar basin is presented in **Fig 4.7.**

Figure 4.7 Sub basin area vs Irrigated area of crops in Parambikulam Aliyar River Basin



The distribution of rain also plays a vital role in crop productivity. Existing cropping pattern during normal rain year (+19% to -19% of normal rainfall) and suggested cropping pattern for Poor rain year (-19% to -59% of normal rainfall) for the Districts covered in this basin are given in the **Table 4.12**.

Table 4.12 Cropping Pattern in the Districts covered in Parambikulam Aliyar River Basin

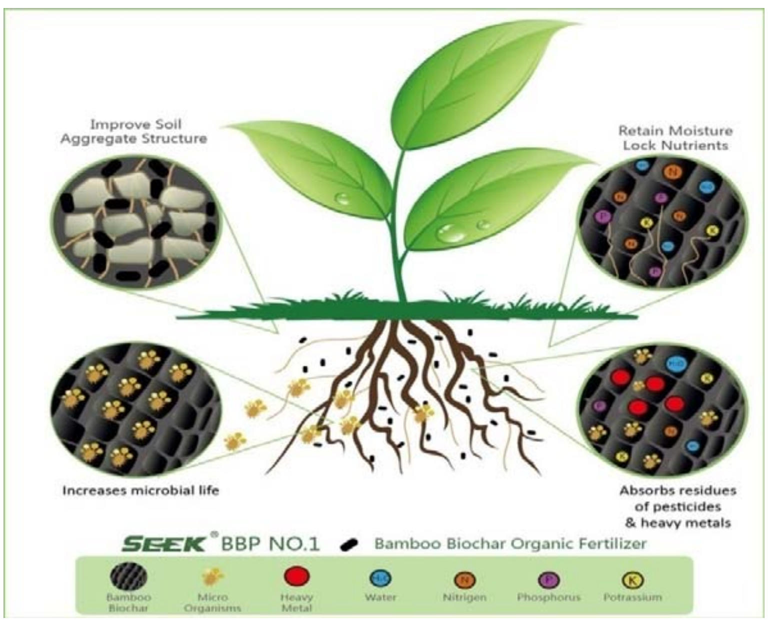
Sl.No.	District	Block	Existing cropping pattern during normal rainfall year	Suggested cropping pattern during poor rainfall year
1	Coimbatore	Anamalai	Paddy – Paddy -Green manure	SD Paddy – Pulses/Millets – Green manure
			Vegetables - Pulses	Vegetables - Pulses
		Kinathukadavu	Cholam- Cowpea	Cholam / Cowpea
		Madukarai	Cholam - Cowpea	Millets / Pulses
		Pollachi(S)	Gingelly / Groundnut – Cholam / Maize	Groundnut / Gingelly – Millets
		Pollachi(N)	Gingelly / Groundnut – Cholam / Maize	Groundnut / Gingelly – Millets
			Cotton - Pulses	Cotton - Pulses
		Sulthanpet	Cholam / Maize -Pulses	Cotton - Pulses
		Thondamuttur	Cholam / Groundnut - Pulses	Millets - Pulses
			Onion – Paddy	Onion – Pulses / Millets
2	Thiruppur	Udumalpet	Maize - Pulses	Millets - Pulses
			Paddy - Pulses	SD Paddy - Pulses

4.8 Biofertilizers

Biofertilizers are defined as preparations containing living cells or latent cells of efficient strains of micro-organisms that help cropsto uptake nutrients by their interactions in the rhizosphere when applied through seed coating or soil. They accelerate certain microbial processes in the soil which augment the extent of availability of nutrients in a form easily assimilated by plants.

Biofertilizers are carrier based preparations containing efficient strains of nitrogen fixing or phosphate solubilizing microorganisms. Biofertilizers are formulated usually as carrier based inoculants. The organic carrier materials are more effective for the preparation of bacterial inoculants. The solid inoculants carry more number of bacterial cells and support the survival of cells for longer periods of time. The mass production of carrier based bacterial biofertilizers involves three stages.

- Culturing of microorganisms
- Processing of carrier material
- Mixing the carrier and the broth culture and packing



(Source :www.agritech.tnau.ac.in: Organice Farming: Biofertilizer Technology)

For enhancing the shelf life of the Biofertilizers, they are now produced in liquid form also.

Use of biofertilizers:

- Biofertilizers are known to play a number of vital roles in soil fertility, crop productivity and production in agriculture as they are eco friendly.
- They increase the crop yield by 20% to 30% and replaces chemical nitrogen and phosphorus by 25%.
- They stimulateplant growth.
- Theyactivate the soil biologically and restores natural soil fertility.
- They provide protection against drought and some soil borne diseases.

The quantity of biofertilizers distribution target, quantity distributed and area utilizing in Hafor the year 2019-20 for the blocks in ParambikulamAliyar RiverBasin have been tabulated in **Table 4.13.**

Table 4.13 Bio fertilizer Production and Distribution Details

Block	No of Production Units	Quantity produced in Tonnes	Distribution target in Tonnes	Quantity distributed in Tonnes	Area utilizing in Ha
Madukkarai	4	10.534	0	10.534	2106
Thondamuthur	1	23.595	0	23.595	4719

(Source: Bio fertilizers details collected from Agriculture Department)

4.9 Organic Fertilizers

Usage of organic fertilizers is encouraged to control the environmental pollution and for healthier life. There are many forms of organic fertilizers like Farm yard manure, Compost, Vermi compost etc.

More emphasis is given to vermin compost as it is environmental friendly and high in plant nutrients.

Vermicompost

Vermicomposting is a method of using earth worms to transform organic waste into a nutrient-rich fertilizer. It is a healthy and clean way to eliminate wastes going into our landfills, which improves the environment. Vermicomposting is inexpensive, and only takes two to three months to produce results.

Function

Vermicompost improves the root structure, plant growth, new shoots and blooms ofplants. An increase in crop production/growth is also noticeable. Vermicompost also has ingredients that repel insects, and it can be used as an insect repellent.

Advantages of Vermicompost

- Vermicompost is rich in all essential plant nutrients.
- Provides excellent effect on overall plant growth, encourages the growth of new shoots / leaves and improves the quality and shelf life of the produce.
- Free flowing, easy to apply, handle and store and does not have a bad odour.
- Improves soil structure, texture, aeration, and waterholding capacity and prevents soil erosion.
- Rich in beneficial micro flora such as a fixers, P- solubilizers, cellulose decomposing micro-flora etc in addition to improving the soil environment.
- Contains earthworm cocoons and increases the population and activity of earthworm in the soil.
- Prevents nutrient losses and increases the use efficiency of chemical fertilizers.
- Free from pathogens, toxic elements, weed seeds etc.
- Minimizes the incidence of pest and diseases.
- Enhances the decomposition of organic matter in soil.
- Contains valuable vitamins, enzymes and hormones like auxins, gibberellins etc.

The farmers are encouraged to produce the required organic manure in their own lands by providing subsidy for establishment of 1400 Vermicompost units at a cost Rs.2.17 crore under National Mission for Sustainable Agriculture (NMSA) – Rainfed Area Development.The details such as subsidy given for Vermicompost production units and area covered under Vermicompostusage in the blocks covered inParambikulamAliyarRiver Basin are tabulated in **Table 4.14**.

Table 4.14 - Details of blocks where vermicompost utilized in Parambikulam Aliyar River Basin

Sl.No.	Block	Vermi compost	
		No. of units for which subsidy given	Vermi compost utilized – Area in Ha
1	Thondamuthur	100	500
2	Udumalpet	3	5
	Total	103	505

(**Source**: Agriculture Department)

4.10 Major Schemes covered in Parambikulam Aliyar Basin by Agricultural Engineering Department

Mission on Sustainable Dry Land Agriculture

The Director of Agriculture has sent a proposal for development of dryland in cluster mode. In that proposal, it is stated that Dryland Agriculture **refers to cultivation of crops which are entirely dependent on rainfall**. Since, large number of farmers depends on dryland agriculture for their livelihood; sustainability in dryland farming assumes more importance for the upliftment of the farming community. In Tamil Nadu, most of the **Millet crops**, **Pulses crops and Oil seeds** are raised under rainfed condition. In rainfed areas, the input usage and yield obtained are always less compared to irrigated areas.

In order to bring maximum dryland area under cultivation in a phased manner, the Department of Agriculture has suggested a mission mode approach viz. Mission on sustainable dryland agriculture (MSDA) wherein **Cluster based activities** will be adopted. Therefore proposals have been sent tothe Government by the Agricultural Department seeking orders for implementation of a new scheme namely **"Mission on Sustainable Dry Land Agriculture"** for the development of 1,000 dryland Clusters in Tamil Nadu at a total cost of Rs.802.90 crore during the period from 2016-17 to 2019-20.

The Department of Agriculture has proposed to form 1,000 dryland clusters at the State level over a period of 4 years. In the first year, 200 clusters will be formed and in the next two years, 400 Clusters will be formed in each year. Activities will be spread in these 1,000 Clusters over 4 years of period.

The mission mode implementation would be under the following Headings:

- Dryland Cluster of 1000 Ha each
- Formation of Cluster Development Team (CDT)
- A Block level team consisting of ADA as Block Coordinator
- Baseline Survey by each Cluster Development Team (CDT)
- Farmer's Clubs
- Capacity Building
- Entry Point Activities
- Comprehensive Land Development Activities / Establishment of Water Harvesting Structures
- Agronomic Interventions - Promotion of dry land crops through appropriate Cropping system
- Institutional Strengthening – Support for Value Addition for Clusters

- Crop Insurance
- Animal Husbandry

Some of the Agricultural Schemes

Sl. No	Schemes	Eligibility and conditions for availing the benefits
1.	**Assistance to farmers for increasing the crop productivity**	
	a. Quality seed Distribution A subsidy of Rs.10 per kg of paddy seeds will be allowed in the sale price at the time of purchase at the Agricultural Extension Centers or 50% cost whichever is less	All farmers are eligible to avail the subsidy under this scheme. Preference will be given to Small/Marginal women farmers and 20% flow will be assured to SC/ST
	b. NADP – National Agricultural Development Programme: Government provides assistance through National Agricultural Development Program (NADP) to increase the area, production and productivity of Paddy and this programme was implemented with a budget outlay of Rs.40.50 Crore for providing incentive for Certified Seed production, distribution subsidy for High yielding certified Paddy Seeds, Paddy Micro Nutrient mixture and Biofertilizer, Assistance for weedicide application, popularization of machine planting, seed drill sowing, Assistance to FIGs or FPGs for popularisation of SRI or Machine Planting, assistance for Conoweeder and Moveable threshing floor(Tarpaulin) during 2019-20. This scheme will be continued during 2020-21 also.	All farmers are eligible to avail the subsidy under this scheme. Preference will be given to Small/Marginal women farmers and 20% flow will be assured to SC/ST

	b. NFSMPulses: The NFSM Pulses comes in a bigger way to attain the selfsufficiencyin Pulses production. Layout of Cluster demonstration plots, Cropping system based demonstration, Intercropping of Pulses, Providing incentive for the production of Certified seeds, Distribution of High yielding varieties of seeds at subsidized cost are the main components of NFSM Pulses. For soil and plant protection management, the components namely, Micro Nutrients, Biofertilizers, Gypsum and Plant Protection Chemicals are distributed at subsidized cost. To carry out farming operations, Rotavators, Sprayers and efficient water application tools like Pipes carrying water from source to field are distributed at subsidized cost. For drying the harvested losses, Tarpaulins are distributed under subsidy. A sum of Rs.40.12 Crore is allotted for this scheme during 2019-10. This scheme NFSM pulses will be continued during 2020-12	All farmers are eligible to avail the subsidy under this scheme. Preference will be given to Small/Marginal women farmers and 20% flow will be assured to SC/ST
2.	**Seed Village Scheme**	
	a.Distribution of Foundation / Certifiedseeds of Paddy at 50% cost for the production of quality seeds by farmers	All the farmers in the State who are willing to produce quality seeds from their lands for their own use and for distribution to other farmers.
	b.Three Days Training on seed production technology in three important phases of the crops to farmers who receive seeds from the department @ 50% cost for production of quality Seeds. 50 farmers per training totally 8000 training per year.	All the farmers in the State who are willing to produce quality seeds from their lands for their own use and for distribution to other farmers.
	c. Supply of Storage Binto the farmers. Rs.3000/- for 20 qtl bin and Rs.1500/- for 10 qtl. bin (or) 33% cost of bin	
	Rs.2000/- for 20 qtl bin and Rs.1000/- for 10 qtl. bin (or) 25% cost of bin	
3.	**Micro irrigation in Coconut Gardens:** Coconut is cultivated in an area of 4.40 lakh Hectare in the State. Under Pradhan MantriKrishiSinchayeeYojana (PMKSY) Scheme, focus is given for the cultivation of Coconut with drip irrigation and since 2017-18, drip irrigation was laid in coconut garden in an area of 10,727 Hectare. Due to various efforts taken by the Government, the Micro irrigation area under Coconut is increasing every year.	All famers are eligible small & marginal farmers are eligible for 75% subsidy where as the other farmers get 75% subsidy of the cost subject to the ceiling of 5 ha

	The Pradhan MantriKrishiSinchayeeYojana(PMKSY) Scheme will be also continued in 2020-21 also.	
4.	**Control of Rugose Spiralling Whitefly in Coconut** Rugose Spirally Whitefly infestation is noticed in Coconut crop in Coimbatore, Tiruppur, Thanjavur, Cuddalore, Erode, Salem, Kanyamari, Dindigul and Theni districts. The Department is making various efforts for the control and further spread of Whitefly in Coconut. The pest in Coconut is kept under control and further spread is prevented by release of beneficial insects, Yellow light trap and usage of jet water spray.	All farmers are eligible to avail the subsidy under this scheme. Preference will be given to Small/Marginal women farmers and 20% flow will be assured to SC/ST
5.	**Tamil Nadu Cotton Cultivation Mission:** An ambitious Tamil Nadu Cotton Cultivation Mission was launched in 2014-2015 in the state to increase the productivity and production of cotton by expansion of cotton area. During 2019-20, this scheme is being implemented at a total cost of Rs.11.00 Crores with a special focus on Extra Long Staple Cotton Cultivation.	All farmers are eligible to avail the subsidy under this scheme. Preference will be given to Small/Marginal women farmers and 20% flow will be assured to SC/ST

(**Source**: Agriculture Department)

4.11 Water Saving Techniques in Crop Production

For some of the major crops grown in Parambikulam Aliyar river Basin, the following specific strategies can be adopted as suggested by the Water Technology Centre, TNAU, Coimbatore.

(i)Paddy:

The **System of Rice Intensification**, known as SRI is a methodology for increasing the productivity of rice by effectively handling the crop during its growth and effectively utilizing soil, water and nutrients. This methodology is based on **four main principles** that interact with each other:

- Early, quick and healthy plant establishment
- Reduced plant density
- Improved soil conditions through enrichment with organic matter
- Reduced and controlled water application

The advantages are less seed requirement (5 kg / Ha),water saving upto 40%, using conoweeder to plough back the weeds, getting higher tillering which enhances yield and hence high income. The methodology involved is mat nursery method, young seedling transplantation (14 days old seedlings), single seedling in square planting method.

System of Rice Intensification (SRI) Method of Paddy Cultivation

(ii) Sugarcane:

Sustainable Sugarcane Initiative (SSI) is a method that aims at providing practical options to the farmers in improving the productivity of land,and at the same time with less consumption of water and labour. SSI is also expected to reduce the overall pressure on water resources and contribute to recovery of ecosystems. Sustainable Sugarcane Initiative is an innovative method of sugarcane production using less seeds, less water and optimum utilization of fertilizers and land to achieve more yields. The major principles that govern SSI can be stated as below:

- Raising nursery using single budded chips, transplanting young seedlings (25-35 days old)
- Maintaining wide spacing (5 x 2 feet) in the main field
- Providing sufficient moisture through water saving efficient irrigation technologies viz., skip furrow, alternate furrow and sub surface drip irrigation.
- Practicing intercropping with effective utilization of land.

Sustainable Sugarcane Initiative (SSI) method promotes mechanization in cultivation. To promote Drip Irrigation, Government provides 100% subsidy for small & medium farmers and 75% for large farmers. When compared to the conventional furrows, irrigation water saving of 50% is achieved in SSI method combined with Drip irrigation.

Sustainable Sugarcane Initiative (SSI)

(iii) Coconut:

Planting of the coconut husks at about 30 cm depth around the coconut trees at a radius of one meter and covering it up with earth, will conserve soil moisture.

Use of coir waste as soil mulch around the tree to a thickness of about 3 cm is advantageous to conserve soil moisture especially under scarcity condition. In the first year, irrigation shall be on alternate days and from the second year till the time of maturity, irrigation shall be given twice a week after which once in 10 days. During summer months and also whenever there is no rain, irrigation is a must depending upon soil moisture. Drip Irrigation is the best method of irrigation for coconut. By this, water saving of 63 percent, yield increase by 7 percent and labour saving of 40 percent could be achieved.

(iv) Vegetables:

Drip irrigation at 75 percent of cumulative pan evaporation has registered increased yield up to 59 percent with water saving up to 29 percent.

(v) Groundnut:

The infiltration rate of water is considerably improved by the application of coir waste. By this method, yield of ground nut is also increased. However, more number of irrigation in pre flowering and maturing phase does not show any substantial increase in the yield. When Drip Irrigation percentage of saving upto 50% can be achieved.

Percentage of saving in water when water saving techniques is adopted on cultivation for the present cultivable area of different crops in Parambikulam Aliyar River Basin is given below.

Sl .No.	Crop	Cultivated area in Ha	Water requirement-conventional method (MCM)	% of saving by adopting saving technique	Savings (MCM)
1	SRI-Paddy	1579	11.51	40	4.61
2	SSI-Sugarcane	493	3.11	50	1.56
3	Coconut - DRIP	68620	362.77	63	228.54
4	Groundnut-DRIP	44	0.17	50	0.08
				Total	**234.79**

4.12 Economic benefits derived from water supply for irrigation – One hectare crop budget.

The crop budget for unit hectare involving inputs like fertilizers and other related expenditures, labour costs and net income have been worked out for irrigated wet crops and irrigated dry crops for Parambikulam Aliyar River Basin. The cost of cultivation of crops in Tamilnadu is also appended in **Appendix 4.1 to 4.9 of Volume-II.**

4.13 Summary

Conclusion

- The Gross irrigated area of crops in ParambikulamAliyarBasin is reported to be 71,735 Ha.
- Irrigated area in Walaiyarsub basin is 10,950 Ha,Palar sub basin is 14,211 Ha, Aliyar sub basin is 22,372 Ha and Sholaiyar sub basin is 24,201 Ha.
- Out of the total area irrigated, about 96% is under Coconut cultivation and the remaining in Paddy, Cholam, Sugarcane, Groundnut, Pulses and millets cultivation.
- Net Irrigation demand of this basin at 75% dependable rainfall is 379.40 MCM.
- Net Irrigation demand of this basin at 50% dependable rainfall is 293.74 MCM.
- Sholaiyar sub basin has the maximum irrigated area of 24,201 Ha which accounts for about 34% of the total irrigated area.
- Walaiyar sub basin has the minimum irrigated area of 10,950 Ha which accounts for about 15% of the total irrigated area.
- Sholaiyar sub basin has the maximum irrigation demand of about 126.96 MCM (about 33%) and Walaiyar sub basin has the minimum irrigation demand of about 71.81MCM (about 19%).
- Organic farming practice is to be extended in greater manner in this Basin.

- As per 2006, Microlevel Study Report of Parambikulam Aliyar River Basin, Net Irrigation demand was calculated as 840 MCM at 75% dependable rainfall for an irrigated crop area of 84,784 Ha in which Irrigated area of Paddy is 25% and Coconut is 53%.
- Presently irrigated area is adopted as 71,735 Ha based on good rainfall year 2019-20.On comparing the cultivated area of the present study, it is found that the total irrigated area has decreased from 84,784 Ha to 71,735 Ha. Irrigated area of Coconut is increased from 45350 Ha to 68,620 Ha and Paddy is decreased from 21,310 Ha to 1,579 Ha.

Recommendation

- By adopting water saving techniques in agriculture, approximately 33% of irrigation water can be saved. In general,
    1. Crop production can be increased when unirrigated area of this basin is brought under irrigation.
    2. Extraction of ground water can be minimized.
    3. Frequency / Intensity of Irrigation can be improved from prevailing intensity of 1.
- Savings in Irrigation demand of about 4.61 MCM can be achieved if 40% of the area under Paddy cultivation practice is changed to SRI method.
- Using SSI irrigation, for the cultivation of sugarcane,50% of irrigation water (1.56 MCM) could be saved.
- Using DRIP and coir pith as soil mulch for coconut trees, 63% of irrigation water could be saved (228.54MCM).
- During poor rainfall years, suitable cropping pattern may be adopted with crops that require lesser irrigation like Cotton, Maize, Sorghum, Pulses, etc.

CHAPTER – 5

SURFACE WATER RESOURCES AND IRRIGATION SYSTEM

CHAPTER–5

SURFACE WATER RESOURCES AND IRRIGATION SYSTEM

5.1 Surface Water Data

Surface runoff is the response of a catchment to precipitation reflecting the integrated effects of a wide range of parameters like orientation and shape of the catchment, climate and intensity of precipitation, duration, the direction of storm, slope, soil, land use, etc.

5.2 Reservoirs and appurtenant structures of PAP

This Parambikulam Aliyar system comprises of 10 reservoirs in which the Upper Nirar Weir, Lower Nirar Dam, Sholayar Dam, Parambikulam Dam, Thunacadavu and Peruvaripallam Dams are located in the Anamalai Hills of the Western Ghats, whereas the Aliyar Dam and the Thirumurthy Dam are located in the plains along with that 4 Power Houses, 6 Main Tunnels, the unique Contour Canal, Leading Channels and a network of 7 Irrigation Canals, Branch Canals and Distributaries. The details of the reservoirs in the PAP System with their catchment area and Gross capacity are given in the **Table 5.1.** There are 35 interstates gauging points in this basin where, the flow is being measured and recorded. (Appendix 5.26 of Vol. II). The flow records are maintained by P.W.D. This also includes the flow measurements that are taken in reservoirs and weirs. They are:

1.UpperNirar 2. Lower Nirar 3. Tamil Nadu Sholayar 4. Parambikulam 5. Thunakadavu 6. Peruvaripallam 7. Aliyar Reservoir 8. Thirumurthy Reservoir 9. ManakadavuWeir (the share of kerala measured at this point)

Table 5.1 Details of Reservoirs of PAP.

Sl.No.	Name of the Reservoir	Catchment Area Sq.Km	Capacity at FRL TMC	Maximum height in m.
1	Upper Nirar Weir	75.11	0.04	27.52
2	Lower Nirar Dam	101.01	0.27	50.29
3	Sholayar Dam	121.73	5.39	105.16
4	Parambikulam Dam	228.44	17.82	73.15
5	Thunakadavu Dam	43.25	0.557	25.91

Sl.No.	Name of the Reservoir	Catchment Area Sq.Km	Capacity at FRL TMC	Maximum height in m.
6	Peruvaripallam Dam	15.80	0.62	33.53
7	Aliyar Dam	180.32	3.86	44.19
8	Thirumurthy dam	80.29	1.94	34.13
9	Upper Aliyar Dam	121.21	0.94	81.00
10	Kadamparai Dam	22.79	1.09	67.50

5.3 Area irrigated in Tamil Nadu

The PAP Agreement does not specify the extent of area to be irrigated with the water diverted from the project in Tamil Nadu. However, optimum planning was made to utilize the water efficiently. Irrigation canals take off from Aliyar and Thirumurthy dams except Sethumadai canal which takes off from Aliyar feeder canal. The extent of old ayacut in the Aliyar basin is about 2591 ha (6400 acres) and 378 ha (934 acres). The total command area under the PAP system as of now is about 1.76 lakh ha (4.35 lakh acres) spread over in Coimbatore, Erode and Tiruppur districts of Tamil Nadu. But in a year the extent of area irrigated by the system in Tamil Nadu is only about 2.35 lakh acres. At present, the total area served by the PAP system is as below:

Table 5.2 Dam/canal wise Command Area

Dam / Canal	(in acres)	(in hectares)
ALIYAR DAM & ALIYAR FEEDER CANAL		
(Fed by Aliyar Feeder Canal, Sethumadai, Pollachi & Vettaikkaranpudur Canals)	44,378	17,966
Old ayacut under anicut channels	6,400	2,591
THIRUMURTHY DAM		
(Fed by Parambikulam Main Canal (PMC), UdumalpetCanal, and High Level Canal)	3,77,152	1,52,693
Uppar ayacut	6,060	2,454
Dhali channel	934	378
TOTAL	**4,34,924**	**1,76,082**

5.4 Zoning pattern of Irrigation

After the completion of the project and the development of the commandarea, water distribution has been followed under different pattern. The old ayacut, under both Aliyar and Thirumurthy dams, is given irrigation supply from 16th May to 15th April as water is supplied to Kerala at Manacadavu weir. For the new command area after many evolutions, the pattern of supplyfollowed in the project under the zoning system is detailed as below.

Table 5.3 Zoning pattern for irrigation in PAP system

Figures in acres

Canal system	**First year**		**Second year**	
	Season I (135 days) 1st August to 15th Dec.	**Season II (135 days) 16th Dec. to 30th April**	**Season I (135 days) 1st August to 15th Dec.**	**Season II (135 days)16th Dec. to 30th April**
Area irrigated by PMC, Udumalpet canal, and High level canal	I 98,558	II 98418	III 94,024	IV 86,152
Area irrigated by Aliyar feeder canal, Sethumadai canal, Vettaikaranpudur canal and Pollachi canal	1st Sep. to 15th Jan.	Jan. to May	1st Sep. to 15th Jan	Jan. to May
	A 22,327		B 22,051	

The command area of 44,378 acres in the Aliyar sub basin has been divided into two near equal zones, whereas the command area of the Parambikulam Main Canal(PMC) system has been grouped into four near equal zones in a manner convenient for facilitating the supply by rotation. The extent of command area, under PMC fed by Thirumurthy reservoir, under the four zones are 98,558 acres, 98,418 acres, 94,024 acres, 86,152 acres respectively, totaling to 3,77,152 acres. This is a unique project in the sense that farmers getwater once in two years for their ayacut for 4 ½ months.

Depending on the availability, water is released for 7 days and off for 7 days to 14 days. Thus, in 125 km long PMC water runs throughout the year. While serving the zones spread over the entire length of the canal, the benefit of recharge of groundwater due to continuous flow in the full length of the canal has been realized. But such an impact could not be realized in all branches and distributaries and many segments of them were remaining dry for more than a year at a stretch.

5.5 Assessment Of Surface Water Potential

The availability of surface water in this basin are mainly from the diversion of the West flowing rivers of Anamalai hills to east to irrigate dry areas of Coimbatore and Tiruppur Districts. This involves the sharing of water between Kerala and Tamil Nadu State. This includes the inter state Periyar, Chalakudi and Bharathapuzha basins. The fact is that, storage structures have been constructed and located in Kerala, whereas the catchment area contributing to the flow into those storage structures is mainly from Tamilnadu. Therefore, only the diversion / storage structures are located in Kerala and the waters generated in the catchment are being shared as per the agreement. As per agreement, the entitled quantity of water for Tamil Nadu from the diverted water is 30.5 TMC (at present is 28 TMC) and for Kerala it is 19.55 TMC in an average year. To know whether the required quantities are met out in each year as per agreement, the flows are being measured at each diversion structure.

"Joint Water Regulation Board" comprising the Chief Engineers, Water resources & Chief Engineers of both the States has been constituted to monitor the availability of water to both states and is functioning.

As per PAP agreement, the water entitled to Kerala is 19.55 TMC and the quantity of water entitled for diversion to Tamil Nadu is 30.5 TMC (at present is 28 TMC), Vide the salient features of agreement shown in Appendix 5.1(Vol II). But after meeting out the required share to Kerala State, the quantity of diverted water available to Tamil Nadu is not always 28 TMC, but much below this. To know the actual quantity available to Tamil Nadu, the flow data from the year 1989-90 to 2018 - 19 and other available years are analysed. The quantity of average annual flows realized in the PAP system at each diversion structure are worked out. The abstract of availability of surface water at each nodal point is given in Appendix 5.2 (Vol II).

The surface water potential is assessed as follows:

- Available diverted quantity at Thirumurthy Dam from Anamalai Hills

- Available diverted quantity from contour canal to feed Vagariyar and Aliyar reservoir.
- Surface water potential available from Aliyar sub basin after meeting out Kerala demand.
- Surface water potential available from the catchment area of Palar River at Thirumurthy Dam.

The total of the above diverted quantities and quantities available from the catchment areas of Aliyar and Palar River gives the total surface water potential of this basin.

The water from the Sholaiyar sub basin is partially diverted. Except Sholaiyar, other sub basin water are used for irrigation.

In this Parambikulam Aliyar river basin, the inflow and outflow datas are used for assessment of surface water potential. The details of the calculations are given below.

Average annual flows realized at Thirumurthy Dam (from Anamalai Hills)

(i) Upper Nirar Weir

There is one weir across Nirar called Upper Nirar Weir to divert the water to Tamil Nadu Sholayar. The free catchment area of this weir is 75.11 Sq.Km (29 Sq.miles).

Quantity of water entitled as per PAP agreement from Upper Nirar Weir	=	9.000 TMC
Actual Availability of water from catchment area (vide Appendix5.3 Vol II)	=	9.081 TMC
Diverted to Kerala (from Oct1 – Jan 31)	=	0.081 TMC
From Upper Nirar Weir the quantity of water diverted to Tamil Nadu Sholayar Dam (vide Appendix5.4 Vol II) through tunnel	=	7.697 TMC

(ii) Lower Nirar Dam

This dam is across Nirarriver below Upper Nirar Weir. The free catchment area of this dam is 101.01 Sq.Km (39 sq.miles). Lower Nirar Dam also gets water from Upper Nirar Weir apart from its own catchment area. The total quantity of water available at Lower Nirar Dam is 2.799 TMC; vide Appendix5.5 (Vol -II).

Total available Quantity at Lower Nirar Dam	=	2.799 TMC
But water to be available as per agreement to TN	=	2.500 TMC
Surplus	=	0.299 TMC

From Lower Nirar Dam, a quantity of 2.859 TMC is also diverted to Sholayar Dam (Tamil Nadu) through a tunnel, vide Appendix 5.6(Vol.II)

Total diversion of water to Sholayar Dam:

a) From Upper Nirar Dam (Appendix 5.4) .(Vol.II)	=	7.697 TMC
b) From Lower Nirar Dam (Appendix5..6) .(Vol.II)	=	2.859 TMC
Total	=	10.556 TMC

But the actual quantity available for diversion,

a) Upper Nirar Dam (From own catchment)	=	9.081 TMC
b) Lower Nirar Dam (From own catchment)	=	2.799 TMC
Total	=	11.880 TMC

Hence out of 11.880 TMC available at the above two structures, a quantity of 10.556 TMC is diverted to Tamilnadu Sholaiyar and moreover 1.200 TMC have to be diverted to Kerala state also.

(iii) Sholayar – Tamil Nadu

The free catchment area of this dam is 121.73 Sq.Km. (47 Sq.miles). The capacity of this dam is 5392 Mcft. Apart from its own catchment area, as explained above; this dam also gets the diverted water, i.e., 10.556 TMC from Nirar river. Hence the total quantity of water available at Sholayar Dam including its catchment area is 21.696 TMC, vide Appendix5 .7.(Vol.II)

Total diversion of water to Sholayar Dam:

a) From Upper Nirar Dam (Appendix5.4) .(Vol.II)	=	7.697 TMC
b) From Lower Nirar Dam (Appendix 5.6) .(Vol.II)	=	2.859 TMC
Total	=	10.556 TMC

Total available quantity at Sholayar Dam Appendix 5 .7.(Vol.II)	=	21.696 TMC
Available quantity from Nirar River	=	10.556 TMC
Hence available quantity from own catchment area	=	11.140 TMC

(iv)Sholayar – Kerala

As per agreement 12.30 TMC of water has to be supplied at Kerala Sholayar reservoirs for power generation by Kerala. This consists of water diverted at Tamil Nadu Sholayar Dam to Kerala Sholayar Dam and the flow from the intermediate catchment area below Tamil Nadu Sholayar Dam to Kerala Sholayar Dam. The diverted quantity at Tamil Nadu Sholayar Dam to Kerala Sholayar Dam for average annual flows works out to 6.239 TMC, vide Appendix 5.8 (Vol.II) and at Kerala Sholayar for average annual flows the total realization is 13.159 TMC, vide Appendix 5.9(Vol.II).

Total quantity of water diverted from Tamil Nadu Sholayar Dam

Water from Tamil Nadu Sholayar Dam is diverted to Kerala - Sholayar dam and Parambikulam reservoir in the following way:

1. The water from Tamil Nadu Sholayar reservoir to Parambikulam reservoir is diverted in three ways. i.e, through Power House I, Saddle spillway and Power House I Byepass.
2. The water from Tamil Nadu Sholayar reservoir to Kerala - Sholayar Reservoir is diverted through Power House II, Reservoir spillway and River sluice. The details of diverted quantity are as follows:

(i) To Kerala Sholayar (Appendix5.8)(Vol.II)	=	6.239 TMC
(ii) To Parambikulam reservoir(Appendix 5.10) .(Vol.II)	=	15.472 TMC
Total	=	21.711 TMC

V) Parambikulam Group of Reservoirs

Parambikulam group of reservoirs consist of Parambikulam, Thunakadavu and Peruvaripallam reservoirs with catchment areas of 88.2 Sq.miles (228.44Sq.km), 16.7 Sq miles (43.25 Sq.km) and 6.10 Sq.miles (15.80 Sq.km) respectively.

Total quantity available

The total quantity of water available from its own catchment area including the diverted quantity from Sholayar Dam which is 15.472 TMC (Appendix5.10) .(Vol.II), is 24.512 TMC, vide Appendix5.11(Vol.II). Hence the quantity of water contributed by catchment area is 9.040 TMC (24.512 -15.472).

Availability of water with respect to agreement

Quantity of water to be available as per agreement	=	14.000 TMC
Actual availability of water from catchment area	=	9.040 TMC
Deficit	=	4.96 TMC

Total diverted quantity to Sarkarpathy Power House

The total quantity of water at Parambikulam group of reservoirs is 24.512 TMC (Appendix5.11) (Vol.II). This water is diverted to Sarkarpathy Power House which s in plains, i.e., at the foot of the hills from where the water is taken for irrigation.

vi) Sarkarpathy Power House (SPH)

The diverted water from Parambikulam group of reservoirs is used to generate power while it is negotiating to reach the plain area. Even though the water available for diversion at Parambikulam group of reservoirs is 24.512 TMC, the realization of water at Sarkarpathy Power House is only 22.574 TMC, Vide Appendix5.12. .(Vol.II)

The quantity available in Parambikulam group of reservoirs	=	24.512 TMC
Available quantity at tail SPH	=	22.574 TMC
Surplus	=	1.938 TMC

Total Deficit of Water At Sarkarpathy Power House

Total quantity of water to be available as per agreement to Tamil Nadu	=	28.000 TMC
Actual quantity of water available at Sarkarpathy Power House at average annual flows	=	22.574 TMC
Total deficit	=	5.426 TMC

The total deficit is 5.426 TMC, i.e., about 19%. So as per average annual flows realized in PAP system, only about 81% of the agreement quantity of water is to be available for Tamil Nadu.

(v) Contour Canal

The Contour Canal is unique of its kind in the whole of South India. This canal is designed to take the tail race waters from the Sarkarpathy Power House and feed Thirumurthy Dam. The execution of this canal is an engineering achievement. It has been constructed against heavy odds in a very difficult terrain amidst forest area involving Rock cutting on one side and filling on other side.The availability of quantities of water furnished hereunder is for average annual flows. The carrying capacity of the contour canal is 32.55 cumecs (1150 c/s). The length of this lined canal uptoThirumurthy reservoir where it empties, is 50 Km. (31.07 miles). At the starting point of the contour canal, there are two diversion points to feed the command area of Vagariyar and Thirumurthy dam. Aliyar dam is fed by Aliyar feeder canal which takeoff from Vagarayar. The quantity of water let down into Vagariyar and Aliyar feeder canal are 1.118 TMC and 1.679 TMC respectively, vide Appendix 5.13 &5.14.(Vol.II). Hence the total water being diverted at head reach is 2.797 TMC (1.118 + 1.679).

A. Quantity of Water available at L.S.0.175 Km of contour canal

The annual flow measured at this point is 19.778 TMC, vide Appendix5.15 (Vol.II)

B. Quantity of Water available at L.S.12.56 Km of contour canal

The annual flow measured at this point is 17.294 TMC, vide Appendix5.16 (Vol.II). But the quantity measured at 0.175 Km. 19.778 TMC. Hence the transmission loss is 2.484 TMC (19.778 – 17.294).

C. Quantity of Water available at L.S.25.10 Km of contour canal

The annual flow measured at this point is 14.917 TMC, vide Table5.17 (Vol.II). But, after L.S. 12.56 Km of this contour canal, a quantity of 1.383 TMC is let down through outlet to feed Aliyar dam, vide Appendix5.18.(Vol.II). So if there is no loss, the quantity here should be 15.911 TMC (17.294 - 0.453) against the measured quantity of 14.917 TMC. But the loss is 0.994 TMC (17.294 – 14.917). It is to be noted here is, that the loss is only from 12.56 to 25.10 Km., that is, in a distance of 12.54 Km. The percentage of loss in this lined canal is about 6.24%.

D. Quantity of Water available at L.S.49.80 Km of contour canal

The annual flow measured at this point is 14.345 TMC, vide Appendix 5.19 .(Vol.II), which is the actual diverted flow available at Thirumurthy reservoir. “Hence the surface water available at Thirumurthy reservoir from the diverted water of Anamalai hills is 14.345 TMC”. If there is no loss, the quantity of water available at this point should also be 14.917 TMC against the measured quantity of 11.786 TMC. Hence the loss of water between L.S. 25.10 to 49.80 is 3.131 TMC (14.917 – 14.345) which is 3.83% in a distance of 24.70 Km.

The details showing the quantity of water available Sarkarpathy Power House (SPH) to Thirumurthy Reservoir, Vagariar, Aliyar feeder canal, Contour outlets at average annual flows, the losses at various locations etc. is furnished below.

Table 5.4 Quantity of water available (From Sarkarpathy Power House to Thirumurthy reservoir)

Sl. No	Description	Gross Quantity available TMC	Vahariar TMC	Aliyar feeder canal TMC	Contour outlets TMC	Loss TMC	Net Quantity available TMC
1.	SPH	22.574	--------	--------	--------	--------	22.574
2.	L.S 0.175 Km	22.574	1.118	1.679	--------	0	19.777
3.	0.175 to 12.56 Km	19.777	------	------	-------	2.484	17.294
4.	12.56 to 25.10 Km	17.294	-------	-----	1.383	0.994	14.917
5.	25.10 to 49.80 Km	14.917	--------	-----	-----	0.572	14.345

Hence the quantity of water available at Thirumurthy reservoir at average annual flows is 11.786 TMC after the diversion and losses.

Total Losses In Contour Canal

While considering the whole length of the contour canal, the total is as follows:

Available quantity at Sarkarpathy Power House	=	22.574 TMC
(i) Supply to Vagariyar (Appendix5.13)	=	1.118 TMC
(ii) Supply to Aliyar Feeder Canal (Appendix5.14)	=	1.679 TMC
(ii) Supply to Aliyar Dam (Appendix5.18)	=	1.383 TMC
Total Supply	=	4.180 TMC
Hence to be available at 49.80 Km. (22.574 – 4.180)	=	18.394 TMC
But actual available quantity at 49.80 Km	=	14.345TMC
Therefore the loss	=	4.049 TMC

E. Quantity of water available at Thirumurthy Reservoir

The quantity of water available at Thirumurthy Reservoir site (Appendix5.25) (Vol.II) = 14.957 TMC

Diverted quantity at 49.80 Km. Of contour canal	=	14.345 TMC
Therefore quantity of water available from catchment area of Thirumurthy Reservoir	=	0.162 TMC

Surface water potential available from Aliyar sub basin after meeting out Kerala demand

There are two Dams across Aliyar river, one is called Upper Aliyar Dam (mainly intended for generation of power) and another is known as Aliyar Dam for irrigation purpose. After producing power at Upper Aliyar Dam, the water is let down to Aliyar Dam. Aliyar Dam also gets water from Aliyar feeder canal taking off from the starting point of Contour canal in the middle reach.

The availability of water at Aliyar Dam from Aliyar feeder canal at 13.30 Km is 1.611 TMC, vide Appendix 5.20(Vol.II). As mentioned earlier, Aliyar dam also receives water from the outlet of the contour canal in the middle reach, which is 1.383 TMC, vide Appendix 5.18 (Vol.II)

Hence the total availability of water at Aliyar Dam including the water available from Upper Aliyar Dam and its own catchment is 11.454 TMC, vide Appendix5.21(Vol.II)

The water from Aliyar dam is let down to irrigate the command area under Tamil Nadu as well as the command area under Kerala State. The total quantity of water let down is 11.457TMC, vide Appendix5.2 (Vol.II)

Quantity of Water letdown for irrigation

(i) For 5 anicuts of Tamil Nadu, vide Appendix5.23	=	2.844 TMC
(ii) Realisation at Manacadavu weir, vide Appendix5.24	=	7.092 TMC
Total	=	9.936 TMC

Surface water potential for Tamil Nadu irrigation

Available quantity at Aliyar reservoir	=	11.454 TMC
Deduct i. From Aliyar Feeder Canal	=	1.611 TMC
ii. From Contour Canal outlet	=	1.383 TMC
Total	=	2.994 TMC
Net Available quantity from catchment area of Upper and	=	8.460 TMC

Lower Aliyar (11.454 – 2.994)

Quantity diverted to Kerala through Manacadavu weir	=	7.092 TMC
Hence, net available quantity from catchment for Tamil Nadu irrigation (8.460 – 7.092)	=	1.368 TMC

Surface Water Potential Available From the Catchment Area of Thirumurthy Reservoir

The quantity of water available at Thirumurthy reservoir includes the water available from contour canal and from its own catchment area. The quantity of water available from the contour canal is 14.345 TMC (Appendix 5.19 Vol II) which has already been mentioned.

Quantity of water from its own catchment

The total available quantity at Thirumurthy Reservoir, Vide Appendix 5.25(Vol.II)	=	14.957 TMC
Deduct Available quantity from Contour canal at L.S 49.80 Km, Appendix 5.19(Vol.II)	=	14.345 TMC
Hence yield from catchment area	=	0.612 TMC

Total Available Surface Water

I. Total diverted quantity

1	Available diverted quantity at Thirumurthy Reservoir	=	14.345 TMC
2	Available diverted quantity from contour canal to feed Vagariar and Aliyar Reservoir	=	4.180 TMC
	Total available diverted quantity	=	18.525 TMC

II. Available quantity from catchment area

1	Surface Water potential from the catchment area of Aliyar Dam	=	1.320 TMC
2	Surface Water potential from the catchment area of Thirumurthy Reservoir	=	0.612 TMC

Total quantity from catchment area = 4.491 TMC

III. Total available surface water

I	Diverted Quantity	=	18.525TMC
II	From catchment area	=	1.980TMC
	Total	=	20.505 TMC

Surface Water Potential

Specifically in the context of Parambikulam Aliyar River Basin, the surface water potential is calculated for average annual flow, as per the actual measurement for Sholayar ,Aliyar, Palar and Walayar due to diversity in nature of the basin.

Table 5.5 Assesment of Surface Water Potential

Sl. No	**Name of Sub basin**	**Total Potential in Mcum**	**Release to Kerala in Mcum**	**Balance available potential at Tamil Nadu in Mcum**
1	Sholayar Sub basin			
	a). Nirar	336	34	
	b). Sholayar	315	177	
	c).Parambikulam	256	-	
	Total	907	211	696
2	Aliyar	240	201	39
3	Palar	17	-	17
4	Walayar	17	-	17
	TOTAL	1181	412	769

5.6 The Existing Surface Water Supply Systems

ParambikulamAliyar Project

Parambikulam Aliyar Project successfully accomplishes the diversion and integration of 8 West flowing rivers; 6 in the Anamalai Hills and 2 in the plains- for the benefit of the drought prone areas in the Coimbatore and Erode Districts of Tamilnadu State and stabilizing the existing irrigation system in Chittoorpuzha of Kerala State. Dams on the 8 rivers with inter connecting tunnels have been constructed. The tunnels divert the waters impounded in the rivers to the plains of the Coimbatore District and Erode District of Tamil Nadu State and Chittur area of the Kerala State.

The reservoirs lies at various elevations ranging between elevation of + 3780 feet and + 1050 ft. and this difference of elevations has made it possible to utilize the drop between them for the development of hydroelectric power.This project is situated in Anamalais range amongst its flora and Fauna and on the arid and semi arid plains of the Southern Taluks of Coimbatore District. All the rivers which has its sources in the Anamalai Range are served by the South-West Monsoon. The Major portion of the Dams and Tunnels are located in the Scenic and scene surroundings of the Anamalai Range and the reservoirs are located amongst picturesque and natural surroundings in the reserved forest areas and Tea Estates. This project takes its name after the two important rivers (1) Parambikulam representing the series of rivers on the west (2) Aliyar representing the east of Western Ghats. In a sense this project is a symbol of Inter-State Co-operation of the two neighbourly States of Kerala and Tamil Nadu.

This multipurpose project has got a long history. The main components of this project comprises of 10 Dams, 4 Power Houses, 6 Main Tunnels and 7 Irrigation canals.

5.7 Reservoirs and Weir

1.Upper Nirar Weir

The Nirar River takes its source from the Kattamalai Hills, and takes the name of Kallar subsequently after its confluence with some of the streams. It runs in a South Westerly direction and falls into Edamalayar, the major tributary of Erode River. Water is diverted from this weir through the Upper Nirar Tunnel to the adjacent Sholayar Basin. The tunnel is about 3.6km length with a carrying capacity of 73.58 cusecs.

Hydraulic Particulars

District	--	Coimbatore
State	--	Tamilnadu
Longitude	--	77^{0} 1' East
Latitude	--	10^{0} 17'30" North
River	--	Nirar
Run off Co-efficient	--	4000
Catchment area	--	29 sq.miles
		(11 T.Nadu 18 Kerala)
Maximum flood discharge	--	37760 Cusees
Area of Water spread	--	0.07 Sq.miles

Crest level	--	3785 feet
Full Reservoir level	--	3800 feet
Maximum Water level	--	3800 feet
Top Bund level	--	3805 feet
Deepest Foundation level	--	3714.70 feet
Capacity at FRL	--	39 mcft
Spillway provided type	--	Radial gates
Vent Numbers	--	4
Vent size	--	32 feet x 15 feet
River Sluice	--	2 Nos
Sill Level	--	3740 feet
Size	--	5 feet x 6 feet
Tunnels (Upper Nirar)	--	1 No
Sill level of Tunnel at entry	--	3745 feet
Maximum height of Dam	--	90 .3 feet
Length of Masonry Dam	--	435 feet
Length of Overflow Section	--	153 feet
Length of Non Overflow Section	--	277 feet

2. Lower Nirar Dam

This dam is constructed across Nirar River at a lower site, about 8 Km, below the Upper Nirar weir to divert water from Anamalaiyar to the Sholayar valley through the un-lined lower Tunnel taking off from the dam site. In addition to this, the yield of the catchment between the Upper Nirar Weir and the Dam will also be diverted to the Sholayar Basin.

Hydraulic Particulars

District	--	Coimbatore
State	--	Tamilnadu
Longitude	--	76^0 59' East
Latitude	--	10^0 16' North
River	--	Nirar
Run off Co-efficient	--	4000
Catchment area	--	39 Sq. miles (21 T.Nadu 18 Kerala)

Maximum flood discharge	--	46020 Cusees
Area of Water spread	--	0.2 Sq.miles
Crest level	--	3325.25 feet
Full Reservoir level	--	3350 feet
Maximum Water level	--	3350 feet
Top Bund level	--	3360 feet
Deepest Foundation level	--	3195 feet
Capacity at FRL	--	274 mcft
Spillway provided type	--	Lift gates
Vents Numbers	--	3
Vents size	--	37'9" feet x 24'9" feet
River Sluice	--	2 Nos
Sill Level	--	3305 feet
Size	--	5 feet x 6 feet
Tunnels (Lower Nirar)	--	1 No
Sill level of Tunnel	-	3310 feet
Capacity at sill level of Tunnel	--	100 M.cft
Maximum height of Dam	--	165 feet
Length of Dam	--	830 feet
Out of this length of Earth Dam	--	210 feet
Out of this length of		
Masonry Dam	--	620 feet
Out of this length of		
Overflow Section	--	95 feet
Out of this length of		
Non Overflow Section	--	525 feet
Drainage Gallery	--	Length 15 meters (5' x 7'6" Size)

3.Sholayar Reservoir

Sholayar river is one of the main tributaries of Chalakudi river. It has its source in Valparai Estate and runs in a westerly direction for about 30 miles before it joins the Parambikulam River. The total catchment area of this river upto its in-fall into Parambikulamriver is 100 Sq.miles of which 55 sq.miles is in the TamilNadu State and the rest in Kerala. The Upper catchment of this river is situated at an elevation from 3000 to 8000'. This is influenced by the South West Monsoon.

The Sholayar dam constructed (maximum height 345 ft) across the river Sholayar has a capacity of 5392M.cft. This is the highest Dam in Tamil Nadu. This reservoir will divert about 2,500 M.cft. to the ParambikulamAliyar Project system through the Sholayar Tunnel-1. In addition to this, the waters received from the Nirar and Anamalayar Valleys will also be diverted to the adjacent Parambikulam Valley through the tunnel. The water thus diverted passes through Power House No.1 and is utilised for power generation. The water that is supplied to the Kerala Sholayar Reservoir is also utilised for Power Generation through Power House No.2. The installed capacity of power generation in Power House No.1 is 70 M.W and Power House No.II is 25 M.W.

Hydraulic Particulars

District	--	Coimbatore
State	--	Tamilnadu
Longitude	--	76^0 53' East
Latitude	--	10^0 18' North
River	--	Chalakudi
Run off Co-efficient	--	4000
Catchment area	--	47 Sq. miles (Tamil Nadu)
Maximum flood discharge	--	56230 Cusecs
Area of Water spread	--	2.21 Sq.miles
Crest level	--	3270 feet
Full Reservoir level	--	3290 feet
Maximum Water level	--	3295 feet
Top Bund level	--	3305 feet
Deepest Foundation level	--	2960 feet
Capacity at FRL	--	5392 MCFT
Spillway provided type	--	Lift gate type
Vent Numbers	--	3
Vent size	--	42 feet x 25 feet
Uncontrolled spillway	--	3 No. of vent Size
at crest 3290	--	25 feet x 5 feet
(+) Additional 2 vent to discharge	--	3290' - 3295'

Surplus waters to Parambikulam between		
River Sluice	--	1 No
Sill Level	--	3180 feet
Size	--	5 feet x 6 feet
Capacity at R.S.SILL	--	1124.72 M.Cft
Tunnels (Sholayar Power Tunnel I&II)	--	2 Nos
Sill level of Tunnel	--	3130 feet
Capacity at sill level of Tunnel	--	338.89 M.cft
Maximum height of Dam	--	345 feet
Length of Dam	--	3091 feet
Earth Dam length	--	2959 feet
Masonry Dam length	--	1132 feet
Length of Overflow Section	--	156 feet
Length of Non Overflow Section	--	976 feet
Drainage Gallery	--	5'0" x 7'6"Size
Foundation Gallery at	--	3018 feet
Intermediate gallery at	--	3066 feet
Top Gallery at	--	3156 feet

4. Parambikulam Reservoir

Parambikulamriver has its origin in Ramakrishna Malai with the name of Erode at an elevation 4,000 to 5,000 ft. in Coimbatore District. Three tributories namely AndimeduAr, ParayanAr, ManampattiAr joins this Parambikulam River along its run.

Parambikulam Reservoir is the largest Reservoir of the Project with a gross storage capacity of about 17,820 M.Cft at F.R.L. + 1825 ft. Water from this reservoir is diverted to the adjacent Thunacadavu Reservoir a Balancing Reservoir through the Parambikulam Tunnel which is 8186 ft. in length.

Hydraulic Particulars

District	--	Palghat

State	--	Kerala
Longitude	--	$76^0 46'$ East
Latitude	--	$10^0 23'$ North
River	--	Chalakudi
Run off Co-efficient	--	3000
Catchment area	--	88.2 Sq. miles
		(60.7 T.Nadu 27.5 Kerala)
Maximum flood discharge	--	59580 Cusees
Area of Water spread	--	8.22 Sq.miles
Crest level	--	1797.76 feet
Full Reservoir level	--	1825 feet
Maximum Water level	--	1825 feet
Top Bund level	--	1835 feet
Deepest Foundation level	--	1595 feet
Capacity at FRL	--	17820 MCFT
Spillway provided type	--	Lift gates
Vents Numbers	--	3
Vents size	--	42 feet x 27.24 feet
Size	--	5 feet x 6 feet
Capacity of R.S.Sill	--	50 M.cft.
Tunnels (Parambikulam)	--	1 No
Sill level of Tunnel	--	1753 feet
Capacity at sill level of Tunnel	--	4366 M.cft
Maximum height of Dam	--	240 feet
Length of Earth dam (Saddle)	--	190 feet
Length of Masonry Dam	--	1044 feet
Out of this length of		
Overflow Section	--	155 feet
Out of this length of		
Non Overflow Section	--	889 feet
Drainage Gallery	--	$5' \times 7'6''$ Size

5. Thunakadavu Reservoir

This is a small balancing reservoir constructed across Thunakadavu River, which is a tributory of Parambikulam River. Its gross capacity is 557 M.Cft. The water that is received from Parambikulam Reservoir and from the Peruvaripallam Reservoir, as well as from its own catchment, is diverted to the Sarkarpathy Power House through the Sarkarpathy Power Tunnel.

Hydraulic Particulars

District	--	Palghat
State	--	Kerala
Longitude	--	76^0 46' East
Latitude	--	10^0 25' 45" North
Basin	--	Chalakudi
Run off Co-efficient	--	3000
Catchment area	--	16.7 Sq. miles (7.7 T.Nadu 9.0 - Kerala)
Maximum flood discharge	--	16100 Cusees
(Peruvaripallam Combined)	--	Connected by open channel
Area of Water spread	--	1.675 Sq.miles
Crest level	--	1745 feet
Full Reservoir level	--	1770 feet
Maximum Water level	--	1770 feet
Top Bund level	--	1779 feet
Deepest Foundation level	--	1694 feet
Capacity at FRL	--	557 mcft
Spillway provided type	--	Lift gates + Breast Wall above 1760
Vents Numbers	--	3
Vents size	--	28 feet x 15 feet
Tunnels (Sarkarpathy)	--	1 No
Sill level of Tunnel (Leading channel BL)	--	1748 feet
Capacity at 1748 Level	--	236.60 M.CftThunacadavu 231.10M.CftPeruvaripallam

Maximum height of Dam	--	85 feet
Length of Dam	--	1150 feet
Out of this length of Earth Dam	--	1050 feet
Out of this length of Masonry Dam		
Spill Way section	--	100 feet

6. Peruvaripalllam Reservoir

This Reservoir is formed by an earthern Dam 1535 feet in length and has a gross capacity of 620 M.Cft. This is connected to the Thunakadavu reservoir by an open cut channel. The combined catchment area of Thunacadavu River and Peruvaripallam is 22.80 sqm. at the dam site.

Hydraulic Particulars

District	--	Palghat
State	--	Kerala
Longitude	--	76^0 46' East
Latitude	--	10^0 26'30" North
River	--	Chalakudi
Run off Co-efficient	--	1500
Catchment area	--	6.10 Sq. miles (Kerala)
Maximum flood discharge	--	16100 Cusecs
Area of Water spread	--	1.12 Sq.miles
Full Reservoir level	--	1770 feet
Maximum Water level	--	1770 feet
Deepest foundation level	--	1668 feet
Top Bund level	--	1779 feet
Capacity at FRL	--	620 MCFT
Maximum height of Dam	--	91 feet
Length of Earth Dam	--	1535 feet

7. Aliyar Reservoir

The Aliyar River has its source in the Anamalai Hills. It flows in a north westerly direction for about 14 miles before it enters the plains. It is joined by Uppar on its left and Palarriver on its right. This river has got an old Ayacut of 6392 acres of wet lands, through a system of 5 anicuts. The last anicut in the series is Vadakaluranicut and below it there are 4 major anicuts in Kerala State irrigating an area of 20,144 acres. The catchment area of this river at the last Anicut in Kerala State is 419 sq.miles of which 366 sq.miles is in Tamil Nadu State.

A Reservoir has been formed by construction of a dam across the River Aliyar and it has a gross capacity of 3,864 M.Cft. Two irrigation canals i.e., Vettaikaranpudur and Pollachi canals take off from this Reservoir. This reservoir is also intended to meet the requirements of the existing command area in TamilNadu State and Kerala State. The catchment area at the Aliyar Dam site is 76 Sq.miles.

Hydraulic Particulars

District	--	Coimbatore
State	--	Tamilnadu
Longitude	--	76^0 58' East
Latitude	--	10^0 29' North
Basin	--	Aliyar
Run off Co-efficient	--	2284
Catchment area	--	76 Sq. miles
Maximum flood discharge	--	40957 Cusees
Area of Water spread	--	2.51 Sq.miles
Crest level	--	1040' feet
Full Reservoir level	--	1050 feet
Maximum Water level	--	1050 feet
Top Bund level	--	1059 feet
Deepest Foundation level	--	914 feet
Capacity at FRL	--	3864 mcft
Spillway provided type	--	Radial
Vent Numbers	--	11
Vent size	--	30' feet x 10' feet
River Sluice	--	1 No
Sill Level	--	930 feet
Size	--	5 feet x 6 feet
Canal Sluices	--	2 Nos
Sill level	--	980 feet Size 5'x6'
Capacity at sill level Canal Sluice	--	311 M.cft

Maximum height of Dam	--	145 feet
Length of Dam	--	10500 feet
Out of this length of Earth Dam	--	75/0 feet
Out of this length of Masonry Dam	--	420 feet
Out of this length of Overflow Section	--	420 feet
Out of this length of Non Overflow Section	--	2570 feet
Construction cost of Dam	--	Rs. 300 Lakhs

8. Thirumurthy Reservoir

This Reservoir has been constructed across the River Palar, which has got its origin at the northern slopes of Anamalai Hills. It is a tributory of Aliyar. About 5 miles below the origin of Palar there exists an old anicut called Dhalianicut which has got open head channels and irrigates about 2800 acres of Which 175 acres are under direct irrigation and rest is through a system of 7 tanks.

This reservoir across the River Palar has a gross capacity of 1,935 M.Cft. Apart from its own catchment it receives the diverted waters from the Upper Reservoirs in the Anamalai Range, through the Sarkarpathy tunnel and the Contour canal. An irrigation canal called, the Parambikulam Main Canal takes off from this Reservoir and it branches into two.

a) A 125 Km long Parambikulam Main Canal and

b) A 30.4 Km long Udumalpet Canal

The Parambikulam Main Canal is the biggest and longest irrigation canal under this project with an entire ayacut. This reservoir also stabilises irrigation for the Old Ayacut of about 3,000 acres under Dhali system of Palar. A High level canal to feed 2477 acres also takes off from this Reservoir.

Hydraulic Particulars

District	--	Coimbatore
State	--	Tamilnadu
Longitude	--	77^0 9' 30" East
Latitude	--	10^0 29' North
River	--	Palar

Run off Co-efficient	--	1500
Catchment area	--	31 Sq. miles
Maximum flood discharge	--	15,800 Cusees
Area of Water spread	--	1.57 Sq.miles
Crest level	--	1325 feet
Full Reservoir level	--	1337 feet
Maximum Water level	--	1337 feet
Top Bund level	--	1344 feet
Deepest Foundation level	--	1222 feet
Capacity at FRL	--	1935 mcft
Spillway provided type	--	Lift gates
Vent Numbers	--	5 Nos
Vent size	--	26 feet x 12 feet
River Sluice	--	1 Nos
Sill Level	--	1277 feet
Size	--	5.4335 x 6 feet
Capacity at R.S. Sill	--	191 M.Cft
Canal Sluice		
Sill level of Common Canal	--	1280 feet
Sill level of H.L.C.	--	1320 feet
Capacity at 1280	--	229 M.Cft
Capacity at 1320	--	1253 M.Cft
Maximum height of Dam	--	128 feet
Length of Dam	--	8792 feet
Out of this length		
of Earth Dam	--	8622 feet
Out of this length of Masonry Dam	--	170 feet

9. UpperAliyar Reservoir

Upper Aliyar Dam has been constructed just above the Aliyar Dam and is mainly intended for generation of power through a Power House situated in the foreshore of the Aliyar Reservoir.

Hydraulic Particulars

District	--	Coimbatore

State	--	Tamilnadu
River	--	Aliyar
Catchment area	--	54.24 Sq. miles
Maximum flood discharge	--	84,000 Cusecs
Crest level	--	2492.50feet
Full Reservoir level	--	2525 feet
Maximum Water level	--	2525 feet
Capacity at FRL	--	938 M.cft
Spillway provided type	--	Lift gate
Vents Numbers	--	2
Vents size	--	40 feet x 32.5 feet
Maximum Height of Dam	-	235 feet
Length of Masonry Dam	--	1035 feet

10. Kadamparai Dam

It has been constructed across the tributary of Aliyarriver, situated above Upper Aliyar Reservoir for power generation.

11. Anaimalaiyar project

Under this proposal a diversion of 2500Mcft each year from Anaimalayar to Tamil Nadu by constructing reservoir across Anaimalayar . Both the states are in negotiation for arriving at a consensus for the implementation of the project, for which supplemental agreement is to be drawn between Tamil Nadu and Kerala.

5.8 Tunnels

Upper Nirar Tunnel

This tunnel connecting Upper Nirar Weir and the adjacent Sholayar basin is unlined and is of horse shoe shape, 20 feet in diameter and designed for a discharge of 2670 Cusecs.

Lower Nirar Tunnel

This tunnel inter - connects the Lower Nirar Dam with the Sholayar basin is unlined and is of 'D' shape, 32 feet in diameter and 26,664 feet long. It is designed for a discharge of 2200 cusecs.

Sholayar Tunnel - 1

The Sholayar tunnel inter-connects the Sholayar Reservoir and the Parambikulam Valley. It is concrete lined, of 9 feet in diameter and 8394 feet long. It is designed for a discharge of 750 cusecs gross head 1327 feet.

Parambikulam Tunnel

The Parambikulam Tunnel Connects the Parambikulam Reservoir to the Thunacadavu Reservoir in the adjacent valley. It is unlined and is of horse shoe shape, 16'9" in diameter and 8186 feet in length. It is designed for a discharge of 1400 cusecs.

Sarkarpathy Tunnel

Sarkarpathy Tunnel diverts the Waters from Thunacadavu Reservoir to the Sarkarpathy Power House. It is concrete lined and is of horse shoe in shape of 12 feet diameter and 12,635 feet in length and designed for a discharge of 1400 cusecs.

Navamalai Tunnel

Navamalai Tunnel carries the Contour Canal from Sarkarpathy Power House to the Thirumurthy Dam for this particular reach. This is a concrete lined tunnel and is of horse shoe shape, 14'3" in diameter and 15,923 feet in length. It is designed to carry a discharge of 1,150 cusecs.

The details of the Tunnels are as given below: -

5.6 DETAILS OF TUNNELS

Serial No	Name of Tunnel	Size & Shape	Length in feet	Discharge in cusecs	Nature
1	Upper Nirar Tunnel (Cost Rs. 227 Lakhs)	20' Horse shoe	15167	2670	Unlined
2	Lower Nirar Tunnel (Cost Rs.693 Lakhs)	22' Horse shoe	26664	2200	Unlined
3	Sholayar Power Tunnel 1 (Cost Rs. 107.25 Lakhs)	9' Horse Shoe	8390	750	Lined
4	Sholayar Power Tunnel	9' Horse Shoe	3500	750	Lined
5	Parambikulam Tunnel (Cost Rs. 56.20 Lakhs)	16'9" Horse Shoe	8186	1400	Unlined
6	Sarkarpathy Tunnel (Cost Rs. 161 Lakhs)	12' Horse Shoe	12635	1400	Lined

5.7 TUNNELS (ALONG CONTOUR CANAL)

Sl. No	Name of Tunnel	Size	Length in feet	Discharge in cusecs	Nature
1	Navamalai Tunnel (17 / 0 / 120) (Cost Rs. 123.25 Lakhs)	14'3" Horse Shoe	15923	1150	Lined
2	Other Small Tunnels 0.6.95 Baby Tunnel I	12' x 14'6" With segmental roof 2' over rectangular Section	Short Length	1150	Lined

3	22.1.103' II Short Tunnel		”	1150	Lined
4	2/6/0		3740	1150	Lined
5	” 5/3/330		2560	1150	Lined
6	” 8/4/0		1220	1150	Lined
7	” 11/1/0		1585	1150	Lined
8	27/3/10		2256	1150	Lined

S.P.T. Byepass Tunnel

Length	--	384 feet
Shape	--	Horse Shoe
Size	--	9 feet lined
Size of Gate at exit	--	4'0 x 7'0
Sill level	--	1660
Sill level exit	--	1655

Surge Shaft

Top level	--	1813.50 feet
Height	--	153.50 feet
Dia	--	50 feet at top and 40 feet at bottom

Minimum surge for 30MW build up 1702 feet.

5.9 POWER HOUSES

The total installed capacity of the four Power Houses of this project is 185 MW.

Sholayar Power House No.1

The fall of 1327 feet at the end of Sholayar Tunnel is utilised for generating Power with an installed capacity of 70 MW.

Power House No. II

A head of 508 feet below the Sholayar Dam has been used to develop 25 MW of Power from the waters released to the Kerala Sholayar Reservoir.

Sarkarpathy Power House

A drop of 326 feet at the end of Sarkarpathy Tunnel is being utilised for generation 30 MW of Power.

Aliyar Power House (Navamalai)

A fall of 1400 feet available in the Aliyar Valley between Upper and Lower Aliyar Reservoir is utilised for generating 60 MW of Power.

5.10 CANALS

The peculiarity of this project is that the entire canal system is lined with concrete, even initially, during execution itself, to prevent seepage losses. There are seven irrigation canals, excluding the Contour canal which carries the discharge from the Parambikulam group of Reservoirs diverted at Sarkarpathy to the Thirumurthy Dam. They are :-

a. Aliyar Feeder Canal

13.15 Km long with a carrying capacity of 286 cusecs, serving an ayacut of 4665 acres in addition to feed Aliyar Reservoir.

b. Sethumadai Canal

8.2 Km. long with 63 cusecs carrying capacity serving an ayacut of 5044 acres.

c. Pollachi Canal

48 Km. long with a carrying capacity of 299 cusecs and serving an area of 23,488 acres.

d. Vettaikaranpudur Canal

17.2 Km. long with a carrying capacity of 95 cusecs and serving an area of 11,181 acres.

e. Parambikulam Main Canal

Parambikulam Main Canal is the longest and the biggest canal.It is 125 Km in Length and is designed to carry a discharge of 1031 cusecs for irrigating an entire ayacut. The above ayacut is fed by the canal taking off from the Thirumurthy dam located in the Palar sub basin of Parambikulam Aliyar Basin and the ayacut is located both in the Parambikulam Aliyar river basin and Cauvery basin. The ayacut in Cauvery basin under PAP is not getting water from the Cauvery basin.

f. Udumalpet Canal

Udumalpet canal - 30Km. long is designed to carry a discharge of 278 cusecs for irrigating an area of 58,292 acres.

g. High Level Canal

Hardly 2 Km. in length, this canal is designed to irrigate an area of 2,477 acres.

Water Potential

The agreement between the State of Tamil Nadu and Kerala regarding the waters to be diverted from the Anamalais for the ParambikulamAliyar Project provides for the diversion of 30.5. T.M.Cft. of water (for Tamil Nadu) when all the aspects of the agreement are completed. The anticipated utilisation is as follows:-

1. Upper Nirar Weir	--	9.0 T.M.Cft.
2. Lower Nirar	--	2.5 T.M.Cft.
3. Sholayar	--	2.5 T.M.Cft.
4. Parambikulam Group of rivers	--	14.0 T.M.Cft.
5. Diversion from Anamalayar rivers	--	2.5 T.M.Cft.
Total		30.5 T.M.Cft.

5.8 Tanks

Sl. No.	Name of Tanks	Name of Sub basin	Name of Village	Total Ayacut in (Acres)	Length of Bund in (Meters)	Nos. of Sluice	Length of Weir in (meter)	Surplus Capacity (Cusec)	Capacity In (mcft)	free Catch-ment (Sq.mile)	Water spread Area (Sq.mile)	Top Bund Width (ft)	Storage Depth in (meter)
1	Devambadivalasu (Non system)	Walayar	Devambadivalasu	121.03	1067	2 Nos.	30	3531.50	6.60	0.70	1.405	10'.00"	5.3
2	Kothavadi Tank (Non system)	Walayar	Kothavadai	312.83	960	2 Nos.	0	8828.75	10.95	44.97	0.849	10'.00"	3.75
3	Elavakkarai Tank (Non system)	Palar	Samathur	250.63	1860	2 Nos.	28.6	784.98	11.34	2.34	3.031	--	3.2
4	KolapathuKulam Tank (Non System)	Aliyar	Odayakulam& Kaliyapu	611.90	1374.65	2 Nos.	36.88	363	30.37	0.27	0.158	--	4.88
5	Valayapalayam Tank (System)	Palar	Valayampalayam	142.99	78.35	4 Nos.	9.8	17233.72	7.80	44.02	0.223	--	3.15

5.11 Surface water quality

Introduction

Most of the human activities including agriculture need ample quantities of water. Increasing demands of food grain by ever increasing population has resulted in the over utilization of water resources. Irrigation water quality refers to the kind and amount of salts present in the water and their effects on crop growth and development. High salt concentrations influence osmotic pressure of the soil solution and affect the ability of plants to absorb water through their roots. However, an appropriate evaluation of the water quality prior to its use in irrigation will help in arresting any harmful effect on plant productivity and ground water recharge. The suitability of water for irrigation is determined in several ways including the degree of acidity or alkalinity (pH), EC, Residual Sodium Carbonate (RSC), Sodium Adsorption Ratio (SAR), and Total Hardness(TH) along with the effects of specific ions. The assessment of water quality criteria for irrigation is based on the consideration of the related aspects like the possible effects on the physico-chemical properties of the soil and the impact on crop yield. When the concentration of sodium ion is high in irrigation water, Na tends to be adsorbed by clay particles, displacing magnesium and calcium ions. This exchange process of sodium in water for Ca and Mg in soil reduces the permeability and eventually results in soil with poor internal drainage. Sodium concentration also plays an important role in evaluating the ground water quality for irrigation because sodium causes an increase in the hardness of soil as well as a reduction in its permeability. The Sodium / Alkali Hazard are typically expressed as the SAR. This index quantifies the proportion of sodium (Na) to calcium (Ca) and magnesium (Mg) ions. Sodium Hazard of irrigation water can be well understood by knowing SAR which determines its utility for agricultural purposes. Salinity and toxicity generally need to be considered for evaluation of the suitable quality of ground water for irrigation.

5.12 Materials and Methods

Water quality from seven surface water locations was collected from study area for investigation. The analysis was carried out in the Geochemical laboratory, Pollachi using instrumental techniques. Standard books and manuals were followed for the analysis.

Conductivity meter was used for the analysis of Electrical Conductivity (EC). pH meter was used to determine the hydrogen ion concentration. Total Hardness and Calcium Hardness were determined volumetrically by using standard EDTA solution. Flame photometer was used for the analysis of Sodium and Potassium. Alkalinity was estimated volumetrically by using standard H_2SO_4.Sulphate was analyzed using turbidity meter and Chloride volumetrically by using standard $AgNO_3$ solution. Nitrate was analyzed using UV – VIS Spectrophotometer.

5.13 Results and Discussion

The results of surface water samples are expressed in Table 1, and the discussions are as follows:

Table 5.9 Surface Water Locations in PAP Basin
June 2019 (Pre Monsoon period)

Location	Long	Lat	EC µS/cm	pH	SO4 mg/l	Cl mg/l	NO3 mg/l	TDS mg/l	TH mg/l	TA mg/l	F mg/l	SAR meq/l
Aliyar	Aliyar	76.966	10.488	80	8.2	3.0	11.0	5.0	51	25	20	0.1
Thunakadavu	Thunakadavu	76.782	10.434	70	7.8	5.0	7.0	6.0	41	20	15	0.1
Thirumoorthi	Thirumoorthi	77.154	10.475	50	8.0	1.0	7.0	5.0	37	15	20	0.2
Peruvaripallam	Peruvaripallam	76.769	10.449	70	7.1	3.0	11.0	4.0	42	25	15	0.1
Parambikulam	Parambikulam	76.764	10.378	49	7.5	1.0	7.1	2.2	32	25	40	0.0
Lower Nirar	Lower Nirar	76.956	11.017	13	6.7	1.0	4.0	2.2	8	10	20	0.0
Sholaiyar	Sholaiyar	76.875	10.313	17	6.3	1.0	4.0	2.2	11	15	25	0.0

Some important parameters for irrigation

(i) Electrical Conductivity (EC)

Electrical Conductivity (EC) is a measure of the degree of the mineralization of the water which is dependent on rock water interaction and thereby the residence time of the water in the rock. As groundwater moves and stays for a longer time along its flow path, the increase in total dissolved concentration and major ions normally occurs.

Groundwater in the recharge area is characterized by a relatively low EC than the groundwater in the discharge area which is higher.

Table: 5.10 Suitability of EC values for irrigation (IS: 11624 – 1986)

Sl.No	EC in µmhos/cm or µS/cm	Salinity Class
1	<1500	Low
2	1500 - 3000	Medium
3	3000 – 6000	High
4	> 6000	Very high

As far as PAP basin is concerned, the EC value ranges from 13 to 80 uS/cm. The EC value is within the desirable limit in all the locations in this basin.

ii) Sodium Adsorption Ration (SAR)

Sodium adsorption ratio is used to estimate the sodicity hazard of the water. The Sodium adsorption ratio is used to predict the danger of sodium accumulation in soil. Excess sodium in water produces the undesirable effects of changing soil properties and reducing soil permeability and soil structure. Hence the assessment of sodium concentration is necessary while considering the suitability for irrigation. The formula for calculating sodium adsorption ratio is:

$$\text{S.A.R.} = \frac{Na^{+}}{\sqrt{\frac{1}{2}(Ca^{2+} + Mg^{2+})}}$$

The concentration is expressed in meq/l. While high salt content (EC) in water leads to the development of saline soil, high sodium content (SAR) leads to the development of an alkaline soil. SAR can indicate the degree to which irrigation water tends to enter cation exchange reaction in soil. Sodium replacing adsorbed calcium and magnesium is a hazard as it causes damage to the soil structure and becomes compact and develops permeability problems. This will support little or no plant growth.SAR is an important parameter for the determination of the suitability of irrigation water because it is responsible for the sodium hazard. The suitability of water based on the values of SAR is listed in Table **5.11**

Table: 5.11 Suitability of SAR values for irrigation

Sl.No.	SAR	Suitability for irrigation
1	<10	Excellent
2	10 – 18	Good
3	18 – 26	Permissible
4	>26	Unsuitable

The SAR value is within the range (<1.0 meq/l) in all the wells in the basin.

iii) Residual Sodium Carbonate (RSC)

Residual Sodium Carbonate index of irrigation water or soil water is used to indicate the alkalinity hazard for soil. The RSC index is used to find the suitability of the water for irrigation in clay soils which have a high cation exchange capacity. When dissolved sodium in comparison with dissolved calcium and magnesium is high in water, clay soil swells or undergoes dispersion which drastically reduces its infiltration capacity. The value of RSC suitable for irrigation is listed in table **5.11**

Table 5.12 Suitability of RSC values for irrigation

Sl.No	RSC (meq/l)	Suitability for irrigation
1	<1.5	Safe
2	1.5 – 3.0	Moderate
3	3.0 – 6.0	High
4	>6.0	Very high

RSC is expressed in meq/L.

The formula for calculating RSC index is:

RSC index = $[HCO_3 + CO_3] - [Ca + Mg]$

The RSC value in this basin is very less (<1.0 meq/l) and hence there are no particular issues regarding RSC.

5.14 Issues In The Management Of Surface Water Resources

Problems in Tanks Irrigation

In a modernised agrarian context, as witnessed in several parts of Tamil Nadu the surface sources of irrigation are becoming scarce year by year. Choosing crops, date of sowing / harvesting under tank / canal irrigation, ultimately depends upon the availability and the timing of the release of water from reservoir / tanks.

Suggestions for Meeting Future Needs

For agriculture, the Surface Water Potential of this basin is being utilized in addition to the supplemental irrigation by ground water. Since the maximum quantity of surface water is consumed for irrigation, the following short term measures are suggested for effective consumption of water in irrigation sector:

Equitable distribution of irrigation water by better water management.

1. Improving the performance of the existing irrigation system by suitable structural measures.
2. Introducing Micro irrigation like, drip and sprinkler irrigation.
3. Conjunctive use of surface and ground water wherever possible.
4. Renovating old tanks and ponds, desilting of supply channels and constructing water harvest structures to improve irrigation potential.
5. Planning for effective rainwater harvesting and saving surface water, which is let into sea during the flood.
6. Adopting better agricultural practices such as crop rotation, raising garden crops and other less water consuming crops.

5.15 Inter Basin Transfer of Water

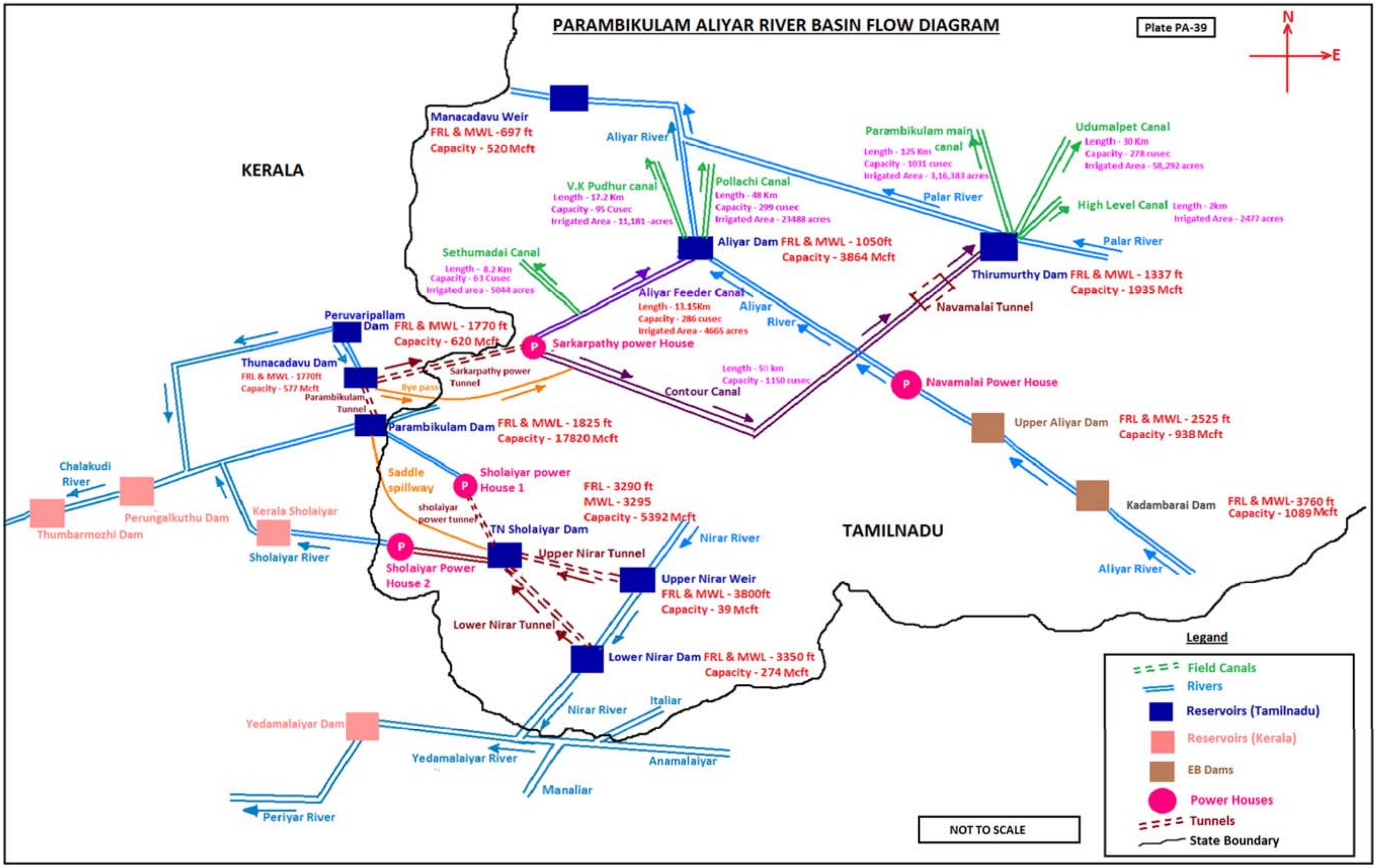
The availability of surface water in this basin is mainly from the diversion of the West flowing rivers of Anamalai hills to East to give irrigation to the dry areas of Coimbatore and Erode Districts. This involves the sharing of water between Kerala and Tamil Nadu State. As per agreement, the share for Tamil Nadu from the diverted water at present is 28 TMC and for Kerala it is 19.55 TMC in an average year. To know whether the required quantities are met out in each year as per agreement, the flows are being measured at each diversion structure.

"Joint Water Regulation Board" comprising the senior Engineers of both the States has been constituted to monitor the availability of water to both states and is functioning.

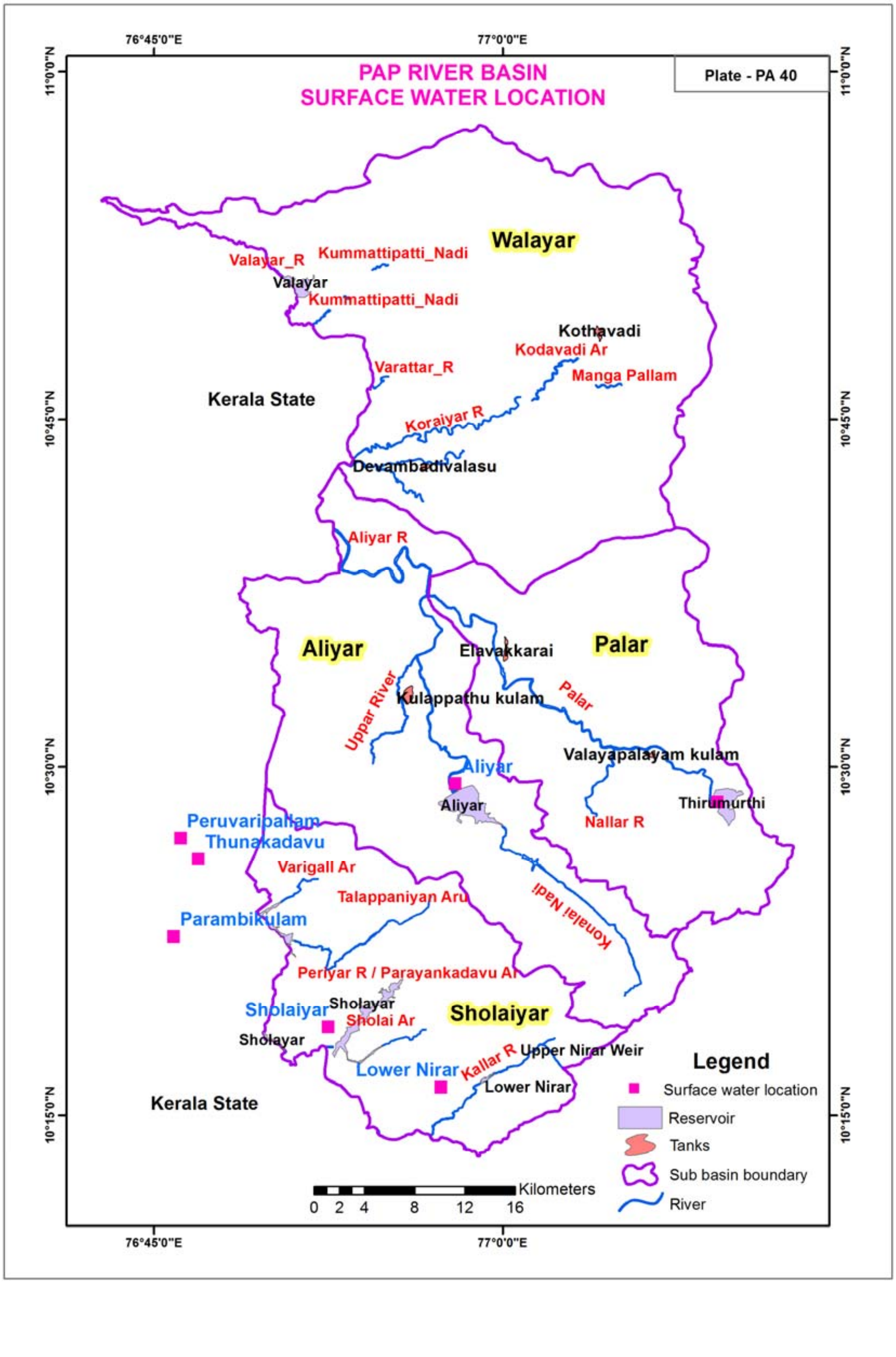
5.16 Conclusion

The annual Surface Water Potential of Parambikulam and Aliyar river basin is calculated for average annual flow is 769 Mcum.

Considering the surface water quality, the present study of the assessment of surface water samples for irrigation has been evaluated on the basis of standard guidelines and it reveals that the Electrical Conductivity (EC), pH, Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC) values for irrigation standard are in the permissible category. Hence it is concluded that the surface water samples of the present study area are completely suitable for irrigation. A continuous monitoring program is required to check the suitability for irrigation purposes. The network for surface water sampling locations should be increased by the SG & SWRDC, Tharamani, Chennai to make the study more effective.


PARAMBIKULAM ALIYAR RIVER BASIN FLOW DIAGRAM
Plate PA-39
N
E
KERALA
TAMILNADU
Manacadavu Weir
FRL & MWL -697 ft
Capacity - 520 Mcft
Aliyar River
Parambikulam main canal
Length - 125 Km
Capacity - 1031 cusec
Irrigated Area - 3,16,383 acres
Udumalpet Canal
Length - 30 Km
Capacity - 278 cusec
Irrigated Area - 58,292 acres
V.K Pudhur canal
Length - 17.2 Km
Capacity - 95 Cusec
Irrigated Area - 11,181 -acres
Pollachi Canal
Length - 48 Km
Capacity - 299 cusec
Irrigated Area - 23488 acres
Palar River
High Level Canal
Length - 2km
Irrigated Area - 2477 acres
Aliyar Dam FRL & MWL - 1050ft
Capacity - 3864 Mcft
Palar River
Sethumadai Canal
Length - 8.2 Km
Capacity - 63 Cusec
Irrigated area - 5044 acres
Thirumurthy Dam FRL & MWL - 1337 ft
Capacity - 1935 Mcft
Aliyar Feeder Canal
Length - 13.15Km
Capacity - 286 cusec
Irrigated Area - 4665 acres
Aliyar River
Navamalai Tunnel
Peruvaripallam Dam FRL & MWL - 1770 ft
Capacity - 620 Mcft
Sarkarpathy power House
Thunacadavu Dam
FRL & MWL - 1770ft
Capacity - 577 Mcft
Sarkarpathy power Tunnel
Bye pass
Parambikulam Tunnel
Length - 50 km
Capacity - 1150 cusec
Contour Canal
Navamalai Power House
Parambikulam Dam FRL & MWL - 1825 ft
Capacity - 17820 Mcft
Upper Aliyar Dam FRL & MWL - 2525 ft
Capacity - 938 Mcft
Chalakudi River
Saddle spillway
Sholaiyar power House 1
FRL - 3290 ft
MWL - 3295
Capacity - 5392 Mcft
Kadambarai Dam FRL & MWL- 3760 ft
Capacity - 1089 Mcft
Perungalkuthu Dam
Kerala Sholaiyar
sholaiyar power tunnel
TN Sholaiyar Dam
Nirar River
Thumbarmozhi Dam
Sholaiyar River
Upper Nirar Tunnel
Sholaiyar Power House 2
Upper Nirar Weir
FRL & MWL - 3800ft
Capacity - 39 Mcft
Aliyar River
Lower Nirar Tunnel
Lower Nirar Dam FRL & MWL - 3350 ft
Capacity - 274 Mcft
Nirar River
Italiar
Yedamalaiyar Dam
Yedamalaiyar River
Anamalaiyar
Manaliar
Periyar River
NOT TO SCALE
Legand
Field Canals
Rivers
Reservoirs (Tamilnadu)
Reservoirs (Kerala)
EB Dams
Power Houses
Tunnels
State Boundary


Drainage Map of Parambikulam Aliyar Basin
Plate PA -8
76°45'45"E
76°56'0"E
77°6'15"E
10°57'45"N
10°47'30"N
10°37'15"N
10°27'0"N
10°16'45"N
Cauvery Basin
Kerala
1. Walayar Sub Basin
2. Palar Sub Basin
3. Aliyar Sub Basin
4. Sholaiyar Sub Basin
Madukkarai
Chettipalaiyam
Chinnanpatti
Ettimadai
Palatturai
Ottakkalmandapam
Puduppati
Navakkarai
Valayar Reservoir
Kummattipatti
Vadachittur
Kinattukkadavu
Kodavadi
Muthukavundanur
Periya Negamam
Govindanur
Senguttaipalayam
Gopalapurm
Mannur
Timmankuttu
Manacadavu Weir
Attupollachi
Uttukuli
Pollachi
Tippampatti
Minakshipuram
Ganapathipalayam
Tenkumarapalayam
Anaimalai
Peddanayakkanur
Tondamuthur
Vettaikkaranpudur
Salaiyur
Malaiyandipattinam
Ardhaharipalaiyam
Sethumadai
Vagarai Ar
Aliyar Feeder Canal
Aliyar Nagar
Tirumurttinagar
Top Slip
Aliyar Reservoir
Contour Canal
Tirumurti Reservoir
Peruvaripallam
Tekkadi Ar
Kolikamatti Pallam
Attakatti
Tunakadavu
Upper Aliyar
Tunakadavu Ar
Ken Todu
Panali Ar
Chinnar
Nallar R
Kurumalai Ar
Vandal Ar
Marugud Ar
Kadambarai Dam
Parambikulam
Pambar
Najjuru Ar
Andimedu Ar
Manampalli
Nadu Ar
Tunakadavu
Valparai
Sholaiyar Reservoir
Chinna Kallar Nadi
Marugali
Sholaiyar Nagar
Upper Nirar Weir
Lower Nirar
1 : 4,00,000
0 4 8 16
Km
PMC
LEGEND
Location
River
Tunnel
Canal
Drainage
Reservoir/Tank
Sub Basin Boundary
Basin Boundary
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113



PAP RIVER BASIN
SURFACE WATER LOCATION
Plate - PA 40
76°45'0"E
77°0'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N
Walayar
Valayar_R
Kummattipatti_Nadi
Valayar
Kummattipatti_Nadi
Kothavadi
Kodavadi Ar
Varattar_R
Manga Pallam
Kerala State
Koraiyar R
Devambadivalasu
Aliyar R
Aliyar
Elavakkarai
Palar
Uppar River
Kulappathu kulam
Palar
Valayapalayam kulam
Aliyar
Aliyar
Thirumurthi
Nallar R
Peruvaripallam
Thunakadavu
Varigall Ar
Talappaniyan Aru
Konalai Nadi
Parambikulam
Periyar R / Parayankadavu Ar
Sholaiyar
Sholayar
Sholai Ar
Sholaiyar
Sholayar
Upper Nirar Weir
Kallar R
Lower Nirar
Lower Nirar
Kerala State
Legend
Surface water location
Reservoir
Tanks
Sub basin boundary
River
Kilometers
0 2 4 8 12 16

UPPER NIRAR WEIR

LOWER NIRAR DAM

SHOLAYAR DAM

PARAMBIKULAM DAM

THUNAKADAVU DAM

PERUVARIPALLAM RESERVOIR

SARKARPATHY POWER HOUSE

ORIGIN OF CONTOUR CANAL

CONTOUR CANAL

NAVAMALAI TUNNEL

ALIYAR RESERVOIR

VETTAIKARANPUDUR CANAL

POLLACHI CANAL

THIRUMURTHY RESERVOIR

PARAMBIKULAM MAIN CANAL OFF-TAKE FROM THIRUMURTHY DAM

KADAMPARAI DAM

UPPER ALIYAR DAM

CHAPTER - 6

GROUNDWATER RESOURCES AND WATER QUALITY

CHAPTER-6

GROUNDWATER RESOURCES AND WATER QUALITY

6.1 Status of Groundwater

Groundwater and surface water are the two water resources of a country and are dependent on rainfall. The quantity of water that reaches the ground water table depends upon the run off rate, infiltration rate and permeability of the formation. A major quantity of rainfall flows as surface runoff and is stored in water bodies like reservoirs, tanks, lakes and ponds. The excessive extraction of groundwater, for various demands, results in fast depletion of groundwater. In order to improve the groundwater level effective methods are to be adopted.

For long term planning, development and management, a systematic and scientific assessment of groundwater resources is quite essential. Groundwater is a more reliable, easily available natural resource, serves as a dependable water resource during drought and in achieving food security. As per the latest assessment, ie as on **March 2017,** the data on **Dynamic Ground Water Resources of India 2017** is as stated below:

- **Total Annual Ground Water Recharge : 431.86 bcm**
- **Annual Extractable Ground Water Resources : 392.70 bcm**
- **Annual Ground Water Extraction : 248.69 bcm**
- **Stage of Ground Water Extraction : 63.33 %.**

Groundwater has steadily emerged as the backbone of India's agriculture and drinking water security. Presently, Groundwater contributes nearly 62% in irrigation, 85% in rural water supply and 45% in urban water supply (Source: Ministry of Water Resources (MoWR), Rural Development & Ganga Rejuvenation).

The dynamic groundwater resource of Tamilnadu was assessed at macro size unit of Block level upto 2009. After **2011,** the assessment is being done at **micro size unit of Firka** level**.** As per the latest assessment, ie as on **March 2017,** the data on **Dynamic Ground Water Resources of the State of Tamilnadu** is as stated below:

- **Total Annual Ground Water Recharge : 20.26 bcm**
- **Annual Extractable Ground Water Resources : 18.23 bcm**
- **Annual Ground Water Extraction : 14.73 bcm**
- **Stage of Ground Water Extraction : 80.81 %**

The following sections explain the groundwater availability and status prevailing in Parambikulam Aliyar Basin.

6.2 Groundwater Estimation Methodology

As per Latest revised guidelines of Ground Water Resources estimation committee-2015, the firka wise dynamic Ground Water resources assessment of State of Tamil Nadu as on 2017 has been carried out and completed by the State Ground and Surface Water Resources Data centre, WRD, PWD in coordination with Central Ground Water Board, Chennai.

Groundwater recharge is estimated season-wise for both monsoon seasons and non monsoon seasons separately. Groundwater recharge is assessed based on recharge from rainfall, seepage from canal, tanks & ponds and return flow from irrigation and fluctuation of water level over a period of time.

6.2.1 Total Annual Ground Water Recharge

The Total Annual Ground Water Recharge of the area is the sum of recharge during monsoon and non monsoon seasons and discharge from rivers and return flow from irrigation.

6.2.2 Annual Extractable Ground Water Resources

The Annual Ground Water Resources is the available groundwater resource after deducting the natural discharges (10%) during non-monsoon season from the total annual ground water recharge.

6.3 Aquifers

6.3.1 General

Groundwater is extracted from shallow aquifer. The Geologists & Engineers have used complicated data to find reliable and representative values of the hydraulic characteristics of aquifers. The groundwater availability in aquifer depends on the type of rock formation in earth layer and hydraulic parameters of aquifer such as Conductivity, Transmissivity, Specific Yield and Storage co-efficient. Pump test in dug wells or bore wells plays a prominent role in evaluating these hydraulic properties of aquifers in different geological formations. Based on the pump test results, yield and recharge rate of aquifers are being predicted.

6.3.2 Aquifer Parameters

Geologically, Parambikulam Aliyar basin is comprised of hardrock formation such as Gneiss, Granite, Charnockite, Pink Granite, Migmatite and Pyroxene granite.

The aquifer parameters of the geological formations in Parambikulam Aliyar River Basin are given in the **Table 6.1.**

Table: 6.1 Aquifer parameter in Hard Rock

S. No	Parameters	Range
1.	Well Yield	50 to 300 lpm
2.	Transmissivity (T) in m^2/day	1.49 to 164.18 m^2/day
3.	Specific Yield	0.015%

Note : lpm = litre per minute

6.3.3 Groundwater Occurrence

There are 69 wells spread over the entire Parambikulam Aliyar Basin and they have been analyzed, over the period of three (3) years to forty seven (47) years. The wells analyzed fall in Coimbatore and Thiruppur districts. The details of these wells in Parambikulam Aliyar basin are presented in **Appendix 6.1 of Vol II** and it's spatial distribution are shown in **Plate: PA-41 .** The periodical water level fluctuations were examined sub-basin wise and geological formation wise, to understand the hydrogeological nature and groundwater occurrence. The number of wells for different geological formations for the 4 sub basins is presented in **Table 6.2**. The ground water occurrence in the 4 sub basins are presented in **Table 6.3.**

Table 6.2 Number of observation wells in different Geological Formations

Sl.No	Type of Geological formation	No of wells			
		Walaiyar Sub - Basin	Palar Sub-Basin	Aliyar Sub-Basin	Sholaiyar Sub-Basin
1	Granitic Gneiss (GGN)	20	8	6	-
2	Gneiss (GNS)	20	7	4	-
3	Charnockite (CNK)	1	2	-	1

Table 6.3 Ground water occurrence

Observation wells

Sl. No	Sub-basin	No of Wells	Pre-monsoon		Post-monsoon	
			Minimum Water level	Maximum Water Level	Minimum Water level	Maximum Water Level
1	Walaiyar	41	**0.76m** (Well No: 63708 in Apr 2008)	**31.61m** (Well No: 63622 in Apr 2014)	**0.55m** (Well No: 63708 in Jan 2015)	**30.50m** (Well No: 63613 in Feb 1989)

Sl. No	Sub-basin	No of Wells	Pre-monsoon		Post monsoon	
			Minimum Water level	Maximum Water Level	Minimum Water level	Maximum Water Level
2	Palar	17	**1.80m** (Well No: 63721 in Mar 2012)	**18.20m** (Well No: 63723 in May 2017)	**1.26m** (Well No: 63809A in Feb 2016)	**18.20m** (Well No: 63809A in Jan 2017)
3	Aliyar	10	**2.65m** (Well No: 63710 in Mar 2016)	**21.72m** (Well No: 63713 in May 1990)	**2.30m** (Well No: 63710 in Jan 2012)	**20.50m** (Well No: 63713 in Feb 1986)

Piezometric wells

Sl. No	Sub-basin	No of Wells	Pre-monsoon		Post-monsoon	
			Minimum Water level	Maximum Water Level	Minimum Water level	Maximum Water Level
1	Walaiyar	41	**2.35m** (Well No: HP1CBE10 in Mar 2006)	**86.84m** (Well No: HP2CBE28A in Apr 2017)	**2.00m** (Well No: HP1CBE10 in Jan 2006)	**75.00m** (Well No: HP2CBE28A in Feb 2018)
2	Palar	17	**3.90m** (Well No: HP2CBE25 in May 2011)	**58.00m** (Well No: HP2CBE36 in Mar 2018)	**3.70m** (Well No: HP2CBE25 in Jan 2006)	**59.00m** (Well No: HP2CBE36 in Jan 2018)
3	Aliyar	10	**4.1m** (Well No: HP1CBE11 in Mar 2005)	**78.60m** (Well No: HP2CBE24A in May 2018)	**3.00m** (Well No: HP1CBE11 in Jan 2005)	**64.00m** (Well No: HP2CBE24A in Feb 2018)
4	Sholaiyar	1	**15.2m** (Well No: HP2CBE26 in May 2011)	**33.05m** (Well No: HP2CBE26 in Apr 2002)	**16.1m** (Well No: HP2CBE26 in Jan 2011)	**30.70m** (Well No: HP2CBE26 in Feb 2008)

6.4 Groundwater Level Fluctuations and Groundwater Flow Regime

Monitoring of groundwater flow regime is an effort to obtain information on water levels. The ground water regime depends on natural and anthropogenic stresses of recharge and discharge parameters with reference to Geology, Climate, Physiographic land use pattern and hydrologic characteristics. The natural conditions affecting the regime involve climatic parameters like rainfall, evapotranspiration etc, and where as anthropogenic influences are desirable from the aquifer, recharge due to irrigation systems and other practices like waste disposal etc.

Groundwater system is dynamic and adjusts continually to short-term and long-term changes due to climate, groundwater withdrawal, and land use pattern. Water level measurements from observation wells are the principal source of information about the hydrologic stresses acting on aquifers and how these stresses affect groundwater recharge, storage, and discharge. Long-term systematic measurements of water levels provide essential data required to evaluate the changes in water resource over time to develop groundwater models and forecast trends; to design, implement and to monitor the effectiveness of groundwater management and protection programs.

It is imperative that, water level measurements must be collected from an observation well without interruption for as many years as possible in order to compile a ground water hydrology record that provides the natural water-level fluctuations and tracks it's trend over time. Though four years is relatively short period for analysis of water level data s, it is at least sufficient to provide an idea of ground water level fluctuation.

Contour maps showing the depths of groundwater table for pre monsoon and post monsoon for July 1987, January 1988, July 1997, January 1998, July 2007, January 2008, July 2017 and January 2018 have been prepared and are presented in **Plate: PA-42 to PA-49** respectively. Groundwater levels of the 69 observation wells are illustrated in the form of hydrographs in **Appendix 6.8 of Vol II** for analysis of the long-term trends.

6.4.1 Groundwater Level Fluctuations

Hydrographs of groundwater level for the 69 wells have been prepared. The linear trend lines drawn in the Hydrograph of wells were used to interpret the long-term trend in water level fluctuation. Rise or fall in water level in the range of 0-2 metre may not be significant due to dynamic nature of groundwater (CGWB 2010). From the trend line, if there is a long term water level depletion or rise, in the range of 2-3 metre, it is classified as moderate depletion or rise. If the depletion or rise is greater than 3 metre, it is classified as high depletion or rise.

In this basin, moderate rise is found in 6 wells and high rise in water level is found in 9 wells. Moderate depletion is found in 7 wells and high depletion in water level is found in 29 wells.

The details of the wells having high rise, long term rise wells and high depletion, long term depletion wells are presented in **Table 6.4 & 6.5**

Table 6.4

High Rise Wells

Sl.No	Well No	Sub-Basin	District
1	63628	Walaiyar	Coimbatore
2	63707		
3	63708		
4	63718		
5	HP2CBE07		
6	HP2CBE23		
7	HP2CBE27		
8	HP2CBE25	Palar	Coimbatore
9	HP2CBE26	Sholaiyar	Coimbatore

Long term Rise Wells

Sl.No	Well No	Sub-Basin	District
1	63615	Walaiyar	Coimbatore
2	63702		
3	63735		
4	63744		
5	HP1CBE03		
6	63714	Palar	Coimbatore

Table 6.5

High Depletion Wells

Sl.No	Well No	Sub-Basin	District
1	63453	Walaiyar	Coimbatore
2	63624		
3	63626		
4	63622		
5	63623A		
6	63627		
7	63711A		
8	63737		
9	63738		
10	63741		
11	63742		
12	63743		
13	HP2CBE14		
14	HP2CBE27 A		
15	HP2CBE 28 A		

Sl.No	Well No	Sub-Basin	District
16	63721	Palar	Coimbatore
17	63723		
18	63726		
19	63727		
20	63728		
21	63729		
22	63731		
23	63733		
24	HP2CBE35		
25	HP2CBE36		
26	63711A	Aliyar	Coimbatore
27	63713		
28	63720		
29	HP2CBE24 A		

Long term Depletion Wells

Sl.No	Well No	Sub-Basin	District
1	63450	Walaiyar	Coimbatore
2	63624		
3	63626		
4	63703		
5	63715	Palar	Coimbatore
6	63725		
7	63809A		Thiruppur

i) Annual Groundwater Level Fluctuations

Annual groundwater level fluctuation is significant in the context that it indicates the level/degree of groundwater recharge. Annual water level fluctuation in observation wells varies from 0.00m to 18.21m in Walaiyar sub-basin, 0.60m to 16.34m in Palar sub-basin, 0.00m to 18.25m in Aliyar sub-basin and Annual water level fluctuation in piezometric wells varies from 0.00m to 63.28m in Walaiyar sub-basin, 0.17m to 44.65m in Palar sub-basin, 1.40m to 49.65m in Aliyar sub-basin and 3.90m to 20.60m in Sholaiyar sub-basin

ii) Monsoon Groundwater Level Variation

a) In observation wells:

- In Walaiyar sub-basin, pre-monsoon groundwater level varies from 0.76m to 31.61m and post monsoon groundwater level varies from 0.55m to 30.05m

- In Palar sub-basin, pre-monsoon groundwater level varies from 1.80m to 18.20m and post monsoon groundwater level varies from 1.26m to 18.20m
- In Aliyar sub-basin, pre-monsoon groundwater level varies from 2.65m to 21.72m and post monsoon groundwater level varies from 2.30m to 20.50m.

b) In piezometric wells

- In Walaiyar sub-basin, pre-monsoon groundwater level varies from 2.35m to 86.84m and post monsoon groundwater level varies from 2.00m to 75.00m
- In Palar sub-basin, pre-monsoon groundwater level varies from 3.90m to 58.00m and post monsoon groundwater level varies from 3.70m to 59.00m
- In Aliyar sub-basin, pre-monsoon groundwater level varies from 4.10m to 78.60m and post monsoon groundwater level varies from 3.00m to 64.00m.
- In Sholaiyar sub-basin, pre-monsoon groundwater level varies from 15.20m to 33.05m and post monsoon groundwater level varies from 16.10m to 30.70m.

6.4.2 Groundwater Flow Regime

The occurrence and movement of groundwater and its storage are controlled by the physiography, climate and the geological formation conditions like texture, lithology and structure, etc. A water table contour map serves as an important tool for finding the direction of groundwater flow. Form the water table contour map of Parambikulam Aliyar basin, it is observed that the groundwater flow is generally from west to east.

The details of Ground water level contour data are tabulated in **Appendix 6.2 of Vol-II**. Pre-monsoon and post-monsoon contour maps (depth to water table) one for each decade: Jul-87& Jan-88, Jul-97& Jan-98 and Jul-2007& Jan-2008, Jul-2017& Jan-2018) have been prepared based on the above data and presented in **Plates PA-42 to PA-49**

6.4.2.1 Groundwater Level Scenario

i) Pre-Monsoon

Groundwater level in July 1987 (15m to 30m) in upper reach, (5m to 15m) in middle reach and (10m to 15m) in tail reach, July 1997 (12m to 28m) in upper reach, (3m to 12m) in middle reach and (6m to 12m) in tail reach, July 2007 (6m to 20m) in upper reach, (3m to 12m) in middle reach and (6m to 29m) in tail reach and July 2017 (10m to 30m) in upper reach, (1m to 20m) in middle reach and (1m to 75m) in tail reach.

ii) Post-Monsoon

Groundwater level in January 1988 (12m to 30m) in upper reach, (3m to 12m) in middle and tail reach., January 1998 (3m to 26m) in upper reach, (3m to 10m) in middle reach and (3m to 6m) in tail reach., January 2008 (5m to 20m) in upper reach, (1m to 10m) in middle reach and (5m to 30m) in tail reach and January 2018 (10m to 72m) in upper reach, (1m to 20m) in middle reach and (1m to 72m) in tail reach.

6.5 Categorization of Firkas

The categorization was done on a fine scale based on firkas as per latest Groundwater assessment done during 2017.The 1,166 revenue Firkas in Tamil Nadu were categorized as Safe, Semi Critical, Critical and Over-Exploited depending upon the stage of groundwater development. The criteria for categorization of Firkas are tabulated as follows:

Table 6.6 Criteria for Categorization of Firkas

Sl.No	Stage of Groundwater Development	Categorization
1	<=70%	Safe
2	>70% and <=90%	Semi Critical
3	>90% and <=100%	Critical
4	>100%	Over Exploited

In general, the prime cause of over-exploitation of groundwater is due to increase in water demand in various sectors like agriculture, industries and domestic.

Parambikulam Aliyar basin encompasses 19 Firkas either fully or partially and all firkas are falling in Coimbatore and Thiruppur districts. Map showing the categorization of firkas falling in Parambikulam Aliyar Basin is presented in **Plate: PA-50**

The list of categorization of 19 firkas in Parambikulam Aliyar Basin based on Dynamic Ground Water Resources of the State of Tamilnadu as on March 2017 is presented in **Table 6.7 & Table 6.8**

Table 6.7 Categorization of Firkas in Parambikulam Aliyar basin

Sl. No.	Firka	Sub-Basin	District	Categorisation of Firkas
1	Alandurai	Walaiyar	Coimbatore	Over exploited
2	Kinathukatavu		Coimbatore	Over exploited
3	Kolarpatti		Coimbatore	Over exploited
4	Kovilpalayam		Coimbatore	Over exploited
5	Madukkarai		Coimbatore	Critical

Sl. No.	Firka	Sub-Basin	District	Categorisation of Firkas
6	Ottakkal Mandabam	Walaiyar	Coimbatore	Over exploited
7	Perianegamam		Coimbatore	Over exploited
8	Perur		Coimbatore	Over exploited
9	Pollachi (North)		Coimbatore	Over exploited
10	Pollachi (South)		Coimbatore	Over exploited
11	Ramapattinam		Coimbatore	Over exploited
12	Selakarichal		Coimbatore	Over exploited
13	Vadachittur		Coimbatore	Over exploited
14	Anamalai	Palar	Coimbatore	Safe
15	Kolarpatti		Coimbatore	Over exploited
16	Kottur		Coimbatore	Critical
17	Perianegamam		Coimbatore	Over exploited
18	Pollachi (South)		Coimbatore	Over exploited
19	Valparai		Coimbatore	Safe
20	Kurichikottai		Thirrupur	Semi-critical
21	Periavalavadi		Thirrupur	Over exploited
22	Anamalai	Aliyar	Coimbatore	Safe
23	Kottur		Coimbatore	Critical
24	Marchinaickenpalayam		Coimbatore	Semi-critical
25	Pollachi (South)		Coimbatore	Over exploited
26	Ramapattinam		Coimbatore	Over exploited
27	Valparai		Coimbatore	Safe
28	Kurichikottai		Thirrupur	Semi-critical
29	Valparai	Sholaiyar	Coimbatore	Safe

Table 6.8 Summary of Categorization of Firkas

Sl.No	Category	2017 Assessment
1	Safe	2
2	Semi Critical	2
3	Critical	2
4	Over Exploited	13
	Total	19

6.6 Groundwater Availability

6.6.1 Groundwater Availability in the Study Area

The sub-basin wise groundwater availability and extraction (draft) are calculated from the Firka's availability and extraction on proportionate basis i.e based on the percentage of firka area falling in the sub-basin. The balance of groundwater availability in each firka for further development is arrived by deducting the gross groundwater extraction from the net groundwater availability. If the balance groundwater availability is found to be negative, that negative value is ignored and the balance is taken as zero for that sub-basin.

The sub-basin wise groundwater availability, extraction and the balance groundwater availability and the stage of groundwater development are presented in **Table 6.9.**

Table 6.9 Groundwater Availability, Extraction and balance Availability

Sl. No.	Sub-Basin	Annual Groundwater Availability in sub basin (MCM)	Annual Groundwater Extraction in sub basin (MCM)	Annual Groundwater Balance Availability in sub basin (MCM)	Stage of Development (%)
1	Walaiyar	10.47	14.71	0.00	140.49
2	Palar	15.27	12.91	5.57	84.50
3	Aliyar	33.98	8.91	25.73	26.21
4	Sholaiyar	65.50	1.42	64.08	2.18
	TOTAL	**125.22**	**37.95**	**95.38**	**253.38**

(Source: Dynamic Ground Water Resources of the State of Tamilnadu as on March 2017, WRD, PWD)

The firka-wise groundwater availability, extraction and balance ground water availability are presented in **Appendix 6.5, 6.6 and 6.7 of Vol II.** The sub-basin wise groundwater availability and extraction is represented in the Bar chart in **Fig.6.1**.

Fig: 6.1 Sub Basin wise Groundwater Availability and Extraction

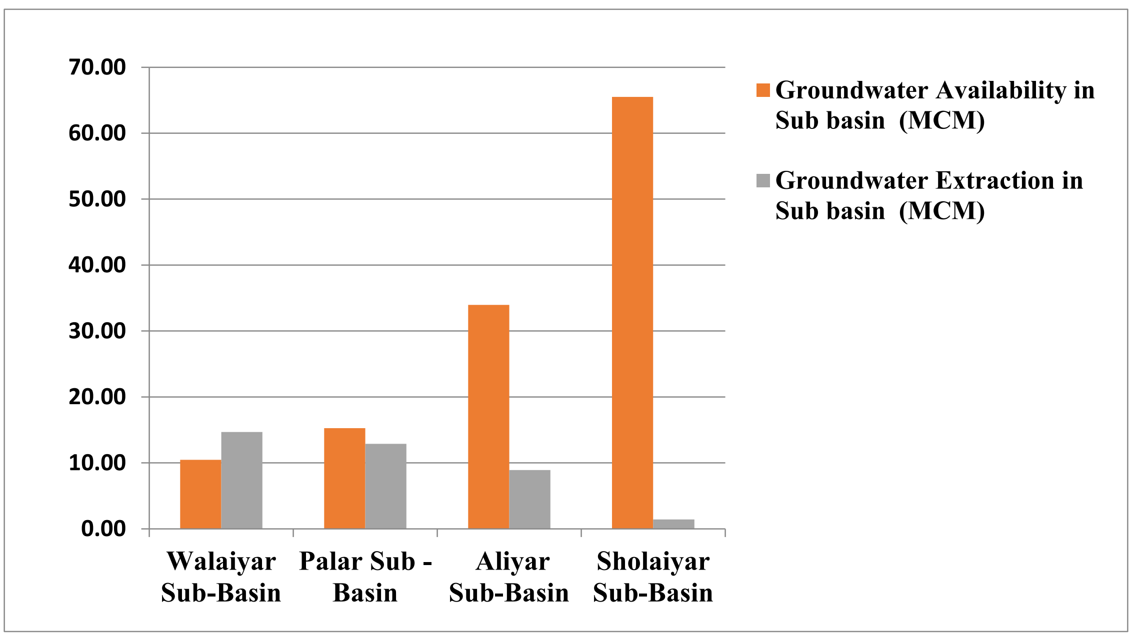


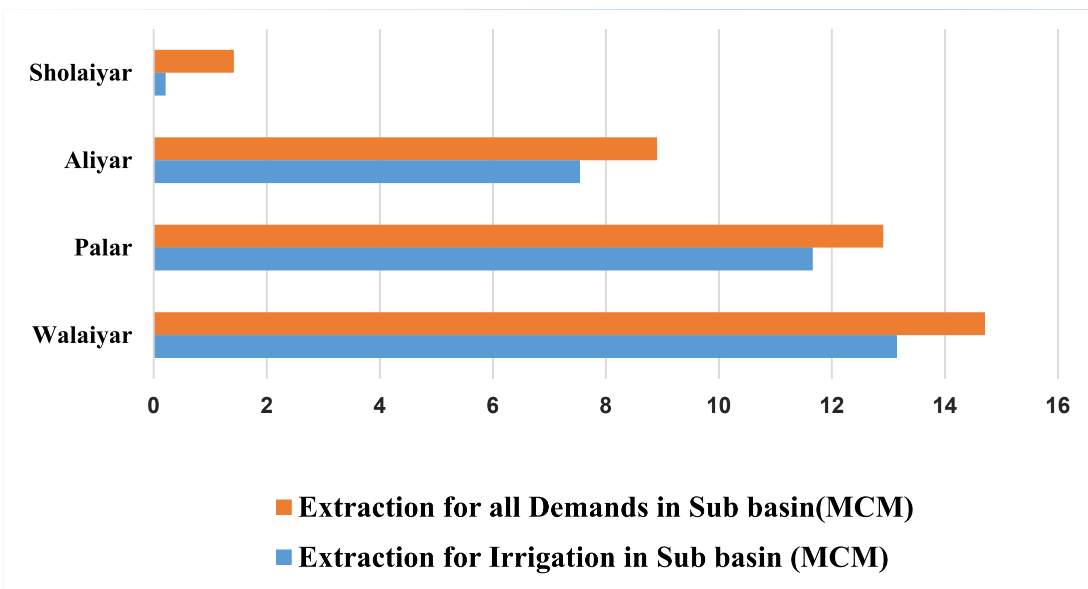
Table 6.10 shows the comparison of groundwater extraction for irrigation demand with respect to total extraction for all demands, based on 2017 assessment. The same is shown pictorially in **Fig: 6.2**.

Table: 6.10 Groundwater extraction for all demands and extraction for irrigation demand

Sl. No	Sub Basin	Extraction for Irrigation in (MCM)	Extraction for all demands (MCM)	Percentage of Irrigation demand
1	Walaiyar	13.15	14.71	**89.39**
2	Palar	11.66	12.91	**90.32**
3	Aliyar	7.54	8.91	**84.62**
4	Sholaiyar	0.21	1.42	**14.79**
	TOTAL	**32.56**	**37.95**	**85.80**

(Source: Dynamic Ground Water Resources of the State of Tamilnadu as on March 2017, WRD, PWD)

Fig: 6.2 Groundwater extraction for all demands and extraction for irrigation demand



6.6.2 Comparison of Groundwater Resources

The Groundwater availability was calculated in Parambikulam Aliyar earlier in 2006 based on assessment done during 2003 with Block as unit. Presently it is calculated with latest assessment done in March 2017 with Firka as unit. The comparison of the above is presented in **Table 6.11**

Table: 6.11 Comparison of groundwater assessment: 2003 and 2017

Sl. No	Sub-Basin	Annual Groundwater Availability (MCM)		Annual Groundwater Extraction (MCM)		Balance Annual Groundwater Availability (MCM)		Stage of Development (%)	
		2003	2017	2003	2017	2003	2017	2003	2017
1	Walaiyar	107.91	10.47	139.27	14.71	0	0	129.06	140.49
2	Palar	63.91	15.27	73.41	12.91	0	5.57	114.87	84.5
3	Aliyar	72.41	33.98	44.64	8.91	27.77	25.73	61.64	26.21
4	Sholaiyar	48.8	65.50	24.29	1.42	24.51	64.08	49.77	2.18
	TOTAL	**293.03**	**125.22**	**281.61**	**37.95**	**52.29**	**95.38**	**355.34**	**253.38**
	Change	**Decreased by 57.26%**		**Decreased by 86.95%**		**Increased by 82.41%**		**Decreased by 28.69%**	

6.7 Groundwater Quality

6.7.1 Introduction

Ground water is a life sustaining resource that plays a major role in irrigated agriculture and influences the health of many ecosystems. But unsustainable depletion of groundwater has been documented on both regional and global scales. The quality of groundwater is equally important to its quantity owing to the suitability of water for various purposes. Intensive agricultural activities, domestic and industrial discharge, over exploitation, uneven rainfall and mismanagement of groundwater have raised serious concern regarding groundwater contamination. The World Health Organization reports that every year more than 3.4 million people die as a result of water related diseases and a leading cause of death around the world. The improvements in irrigation, infrastructure, quality seeds, innovation mechanization, chemical fertilizers and pesticides deteriorated both groundwater quality and soil health.

Suitability of groundwater for domestic and irrigation purposes is determined by its groundwater geochemistry because each groundwater system has a unique chemical composition and any alteration depends on several factors such as rock – water interaction, mineral dissolution, soil – water interaction, interaction time, temperature and anthropogenic activities. In order to prevent water borne diseases, damage to sensitive crops and soil health, groundwater quality measures should be ensured.

6.7.2 Methodology for groundwater quality study

A total of 21 observation wells and bore wells (**Plate : PA 51**)were taken for the study, for the pre monsoon period of the year 2018 (July 2018).The water quality data was collected from the Office of the Chief Engineer, State Ground & Surface Water Resources Data Center (SG&SWRDC), Tharamani, Chennai. Major cations and major anions were analyzed for the study.

The physico – chemical analysis was performed following the standard methods. The brief details of analytical methods and equipments used in the study are given in the **Table 6.12**

Table 6.12 Analytical methods and equipments used in the study.

Sl.No.	Parameter	Method	Equipment
1	Conductivity	Electrometric	Conductivity Meter
2	pH	Electrometric	pH Meter
3	Calcium	Titration by EDTA	-
4	Magnesium	Titration by EDTA	-
5	Sodium	Flame Emission	Flame photometer
6	Potassium	Flame Emission	Flame Photometer
7	Alkalinity	Titration by H2SO4	-
8	Sulphate	Turbidimetric	Turbidity meter
9	Chloride	Titration by AgNO3	-
10	Nitrate	UV Screening	UV – VIS Spectrophotometer
11	Hardness	Titration by EDTA	-
12	Fluoride	SPADNS	UV – VIS Spectrophotometer

Water is a prime natural resource, a basic human need and precious natural asset. The provision of drinking water is a matter of high priority. Looking to the seriousness of groundwater contamination is now a great concern. Therefore all the groundwater samples collected have been compared with the present Indian standards for drinking in this report. The BIS - 10500 and WHO guideline has been presented in **Table 6.13**

Table 6.13 Indian Standards & WHO Guidelines for drinking water (IS 10500: 2012)

Sl.No	Parameter	BIS Standards		WHO Guideline
		Desirable Limit	Permissible limit	Maximum allowable Concentration
1	Colour, (Hazen units), Max	5	25	15
2	Turbidity (NTU), Max	5	10	5
3	pH Value	6.5 to 8.5	No Relaxation	6.5 - 8.5
4	Total Hardness (as $CaCo_3$) mg/L, Max	300	600	500
5	Chlorides (as Cl) mg/L, Max.	250	1000	250
6	Residual, free chlorine, mg/L, Min	0.2	--	-
7	Total Dissolved solids mg/L, Max	500	2000	1000
8	Calcium (as Ca) mg/L, Max	75	200	-
9	Sulfate (as SO_4) mg/L, Max	200	400	400
10	Nitrate (as NO_3) mg/L, Max	45	No Relaxation	10
11	Fluoride (as F) mg/L, Max	1	1.5	1.5
12	Phenolic Compounds (as C_6H_5OH) mg/L, Max	0.001	0.002	-
13	Anionic detergents (as MBAS) mg/L, Max	0.2	1	-
14	Mineral Oil mg/L, Max	0.01	0.03	-
15	Alkalinity mg/L, Max	200	600	-
16	Boron mg/L, Max	1	5	-
Micro Pollutants (Heavy metals & pesticides)				
17	Zinc (as Zn) mg/L, Max	5	15	5
18	Iron (as Fe) mg/L, Max	0.3	1	0.3
19	Manganese (as Mn)mg/L, Max	0.1	0.3	0.1
20	Copper (as Cu) mg/L, Max	0.05	1.5	1.0
21	Arsenic (as As) mg/L, Max	0.05	No relaxation	0.05
22	Cyanide (as CN) mg/L, Max	0.05	No relaxation	0.1
23	Lead (as Pb) mg/L, Max	0.05	No relaxation	0.05
24	Chromium (as Cr^{6+}) mg/L, Max	0.05	No relaxation	0.05
25	Aluminium (as Al) mg/L, Max	0.03	0.2	0.2
26	Cadmium (as Cd) mg/L, Max	0.01	No relaxation	0.005
27	Selenium (as Se) mg/L,Max	0.01	No relaxation	0.01
28	Mercury (as Hg) mg/L, Max	0.001	No relaxation	0.001
29	Total Pesticides	Absent	0.001	-
30	Sodium, mg/L, Max	-	-	200

The present study is undertaken to investigate the qualitative analysis and some physicochemical parameters of groundwater in Parambikulam Aliyar river basin of Tamilnadu.

6.7.3 Groundwater quality scenario in Parambikulam Aliyar River Basin

Water quality data of Coimbatore and Tiruppur districts coming under the jurisdiction of PAP river basin were collected from the Office of the Chief Engineer, State Ground & Surface Water Resources Data Center, Tharamani, Chennai. A total of 21 wells (Observations wells and Bore wells) were analyzed for the study for the pre monsoon period of 2018. The list of wells is listed in **Table 6.14.**

Table 6.14 Groundwater sampling locations in PAP Basin

Well No.	District	Village	Latitude	Longitude	Source
63402	Coimbatore	Vadavalli	10.881	77.151	CW
63613A	Coimbatore	Kurichy	10.956	76.972	CW
63702	Coimbatore	Andipalayam	10.800	77.104	CW
63704	Coimbatore	Periyanegamam	10.747	77.100	CW
63709	Coimbatore	Pollachi	10.650	76.989	CW
63710	Coimbatore	Ambrampalayam	10.629	76.883	CW
63713	Coimbatore	Sethumadai	10.511	76.889	CW
63717	Coimbatore	Gopalapuram	10.692	76.879	CW
63718	Coimbatore	Puravaipalayam	10.729	76.949	CW
63719	Coimbatore	Kinathukadavu	10.817	77.017	CW
HP1CBE11	Coimbatore	Ganapathi palayam	10.617	76.847	BW
HP2CBE06	Coimbatore	Thenkarai	10.947	76.847	BW
HP2CBE10A	Coimbatore	Edayarpalayam	11.038	76.926	BW
HP2CBE23	Coimbatore	Mettupalayam	10.747	77.029	BW
HP2CBE24A	Coimbatore	Sethumadai	10.504	76.887	BW
HP2CBE26	Coimbatore	Valparai	10.325	76.956	BW
63801	Tiruppur	Ramachandrapuram	10.725	77.176	CW
63806	Tiruppur	Kongalnagaram	10.672	77.194	CW
63811	Tiruppur	Udumalpet	10.574	77.240	CW
63817A	Tiruppur	Komaralingam	10.486	77.351	CW
63818A	Tiruppur	Neelammbur	11.056	77.098	CW

Note: BW – Bore Well; CW – Control Well

The groundwater quality of the Parambikulam Aliyar River project has been assessed to see the suitability of groundwater for drinking purposes and domestic applications. The water quality data for the pre monsoon period of the year 2018 were collected and analysed for the physico chemical parameters with reference to BIS and WHO standards. Total Dissolved Solids, Chloride, Total Hardness, Alkalinity, Sulphate and Nitrate are considered as the deciding parameters for discussion. Water quality of the PAP river basin is detailed below sub basinwise:

Walayar Sub basin

Total Dissolved Solids (TDS) is the most important deciding factor for water quality determination. Good quality of Total Dissolved Solids (<500 mg/l) was observed in Sultanpet and Kinathukadavu blocks of this sub basin. Moderate quality of TDS (500 – 2000 mg/l) was observed in Thondamuthur, Madukkarai and Pollachi North blocks of this sub basin. Good to moderate quality of TDS was observed in Anaimalai block of this sub basin.

Total Hardness is another important parameter for water quality determination. Total Hardness value is good (<300 mg/l) in almost all the blocks in the sub basin. Parts of Pollachi north and Thondamuthur show moderate quality of TH (300 – 600 mg/l) in the sub basin.

Apart from TDS and TH, chloride is also an important parameter for water quality. Good quality of chloride (<250 mg/l) is observed in all the blocks of the sub basin whereas a few part of Thondamuthur shows moderate quality of chloride.

Generally the water quality is good in most of the blocks and moderate in a few blocks of this sub basin.

Palar Sub basin

TDS value is within the desirable limit of 500 mg/l in both the blocks (Pollachi south and Udumalpet) in this sub basin.

TH value is within the desirable limit of 300 mg/l in this sub basin.

Chloride value is also within the standards (<250 mg/l) specified for drinking purposes.

Generally the quality of water is good in this sub basin.

Aliyar Sub basin

Good to moderate quality of TDS is observed in this sub basin.

Good quality of TH is observed in almost all the villages of this sub basin except Sethumadai village, where the quality observed is moderate.

Chloride value is within the desirable limit (<250 mg/l) in this sub basin.

Sholaiyar Sub basin

This sub basin is fully covered by hills and hence there is no observation well in this sub basin.

Table 6.15 Groundwater quality observation and % sample violation with respect to drinking water standards in PAP basin

Sl.No	Parameters (All are in mg/l except pH)	Range in the water sample	Stds. BIS/WHO guideline	% Sample violation (DL - PL, Analysis of 21 samples)	Observation
1	pH value	7.4 - 8.5	6.5 – 8.5	Nil	All values are within the desirable limit
2	Total Hardness (as $CaCO_3$)	20 - 375	300-600	71% within DL while 29% exceeds the DL but are within the permissible limit.	Value of TH is good to moderate in the basin.
3	Chloride	7 - 284	250 - 1000	95% within DL while 5% within PL.	Chloride value is good in almost all the wells except in Kurichy village. Here the value (284 mg/l) is slightly higher than the desirable limit.
4	Total Dissolved Solids	45 - 907	500-2000	62 % within DL while 38 % within PL.	TDS value ranges from good to moderate value. No poor quality is observed.
5	Calcium	4 - 84	75-200	86 % of samples comes under DL and 14% comes under PL .	All the values fall within the permissible limit.
6	Sulphate	5 - 84	200-400	100 % of water samples fall within the DL.	All the samples are well within the desirable limit of drinking water.
7	Nitrate	1.0 - 46	45	100 % of samples fall within the desirable limit.	All the samples are well within the desirable limit of drinking water.
8	Fluoride	0.05 – 1.61	1.0-1.5	100 % of samples fall within the desirable limit.	All the samples are well within the desirable limit of drinking water.
9	Sodium	3 – 265	200(WHO limit)	95 % comes under WHO limit while 5 % violated the WHO limit.	High sodium concentrations is not suitable for irrigation purpose due to sodium sensitivity of crops / plants.

Sl.No	Parameters (All are in mg/l except pH)	Range in the water sample	Stds. BIS/WHO guideline	% Sample violation (DL - PL, Analysis of 21 samples)	Observation
10	Potassium	0.1 - 70	Not prescribed	67 % of samples have potassium value below 10 mg/l while 33 % of samples have potassium value above 10 mg/l	The BIS has not included potassium in drinking water standards.
11	Magnesium	2 - 53	30 - 100	67 % falls within DL; 33% falls within PL.	Value of magnesium ranges from good to moderate values.
12	Electrical Conductivity (μS/cm)	70 - 1960	1000	62 % comes within DL; 38 % comes within PL.	EC value falls between good to moderate values in the basin.
13	Alkalinity (as HCO3)	15 - 537	200-600	57 % falls within DL; 43 % falls within PL.	Values of alkalinity fall within the permissible limit in the basin.

Note: The abbreviation indicated above as "DL" – Desirable Limit, "PL" – Permissible Limit, EEC – European Union Standards, WHO – World Health Organization, BIS – Bureau of Indian Standards.

6.7.4 Conclusion

1. The TDS value in the basin ranges from 45 mg/l (Valparai village) to 907 mg/l (Kurichy village). Generally the TDS value ranges from good to moderate in this basin.(**Plate : PA 52**)
2. The TH value in the basin ranges from 20 mg/l to 375 mg/l in the basin which is well within the permissible limit prescribed by the BIS standards.(**Plate : PA 53**)
3. The chloride value in the basin ranges from 7 mg/l to 284 mg/l in the basin. Generally the chloride value is good in most of the wells except a few wells where the value is moderate.(**Plate : PA 54**)
4. pH value ranges from 7.4 to 8.5 which is within the desirable limit of the BIS standards.
5. Nitrate value is within the desirable limit of 45 mg/l in all the wells in the sub basin.
6. Fluoride value in the basin ranges from 0.05 to 1.61 mg/l and the value is within the desirable limit specified by the BIS.
7. Generally the water quality is good in most of the wells in the basin while a few wells have moderate quality of groundwater in the basin.

6.7.5 Measures to protect the Groundwater quality

1. **Natural Sources:** Some substances found naturally in rocks and soils such as iron, manganese, arsenic, chlorides, fluorides, sulphates etc., can become dissolved in groundwater. Groundwater that contains unacceptable concentrations of these substances is not used for drinking water or other domestic water unless it is treated to remove these contaminants.
2. **Septic Systems:** Local regulations require specific separation distances (minimum horizontal distance of 50 to 100 feet) between septic systems and drinking water.
3. **Improper disposal of hazardous waste:** Hazardous waste should always be disposed of properly by a licensed hazardous waste handler or through municipal hazardous waste handler.
4. **Pesticides and fertilizer use:** Replacing organic manures instead of chemical fertilizers can improve the groundwater quality suitable for drinking purposes.
5. Water scarcity will intensify in areas where water withdrawals are not sustainable which can constrain agricultural production, threaten ecosystems and affect the income and livelihood opportunities of many residents in rural and urban areas. In addition to groundwater depletion, groundwater pollution and aquifers salinization due to sea water intrusion are also growing concerns. In such a case, quality of existing groundwater can be improved by the simple technique of **rain water harvesting** structures.

Table 6.16
Safe limits for Electrical Conductivity for Irrigation Water

Sl.No	Nature of soil	Crop growth	Upper permissible limit of EC in water µmhos/cm at 25°C
1	Deep black soil and alluvial soils having clay content more than 30% soils that are fairly to moderately well drained.	Semi-tolerant	1500
		Tolerant	2000
2	Heavy textured soils having clay contents of 20-30% soils that are well drained internally and have good surface drainage system.	Semi-tolerant	2000
		Tolerant	4000
3	Medium textured soils having clay 10-20% internally very well drained and having good surface drainage system.	Semi-tolerant	4000
		Tolerant	6000
4	Light textured soils having clay less than 10% soil that have excellent internally and surface drainage system.	Semi-tolerant	6000
		Tolerant	8000

Table 6.17
Guidelines for Evaluation of Quality of Irrigation Water

Water class	Sodium (Na) %	EC µmhos/cm at 25°C	Alkalinity hazards	
			SAR	RSC (meq/1)
Excellent	<20	<250	<10	<1.25
Good	20-40	250-750	10-18	1.25-2.0
Medium	40-60	750-2250	18-26	2.0-2.5
Bad	60-80	2250-4000	>26	2.5-3.0
Very bad	>80	>4000	>26	>3.0

Table 6.18
Rating of irrigation water based on Boron concentration in the water (U.S. Salinity Laboratory Staff)

Class of water	Boron concentration, mg/l		
	Sensitive Crops	Semi-tolerant crops	Tolerant crops
Excellent	< 0.33	< 0.67	< 1.00
Good	0.33 – 0.67	0.67 – 1.33	1.00 – 2.00
Permissible	0.67 – 1.00	1.33 – 2.00	2.00 – 3.00
Doubtful	1.00 – 1.25	2.00 – 2.50	3.00 – 3.75
Unsuitable	> 1.25	> 2.50	> 3.75

Table 6.19
Trace elements tolerance for irrigation waters (Environment Studies Board, 1973)

Trace Element	Trace elements tolerance limit mg/l	
	Acid soils or all soils in continuous use	Fine textured alkaline soils
Aluminium	5.0	20.0
Arsenic	0.1	2.0
Beryllium	0.1	0.5
Boron	0.5	1.0
Cadmium	0.01	0.05
Chromium	0.10	1.0
Cobalt	0.05	5.0

Trace Element	Trace elements tolerance limit mg/l	
	Acid soils or all soils in continuous use	**Fine textured alkaline soils**
Copper	0.20	5.0
Iron	5.0	20.0
Lead	5.0	10.0
Lithium	2.5	2.5
Manganese	0.2	10.0
Molybdenum	0.01	0.01
Nickel	0.2	2.0
Vanadium	0.1	1.0
Zinc	2.0	10.0

Table 6.20
Tolerance Limits for Industrial Effluence (IS: 2490, Part-I-1981)

Sl.No	Characteristic	Maximum tolerance limits for industrial effluents discharged (mg/l)			
		Into inland surface water	**Into public sewers**	**On land for irrigation**	**Marine/Coastal Area**
1	Colour and Odour	Absent	-	Absent	Absent
2	Suspended solids	100	600	200	a)For Process waste water 100 b)For cooling water effluent 10 percent above total suspended matter of effluent
3	Particle size of suspended solids	Shall pass 850 micron IS Sieve	-	-	a)Floatable solids, max. 3 mm b)Settleable solids max 856 microns
4	Dissolved solids (inorganic)	2100	2100	2100	-
5	pH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
6	Temperature ˚C	Shall not exceed 40 in any section of the stream within 15 meters downstream from the effluent outlet	45 at the point of discharge	-	-
7	Oil and grease	10	20	10	20

Sl.No	Characteristic	Maximum tolerance limits for industrial effluents discharged (mg/l)			
		Into inland surface water	**Into public sewers**	**On land for irrigation**	**Marine/Coastal Area**
9	Ammonical nitrogen (as N)	50	50	-	50
10	Total kjeldahl nitrogen (as N)	100	-	-	100
11	Free ammonia (as NH3)	5.0	-	-	5.0
12	BOD (5 days at 20˚C)	30	350	100	100
13	Chemical Oxygen Demand	250	-	-	250
14	Arsenic (as As)	0.2	0.2	0.2	0.2
15	Mercury (as Hg)	0.01	0.01	-	0.01
16	Lead (as Pb)	0.1	1.0	-	2.0
17	Cadmium (as Cd)	2	1.0	-	2.0
18	Hexavalant Chromium (as Cr+6)	0.1	2.0	-	1.0
19	Total Chromium (as Cr)	2.0	2.0	-	2.0
20	Copper (as Cu)	3.0	3.0	-	30
21	Zinc (as Zn)	5.0	15	-	15
22	Selenium (as Se)	0.05	0.05	-	0.05
23	Nickel (as Ni)	3.0	3.0	-	-
24	Boron (as B)	2.0	2.0	2.0	-
25	Percent sodium	-	60	60	-

Table 6.21
Effects of water quality parameters of water being used in industries

Sl.No.	Parameters	Prescribed limits IS:10500, 1991		Probable effects
		Desirable limit	**Permissible limit**	
1	pH value	**6.5**	**8.2**	Low pH increases corrosion of concrete, pH 7.0 is required for most industry, pH 2.7- 7.2 advised for carbonated beverage industry.
2	Total dissolved solids, mg/l	**50**	**3000**	Causes foaming in boilers and solids interfere with clearness, colour or taste of finished products. Low TDS value are required in most industries. High TDS leads to corrosion.
3	Iron mg/l	**0.1**	**2.0**	Recommended value for food processing units is 0.2, for paper and photographic industry iron of 0.1 mg/l is recommended iron less than 0.1 mg/l is recommended in cooling waters.
4	Chloride mg/l	**25**	**200**	Significantly affect the rate of corrosion of steel and Aluminium.
5	Fluoride mg/l	**0.2**	**1.0**	Harmful in industries involved in production of food beverages, pharmaceuticals and medical items.
6	Calcium 20 mg/l	**20**	**500**	High calcium leads to spots on films. Have undesirable effects like forming scale, precipitates and curds in industry. It may interferes in formation of emulsions and processing of colloids upsetting fermentation process, and electroplating rinsing operation.
7	Magnesium mg/l	**5**	**30**	-
8	Sulphate mg/l	**25**	**250**	Increases corrosiveness of water towards concrete, low sulphates (20 mg/l) is recommended for sugar industries.
9	Nitrate mg/l	**15**	**30**	Injurious to dyeing of wool and silk fabrics and harmful in fermentation process for brewing, Nitrate in some water protects metal in boilers from inter-crystalline cracking.

Sl.No.	Parameters	Prescribed limits IS:10500, 1991		Probable effects
		Desirable limit	Permissible limit	
10	Copper mg/l	0.01	0.5	Copper is undesirable in food industry as it has colour reactions and impart fishy taste to finished products. Affects smoothness and brightness of metal deposits in metal plating, baths
11	Chromium mg/l	N.A.	N.A.	It is a corrosion inhibitor
12	Zinc	N.A.	N.A.	Zinc bearing water should not be used in Acid drinks like lemonade.
13	Lead	N.A.	N.A.	Traces of lead in metal plating baths will affect smoothness and brightness of deposits.

6.8 Management of Groundwater Resources

Studies show that groundwater recharge and discharge conditions are reflection of the precipitation regime, climatic variables, landscape characteristics and human impacts. Hence, predicting the behavior of recharge and discharge conditions under changing climate is of great importance for groundwater conservation & management.

The groundwater crisis prevailing in the State is not only due to natural factors, but also due to human interventions. The number of wells drilled for irrigation ie. both for food grains and for cash crops have rapidly and indiscriminately increased. India's rapidly growing population and changing lifestyles have also increased the domestic water demand. Similarly, the industrial demand has also increased. Hence, management of groundwater is an essential requirement and it requires an understanding of balancing the management on supply side and demand side.

6.8.1 Supply-side Management of Groundwater

Constructing Artificial Recharge Structures like check dams, percolation ponds, recharge pits, shafts or wells are considered to be the best option in rural areas for recharging groundwater where soil condition is favourable. Accordingly favorable groundwater recharge sites are identified with the application of GIS after focusing appropriate weight-age for spatial and non-spatial parameters like geo-morphology, geology, lineament, depth to bed rock, soil, aquifer and rainfall level.On the other hand, roof-top rainwater harvesting, either as direct use or recharge into the aquifers is suited for urban habitations with its characteristic space constraints.

Many structural measures have been taken by the Government to increase the groundwater availability. Various State Government agencies namely, Water Resources Department, Agricultural Department, Agricultural Engineering Department, TWAD Board and Forest Department with and without Central Government assistance have taken up augmentation of ground water resources through artificial recharge structures.

Success of Artificial Recharge Structures (ARS) depends largely on geological and hydrological features of an area and design of ARS. Percolation ponds, check dams, recharge shafts and sub-surface barriers are effective structures in hard rock areas, recharge trench and recharge tube wells are more suitable in alluvial areas. In the coastal zone, tidal regulators which impound the fresh water upstream and enhance the natural recharge, help control salinity ingress effectively. In case of urban areas and hilly terrains with high rainfall, roof top rain water structures are most useful.

6.8.2 Demand-side Management of Groundwater

In Parambikulam Aliyar basin, the total groundwater extraction is **37.95 MCM** out of which the extraction for irrigation sector is **32.56 MCM.**

Table: 6.22 Groundwater Availability and Extraction as per 2017 Assessment

Sl. No	Sub Basin	Annual Groundwater Availability in Sub basin (MCM)	Annual Groundwater Extraction for irrigation in Sub basin (MCM)	Annual Groundwater Extraction for other purposes in Sub basin (MCM)	Total Annual Groundwater Extraction in Sub basin (MCM)	Annual Irrigation Extraction in Total Extraction (%)
1	Walaiyar	10.47	13.15	1.56	14.71	**89.39**
2	Palar	15.27	11.66	1.25	12.91	**90.32**
3	Aliyar	33.98	7.54	1.37	8.91	**84.62**
4	Sholaiyar	65.50	0.21	1.21	1.42	**14.79**
	Total	**125.22**	**32.56**	**5.39**	**37.95**	**85.80**

It is observed that the Ground water Extraction in Parambikulam Aliyar basin for irrigation is 86% whereas the total ground water extraction for all demands in Tamilnadu is 81%. This raises concern on the management of the ground water resources. It is imperative to focus special attention on irrigation sector to reduce the groundwater extraction. The farmers have to be educated to understand the consequences of over exploitation of groundwater for irrigation and motivate them to switch over to more efficient mode of irrigation practices like drip irrigation and sprinkler irrigation to reduce the groundwater extraction for irrigation. The predominant crop in this basin is coconut and in order to reduce the water consumption at field level, The farmers have to be insisted to adopt the latest less water consumption agricultural technique like drip irrigation.

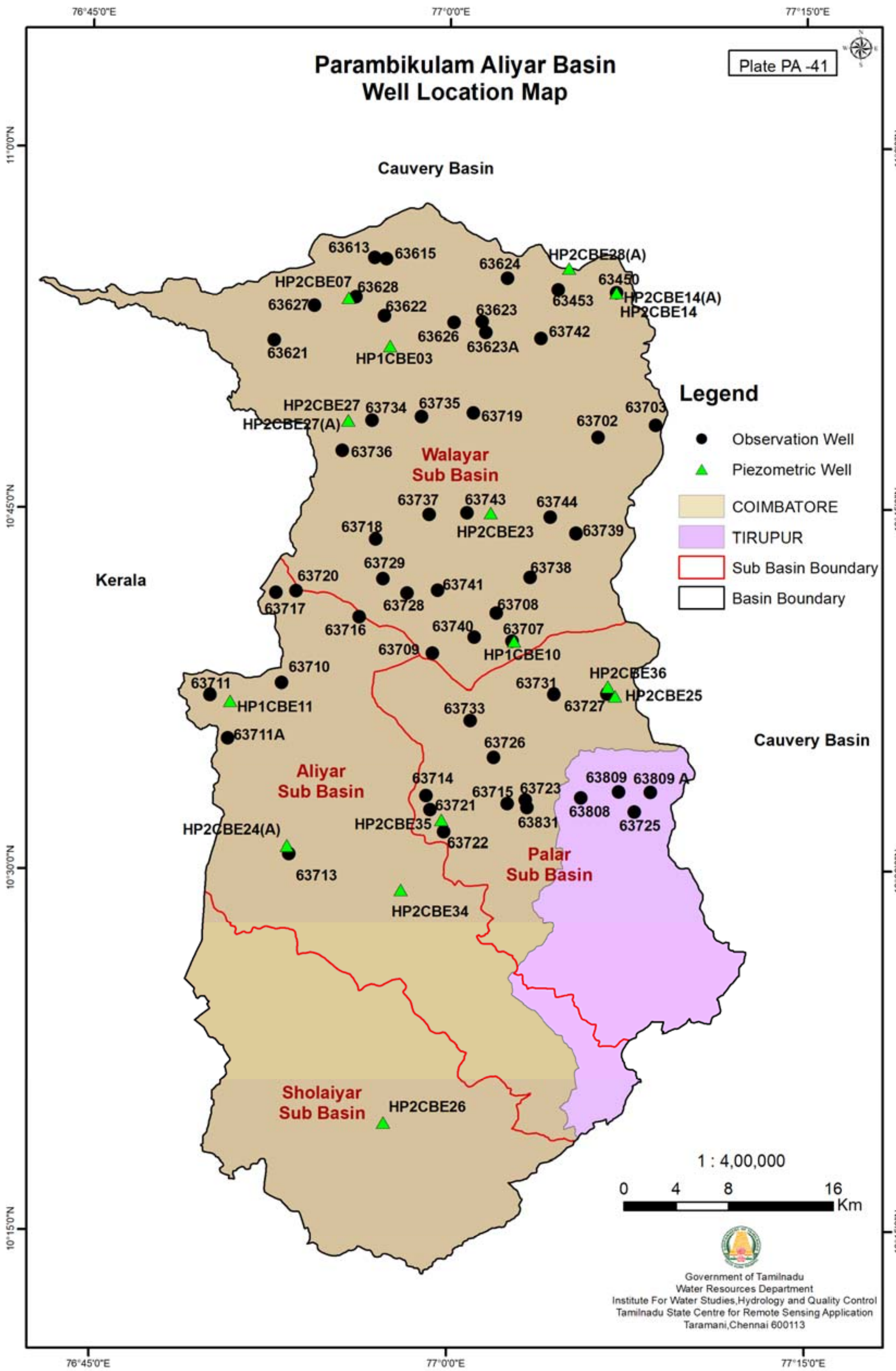
6.9 Summary

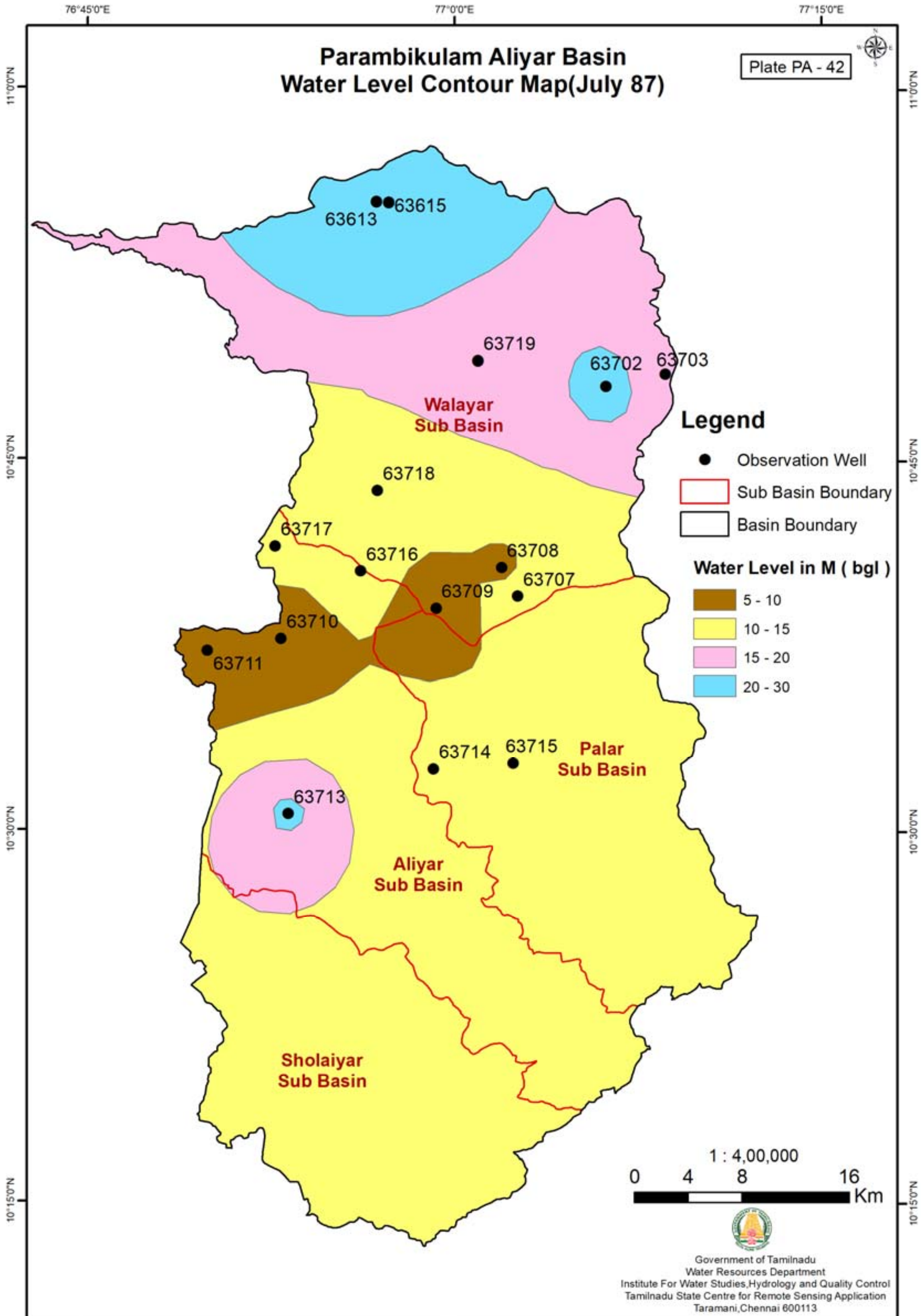
69 wells spread over the entire Parambikulam Aliyar Basin has been scrutinized for study purpose. Sub basin-wise groundwater availability, extraction and balance have been worked out. Long-term trend in water level fluctuation has been analyzed and pre-monsoon & post-monsoon contours maps of aquifers are prepared.

- ❖ Net annual groundwater availability in Parambikulam Aliyar Basin is 125.23MCM and total annual groundwater extraction in the basin is 37.95MCM (30.3%). The balance groundwater available for further development is 95.38MCM.
- ❖ Whilst comparing the groundwater resources of Parambikulam Aliyar Basin calculated in Appraisal report prepared in 2006 with this Reappraisal report, it is observed that the total annual groundwater availability has decreased by **57.26%** (from 293.03MCM to 125.22MCM) and total annual groundwater extraction has also decreased by **86.95%** (from 281.61MCM to 37.95MCM). The balance annual groundwater availability of is increased by **82.41%** (from 52.29MCM to 95.38MCM)
- ❖ Annually groundwater extracted for irrigation in Parambikulam Aliyar basin is **32.56** MCM which is 85.80 % in total annual groundwater extraction of **37.95** MCM for all sectoral demands.

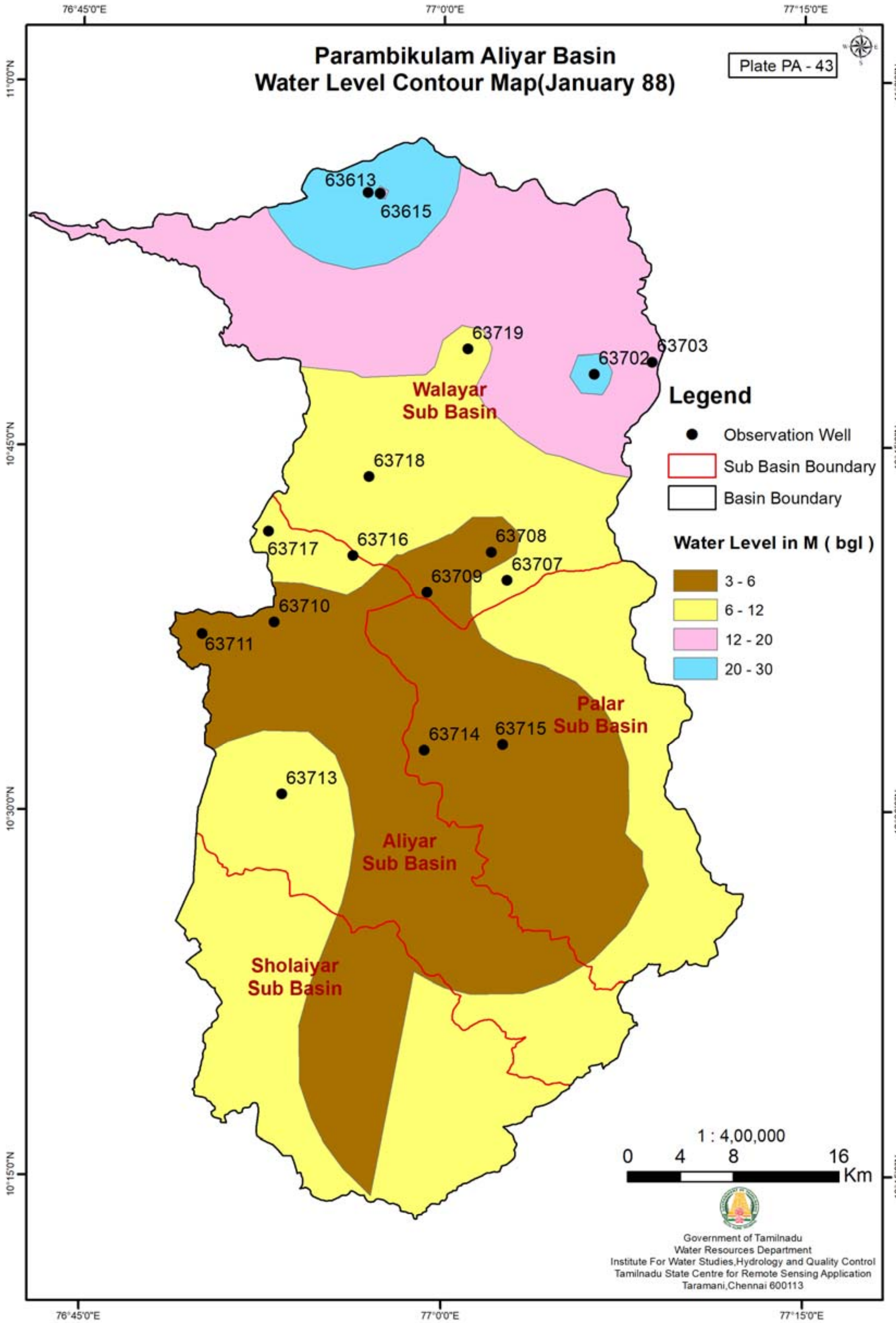
Recommendations:

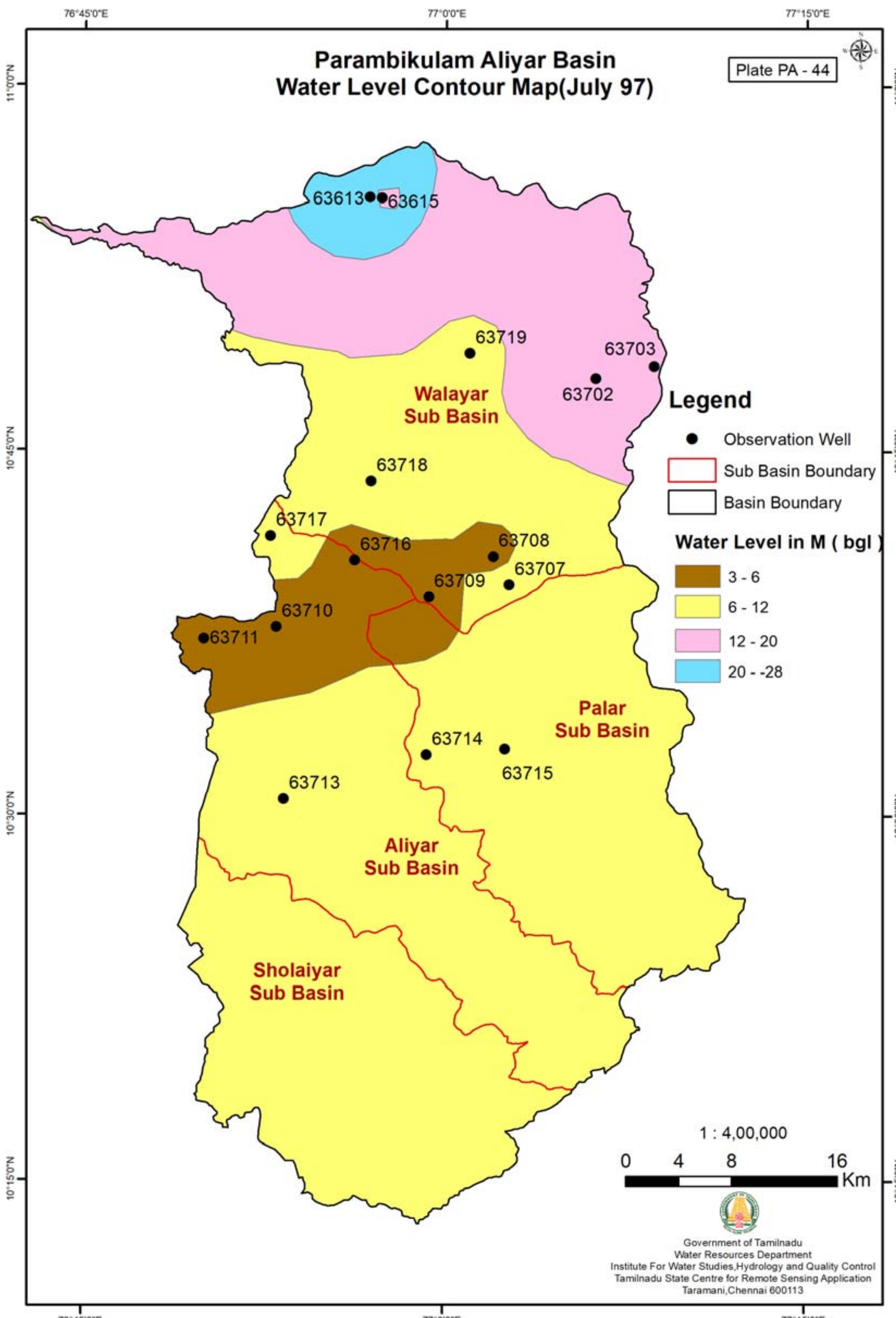
- ➢ Even though the Groundwater extraction for all demands is 30.30%, the extraction for irrigation sector in Parambikulam Aliyar basin is high at 85.80% in total extraction. In order to reduce the groundwater extraction for irrigation, modern irrigation method like drip and sprinkler irrigation and latest cultivation practices like System of Rice Intensification (SRI) and Sustainable Sugarcane Initiative (SSI) have to be implemented in large scale.


Parambikulam Aliyar Basin
Well Location Map
Plate PA -41
76°45'0"E
77°0'0"E
77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N
Cauvery Basin
Kerala
Cauvery Basin
Walayar Sub Basin
Aliyar Sub Basin
Palar Sub Basin
Sholaiyar Sub Basin
63613
63615
63624
HP2CBE28(A)
63450
HP2CBE07
63628
63453
HP2CBE14(A)
HP2CBE14
63627
63622
63623
63742
63621
63626
63623A
HP1CBE03
HP2CBE27
63734
63735
63719
63702
63703
HP2CBE27(A)
63736
63737
63743
63744
63718
HP2CBE23
63739
63729
63738
63720
63741
63717
63728
63708
63716
63740
63707
63709
HP1CBE10
63710
HP2CBE36
63711
63731
HP2CBE25
HP1CBE11
63727
63733
63711A
63726
63714
63809
63809 A
63715
63723
63721
63808
63725
HP2CBE35
63831
HP2CBE24(A)
63722
63713
HP2CBE34
HP2CBE26
Legend
Observation Well
Piezometric Well
COIMBATORE
TIRUPUR
Sub Basin Boundary
Basin Boundary
1 : 4,00,000
0 4 8 16
Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113



76°45'0"E
77°0'0"E
77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N
Parambikulam Aliyar Basin
Water Level Contour Map(July 87)
Plate PA - 42
63613
63615
63719
63702
63703
Walayar
Sub Basin
63718
63717
63716
63708
63707
63709
63710
63711
63714
63715
Palar
Sub Basin
63713
Aliyar
Sub Basin
Sholaiyar
Sub Basin
Legend
Observation Well
Sub Basin Boundary
Basin Boundary
Water Level in M (bgl)
5 - 10
10 - 15
15 - 20
20 - 30
1 : 4,00,000
0 4 8 16
Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113


Parambikulam Aliyar Basin
Water Level Contour Map(January 88)
Plate PA - 43
63613
63615
63719
63702
63703
Walayar Sub Basin
63718
63717
63716
63708
63709
63707
63710
63711
63714
63715
Palar Sub Basin
63713
Aliyar Sub Basin
Sholaiyar Sub Basin
Legend
Observation Well
Sub Basin Boundary
Basin Boundary
Water Level in M (bgl)
3 - 6
6 - 12
12 - 20
20 - 30
1 : 4,00,000
0 4 8 16 Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113
76°45'0"E
77°0'0"E
77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N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77°0'0"E
77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N
Parambikulam Aliyar Basin
Water Level Contour Map(July 97)
Plate PA - 44
63613
63615
63719
63703
63702
Walayar
Sub Basin
63718
63717
63716
63708
63707
63709
63710
63711
Palar
Sub Basin
63714
63715
63713
Aliyar
Sub Basin
Sholaiyar
Sub Basin
Legend
Observation Well
Sub Basin Boundary
Basin Boundary
Water Level in M (bgl)
3 - 6
6 - 12
12 - 20
20 - -28
1 : 4,00,000
0 4 8 16
Km
Government of Tamilnadu
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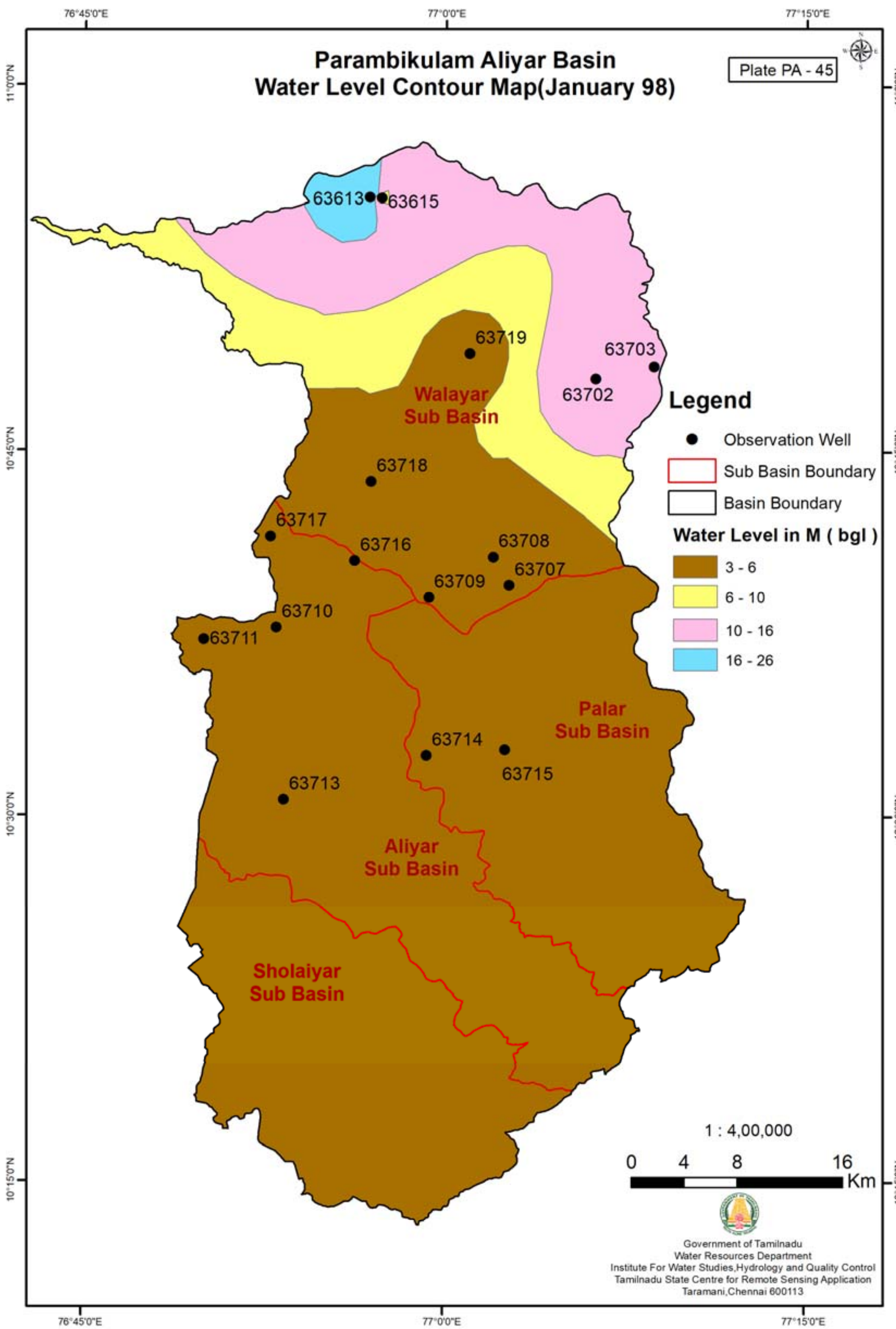

Parambikulam Aliyar Basin
Water Level Contour Map(January 98)
Plate PA - 45
63613
63615
63719
63703
63702
Walayar Sub Basin
63718
63717
63716
63708
63707
63709
63710
63711
Palar Sub Basin
63714
63715
63713
Aliyar Sub Basin
Sholaiyar Sub Basin
Legend
Observation Well
Sub Basin Boundary
Basin Boundary
Water Level in M (bgl)
3 - 6
6 - 10
10 - 16
16 - 26
1 : 4,00,000
0 4 8 16 Km
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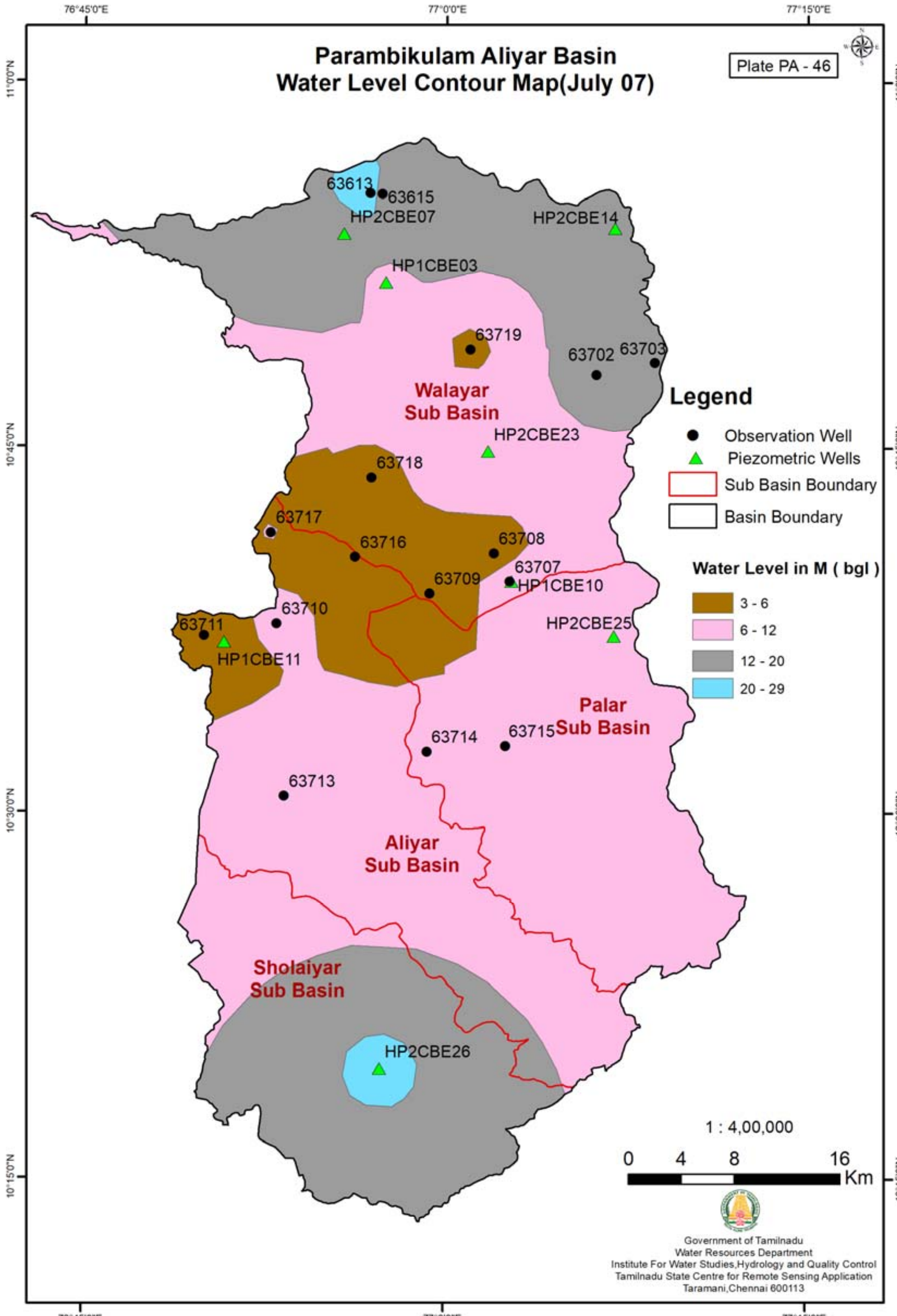
Taramani,Chennai 600113



Parambikulam Aliyar Basin
Water Level Contour Map(July 07)
Plate PA - 46
76°45'0"E
77°0'0"E
77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N
63613
63615
HP2CBE07
HP2CBE14
HP1CBE03
63719
63702
63703
Walayar Sub Basin
HP2CBE23
63718
63717
63716
63708
63707
HP1CBE10
63709
63710
63711
HP1CBE11
HP2CBE25
Palar Sub Basin
63714
63715
63713
Aliyar Sub Basin
Sholaiyar Sub Basin
HP2CBE26
Legend
Observation Well
Piezometric Wells
Sub Basin Boundary
Basin Boundary
Water Level in M (bgl)
3 - 6
6 - 12
12 - 20
20 - 29
1 : 4,00,000
0 4 8 16 Km
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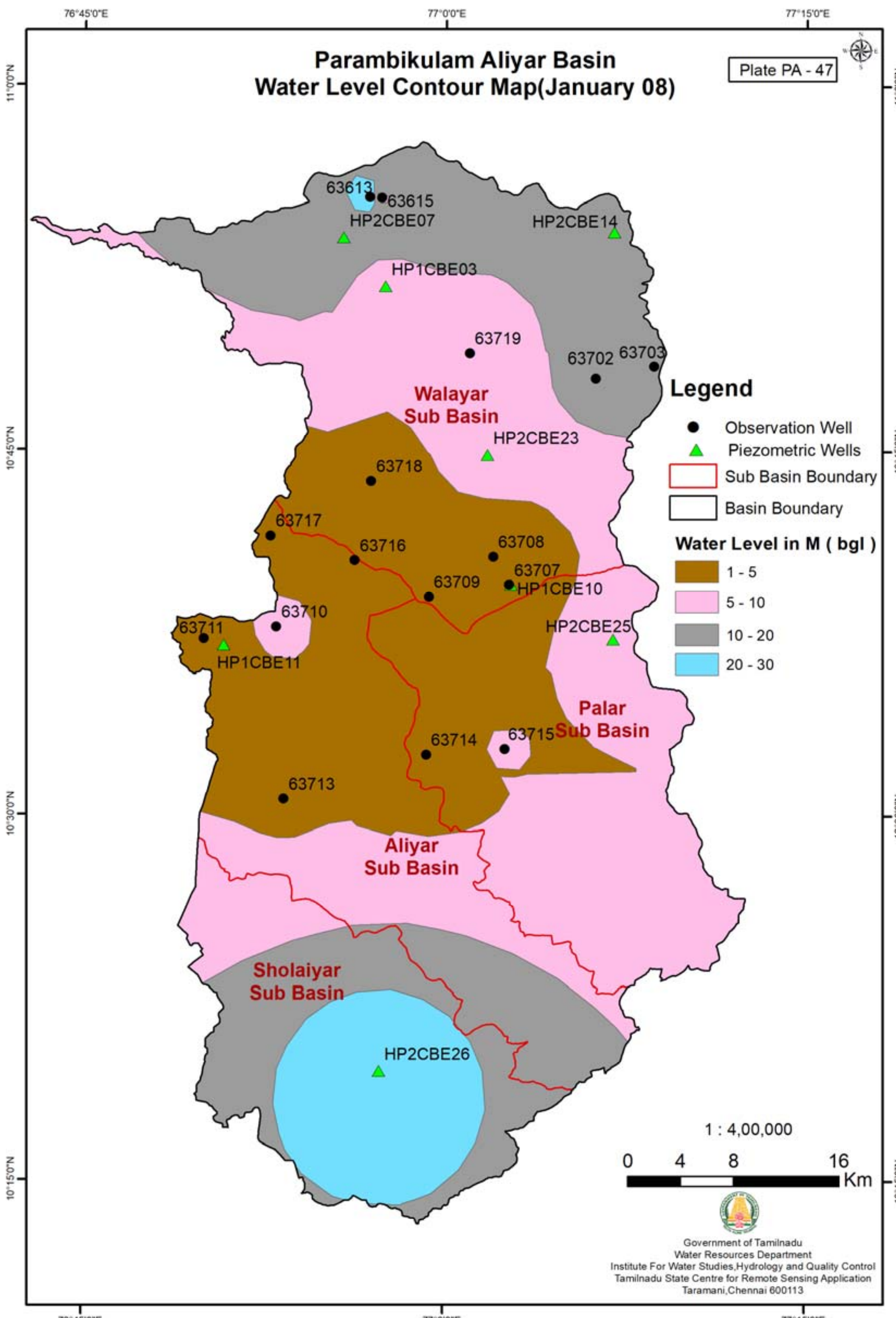
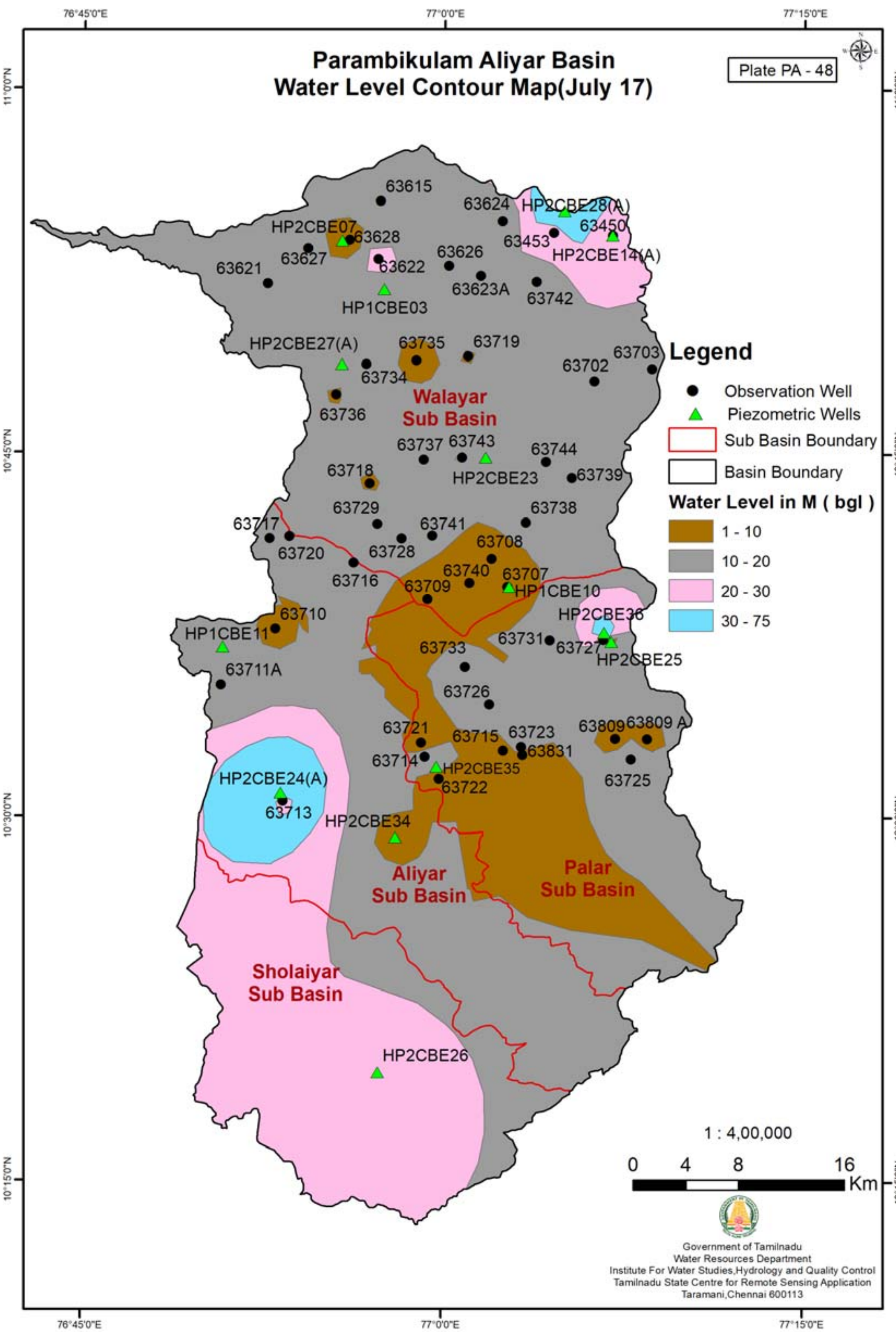
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113


Parambikulam Aliyar Basin
Water Level Contour Map(January 08)
Plate PA - 47
76°45'0"E
77°0'0"E
77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N
63613
63615
HP2CBE07
HP2CBE14
HP1CBE03
63719
63702
63703
Walayar
Sub Basin
HP2CBE23
63718
63717
63716
63708
63707
HP1CBE10
63709
63710
63711
HP1CBE11
HP2CBE25
Palar
Sub Basin
63714
63715
63713
Aliyar
Sub Basin
Sholaiyar
Sub Basin
HP2CBE26
Legend
Observation Well
Piezometric Wells
Sub Basin Boundary
Basin Boundary
Water Level in M (bgl)
1 - 5
5 - 10
10 - 20
20 - 30
1 : 4,00,000
0 4 8 16
Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113


Parambikulam Aliyar Basin
Water Level Contour Map(July 17)
Plate PA - 48
76°45'0"E
77°0'0"E
77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N
Legend
Observation Well
Piezometric Wells
Sub Basin Boundary
Basin Boundary
Water Level in M (bgl)
1 - 10
10 - 20
20 - 30
30 - 75
Walayar Sub Basin
Aliyar Sub Basin
Palar Sub Basin
Sholaiyar Sub Basin
63615
63624
HP2CBE28(A)
63450
63453
HP2CBE14(A)
HP2CBE07
63628
63627
63621
63622
63626
63623A
63742
HP1CBE03
HP2CBE27(A)
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HP2CBE23
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HP1CBE10
63710
HP1CBE11
HP2CBE36
63731
63727
HP2CBE25
63733
63711A
63726
63721
63715
63723
63809
63809 A
63714
63831
HP2CBE35
63722
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HP2CBE24(A)
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HP2CBE34
HP2CBE26
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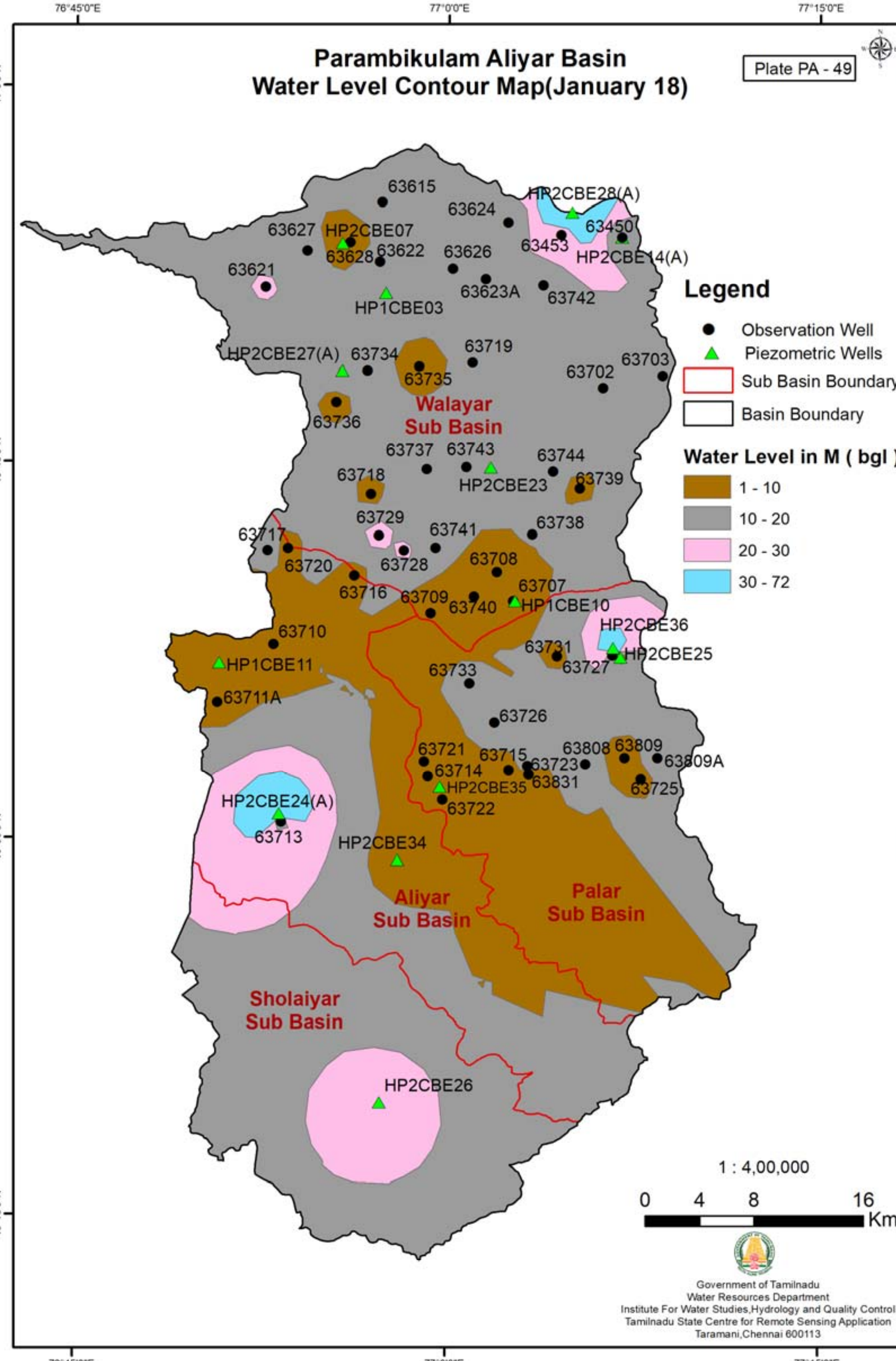
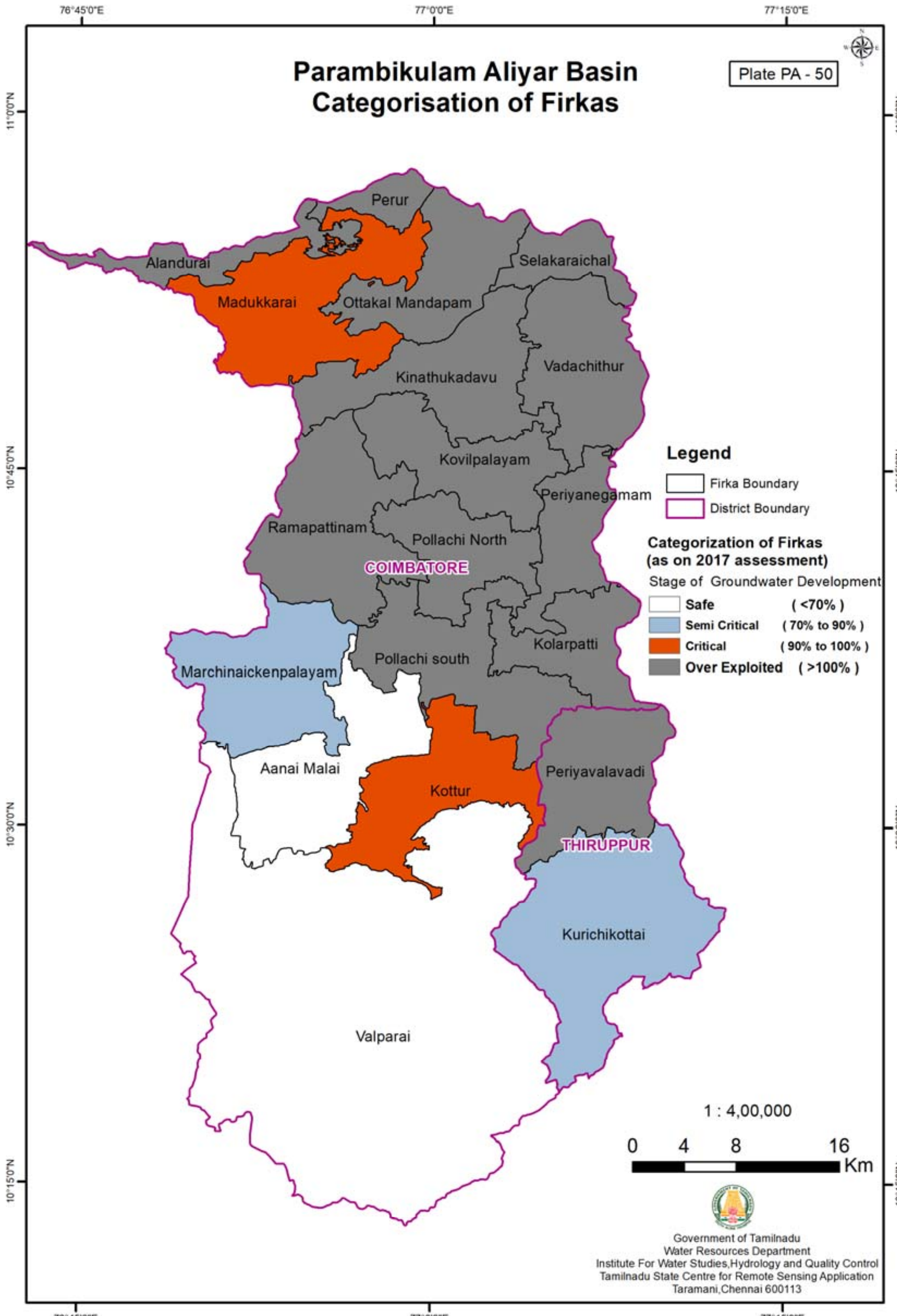
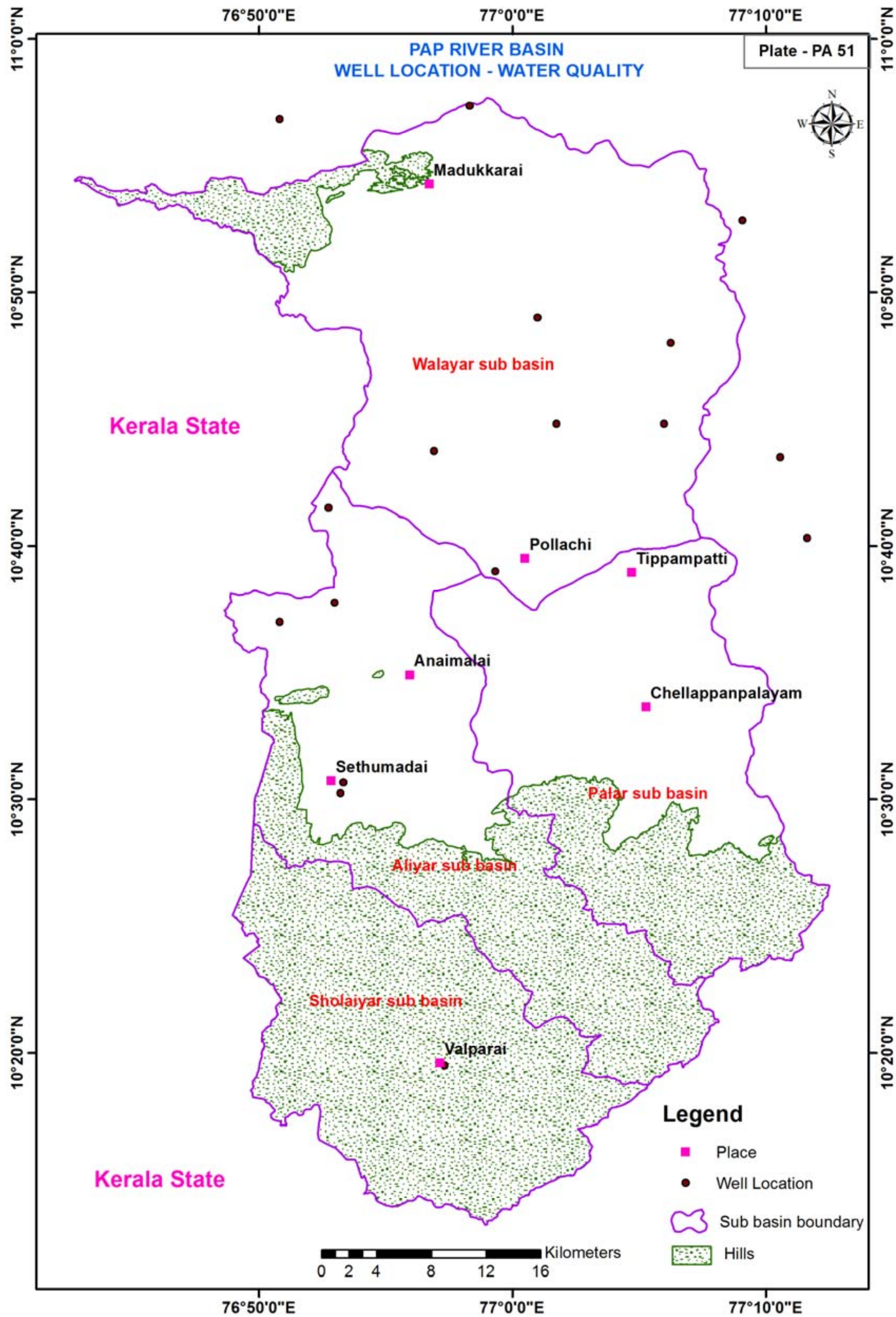
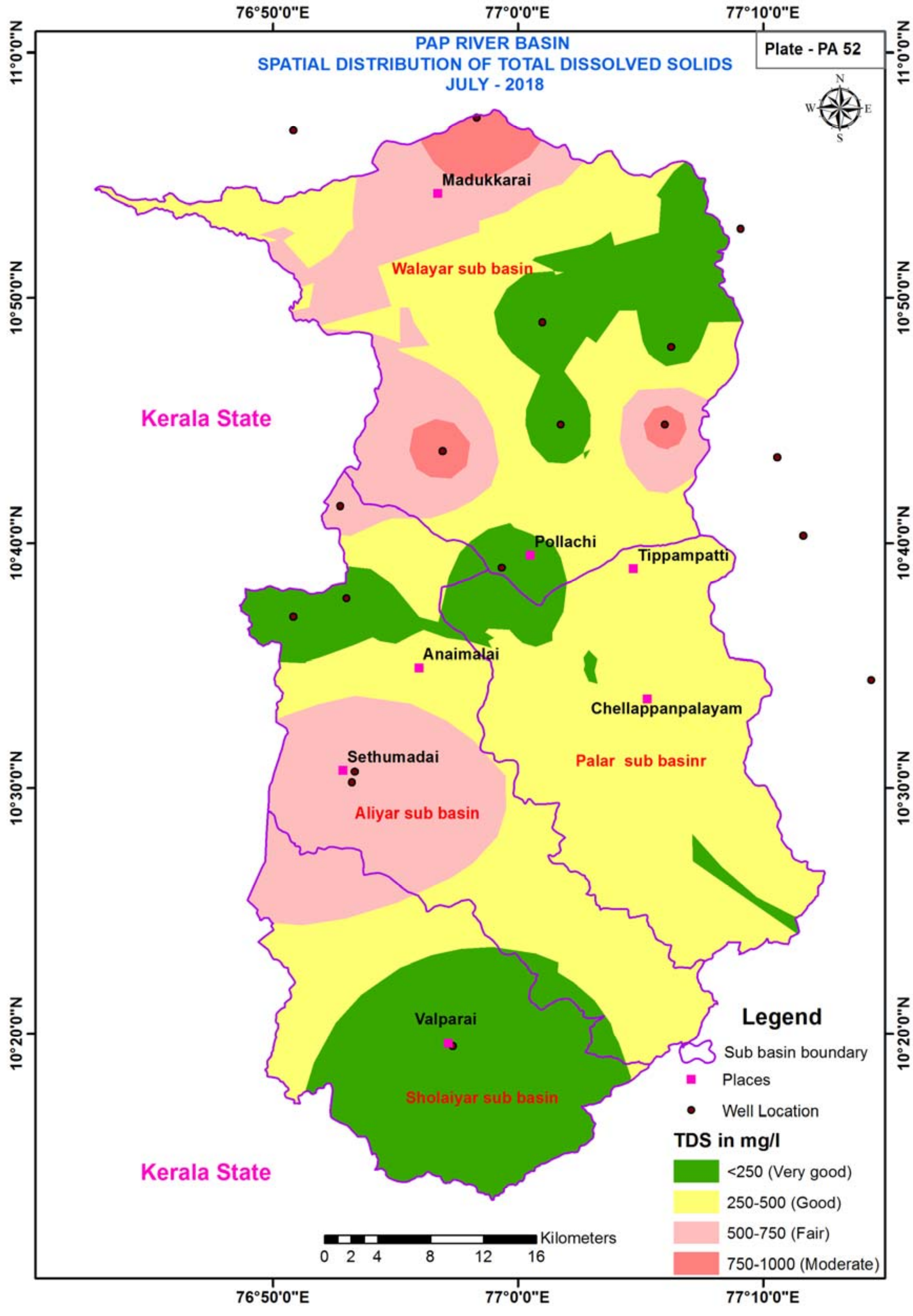


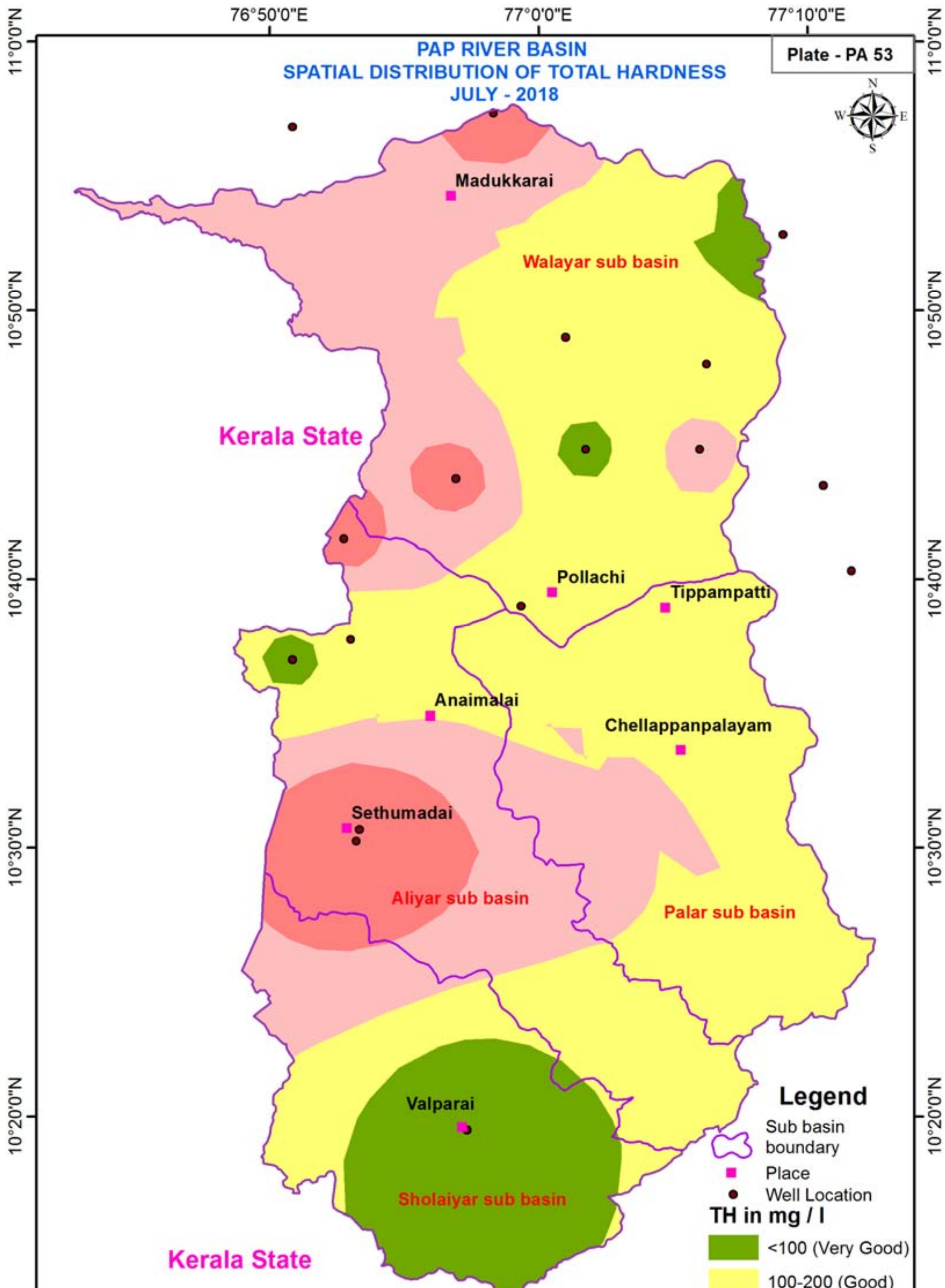
Parambikulam Aliyar Basin
Water Level Contour Map(January 18)
Plate PA - 49
Legend
Observation Well
Piezometric Wells
Sub Basin Boundary
Basin Boundary
Water Level in M (bgl)
1 - 10
10 - 20
20 - 30
30 - 72
Walayar Sub Basin
Aliyar Sub Basin
Palar Sub Basin
Sholaiyar Sub Basin
1 : 4,00,000
0 4 8 16 Km
76°45'0"E
77°0'0"E
77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113

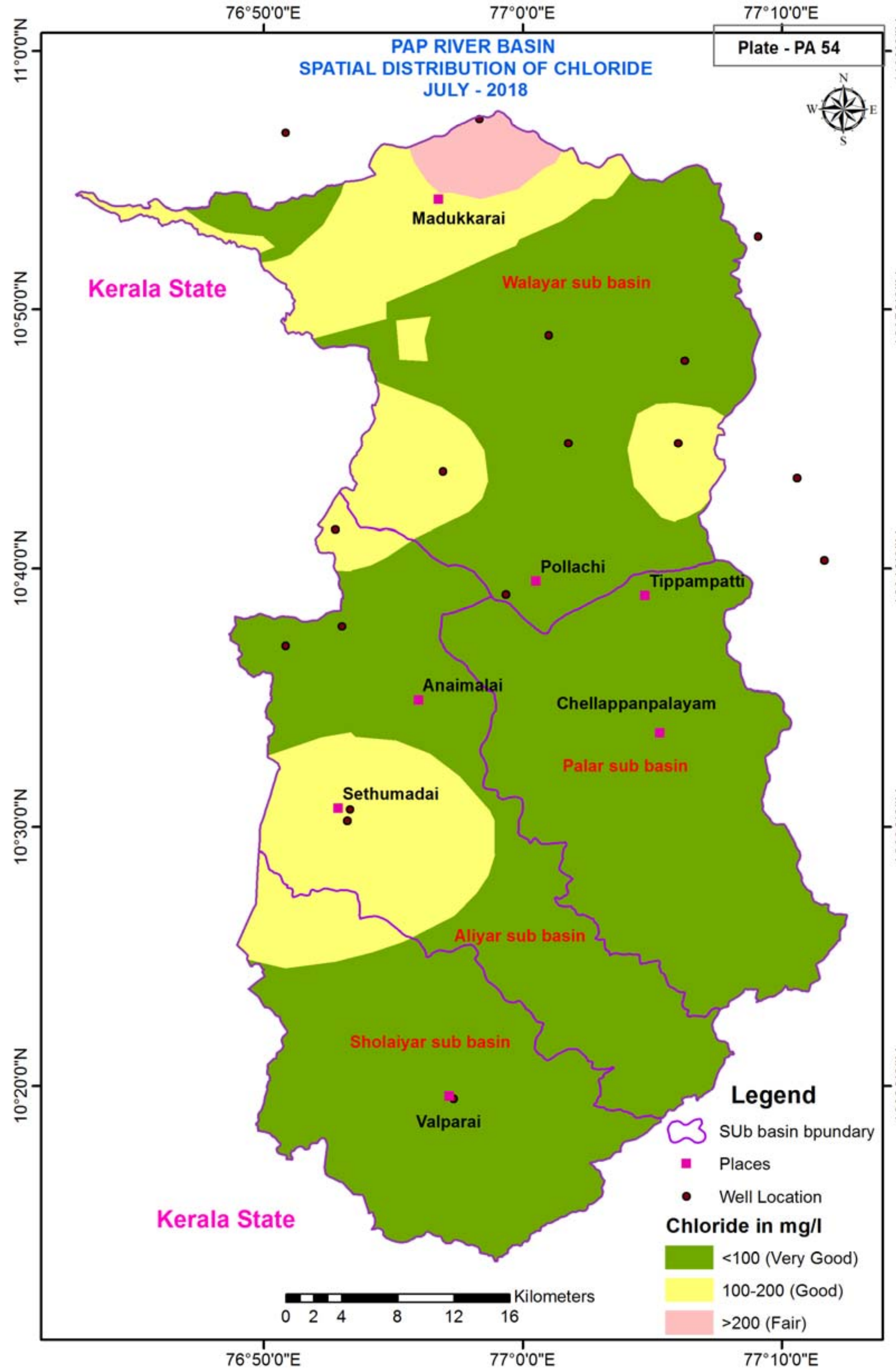

Parambikulam Aliyar Basin
Categorisation of Firkas
Plate PA - 50
76°45'0"E
77°0'0"E
77°15'0"E
11°0'0"N
10°45'0"N
10°30'0"N
10°15'0"N
Perur
Alandurai
Selakaraichal
Madukkarai
Ottakal Mandapam
Vadachithur
Kinathukadavu
Kovilpalayam
Periyanegamam
Ramapattinam
Pollachi North
COIMBATORE
Kolarpatti
Pollachi south
Marchinaickenpalayam
Aanai Malai
Kottur
Periyavalavadi
THIRUPPUR
Kurichikottai
Valparai
Legend
Firka Boundary
District Boundary
Categorization of Firkas
(as on 2017 assessment)
Stage of Groundwater Development
Safe (<70%)
Semi Critical (70% to 90%)
Critical (90% to 100%)
Over Exploited (>100%)
1 : 4,00,000
0 4 8 16
Km
Government of Tamilnadu
Water Resources Department
Institute For Water Studies,Hydrology and Quality Control
Tamilnadu State Centre for Remote Sensing Application
Taramani,Chennai 600113


PAP RIVER BASIN
WELL LOCATION - WATER QUALITY
Plate - PA 51
76°50'0"E
77°0'0"E
77°10'0"E
11°0'0"N
10°50'0"N
10°40'0"N
10°30'0"N
10°20'0"N
N
S
E
W
Madukkarai
Walayar sub basin
Kerala State
Pollachi
Tippampatti
Anaimalai
Chellappanpalayam
Sethumadai
Palar sub basin
Aliyar sub basin
Sholaiyar sub basin
Valparai
Kerala State
Legend
Place
Well Location
Sub basin boundary
Hills
Kilometers
0 2 4 8 12 16



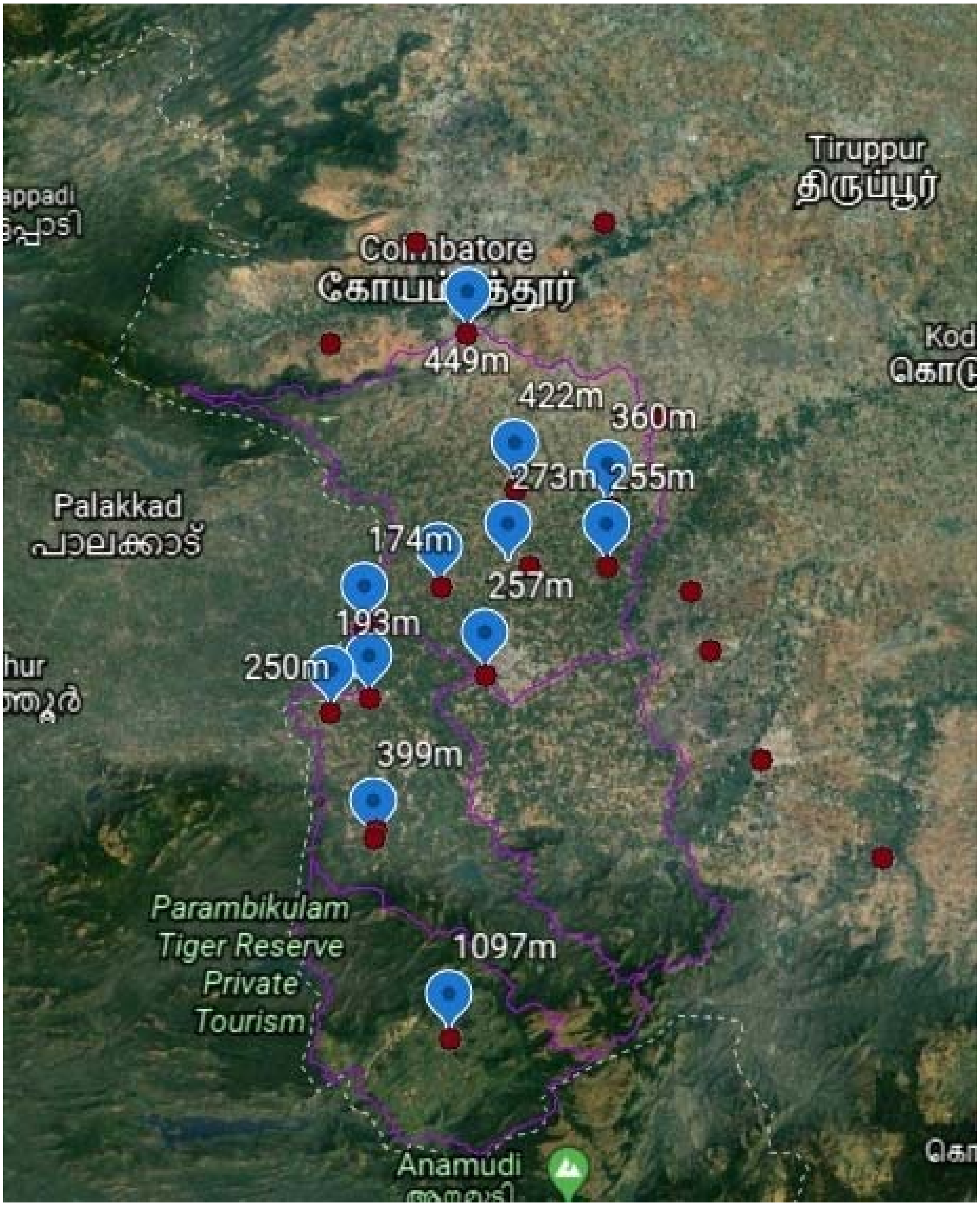
76°50'0"E
77°0'0"E
77°10'0"E
11°0'0"N
10°50'0"N
10°40'0"N
10°30'0"N
10°20'0"N
PAP RIVER BASIN
SPATIAL DISTRIBUTION OF TOTAL DISSOLVED SOLIDS
JULY - 2018
Plate - PA 52
N
E
S
W
Madukkarai
Walayar sub basin
Kerala State
Pollachi
Tippampatti
Anaimalai
Chellappanpalayam
Sethumadai
Palar sub basinr
Aliyar sub basin
Valparai
Sholaiyar sub basin
Kerala State
Legend
Sub basin boundary
Places
Well Location
TDS in mg/l
<250 (Very good)
250-500 (Good)
500-750 (Fair)
750-1000 (Moderate)
Kilometers
0 2 4 8 12 16


PAP RIVER BASIN
SPATIAL DISTRIBUTION OF TOTAL HARDNESS
JULY - 2018
Plate - PA 53
76°50'0"E
77°0'0"E
77°10'0"E
11°0'0"N
10°50'0"N
10°40'0"N
10°30'0"N
10°20'0"N
N
S
E
W
Madukkarai
Walayar sub basin
Kerala State
Pollachi
Tippampatti
Anaimalai
Chellappanpalayam
Sethumadai
Aliyar sub basin
Palar sub basin
Valparai
Sholaiyar sub basin
Kerala State
Legend
Sub basin boundary
Place
Well Location
TH in mg / l
<100 (Very Good)
100-200 (Good)
200-300 (Fair)
>300 (Moderate)
Kilometers
0 2 4 8 12 16



76°50'0"E
77°0'0"E
77°10'0"E
11°0'0"N
10°50'0"N
10°40'0"N
10°30'0"N
10°20'0"N
PAP RIVER BASIN
SPATIAL DISTRIBUTION OF CHLORIDE
JULY - 2018
Plate - PA 54
N
W
E
S
Madukkarai
Kerala State
Walayar sub basin
Pollachi
Tippampatti
Anaimalai
Chellappanpalayam
Palar sub basin
Sethumadai
Aliyar sub basin
Sholaiyar sub basin
Valparai
Kerala State
Legend
SUb basin bpundary
Places
Well Location
Chloride in mg/l
<100 (Very Good)
100-200 (Good)
>200 (Fair)
Kilometers
0 2 4 8 12 16

PAP RIVER BASIN (ALTITUDE OF THE WELLS)



CHAPTER-7

PRESENT AND FUTURE WATER DEMAND

CHAPTER -7

PRESENT AND FUTURE WATER DEMAND

7.1 Water use and Water demand

The term water use and water demand are often used interchangeably. However, these terms have different meanings.

7.1.1 Water Use

Water use is the amount of water used by a household or a country, or the amount used for a given task or for the production of a given quantity of some product or crop, or the amount allocated for a particular purpose.

7.1.2 Water Demand

Water demand is defined as the volume of water required for various sectors such as domestic, irrigation, industrial, livestock, aquaculture and power generation, etc.

The estimation of amount of water available and the water demand for various sectors within the basin helps in carrying out the water balance study for River Basin. In this chapter, the requirement of water for various sectoral uses such as domestic, irrigation, industrial, livestock, aquaculture & power generation in Parambikulam & Aliyar River Basin is estimated. Forecasting of the future water demand in all these sectors is also necessary to identify the options and strategies to mitigate future risks that might arise in water resource planning of river basin. Hence, the estimated water demand in various sectors of the Parambikulam & Aliyar River Basin is projected to the future years 2020, 2030, 2040 & 2050 in this Chapter.

7.1.3 Improvements suggested for bridging the gap between supply and demand

In order to bridge the gap in supply and demand, the following improvements can be made,

- Improving the supply system properly by removing the sedimentation.
- Maintaining the water supply system periodically to prevent leakage.
- Artificial recharge through construction of check dams, anicuts and recharge shafts.
- Construction of rain water harvesting structures for recharging the aquifer.
- Improving the irrigation efficiency by rehabilitation of irrigation structures.

- Adoption of modern techniques agricultural practices there by reducing Irrigation demand.
- Recycling of the waste water generated where ever possible.

7.2 Domestic Water Supply

The Tamil Nadu Water Supply and Drainage Board (TWAD) is implementing Water Supply Schemes in the Parambikulam & Aliyar River Basin. The combined water supply schemes (CWSS) provided by the TWAD Board for the Parambikulam & Aliyar River Basin is given below in **Table 7.1**. The TWAD Board is supplying 60.094 MLD of water in the Parambikulam & Aliyar River Basin.

Table 7.1 Water Supply Schemes by TWAD

Sl. No	District	Name of CWSS	Location	Type of Source	Designed Quantity in MLD
1	Coimbatore	CWSS to 3 TPs and 64 habs	Ambarampalayam	Surface	7.981
2	Coimbatore	CWSS to 295 Habs	Kulathur	Surface	19.41
3	Coimbatore	CWSS to Kurichi, Kuniya-muthur Mptly and Kinathu-kadavu T.P.	Athupollachi	Surface	8.840
4	Coimbatore	CWSS to Zamin Uthukuli Town Panchayat and 63 Rural Habitations in Pollachi North and Pollachi South Unions in Coimbatore District (Scheme is under Contractor's maintenance from 09.09.2016 for one year)	Ambrampalayam	River	2.453
5	Thirupur	CWSS to Kanakkam palayam and 144 habs	Dhali cannel	Thirumurthi dam	7.4
6	Thirupur	CWSS to Poolan-kinar and 38 habs	Dhali cannel	Thirumurthi dam	2.25
7	Thirupur	CWSS to Madathu kulam & 3 TPs & 112 habs	Dhali cannel	Thirumurthi dam	11.76
			Total		**60.094**

7.3 Domestic Water Demand

Domestic consumption of water per capita is the amount of water consumed per person. This is an indicator of the quantity of water required to individuals of different class of habitations for their basic needs.With the increase in economic and social development of the people the per capita requirement of domestic water may also increase.

The Central Public Health and Environmental Engineering Organization (CPHEEO) recommended norms for per capita water demand is given in **Table 7.2**

Table 7.2 Recommended Norms for Per Capita Water Supply by CPHEEO

Sl. No	Classification of towns/cities	Recommended maximum water supply levels (lpcd)
1	Towns provided with piped water supply but without sewerage system	70
2	Cities provided with piped water supply where sewerage system is existing/contemplated	135
3	Metropolitan and Mega cities provided with piped water supply where sewerage system is existing/contemplated	150

In the above norms, **an additional 15%** should be added in each classification to meet “Unaccounted for Water (UFW)”. The norms recommended by CPHEEO are adopted for estimating present and future domestic water demand.

The sub basin wise population of the River Basin as per census 2011 given in Chapter 2 of this report is used for calculating the domestic water requirement.

7.3.1 Future Domestic Water Demand

The domestic water requirement may increase in future with the increase in population, development in living standards of the people, etc. The annual growth rate of population is also determined in the chapter 2.10 and the projection of population in the river basin as given below

Population sector	Annual Growth Rates
Urban	0.04 % per year
Rural	0.02 % per year

Exponential growth formula is adopted for the population growth in the present study.

Projections may be made with reference to the recent observed trend in growth. Hence, for this present forecast the growth rate may be adopted as 1% for Rural population and Urban Population.

Exponential Growth Formula Method

The exponential growth formula is

$$\mathbf{P_t = P_o (1+X)^t}$$

Where P_t = Population after‘t’ years

P_o = Population in the beginning years

X = Annual growth rate

t = Period in years

Exponential interpolations of, possible changes in trends of growth rates resulting from economic or cultural development, or differences in observed growth rates between various sub-basins are taken into account in this method of population projection.

The population of Parambikulam & Aliyar River Basin arrived in Chapter 2 sub basin wise is projected for the present year 2019 and the target years 2020, 2030, 2040 & 2050. The sub-basin wise population projection for the Parambikulam & Aliyar River Basin for the present year 2019 and the target years 2020, 2030, 2040 & 2050 are arrived as **1.159 million, 1.170 million, 1.293 million, 1.428 million & 1.577 million** respectively and is given in **Table No. 7.3.**

Accordingly, the domestic water demand for the present year 2019 and the target years 2020, 2030, 2040 & 2050 are obtained as **52.69 Mcum, 53.22 Mcum, 58.78 Mucm, 64.93 Mcum & 71.727 Mcum** respectively and are given in **Table No.7.4.**

7.4 Irrigation Demand

Agriculture is the prime driving force for food security, rural economy and sustainable socio economic development of farmers.

Irrigation is a vital input for food production in the State of Tamilnadu. Medium and minor irrigation schemes are implemented in the State for augmenting the water required for Irrigation.

Irrigation water demand for 75% rainfall dependability of Parambikulam & Aliyar River Basin is tabulated in **Table 7.5** and the season wise Irrigation water demand (mcum) at 75 % rainfall dependability in Parambikulam & Aliyar River Basin is tabulated in **Table 7.6**

The major crops cultivated in Parambikulam & Aliyar River Basin are Paddy, Coconut, Fruits & Vegetables, Sugarcane, Ground nut, and Chillies. The irrigated area for the year 2019-2020 in Parambikulam & Aliyar River Basin under different crops was 71735 ha with Coconut as the main crop of the basin cultivated in 68620 ha.

7.5 Industrial Water Demand

The department of Industries and Commerce has classified the industries as large, medium and small scale industries. The list of small, medium and large scale industries in Coimbatore and Trippur districts along with their water requirement is collected from the Tamil Nadu Pollution Control Board. From that, small, medium and large scale industries falling in Parambikulam & Aliyar River Basin are listed out and given in appendix 7.1 to 7.6. At present in the Parambikulam & Aliyar River Basin there are **190 numbers of large and medium industries** and **906 numbers of small scale industries**. Accordingly, the yearly requirement of water for Large & Medium and small scale industries at present is estimated as **4.756 Mcum** &**1.834 Mcum** respectively.

7.5.1 Industrial water Demand Projection.

For forecasting the water demand of Industries for future years, a simple arithmetic increase of 8% per annum (as per the Annual Survey of Industries) over the present requirement has been adopted.

The Industrial Water Demand in Parambikulam & Aliyar River Basin for the year 2019 for the small scale industries is assessed as **1.834Mcum** and for the target years 2020, 2030, 2040 and 2050 also and is given in **Table 7.7 .**

The Industrial Water Demand in Parambikulam & Aliyar River Basin for the year 2018 for the Large & Medium scale industries is assessed as **4.756 Mcum** and for the target years 2020, 2030, 2040 and 2050 also and is given in **Table 7.8.**

Table 7.3 Sub basin wise Projected Population for Parambikulam & Aliyar River Basin
(Population in Million)

SI. No	Name of Sub basin	Population during 2019			Population during 2020			Population during 2030			Population during 2040			Population during 2050		
		Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
1	Walayar	0.256	0.478	0.733	0.258	0.482	0.740	0.285	0.533	0.818	0.315	0.589	0.903	0.348	0.650	0.998
2	Palar	0.122	0.040	0.162	0.124	0.040	0.164	0.137	0.045	0.181	0.151	0.049	0.200	0.167	0.055	0.221
3	Aliyar	0.076	0.089	0.165	0.077	0.090	0.166	0.085	0.099	0.184	0.093	0.109	0.203	0.103	0.121	0.224
4	Sholaiyar	0.016	0.082	0.099	0.017	0.083	0.100	0.018	0.092	0.110	0.020	0.101	0.122	0.022	0.112	0.134
	Total	**0.470**	**0.689**	**1.159**	**0.475**	**0.696**	**1.170**	**0.524**	**0.768**	**1.293**	**0.579**	**0.849**	**1.428**	**0.640**	**0.938**	**1.577**

Table 7.4 Sub basin wise Domestic Water Demand of Parambikulam and Aliyar River Basin
(Water Demand in Mcum`

Sl. No	Name of the Sub Basin	Water Demand 2019			Water Demand 2020			Water Demand 2030			Water Demand 2040			Water Demand 2050		
		Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
1	Walayar	7.46	27.02	**34.48**	7.54	27.29	**34.82**	8.33	30.14	**38.47**	9.20	33.30	**42.49**	10.16	36.78	**46.937**
2	Palar	3.57	2.27	**5.84**	3.61	2.29	**5.90**	3.99	2.53	**6.52**	4.40	2.79	**7.20**	4.86	3.09	**7.950**
3	Aliyar	2.21	5.02	**7.24**	2.24	5.07	**7.31**	2.47	5.60	**8.07**	2.73	6.19	**8.92**	3.01	6.84	**9.852**
4	Sholaiyar	0.48	4.66	**5.13**	0.48	4.70	**5.18**	0.53	5.19	**5.73**	0.59	5.74	**6.33**	0.65	6.34	**6.988**
Total		**13.73**	**38.96**	**52.69**	**13.86**	**39.35**	**53.22**	**15.31**	**43.47**	**58.78**	**16.92**	**48.02**	**64.93**	**18.69**	**53.04**	**71.727**

Table 7.5 Irrigation Water Demand (Mcum) At 75 % Rainfall Dependability

Sl.No	Sub Basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	Walayar	6.78	0.07	9.21	6.23	7.83	0.04	10.03	8.88	8.91	0.01	0.01	13.82	**71.81**
2	Palar	6.30	7.93	7.17	10.17	0.00	17.58	0.32	17.27	0.20	0.17	0.07	11.70	**78.88**
3	Aliyar	13.20	10.87	16.56	16.19	0.00	1.51	0.53	0.77	18.08	0.46	0.17	23.39	**101.74**
4	Sholaiyar	14.91	13.19	21.52	0.00	31.08	1.62	0.58	0.84	0.28	0.50	21.02	21.42	**126.96**
	TOTAL	41.20	32.06	54.46	32.59	38.91	20.76	11.46	27.75	27.47	1.14	21.26	70.34	**379.40**

(For Ultimate ayacut area of 88751 ha, irrigation demand is 469.40 Mcum.)

Table 7.6 Irrigation Water Demand (Mcum) At 75 % Rainfall Dependability in Parambikulam and Aliyar River Basin (Season Wise)

Sub basin	Winter	Summer	Southwest	Northeast	Total
Walayar	6.85	15.43	26.78	22.75	**71.81**
Palar	14.24	17.34	35.16	12.14	**78.88**
Aliyar	24.07	32.75	2.82	42.10	**101.74**
Sholaiyar	28.10	21.52	34.12	43.21	**126.96**
Total	73.26	87.05	98.88	120.20	**379.40**

Table 7.7 Water Demand of Small Scale Industries in Parambikulam & Aliyar River Basin

Sl.No	Name of the Sub Basin	2019		2020		2030		2040		2050	
		Number of Industries	Water Demand in Mcum	Number Of Industries	Water Demand in Mcum	Number Of Industries	Water Demand in Mcum	Number of Industries	Water Demand in Mcum	Number of Industries	Water Demand in Mcum
1	Walayar	734	1.377	793	1.487	1427	2.676	2568	4.818	4623	8.672
2	Palar	89	0.180	96	0.194	173	0.350	311	0.630	561	1.133
3	Aliyar	56	0.174	60	0.188	109	0.338	196	0.609	353	1.097
4	Sholaiyar	27	0.103	29	0.112	52	0.201	94	0.361	170	0.651
Total		**906**	**1.834**	**978**	**1.981**	**1761**	**3.566**	**3170**	**6.418**	**5706**	**11.552**

Table 7.8 Water Demand of Large & Medium Scale Industries in Parambikulam & Aliyar River Basin

Sl.No.	Name of the Sub Basin	2019		2020		2030		2040		2050	
		Number of Industries	Water Demand in Mcum	Number of Industries	Water Demand in Mcum	Number of Industries	Water Demand in Mcum	Number of Industries	Water Demand in Mcum	Number of Industries	Water Demand in Mcum
1	Walayar	158	2.993	171	3.232	307	5.818	553	10.472	995	18.849
2	Palar	14	0.866	15	0.935	27	1.684	49	3.031	88	5.455
3	Aliyar	13	0.885	14	0.956	25	1.721	45	3.097	82	5.575
4	Sholaiyar	5	0.012	5	0.013	10	0.024	17	0.043	31	0.078
Total		**190**	**4.756**	**205**	**5.137**	**369**	**9.246**	**665**	**16.643**	**1197**	**29.958**

Table 7.9 Total Industrial Water Demand In Parambikulam & Aliyar River Basin
(Water Demand in Mcum)

Sl.No.	Name of the Sub Basin	2019			2020			2030			2040			2050		
		L&MI	SSI	Total	L&MI	SSI	Total	L&MI	SSI	Total	L&MI	SSI	Total	L&MI	SSI	Total
1	Walayar	2.993	1.377	**4.369**	3.232	1.487	**4.719**	5.818	2.676	**8.494**	10.472	4.818	**15.289**	18.849	8.672	**27.521**
2	Palar	0.866	0.180	**1.046**	0.935	0.194	**1.130**	1.684	0.350	**2.034**	3.031	0.630	**3.660**	5.455	1.133	**6.589**
3	Aliyar	0.885	0.174	**1.059**	0.956	0.188	**1.144**	1.721	0.338	**2.059**	3.097	0.609	**3.706**	5.575	1.097	**6.672**
4	Sholaiyar	0.012	0.103	**0.116**	0.013	0.112	**0.125**	0.024	0.201	**0.225**	0.043	0.361	**0.405**	0.078	0.651	**0.729**
Total		**4.756**	**1.834**	**6.590**	**5.137**	**1.981**	**7.118**	**9.246**	**3.566**	**12.812**	**16.643**	**6.418**	**23.061**	**29.958**	**11.552**	**41.510**

7.6 Live stock Water Demand

Tamil Nadu has vast resource of livestock which play a vital role in improving the socio-economic conditions of rural masses. Livestock provides nutrient-rich food products such as milk, meat, egg, dung as organic manure and domestic fuel, hides and skin, and is a regular source of cash income for rural households. In the recent decade, demand for various livestock based products has increased significantly due to increase in per-capita income, urbanization and increased awareness about food nutrition. Also with the rapid increase in human population the demand for livestock based products also increases.

The 20th livestock census, collected from the Department of Animal Husbandry and Veterinary Services contains the District wise population of different categories of Livestock. The District wise livestock populations are distributed to the sub basins of Parambikulam & Aliyar River Basin. The livestock population details of each sub basins are given in **Appendix 7.1, 7.8 and 7.9**

The norms of the Indian Council of Agriculture and Research for the live stock per capita water requirement have been adopted in the estimation of livestock water demand and are given in **Table 7.10**

Table 7.10 Water Requirement for Live Stock

Sl. No.	Name	Standard Norms in lpcd
1	Cattle	110
2	Buffalo	150
3	Sheep	20
4	Goats	20
5	Horses & Ponies	150
6	Donkeys	40
7	Pigs	40
8	Dogs	15
9	Rabbits	0.35
10	Poultry	0.25

(Source: Indian council of Agriculture and Research)

Table 7.11 - Parambikulam Aliyar River Basin - Livestock Population

Sl.No	Name of the Sub Basin	Cattle	Buffaloes	Bovines	Sheep	Goat	Horses & Ponies	Donkeys	Pigs	Dogs	Rabbits	Backyard Poultry	Farm Poultry	Total
1	Walayar	74870	1035	56363	8484	42557	273	451	293	26438	87	107823	4668998	**4987672**
2	Palar	33000	1020	22464	4013	18491	41	18	686	13251	54	54824	1398019	**1545881**
3	Aliyar	26828	1843	21020	1661	15339	35	126	481	488	28	47597	454330	**569776**
4	Sholaiyar	1740	49	1740	110	233	0	1	174	174	28	7763	0	**12012**
TOTAL		**136438**	**3947**	**101587**	**14268**	**76620**	**349**	**596**	**1634**	**40351**	**197**	**218007**	**6521347**	**7115341**

Table 7.12 Parambikulam Aliyar Basin - Livestock Water Demand (Water Demand in Mcum)

Sl.No.	Name of the Sub Basin	Cattle	Buffaloes	Bovines	Sheep	Goat	Horses & Ponies	Donkeys	Pigs	Dogs	Rabbits	Backyard Poultry	Farm Poultry	TOTAL
		110	**150**	**110**	**20**	**20**	**150**	**40**	**40**	**15**	**0.35**	**0.25**	**0.25**	
1	Walayar	3.006	0.057	2.263	0.062	0.311	0.015	0.007	0.004	0.145	0.000	0.010	0.426	**6.305**
2	Palar	1.325	0.056	0.902	0.029	0.135	0.002	0.000	0.010	0.073	0.000	0.005	0.128	**2.665**
3	Aliyar	1.077	0.101	0.844	0.012	0.112	0.002	0.002	0.007	0.003	0.000	0.004	0.041	**2.205**
4	Sholaiyar	0.070	0.003	0.070	0.001	0.002	0.000	0.000	0.003	0.001	0.000	0.001	0.000	**0.149**
TOTAL WATER REQUIREMENT IN MCUM		**5.478**	**0.216**	**4.079**	**0.104**	**0.559**	**0.019**	**0.009**	**0.024**	**0.221**	**0.000**	**0.020**	**0.595**	**11.324**

From the 20th livestock census data the sub basin wise livestock population is arrived and the same is adopted for the present year 2019 in the **table 7.10** and same value is assumed for the target years 2020, 2030, 2040 & 2050 . The livestock water demand during 2019, is worked out as **11.324 Mcum** in the **table 7.11** and the same value is assumed for the years 2020, 2030, 2040 & 2050.

7.7 Total Water Demand

The total water demand of four sectors, i.e., Domestic, Irrigation, Livestock and Industries of Parambikulam & Aliyar River Basin for the present year 2019 and the projected target years 2020, 2030, 2040 & 2050 are worked out respectively and are given in **Table No.7.14**.

The Comparison between the Microlevel and Reappraisal study of Parambikulam & Aliyar River Basin carried out during 2006 and 2019 is presented in the T**able 7.13**

Table 7.13 Comparison between the reappraisal studies of Parambikulam & Aliyar River Basin carried out during 2006 and 2019

(Water Demand in Mcum)

SI.No	Water Demand	Year	
		2006	**2019**
1.	Domestic Demand	**28.077**	**52.69**
2.	Irrigation Demand	**629.83**	**379.40**
3.	Industrial Demand	**50.34**	**6.590**
4.	Livestock Demand	**14.670**	**11.324**
Total demand		**722.917**	**450.004**

The total water demand of our sectors, i.e., Domestic, Irrigation, Livestock, and Industries of Parambikulam & Aliyar River Basin for the present year 2019 was worked out as **450.004** Mcum. But the water demand in 2006 was 722.917Mcum. This shows that there is 37.75 % decrease in water demand within 13 years for the present year, when compared to the water demand during 2006.

Table 7.14 Sub Basin Wise Projected total Water Demand in Parambikulam & Aliyar River Basin (Water Demand in Mcum)

Sl. No	Name of the Sub Basin	2019					2020					2030				
		Domestic	Irrigation	livestock	Industries	Total	Domestic	Irrigation	livestock	Industries	Total	Domestic	Irrigation	livestock	Industries	Total
1	Walayar	34.48	71.81	6.305	4.37	**116.964**	34.82	71.810	6.305	4.719	**117.654**	38.47	71.810	6.305	8.49	**125.079**
2	Palar	5.84	78.88	2.665	1.05	**88.431**	5.9	78.880	2.665	1.13	**88.575**	6.52	78.880	2.665	2.03	**90.099**
3	Aliyar	7.24	101.74	2.205	1.06	**112.244**	7.31	101.740	2.205	1.144	**112.399**	8.07	101.740	2.205	2.06	**114.074**
4	Sholaiyar	5.13	126.96	0.149	0.12	**132.355**	5.18	126.960	0.149	0.125	**132.414**	5.73	126.960	0.149	0.23	**133.064**
Total		52.690	379.40	11.324	6.590	**449.994**	53.210	379.40	11.324	7.118	**451.042**	58.78	379.40	11.324	12.8	**462.306**

Sl. No	Name of the Sub Basin	2040					2050				
		Domestic	Irrigation	livestock	Industries	Total	Domestic	Irrigation	livestock	Industries	Total
1	Walayar	42.490	71.810	6.305	15.289	**135.894**	46.937	71.810	6.305	27.521	**152.573**
2	Palar	7.200	78.880	2.665	3.660	**92.405**	7.950	78.880	2.665	6.589	**96.084**
3	Aliyar	8.920	101.740	2.205	3.706	**116.571**	9.852	101.740	2.205	6.672	**120.469**
4	Sholaiyar	6.330	126.960	0.149	0.405	**133.844**	6.988	126.960	0.149	0.729	**134.826**
Total		64.93	379.40	11.324	23.061	**478.705**	71.73	379.40	11.324	41.51	**503.95**

CHAPTER – 8

WATER BALANCE

CHAPTER – 8

WATER BALANCE

The main aim of water resources planning in each river basin is to find out whether the availability of water in the basin is enough to meet out the demand. If the availability of water is less than the requirements, then suitable measures are to be taken for optimum utilisation. If the availability of water is more than the demand, suitable utilization of the excess water has to be planned either within the basin or the excess could be transferred to nearby deficit basins. Better water management is also necessary. Hence, water balance is a tool to utilize the water optimally in a river basin.

8.1 Water Potential of Parambikulam Aliyar river basin

Total water potential is the sum of surface water potential and ground water potential. In this PAP Basin inflow and outflow datas are incorporated for assessment of surface water potential.The surface water potential of Parambikulam Aliyar basin is estimated and is furnished in **Table 5.5 of Chapter 5** .The ground water availability of the basin is estimated as per GEC norms and is furnished in **Table 6.9 of Chapter 6.**The total water potential of Parambikulam Aliyar basin is 894.22 Mcum calculated as below:

Surface water potential assessed (Based on inflow and outflow datas)	=	769 .00 Mcum
Ground water availability	=	125.22 Mcum
Total Water Potential of the basin	=	894.22 Mcum

8.2 Water Demand of Parambikulam Aliyar river basin

Total water demand is the sum of the various sectoral demands such as Domestic demand, Irrigation demand, Livestock demand, Industrial demand, and Ecological demand. The various sectoral demands except Ecological demand are determined for the present study year and also projected for the years 2020,2030,2040 & 2050 and furnished in **Chapter 7**.The Irrigation demand is assessed in **Chapter 4**. In order to maintain the health and biodiversity of rivers, the Environmental Flow Requirement (EFR) is necessary. This is termed as Ecological demand. Hence in this assessment, provisions are given for ecological requirements at a rate of 0.05% of Surface Water Potential for 2019 and at 1% for 2020, 2030, 2040 and 2050. This is added to total water demand. The total water demand in Parambikulam Aliyar river basin for different years is tabulated in **Table 8.1**.

Table 8.1
Total Sectoral Water Demand in Parambikulam Aliyar Basin

Sl. No.	Type of Demand	Total Demand in Mcum				
		2019	2020	2030	2040	2050
1	Domestic	52.69	53.22	58.78	64.94	71.73
2	Irrigation (including losses)	783.90	783.90	783.90	783.90	783.90
3	Live Stock	11.32	11.32	11.32	11.32	11.32
4	Industries	6.59	7.12	12.81	23.06	41.51
5.	Ecological	3.85	7.69	7.69	7.69	7.69
	Total	858.35	863.25	874.50	890.91	916.15

8.3 Water Balance

Water Potential for the year 2019 = 894.22 Mcum

Water demand for the year 2019(75% dependability) = 858.35 Mcum

Water Balance = 35.87 Mcum

% Water Balance with respect to potential = 4.02 %

Parambikulam Aliyar basin as such shows a water balance by 35.87 Mcum(4.02 %) for the year 2019 at 75% dependability when considering the value of both surface water potential and ground water potential. But in practice, the Ground Water potential is tapped in deep aquifers and hence tapping the water from the aquifers is difficult. Therefore, the contribution from Ground water potential is very meager.

Water balance is determined for the years 2020, 2030, 2040 and 2050. In respect of the water potential demand is different for future years as population increases. Hence the water balance for the present and the future is carried out separately and tabulated in **Table 8.2**.

Table 8.2
Water Balancing for Parambikulam Aliyar River Basin
Water Potential, Demand and Deficit (Both long & short term)

Sector	2019	2020	2030	2040	2050
Total Water Potential in Mcum	894.22	894.22	894.22	894.22	894.22
Total Water Demand in Mcum	858.35	863.25	874.50	890.91	916.15
Total water balance in Mcum	35.87	30.97	19.72	3.31	-21.93
Percentage of water balance with respect to potential	4.02%	3.47%	2.21%	0.37%	-2.46%

From the table, it is observed that the Parambikulam Aliyar river basin for the year 2019 appears surplus by 4.02 % of total water potenial available in the basin.

8.4 Water Balance for Different scenarios:

The following different planning scenarios for Parambikulam Aliyar river basin are considered:

1) Existing scenario

The water balance in the above sections 8.1 and 8.2 has considered the surface water potential arrived due to rainfall alone. In this scenario, tanks in Parambikulam Aliyar river basin are assumed to attain its full capacity. Hence net capacity of tank is added to the surface water potential. To account for the losses a factor of 1.67 is used with the irrigation demand.

2) Improved agricultural methods

This scenario is based on the identification of changes in the present cropping or cultivation pattern, which would result in, some reasonable lower limit for the future demand of irrigation water in the basin.

Less water consuming Coconut variety and latest irrigation techniques may be considered for planning purpose.

8.5 Conclusion

Thus the Water Balance study of Parambikulam Aliyar river basin for the existing scenario for the current year shows that the irrigation demand value accounts for about 91% of the total water demand.

Steps may be taken to improve the use of ground water and also to reduce the losses by lining canals, proper maintenance of irrigation infrastructures, and adopting improved irrigation techniques. More artificial recharge structures based on scientific methods may be provided in suitable locations in the basin for improving the water potential.

For Irrigated Area 71,735 ha

Table 8.3

PARAMBIKULAM ALIYAR BASIN - Sub Basin wise water balance at 75% dependability (Existing scenario)

2019

Details of Water Potential and Demand		**Walayar**	**Palar**	**Aliyar**	**Sholaiyar**	**Total**
Water potential in Mcum	Surface water potential assessed from rainfall	17.00	17.00	39.00	696.00	769.00
	Ground water potential	10.47	15.27	33.98	65.50	125.22
	Total water potential	27.47	32.27	72.98	761.50	894.22
Water demand in Mcum	Domestic demand	34.48	5.84	7.23	5.14	52.69
	Irrigation demand	119.92	131.73	169.91	212.02	633.58
	Livestock demand	6.30	2.66	2.21	0.15	11.32
	Industrial demand	4.37	1.05	1.06	0.12	6.59
	Ecological demand	0.09	0.09	0.20	3.48	3.85
	Total water demand	165.16	141.37	180.60	220.91	708.03
Total water potential in Mcum	Total water potential after considering the reuse of waste water	**27.47**	**32.27**	**72.98**	**761.50**	**894.22**
Total Demand in Mcum	Total water demand	**165.16**	**141.37**	**180.60**	**220.91**	**708.03**
Water Balance in Mcum		**-137.69**	**-109.09**	**-107.61**	**540.59**	**186.19**
Percentage		**-501.25%**	**-338.03%**	**-147.45%**	**70.99%**	**20.82%**
Water Balance in Parambikulam Aliyar basin		=	**186.19**	**Mcum**		**20.82%**

Table 8.4

PARAMBIKULAM ALIYAR BASIN - Sub Basin wise water balance at 75% dependability (Existing scenario)

2020

Details of Water Potential and Demand		Walayar	Palar	Aliyar	Sholaiyar	Total
Water potential in Mcum	Surface water potential assessed from rainfall	17.00	17.00	39.00	696.00	769.00
	Ground water potential	10.47	15.27	33.98	65.50	125.22
	Total water potential	27.47	32.27	72.98	761.50	894.22
Water demand in Mcum	Domestic demand	34.83	5.90	7.31	5.18	53.22
	Irrigation demand	119.92	131.73	169.91	212.02	633.58
	Livestock demand	6.30	2.66	2.21	0.15	11.32
	Industrial demand	4.72	1.13	1.14	0.12	7.12
	Ecological demand	0.17	0.17	0.39	6.96	7.69
	Total water demand	165.95	141.59	180.96	224.44	712.93
Total water potential in Mcum	Total water potential after considering the reuse of waste water	**27.47**	**32.27**	**72.98**	**761.50**	**894.22**
Total Demand in Mcum	Total water demand	**165.95**	**141.59**	**180.96**	**224.44**	**712.93**
Water Balance in Mcum		**-138.48**	**-109.32**	**-107.97**	**537.06**	**181.29**
Percentage		**-504.10%**	**-338.74%**	**-147.94%**	**70.53%**	**20.27%**
Water Balance in Parambikulam Aliyar basin		=	**181.29**	**Mcum**		**20.27%**

Table 8.5

PARAMBIKULAM ALIYAR BASIN - Sub Basin wise water balance at 75% dependability (Existing scenario)

2030

Details of Water Potential and Demand		**Walayar**	**Palar**	**Aliyar**	**Sholaiyar**	**Total**
Water potential in Mcum	Surface water potential assessed from rainfall	17.00	17.00	39.00	696.00	769.00
	Ground water potential	10.47	15.27	33.98	65.50	125.22
	Total water potential	27.47	32.27	72.98	761.50	894.22
Water demand in Mcum	Domestic demand	38.47	6.52	8.07	5.72	58.78
	Irrigation demand	119.92	131.73	169.91	212.02	633.58
	Livestock demand	6.30	2.66	2.21	0.15	11.32
	Industrial demand	8.49	2.03	2.06	0.22	12.81
	Ecological demand	0.17	0.17	0.39	6.96	7.69
	Total water demand	173.36	143.12	182.63	225.08	724.19
Total water potential in Mcum	Total water potential after considering the reuse of waste water	**27.47**	**32.27**	**72.98**	**761.50**	**894.22**
Total Demand in Mcum	Total water demand	**173.36**	**143.12**	**182.63**	**225.08**	**724.19**
Water Balance in Mcum		**-145.89**	**-110.84**	**-109.65**	**536.42**	**170.03**
Percentage		**-531.10%**	**-343.46%**	**-150.24%**	**70.44%**	**19.01%**
Water Balance inParambikulam Aliyar basin		=	**170.03**	**Mcum**		**19.01%**

Table 8.6

PARAMBIKULAM ALIYAR BASIN - Sub Basin wise water balance at 75% dependa bility (Existing scenario)

2040

Details of Water Potential and Demand		Walayar	Palar	Aliyar	Sholaiyar	Total
Water potential in Mcum	Surface water potential assessed from rainfall	17.00	17.00	39.00	696.00	769.00
	Ground water potential	10.47	15.27	33.98	65.50	125.22
	Total water potential	27.47	32.27	72.98	761.50	894.22
Water demand in Mcum	Domestic demand	42.50	7.19	8.92	6.33	64.94
	Irrigation demand	119.92	131.73	169.91	212.02	633.58
	Livestock demand	6.30	2.66	2.21	0.15	11.32
	Industrial demand	15.29	3.66	3.71	0.40	23.06
	Ecological demand	0.17	0.17	0.39	6.96	7.69
	Total water demand	184.19	145.41	185.13	225.87	740.60
Total water potential in Mcum	Total water potential after considering the reuse of waste water	**27.47**	**32.27**	**72.98**	**761.50**	**894.22**
Total Demand in Mcum	Total water demand	**184.19**	**145.41**	**185.13**	**225.87**	**740.60**
Water Balance in Mcum		**-156.72**	**-113.14**	**-112.14**	**535.63**	**153.62**
Percentage		**-570.50%**	**-350.58%**	**-153.66%**	**70.34%**	**17.18%**
Water Balance in Parambikulam Aliyar basin		=	**153.62**	**Mcum**		**17.18%**

Table 8.7

PARAMBIKULAM ALIYAR BASIN - Sub Basin wise water balance at 75% dependability (Existing scenario)

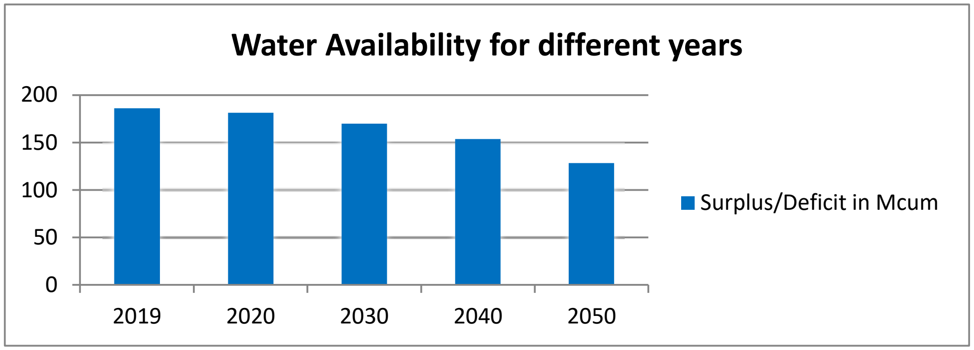
2050

Details of Water Potential and Demand		**Walayar**	**Palar**	**Aliyar**	**Sholaiyar**	**Total**
Water potential in Mcum	Surface water potential assessed from rainfall	17.00	17.00	39.00	696.00	769.00
	Ground water potential	10.47	15.27	33.98	65.50	125.22
	Total water potential	27.47	32.27	72.98	761.50	894.22
Water demand in Mcum	Domestic demand	46.94	7.95	9.85	6.99	71.73
	Irrigation demand	119.92	131.73	169.91	212.02	633.58
	Livestock demand	6.30	2.66	2.21	0.15	11.32
	Industrial demand	27.52	6.59	6.67	0.73	41.51
	Ecological demand	0.17	0.17	0.39	6.96	7.69
	Total water demand	200.86	149.10	189.02	226.85	765.84
Total water potential in Mcum	Total water potential after considering the reuse of waste water	**27.47**	**32.27**	**72.98**	**761.50**	**894.22**
Total Demand in Mcum	Total water demand	**200.86**	**149.10**	**189.02**	**226.85**	**765.84**
Water Balance in Mcum		**-173.39**	**-116.83**	**-116.04**	**534.65**	**128.38**
Percentage		**-631.19%**	**-362.00%**	**-159.00%**	**70.21%**	**14.36%**
Water Balance in Parambikulam Aliyar basin		=	**128.38**	**Mcum**		**14.36%**

Figure - 8.1

Parambikulam Aliyar river basin - Water availability forecast for future decades (Existing Scenario)

Sl.No.	Years	Surplus/Deficit in Mcum
1	2019	186
2	2020	181
3	2030	170
4	2040	154
5	2050	128



CHAPTER – 9

ENVIRONMENTAL ASPECTS

CHAPTER - 9
ENVIRONMENTAL ASPECTS

Introduction

The word Environment is derived from the French word “Environ” which means “surrounding”. Our surrounding includes biotic factors like human beings, plants, animals, microbes, etc and abiotic factors such as light, air, water, soil, etc. Environment is a complex of many variables, which surrounds man as well as the living organisms. It includes water, air and land and the interrelationships which exist among and between water, air and land and human beings and other living creatures such as plants, animals and micro organisms.

Environmental changes are based on factors like urbanization, population and economic growth, increase in energy consumption and agricultural intensification. The degradation has adverse impacts on human beings, plants, animals and micro-organisms.

Environmental pollution is one of the most serious problems facing humanity and other life forms on our planet today. Pollutants can be naturally occurring substances or energies, but they are considered contaminants when in excess of natural levels. Any use of natural resources at a rate higher than nature’s capacity to restore itself can result in pollution of air, water, and land.

This chapter deals with the environmental issues and remedial measures in Parambikulam Aliyar River Basin.

The major environmental issues dealt in this chapter are Pollution sources, Sedimentation, Water weeds, Encroachment, Catchment Area Treatment, Fisheries, Public Health, Solid Waste Management, Forest and Wild life, Tourism, Socio-economic aspects and Public Awareness & Participation.

9.1 Pollution Sources

The major sources of pollution are as follows.

1. Industries
2. Domestic
3. Agriculture

9.1.1 Industrial Pollution

Industrial activities cause series of problems relating to environmental pollution.

Industries are classified into three categories with respect to the pollution level. Highly polluting industries are categorized as **Red**, medium polluting industries are categorized as **Orange** and less polluting industries are categorized as **Green**.

Tamil Nadu Pollution Control Board (TNPCB) is the authority for monitoring the quality of effluents from the industries. Individual Treatment Plants are installed by the industries. For a cluster of Industries, Common Effluent Treatment plants are installed.

9.1.1.1 Industries in Parambikulam Aliyar River Basin

In Parambikulam Aliyar basin, the highly polluting, medium and less polluting industries are as shown in **Table 9.1.**

Table 9.1 Polluting Industries in Parambikulam Aliyar River Basin

Sl. No.	Name of sub basin	Highly polluting industries (Red)	Medium polluting industries (Orange)	Less polluting Industries (Green)
1	Walayar	12	5	3
2	Palar	1	0	1
3	Aliyar	8	1	0
4	Sholaiyar	0	0	1

(Source: Chapter 7)

The details of the large, medium & small scale industries in the basin along with the wastewater generated is given below in **Table 9.2 & Table 9.3**

Table 9.2 Waste Water generated in Large & Medium Industries in Mcum/ year

Sl. No.	Name of sub basin	Number of large & medium industries	Water demand in Mcum per year	Waste water generated in Mcum per year (80 % of water demand)
1	Walayar	158	2.993	2.394
2	Palar	14	0.866	0.693
3	Aliyar	13	0.885	0.708
4	Sholaiyar	5	0.012	0.010
Total		**190**	**4.756**	**3.805**

(Source: Chapter 7)

Table 9.3 Waste water generated in Small Scale industries in Mcum/ year

Sl. No.	Name of sub basin	Number of small scale industries	Water demand in Mcum per year	Waste water generated in Mcum per year (80 % of water demand)
1	Walayar	734	1.377	1.102
2	Palar	89	0.18	0.144
3	Aliyar	56	0.174	0.139
4	Sholaiyar	27	0.103	0.082
Total		**906**	**1.834**	**1.467**

(Source: Chapter-7)

Waste water from Large & medium Scale Industries = 3.805 Mcum per year

Waste water from Small Scale Industries = 1.467 Mcum per year

Total = 5.272 Mcum per year

9.1.1.2 Effects of Industrial Pollution

- Pollution by the industrial effluent is caused due to contamination by heavy metals, harmful chemicals and organic wastes. The water polluted for a long period causes serious impact on the health of our eco-system.
- Soil pollution due to the effluents of the industries is creating problems in agriculture, destroy local vegetation and affect the health of animals.
- Air pollution by the toxic gases affects the people in the area with deadly diseases like asthma, cancer etc.

9.1.1.3 General Mitigation measures

- Treated Effluents should be used in Industries for cooling process. The treated waste water of one industry may be used as input for cooling tower of other industries like Thermal plant, Pharmaceutical, petro chemical, Refineries, Fertilizer industries, and so on, so that the fresh water requirement for those industries getting reduced. The residue from the treatment plant may be utilized for manufacture of fertilizers.
- Agglomeration of industries shall be encouraged so that the by-product or waste of one industry may be a raw material for some other industries, which will lead

to reduction of natural water requirements.

- The proper choice of the process for treatment of the solid wastes as well as gaseous and liquid effluents before discharging to the environment has to be made.
- The selection of industrial site should be properly examined considering the climatic and topographical characteristics.

9.1.2 Domestic Sector

Small towns are discharging the sewage directly into the drains and streams nearby. Practically there is Zero discharge of domestic sewage in the case of villages. The agricultural drains and the raw sewage contain more Nitrogen, Potassium and Phosphate load that cause eutrophication, which in turn reduces the efficiency of the irrigation structures.

A detailed statement is furnished hereunder regarding the quantity of domestic effluent generated, assuming 80% of the per capita water supply. The generation of sewage in rural areas and urban areas in Parambikulam Aliyar River Basin which is assumed as 80% of water demand is shown in **Table 9.4 & Table 9.5.**

Table 9.4 Generation of Sewage in Rural Areas

Sl. No.	Name of the Sub basin	Projected Population in 2019 in million	Water Demand 2019 in Mcum	Volume of sewage generated in Mcum/ year (80% of Water Demand)
1.	Walayar	0.256	7.460	5.968
2 .	Palar	0.122	3.570	2.856
3 .	Aliyar	0.076	2.210	1.768
4	Sholaiyar	0.016	0.480	0.384
TOTAL		**0.470**	**13.720**	**10.976**

(Source: Chapter-7)

Table 9.5 Generation of Sewage in Urban Areas

Sl. No.	Name of the Sub basin	Projected Population in 2019 in million	Water Demand 2019 in Mcum	Volume of sewage generated in Mcum/ year (80% of Water Demand)
1.	Walayar	0.478	27.020	21.616
2 .	Palar	0.040	2.270	1.816
3 .	Aliyar	0.089	5.020	4.016
4	Sholaiyar	0.082	4.660	3.728
TOTAL		**0.689**	**38.970**	**31.176**

(Source: Chapter-7)

Sewage from Rural Areas = **10.976** Mcum per year

Sewage from Urban Areas = **31.176** Mcum per year

Total = **42.152** Mcum per year

Mitigation

- Awareness has to be created among the public to prevent pollution of water bodies.
- It is recommended to recycle / reuse of waste water in a phased manner to meet the growing demand.
- Public may be encouraged to reuse the treated water for different purposes like pisciculture, aquaculture, horticulture and irrigation.
- Sanitary facilities have to be provided at public places.

9.1.2.1 Waste Water Management

Sewage Treatment Process

Sewage treatment involves physical, chemical, and biological processes to remove physical, chemical and biological contaminants. The objective of the sewage treatment is to produce a disposable effluent without causing harm to the surrounding environment and prevent pollution.

In Parambikulam Aliyar River Basin, the sewage treatment plants have been implemented in Coimbatore and Tiruppur districts as part of an underground sewerage schemes and being executed by the Tamil Nadu Water Supply and Drainage Board.

The details of ongoing Sewerage Treatment Plants in Coimbatore and Tiruppur districts are given below in **Table 9.6**

Table 9.6 Sewage Treatment Plant in Coimbatore and Tiruppur Districts

<table>
<tr><th>Sl. No.</th><th>Name of the District</th><th>Name of the UGSS (Underground Sewerage System)</th><th>STP location</th><th>Technology</th><th>STP Capacity in MLD</th></tr>
<tr><td rowspan="3">1.</td><td rowspan="3">Coimbatore</td><td>Pollachi Municipality</td><td>Cattle market, Pollachi</td><td>Sequential Batch Reactor</td><td>11.25</td></tr>
<tr><td>Mettupalayam Municipality</td><td>Mettupalayam Municipality Composite yard, Chickadasampalayam Panchayat</td><td>Sequential Batch Reactor</td><td>8.65</td></tr>
<tr><td>Kurichi Kuniyamuthur areas of Coimbatore Corporation</td><td>Coimbatore corporation Composite dumping yard, Vellalore</td><td>Sequential Batch Reactor</td><td>30.53</td></tr>
<tr><td>2</td><td>Tiruppur</td><td>Udumalpet Municipality</td><td>Senjerimalai Road, Chinna veeram patti village</td><td>Activated Sludge Process (ASP)</td><td>7.81</td></tr>
</table>

(Source: TWAD, Chennai)

9.1.2.2 General Mitigation Measures

- A properly installed and maintained system for treating sewage will minimize the impact on ground water and surface water.
- It is recommended to recycle/ reuse waste water in a phased manner to meet the growing demand.
- For Non potable uses (Fire Fighting, Toilet Flushing etc) recycled waste water could be used and sanitary facilities have to be provided at public places.
- Awareness has to be created among the public to prevent open discharge of sewage into water bodies and to reuse the treated water effectively for different purposes like pisciculture, aquaculture, horticulture and irrigation.

9.1.3 Agricultural Pollution

Agricultural pollution refers to biotic and abiotic byproducts of farming practices that result in contamination or degradation of the environment and surrounding ecosystems, and/or cause injury to humans and their economic interests.

9.1.3.1 Causes of Agricultural pollution

Pesticides & fertilizers once sprayed do not disappear completely. Some of it mixes with the water and seeps into the ground. The rest of it is absorbed by the plant itself. As a result, the local streams that are supplied water from the ground become contaminated, as do the animals that consume these crops and plants.

9.1.3.2 Fertilizers and Pesticides Consumption in Parambikulam Aliyar River Basin

In Parambikulam Aliyar basin, the main elements of agricultural pollution are phosphates, nitrates, potassium etc. The year wise consumption of fertilizers and Pesticides in Parambikulam Aliyar River Basin is furnished in **Table 9.7 and 9.8**

Table 9.7 Consumption of Fertilizers in Parambikulam Aliyar River Basin

Year	N in MT	P in MT	K in MT	Total (NPK) in MT
2008-09	7942	3388	3078	**14408**
2009-10	10146	5048	3715	**18908**
2010-11	11269	5608	4105	**20982**
2011-12	9901	4567	3988	**18456**
2012-13	10817	4988	4743	**20548**
2013-14	10967	4891	4448	**20306**
2014-15	11134	4987	4397	**20519**
2015-16	12937	6126	4578	**23641**
2016-17	11785	5185	4525	**21495**
2017-18	12418	5448	4839	**22706**
Total	**109316**	**50236**	**42414**	**201966**

(Source: Joint Director of Agriculture, Coimbatore and Thiruppur)

Table 9.8 Consumption of Pesticides in Parambikulam Aliyar River Basin

Year	Liquid (litres)	Dust /Solid (kgs)
2008-09	40549	54596
2009-10	50918	56491
2010-11	48805	54652
2011-12	49928	59713
2012-13	54942	63064
2013-14	53963	64545
2014-15	55848	66290
2015-16	65735	71446
2016-17	59669	66349
2017-18	64160	72200
Total	**544517**	**629347**

(Source: Joint Director of Agriculture, Coimbatore and Thiruppur)

The consumption of fertilizers such as Nitrogen, phosphorus and Ammonia (in M.T) are presented as chart in **Fig 9.1** and the consumption of Pesticides in Liquid form(in litres) and Dust/Solid form (in Kgs) are depicted as chart in **Fig: 9.2**

Fig 9.1 Consumption of Fertilizers in Parambikulam Aliyar River Basin

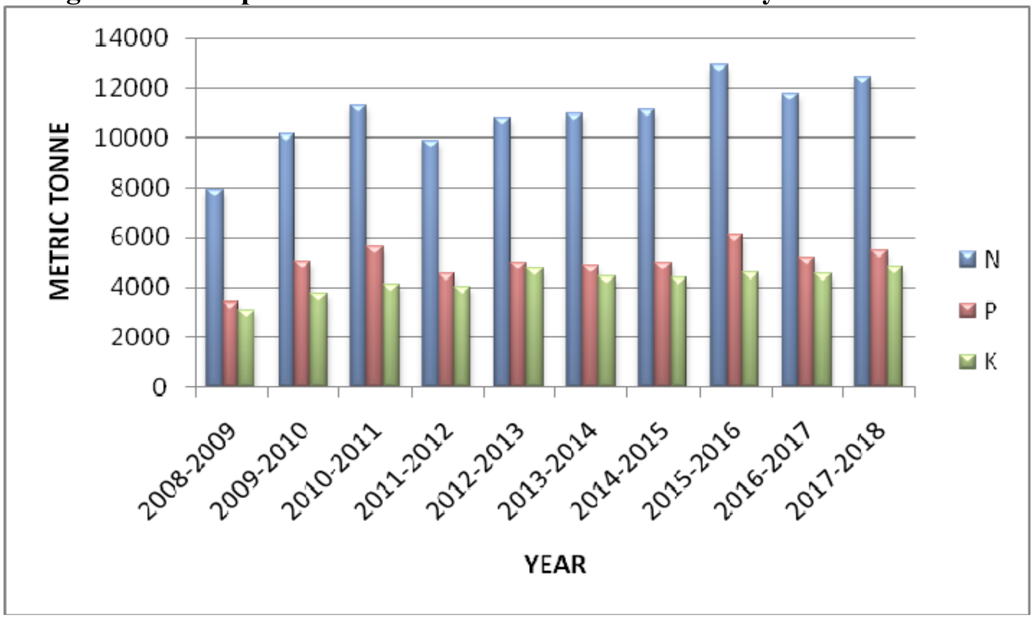
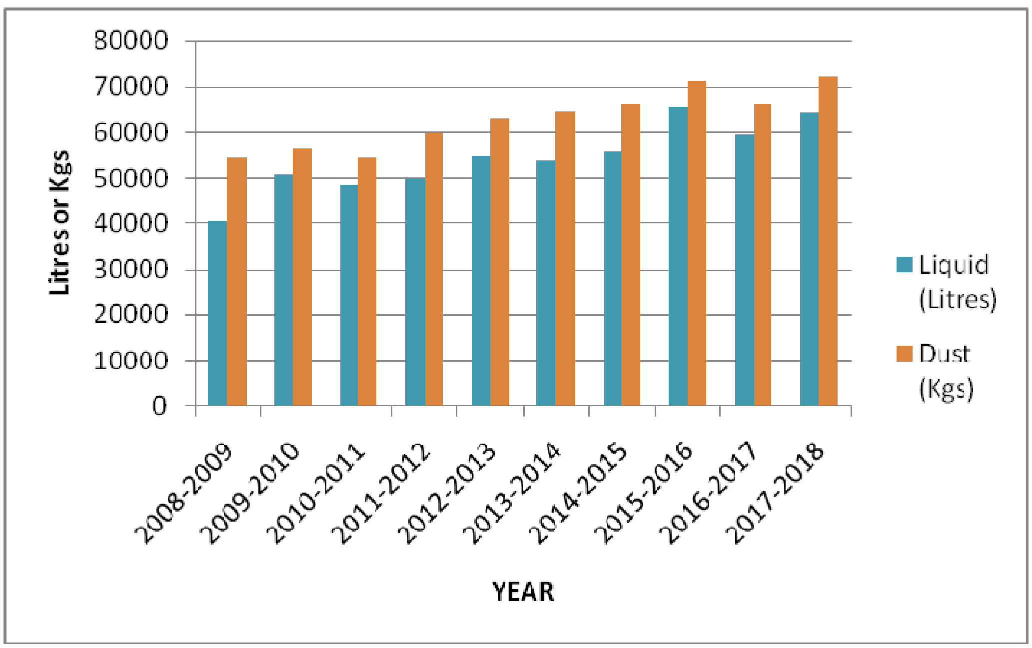


Fig 9.2 Consumption of Pesticides in Parambikulam Aliyar River Basin



From the above graphs, it is inferred that the consumption of nitrogen fertilizer was high during the year 2015-16 and subsequently reduced in the following year. The consumption of pesticides (in liquid form) was also high during the year 2015-16 and subsequently reduced in the following year.

9.1.3.3 Effects of Agricultural Pollution

- Agricultural Runoff- The excessive use of fertilizers and pesticides in agriculture pollute the land and water, both surface and groundwater. The salt content of the fertilizers is retained in the top soil and is carried away to the canal or river when water is drained.
- A portion of this salt content also permeates in to the sub-soil and reaches the groundwater making it more saline. Again when there is water logging problem, the groundwater is prone to become saline.
- Fertilizers, Manure, waste and ammonia turns into nitrate that reduces the amount of oxygen present in water which results in the death of many aquatic animals.
- Excessive rates of fertilizer application adversely affect the crop growth. High nitrate concentrations in drinking water causes Blue Baby syndrome which cause death in infants.

9.1.3.4 Mitigation measures

- Managing the correct disposal of animal wastes and keeping farm animals away from water will reduce the nitrogen pollution of the water.
- Educating farmers and agro industries about reducing the nutrient loads entering the water bodies by ensuring better management of household and live stock waste in the villages, crop nutrient management, planting of buffer strips and conservation tillage.
- Strengthening Environmental State policy, regulatory enforcement and institutional capacity against agricultural nutrient pollution and also encouraging organic farming.
- Usage of Bio pesticides and fungicides to control the pest and diseases has to be encouraged.
- Creating awareness among the farmers to follow integrated nutrient management and Integrated Pest management technologies.

9.1.3.5 Organic farming

Organic farming is a method of crop and livestock production that involves much more than choosing not to use pesticides, fertilizers, genetically modified organisms, antibiotics and growth hormones. The principal goal of organic production is to develop enterprises that are sustainable and harmonious with the environment.

9.1.3.6 Advantages of Organic Farming

- Organic manures produce optimal condition in the soil for high yields and good quality crops. They supply the entire nutrient required by the plant (NPK, secondary and micronutrients).
- They improve the soil's physical properties such as granulation and good tilt, good aeration, easy root penetration and improved water holding capacity and soil's chemical properties such as supply and retention of soil nutrient and promote favorable chemical reaction.
- Organically grown crop provide more healthy and nationally superior food for man and animals that those grown with commercial fertilizers and it helps to avoid chain reaction in the environment for chemical spray and dusts and prevent environment degradation.

9.2 Sedimentation

Sedimentation is generally generated by the disintegration of the earth's crust mainly by the action of temperature, running water, wind, ice, vegetation, landslides, etc.,. The process of sediment is unique to every reservoir. In general the coarser, heavier sediments, the gravel and sand, tend to settle out at the upper end of reservoir, forming a backwater delta which gradually advances towards the dam. The lighter sediments, the silt and clay tend to be deposited nearer the dam. The rate of reservoir sedimentation depends mainly on the size of reservoir relative to the amount of sediment flowing into it. Also the sediment flows vary widely both annually and seasonally over time. The amount of sediment carried into a reservoir is at its highest during floods. As the sediment accumulate in the reservoir, the dam gradually loses its ability to store water for the purposes for which it was built.

9.2.1 Reservoir Sedimentation Problems

The loss of storage capacity is the major problem. Other few important problems are listed below:

1. In a single purpose reservoir, the loss of storage capacity and thus the useful life and its service function.
2. In a multipurpose reservoir, the loss of storage allotted to each purpose by vertical zones and the necessity to correct it from time to time.
3. Loss of storage due to urbanization. A useful concept for recreation facilities to consider depth area-time relationship.
4. Rising of stream beds and increasing flood heights, meandering and overflow along the banks devastating the fertile lands, and choking up of irrigation and navigation canals.
5. Shoaling of the inlets and caves that are attractive for boat launching and docking. This area may become useless due to deposition of sediments or blocked by a bar formed by lateral transport by wave action or materials eroded from adjacent high banks.

The dams constructed in Parambikulam Aliyar basin are as follows:-

1. Parambikulam Reservoir
2. Thunakkadavu Dam
3. Sholaiyar Reservoir
4. Peruvari Pallam Reservoir
5. Aliyar Dam
6. Thirumurthy Dam
7. Kadamparai Dam

Among the above said dams, the sedimentation study was conducted by the Water Shed Management Division and the details are as follows in Table **9.9**

Table 9.9 Sedimentation Studies on Reservoir

S.No	Name of Reservoir	Original capacity in M.Cu.m	Present Capacity in M.Cu.m	Year of Survey	Capacity Loss in M.Cu.m	Capacity Loss in %	Average annual silt rate (M.Cum /Yr)
1	Parambikulam	504.66	442.29	2013	62.37	12.36%	1.3559
2	Thunakkadavu	15.76	13.15	2013	2.61	16.56%	0.0544
3	Sholaiyar	152.49	132.72	2015	19.77	12.96%	0.4493
4	Peruvari Pallam	17.56	15.01	2015	2.55	14.52%	0.0580
5	Aliyar	112.54	97.797	2017	14.957	13.27%	0.24
6	Thirumurthy	54.8	45.7466	2018	9.0534	16.52%	0.31
7	Kadamparai	30.85	29.55	2016	1.3	4.21%	0.0404

(Source: Chief Engineer, DR& CS, WRD, Chepauk, Chennai)

From the above table it is referred that in Thunakkadavu Dam, the loss in Capacity was found to be 16.56% which is more.

9.2.2 Impact of sedimentation

The environmental impact of sedimentation includes loss of important or sensitive aquatic habitat, decrease in fishery resources, loss of coral reef communities, human health concerns, changes in fish migration, loss of wetlands, changes in nutrient balance, increase in turbidity, loss of submerged vegetation, loss of recreation attributes and coastline alteration.

Considering the above facts, periodic capacity surveys and sedimentation studies are essential to assess the rate of siltation and the impact of sedimentation on the performance of the Reservoirs and tanks.

It is suggested to carry out sedimentation studies at least in the major tanks so as to assess the present storage capacity of the tanks for its efficient utilization.

9.2.3 Mitigation measures

- Operation of Reservoir may be arranged in such a way that more of suspended sediment water is withdrawn at appropriate time.
- Construction of dykes, check dams and detention basins may be formed in the main river and tributaries.
- Formation of Gullies control and stream bank protection measures may be adopted.

- Adoption of soil conservation measures by arresting soil erosion, agronomic and vegetative methods may be intensified.
- Watershed management including afforestation and the promotion of farming practices which reduce soil erosion is frequently advocated as the best way of controlling sediment deposition in reservoirs.
- Ensuring environmentally acceptable methods for the disposal of dredged sediments and ensuring use of sediments for enhancement where appropriate.
- To manage sediments supply at source by putting in places the best agricultural practice and techniques.

9.3 Water Weeds

Water weeds can be defined as unwanted and undesirable vegetation that are adapted to grow and reproduce under aquatic conditions. Weeds are one of the major threats to the natural environment. They are destroying native habitats, threatening native plants and animals and choking, natural systems including rivers and forests.

9.3.1 Types of Water weeds

Water weeds are broadly classified as Floating type, Submerged type and Emergent type.

1. Floating weeds – Weeds float in the surface of water and are not attached to the plant.
2. Submerged weeds – Weeds are rooted in the sediment and they usually grow entirely under the water.
3. Emergent weeds – Weeds are rooted in the lake bottom, but extended out of water.

9.3.2 Reasons for the abundance of waterweeds

- Eutrophication of riverine ecosystem due to and sewage drainage from agricultural fields and return flow.
- Lack of proper waterweed management plan.
- Lack of controlling measures of weed invasion.

9.3.3 Effect of Water Weeds

- Creates ideal situation for breeding of mosquitoes, responsible for the spread of Malaria, Yellow fever, river blindness and encephalitis.

- Provides shelter to predatory weed fishes and mollusks which play a crucial role in the life-cycle of blood and liver flukes (parasitic worms)
- Upsets the equilibrium of physico-chemical properties of water.
- Causes imbalance in the biological oxygen demand due to excessive organic loading.
- Displaces natural vegetation and destroys aquatic life.
- Affects the fish habitat in the water bodies.
- Increases emission of CO2 and CO into the atmosphere due to decomposition of huge volume of aquatic weeds creating foul smell that are unpleasant to public convenience.
- Organic matter content of water is increased which affects the strength of the concrete structures when used for curing and mixing.

9.3.4 Water weeds in Parambikulam Aliyar basin

Water weed problem is not seen in Parambikulam Aliyar basin.

9.4 Encroachment

Rivers, streams, supply channels and tanks are becoming the easiest pray for land grabbing for various uses across the basin. The encroachments shall be broadly categorized into two as public and private. The Farmers, general public and others do the private encroachments mostly for economical reasons such as cultivation, well digging, tree plantations, housing, dumping yards and cattle yards etc. Encroachments are done by different segments of the society varying from the landless, poor and the rich farmers.

The places and the nature of activity in the encroached areas are depicted in **Table 9.10.**

Table 9.10 Encroachment of Tanks

Sl No	Division	Name of the Tank	No. of tanks under the control of W.R.D	No. of tanks fully restored	No. of tanks under different stages of restoration				No. of tanks yet to be Surveyed
					Surveying	Eviction of encroachment (*)	Erecting boundary stones	Live fencing	
1	Thirumurthy division	Valayapalayam	1	1	-	-	-	-	-
2	Aliyar basin division	Kothavadi	1	1	-	-	-	-	-
		Devambadi	1	1					
3	Parambikulam division	Elavakkarai	1	-	1	-	1	Action is being taken for live fencing	-
		Kulappathu Kulam	1		1		1		
4	Sholaiyar division	Nill							

(*Source*: *SE, PWD/WRD, Parambikulam Aliyar basin Circle, Pollachi*)

9.4.1 Impact due to Encroachment

- The carrying capacity of the system is reduced due to the encroachment in riverbanks and channels. This results in serious problems of drainage systems during rainy season.
- Encroachment by house construction etc reduces the storage capacity of ponds, which in turn reduces the underground water levels and pollutes the water bodies.
- Reducing the flow-width of the river decreases the inflow of water resulting in reduced storage capacity, which leads to scarcity of water for agricultural and domestic purposes.
- The water holding capacity of rivers, ponds and channels gets decreased.
- The dumping of domestic wastes, kitchen wastes, garden wastes etc, into the ponds leads to decaying of organic matter, stagnation of water, egg laying mosquitoes and consequent health problems including water borne diseases.

9.4.2 Mitigation measures

- Periodic monitoring has to be done to avoid the encroachments.
- Awareness regarding the importance of the water bodies to the human livelihood is to be created among the public by encouraging and active participation of various Governmental and non- Governmental organization. Institutions, Forest department, Agriculture and Public representation are vital.
- Effective steps have to be taken by the Government at initial stage itself to prevent encroachments in water bodies. Implementation on Tamil Nadu Protection of tanks and Eviction of Encroachment Act No 8 of 2007 effectively at all levels.
- Construction of buildings near to water bodies should be avoided. Looking into the land requirements of marginalized people and house sites to be provided.

9.5 Sea Water Intrusion

Sea water intrusion is a major concern commonly found in coastal aquifers around the world. Sea water intrusion is the flow of sea water into freshwater aquifers primarily caused by over development of groundwater near the coast, where groundwater is being over exploited from aquifers that are having hydraulic connection with the sea. Generally, development of ground water for aquaculture, small scale industries and coastal resort makes impact on the coastal aquifer.

As there is no coastal area in Parambikulam Aliyar river basin, there is no possibility for sea water intrusion in this basin.

9.6 Salinity

Salinity is an important land degradation problem. The saline degradation is due to natural causes and poor irrigation, which disturb the water cycle. Expansion of canal irrigation is also responsible for widespread water logging and salinity problems. A continual supply of water in excess of that required by growing crop and without adequate drainage results in rising of the water table to levels from which salts can be drawn by capillary water movement and evapo-transpiration by crops. When the water dries up, the salts are left on the upper surface as a crust or layer.

Based on the analysis of water quality data in Parambikulam Aliyar river basin, all the water quality parameters are within the permissible limits. Hence water are used for both domestic and irrigation purposes. No salinity is observed in the basin.

9.7 Catchment Area Treatment

Catchment Area Treatment is the management technique to control erosion in the Catchment Area of Reservoir/tanks. The main aim of the catchment area treatment is to rejuvenate various potential and degraded ecosystems in the catchment area.

9.7.1. Objectives of Catchment area treatment

1. To facilitate the hydrological functioning of the catchment and to augment the quantity and improve quality of water of the river and its tributaries.
2. Conservation of soil cover and to arrest the soil erosion, floods and siltation of the river and its tributaries and consequent reduction of siltation in the reservoir.
3. Rehabilitation of degraded forest through afforestation. Ecosystem conservation resulting from increased vegetative cover and water retaining properties of soil.
4. Employment generation through community participation and conservation.

The study of erosion and sediment yield from catchment is of utmost importance as the deposition of sediment in reservoir reduces its capacity, thus affecting the water available for the designated use. The removal of top fertile soil from catchment adversely affects the agricultural production and silt laden water affect the turbine blades thereby affect the hydro power production.

Thus, a well-designed Catchment Area Treatment (CAT) Plan is essential to prevent the above process of soil erosion. The catchment area treatment involves the understanding of the erosion characteristics of the terrain and identifying / suggesting remedial measures to reduce the erosion rate.

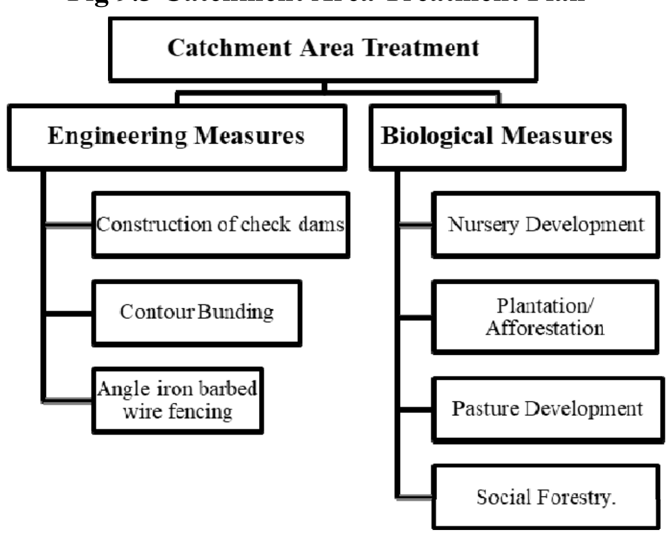
9.7.2 Catchment Area in Parambikulam Aliyar basin

The total area of PAP basin is 2406.38sq.km. Approximately One third of the basin area is covered with hills and dense forest cover. This basin is bounded in north and east by Cauvery basin, south and west by Kerala state. There is no Catchment area degradation in Parambikulam Aliyar basin. (S*ource: SE, PWD/WRD, Parambikulam Aliyar basin circle, Pollachi*)

9.7.3 Catchment Area Treatment Plan

The basis for formulating appropriate Catchment Area Treatment Plan depends upon the parameters of the watershed such as geology, geomorphology, topography, soil, land use/ land cover, climate, hydrology, drainage pattern, etc. Considering the topographic factors, soil type, climate, land-use/land-cover in the catchment area, the following Engineering and Biological measures may be undertaken with the aim to check soil erosion, prevent/check siltation of reservoir.

Fig 9.3 Catchment Area Treatment Plan



In addition, selection of Catchment Area Treatment Measures also depends upon the type of problem encountered as given in the **Table 9.11** below.

Table 9.11 Catchment Area Treatment measures

Sl. No.	Catchment Area Treatment Measures	Basis for selection
1.	Social forestry, fuel wood and fodder grass development	Near settlements and to control tree felling
2.	Contour Bunding	Control of soil erosion from agricultural fields
3.	Pasture Development	Open canopy, barren land, degraded surface
4.	Afforestation	Open canopy, degraded surface, high soil erosion, gentle to moderate slope
5.	Barbed wire fencing	In the vicinity of afforestation work to protect it from grazing etc.
6.	Step drain	To check soil erosion in small streams, steps with concrete base are prepared in sloped area where silt erosion in the stream and bank erosion is high due to turbidity of current.
7.	Nursery	Centrally located points for better supervision of proposed afforestation minimize cost of transportation of seedling and ensure better survival.

9.7.4 Mitigation Measures

The following mitigation measures can be adopted to control the catchment area degradation problem.

- Prevention of soil erosion by preserving the forest area and grasslands.
- Afforestation in the degraded forest areas.
- Construction of contour stonewalls (stone terracing) and bench terracing.
- Construction of gully plugging and temporary check dams.

9.8 Fisheries

Tamil Nadu is one of the leading States in India in fisheries development having a coastal length of 1076 km. There are 2500 species of fishes found in different aquatic environment. The fishery in the state is one of the vital sources for food security. Climate Change has affected inland and offshore fisheries.

9.8.1 Types of Fisheries Sector

The fisheries sector in Tamil Nadu can be broadly categorized as Inland fisheries, Marine fisheries and Aquaculture.

9.8.1.1 Inland Fisheries

Tamil Nadu ranks eighth in inland fisheries production in the country. It has 3.7 lakh hectare of water spread area, suitable for fish culture, comprising major reservoirs (52,000 ha.), Big/small Irrigation tanks (98000 ha.), small lakes and rural Fishery Demonstration tanks (158000 ha.) and Brackish water areas, swamps, estuaries (63,000 ha.) which are amenable to culture fisheries.

9.8.1.2 Marine Fisheries

TamilNadu is one of the leading States in marine fish production with a coastal length of 1076 km (13% of the country's coast line) and continental shelf of 41,412 sq.km. The State has marine fishermen population of 2 lakh who are actively engaged in fishing from 591 marine fishing hamlets scattered along the 13 coastal districts. TamilNadu contributes 10-12 % of the total marine fish production in India.

9.8.1.3 Coastal Aquaculture

Tamil Nadu is having the second longest coastline in the country with rich natural resources in coastal areas for coastal aqua farming. The total estimated brackish water area of Tamil Nadu is about 56,000 ha.

9.8.2. Details of Fisheries in Parambikulam Aliyar River Basin

Because of devoid of sea coast, Marine Fisheries and Coastal aquaculture does not exist. District wise details of Inland fisheries, Fishermen population and schemes implemented in the Parambikulam Aliyar river basin is given in **Tables 9.12, 9.13 and 9.14** respectively**.**

From the table, it is inferred that in Coimbatore district, the inland fish production has increased from the year 2008-2009 to 2012-2013and decreased from the year 2013-14 to 2016-17 and after which it started to increase again. In Tiruppur district, there is an increase from the year 2008-09 to 2011-12 and then decreased from the year 2012-13 to 2014-15 after which it started to increase again. The fishermen population has also increased in all the districts from the year 2008-09 to 2018-19.

Table 9.12 Year wise Inland Fish production (in Tonnes)

Sl.No	Districts	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
1	Coimbatore	150.750	156.000	163.250	170.165	180.000	172.350	177.182	147.741	148.185	206.000	208.650
2	Tiruppur	190.850	210.650	225.310	260.340	247.670	236.550	247.690	306.330	353.310	444.000	456.060

(Source: Fisheries Department, Chennai)

Table 9.13 Year wise Fishermen Population (in numbers)

Sl.No	Districts	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
1	Coimbatore	1500	1550	1565	1593	1660	1720	1850	1900	2000	2142	2175
2	Tiruppur	410	520	550	585	610	635	660	675	686	709	730

(Source: Fisheries Department, Chennai)

Table 9.14 Schemes implemented for Inland fisheries and aquaculture

Sl.no	Districts	Schemes implemented
1	Coimbatore	**1.NADP 2012-13** Giving 50% subsidy assistance for Expansion of fish culture area by encouraging farmers of Tamil Nadu. **2.NADP 2013-14** Giving 50% input subsidy assistance to 25 Multi Purpose farm pond beneficiaries (Area 225 sqm) subsidy Amt Rs.61,620/- **3.TN IAMWARM 2014-15 Establishment of Earthen Fish seed bank** Three fish seed bank established in Azhiyar Sub basin, Coimbatore district. Unit cost Rs.2.55 lakh. (with farm accessories Oxygen cylinder, Packing room, Fish seed and Fish Feed) **4.NFDB 2014-15** a. Giving 50% subsidy assistance for Establishment of 25 Nos.of Ornamental Hub for upliftment of Rural women.(Unit cost Rs.1.00 lakh) b.Fish seed stocking in panchayat tanks 2014-15 **5.NADP 2016-17** Stocking of grass carps in Aquatic weed infested water bodies of Tamil Nadu. 42500 Grass Carp seeds stocked in the four Aquatic weed infested water bodies of sulur block (85 Ha) in Coimbatore district. **6.Special Area Development Programme (2016-17 and 2017-18)** Giving 50% subsidy assistance for coracles and fishing nets and direct stocking of carp fish seeds in Karamadai and Anamalai Blocks Panchayat water. 50% subsidy amount for fishing implements of Rs.75000/- to 10 inland fishermen and 0.1875 lakh No. Of IMC Advance fingerlings stocked in inland water bodies. **7.Special Free Housing Scheme for Fishermen (IAY) Unit cost Rs.1.70 Lakh (2016-17)** PMAY House allotted to Six (6) Inland fishermen in Metupalayam block of Coimbatore district. **8. CSS 2016-17 Renovation of MNRGES Farm ponds with input subsidy.** Renovation of 1.0938 Ha. Multipurpose Farm pond by the Twenty two (22) beneficiaries with 1.5 mt depth. 50% Subsidy amount Rs.1.32253 lakh for construction and 50% Input Subsidy amount Rs.1.64070 lakh released to all beneficiaries. **9.Giving 50% subsidy assistance for Excavation of Multipurpose farm pond.(2017-18)** (Subsidy cost with input subsidy Rs.64250/- per unit) Construction of Multi-Purpose Farm ponds by the Eight (8) beneficiaries have been completed with the area of 2500sq.mt and

		1.5 mt depth. **10. CSS 2017-18 Pilot project on ornamental fisheries**. Giving 40% subsidy assistance to One Medium scale new ornamental unit. And 3 backyard new ornamental units. Given Capacity building training to 30 ornamental farmers by Ornamental pilot project 2017-18 with the cost of Rs.1.83 lakh **11.Ornamental Fisheries-Pilot project 2017-18** Establishment of One Aquarium Units in Schools with 100% subsidy **12. Giving 50% subsidy assistance for Coracles and Fishing nets Upgradation of Fishing efficiency 50% subsidy amount released.** Net subsidy Gill net-08 Nos – Subsidy amount Rs.0.48 lakh (2013-14) Net subsidy Gill net-42 Nos – Subsidy amount Rs.3.00 lakh (2014-15) Net subsidy Gill net-50 Nos – Subsidy amount Rs.3.6125 lakh (2015-16) Net subsidy Gill net-20 Nos – Subsidy amount Rs.2.00 lakh (2017-18) Coracle -20 Nos **13.40% Subsidy assistance to Fishing implements under National Agricultural Development Programme 2019-20** Net subsidy to 80 beneficiaries (Subsidy cost Rs.8000/beneficiary).40% subsidy assistance of coracle 25 units-(Unit cost Rs.15000/coracle) beneficiary contribution (Rs.7200/-) **14.General Activities** ❖ Reservoir fisheries (Pillur,Sholayar,Aliyar) ❖ Fish seed rearing units in Aliyar. ❖ DFFDA Activities ❖ Leasing fishing rights of PWD and Panchayat tanks to FCS members
2	Tiruppur	**1.NADP 2013-14** Giving 50% input subsidy assistance to Multi-Purpose farm pond beneficiaries (Area 225 sqm) Area covered 0.8550 ha. **2.CSS 2016-17 Giving 50% subsidy assistance to New Pond Construction and Renovation of existing fish pond** New farm construction -1.027 ha (Unit cost Rs.7.00 lakhs/ha.) Renovation of fish farm-0.42 ha (Unit cost Rs.3.50 lakhs/ha.) **3.CSS 2016-17 Giving 50% Subsidy assistance to Renovation of existing farm ponds** Renovation of 0.4776 Ha. Multipurpose farm pond by the Twenty two (09) beneficiaries with 1.5 mt depth **4.Upgradation of fishing efficiency** Net subsidy Gill net – 65 Nos (2014-15)

		Net subsidy Gill net – 56 Nos.,coracle 5Nos, (2015-16) Net subsidy Gill net – 20 Nos (2016-17) Net subsidy Gill net – 20 Nos and coracle 10 Nos (2017-18) 5.40% subsidy assistance to Fishing implements under National Agricultural Development Programme 2019-20 Net subsidy to 50% beneficiaries (Subsidy cost Rs.8000/beneficiary). 40% subsidy assistance of coracle 11 units-(Unit cost Rs.15000/Coracle) beneficiary contribution (Rs.7200/-) **6.Special Free Housing Scheme for Fishermen (IAY) Unit cost Rs.1.70 lakh (2016-17)** PMAY House allotted to Five (5) Inland fishermen in Tirupur district. **7.NADP 2016-17** Stocking of grass carps in Aquatic weed infested water bodies of Tamil Nadu. 164000 Grass carp seeds stocked in the Aquatic weed infested water bodies (328 Ha) in Tirupur district. **8.Giving 50% subsidy assistance for Excavation of Multipurpose farm pond (2017-18)** (Subsidy cost with input subsidy Rs.64250/-per unit) Construction of Multi-Purpose Farm ponds by the Eight (8) beneficiaries have been completed with the area of 2500 sq.mt. and 1.5 mt depth **9.CSS 2017-18 Pilot project on ornamental fisheries** Giving 40% subsidy assistance to One backyard new ornamental unit. **10.Ornamental Fisheries- Pilot project 2017-18** Establishment of Four Aquarium Units in Schools with 100% subsidy (Two Large aquarium tanks and Two small aquarium tanks) **11. NFDB** -Dharapuram Fish market. Project cost Rs.93 lakhs **12.General Activities** ❖ Reservoir Fisheries (Nallathangal odai,Amaravathi and Tirumoorthy) ❖ Fish seed rearing units in Amaravathi and Tirumoorthy. ❖ DFFDA Activities ❖ Leasing fishing rights of PWD and Panchayat tanks to FCS Members.

(Source: Fisheries Department, Chennai)

From the table **9.14**, it is inferred that various schemes implemented with subsidy for inland fisheries and aquaculture in the districts of Coimbatore and Tiruppur from the year 2012-18 was also contributed in the growth of Fish production.

9.8.3. Mitigation Measures

- Expansion in area of Fish culture through stocking of all culturable water bodies by leasing, licensing, share fishing and introduction of fish culture in Muliti Purpose farm ponds/water recharge ponds.
- Expansion by increasing stocking density & improving survival through improved aeration, supply of quality feed material, water quality management and disease prevention programme; Introduction of short seasonal fish varieties like Gift Tilapia, Amur carp, Pangasius and Jayanthi Rohu. Promoting ornamental Fish culture as a commercial activity.

9.9 Public health

Public health is the science and practice of protecting and improving the health of the community, as by preventive medicine, health education, control of communicable diseases, application of sanitary measures, and monitoring of environmental hazards.

In Tamil Nadu, Public Health tasks are undertaken by the Department of Public Health and Preventive Medicine. The activities undertaken by this department are provisions of primary health care, which includes Maternity and Child Health Services, Immunisation of children against vaccine preventable diseases, control of communicable diseases, control of malaria, japanese encephalitis, elimination of leprosy, controlling iodine deficiency disorder control programme, prevention of food adulteration, health checkup for school children, health education of the community and collection of vital statistics under birth and death registration system and environmental sanitation, prevention and control of waterborne diseases like Acute Diarrheal Diseases, Typhoid, Dysentry prevention and control of sexually transmitted diseases including HIV / AIDS. Primary Health Centres at the block level of each district is taking care of the health needs of the people.

The blockwise details of diseases prevailing in Parambikulam Aliyar river basin is depicted in **Table 9.15 to Table 9.19.**

Table 9.15 LEPTOSPIROSIS																									
SL.NO	**BLOCK**	**2008**		**2009**		**2010**		**2011**		**2012**		**2013**		**2014**		**2015**		**2016**		**2017**		**2018**		**2019**	
		C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**
1	THOONDAMUTHUR	0	0	0	0	0	0	2	Nil	0	Nil	0	Nil	3	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil
2	MADHUKARAI	0	0	0	0	0	0	2	Nil	0	Nil	0	Nil	2	Nil	0	Nil	0	Nil	0	Nil	0	Nil	2	Nil
3	SULTANPET	0	0	0	0	0	0	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil
4	KINATHUKIDAVU	0	0	0	0	0	0	2	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	1	Nil	1	Nil
5	POLLACHI NORTH	0	0	0	0	0	0	0	Nil	0	Nil	0	Nil	1	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil
6	POLLACHI SOUTH	0	0	0	0	0	0	0	Nil	0	Nil	6	Nil	2	Nil	0	Nil	0	Nil	0	Nil	2	Nil	2	Nil
7	ANAIMALAI	0	0	0	0	0	0	0	Nil	0	Nil	1	Nil	0	Nil	1	Nil	0	Nil	0	Nil	1	Nil	2	Nil
8	UDUMALAI	0	0	2	0	0	0	0	0	0	0	2	0	2	0	2	0	0	0	1	0	0	0	1	0
	TOTAL	**0**	**0**	**2**	**0**	**0**	**0**	**6**	**0**	**0**	**0**	**9**	**0**	**10**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**8**	**0**
(C- Case Reported, D- Deaths)																									

(Source: Public Health Department, Chennai).

Table 9.16 JAPANESE ENCEPHALITIS																									
SL.NO	**BLOCK**	**2008**		**2009**		**2010**		**2011**		**2012**		**2013**		**2014**		**2015**		**2016**		**2017**		**2018**		**2019**	
		C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**
1	THOONDAMUTHUR	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil
2	MADHUKARAI	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil
3	SULTANPET	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil
4	KINATHUKIDAVU	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil
5	POLLACHI NORTH	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil
6	POLLACHI SOUTH	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil
7	ANAIMALAI	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil
8	UDUMALAI	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	**0**	**Nil**	**0**	**Nil**	**0**	**Nil**	**0**	**Nil**	**0**	**Nil**	**1**	**Nil**	**0**	**Nil**	**0**	**Nil**	**0**	**Nil**	**0**	**Nil**	**0**	**Nil**	**0**	**Nil**
(C- Case Reported, D- Deaths)																									

(Source: Public Health Department, Chennai).

Table 9.17 CHIKUNGUNYA																									
SL.NO	**BLOCK**	**2008**		**2009**		**2010**		**2011**		**2012**		**2013**		**2014**		**2015**		**2016**		**2017**		**2018**		**2019**	
		C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**
1	THOONDAMUTHUR	0	0	0	0	0	0	0	0	13	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil
2	MADHUKARAI	0	0	0	0	0	0	0	0	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	5	Nil	2	Nil
3	SULTANPET	0	0	0	0	0	0	0	0	0	Nil	0	Nil	1	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil
4	KINATHUKIDAVU	0	0	0	0	0	0	0	0	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil
5	POLLACHI NORTH	0	0	0	0	0	0	0	0	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil
6	POLLACHI SOUTH	0	0	0	0	0	0	0	0	0	Nil	0	Nil	3	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil
7	ANAIMALAI	0	0	0	0	0	0	0	0	0	Nil	0	Nil	1	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil
8	UDUMALAI	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**13**	**0**	**0**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5**	**0**	**2**	**0**
(C- Case Reported, D- Deaths)																									

(Source: Public Health Department, Chennai).

Table 9.18 DENGUE																									
SL.NO	**BLOCK**	**2008**		**2009**		**2010**		**2011**		**2012**		**2013**		**2014**		**2015**		**2016**		**2017**		**2018**		**2019**	
		C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**
1	THOONDAMUTHUR	0	0	0	0	6	Nil	11	Nil	9	Nil	18	Nil	14	Nil	6	Nil	8	Nil	62	Nil	4	Nil	27	Nil
2	MADHUKARAI	0	0	0	0	15	Nil	13	Nil	31	Nil	33	Nil	14	Nil	10	Nil	20	Nil	55	Nil	20	Nil	32	Nil
3	SULTANPET	0	0	0	0	0	Nil	0	Nil	6	Nil	24	Nil	7	Nil	0	Nil	6	Nil	37	Nil	6	Nil	7	Nil
4	KINATHUKIDAVU	0	0	0	0	0	Nil	3	Nil	21	Nil	39	Nil	4	Nil	3	Nil	6	Nil	50	Nil	8	Nil	8	Nil
5	POLLACHI NORTH	0	0	0	0	1	Nil	6	Nil	21	Nil	39	Nil	10	Nil	4	Nil	4	Nil	73	Nil	4	Nil	6	Nil
6	POLLACHI SOUTH	0	0	0	0	1	Nil	1	Nil	17	Nil	46	Nil	6	Nil	9	Nil	10	Nil	107	Nil	12	Nil	14	Nil
7	ANAIMALAI	0	0	0	0	6	Nil	3	Nil	20	Nil	31	Nil	3	Nil	6	Nil	5	Nil	71	1	5	Nil	7	Nil
8	UDUMALAI	0	0	2	0	0	0	1	0	14	0	75	0	5	0	17	0	20	0	126	0	16	0	9	0
	TOTAL	**0**	**0**	**2**	**0**	**29**	**0**	**38**	**0**	**139**	**0**	**305**	**0**	**63**	**0**	**55**	**0**	**79**	**0**	**581**	**1**	**75**	**0**	**110**	**0**
(C- Case Reported, D- Deaths)																									

(Source: Public Health Department, Chennai).

Table 9.19 **MALARIA**																									
SL.NO	**BLOCK**	**2008**		**2009**		**2010**		**2011**		**2012**		**2013**		**2014**		**2015**		**2016**		**2017**		**2018**		**2019**	
		C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**
1	THOONDAMUTHUR	0	0	0	0	0	0	1	Nil	2	Nil	0	Nil	0	Nil	0	Nil	1	Nil	0	Nil	0	Nil	0	Nil
2	MADHUKARAI	0	0	0	0	0	0	2	Nil	1	Nil	1	Nil	3	Nil	0	Nil	3	Nil	0	Nil	0	Nil	3	Nil
3	SULTANPET	0	0	0	0	0	0	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	1	Nil	1	Nil
4	KINATHUKIDAVU	0	0	0	0	0	0	1	Nil	0	Nil	1	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil
5	POLLACHI NORTH	0	0	0	0	0	0	0	Nil	0	Nil	0	Nil	0	Nil	0	Nil	1	Nil	0	Nil	0	Nil	0	Nil
6	POLLACHI SOUTH	0	0	0	0	0	0	0	Nil	3	Nil	0	Nil	1	Nil	1	Nil	0	Nil	0	Nil	0	Nil	1	Nil
7	ANAIMALAI	0	0	0	0	0	0	0	Nil	0	Nil	0	Nil	0	Nil	1	Nil	1	Nil	0	Nil	1	Nil	0	Nil
8	UDUMALAI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**6**	**0**	**2**	**0**	**4**	**0**	**2**	**0**	**6**	**0**	**0**	**0**	**2**	**0**	**5**	**0**
(C- Case Reported, D- Deaths)																									

(Source: Public Health Department, Chennai).

9.9.1 Mitigation measures

- The domestic and Trade effluents have to be treated before letting into any sources after ascertaining the permissible limits.
- Immunization is a successful and cost-effective public health strategy that saves lives.Frequent surveillance should be carried out particularly during the rainy season to control the spread of diseases.
- The sewage and industrial effluents have to be treated properly to acceptable standards before letting into any sources.
- Payer pays policy (Make the industries pay taxes for the environmental harm).
- Rain water harvesting to reduce the dependency and overuse of the water bodies. Agriculture pollution due to agricultural run- off has to be analysed periodically.
- The drinking water should be consumed only after boiling or chlorination or by using any electrical purifier.
- Environmental awareness campaign to the general public is the most effective way in improving health and better life.
- Anti larval measures may be undertaken frequently by source reduction of vector breeding places like artificial containers such as broken utensils, discarded tyres, plastic waste cups and broken bottles for the control of Aedes mosquitoes which spread dengue fever.

9.10 Solid Waste Management

Solid waste is the unwanted or useless solid materials generated from combined residential, industrial and commercial activities in a given area.

9.10.1 Types and sources of solid waste:

Solid wastes are classified

- ✓ Based on their sources of origin (Residential wastes, Industrial wastes, Commercial wastes, Institutional wastes, Municipal wastes and Agricultural wastes).
- ✓ Based on physical nature (Garbage, Ashes, Combustible and non-Combustible wastes, Demolition & Construction wastes and Hazardous wastes).

Table 9.20 Classification of Solid waste sources

Source	Typical waste generators	Types of solid wastes
Residential	Single and multifamily dwellings	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ash, special wastes
Industrial	Light and heavy manufacturing fabrication, construction sites, power and chemical plants	Housekeeping wastes, packaging, food wastes, construction and demolition materials, ash, special
Commercial	Stores, hotels, restaurants, markets, office buildings	Paper, cardboard, plastics, wood, food, glass, metals, special and hazardous wastes
Institutional	Schools, hospitals, prisons, government centres	Same as commercial
Municipal services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and	Street sweepings, landscape and tree trimmings, general wastes from parks, beaches and other
Process (manufacturing etc.,)	Heavy and light manufacturing, refineries, chemical plants, power plants, power plants, mineral	Industrial process wastes, scrap materials, off-specification products, slay, tailings.
Agriculture	Crops, Orchards, Vineyards, dairies, feedlots,	Spoiled food wastes, agricultural wastes, hazardous
Construction and demolition	New construction sites, road repair, renovation sites, demolition of buildings	Wood, steel, concrete, dirt etc.,
Garbage (Biodegradable food waste)	Houses, Hotels, Dairies, meat stalls	Residual vegetable or animal waste
Ashes	Fire places, Kitchen of houses, hotels	Residues remaining after burning of wood, coal, coke
Combustible and non-Combustible wastes	House Holds, Hotels ,Offices, markets	Combustible solid waste as paper, cardboard, plastics, textile, rubber, leather, wood etc.,Non- combustible solid

9.10.2 Effects of Solid Waste

- Municipal solid wastes heap up on the roads due to improper disposal system. This type of dumping of allows biodegradable materials to decompose under uncontrolled and unhygienic conditions. This produces foul smell and breeds various types of insects and infectious organisms besides spoiling the aesthetics of the site.
- Industrial solid wastes are sources of toxic metals and hazardous wastes, which may spread on land and can cause changes in physicochemical and biological characteristics thereby affecting productivity of soils.
- Toxic substances may leach or percolate to contaminate the ground water. In refuse mixing, the hazardous wastes are mixed with garbage and other combustible wastes. This makes segregation and disposal all the more difficult and risky.

9.10.3 Solid Waste Management in Parambikulam Aliyar Basin

Solid waste management is the process of storage, collection, transportation and recycling, disposal and monitoring of solid waste in a systematic, economic and hygienic manner. In Parambikulam Aliyar river basin, the collection, transportation and disposal of solid wastes is done by the local bodies. The details of Solid Waste Management in Parambikulam Aliyar river basin is given in the **Table 9.21**.

9.10.3.1 Impact of solid waste to the Environment

- Groundwater and surface water pollution
- Reduction in Capacity of reservoir and tanks
- Health problems
- Odour and flies
- Reduction in carrying capacity of rivers, streams, canals and channels.

Table 9.21 Solid waste management for blocks covered in Coimbatore & Tiruppur District

District	BLOCK	Population in numbers	Generation of solid waste in Tonnes/day	Collection of solid waste in Tonnes/day	Segregation of solid waste in Tonnes/day	Disposal of solid waste per day in Tonnes	Disposal methods
Coimbatore	CCMC limits (100wards)	1600000	975	930	300	654	Windrow compositing , Vermi compositing and bio gas plant
Tiruppur	Udumalpet Municipality	61150	23	23	21	0.5	Wet wastes-converted into manure Dry wastes: 1. Recyclable materials sold to vendors 2. Non Recyclable materials send to cement factories

(Source:Coimbatore and Tiruppur Municipality)

9.10.4 Mitigation Measures

- Waste Minimization which includes reducing waste at source, reusing materials and recycling waste materials (3R).
- By Vermi composting and Indigenous composting method, the combustible solid waste can be made as Organic manure. This is one way of disposing the solid waste and due to this; the usage of chemical fertilizers also gets reduced.
- Proper waste disposal methods such as sanitary landfill, incineration, composting and pyrolysis.
- Selection of dumping sites far from residential areas.
- Reducing the usage of non-biodegradable materials such as plastic shopping bags.
- Integrated Solid Waste Management can be adopted to mitigate the effects of solid waste.
- Public awareness, effective community participation, transparent and clean administrations and accountability at all levels can only bridge the gap of governance in waste management and issues pertaining to successful management of waste.

9.11 Forest and Wild Life

Tamil Nadu has been a pioneer State in Protected Area management and development of forest resources and wildlife. The total area under the protected area management is 7,072.95sq.km which comes to 30.92% of the state's forest area.

The forest cover of the state as per 2017 assessment is 26,281sq.km which is 20.21% of the state geographical area. As per ISFR 2019 assessment, the forest cover is 26,364sq.km which is 20.27% of the state's geographical area. There is an increase of 83.02sq.km in the forest cover of the state as compared to 2017 assessment.

In order to cater to the needs of the booming population and rapid urbanization, the fertile swamps, marshes and many wetlands are being converted into agricultural lands and paddy fields the world over. In recent years, with the introduction of powerful dredging, draining and earthmoving machinery the conversion of wetland to farmland has become particularly profitable. The draining of wetlands not only eliminates wildlife and also lowers the water tables.

9.11.1 Forest and Wild life scenario in Parambikulam Aliyar basin

The forest area covered in Parambikulam Aliyar river basin is about 707.70 sq.km which accounts to 29.41% of the total basin area. The total area of PAP basin is 2406.38 sq.km. This is situated in Anamalais range amongst its flora and fauna and on the arid and semi arid plains of the southern taluks of Coimbatore District. All the rivers, which has its source in the Anamalai range, is served by the South-West Monsoon. The Major portion of the Dams and Tunnels are located in the scenic and scene surrounding of the Anamalai range and the reservoirs are located amongst picturesque and natural surroundings in the reserved forest areas and Tea Estates.

Parambikulam Aliyar river basin is the only basin in Tamilnadu having west flowing rivers. Among the west flowing rivers, the rivers Nirar, Anamaliyar, Sholayar, Parambikulam, Thunakadavu, and Peruvaripallam are in Anamalai Hills and the rivers Kummapatti Nadhi, Varattar, Koraiyar, Aliyar and Palar are flowing in plains. The Walayar Reservoir is located in the north west of the basin area.

Indira Gandhi Wildlife Sanctuary and National Park

The National Park is 108 sq.kms core area of the total 958 Sq. Kms sanctuary zone. Indira Gandhi Wild Life Sanctuary was declared a Project Tiger Zone in the year 2008. Elephants, Gaur, Tiger, Panther, Sloth Bear, Pangolin, Black Headed Oriole, Green Pigeon and Civet cat can be seen in this Sanctuary. Karian and Anaikunthi Sholas, Grass Hills, Waterfalls, Groves, Teak forests, Estates, Dams and Reservoirs add beauty to Anamalai Hills and attracts visitors in large numbers. Elephant Safari and Van services are available at the Top Slip to take the tourists around the Sanctuary. The sanctuary is shown in Fig **9.4**

Fig.**9.4 Indira Gandhi Wildlife Sanctuary**

9.12 Tourism

Tourism in India has shown a phenomenal growth in the past decade. India travel tourism has grown rapidly with a great influx of tourists from all across the globe who have been irresistibly attracted to the rich culture, heritage, and incredible natural beauty of India. The state has the largest tourism industry in India with an annual growth rate of 16%.Tamil Nadu ranks the First and the Second in terms of number of Domestic and Foreign tourists arrivals in 2018.

Tamil Nadu is a State with several distinguished tourism genre. It has cerulean mountains, verdant vegetations, sandy beaches, mammoth monuments, timeless temples, fabulous wildlife, scintillating sculptures and reverberating rural life. It has picturesque spots, continuing heritage, cultural confluence and aesthetic magnificence. Due to its abundant tourism potential, tourists from all over the country and abroad flock the tourist spots in the State throughout the year.

9.12.1. Sholayar Dam

Fig.**9.5 Sholayar Dam**

The Sholayar Dam is part of the Sholayar Hydroelectric Project (HEP). The project comprises the main Sholayar Dam, the Sholayar Flanking, and the Sholayar Saddle Dam. Upper Solaiyar or Upper Sholayar Dam is located 20 km (12 mi) from Valparai, a hill station in the Anaimalai Hills of the Coimbatore district, Tamil Nadu ,India. As it is a part of the hydroelectric project of Tamil Nadu, special permission is required to visit the dam.Valparai is located 64 km (40 mi) from Pollachi and 104 km (65 mi) from Chalakudy, Kerala. The nearest railway station is Pollachi. The Sholayar dam constructed (maximum height 345 ft) across the river Sholayar has a capacity of 5392M.cft. This is the highest Dam in Tamil Nadu. The reservoir's overflowing waters are let into the Parambikulam Reservoir through the saddle dam. It was constructed by a team working under K. Gopalswamy Mudhaliar, the most popular engineer in that area. The dam is shown in **Fig 9.5**.

9.12.2 Thirumoorthi Dam

It is a nice place for a one-day outing from Tiruppur. The drive is simply great with the whole route surrounded by sunflower gardens, coconut groves, and paddy fields. This Reservoir has been constructed across the River Palar which has its origins at the northern slopes of Anamalai Hills. The dam is shown in fig **9.6**.

Fig**.9.6 Thirumoorthi Dam**

Fig**.9.7 Aliyar Dam**

9.12.3 Aliyar Dam

Aliyar Dam is a charming location surrounded by Anaimalai Hills with wonderful natural views. It is located between Pollachi and Valparai.At a distance of 64 Kms from Coimbatore, 24 Kms from Pollachi & 545 Kms from Chennai. There is a well maintained park built at bottom of the Dam .The dam is shown in fig **9.7**.

9.12.4 Impacts of Tourism

The impact of tourism (positive and negative impacts) can be categorized into economic, socio-cultural and of environment. While the positive impact of tourism is mainly on economic aspect such as employment opportunities, growth in income, increase in foreign exchange, infrastructure and facilities development, it also includes the socio-cultural and environmental aspects such as preservation of heritage, culture, local customs and conservation of natural habitats.

The greater concerns for the negative impact of tourism include seasonal unemployment, shortage of facilities, increased crime and possible threats to natural resources.

9.12.5 Mitigation measures

The mitigation measures recommended to reduce the negative impact of tourism are as follows

- Putting increased focus on Eco-tourism ie. Tourism which is ecologically sustainable and encouraging, Green tourism ie. Responsible, sustainable and ethical tourism.
- Total ban on non-biodegradable products such as plastics have an enormous positive impact on the planet's environment.
- Utilization of revenue from parks and other tourist spots for the overall development and management of environmentally sensitive areas.
- Providing environmental information and raising awareness among tourists about the environmental consequences and their remedial actions.

9.13 Socio Economic Aspects

Socioeconomic refers to society related economic factors. These factors relate to and influence one another.

In Parambikulam Aliyar Basin, the total population is about 1.067 million (as projected to 2018) out of which Urban population is about 0.636 million and Rural population is about 0.431 million. Overall literacy rate of the basin is found to be 70.79%.

Agriculture is the major occupation of the people in this basin. In this basin coconut plantation is predominant followed by paddy, Blackgram, Groundnut, Cotton and sugarcane. The forest land is composed of deciduous forest, degraded forest, and forest plantation. Tea plantation is common in the hill top areas, slopes and valleys. The educational level of farmers are favourable to adopt modern water management practices, cropping pattern etc.

Fishing is another important source of livelihood in this basin and occupies a prime place in acceleration of socio-economic development in the basin.

Large, medium & small scale industries in this basin provide employment opportunity to the local people. There is a good scope for food processing and agro based industries. Participation of local people in planning, implementing and monitoring of these actions is decisive for sustainable outcomes.

9.13.1. Laws/Rules

With the institutional and governance issues getting greater importance in the policy discourse in recent years, the relevance of legal aspects, which are an integral part of the governance system, is also increasing in many fields. Understandably, one of these fields relates to water a resource the scarcity or mismanagement of which could be a major constraint for food security and economic development.

9.13.2 Conservation laws

The following are the constitutional provisions available for protecting the environment.

Article 48-A: The State shall endeavor to protect and improve the environment and to safe guard the forests and wildlife of the country.

Article 51-A (g): It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wild life and to have compassion for living creatures.

9.13.3 Acts related to Water Resources, Environment & Encroachment.

Some of the major Acts/rules is given below in the **Table 9.22**

Table 9.22 Name of Acts / Rules

Sl.No	Name of Acts / Rules
1	The Water (Prevention and Control of Pollution) Act,1974
2	The Environment (Protection) Act,1986
3	TamilNadu Land encroachment Act,1905
4	Tamil Nadu Protection of Tanks and Eviction of Encroachment Act,2007
5	Tamil Nadu Farmers' Management of Irrigation Systems - Act, (TNFMIS) ,2000
6	The Environment (Protection) Rules,1986
7	The Tamilnadu Water (Prevention and Control of Pollution) Rules,1983
8	Manufacture, Storage and Import of Hazardous Chemical Rules,1989
9	Solid Waste Management Rules,2016
10	E-Waste Management Rules,2016
11	Bio-Medical Waste Management Rules,2016
12	Hazardous and Other Waste (Management and Transboundary) Rules,2016
13	Plastic Waste Management Rules,2016

9.14 Public Awareness and Participation

There is an urgent need to safeguard the environment for the future generation. Environmental pollution and degradation cannot be prevented by laws alone. Public participation is equally important with regard to environmental protection. So to prevent further degradation of the environment, it is imperative to impart Environmental Education to the general public and initiate environmental protection awareness and participation through government and non-government agencies.

9.14.1 Environmental Awareness in Parambikulam Aliyar river basin

Environmental awareness can be created at this basin as follows.

- At primary & secondary schools and at colleges levels to impart elementary knowledge about environmental issues and problems, understanding of environmental problems, to develop skills to tackle the management problems of natural resources, for experimentation and solution to environmental problems and methods for conservation of natural resources.
- Through Adult Education to create a collective action in solving the environmental problems.
- Through Mass-Media which plays a vital role in creating awareness among public about environment and conservation of natural resources

Tamil Nadu Pollution Control Board, Public Health Department, Department of Environment and Forest and Municipalities of the districts falling in the basin are creating awareness among public and students about proper disposal of solid waste management, prevention of diseases etc.

Plastic Ban Awareness Programme

To make Tamil Nadu free from plastic pollution and ensure a better quality of life, on June 5th 2018 (World Environment Day), the Tamil Nadu government announced a ban on "one time use and throw away plastics" irrespective of thickness with effect from 01.01.2019 under the provisions of Environmental (Protection) Act vide G.O Ms (No) 84, Environment & Forest (EC.2) Department, dated: 25.06.18.

TNPCB has requested all the industries in Tamil Nadu, Plastic Manufacturers' Associations, Hotel Associations, textile and Rice Mill Associations, Kalyana mandapam Associations, CII, etc. to ban the one-time Use and Throwaway plastics in their premises and create awareness among the public and stakeholders about the ill-effects of plastics.

The Plastic ban awareness programme conducted by TNPCB at Coimbatore and Tiruppur districts is shown in **Fig 9.8 and 9.9** respectively.

Fig **9.8 TNPCB at Coimbatore – Meeting to ban Use & Throwaway plastics**

Fig **9.9 TNPCB at Tiruppur –Meeting to ban Use &Throwaway plastics**

Corona Virus Awareness Conference

Precaution and preventive measures on Corona Virus discussion meeting was held at Tiruppur on 05.03.2020 headed by the District Collector, Tiruppur. Conference on Corona Virus awareness was held at the Indian Medical Association auditorium, Coimbatore on 11.03.2020 headed by the District Collector, Dean, Govt.Medical College,Joint Director (Health and Rural Welfare), many Doctors and Rural workers were attended.

9.15 Summary

In Parambikulam Aliyar basin, effluent from large, medium & small scale industries and domestic sewage pollute the water bodies and also affect the public health. The consumption of fertilizers and pesticides is considerably getting increased every year which lead to agricultural pollution. The small and medium scales industries have been increased in this basin which should have proper treatment and disposal systems. Some of the most important general mitigation measures that can be adopted to reduce the environmental degradation in this basin are given below:

1. Agglomeration of industries shall be encouraged so that the by-product or waste of one industry may be a raw material for some other industries, which will lead to reduction of natural water requirements.
2. Usage of Bio pesticides and fungicides to control the pests and diseases will also minimize the pollution.

3. Introduction of fish culture in Multi Purpose farm ponds/water recharge ponds and promoting ornamental fish culture as a commercial activity.
4. Payer pays policy (Make the industries pay taxes for the environmental harm).
5. Organizing Environmental awareness campaign.
6. Waste Minimization which includes reducing waste at source, reusing materials and recycling waste materials (3R).
7. Proper waste disposal methods such as sanitary landfill, incineration, composting and pyrolysis.
8. Integrated Solid Waste Management can be adopted to mitigate the effects of solid waste.
9. Chemical fertilizers should be replaced with organic fertilizers in a phased manner.
10. Environmental management of facilities to tourism spots can boost the revenue to Government and increase the benefits by careful planning for controlled development.

By adopting suitable mitigation measures, environmental sustainability can be achieved.

CHAPTER – 10

PRESENT INSTITUTIONAL SETUP

CHAPTER - 10

PRESENT INSTITUTIONAL SETUP

Institutional arrangements are sets of working rules that are used to determine who is eligible to make decisions in some area, and what actions are allowed or constrained in management of water resources in a river basin. Suitable institutional arrangements are necessary to enable effective water management in River Basins.

10.1 Present Institutional Set Up

The various Departments / Institutions of the Government of Tamil Nadu / Government of India vested with water resources management are detailed as below;

10.1.1 Tamil Nadu Water Supply and Drainage Board (TWAD)

Tamil Nadu Water Supply and Drainage Board is responsible for implementation of Water Supply and Sewerage facilities to the public of the entire State of Tamil Nadu except for Chennai Metropolitan city. Parambikulam Aliyar River Basin falls under the jurisdiction of the Chief Engineer, TWAD Board, Coimbatore, Superintending Engineer, Erode, under the control of Engineering Director, Chennai implements the various schemes in Parambikulam Aliyar River Basin with the assistance of their Executive Engineers. Details of water supply schemes implemented in urban and rural areas of Parambikulam Aliyar River Basin are collected from the TWAD Board.

10.1.2 Tamil Nadu Pollution Control Board (TNPCB)

Tamil Nadu Pollution Control Board is functioning with the Chairman as its head, Member Secretary, 2 Additional Chief Environmental Engineers, 10 Joint Chief Environmental Engineers, 32 District Environmental Engineers and 2 Assistant Environmental Engineers. The Chief Environmental Engineers are implementing the Pollution Control Legislations and Rules and Notifications framed therein, collects and disseminates data relating to water, air and land pollution, lays down standards for sewage / trade effluent and emissions. This Board monitors the industrial effluents discharges into water bodies from pollution point of view. The Board has established 5 Advanced Environmental Laboratories, 10 District Environmental Laboratories to assist in the analytical and scientific side by experimental analysis and conducting research in abating pollutants. The District offices of Tamil Nadu Pollution Control Board functioning with the District Environmental Engineer as its head is located at Coimbatore (North), Coimbatore (South), Tiruppur (North), Tiruppur (south). The District Environmental Engineer monitors and controls the Industrial Pollution in Parambikulam Aliyar River Basin. The District Environmental Engineers handles the issues regarding pollution in the District, issue renew the consent to orange & green industries, renews consent to red small industries, issues show cause notice to the erring industries.etc.

List of industries, type of industries, water requirement, treatment method adopted and sewage effluent are collected from the TNPCB office. These details were used to arrive the industrial demand at present and in future.

10.1.3 Public Health and Preventive Medicines Department

This department takes care of preventive and control measures in the event of outbreak of epidemics, undertakes the testing of water samples, educate the public on water borne and water related diseases. This department is headed by a Director (Public Health & Preventive Medicines) at Chennai. The Deputy Director of Health services at Coimbatore and Tiruppur districts covers Parambikulam Aliyar River Basin area. The details of registered births and deaths in Districts falling under Parambikulam Aliyar River Basin as per the Statistical Handbook of Tamil Nadu 2019 are collected from the above department. These details are used to document the population dynamics in Parambikulam Aliyar River Basin.

10.1.4 Animal Husbandry & Veterinary Science Department

Animal Husbandry Department is headed and governed by the Director, Animal Husbandry & Veterinary Sciences, along with Additional Director at Chennai. The Regional Joint Director at Coimbatore and Tiruppur districts along with their Assistant Directors are responsible for all the activities of this Department in Parambikulam Aliyar River Basin. The Livestock sector provides livestock based food products such as milk, egg, meat, raw materials like wool for industries, manure etc., The Animal Husbandry Department provides comprehensive veterinary assistance and health cover to all livestock and poultry across the State of Tamil Nadu. With the implementation of cross breeding programme and various other schemes by the department, livestock farming has become economically viable and remunerative to large number of rural households.

The functions of department are as follows (i)Augmenting the production potentialities of livestock and poultry and thus increasing the production of milk, egg and meat (ii) Providing necessary and timely modern veterinary assistance and health cover to the livestock and poultry (iii) Implementing various central and state Government schemes for the upliftment of rural poor (iv)Providing information and training on basic and latest animal husbandry practices (v) Protecting human health by preventing major zoonatic diseases of animals.

The district wise of livestock census details in Parambikulam Aliyar River Basin were collected from the Animal Husbandry & Veterinary Sciences Department, Chennai. These details were used to arrive the Livestock Water demand at present and in future.

10.1.5 Water Resources Department (WRD)

The Water Resources Department is a part of the Public Works Department. The Water Resources Department is responsible for the maintenance & rehabilitation of all the Irrigation Structures and improving the irrigation infrastructure as well as monitoring floods. One of the main objectives of the Water Resources Department is to ensure effective management and distribution of surface and ground water to achieve optimum utilization in a rational and scientific way for maximizing the production and productivity of all the sectors requiring water in the State of Tamil Nadu.

10.1.6 Water Utilization Committee

The Government constituted Water Utilization Committee and Technical sub Committee to Water Utilization Committee in order to take final decision on the proposals seeking permission for surface/ ground water drawl, by various organizations / institutions. The various proposals seeking requisition for water drawl from surface / ground water are scrutinized based on the assessment of the available surface and ground water potential and existing scenario of water demand at which drawl is requested.

10.1.7 Participatory Irrigation Management (PIM) / Water User's Association

Under the Water Resources Consolidation Project & IAMWARM project, farmer's organizations are formed in the project implementation areas, to regulate the use of water among the various users, to manage the operation and maintenance of the irrigation systems. The farmer's organization comprises of Water User Association, Distributory Committee, Project Committee and Apex Committee with each having various functions.

Participatory Irrigation Management (PIM)

This Component aims to improve farmers (water users) involvement in management and operation of irrigation system. For this purpose, the project would work towards integrating Participatory Irrigation Management (PIM) practices into operations of the WRD. The sub component will assist in establishing and strengthening Water Users Associations (WUAs), including operationalizing WUAs to undertake operation and maintenance of field channels, and equitable water distribution within their command areas.

Water Users Associations are delineated based on the command area of the major / medium irrigation system. Water Users Association at the primary level consists of all the water users in such association area as members. A Water User Association can be called by its local distinct name. Every Water User Association shall be divided into Territorial Constituencies (TC) which should not be less than four and not greater than ten. A Territorial Constituency means a contiguous block of command area of one or more sluices under a Water Users Association area. There is a Management Committee for every Water User Association and a President of the Management Committee is elected by the members of the Water Users Association.

A competent authority, an officer of the Water Resources Department is appointed by the Government to Farmers organization to implement and execute the decisions taken by the farmer's organization. The farmer's organization shall extend its assistance and co-operation to the competent authority.

The farmer's organization may, for carrying out the purposes of this Act, and or achieving the objects of such organization and performing its functions, levy and collect such fees not exceeding five hundred rupees per hectare per year from every water user, as prescribed, from time to time. The other sources of funds to the farmers organization are grants received from Government as a share of water charges, Central / State Government fund for development of that area, resources raised from any financial agency for undertaking any economical development activities, income from properties and assets attached to the irrigation system as granted by the Government.

10.1.8 Functions of WUA

1. To prepare and implement an operational plan and a rotational water supply for each irrigation season. consistent with the operational plan, prepared by the distributor committee and the project committee and based upon the entitlement area soil and cropping pattern as approved by the managing committee or as the case may be of the project committee.

2. To prepare a plan for the maintenance of irrigation system in the area of its operation at the end of each crop season and carry out the maintenance works of both distributary system, water courses and field drains in its area of operation with the funds of the water users association from time to time.

3. To regulate the use of water among the various sluices under its area of operation according to the rotational water supply.

4. To assist the authorities of the revenue department of the government in the preparation of demand and collection of water charges.

5. To prepare and maintain an inventory of the irrigation system within the area of operation.

6. To resolve the disputes if any between the members of the water users association in its area of operation.

7. To conduct general body meeting in such a manner as may be prescribed.

8. To encourage avenue plantation on canal and tank poromboke and to protect and maintain such plantations.

9. To conduct regular water budgeting and also to conduct periodical social audit as may be prescribed.

10. To remove the encroachments on canal drains and tank poromboke in the area of jurisdiction of the water users association.

The sub-basin wise WUA details of Parambikulam Aliyar river basin is given below in **Table 10.1**

PARAMBIKULAM ALIYAR RIVER BASIN (WUA Details)

Table 10.1 WUA'S Details under IAMWARM & WRCP

SI. No.	**Name of Division**	**No. of WUA Formed**		
		UNDER IAMWARM	UNDER WRCP	TO BE FORMED
1	Walayar	-	-	-
2	Palar	1	112	1
3	Aliyar	5	38	1
4	Sholaiyar	**-**	**-**	**-**
	Total	**6**	**150**	**2**

Table 10.2 List of WUA's formed

SI. No.	Name of the sub basin	President -Details			TC Members -Details		
		Total	Elected as on Date	Balance left out	Total	Elected as on Date	Balance left out
1	Walayar	Tenure Completed. Election to be conducted					
2	Palar						
3	Aliyar						
4	Sholaiyar						

Table 10.3 Basin Management

(Main Activities and Agencies Responsible)

Activities in Basin	Agency Responsible	Key Functions
Providing drinking water and sanitation facilities	Tamil Nadu water supply and Drainage Borad	➢ Provides rural and urban water supply (except for Chennai city) also meeting the industrial water needs- Execution of sanitation schemes.
Pollution Prevention	Tamil Nadu Pollution Control Board	➢ Monitors the effluents released by industries. ➢ Accords permission for starting new industries from the environmental point of view.
Water Resources Management	Water Resources Department/PWD	➢ Planning, Designing and Execution of New Irrigation projects. ➢ Operation and maintenance of existing Irrigation systems.

Ground water level and quality monitoring	State Ground and Surface Water Resources Data Centre, WRD	➢ Installation & Maintenance of Observation wells and Piezometers. ➢ Collection and Testing of water samples from Observation wells and Piezometers. ➢ Construction of Artificial Recharge Structures. ➢ Observation, Documentation and Supply of Ground Water Data.
Surface water and hydrological data collection.	State Ground and Surface Water Resources Data Centre, WRD.	➢ Installation & Maintenance of Rain gauge Station, Climatic Stations, Automatic Weather stations and Gauge discharge station. ➢ Observation, Documentation and supply of Rainfall and Hydro meteorological data. ➢ Collection and Testing of water samples from rivers at selected locations.

CHAPTER – 11

CONCLUSION AND ACTION PLAN

CHAPTER – 11

CONCLUSION AND ACTION PLAN

11.1 Conclusion

11.1.1 Introduction and Methodology

River basins refer to the hydrological area draining through a system of streams and rivers to the same outlet. Basins are often recognized as the practical unit of water resources management.

The first National Water Policy summarizes the idea of River Basin Planning and Management as, "Water resources development and management will have to be planned for a hydrological unit such as drainage basin as a whole or for a sub-basin, multi-sectorally, taking into account surface and ground water for sustainable use, incorporating quantity and quality aspects as well as environmental considerations".

There are 34 river basins in Tamil Nadu consisting of major, medium and minor basins and they are grouped into 17 major river basins for the purpose of hydrological studies and water resources planning activities. These river basins are subdivided into 127 sub basins. Considering the developments in the river basins, basin studies are to be updated periodically and adopting new methodology and software. Micro level reappraisal studies for Kodaiyar, Vaigai, Vaippar, Vellar, Tamiraparani, Palar, Pennaiyar, Paravanar Varahanadhi and Pambar Kottakkaraiyar river basins were completed. Now, the micro level reappraisal study of Parambikulam Aliyar basin has been carried out, for which, earlier study was carried out during 2005- 2006. River basin planning and management is a process of assessing the limited water resource availability in the basin and equitable distribution to meet the competing demands of various sectors.

The general methodology adopted for this reappraisal study includes the data collection, sorting and validation of those data used for the study.

The following are the earlier studies that had been carried out in Parambikulam and Aliyar river basin:

- Parambikulam –Aliyar project- a brochure Government of Tamil Nadu 1988.
- A brief note on Parambikulam–Aliyar Project Complex, September,1988 (IWS-Library Book No.B/260 dated 27.11.1989).
- Crop water requirement and Scheduling Irrigation for crops in Tamilnadu state IMTI Report, Thuvakudi, Trichi – 620 015 (Publication No.2)
- Discussion papers – Meeting of Environmental of Parambikulam and Aliyar river basin - Institute for Water Studies, Chennai-113 - July 1995.
- State Framework Water Resources Plan for PAP basin

- A brief Note on Parambikulam Aliyar Project Complex
- Microlevel Environmental Status report on Parambikulam Aliyar River Basin (Plan Formulation Report)

11.1.2 Description of the Basin

The Parambikulam Aliyar Project Area is considered as “River basin " since the area falling under this scheme is surrounded by ridges / water divide, and the rivers draining in this basin are west flowing, hence cannot be appended with the adjacent Cauvery river basin of Tamil Nadu. Thus it become one among the 17 river basins of Tamil Nadu and based on the geographical location from North, the Parambikulam - Aliyar basin is the eighth basin from Chennai basin. The basin is Inter State in nature. Total geographical area of the Parambikulam - Aliyar basin (Tamil Nadu part) is 2406.38 sq.km and located in between N. Latitude 10° 12’ 50” - 10° 57’ 45” and E. Longitude 76° 42’ 30” - 77° 12’ 40”. The basin falls in Survey of India Topographic sheets " 58 / B9, B13, B14, B15, B16 and 58 / F1, F2, F3 ,F4 on 1:50,000 scale. Parambikulam - Aliyar basin is bounded by the Cauvery river basin in the east and north, Kerala State in the west and south .

The Parambikulam Aliyar basin is further delineated into four sub basins namely, Walayar, Palar, Aliyar and Sholaiyar. Walayar is the largest sub basin among the four sub basins with an area of 875.13 sq.km. The northern and eastern sides bounded by Cauvery basin and the western part bounded by Kerala State. The southern part bounded by Aliyar and Palar sub basins.

Palar sub basin having an area of 520.60 sq.km, which is bounded by Walayar sub basin in the north, Aliyar sub basin in the west and Cauvery basin in the east and south. The Aliyar sub basin is bounded by Walayar sub basin in the north, and Palar Sub basin in the east, Kerala State and Sholaiyar in south and Kerala State in the west. The total geographical area of the sub basin is 564.55 sq.km. Sholaiyar sub basin is the smallest among the four, having an aerial extent of 446.11sq.km which is bounded by Aliyar sub basin in the north, Kerala State in the east, west and in the south.

Administratively an area of 44.85 percent of Coimbatore district and 5.48 percent of Tiruppur district fall in the Parambikulam Aliyar basin. Podanur, Madukkarai, Anamalai, Valparai and Pollachi are the important towns located in the basin.

Eight taluks namely Perur, Madukkarai, Sulur, Kinathukadavu, Pollachi, Anaimalai, Valparai and Udumalaipet are spread over in this basin. There are eight blocks covered in this basin, out of which, Anamalai is the only full block and the remaining are part blocks

The project contemplated integration of seven rivers. Five rivers on the Anaimalai hills viz., Nirar, Sholaiyar, Parambikulam, Tunakadavu, Peruvaripallam, and two rivers in the plains viz., Aliyar and Palar.

The study of Geology of the Parambikulam-Aliyar Basin is based on the District Resource maps published by the Geological Survey of India and the inferences derived from the lithology obtained through investigation borehole and water level observation well of SG&SWRDC.

Parambikulam-Aliyar Basin is predominantly composed of weathered and fractured hard crystalline rock formations of Archean eon and sparsely by soft rock and unconsolidated sediment.

The geomorphological study was carried out in the Parambikulam Aliyar basin by interpreting the satellite image LISS III with date of pass on 1 April 2019 by its characteristics such as tone, texture, shape, pattern and associated features etc. Geomorphologically, being a stable land mass, Tamil Nadu is characterized by the Western Ghats made up of Archaean Complex, comprising different types of metamorphosed gneisses and Charnockites in the west, with a central plain, Eastern Ghats and Coastal plain.

For Parambikulam Aliyar Basin land use study, satellite imageries of LISS III acquired on January 1999 and of December 2018 have been interpreted.

In the Parambikulam Aliyar basin, the settlement area covers 0.95 %. Apart from dwelling area which is 19.92 sq. km the factories and quarry land covers 3.05 sq. km of the Parambikulam Aliyar basin. Important urban settlements in this area are part of Coimbatore, Pollachi, Kinathukdavu and Metupalayam. Quarry land occupies 2.39 sq.km, which is 0.1 % of the total area. Most of the quarrying activities are witnessed in the northern portion of the study area where the Gneissic rocks are exploited for various purposes. Some of the locations are, east of Ramachandrapuram, east of Pudur and north of Poravipalayam and a quarry is located in the Boluvampatti Reserved forest.

The extent of agricultural land is 1512.69 sq.km which is 63 % of the study area. Fallow land covers much of the agricultural land followed by groves. Coconuts are predominantly raised in the area. Tea plantation in the hilly portion of Anaimalai consumes 5.8% of the total cultivated area of the basin.

In Parambikulam Aliyar basin topsoil layer is found in shallow depths. The shallow layer of 2-2.5 m bgl occurs sparsely in the western and north western part of the basin. In western part it occurs sparsely in and around Meenakshipuram and in north western part occurs around Sattakalpudur. The shallow layer of 2.5-3 m bgl covers majority of the basin. This layer is found in central region and along the western boundary of the basin. Small patch of this layer is also found in northern part of the basin. Another layer of 3-3.5 m bgl is second most observed formation and fully covers northern part of the basin and found towards the southern reaches of the basin which is covered by hills and reserve forest. Comparatively deeper layer of top soil formation which is 3.5-4 m bgl is observed in very limited area in the northern reaches of the basin near Boluvampatti reserve forest.

The population of Parambikulam Aliyar River Basin as per 2011 Census is 1.070 Million of which 0.434 Million people live in rural area, 0.636 Million people live in urban area. The average annual exponential growth rate of rural and urban between census 1991 - 2001 and Census 2001-2011 is 0.02% for rural areas and 0.04% for urban areas

Projected population in Parambikulam Aliyar River Basin for 2020 is 1.17 million of which 0.475 million population in rural area and 0.696 million in urban area.

11.1.3 Hydro-meteorological Characteristics

Hydrometeorology is an interdisciplinary field of science that combines knowledge from the atmospheric sciences and hydrology to study the transfer and exchange of water and energy between land and the lower atmosphere. This field is the interface of two well-developed disciplines, meteorology and hydrology.

Daily rainfall data for the period of 33years from 1986 to 2019 has been collected from State Ground & Surface Water Resources Data Centre (SG&SWRDC), PWD, Chennai. This data is used for Yearly, Monthly and Seasonal Rainfall Probability analysis.

There are 24 rain gauge stations in and around the Basin. Considering the distribution of rain gauge stations and the stations having long term records, out of 24 rain gauge stations, only 15 rain gauge stations were selected for detailed analysis.

Details of 15 Selected Rain Gauge Stations

Sl.No	Name of sub basin	Sub basin area (sq.km.)	Name of Raingauge station	No.of Raingauge Stations
1	Walayar	875.13	Pothanur, Sultanpet	2
2	Palar	520.60	Nallar,Poolankinaru,Thirumoorthy	3
3	Aliyar	564.55	Aliyar,Attakatti,Topslip,Vettaikapudur, Weaverly	5
4	Sholaiyar	446.11	Anaimalai,Iyerpadi,Parambikulam, Valparai, Sholaiyar	5
Total		**2406.38**		

Dependable rainfall at 50% & 75% dependability and season wise average and annual rainfall for each of the sub basins have been analysed.

In general, Parambikulam Aliyar basin receives more rainfall in South West monsoon than North East monsoon. The highest rainfall of 2860.8 mm was recorded in Sholaiyar sub basin. Similarly lowest rainfall of 586.55 mm was recorded in Aliyar sub basin .The 33 years annual average rainfall of the basin is 1351.88 mm.

On viewing the climatic pattern, it is observed that there is decrease in number of rainy days, further, trend line of annual rainfall shows marginal declination, a slight decrease in summer and winter maximum temperature trend, a marginal increase in summer and reasonable increase in winter minimum temperature trend.

11.1.4 Irrigation and Agriculture

Irrigation is the artificial application of water to the land in order to fulfill the water requirements of the crops throughout the crop period for the full nourishment of crops. The State has a net irrigated area of 26.27 lakh hectares as per the season and crop report 2017-18. About 56.62% of the net area sown is benefitted by irrigation. The total Gross Irrigated area of Parambikulam Aliyar Basin is 98,048 Ha as per the season and crop report 2017-18 year crop area. The main crops cultivated in Parambikulam Aliyar Basin are Coconut, Paddy, Sugarcane, Cholam, Maize and Pulses in addition to Fruits and Vegetables.

PAP – A Unique Project - The flows in the rivers of the PAP system are regulated and diverted by the storage / diversion structures which have been constructed with the intention to serve the drought prone areas in the Cauvery basin also. Part of the area irrigated by the PAP system fed by the canals taking off from the Thirumurthy Reservoir viz., Parambikulam Main Canal, Udumalpet Canal and the High level Canal falls in the Cauvery basin. The total command area spread over in Coimbatore, Erode and Tiruppur districts of Tamil Nadu lies both in "Parambikulam Aliyar basin" and Cauvery basin. The command area of the Parambikulam Main Canal system has been grouped into four near equal zones in a manner convenient for facilitating the supply by rotation. The extent of command area, under PMC fed by Thirumurthy reservoir, under the four zones are 98,558 acres, 98,418 acres, 94,024 acres, 86,152 acres respectively, totalling to 3,77,152 acres. This is a unique project in the sense that farmers get water once in two years for their ayacut for 41/2 months. The Palar sub basin irrigated area is fed by Thirumurthy Reservoir. The command area of 44378 acres in Aliyar sub basin has been divided into two near equal zones. In a normal year about 2.35 Lakh acres are expected to be irrigated by the PAP system.

A combination of factors such as increasing industrialization, urbanization, housing activities and infrastructure development triggered the conversion of agricultural land into non agricultural uses. This has resulted in a declination of area under cultivation. The scope for the expansion of area available for cultivation is also very limited.

As per the latest Agricultural Census 2017-18, the State had 79.38 lakh holdings with an operating area of 59.70 lakh Ha. The land holding details of this basin are as detailed below.

- **Marginal farmers (area less than 1 Ha) : 30492 (43.14%)**
- **Small farmers (1 to 1.99 Ha) : 19721 (27.90%)**
- **Semi-medium farmers (2 to 3.99 Ha) : 13208 (18.69%)**
- **Medium farmers (4 to 9.99 Ha) : 6294 (8.91%)**
- **Large farmers (more than 10 Ha) : 959 (1.36%)**

The Gross irrigated area of crops in Parambikulam Aliyar Basin is reported to be 71,735 Ha.

- Out of the total area irrigated, about 96% is under Coconut cultivation and the remaining in Paddy, Cholam, Sugarcane, Groundnut, Pulses and millets cultivation.
- Net Irrigation demand of this basin at 75% dependable rainfall is 379.40 MCM.
- Net Irrigation demand of this basin at 50% dependable rainfall is 293.74 MCM.
- Organic farming practice is to be extended in greater manner in this Basin.

As per 2006, Microlevel Study Report of Parambikulam Aliyar River Basin, Net Irrigation demand was calculated as 840 MCM at 75% dependable rainfall for an irrigated crop area of 84,784 Ha in which Irrigated area of Paddy is 25% and Coconut is 53%.

Presently irrigated area is adopted as 71,735 Ha based on good rainfall year 2019-20. On comparing the cultivated area of the present study, it is found that the total irrigated area has decreased from 84,784 Ha to 71,735 Ha. Irrigated area of Coconut is increased from 45350 Ha to 68,620 Ha and Paddy is decreased from 21,310 Ha to 1,579 Ha.

Percentage of saving in water when water saving techniques are adopted on cultivation for the present cultivable area of different crops in Parambikulam Aliyar River Basin is given below.

Sl.No.	Crop	Cultivated area in Ha	Water requirement-conventional method (MCM)	% of saving by adopting saving technique	Savings (MCM)
1	SRI-Paddy	1579	11.51	40	4.61
2	SSI-Sugarcane	493	3.11	50	1.56
3	Coconut - DRIP	68620	362.77	63	228.54
4	Groundnut-DRIP	44	0.17	50	0.08
				Total	**234.79**

- By adopting water saving techniques in agriculture, approximately 33% of irrigation water can be saved. In general,
    1. Crop production can be increased when unirrigated area of this basin is brought under irrigation.
    2. Extraction of ground water can be minimized.
    3. Frequency / Intensity of Irrigation can be improved from prevailing intensity of 1.
- Savings in Irrigation demand of about 4.61 MCM can be achieved if 40% of the area under Paddy cultivation practice is changed to SRI method.
- Using SSI irrigation, for the cultivation of sugarcane,50% of irrigation water (1.56 MCM) could be saved.
- Using DRIP and coir pith as soil mulch for coconut trees, 63% of irrigation water could be saved (228.54MCM).
- During poor rainfall years, suitable cropping pattern may be adopted with crops that require lesser irrigation like Cotton, Maize, Sorghum, Pulses, etc.

11.1.5 Surface Water Resources and Irrigation System

Surface runoff is the response of a catchment to precipitation reflecting the integrated effects of a wide range of parameters like orientation and shape of the catchment, climate and intensity of precipitation, duration, the direction of storm, slope, soil, land use, etc.

Parambikulam Aliyar system comprises of 10 reservoirs in which the Upper Nirar Weir, Lower Nirar Dam, Sholayar Dam, Parambikulam Dam, Thunacadavu and Peruvaripallam Dams are located in the Anamalai Hills of the Western Ghats, whereas the Aliyar Dam and the Thirumurthy Dam are located in the plains along with that 4

Power Houses, 6 Main Tunnels, the unique Contour Canal, Leading Channels and a network of 7 Irrigation Canals, Branch Canals and Distributaries.

There are 35 interstates gauging points in this basin where, the flow is being measured and recorded. The flow records are maintained by P.W.D. This also includes the flow measurements that are taken in reservoirs and weirs.

"Joint Water Regulation Board" comprising the Chief Engineers, Water resources & Chief Engineers of both the States has been constituted to monitor the availability of water to both states and is functioning.

To know the actual quantity available to Tamil Nadu, the flow data from the year 1989-90 to 2018 - 19 and other available years are analysed. The quantity of average annual flows realized in the PAP system at each diversion structure are worked out.

The annual Surface Water Potential of Parambikulam and Aliyar river basin is calculated for average annual flow is 769 Mcum.

Considering the surface water quality, the present study of the assessment of surface water samples for irrigation has been evaluated on the basis of standard guidelines and it reveals that the Electrical Conductivity (EC), pH, Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC) values for irrigation standard are in the permissible category. Hence it is concluded that the surface water samples of the present study area are completely suitable for irrigation. A continuous monitoring program is required to check the suitability for irrigation purposes. The network for surface water sampling locations should be increased by the SG & SWRDC, Tharamani, Chennai to make the study more effective.

11.1.6 Groundwater Resources and Water Quality

Groundwater and surface water are the two water resources of a country and are dependent on rainfall. The quantity of water that reaches the ground water table depends upon the run off rate, infiltration rate and permeability of the formation. A major quantity of rainfall flows as surface runoff and is stored in water bodies like reservoirs, tanks, lakes and ponds. The excessive extraction of groundwater, for various demands, results in fast depletion of groundwater. In order to improve the groundwater level effective methods are to be adopted.

The dynamic groundwater resource of Tamilnadu was assessed at macro size unit of Block level upto 2009. After 2011, the assessment is being done at micro size unit of Firka level

Parambikulam Aliyar basin encompasses 19 Firkas either fully or partially and all firkas are falling in Coimbatore and Thiruppur districts and the categorization summary is as stated below:

Sl.No	Category	2017 Assessment
1	Safe	2
2	Semi Critical	2
3	Critical	2
4	Over Exploited	13
	Total	19

As per the latest assessment, ie as on **March 2017,** the data on **Dynamic Ground Water Resources of the State of Tamilnadu** is as stated below:

- **Total Annual Ground Water Recharge : 20.26 bcm**
- **Annual Extractable Ground Water Resources : 18.23 bcm**
- **Annual Ground Water Extraction : 14.73 bcm**
- **Stage of Ground Water Extraction : 80.81 %**

Groundwater is extracted from shallow aquifer. The Geologists & Engineers have used complicated data to find reliable and representative values of the hydraulic characteristics of aquifers. The groundwater availability in aquifer depends on the type of rock formation in earth layer and hydraulic parameters of aquifer such as Conductivity, Transmissivity, Specific Yield and Storage co-efficient. Pump test in dug wells or bore wells plays a prominent role in evaluating these hydraulic properties of aquifers in different geological formations. Based on the pump test results, yield and recharge rate of aquifers are being predicted.

There are 69 wells spread over the entire Parambikulam Aliyar Basin and they have been analyzed, over the period of three (3) years to forty seven (47) years. The wells analyzed fall in Coimbatore and Thiruppur districts.

Hydrographs of groundwater level for the 69 wells have been prepared. The linear trend lines drawn in the Hydrograph of wells were used to interpret the long-term trend in water level fluctuation. Rise or fall in water level in the range of 0-2 metre may not be significant due to dynamic nature of groundwater (CGWB 2010). From the trend line, if there is a long term water level depletion or rise, in the range of 2-3 metre, it is classified as moderate depletion or rise. If the depletion or rise is greater than 3 metre, it is classified as high depletion or rise.

In this basin, moderate rise is found in 6 wells and high rise in water level is found in 9 wells. Moderate depletion is found in 7 wells and high depletion in water level is found in 29 wells.

Water quality is good to moderate in this basin.

69 wells spread over the entire Parambikulam Aliyar Basin has been scrutinized for study purpose. Sub basin-wise groundwater availability, extraction and balance have been worked out. Long-term trend in water level fluctuation has been analyzed and pre-monsoon & post-monsoon contours maps of aquifers are prepared.

- ❖ Net annual groundwater availability in Parambikulam Aliyar Basin is 125.22MCM and total annual groundwater extraction in the basin is 37.95MCM (30.3%). The balance groundwater available for further development is 95.38MCM.
- ❖ Whilst comparing the groundwater resources of Parambikulam Aliyar Basin calculated in Appraisal report prepared in 2006 with this Reappraisal report, it is observed that the total annual groundwater availability has decreased by **57.26%** (from 293.03MCM to 125.22MCM) and total annual groundwater extraction has also decreased by **86.95%** (from 281.61MCM to 37.95MCM). The balance annual groundwater availability of is increased by **82.41%** (from 52.29MCM to 95.38MCM)
- ❖ Annually groundwater extracted for irrigation in Parambikulam Aliyar basin is **32.56** MCM which is 85.80 % in total annual groundwater extraction of **37.95** MCM for all sectoral demands.

11.1.7 Present Future Water Demand

The major sectors that are considered in water demand study are domestic, irrigation, livestock and industry.

The domestic demand is of primary importance and depends on the population.The Central Public Health and Environmental Engineering Organization (CPHEEO) recommended norms for per capita water demand in the domestic sector is as stated below.

Sl. No	Classification of towns/cities	Recommended maximum water supply levels (lpcd)
1	Towns provided with piped water supply but without sewerage system	70
2	Cities provided with piped water supply where sewerage system is existing/contemplated	135
3	Metropolitan and Mega cities provided with piped water supply where sewerage system is existing/contemplated	150

An additional 15% should be included above the norms in each classification to meet "Unaccounted for Water (UFW)"

The annual growth rate adopted in this basin for estimation of population growth from 2011 census is as given below:-

<u>**Sector**</u>	<u>**Annual Growth rates**</u>
Urban	0.04% per year
Rural	0.02% per year

The domestic water demand for the present year 2019 and the target years 2020, 2030, 2040 & 2050 are obtained as 52.69 Mcum, 53.22 Mcum, 58.78 Mucm, 64.93 Mcum & 71.727 Mcum respectively.

The domestic water requirement may increase in future due to increase in population, development in living standards of the people etc.

Irrigation water demand at 75% dependable rainfall in Parambikulam Aliyar basin is 379.40 MCum and this quantity is maintained for the target years 2020, 2030, 2040 & 2050 without increasing the demand.

At present in the Parambikulam & Aliyar River Basin there are 190 numbers of large and medium industries and 906 numbers of small scale industries. Accordingly, the yearly requirement of water for Large & Medium and small scale industries at present is estimated as 4.756 Mcum & 1.834 Mcum respectively.

For forecasting the water demand of Industries for future years, a simple arithmetic increase of 8% per annum (as per the Annual Survey of Industries) over the present requirement has been adopted.

As per 20th livestock census, the livestock strength in Parambikulam Aliyar basin is 71,15,341. Maintaining these values for the current year its current water demand is 11.324 MCum.

The total water demand of all sectors, i.e., Domestic, Irrigation, Livestock, and Industries of Parambikulam & Aliyar River Basin for the present year 2019 was worked out as 450.004 Mcum. But the water demand in 2006 was 722.917Mcum This shows that there is 37.75 % decrease in water demand within 13 years for the present year, when compared to the water demand during 2006.

11.1.8 Water Balance Study

The main aim of water resources planning in each river basin is to find out whether the availability of water in the basin is enough to meet out the demand. If the availability of water is less than the requirements, then suitable measures are to be taken for optimum utilisation. If the availability of water is more than the demand, suitable utilization of the excess water has to be planned either within the basin or the excess could be transferred to nearby deficit basins. Better water management is also necessary. Hence, water balance is a tool to utilize the water optimally in a river basin.

Different planning scenarios for Parambikulam Aliyar river basin are considered:

1. Exisiting Scenario

2. Improved Agricultural Methods

Water Balance

- Water Potential for the year 2019 = 894.22 Mcum
- Water demand for the year 2019
  (75% dependability) = 858.35 Mcum

Water Balance = 35.87 Mcum

- % Water Balance with respect to potential = 4.02 %

Parambikulam Aliyar basin as such shows a water balance by 35.87 Mcum (4.02 %) for the year 2019 at 75% dependability when considering the value of both surface water potential and ground water potential. But in practice, tapping Groundwater from deep aquifers is difficult. Therefore, the contribution from Ground water potential is very meager.

Thus the Water Balance study of Parambikulam Aliyar river basin for the existing scenario for the current year shows that the irrigation demand value accounts for about 91% of the total water demand.

Steps may be taken to improve the use of ground water and also to reduce the losses by lining canals, proper maintenance of irrigation infrastructures, and adopting improved irrigation techniques. More artificial recharge structures based on scientific methods may be provided in suitable locations in the basin for improving the water potential.

11.1.9 Environmental Aspects

Environment means "surrounding" which includes biotic factors like human beings, plants, animals, microbes in addition to inorganic factors. It is a complex aspect with many variables that surrounds man as well as the living organisms.

Environmental pollution is one of the most serious problems faced by humanity and other life forms on our planet today. The major sources of pollution are Industries, Domestic and Agriculture.

Industries are classified into three categories with respect to the pollution level. Highly polluting industries are categorized as Red, medium polluting industries are categorized as Orange and less polluting industries are categorized as Green.

There are 190 large & medium industries and 906 small scale industries in this basin and the waste water generated from the industries is 5.275 MCum per year

The generation of sewage in rural areas and urban areas in Parambikulam Aliyar River Basin is assumed as 80% of water demand. The volume of sewage generated in rural and urban areas of Parambikulam Aliyar River Basin is 42.152 MCum per year

Sewage treatment involves physical, chemical and biological processes to remove physical, chemical and biological contaminants. The objective of the sewage treatment is to produce a disposable effluent without causing harm to the surrounding environment and prevent pollution.

In Parambikulam Aliyar River Basin, the sewage treatment plants have been implemented in Coimbatore and Tiruppur districts as part of an underground sewerage schemes and being executed by the Tamil Nadu Water Supply and Drainage Board.

Agricultural pollution refers to biotic and abiotic by products of farming practices that result in contamination or degradation of environment and surrounding ecosystems, and/or cause injury to humans and their economic interests. Pesticides & fertilizers once sprayed do not disappear completely. Some of it mixes with the water and seeps into the ground. The rest of it is absorbed by the plant itself. As a result, the local streams that are supplied water from the ground become contaminated, as do the animals that consume these crops and plants.

In Parambikulam Aliyar Basin the main elements of agricultural pollution are phosphates,nitrates,potassium etc., The year wise consumption of fertilizers and pesticides in Parambikulam Aliyar Basin is furnished below,

- Consumption of fertilizers in Coimbatore and Tiruppur districts from 2008-09 to 2017-18: Total NPK - 2,01,966 MT
- Consumption of pesticides in Coimbatore and Tiruppur districts from 2008-09 to 2017-18: Liquid- 5,44,517 Litres, Dust /Solid- 6,29,347 kgs

It is inferred that the consumption of nitrogen fertilizer was high during the year 2015-16 and subsequently reduced in the following year. The consumption of pesticides (in liquid form) was also high during the year 2015-16 and subsequently reduced in the following year.

Based on the analysis of water quality data, all the water quality parameters are within the permissible limits. Hence water are used for both domestic and irrigation purposes. No salinity is observed in the basin,

Solid waste is the unwanted or useless solid materials generated from combined residential, industrial and commercial activities. Solid waste management is the process of storage, collection, transportation and recycling, disposal and monitoring of solid waste in a systematic, economic and hygienic manner.

In Udumalpet municipality, as per 2011 census,the total population in the Tiruppur district is 61,150. The total solid waste generated per day is 23 tonnes and out of which 0.5 Metric Ton is cleared every day. In Tiruppur Corporation wet wastes are converted into manure. In dry waste materials Recyclable materials sold to vendors and non Recyclable materials send to cement factories.

In Coimbatore Corporation, as per 2011 census, the total population in the Coimbatore district is 16, 00,000. The total solid waste generated per day is 975 tonnes and out of which 654 tonnes is cleared every day. In Coimbatore Corporation, the disposal methods adopted is Windrow composting, Vermi composting and Bio Gas plant.

Indira Gandhi Wildlife Sanctuary is located in this basin.

Tourism in India has shown a phenomenal growth in the past decade. India travel tourism has grown rapidly with a great influx of tourists from all across the globe who have been irresistibly attracted to the rich culture,heritage,and incredible natural beauty of

India. Some of the tourist places in Prambikulam Alliyar basin are Sholaiyur dam,Thirumoorthi dam and Aliyar dam.

Some of the most important general mitigation measures that can be adopted to reduce the environmental degradation in this basin are given below:

1. Agglomeration of industries shall be encouraged so that the by-product or waste of one industry may be a raw material for some other industries, which will lead to reduction of natural water requirements.
2. Usage of Bio pesticides and fungicides to control the pests and diseases will also minimize the pollution.
3. Introduction of fish culture in multipurpose farm ponds/water recharge ponds and promoting ornamental fish culture as a commercial activity.
4. Payer pays policy (make the industries pay taxes for the environmental harm)
5. Organizing Environmental awareness campaign.
6. Waste minimization which includes reducing waste at source, reusing materials and recycling waste materials (3R).
7. Proper waste disposal methods such as sanitary landfill, incineration, composting and pyrolysis.
8. Integrated Solid Waste Management can be adopted to mitigate the effects of solid waste.
9. Chemical fertilizers should be replaced with organic fertilizers in a phased manner.
10. Environmental management of facilities to tourism spots can boost the revenue to Government and increase the benefits by careful planning for controlled development.

11.1.10 Present Institutional Setup

The Water Resources Department is a part of the Public Works Department. The Water Resources Department is responsible for the maintenance and rehabilitation of all the Irrigation structures and improving the irrigation infrastructure as well as monitoring floods. One of the main objectives of the Water resources Department is to ensure effective management and distribution of surface and ground water to achieve optimum utilization in a rational and scientific way for maximizing the production and productivity of all the sectors requiring water in the State of Tamil Nadu.

The other departments, Agriculture Department, Agricultural Engineering Department, Statistics and Economics Department, Tamil Nadu Water Supply and Drainage Board, Forest Department, Tamil Nadu Pollution Control Board, Industries & Commerce Department, Animal Husbandry & Veterinary Sciences Department, Public Health & Preventive Medicines Department, Census Operation Department, Fisheries Department and Tamil Nadu Generation and Distribution Corporation are the line departments connected with water resources and data were obtained from those departments for Parambikulam Aliyar Basin Micro Level Reappraisal Study.

The Government constituted Water Utilization Committee and Technical Sub-Committee to Water Utilization Committee in order to take final decision on the proposals seeking permission for surface/ground water drawl, by various organizations/Institutions. The various proposals seeking requisition for water drawl from surface/ground water are scrutinized based on the assessment of the available surface and ground water potential and existing scenario of water demand at which drawl is requested.

Participatory Irrigation Management (PIM) system aims to improve farmers' (water users) involvement in management and operation of irrigation system. For this purpose, the project would work towards integrating Participatory Irrigation Management practices into operations of WRD. In Parambikulam Aliyar Basin 6 WUA's were formed under IAMWARM, 150 under WRCP and 2 WUA committee is to be formed.

11.2 Strategic Objectives and Action Plan

- **Strategic Objective 1: Installation of Weather Station**

Sl. No	Issues	Strategies Recommended	Action to be Taken by
1.1	Only two weather stations (Sethumadai & Aliyar) are functioning in this basin. Sethumadai doesn't have long term data. Hence Aliyar data is taken. These stations are located closely and doesn't cover a wide spread area.	Suggested to install more weather stations covering the entire basin and record data continuously throughout the year without break.	**The Chief Engineer, SG&SWRDC, Chennai**

- **Strategic Objective 2: Ground water quality**

Sl. No	Issues	Strategies Recommended	Action to be Taken by
2.1	Bore well & observation well water quality data is not sufficient to represent the entire basin. Ground water assessment is done at firka level	More network for water quality stations to cover the entire basin area for accurate Ground water assessment scientifically The Ground water assessment maybe done hydrometeorological boundary wise (sub basin / watershed) instead of Administrative boundary wise (firka)	**The Chief Engineer, SG&SWRDC, Chennai**.

- **Strategic Objective 3: Surface Water quality**

Sl. No	Issues	Strategies Recommended	Action to be Taken by
3.1	Surface Water quality is not available for the 5 Tanks viz (Devambadivalasu, Kothavadi, Elavakkarai, Kolapathu Kulam, Valayapalayam kulam) Surface water quality data is available for seven reservoirs.	It is recommended to take water samples periodically during the monsoon period in all 5 Tanks under WRD. It is also recommended to take the water samples in all the ten reservoirs in this basin periodically.	**The Chief Engineer, SG&SWRDC, Chennai** .

➢ **Strategic Objective 4: Sustainability of Environment**

Sl. No	Issues	Strategies Recommended	Action to be Taken by
4.1	Consumption of pesticides and fertilizers is high	Suggested to use bio-pesticides and fungicides to control the pests and diseases instead of using chemical pesticide in order to minimize the environmental pollution wherever feasible.	**Agriculture Department**

➢ **Strategic Objective 4: Industrial pollution**

Sl. No	Issues	Strategies Recommended	Action to be Taken by
5.1	Reduce the effluent discharged from polluting industries	Treated waste water of one industry may be used as input for other industries so as to reduce fresh water requirement. Suggested that the effluent from the industries should be treated before discharging into water bodies.	**Tamilnadu Pollution Control Board**

Even though Parambikulam Aliyar Basin is not a deficit basin considering the availability of Groundwater also for sustained development of the basin, the aforesaid suggested action plans have to be implemented without any lapse.

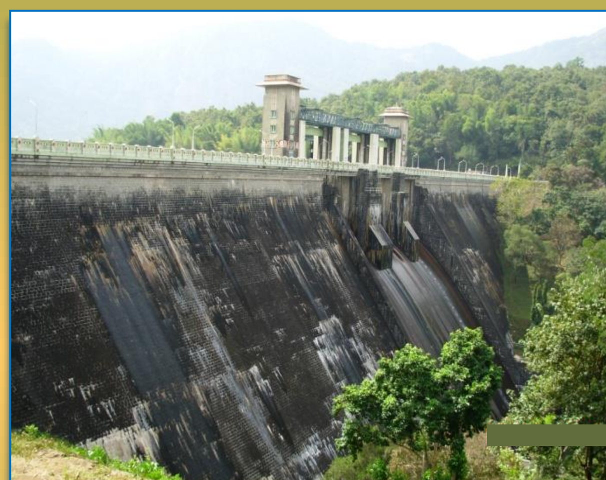
WATER IS BECOMING MORE AND MORE SCARCE COMMODITY DAY BY DAY, THEREFORE EFFICIENT USE OF SINGLE DROP OF WATER IS MANDATORY IN THE PRESENT SITUATION.

TN SHOLAYAR DAM

ALIYAR RESERVOIR

LOWER NIRAR DAM

PARAMBIKULAM DAM



THUNAKADAVU DAM

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