GOVERNMENT OF TAMILNADU
WATER RESOURCES DEPARTMENT

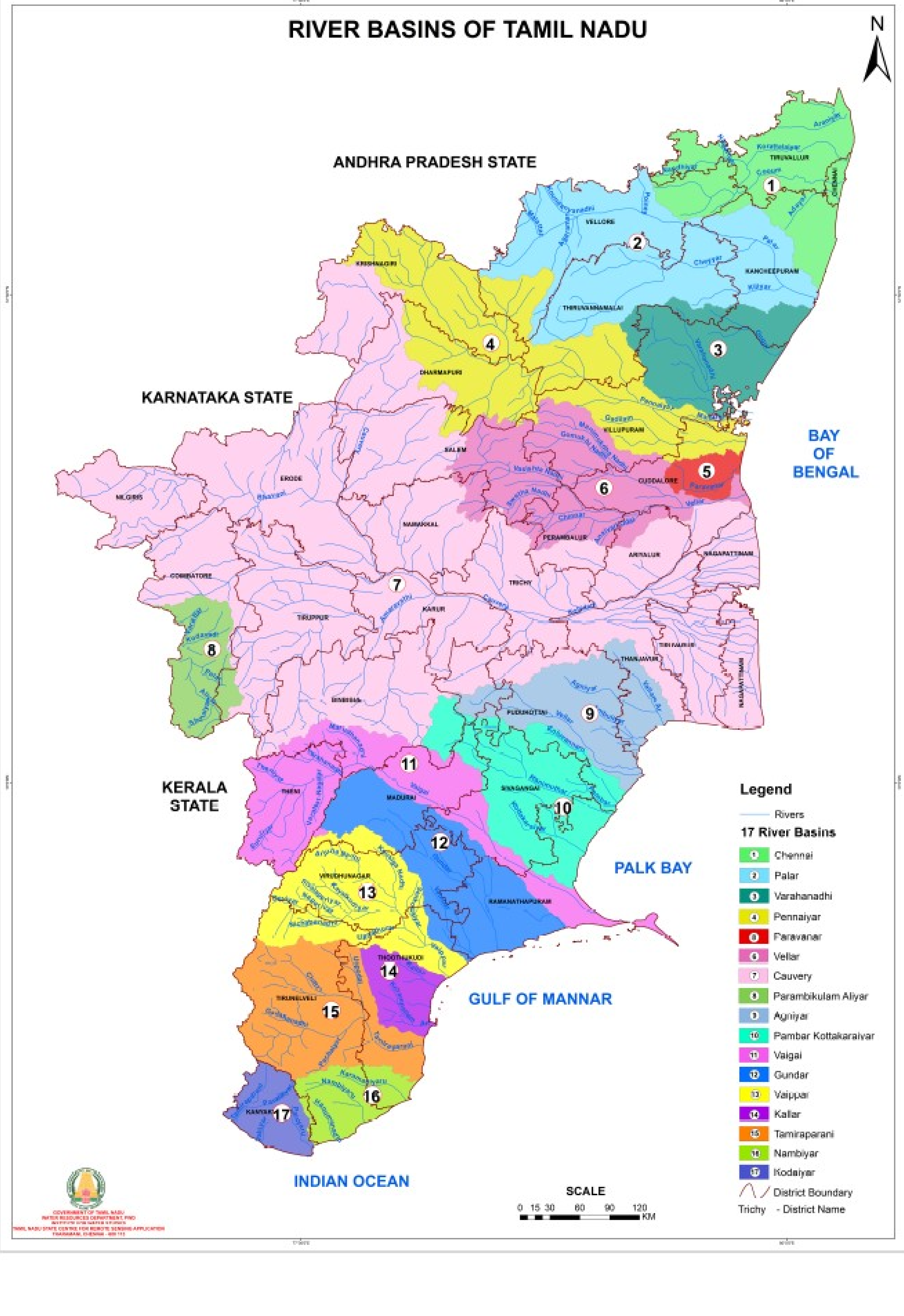
MICRO LEVEL REAPPRAISAL STUDY OF

AGNIYAR BASIN

VOLUME - I

INSTITUTE FOR WATER STUDIES , HYDROLOGY & QUALITY CONTROL
THARAMANI, CHENNAI 600113

JANUARY 2023



RIVER BASINS OF TAMIL NADU
N
ANDHRA PRADESH STATE
KARNATAKA STATE
KERALA STATE
BAY OF BENGAL
PALK BAY
GULF OF MANNAR
INDIAN OCEAN
Legend
Rivers
17 River Basins
1 Chennai
2 Palar
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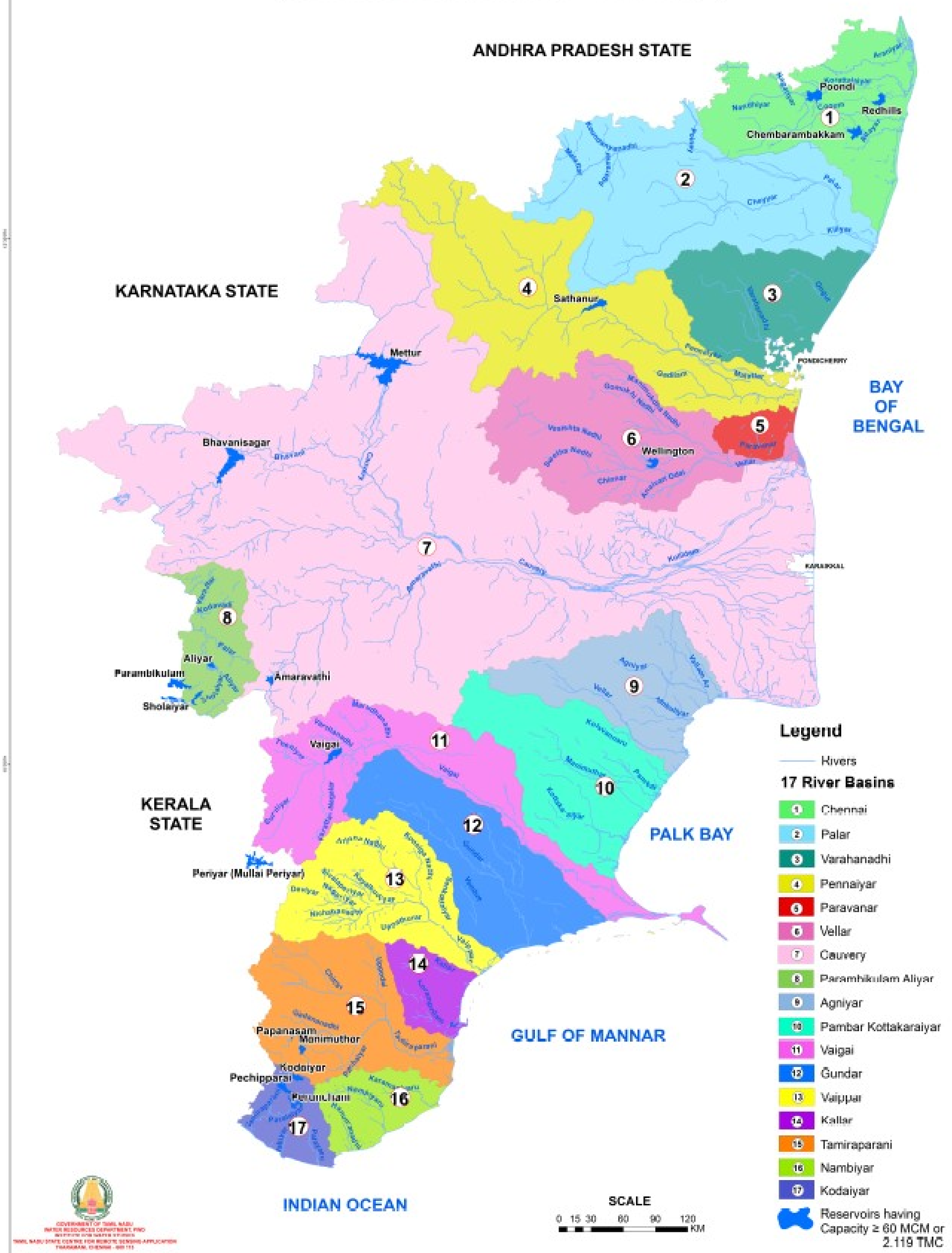
8 Parambikulam Aliyar
9 Agniyar
10 Pambar Kottakaraiyar
11 Vaigai
12 Gundar
13 Vaippar
14 Kallar
15 Tamiraparani
16 Nambiyar
17 Kodaiyar
District Boundary
Trichy - District Name
SCALE
0 15 30 60 90 120 KM

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 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, the 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, Varahanadhi and Pambar Kottakkaraiyar, Parambikulam Aliyar basins have been completed. The Micro level Reappraisal study of **Agniyar Basin** has been taken up for the year 2021 - 2022.

Subsequently, to assess the present water potential, demand and balance as per latest data availability upto the year 2020, the Micro level Reappraisal study of Agniyar Basin has been taken up in 2021-2022. With the advent of latest satellite imagery and remote sensing techniques various thematic maps of the **Agniyar 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 and better management of water resources to benefit the basin society and Tamilnadu state.

Chief Engineer & Director,
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 Additional Chief Secretary to Government, Water Resources Department for continuous advice and support in preparing the Micro level reappraisal study report of Agniyar Basin.

The officials of this Institute sincerely thank the Engineer-in-Chief, WRD for timely contribution for his guidance during course of preparation of Micro level reappraisal study report of Agniyar Basin.

The officials of this Institute whole heartedly record our 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 **Agniyar 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, Trichy Region, the Chief Engineer, WRD, Madurai Region, and the Chief Engineer, WRD, State Ground & Surface Water Resources Data Center, Chennai for sharing surface water data and hydrological & meteorological data respectively which are fundamental in carrying out the Micro level reappraisal study of Agniyar Basin.

The officials of this Institute also thank the Superintending Engineer, WRD, Middle Cauvery Basin Circle, the Superintending Engineer, WRD, Lower Cauvery Basin Circle, the Executive Engineer, WRD, Agniyar Basin Division, Pattukkottai, the Executive Engineer, WRD, South Vellar Basin Division, Pudukkottai, the Superintending Engineer, WRD, Periyar Vaigai Basin Circle, the Superintending Engineer, WRD, Lower Vaigai Basin Circle, 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 Agniyar Basin.

With earnest belief, I assure that the methodology and suggestions put forth in this report for Water Resources planning in Agniyar 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 Agniyar Basin.

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

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ABBREVIATIONS

ADD	Acute Diarrhoea Disease
AED	Agricultural Engineering Department
AG	Agniyar Basin
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	Low Imaging Sensing Satellite
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
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

MICRO LEVEL REAPPRAISAL STUDY

AGNIYAR BASIN

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CHAPTER – 1

INTRODUCTION AND METHODOLOGY

CHAPTER - I

INTRODUCTION AND METHODOLOGY

1.1 Introduction

Climate and the terrestrial water cycle have a very close and complex relationship. Changes in climate variability will affect water resources. For example, a deficit rainfall will reduce soil moisture, river flow and ground water recharge, but the magnitude of these follow-on effects will depend on local conditions such as soil properties, geology, vegetation and water use.

Because of the different time scales of the involved processes, the impacts on ground water deficit may last for much longer than the original meteorological drought that caused by them. Floods, on the other hand, may have an impact on water availability, sanitation and other facets of human livelihoods through damage to key infrastructure and services.

At the same time, the hydrological cycle is itself an essential component of the climate system, controlling the interaction between the atmosphere and the land surface and providing feedback mechanisms for the transport, storage and exchange of mass and energy.

Water resources are affected by a variety of anthropogenic factors also including but not limited to land use and land cover change, water regulation and withdrawal systems, and water contamination. Through the construction of water resources infrastructure, the development of agricultural and other water use practices, human kind has improved access to safe water supply and sanitation services throughout its history. Thus water resources are being affected in numerous ways, and therefore require a new, smart approach for better water resources management by way of balancing the supply & demand judiciously without affecting the environment.

1.2 Water Resources Planning

Historically, water resources planning has been focused on the development of water resources and associated infrastructure to meet the water requirements of economic and social development, identified separately from the basin planning process. For example, development plans may identify the need for an expansion in irrigation or industry in one part of the basin, or to provide flood protection for certain cities or regions. In such circumstances, the role of water resources planning is to develop a technical and engineering solution to meet those needs. The advantage of water resources planning is procedurally and relatively simple. It is usually undertaken by water resources planners supported by social, environmental and economic practitioners, and relies heavily on water resources system models. It is particularly applicable to systems that are flooding, or basins that have water resources available for further development.

1.3 River Basin Planning

"River basin planning" concept differs fundamentally from long-standing ideas of relatively centralized planning for water at a basin scale. The most common tenets of current usage of "basin planning" are that all stakeholders in the basin should be involved in discussions regarding its management, all aspects of water quality and quantity in the basin should be considered, and that the parties should have great flexibility in arriving at a consensus solution. The emphasis is on developing consensus-based water plans, involving all major stakeholders and agencies. Basin planning seems to be more successful where there is a balance between expectations and resources/funding, effective leadership and management, interpersonal trust, committed participants, and a flexible and informal structure.

In short basin planning is the process of identifying the way in which a river and its limited natural resources may be used to meet competing demands, while maintaining river health. It includes the allocation of scarce water resources between different users and purposes, choosing between environmental objectives and competing human needs, and choosing between competing flood risk management requirements.

National Water Policy and 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 3 of these policies have categorically stressed that water resources planning have to be done with a hydrological boundary unit such as a river basin as a whole or a sub-basin.

1.3.1 Strategic Basin Planning

Strategic basin planning can be defined as a coherent multi-disciplinary approach for managing basin water resources and their uses in order to identify and satisfy social, economic and environmental priorities. The aim of strategic basin planning is not just to meet straightforward, externally set objectives, but to choose between a series of possible water management objectives that will best contribute to a range of competing economic, social and ecological goals. Further, achieving these goals typically involves the participation of a range of government bodies and stakeholders, beyond those directly involved with water management. The following factors characterize this more strategic approach to basin planning:

- Trade-offs between alternative economic, social and environmental objectives, and between existing and potential future demands.
- Sophisticated approach to recognize environmental requirements for water and the importance of aquatic ecosystem functioning in providing goods and services for social and economic development.
- Understanding basin interactions, including a range of hydrological, ecological, social and economic systems and activities at work within a basin.
- Robust scenario-based analysis to addresses uncertainty in future development and climate, by assessing alternative hydro-economic scenarios.
- Prioritisation, whether in terms of the needs for economic development, social justice or environmental protection.
- The involvement of multi-disciplinary teams.

1.4 River Basin Management

With intensifying water use, climate change, and land use changes, achieving sustainable water management on the river basin scale is becoming more and more challenging. Water needs to be allocated between different sectors such as irrigation, industry, drinking water supply, power generation and nature. Basin-scale plans for distribution of water and prioritization of water uses under stressed conditions need to be implemented to achieve this. A range of environmental, social and political issues need to be considered to achieve a sustainable supply of water, of the right quality and quantity, to the correct location, at the right time. With water demands already exceeding availability in many regions, changes in climate patterns (often leading to prolonged droughts and more extreme rainfall events) are expected to further enhance complexities faced by decision makers. National Governments, (trans-boundary) river basin management authorities, regional water boards, and NGOs increasingly require decision support tools and advice that address the issues related to water demand vs. water supply discrepancies, in order to ensure adequate supply of fresh water to all water users in a basin, now and in the future.

River basin management affects river basins in many ways. It may alter the natural physical processes in a river basin by constructing structures to store and carry water; regulate the use of water with the help of allocation rules, prices, water rights and permits; and apply economic instruments, such as taxes and subsidies to control the water usage. Different inputs are necessary to apply these instruments, such as money, personnel, legal, and appropriate policy directives. River basin management may also induce change in the behavior of the users by penalizing or allowing/encouraging certain activities. An effective river basin management will require a mix of instruments depending on circumstances. For long-term sustenance, it is necessary to build in-house capacity by training staff and keep the general public well informed.

1.4.1 Integrated River Basin Management (IRBM)

Integrated River Basin Management (IRBM) emphasises cross disciplinary coordination of water, land and related resources in a river basin, watershed or catchment to achieve long-term sustainability. IRBM highlights the importance of ecosystem function in the long term, and reminds us that an integration of policies, decisions and costs are necessary across a multitude of sectors.

Effective river basin planning and management can have benefits as wide as poverty alleviation, sustainable development, access to energy, healthy ecosystems, gender equality and thriving livelihoods. Yet complex hurdles threaten to stand in the way of a water-secure world. When rivers cross international, interstate, or administrative boundaries, there are often different institutional, regulatory, policy, and planning procedures and processes in place and no coordinating mechanisms to bring these together. Across sectors, there are different indicators for success, and across communities there are a variety of competing reasons to use water resources.

Integrated river basin management aims to break these barriers to establish a holistic framework for coordination, bringing together diverse regulatory, policy and planning. It involves all stakeholders involved in river basin planning and management collaboratively develop an agreed set of policies and strategies to achieve a balanced approach to land, water, and natural resource management. It helps us understand that we can find best practice river management in many activities from community use to environmental science, economics, urban planning or business management. And, it puts the focus back onto achieving healthy river ecosystems with wide-ranging benefits for all communities, economies and biological processes within it. Integrated river basin management is how we can revive our rivers and is crucial to a sustainable water future.

1.5 River Basins of Tamil Nadu

River basins are the natural hydrological unit of area in which rain or stream waters collect and discharges it through a common outlet at its minimum elevation (the river mouth). The area of the basin is generally determined from the topography or water divide. The divide represents the highest elevation points along the basin perimeters.

Tamil Nadu is endowed with many rivers and 34 of them are classified as independent rivers which originates and confluence with Bay of Bengal independently. These 34 river basins are grouped into 17 major river basins (**Plate AG - 1**) and the river basins were further sub divided into 127 sub basins **(Table 1.1)** for the purpose of precise water resources planning and management.

1.6 Background and Purpose of Study

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 watersheds, 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 watershed development.

The purpose of the basin study is to evaluate the surface and groundwater availability and balance water potential for judicial water resource management in the basin with a series of possible water management objectives that will best contribute to a range of competing economic, social and ecological goals with the help of updating geodatabase previously used with latest software for appropriate methodology.

1.6.1 Previous Study

During the year 2008, micro level study for Agniyar basin had been completed All thematic layers were prepared in 1:250,000 scale. For rainfall and climatological parameters such as temperature, humidity, evaporation, evapo-transpiration, wind speed and sun shine hours analysis of data up to the year 2005 have been utilized. Groundwater quality has been assessed in the basin for the periods of pre and post monsoon for the years 1985, 1995 and 2005. Groundwater Control well data of pre and post monsoon periods of the year 2005 had been used and analysed for water level fluctuation

For the preparation of geomorphology and lineament maps the satellite data of IRS ID LISS III data of January 2004 was utilized. IRS P6 LISS III, March 2004 satellite data had been used to prepare land use/land cover classification and mapping. Groundwater development in the basin was obtained based on the block-wise groundwater assessment as on March 2003 and the same data has been used to estimate sub basin wise groundwater potential, extraction and balance. Census data of the year 2001 has been used for demographic analysis in the basin.

For updation and bridging the gap of the data for 15 years (2006 to 2020) on climatological parameters, hydrology, hydrogeology, water quality and to carryout the statistical and spatial analysis to understand the dynamic variations over the period in the Agniyar basin, the Micro Level Reappraisal study is taken up. In this reappraisal study, IRS Resource Sat IIA LISS III Satellite data of the year 2021 is used for land use / land cover classification. For preparing geomorphology and lineament layers IRS Resource Sat IIA LISS III 2021data is used. Updated technologies with latest software for updated methodology for water resource study are used.

The micro level reappraisal of the study of Agniyar river basin is taken up to explore the current scenario of the basin and find out the changes in the hydro dynamics and geodynamic parameters so as to recommend judicious planning and management of water resources of the basin.

1.7 Methodology for the Study Adopted Now

The Agniyar Micro Level Reappraisal Study adopted the new methodology , which includes the analysis of geospatial and non-spatial attributes collected to derive,

- Physiographic, drainage network and gradient assessment
- Sub basin wise drainage morphometric analysis carried out for qualitative assessment of terrain to know about its property towards hydrology.
- Geophysical resistivity Vertical Electrical Sounding data obtained from Wenner Configuration method and used to explore the aquifer characters and to examine the spatial distribution and thickness of unconsolidated soil, weathered rock and fractured rock in the basin.
- Digital land use/ Land cover classification to for the periods 2005 and 2021 were carried out to evaluate landuse changes in 15 years using image processing software.

- Variation of climatological parameters such as temperature, evaporation, evapotranspiration, wind speed and sun shine hours
- Rainfall variation, distribution, intensity, frequency and evaluation of spatio temporal rainfall dynamics.Season wise rainfall analysis was carried out and isohyets were generated using ArcGIS software to explore the rainfall spatial distribution and influence in the basin.
- Groundwater level distribution for evaluation of groundwater regime.Groundwater level data for pre and post monsoon periods were analyzed to examine the spatial distribution of subsurface water table and fluctuation in the basin.
- Selected parameters of water quality data for pre and post monsoon periods were analyzed using Water Quality Index (WQI) method for evaluation of drinking groundwater and surface water quality. Spatial distribution of ground and surface water quality was also done in the study area.
- Monthly Runoff Simulation (MRS) model and Runoff coefficient methods were used for estimating the sub basin wise surface water potential.
- Estimation of sectorial water demands in sub basin wise carried out.
- Water balance based on available surface and groundwater potential and demand was determined.
- Environmental scenario in the basin including aqua culture, sea water intrusion, etc were brought out.

The space technology data using Remote Sensing and GIS techniques were employed wherever it requires to aid the study. The digital space technology 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.

. Using digital image processing software, visual as well as digital interpretation of satellite data were done and the outputs themes were bring into GIS platform for spatial analysis. Aerial Photographs on 1:50000 scale were used for interpreting the geological structures such as lineaments. The IRS Resource Sat IIA data of 2021data were used to derive of geomorphologic features and lineaments.

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

1:50,000 scale graticule has been adopted for database. Transverse Mercator projection and WGS 1984 UTM projected coordinate system are adopted for geo-database, which represents the actual ground distance in meters.

1.8 Data Collection and Validation

The spatial and non spatial data related to water resource planning and management are essentially required. Insufficiency, inconsistency data, gap/non availability of data and error data give wrong prediction on water resources assessment and it is necessary to validate all relevant data collected. The geodynamic spatial data related to physiography, drainage, geology, geomorphology, land use/land cover, lineament, soil, Digital Elevation Model, etc. have been collected from different sources. Non spatial data such as temperature, evaporation, evapotranspiration, wind speed, sun shine hours, rainfall, groundwater level, water quality, irrigation, environment, socio-economic, health, agricultural, population, livestock, industries, etc. have been collected from the respective Government organizations such as SG&SWRDC, WRD, TWAD Board, Central Ground Water Board, Statistical Department, Animal Husbandry Department, Agricultural Department and Agricultural Engineering Department, Forest Department, respective District Collectorate in the basin, Survey of India, Central Survey and Settlement, TNPCB, Industries etc., for interpretation, analysis and presenting the results in spatial and non-spatial formats.

Space technology data used for interpretation, analysis and mapping for this reappraisal micro level study are as below.

1. IRS Resource Sat IIA, LISS III of March, 2021
2. Aerial Photographs on 1:50000 scale
3. Shuttle Radar Tophography Mission (SRTM) 30 m DEM

1.8.1 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.

1.8.2 Updates and Revisions

The planning process is considered as a continuous effort. The assessment and planning process adopted in previous micro level report is based on the scenario of 2005. 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 the methodology, the 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 micro level planning study, which is proposed for its updating, is presented in **Figure 1.2**

The present report is the state-of-art for the year 2021 which is updated with latest data and analysed with modern technology tools available as on date , will be most useful for the field officers of WRD and all line departments in the Agniyar river basins.

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

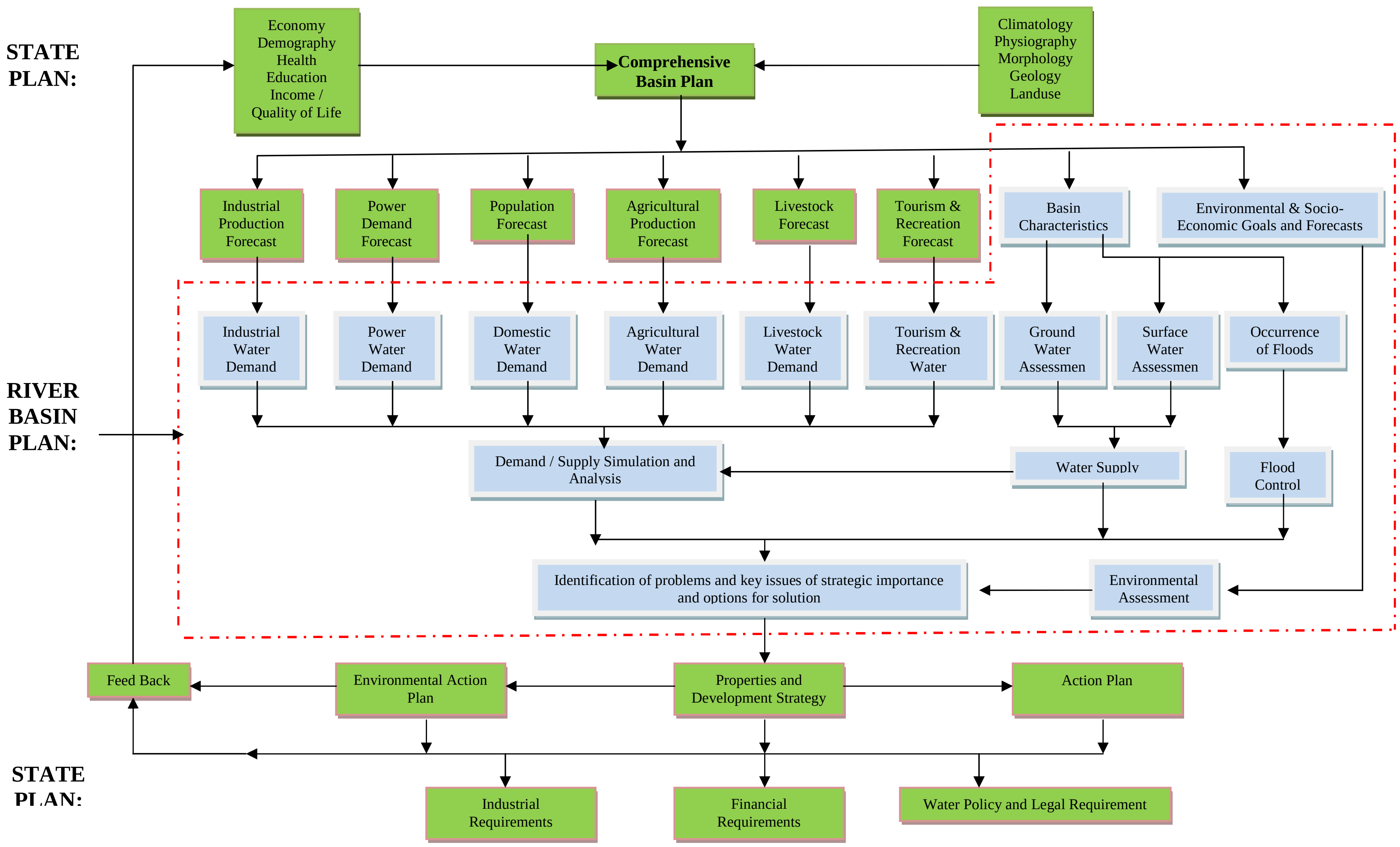
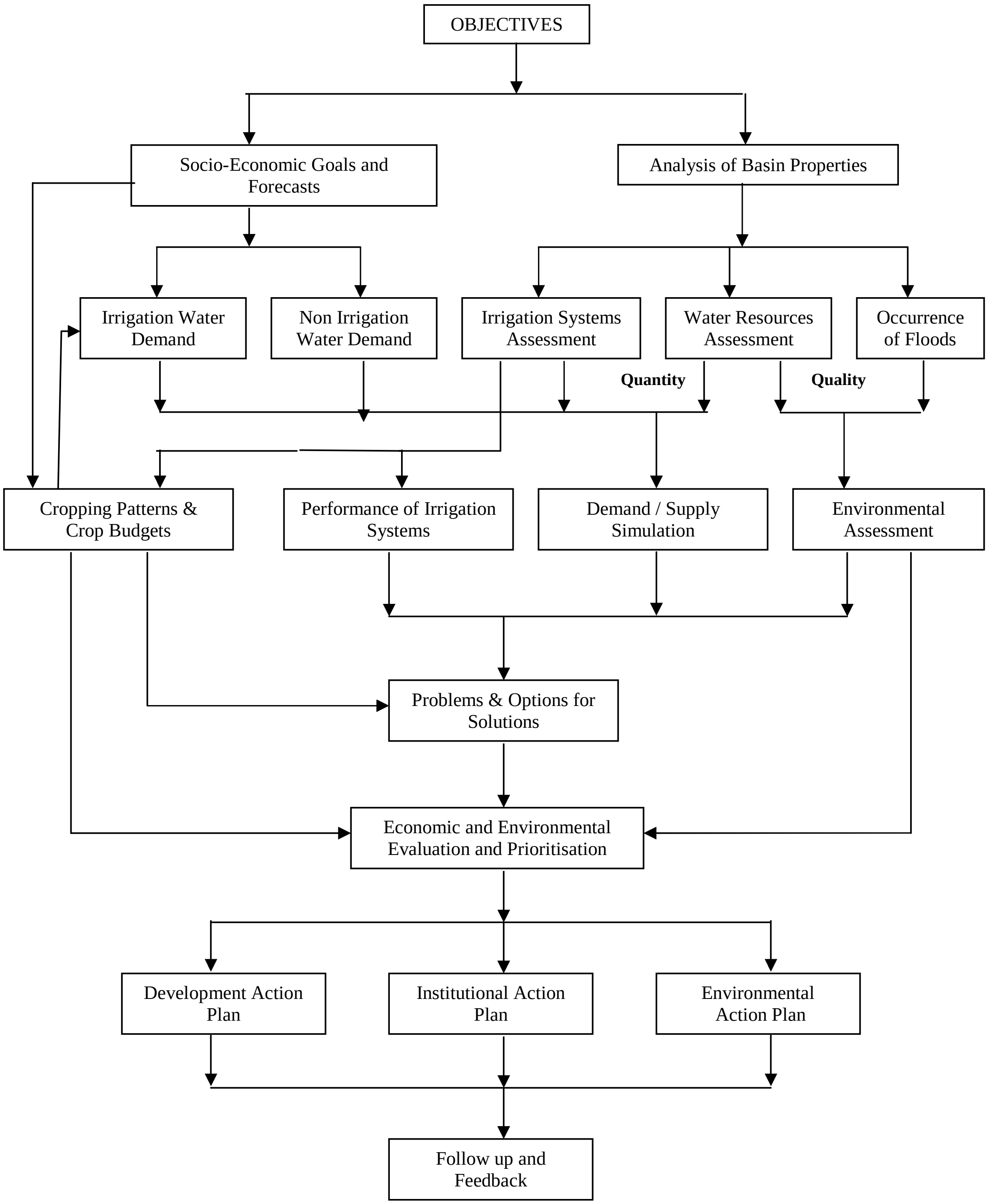


Fig. 1.2 FLOW CHART FOR PRESENT PLANNING STUDY



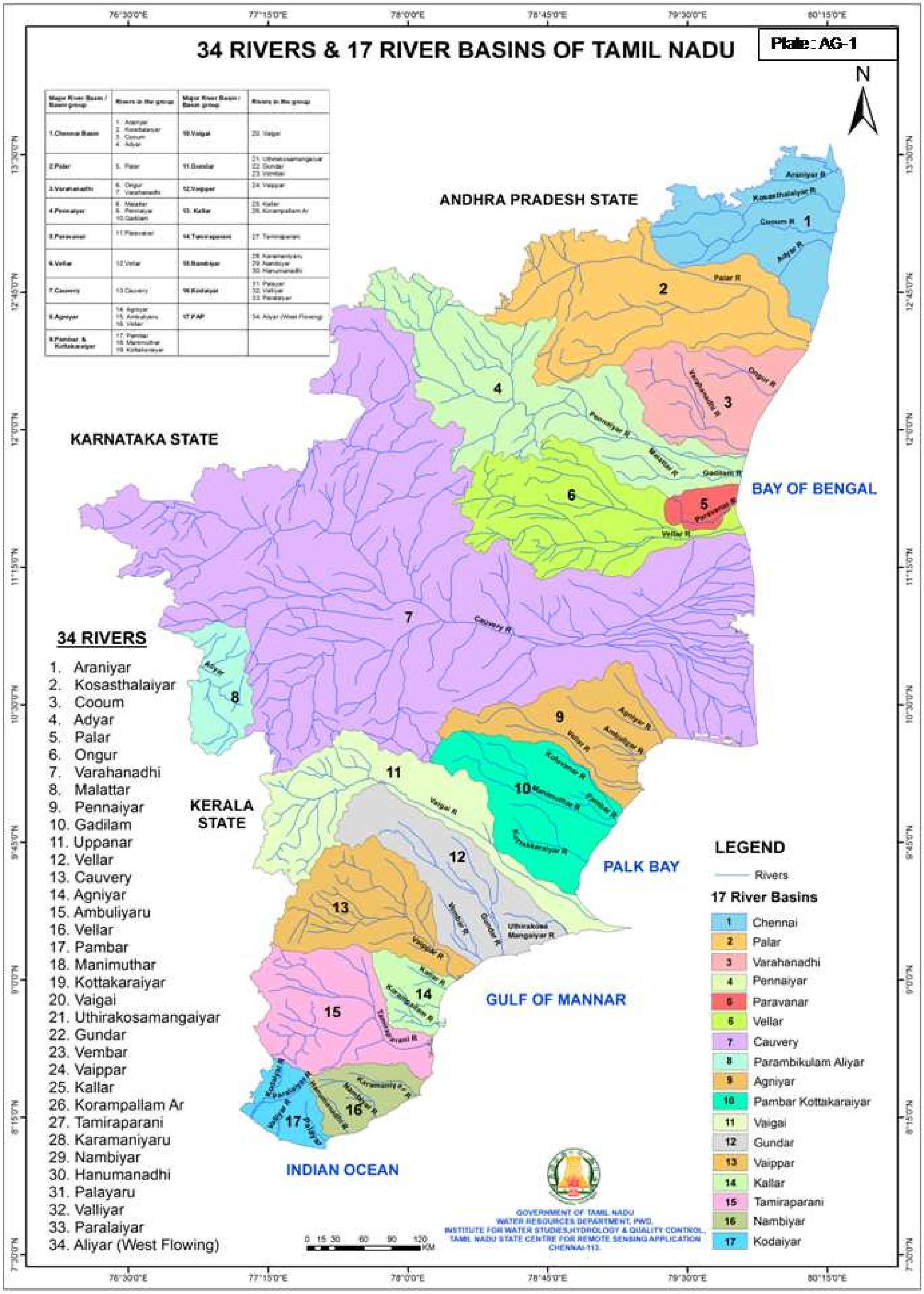

34 RIVERS & 17 RIVER BASINS OF TAMIL NADU
Plate : AG-1
N
ANDHRA PRADESH STATE
KARNATAKA STATE
KERALA STATE
BAY OF BENGAL
PALK BAY
GULF OF MANNAR
INDIAN OCEAN
34 RIVERS
1. Araniyar
2. Kosasthalaiyar
3. Cooum
4. Adyar
5. Palar
6. Ongur
7. Varahanadhi
8. Malattar
9. Pennaiyar
10. Gadilam
11. Uppanar
12. 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
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 : 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

Basin Name	Sub basin.No.	Sub Basin Name
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

Basin Name	Sub basin.No.	Sub Basin Name
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 Brief:

Agniyar Basin is the ninth River basin from North and located in the middle part of the east coast of Tamil Nadu, adjoining the Palk bay. Geographically it spreads from 10^o 44' 32'' N to 9^o 56' 55'' N latitudes to 79^{o}25'21''E to 78^o 16'22'' E longitudes. Agniyar Basin is named after a prominent river named Agniyar that drains in the basin. The Agniyar river basin falls in the Survey of India- Toposheets numbered 58 J/6, 7, 10, 11, 14, 15 &16 ; 58 N/2, 3, 4, 6, 7 & 8 and 58 O/1&2 (1: 50000 scale). The index map of Agniyar basin is shown in Plate AG-2

The basin is bounded by Cauvery River basin in the North and West , Pambar - Kottakaraiyar River basin in the south and west and and Bay of Bengal in the East. The Agniyar river basin covers a geographical extent of 4702 Sq km. Three main rivers draining in the basin ,namely Agniyar, Ambuliyar and SouthVellar respectively form the Agniyar Sub Basin, Ambuliyar Sub Basin and South Vellar Sub Basin. The Agniyar Sub basin is around 2107 Sq km and is the largest among the three sub basins. The South Vellar Sub Basin stretches to around 1770 Sq Km in area. The Ambuliyar Sub Basin sandwiched between Agniyar and South Vellar sub Basins,is the smallest among the three with an area of 826 Sq Km. The South Vellar Sub Basin is the longest among the three.

The three rivers viz., Agniyar, Ambuliyar and South Vellar are non-perennial rivers start as small streams and then flows towards the south eastern direction and drain into the Palk Strait and Palk bay portions of the Bay of Bengal. All the rivers originate and confluence within the State.

Total number of water bodies excluding the streams and rivers are 5471 nos, out of which 1191 are being maintained by Water Resources Department. There is no Dam or Reservoir in the Basin.

2.1.1 Administrative Set up of the Basin:

The Agniyar River Basin spreads across 5 districts of Tamil Nadu namely Pudukkottai, Thanjavur ,Trichirapalli, Sivagangai and Dindigul districts. Pudukkottai and Thanjavur districts occupy a major portion of the basin in the central and eastern part of the basin respectively. Dindigul, Sivagangai and Trichirapalli districts occupy only a small portion in the western part of the basin.

Other major administrative units of Agniyar Basin include **19 Taluks , 25 Blocks, 71 Firkas and 899 Revenue Villages.** The detailed tabulation showing the list of Administrative units with percentage of the area occupied in Sub basins are given in the following tables.

Table 2.1.1. Districts in Agniyar Basin

Sl.No	District	Percentage of District Area falling in Agniyar Basin (in %)	Sub Basin in which the District falls	Percentage of District Area falling in the respective sub basins of Agniyar Basin (in %)
1	Dindigul	0.21	South Vellar	0.22
2	Pudukkottai	66.34	South Vellar	28.99
			Ambuliyar	12.07
			Agniyar	25.33
3	Sivagangai	1.45	South Vellar	1.45
4	Thanjavur	35.17	South Vellar	0.21
			Ambuliyar	7.75
			Agniyar	27.19
5	Trichirapalli	7.62	South Vellar	7.62

Table 2.1.2. Taluks in Agniyar Basin

District	Sl.No	Taluk	Percentage of the Area of taluk falling in the Basin (in %)	Sub Basin in which the Taluk falls	Percentage of the Area of taluk falling in the Sub Basin (in %)
Pudukkottai	1	Alangudy	100.00	Ambuliyar	71.21
				Southvellar	27.45
				Agniyar	1.34
	2	Arantangi	92.76	Ambuliyar	59.10
				Southvellar	33.64
	3	Avadaiyarkovil	19.18	Southvellar	19.18
	4	Gandarvakottai	80.78	Agniyar	80.14
	5	Iluppur	69.69	Southvellar	60.13
				Agniyar	8.93
	6	Karambakudi	100.00	Ambuliyar	5.55
				Agniyar	94.45
	7	Kulathur	63.86	Southvellar	1.22
				Agniyar	62.04
	8	Manamelkudi	82.45	Southvellar	82.27

District	Sl.No	Taluk	Percentage of the Area of taluk falling in the Basin (in %)	Sub Basin in which the Taluk falls	Percentage of the Area of taluk falling in the Sub Basin (in %)
Pudukkottai	9	Ponnamaravathy	70.47	Southvellar	70.44
	10	Pudukkottai	100.00	Ambuliyar	0.92
				Southvellar	20.31
				Agniyar	78.77
	11	Thirumayam	38.36	Southvellar	38.36
	12	Viralimalai	4.26	Southvellar	3.92
				Agniyar	0.08
Thanjavur	13	Orathanadu	55.03	Agniyar	54.63
	14	Pattukkottai	64.50	Ambuliyar	2.82
				Agniyar	61.42
	15	Peravurani	99.31	Ambuliyar	87.01
				Southvellar	1.68
				Agniyar	10.60
	16	Thanjavur	32.04	Agniyar	31.27
Sivagangai	17	Thirupattur	7.14	Southvellar	7.14
Tiruchirappalli	18	Marungapuri	74.25	Southvellar	73.40
Dindigul	19	Natham	1.54	Southvellar	1.48

Table 2.1.3. Blocks in Agniyar Basin

Sl.No	Block	DISTRICT	Percentage of Area of the Block falling in Agniyar Basin (in %)	Sub Basin in which the Block falls	Percentage of Area of the Block falling in the respective sub basins of Agniyar Basin (in %)
1	Annavasal	Pudukkottai	81.91	Agniyar	24.94
				South Vellar	56.97
2	Aranthangi	Pudukkottai	100.00	Ambuliyar	96.46
				South Vellar	3.54
3	Arimalam	Pudukkottai	50.88	South Vellar	50.88
4	Avudayarkovil	Pudukkottai	24.81	South Vellar	24.81
5	Gandarvakottai	Pudukkottai	80.50	Agniyar	80.50
6	Karambakkudi	Pudukkottai	100.00	Ambuliyar	3.07
				Agniyar	98.06

Sl.No	Block	DISTRICT	Percentage of Area of the Block falling in Agniyar Basin (in %)	Sub Basin in which the Block falls	Percentage of Area of the Block falling in the respective sub basins of Agniyar Basin (in %)
7	Kunnandarkovil	Pudukkottai	72.00	Agniyar	72.00
8	Madukkur	Thanjavur	2.86	Agniyar	2.86
9	Manamelkudi	Pudukkottai	80.82	South Vellar	80.82
10	Ponnamaravati	Pudukkottai	70.33	South Vellar	70.33
11	Pudukkottai	Pudukkottai	100.00	Ambuliyar	0.91
				Agniyar	79.73
				South Vellar	19.36
12	Tirumayam	Pudukkottai	28.27	South Vellar	28.27
13	Tiruvarangulam	Pudukkottai	100.00	Ambuliyar	61.07
				Agniyar	3.87
				South Vellar	35.06
14	Viralimalai	Pudukkottai	3.68	Agniyar	0.82
				South Vellar	2.86
15	Orattanadu	Thanjavur	37.23	Agniyar	37.23
16	Pattukkottai	Thanjavur	74.31	Agniyar	74.31
17	Peravurani	Thanjavur	72.84	Ambuliyar	32.93
				Agniyar	39.91
18	Sethubavachatram	Thanjavur	100.00	Ambuliyar	56.02
				Agniyar	34.31
				South Vellar	2.61
19	Thanjavur	Thanjavur	27.86	Agniyar	27.86
20	Tiruvonam	Thanjavur	98.33	Agniyar	98.33
21	Nattam	Dindigul	2.28	South Vellar	2.28
22	Manaparai	Trichirapalli	1.23	South Vellar	1.23
23	Marungapuri	Trichirapalli	77.17	South Vellar	77.17
24	Semmampattipudur	Sivagangai	38.87	South Vellar	38.87
25	Tiruppattur	Sivagangai	0.11	South Vellar	0.11

The Map showing Districts and Taluks of Agniyar is given in Plate AG-3. The District wise Blocks falling in agniyar is shown in Plate AG-4.

Table 2.1.4 Firkas in Agniyar Basin:

Sl.No	Firka	Taluk	District	Percentage of Firka area falling in Agniyar Basin (in %)	Sub basin in which the Firka falls	Percentage of Firka area falling in the respective Sub basin (in %)
1	Adirampattinam	Pattukkottai	Thanjavur	100.00	Agniyar	100.00
2	Alangudi(P)	Alangudy	Pudukkottai	100.00	Agniyar	9.60
					Ambuliyar	90.40
3	Andikkadu	Pattukkottai	Thanjavur	100.00	Agniyar	98.53
					Ambuliyar	1.47
4	Aranthangi	Arantangi	Pudukkottai	79.23	Ambuliyar	23.70
					South Vellar	55.53
5	Arasamalai	Ponnamaravathi	Pudukkottai	98.01	South Vellar	98.01
6	Arasarkulam	Arantangi	Pudukkottai	100.00	Ambuliyar	100.00
7	Athani	Arantangi	Pudukkottai	100.00	Ambuliyar	35.73
					South Vellar	64.27
8	Avanam	Peravurani	Thanjavur	100.00	Agniyar	17.73
					Ambuliyar	82.27
9	Avudaiyarkoil	Avadaiyarkovil	Pudukkottai	75.97	South Vellar	75.97
10	Eachankottai	Orathanad	Thanjavur	100.00	Agniyar	100.00
11	Gandarvakottai	Gandarvakottai	Pudukkottai	55.31	Agniyar	55.31
12	Ilayathakudi	Tiruppattur	Sivagangai	0.00	South Vellar	0.00
13	Illuppur	Iluppur	Pudukkottai	39.01	Agniyar	0.23
					South Vellar	38.78
14	Kallakkottai	Gandarvakottai	Pudukkottai	100.00	Agniyar	100.00
15	Karaiyur	Ponnamaravathi	Pudukkottai	94.31	South Vellar	94.31
16	Karambakudi	Karambakudi	Pudukkottai	100.00	Agniyar	100.00
17	Kavalipatti	Orathanad	Thanjavur	100.00	Agniyar	100.00

Sl.No	Firka	Taluk	District	Percentage of Firka area falling in Agniyar Basin (in %)	Sub basin in which the Firka falls	Percentage of Firka area falling in the respective Sub basin (in %)
18	Keelanilai	Tirumayam	Pudukkottai	23.59	South Vellar	23.59
19	Keeramangalam	Alangudy	Pudukkottai	100.00	Ambuliyar	100.00
20	Keeranur	Kulathur	Pudukkottai	96.48	Agniyar	96.48
21	Killukkottai	Kulathur	Pudukkottai	16.94	Agniyar	16.93
22	Kodumbalur	Viralimalai	Pudukkottai	9.69	South Vellar	9.69
23	Kottaipattinam	Manamelkudi	Pudukkottai	56.63	South Vellar	56.63
24	Kottur(P)	Tirumayam	Pudukkottai	59.91	South Vellar	59.91
25	Kudumiyanmalai	Iluppur	Pudukkottai	100.00	Agniyar	0.01
					South Vellar	99.99
26	Kunnandarkoil	Kulathur	Pudukkottai	93.62	Agniyar	93.62
27	Kurichi(T)	Pattukkottai	Thanjavur	100.00	Agniyar	100.00
28	Kuruvikarambai	Peravurani	Thanjavur	100.00	Agniyar	27.47
					Ambuliyar	72.53
29	Madukkur	Pattukkottai	Thanjavur	3.00	Agniyar	3.00
30	Malaiyur(P)	Karambakkudi	Pudukkottai	100.00	Agniyar	95.22
					Ambuliyar	4.78
31	Manamelkudi	Manamelkudi	Pudukkottai	93.18	South Vellar	93.18
32	Marungapuri	Marungapuri	Tricuchirapalli	67.27	South Vellar	67.27
33	Mathoor	Kulathur	Pudukkottai	7.79	Agniyar	7.79
34	Nagudi	Arantangi	Pudukkottai	100.00	Ambuliyar	36.63
					South Vellar	63.37
35	Nambivayal	Pattukkottai	Thanjavur	100.00	Agniyar	100.00
36	Nanjikottai	Thanjavur	Thanjavur	58.81	Agniyar	58.80

Sl.No	Firka	Taluk	District	Percentage of Firka area falling in Agniyar Basin (in %)	Sub basin in which the Firka falls	Percentage of Firka area falling in the respective Sub basin (in %)
37	Narthamalai	Kulathur	Pudukkottai	100.00	Agniyar	92.02
					South Vellar	7.98
38	Nerkuppai	Tiruppattur	Sivagangai	0.56	South Vellar	0.56
39	Orathanad	Orathanad	Thanjavur	22.81	Agniyar	22.82
40	Panapatti	Manapparai	Tricuchirapalli	0.04	South Vellar	0.04
41	Pattukkottai	Pattukkottai	Thanjavur	95.52	Agniyar	95.52
42	Peravurani	Peravurani	Thanjavur	100.00	Ambuliyar	100.00
43	Perumagalur	Peravurani	Thanjavur	100.00	Ambuliyar	90.41
					South Vellar	9.59
44	Perumaruthur	Manamelkudi	Pudukkottai	70.15	South Vellar	70.15
45	Ponnamaravathy	Ponnamaravathi	Pudukkottai	19.89	South Vellar	19.89
46	Ponpette	Avadaiyarkovil	Pudukkottai	0.15	South Vellar	0.14
47	Poovathakudi	Arantangi	Pudukkottai	100.00	Ambuliyar	100.00
48	Pudukkottai	Pudukkottai	Pudukkottai	100.00	Agniyar	48.81
					Ambuliyar	0.55
					South Vellar	50.64
49	Pudunagar	Gandarvakottai	Pudukkottai	91.60	Agniyar	91.60
50	Sendurai	Nattam	Dindigul	7.45	South Vellar	7.45
51	Sengeerai	Tirumayam	Pudukkottai	56.69	South Vellar	56.69
52	Silattur	Arantangi	Pudukkottai	90.63	Ambuliyar	48.84
					South Vellar	41.79
53	Sillathur	Orathanad	Thanjavur	100.00	Agniyar	100.00
54	Ulur	Orathanad	Thanjavur	5.51	Agniyar	5.51

Sl.No	Firka	Taluk	District	Percentage of Firka area falling in Agniyar Basin (in %)	Sub basin in which the Firka falls	Percentage of Firka area falling in the respective Sub basin (in %)
55	Sinkavanam	Manamelkudi	Pudukkottai	100.00	South Vellar	100.00
56	Sithanavasal	Iluppur	Pudukkottai	100.00	Agniyar	47.98
					South Vellar	52.02
57	Thambikkottai	Pattukkottai	Thanjavur	21.83	Agniyar	21.83
58	Thekkur	Orathanad	Thanjavur	100.00	Agniyar	100.00
59	Thirumayam	Tirumayam	Pudukkottai	0.49	South Vellar	0.49
60	Thondarampattu	Orathanad	Thanjavur	41.13	Agniyar	41.13
61	Thuvarangurichi	Marungapuri	Tricuchirapalli	75.54	South Vellar	75.54
62	Thuvarankurichi	Pattukkottai	Thanjavur	60.68	Agniyar	60.68
63	Tiruchitrambalam	Pattukkottai	Thanjavur	100.00	Agniyar	70.03
					Ambuliyar	29.97
64	Valanadu	Marungapuri	Tricuchirapalli	79.14	South Vellar	79.14
65	Vallam	Thanjavur	Thanjavur	42.94	Agniyar	42.94
66	Vallanadu	Alangudy	Pudukkottai	90.89	Ambuliyar	32.85
					South Vellar	58.04
67	Varappur	Singampunari	Sivagangai	37.97	South Vellar	37.97
68	Varappur(P)	Pudukkottai	Pudukkottai	100.00	Agniyar	98.77
					Ambuliyar	1.23
69	Veerapatty	Iluppur	Pudukkottai	52.79	Agniyar	12.55
					South Vellar	40.24
70	Vennavalkudi	Alangudy	Pudukkottai	100.00	Ambuliyar	45.13
					South Vellar	54.87
71	Virachilai	Tirumayam	Pudukkottai	33.71	South Vellar	33.71

The Firkas falling in agniyar basin is shown in Plate AG-5

Villages in Agniyar Basin:

The Agniyar basin is comprising over 899 villages .The list of Villages falling in the Agniyar basin is given in annexure 2.1

The map of Villages in Agniyar are shown in Plate AG- 6

2.1.2 Major Places in Agniyar Basin:

Agniyar basin is a home to important towns like Anandur, Kottaipatti, Marungapuri, Karakottai, Kurumbur, Thiruchittrambalam, Kulipirai and Pudukkottai. The famous ancient Jain Cave Complex “Sittannavasal” is located in Pudukkottai. The towns Thiruchittrambalam and Pattukottai are famous for their ancient sculptures and temples.

2.1.3 Transport Network:

Transport in the Agniyar Basin is supported by a well connected network of National Highways and State Highways that connect major cities and towns in the basin. The significant ones are the East Coast Road, Kovalam Road, Avinashi Road, National Highways: NH 45B, NH 226 and State Highways SH 71, SH 99, SH28, H 201. Also a network of railways run through the basin connecting major Railway Stations such as Pattukottai, Pudukkottai, Keeranur .The transport network map of the basin is shown in Plate AG-7

2.2 Physiography

Physiography (**Plate** AG-**8)** is the study of terrain morphology of an area which include major hills and valleys with elevation details such as contours, spot heights, slope, river systems and forest cover etc. These physiographic features are derived for Agniyar 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 +842 m AMSL and +1 m AMSL and the mean elevation is +422 m AMSL. The highest elevation (+842 m AMSL) is observed at Vellamalai reserved forest, Trichirapalli district at western side of the basin. The lowest elevation (1 m AMSL) is observed at Thanjavur District, east near the cost of the river basin.

The basin area is covered by hills with reserved forests at the west and most of the central portion. Varous hillocks are spread over the basin.

2.2.1 Topographical trend

The terrain trends from west to east where the maximum contour is 760 m and minimum of 20 m. Hence the rivers in the area are east flowing and confluences in Bay of Bengal.

2.2.2 Gradient

Gradients for Agniyar 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 Agniyar sub basin has four rivers viz., Nasuvunni R, Maharajasamudram, Agniyar R and Kattar R. The north most Nasuvunni R flows for a distance of 40.65 Km and the gradient along the river is 0 to 1.8 m/km. The gradient of Maharaja samudram River which flows for 60.32 Km is 0 to 2.8 m/Km. The Agniyar River flows in a gradient of 0 to 2.16 m/Km for a distance of 62.17 Km. The southernmost river in the sub basin, Kattar River flows in the gradient of 0 to 1.5 m/Km for 8.57 km before confluences into the sea.

The Ambuliyar sub basin is drained by Punaikkuttai R, Ambuliyar R, Velunniyar R and Tedakkiar R. The respective length and gradient of Punaikkuttai R are 20.25 km and 0 to 1.52 m/Km. The same for Ambuliyar R are 34.67 Km and 0.012 to 1.67 m/km. The Velunniyar R flows for 25.5 Km and the gradient of the terrain along river ranges from 0.019 to 0.13 m/km. the Tedakkiar R has a river course of 9.96 Km and the gradient ranges from 0 to 0.081 m/Km.

The South Vellar Sub Basin has Kundar R, Vellar R and Karai Ar. The Kundar R (14.38 Km) flows in gradient of 0.069 to 2.1 m/ Km before confluences with Vellar R. The longest river in the basin, Vellar R flows for 106.5 Km and the gradient ranges from 0 to 2 m/Km. The shortest river, Karai Ar (3.62 km) flows at gradeient of 0.07 to 0.15 m/km.

2.2.3 Hills and Reserve Forest

The western part of the Agniyar sub basin is covered by Narthamalai, Sembattur, Vaittukoil, Virakkudi, Perungalur East, Perungalur west, Malaiyur, Maniyachchi, Nemmeli, Varappur, Tudiyamparai, Sunakkaiveeran pathai, Mangottai and Komapuram Reserved forests. Part of Chinnavalakkattu, Periyavalakkattu reserved forests are falling in the sub basin where and they forms the subbasin boundary between agniyar and south velar subbasins.

In Ambuliyar sub basin, Pannikuzhikkadu Reserved forest falls completely within the subbasin whereas Thiruvarungulam, Vennavalkudi and Kurumbur Reserved forests falls partly in the sub basin and the rest covers south velar subbasin forming subbasin boundary.

The western portion of South Vellar Sub basin comprises part of Kumarikatti, Ayyalur, Sendurai, Vellimalai, Karumalai, Marungapuri, Vembanur and Mangalattu malai reserve forests. These reserved forests are located on the respective hills and are forming the ridge (elevation boundary) for the basin. Kayamalai, Palaiyam, Valandu, Ichamalai, Thachamalai, Tenipillaiyar Malai and Periya malai reserve forests are completely falling in the sub basin. In the middle Sengirai, Vellar Reserved forests and part of Chinnavalakkattu, Periyavalakkattu, Thiruvarungulam, Vennavalkudi and Kurumbur Reserved forests are located.

Following is a graphical representation of the hills and reserved forests fall in each subbasins.

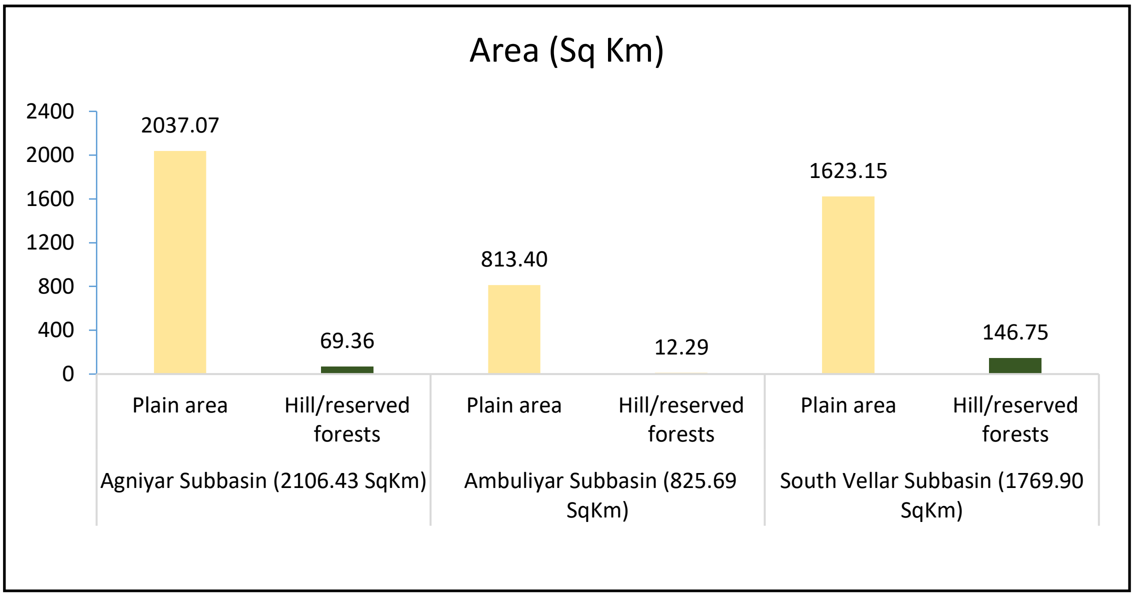


Fig. 2.2.1 Plains, Hills and Reserved forest area in Sub Basins

2.3 Drainage System

A **drainage system** can be defined as the pattern formed by the rivers, streams and tanks, ponds, lakes in a particular basin. They are governed by the topography of the land, whether a particular region is governed by hard or soft rocks, and the slope of the land. In Agniyar river basin, Agniyar, Ambuliyar and Vellar are the major rivers draining the area and confluence with Bay of Bengal. Eight tributaries are contributing waters to the three major rivers. A drainage system is derived and mapped (Plate AG- 9) from Survey of India topo sheets on 1:50000 scale.

The Grand Anicut Canal (G.A. Canal) enters this basin near Uanchimansalai and end with Kanalvayal tank. The total length of G.A. Canal including its extension is 98.07 Km. Rajamatam canal off-take from G.A. canal at in the west of Aliyavaykkal Therkunattam routed in this basin through Pattukottai upto Narasingapuram. The total length of the Rajamatam canal is 46.11 Km. Naduvikottai canal off-take from G.A.Canal distribute water in the basin by running a distance of 9.71 Km. Olavayal branch canal from G.A canal near Karuppattipatti runs in this basin for a distance of 27.49 Km and end in Agambadiyatteru village. Pudupattinam canal off-take from G.A. canal near Suryanarayanapuram distribute water for a distance of 21.09 Km upto Umattanadu tank. Alivalam branch canal is offtaking from G.A. canal at Uranikadu carrying water for a distance of 16.56 Km upto Kalugapallkadu village. Ammani Chattram Canal is running from G.A. canal upto Solaikadu village at a distance of 15.13 km. Anavayal canal off-take from G.A. canal in the south of Arasakulam and runs about 12.2 Km upto Rudrachintamani tank.

2.3.1 Agniyar Sub Basin

The Agniyar sub basin is the first sub basin geographically formed by southwestern portion of the basin having an aerial extent of 2106.43 Sq.Km Kattar/Nasuvunni, Kattar, Maharajasamudram and Agniyar rivers drain in this sub basin ((Plate AG- 10).

In this sub basin surplus course of a tank in the east of Aliyavoykkal Terkunattam form a river Kattar and run through Chozhagankarai tank. The river is very narrow in between Vedanayakipuram and Kattarikollai villages and below that the river gain the broad width and called as Nasuvunni river running towards south east from north and finally confluence with Bay of Bengal in the south of Maravakadu. The total length of the river is 39.97 km.

A right arm (6.39 Km) originates near east of Kaduviranpatti and a left arm (9.09 Km) originates near Vallam and west of Pudupatti, and join together near Karungulam and form a Kattar river and join with Maharajasamudram river near west of Avichchikanpatti. The total length of the river is 11.49 Km from the origin point at left arm to the joining point with Maharajasamudram river.

The right arm of Maharajasamudram river originates from the surplus course of Mattangal tank. The length of the right arm is 14.48 Km. The left arm of the Maharajasamudram river originates in the west of Parukkaividudi and joins with the river near Kirattur. The length of the left arm is 5.41 Km and The water drained from Naduvikkottai branch canal and surplus water from Alivalam tank form an another right arm to the river. The Maharajasamudram river running from north to south east and joins with Agniyar river in the west of Tokkalikkadu after running 62.25 Km from the origin of Mattangal tank. This river almost running parallel to Nasuvunni river.

The river Agniyar originates from the surplus course of Kulattur tank and confluence with Bay of Bengal near Kilathotam after running a distance of 102.67 Km from its origin at Kulattur tank. Agniyar river running towards south east upto Malatur RF and take the direction towards east and from Valateru village, the river turns towards south and running in the direction of south east upto its confluence point.

Kattar another river originates from the surplus course of a big tank in the west of Vilakkuvattikadu and confluence with Bay of Bengal in the south of Selvanayakkanpattinam. This river also running towards south east direction. The total length of this river is 10.88 Km.

In this sub basin the popular Grand Anicut canal (GA Canal) enters at Uchimansolai crosses the river Maharajasamudram river at 23.18 km, Agniyar river at 43.5 Km by a syphon aqueduct from the entering location in the sub basin.

2.3.2 Ambuliyar Sub Basin

The total area of the Ambuliyar sub basin is 825.69 Sq.Km. Five rivers namely, Punaikuttiyar, Ambuliyar, Velunniyar, Perumagalur Ar and Tedakkiar are wetted in this sub basin (Plate AG-11).

Punaikuttiar river a left arm tributary of Ambuliyar river originates from the surplus course of Adidravidarkulam in Krishnapuram village located in between Neduvasal and Chittukkadu. This river runs towards south from north and joins with Ambuliyar river in the south east of Periyakattikottai at a distance of 18.13 Km from its origin.

The Ambuliyar begins as the outflow of Karumenikulam in Kilattur village east of the town of Alangudi. From its source the river flows southeast, passing the town of Kottamangalam and west of Keeramangalam, the Ambuliyar is joined on its right bank by the Velluniyar river, its largest tributary, which flows into the Ambuliyar from the west. Almost immediately past this confluence, the Ambuliyar is joined on its left bank by the Punakkuttiyar river, which flows into it from the north. After this confluence, the Ambuliyar flows towards east until it empties into the Palk Strait in between Amman Chattram and Sembaippattinam., forming a small estuary. The river runs for a total length of 35.22 Km.

Velunniyar river the right arm tributary of Ambuliyar originates from the outflow of Tirunalur tank. The river runs towards east upto Panagulam afterwards, it take the course towards south upto Ayangudi then it turns to south east and joins with Ambuliyar river in the south east of Periyakattikottai after travelling a distance of 27.34 Km.

The Maruthankudiyar also called as Perumagalur river originates from the outflow of Kurumbadu and Rajendrapuram tanks runs towards north east upto Vilanattuvayal and then it turn towards east and joins with Velunniyar river at a distance of 17.11 Km from its origin in the north east of Pokkankadu.

Tedakkiyar river in the Ambuliyar sub basin originates from Tedakki and Kukkur tanks. This river runs towards south east and empty into Palk Strait in the east of Suppama Chatram after traveling a distance of 14.68 Km.

The G.A. canal enters in this sub basin near Suriyanarayanapuram and crosses the rivers Ambuliyar at a distance of 10.52 Km, Velunniyar at a distance of 20.55 Km and Maruthangudiyar/Perumagalur at a distance of 26.52 Km from the entering point and cross this Ambuliyar sub basin at Nakkudi. The total length of the G.A. Canal in this sub basin is 44.35 Km. The Pudupattanam canal runs about 18.79 Km and end with Marakayanvalasu tank in this sub basin. Tiruvappadi canal from G.A. canal runs a distance of 13.61 Km to feed water for Karuppattikadu.

2.3.3 South Vellar Sub Basin

South Vellar sub basin has an area of 1769.90 Sq,Km, which is drained by four rivers namely Narasingar river, Kondar river, Kundar river, Vellar river and Karaiyar river (Plate AG- 12). Among these Kundar and Kondar rivers are the tributary of Vellar river. Vellar river coined the name of South Vellar for separately identification from the Vellar river which is draining in the northern part of Tamil Nadu.

Narasingar river is originating from the surplus waters of Pakkathi Eri in Kilkudi village and confluence with Palk Strait in the north of Jumbumahadevipattinam after travelling a distance of 17.75 Km towards east.

Kondar, a small river originates from the outflow of Kavinad big tank near Tiruvapur joins with Vellar river near Kadayakkudi as a left arm after travelling a distance of 8.63 Km towards south east.

The right arm of Kundar river originates from Karaiyur big tank and left arm originates from Nerinjukudi big tank and so the river also called as Nerinjikudiyar river runs a distance of 16 Km towards east and joins with Vellar river in the north of Kummangudi.

The surplus course of Minaveli big tank through the Vembanur big tank form the Vellar/South Vellar river runs towards south upto the joining point of the Kundar river in the right arm. The river then turns towards south east upto the joining point of the river Kondar in the left arm, after that the Vellar river take its course towards south upto Vadakkalur and it turns towards east till its confluence with Palk Strait in between Manpalai Pattinam and Vadakku Amma Pattinam. The total length of the Vellar river is 116.18 Km and it passes through the major towns such as Arimalam, Aranthangi and Avudaiyarkovil.

Karaiyar a small river drains in the lower part of the South Vellar sub basin originates from the surplus course of Karakattikkottai tank and runs towards south for a distance of 4.67 Km and confluence with Palk Strait in the west of Kottaipattinam.

Extension G.A. canal enter in the South Vellar sub basin at Nakkudi and end with Munpalai tank. The total length of the G.A.canal in this sub basin is 24.71 Km. The Amman Chatram canal designated to feed water upto Tiruvattevan tank. The total length of this canal from G.A.Canal is 15.13 Km.

2.4 Drainage Morphometry

Drainage basin or a watershed refers to the entire area providing runoff to and sustaining part or all of the stream flow of, the main stream and its tributaries. Quantitative analysis of drainage network within a basin or watershed can throw light upon the form and predominant processes in them, a knowledge which is indispensible for planning relating to watershed management, floods, soil erosion, mass movement, neotectonic activities, surface and groundwater, derivation of hydrographs and understanding discharge characteristics of ungauged stream, ecology, etc. The description of drainage network within a basin which was purely qualitative was transferred into a rigorous quantitative science capable of providing numerical data of practical value by Horton (1932, 1945). The study has been carried out with topographic maps and other related data such as geology and Digital Elevation Model (DEM) of Shuttle Radar Topography Mission (SRTM). The Remote Sensing and Geographical Information System (GIS) technology has taken the morphometry analysis to the advance level to understand the form and processes of the drainage basins. The inhabitants of the study area depend upon the streams that flow through the basin for catering their water needs. The rain water that flows through the streams is the major source of water flow for the important rivers.

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. The sub basin wise morphometric analysis is carried out in following heads:

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

The morphometry analysis is followed by the mapping of drainage network from the Survey of India’s topographic sheets of 1:50,000 scale. For identity purpose, the name of the rivers that flows through the basins was assigned to the each of the sub basins. Later, the stream networks within each of the sub basins were digitized using GIS software. The widely used Strahler’s method of stream ordering was followed for ordering the streams in the sub basin. GIS software was utilized to calculate/measures number of streams, length of streams, area, perimeter and length of Agniyar, Ambuliyar and South Vellar sub basins in Agniyar basin, and elevation ranges and were made use to estimate a number of parameters relating to linear (bifurcation ratio, length ratio), areal (drainage density, stream frequency, shape, length of overland flow, etc.) and relief aspects (relief, relative relief, ruggedness number, etc.) in each of the sub basins of Agniyar basin. These estimations were made use to understand the form and dominant processes within each of the sub basins of Agniyar basin. 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 three sub basins in Agniyar basin were arrived**,** 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. Maximum height (H) is the difference between the maximum elevation and the minimum elevation and, are calculated by extrapolation. Mean elevation for each sub basin also derived by dividing the sum of frequency of each pixel elevation by the total number of pixel in the sub basin. Details of the morphometric parameters are tabulated followed by analysis of the parameters through bivariate plots.

2.4.1 Linear Aspects of the Stream System

Linear aspects of the basins are related to the channel patterns of the drainage network wherein the topological characteristics of the stream segments in terms of open links of the network system (streams) were analysed. The study of linear aspect includes the analysis of stream order, stream number, bifurcation ratio, stream lengths and length ratio. These parameters were estimated for all the sub basins and are shown in **Table 2.4.1.** The results of their analysis and the inferences drawn are discussed in the following section.

Table 2.4.1 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})
Agniyar	1	798			988.55	1.24			
	2	201	3.97		324.29	1.61			
	3	34	5.91		96.32	2.83			
	4	8	4.25		106.2	13.29			
	5	1	8.00	5.53	6.36	6.36	2106.43	0.75	0.52
Ambuliyar	1	315			380.42	1.21			
	2	63	5.00		130.27	2.07			
	3	7	9.00		41.99	6.00			
	4	1	7.00	5.25	5.71	5.71	825.69	0.68	0.47
South Vellar	1	1056			841.03	0.80			
	2	346	3.05		298.22	8.86			
	3	84	4.12		137.26	1.63			
	4	2	42.00	12.29	4.33	2.17	1769.9	0.72	0.84

2.4.1.1 Stream Order (Nu)

Stream ordering, the first step in morphometric analysis of drainage basin analysis, is a measure of the position of a stream in the hierarchy of tributaries (Strahler 1964). As mentioned earlier, for the present study the widely followed Strahler's method of stream ordering has been adopted towards ordering the streams of the drainage network in all the sub basins. Such ordering of the streams is an essential input towards estimating several other drainage morphometric parameters considered for the study. Besides this, it has been used to find out the maximum stream order (the stream segment of the highest order) within each sub basin. This maximum stream order, viz., the trunk stream, through which all the discharge of a watershed finds its outlet, has been used to designate each watershed of the basin area. Among the sub basins of the Agniyar basin, the maximum stream order ranges from fourth order to fifth order. Two sub basins (Ambuliyar and South Vellar) are fourth order watersheds **(Plate** AG- **14 and Plate** AG- **15)** and only one by fifth order (Agniyar) watershed **(Plate** AG- **13).** Apart from its use in designating watersheds, the maximum stream order of the watershed can also be used to designate the trunk stream of the watershed. In general, streams up to third order are designated as headwater streams, from fourth to sixth order they are designated as river. The maximum stream order in all the watersheds of the Agniyar basin area, with ranges from fourth to fifth order implies that the trunk stream in all the watersheds of the study area is a medium stream.

2.4.1.2 Stream Number

Stream number of a watershed refers to the number of stream segments within a watershed. Estimations regarding order wise stream number and total number of streams in each sub basin were made and their analysis shows the existence of wide variation in the total number of streams among the sub basins of the Agniyar basin ranging from 386 (in Ambuliyar) to 2597 (in Agniyar sub basin). The number of stream segments decreases with increasing stream order in all the sub basins of the Agniyar basin. Among the various stream orders, the proportion of first-order streams, constitute bulk of the total number of streams in all the sub basins. It is observed that the lower order streams, viz., both first and second-order streams constitute most of the streams in each watershed. In the study area, the lower order streams are relatively lower in proportion reflects the relatively lesser slope steepness and less quick stream flows.

The total area of the Agniyar sub basin is 2106.43Sq.Km and the water shed has 5th order drainage system **(Plate** AG-**13).** In this sub basin, 798 streams are in 1st order, 201 are 2nd order, 34 are 3rd order, 8 are in 4th order and 1 in 5th order. Total streams in all orders were counted as 1042. In this sub basin parallel drainage pattern has been observed. **Parallel drainage** system is a pattern of rivers caused by steep slopes with some relief. Because of the steep slopes, the streams are swift and straight, with very few tributaries, and all flow in the same direction. Parallel drainage patterns form where there is a pronounced slope to the surface. Parallel drainage patterns **(Fig.2.4.1)** 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**.** The parallel drainage patterns are observed in the south western portion of the sub basin covering Vaittur and Perungalur villages and Kaduviranpatti, Gandarvakottai and Pudupatti villages in the northern part of the basin.

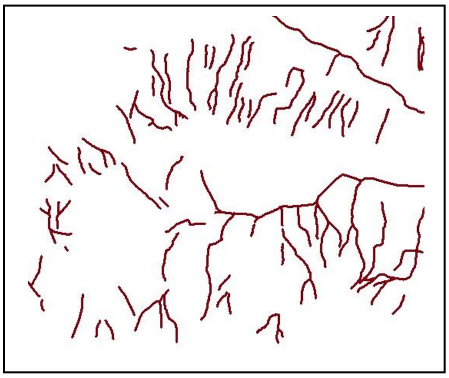


Fig. 2.4.1 Parallel drainage pattern in Agniyar sub basin

The Ambuliyar sub basin has the 4th order drainage system with a total stream segments of 386.The total geographical area of this sub basin is 825.69 Sq.Km. The number of 1st order stream is 315, 2nd order is 63, 3rd order is 7, 4th order is 1segment **(Plate** AG- **14)**. Parallel drainage patterns **(Fig. 2.4.2)** are noticed in the north western part covering Manjamvidudi, Pilappatti and Tavalappallam villages.

Fig. 2.4.2 Parallel drainage pattern in Ambuliyar sub basin

Drainage analysis in South Vellar sub basin reveals that 4th order streams are formed with a total number of 1488 stream segments in this sub basin **(Plate** AG- **15)**. The 4th order has 2 segments, 3rd order has 84, 2nd order has 346 and 1st order 1056 stream segments. In this sub basin dentritic, parallel and radial drainage patterns are observed. Dendritic patterns, which are by far the most common, develop in areas where the rock (or unconsolidated material) beneath the stream has no particular fabric or structure and can be eroded equally easily in all directions. Examples would be granite, gneiss and sedimentary rock that has not been folded. That is, the subsurface geology has a similar resistance to weathering so there is no apparent control over the direction the tributaries take. Tributaries joining larger streams at acute angle (less than 90 degrees). Dendritic patterns in the sub basin are noticed in the Ayyalur and Kumarikatti reserved forest areas in the north eastern part.

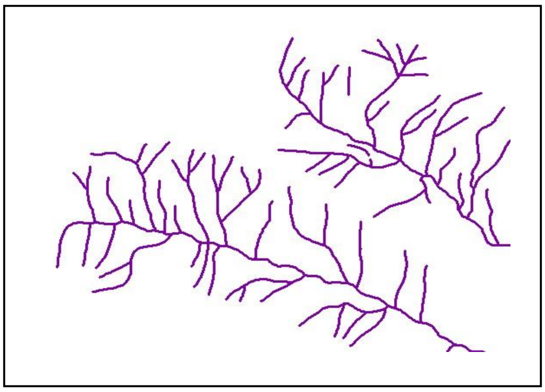


Fig. 2.4.3 Dentritic drainage pattern in South Vellar sub basin

Radial drainage system, develops around a central elevated point. Other geological features on which radial drainage commonly develops are domes and laccoliths. On these features the drainage may exhibit a combination of radial patterns **(Fig.2.4.4).** The radial drainage pattern is observed in the Velamalai reserved forest at an altitude of 847 m MSL in the South Vellar sub basin.

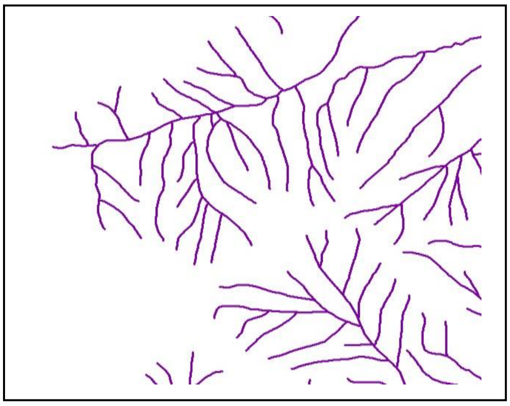


Fig. 2.4.4 Radial drainage pattern in South Vellar sub basin

Parallel drainage patterns also observed in the sub basin in Minaveli, Tirukkattalai and Tiruvarangulam reserved forest area in the sub basin **(Fig.2.4.5).**

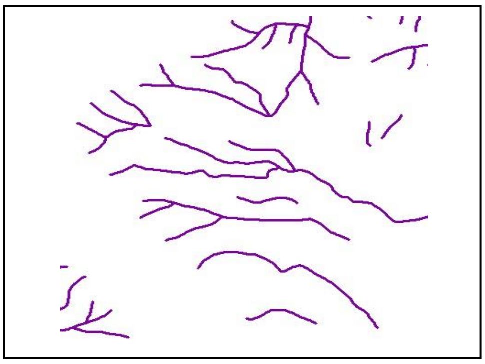


Fig. 2.4.5 Parallel drainage pattern in South Vellar sub basin

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 (Horton, 1945). The number of streams usually decreases in geometric progression as the stream order increases in all the sub basins **(Fig.2.4.6);** the variation in stream order and size of drainage basins is largely depends on physiographical, geomorphological and geological condition of the area.

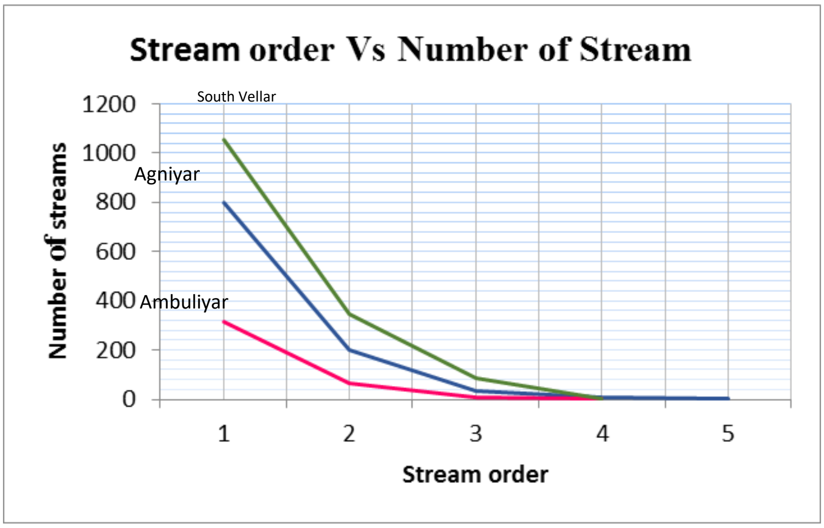


Fig. 2.4.6 Number of streams vs. Stream order

2.4.1.2 Stream Length (Lu)

The length of a stream is the distance measured along the stream channel from the source to a given point or to the outlet. This distance was estimated for all stream orders within a watershed and they were added together to find out the total stream length of the watershed. This measure is an essential input for computing various other morphometric parameters such as mean stream length, drainage density, length of overland flow, etc. The stream length in Agniyar sub basin is 1521.72 Km, Ambuliyar is 558.39 Km and South Vellar is 1280.84 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. 2.4.7)**. As the total stream length is directly related with the mean annual runoff (Morisawa 1962), it can be inferred that the mean annual runoff would be higher in Agniyar and South Vellar watersheds on account of their high total stream lengths, and relatively lower in Ambuliyar sub basin on account of its low total stream lengths.

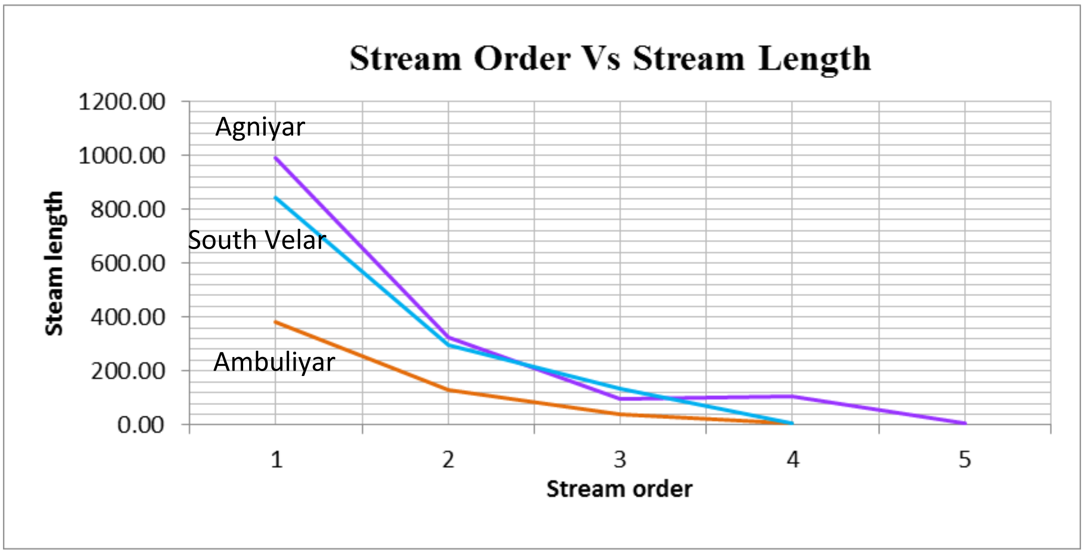


Fig. 2.4.7 Stream length vs. Stream order

2.4.1.3 Mean Stream Length (Lsm)

The mean stream length is a dimensional property, revealing the characteristic size of the components of a drainage network and its contributing basin surface (Strahler 1964). Stream order-wise mean length in each sub basin was obtained by dividing the total length of streams of a particular order by the total number of stream segments of the order. The Lsm values for the Agniyar sub basin ranges from 1.26 to 13.29 Km with the mean Lsm 5.07 Km. In case of Agniyar watershed 5th order mean stream length is abnormally lower than the 4th order mean stream length. This anomaly can be attributed to the distinct variations in slope and topography in the watershed (**Table 2.4.2**). The mean stream length (Lsm) of Ambuliyar sub basin ranges from 1.21 to 6.0 Km and the mean Lsm value is 3.75 km. In this sub basin also

4th order mean stream length is lower than the 3rd order mean stream length. In the South Vellar sub basin, the Lsm value ranges from 0.80 to 2.17 Km and the mean Lsm is 1.36 Km.

2.4.1.4 Bifurcation Ratio (Rb)

The bifurcation ratio (Rb) refers to the ratio of the number of streams of a given order to the number of streams of the next higher order, and it is a measure of the amount of branching in the stream network (Doornkamp and King 1971) within a watershed. Lower the mean bifurcation ratio, greater the branching in the stream network within a watershed and vice-versa. Bifurcation ratio for the various stream orders within a watershed, and the mean Rb value for each sub basin were estimated, and their analysis shows that it distinctly varies among various orders in each watershed, reflecting the variations in local physiography and geological conditions within each watershed. Strahler (1957) has observed that the mean Rb value ranges from 2 to 5 in watersheds with well developed drainage network.

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

The mean bifurcation ratio (Rbm) of Agniyar sub basin is 5.53 (**Table 2.4.2**), which shows the sub basin is affected by geological structures. In Ambuliyar sub basin, the mean bifurcation ratio shows 5.25 and hence this sub basin has not much disturbed by the geological formations. The mean bifurcation ratio (Rbm) of South Vellar sub basin is 12.29 which shows the sub basin is under disturbance of geological features. The average mean bifurcation ratio of Agniyar basin is 7.69 shows that the entire basin area is tectonically active (Somashekar. et.al, 2011).

Apart from serving as an indices to infer the degree of branching of stream network within a watershed, it can also throw light upon the shape of the watersheds: high Rb values reflect elongated shape whereas low values reflect circular or rotund shape (Chow 1964). Assuming precipitation and other controls to be the same, elongate watersheds yield low but extended peak flow whereas rotund watersheds produce sharp peak (Chow 1964; Chorley 1969). In short, the lower the mean Rb of the watershed, the greater the probability of flash flood. In the Agniyar basin the mean Rb is relatively lesser (5.25) in Ambuliyar and Agniyar (5.53)watersheds, and relatively high (12.29) in South Vellar watershed. This implies the relatively greater degree of branching, lesser elongation, and higher flash flood potential of Agniyar and Ambuliyar sub basins, and lesser degree of branching, greater elongation and lesser flash flood potential of South Vellar watershed.

2.4.1.5 Basin Length

Basin length is the longest length of the basin, from the catchment to the point of confluence (Gregory and Walling 1973) and this measure is essential to estimate the shape, and also the relative relief of the watersheds. The length of Agniyar sub basin is 85.21 Km; Ambuliyar length is 49.60 Km and the length of South Vellar watershed is 120.83 Km.

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 2.4.2**.

2.4.2.1 Drainage Density (Dd)

Drainage density refers to the length of streams within a watershed per unit area (Horton 1932). Drainage density is one of the most sensitive and variable morphometric parameters and it has direct relationship with rainfall intensity (Chorley 1957a, b; Chorley and Morgan 1962), rock resistivity (Zavoianu 1985; Gardiner 1996; Sangireddy et al. 2016), mean annual run off (Morisawa 1962), and an inverse relationship with the degree of development of a drainage network within a basin (Horton 1945), infiltration capacity (Horton 1945; Melton 1957), permeability (Strahler 1956; Zavoianu 1985), vegetation cover (Chorley 1957a, b) and texture of landscape dissection and spacing of streams (Chorley 1969). Drainage density affects the runoff pattern, in that a high drainage density removes surface runoff rapidly, decreasing the lag time and increasing the peak of the hydrograph (Chorley 1969).

Drainage density of Agniyar sub basin is 0.75 Km/Sq.Km, Ambuliyar drainage density is 0.68 km/sq.km and South Vellar is 0.72 km/sq.km (**Plate** AG-**16).** From the above described relationship drainage density has with several drainage basin characteristics, it can be inferred that on account of low drainage density, all the sub basins are likely to have lower rainfall intensity, lower rock resistivity, lower mean annual run off, higher infiltration capacity/permeability, higher vegetation cover and are well drained.

The lower drainage density in all three sub basins shows that the basin area underlined by gneiss in major portion followed by pink migmatite and charnockite. Geomorphologically, buried pediment moderate is under lined in major parts of the basin. The lower drainage density is indicative of moderate relief and slope, high infiltration capacity and low water regimes throughout the basin.

2.4.2.2 Stream Frequency (Fs)

The stream frequency is the ratio between the total number of stream segments of all orders in a watershed and the basin/watershed area (Horton 1945). It refers to the number of streams per unit area. Estimation of stream frequency value for the Agniyar sub basin is 0.52, Ambuliyar is 0.47 and South Vellar is 0.84 streams/Sq.Km. Stream frequency is directly related to the degree of dissection (Pankaj and Kumar 2009) and run off (Sujata Biswas and Sudhakar Desai 1999), and inversely related to mean annual rainfall (Morisawa 1962). This implies that sub basins with low stream frequency values are likely to have higher mean annual rainfall and lower degree of dissection and lower run off.

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. Collectively drainage density and drainage frequency can be called drainage texture. 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). 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. The drainage texture values of Agniyar, Ambuliyar and South Vellar is 3.06, 2.07 and 3.11 respectively. These values exhibit that the entire area is under coarse drainage texture.

2.4.2.4 Basin Shape

Basin shape is the direct outcome of the drainage development in a particular basin. Form factor (F), suggested by Horton (1932) as an index for determining the shape of the basin has been made use of for the purpose. It is defined as the ratio of the area of the basin to the square of the length of the basin, and according to Horton (1932), the value of 'F' varies from 0 (for basins with highly elongated shape) to 1 (for a basin with perfect circular shape). 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 Agniyar, Ambuliyar and South Vellar sub basins are 0.59, 0.65, and 0.39 respectively and these values indicate the high relief with steep slope of the terrain that are 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 shape of the watershed influences the way in which floods are formed and move. It is known that floods are formed and travel more rapidly in a circular watershed which implies that and floods are stronger and have a higher velocity (Zavoianu 1985) in such watersheds. This is due to the fact that in a circular basin run off from various parts of the basin reach the outlet at the same time resulting in a shorter lag time and a higher peak flow (Zavoianu 1985; Waugh 1995). In case of elongated basins, the tributaries flow into the main stream at greater intervals of time and space and this broader distribution of flow path lengths and, therefore, a wide range of travel time results in lower peak flow of longer duration. This implies that the food flows are easier to manage in elongated basins whereas in case of circular basins it is difficult to manage. Though the form factor values clearly reflect the absence of a perfectly circular watershed and hence the absence of any highly food prone watershed in the study area, it is possible to identify watersheds which are the least, and moderately prone for flash floods.

The Agniyar and Ambuliyar sub basins having the circularity ratio values of 0.37 and 0.45 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. The lower circularity ratio values for the South Vellar sub basin (0.19) with low elongation ratio (0.39) shows that 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 (Ff)

Form factor (Ff), suggested by Horton (1932) as an index for determining the shape of the basin has been made use of for the purpose. It is defined as the ratio of the area of the basin to the square of the length of the basin, and according to Horton (1932), the value of 'Ff' varies from 0 (for basins with highly elongated shape) to 1 (for a basin with perfect circular shape). 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.

The Ff values of Agniyar and Ambuliyar sub basins are 0.28 and 0.34, which indicates the basins are near-circular. It also indicates higher peak flow in limited times whereas the Ff values of South Vellar sub basin is 0.12. This indicate the sub basin is in elongated shape with less peak flow. The elongated basin with low form factors indicate that the sub basin 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 the product of drainage density and stream frequency, and it reflects the infiltration potential of a watershed. Lower infiltration numbers indicate higher infiltration and lower run-off (Faniran 1968; Das and Mukherjee 2005; Joji et al. 2013; Elewa et al. 2016). All the three sub basins have lower infiltration numbers viz, 0.39, 0.32 and 0.60 This implies that all watersheds with lower infiltration values such as Agniyar, Ambuliyar and South Vellar watersheds infiltration potential is higher.

2.4.2.9 Length of overland flow (Lg)

Length of overland flow which is half the reciprocal of drainage density (Horton 1945) is used to describe the length of flow of water over the ground before it becomes concentrated in definite stream channels. In watersheds with shorter length of overland flow values, rain water will enter the stream relatively quickly, and lesser rainfall is sufficient to contribute a significant volume of surface run off to stream discharge. Also this factor has an important control over lag time (Chorley 1969) due to the fact that the mean velocity of the un-concentrated overland flow is less than concentrated channel flow. Smaller values can cause flooding in days of heavy rain, due to the reduced possibility of water infiltration into the soil (Olszevski et al. 2011). The length of overland values of Agniyar, Ambuliyar and South Vellar are 0.66, 0.73 and 0.69. From the above inferences, it is evident that in all sub basins with shorter length of overland flow values rain water will enter the stream relatively quickly, and lesser rainfall is sufficient to contribute a significant volume of surface run off to stream discharge, and the lag time will be shorter making them flash food prone.

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). It can be expressed as a required minimum area for the maintenance and development of a channel (Dutta and Roy, 2012) and is expressed in Sq.Km/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.

Agniyar sub basin has lowest constant of channel maintenance 1.33 km^2/km with highest value of drainage density (0.75). It means that on an average of 1.33 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. Ambuliyar and South Vellar sub basins show constant of channel maintenance values of 1.47 and 1.39 having drainage density value of 0.68 and 0.72. These higher value of constant channel maintenance in all sub basins indicate that high infiltration capacity, low drainage density and mature geomorphological adjustment prevailed.

2.4.3 Relief Aspects

The relief aspects of the drainage basins are related to the study of the three dimensional features of a basin/watershed involving area, volume and attitude of the vertical dimension of landforms. In short, this refers to the vertical component of a drainage basin. The relief aspects considered for the present study include basin relief, relief ratio and ruggedness number.

2.4.3.1 Basin Relief (Bh)

Relief of the watershed is the elevation difference between mouth and the highest point on the watershed perimeter. As relief possesses direct relationship with potential energy (Strahler 1968), denudation rate (Ahnert 1970), amount of sediment that can be transported (Hadley and Schumm 1961) and discharge rate (Mociornita 1964; Diaconu 1966) of a watershed, it is likely that the potential energy, denudation rate, the amount of sediment transported and discharge rate are likely to be higher in watersheds with higher relief. 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. Agniyar sub basin relief ranges from 4 to 139 m. The relief range of Ambuliyar sub basin is 10 to 130 m, and South Vellar sub basin relief ranges from 10 to 842 m.

2.4.3.2 Relief Ratio (Rh)

It is the ratio between the total relief of the basin and its longest dimension parallel to the principal drainage line. Relief ratio is an indicator of steepness (Schumm 1956), intensity of erosion process (Chopra et al. 2005; Javed et al. 2009; Ajibade et al. 2010), and also a measure of potential energy available to move water and sediment down slope (Sarkar and Gundekar 2007) and is directly related with all these processes. For the watersheds of the study area, the estimated relief ratio values of sub basins Agniyar, Ambuliyar and South Vellar are 1.58, 2.42 and 6.89 respectively. The relief ratio is low in Agniyar sub basin and moderate in Ambuliyar sub basin.. From the interrelationship relief ratio has with the factors discussed above it is likely that steepness, potential energy and the intensity of erosion process are likely to be high in watersheds with high relief ratio in South Vellar. Whereas these factors are likely to be low in Agniyar and Ambuliyar where the relief ratio values are low and moderate in other watersheds on account of their moderate relief ratio values.

2.4.3.3 Ruggedness Number (Rn)

Ruggedness number, the product of relief and drainage density is an index which reflects slope steepness and length. It was estimated using the relationship, Ruggedness Number = ((Drainage Density × Relief)/5280) as suggested by Hart (1986). Extremely high values of the ruggedness number occur when both variables are large, i.e., when slopes are not only steep but long as well (Chow 1964). Further, it is found to be directly proportional to relative peak discharge (Patton 1988). The estimated ruggedness number value for the watersheds of Agniyar, Ambuliyar and South Vellar are 337.5, 81.6 and 599.04 respectively. From the relationship ruggedness number possesses with slope and relative peak discharge put forward by Chow (1964), it is likely that the slopes are steep and long, and also the peak discharge is relatively high in Agniyar, Ambuliyar and South Vellar watersheds, where the estimated ruggedness number value is high.

2.4.4 Inference from Drainage Morphometric Analysis

2.4.4.1 Agniyar Sub Basin

This basin has a 5th order drainage system. The drainage density and infiltration number are high in Agniyar sub basin. The sub basin has near-circular shape with higher peak flow in limited times of flow, high infiltration capacity and flood flows are easier to manage.

2.4.4.2 Ambuliyar Sub Basin

The fourth order drainage system with steep slope and high relief prevailed in Ambuliyar sub basin. It has less drainage density with low stream frequency. The near-circular shape of the basin has higher peak flow. It has lower infiltration number with longer duration of flow.

2.4.4.3 South Vellar Sub Basin

The drainage density, stream frequency and texture ratio are high in this sub basin. The elongated sub basin 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.

The morphometric analysis of Agniyar basin reveals that,

1. Two of the sub basins of Agniyar basin are fourth order and one sub basin is fifth order.
2. The number of streams decreases with increasing stream order in the study area. The lower order (first and second order) streams constitute very high proportion
3. Dendritic, radial and parallel drainage systems prevail in the basin.
4. The distinct variation of bifurcation ratio values among various orders in each sub basin, reflects the variations in local physiography and geological conditions within each sub basin.
5. The average mean bifurcation ratio of Agniyar basin is 7.69 which reveals that the basin is tectonically active.
6. The analysis of mean bifurcation ration values of the sub basins shows that the drainage network in all the sub basins of the study area is well developed. It also shows the relatively greater degree of branching, lesser elongation, and higher flash flood potential

7. Generally the drainage density in the Agniyar basin is low due to the lithological disturbances and the presence of geomorphologic landforms such as shallow and moderate pediments and high infiltration formation.
8. The drainage frequency in the upper part of the basin is higher and in the lower part of the basin low. It clearly indicates that the drainage development in the basin is geologically controlled.
9. Agniyar basin has coarse drainage texture with high infiltration rate which reflect that most part of the basin area has potential zone.
10. The values of relief ratio in the basin indicate the presence of soft rocks in most of the area. 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.
11. The analysis of areal extent of the sub basins shows higher mean annual run off, higher mean discharge, lower sediment yield and lower flood discharge per unit area in Agniyar basin
12. Shorter length of overland flow in the basin implies that rain water will enter the stream relatively quickly, and lesser rainfall is sufficient to contribute a significant volume of surface run off to stream discharge, and the lag time will be shorter making them flash flood prone
13. Longer lag time in this basin implies easier flood management
14. The analysis of infiltration number reveals that infiltration potential is higher in Agniyar basin on account of lower infiltration number values.

2.5 Geology

The study of Geology of the Agniyar basin is primarily based on the District resources maps published by the Geological Survey of India. A Geological map on 1:50,000 scale (Plate AG- 17) was prepared, showing the surface geology of the basin. And also vertical cross section of selected well lithology is prepared for better understanding of various lithounits of the basin (Fig.2.5.4) The tentative stratigraphy of the study area is given hereunder.

Stratigraphy of the Study area

<table>
<tr><th>Lithology</th><th>Age</th><th>Era</th><th>Characteristics</th></tr>
<tr><td>Fluvial, Fluvio-Marine, Aeolian Sediments</td><td>Recent-Pleistocene</td><td>Quaternary</td><td>Soft, Unconsolidated sediments</td></tr>
<tr><td>Laterite</td><td>Early to Middle Pleistocene</td><td>Tertiary</td><td>Soft, Unconsolidated sediments</td></tr>
<tr><td>Sandstone (Cuddalore Formation)</td><td>Mio Pliocene</td><td>Tertiary</td><td>Soft gentle rock formation</td></tr>
<tr><td>Pink granite, Granite Gneiss (Pudukkottai Formation)</td><td>Acid Intrusives</td><td>Proterozoic</td><td>Hard massive rock formation</td></tr>
<tr><td>Hornblende Biotite Gneiss</td><td></td><td rowspan="5">Archaean</td><td>Hard jointed massive rocks</td></tr>
<tr><td>Ultramafics</td><td></td><td>Hard intrusive rocks</td></tr>
<tr><td>Charnockite</td><td></td><td>Hard massive rocks</td></tr>
<tr><td>Quartzite</td><td rowspan="2"></td><td>Hard patches of rocks</td></tr>
<tr><td>Garnet-Sillimanite Gneiss</td><td>Hard massive rocks</td></tr>
</table>

The Agniyar basin is predominantly composed of soft, unconsolidated Quaternary and Tertiary sediments towards eastern, north-eastern and south-eastern reaches of the basin. The western basin area is traversed by hard crystalline rocks of Proterozoic and Archaean era. The basin can be divided into hard and soft rock regions by a contact zone traversing in the middle of the basin. The western reaches of the contact zone is comprised of hard massive rocks recognized as Migmatite Complex, Charnockite Group, Khondalite Group etc. The oldest group of rocks recognized is the khondalite group comprising Garnetiferous Silliminite gneiss with or without graphite, and quartzite. The charnockite group of rocks comprises charnockite and Pyroxene granulite and migmatite quartzite. The khondalite and charnockite group of rocks occur closely associated with each other. The pink granite is occuring as intrusive body in the country rock migmatite complex of proterozoic age. Hornblende biotite gneiss forms the migmatite complex. Hornblende biotite gneiss is the predominant rock type among hard rocks which covers most of the western region of the basin. It widely spreads in and around major locations like Kunnandarkoil, Andakkulam, Vaittur, Tekkattur towards the centre of the basin and Vembanur, Valanadu, Alattur, Melataniyam, Kurumbur, Tenur etc. in the western region of the basin. After that Pudukkottai granite of Proterozoic age, which is made up of pink granite and granite gneiss makes second most dominant hard rock type. It is found in and around Kudumiyamalai, Mangudi, Nachchanndupatti, Namanasamudram, Nartamalai, Perumanadu, Puttambur and Virappatti etc.The pink granite and grey granites are extensively quarried for dimensional stones in and around Nartamalai. The khondalite group comprising Garnetiferous Sillimanite gneiss and charnockite rocks found closely associated with each other along the western most boundary of the basin in locations such as Sevalpatti, Adikaram, Lingampatti, Nattarpatti, Kurumbur etc. Large bands of Quartzites are found as discontinuous patches in the western region near Tovarankurichchi, Kottaippatti, Karisalpatti, Alavayal, Karumalai etc. Ultramafics intrusives is found as a thin band near Idaiyappatti and Valanadu.

The eastern part of the study area is covered by soft, unconsolidated sediments and gentle rocks. Laterite and lateritic soil of tertiary period covers vast stretches of the sedimentary region in the eastern basin area within which isolated patches of Cuddalore sand stone is found to occur. It is found in places such as Varappur, Gandarvakottai, Kottamangalm, Tavalapallam, Raghunathapuram, Perungalur, Malayur, Andanur etc. Another prominent lithology is Sandstone (Cuddalore Formation) which is found towards south of lateritic formation. This tertiary formation comprises pebbly sand stone, grits, ferruginous sandstones capped by lateritic soil. The sand stone formations are good aquifers. Major locations covering cuddalore sandstone are Pinnavasal, Uranikkadu, Tiruchitrambalam, Tuvarangurichchi, Ravusappatti, Poyyundarkottur, Peravurani, Pappanad, Avanam, Kayavur, Pallattur, Marungulam etc. The south and south -eastern region along the coast of the study area is covered by aeolian, fluvial, fluvio marine and marine sediments of Quaternary age. The fluvial sediments are made up of unconsolidated deposits of sand, silt, and clay. The marine deposits of fine to medium sands and black clays are seen as beach, tidal flats, sand bars etc. Aeolian deposits in the form of fine sands occurring along the coast in Kottaipattinam and Kavanur.

Out of the total area of the basin, hard rock occupies 1603.12 sq.km and soft occupies 3098.90 sq.km. The percentage area in the basin comprised by hard rock is 34.09% and soft area is 65.91% .(fig.2.5.1) The minimum area of one particular litho unit is occupied by Ultramafics (Amphibolite,Norite) with an area of 2.98 sq.km (Fig. 2.5.3) and maximum area of 1323.04 sq.km by Laterite. (Fig. 2.5.2).

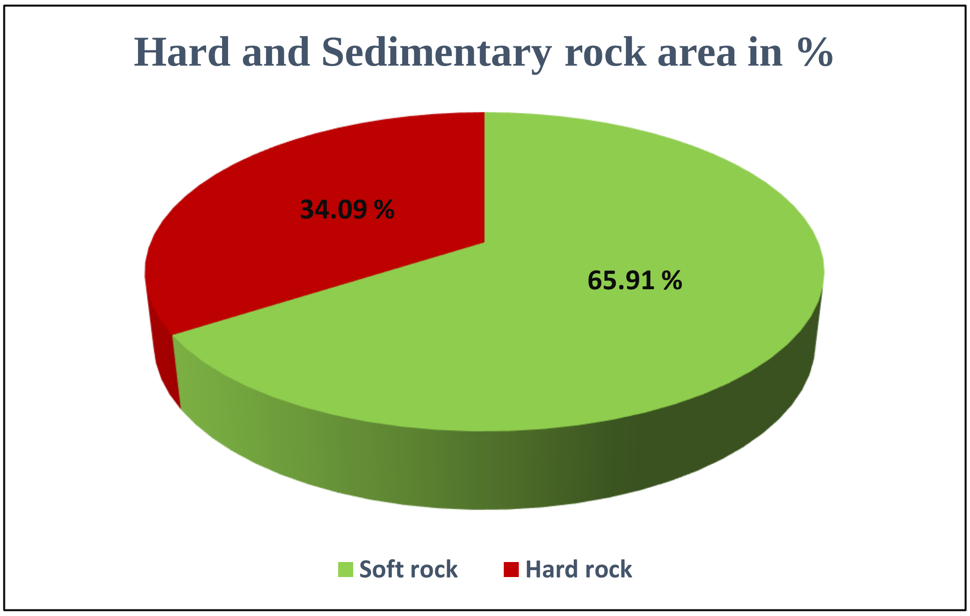


Fig .2.5.1 % of area occupying by hard and sedimentary rocks in the basin

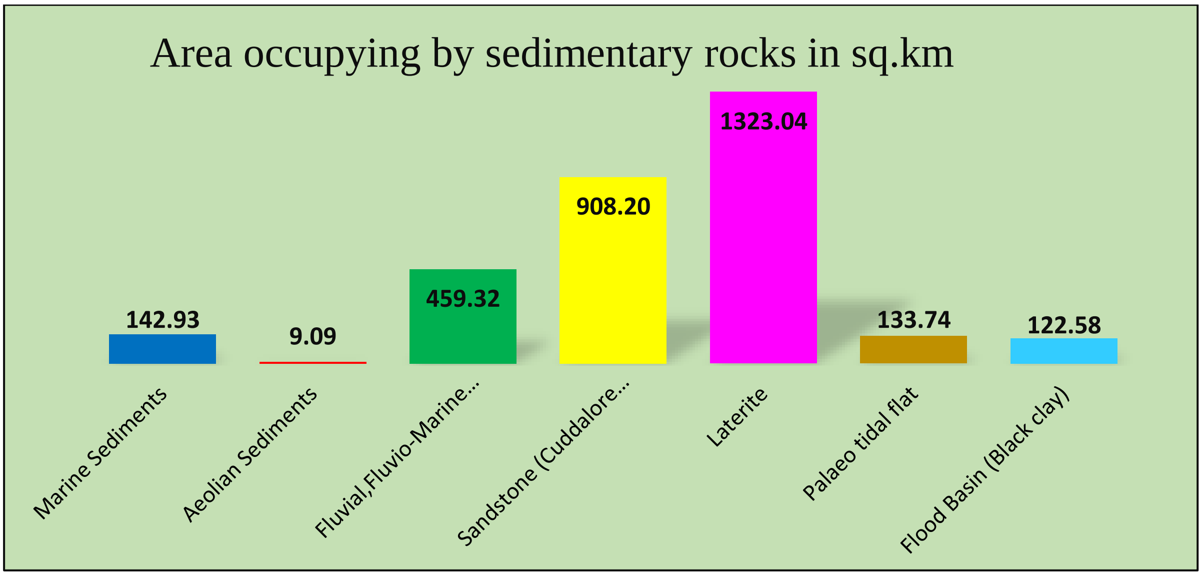


Fig .2.5.2 Area occupying by sedimentary rocks in the basin

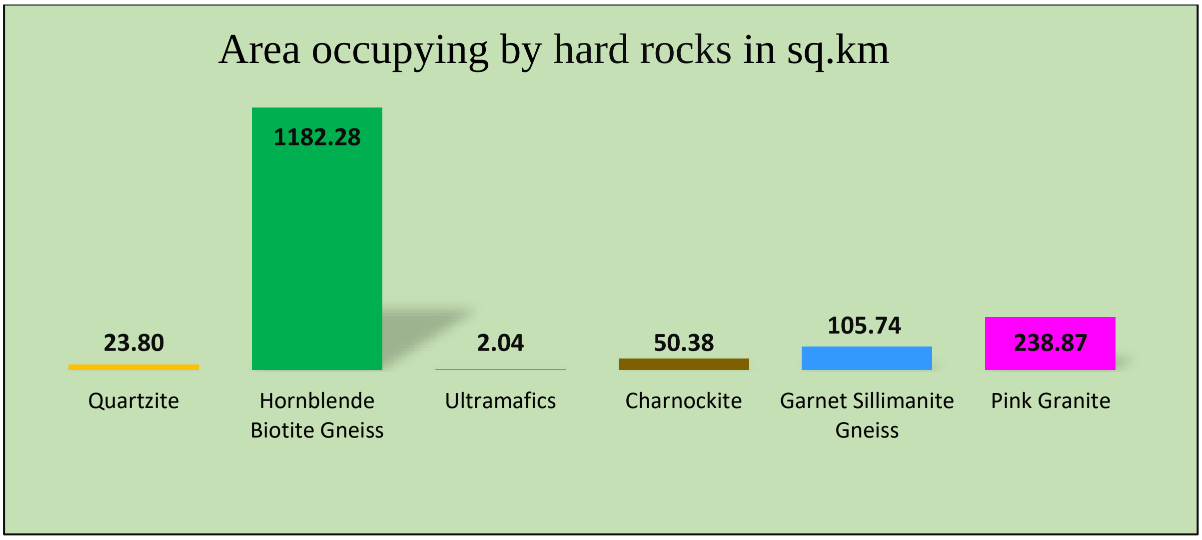


Fig .2.5.3 Area occupying by hard rocks in the basin

The occurrence of groundwater in the hard rock terrain depends upon the depth of weathering, intensity of joints, fractures and shearing effect due to lineaments in the sub surface apart from the topography, geomorphology, rainfall and surface water bodies located in that area. The yield in hard rock varies from place to place due to its heterogeneity in nature.

Hornblende biotite gneiss is the predominant rock type among hard rocks. This metamorphic crystalline rocks only acquire porosity and permeability when they have fractures / joints or by massive weathering. In this basin, hornblende biotite gneiss is found as jointed/fractured and massively weathered formations. Hence groundwater potential is moderately good.

Pink granite is hard crystalline rock. Granitic rocks are non-porous and impermeable to hold and transmit ground water because this is formed by the crystallization of the magma which leaves no chance to form pores. In the basin these rocks are found as massive hard rocks without much fractures or weathering due to which groundwater potential is moderately poor.

Garnetiferous Sillimanite gneiss and charnockite rocks found closely associated with each other in very limited area in the basin are of metamorphic origin. These are devoid of pores as these are formed by metamorphic processes in parent crystalline hard rocks that lacks porosity by origin. Thus this has no importance in groundwater prospects in the basin.

Quartzite and ultramafic amphibolites are found in negligible area and are also impermeable rocks which has poor groundwater potential.

The sedimentary rocks in the eastern basin comprises of tertiary and quaternary aquifers.They have greater porosity and permeability than other rock types which makes them good aquifers.

Cuddalore sand stone of mio-pliocene age and Lateritic formation of early to middle Pleistocene comprises the tertiary sediments .These two prominent litho units covers most of the eastern basin and are good aquifers. The sand stone formation comprises pebbly sand stone, grits, ferruginous sandstones capped by lateritic soil. Sandstones are excellent aquifers as they are highly porous and permeable formations. The Sandstone is having good groundwater potential. Lateritic formation has poor permeability and will undergo only less degree of weathering. Hence groundwater prospects is less compared to sandstone.

The quaternary formation comprises sediments of fluvial, fluvio-marine and marine regime. The sediments includes fine to coarse-grained sands, silts, clays, gravels etc. These are good aquifers as it is comprised most by unconsolidated sand and silt which has good porosity and permeability.

2.5.1 Hydrogeology

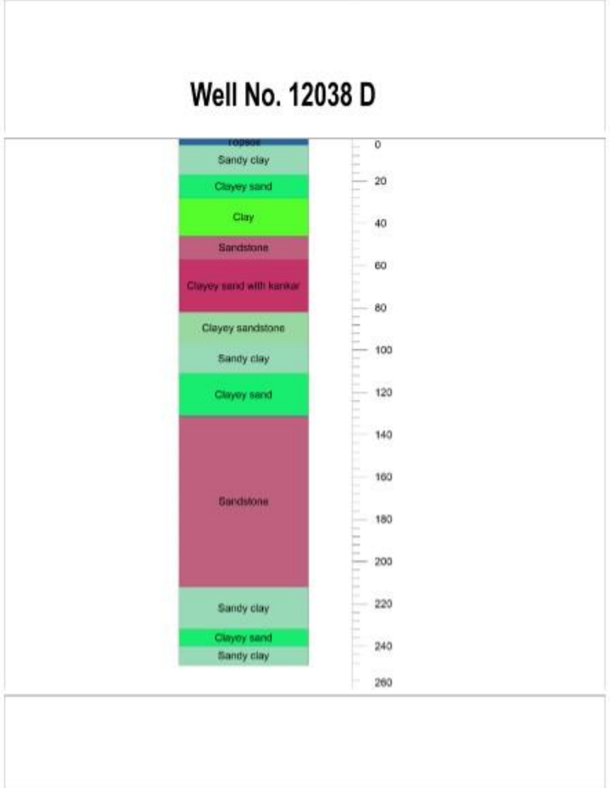
The major aquifer systems in the district are constituted by (1) weathered and fractured crystalline rocks consisting mainly hornblende gneisses, granitic gneisses and pink granites, (2) sedimentary formations ranging in age from Tertiary to Recent, consisting of sand stones, laterite and unconsolidated sediments. In the former, ground water occurs under phreatic conditions in the weathered mantle at shallow depths and semi-confined conditions in the fractured systems at deeper levels, and in the latter, it occurs under phreatic to confined conditions.The sand stone formations are good aquifers. The groundwater occurs under water table conditions in weathered, jointed and fractured zones of crystalline rocks in western part of the study area and in the eastern part of the study area in the soft bedded sedimentary formations groundwater occurs both under water table and confined conditions.

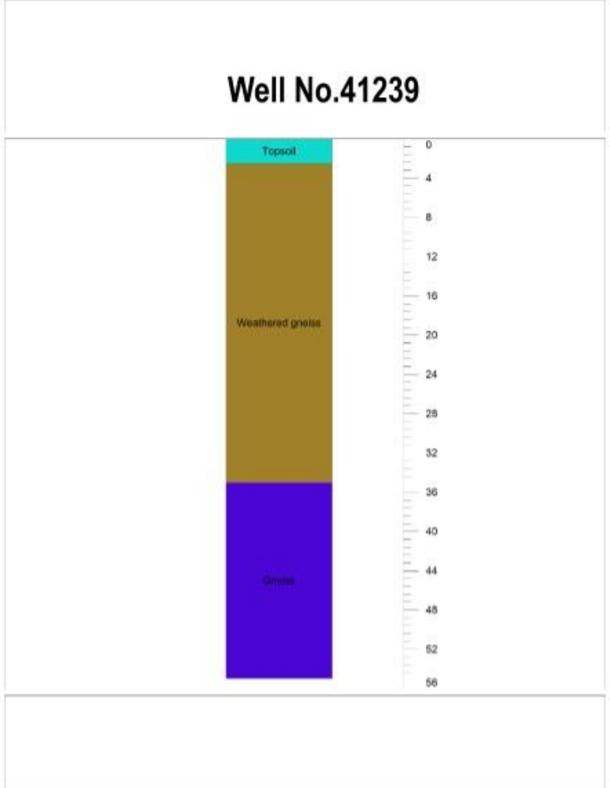
In Agniyar basin, 125 boreholes were taken for hydro geological studies (Location of boreholes - Plate AG-18). Out of these, 70 were drilled in sedimentary formations and 55 bore wells located in hard crystalline formation. In hard crystalline formation, the depths of wells ranging from 12 m to 55 m below ground level (bgl). In sedimentary formation, the depth of exploratory boreholes ranges from 50 m to 380 m below ground level (bgl). In crystalline formation most of the boreholes are shallow in depth and sedimentary formations have both shallow and deeper boreholes because of the existence of deeper aquifer.

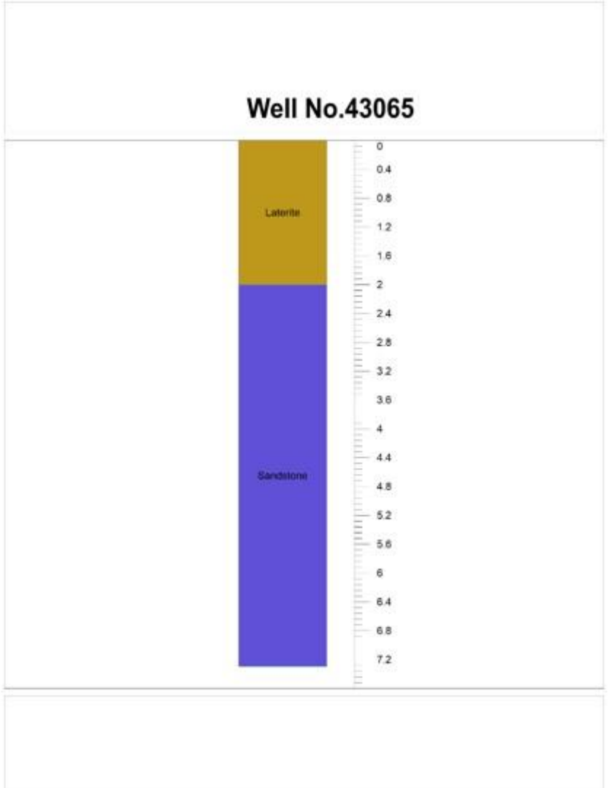
Aquifer parameter values have been determined by aquifer performance test. The general yield of dug wells tapping crystalline formation is 5 lps for a pumping of 2-4 hrs, while the dug wells tapping in porous formations can sustain a yield of 5 lps for a pumping of 4-6 hrs. The transmissivity value is less than 1 m^2/day - 145 m^2/day. The general specific yield is between 0.015- 0.12 %.(CGWB Technical Report Series, 2008)

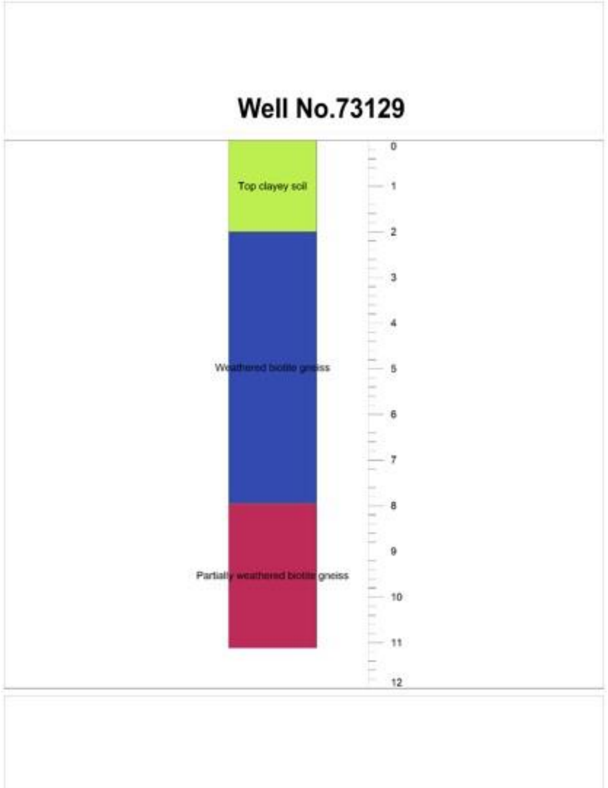
Regarding water quality, ground water in phreatic aquifers of the basin, in general, is colourless, odourless and alkaline in nature. The electrical conductivity of groundwater is in the range of 90-16000 µS/cm.

Fig 2.5.4 Vertical lithologs of selected wells

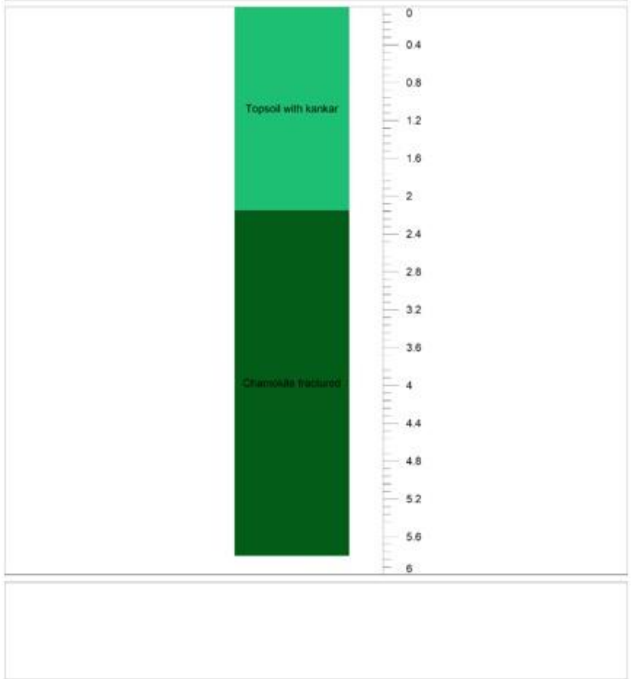




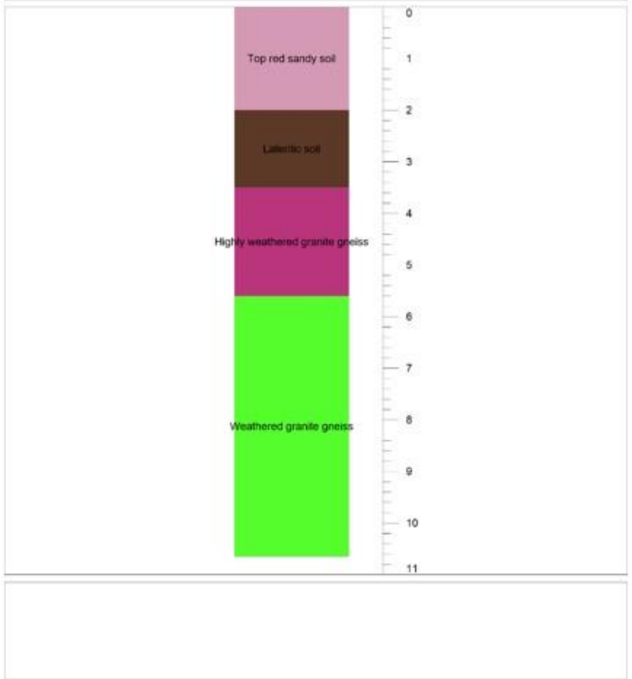

Well No.43065
Laterite
Sandstone
0
0.4
0.8
1.2
1.6
2
2.4
2.8
3.2
3.6
4
4.4
4.8
5.2
5.6
6
6.4
6.8
7.2

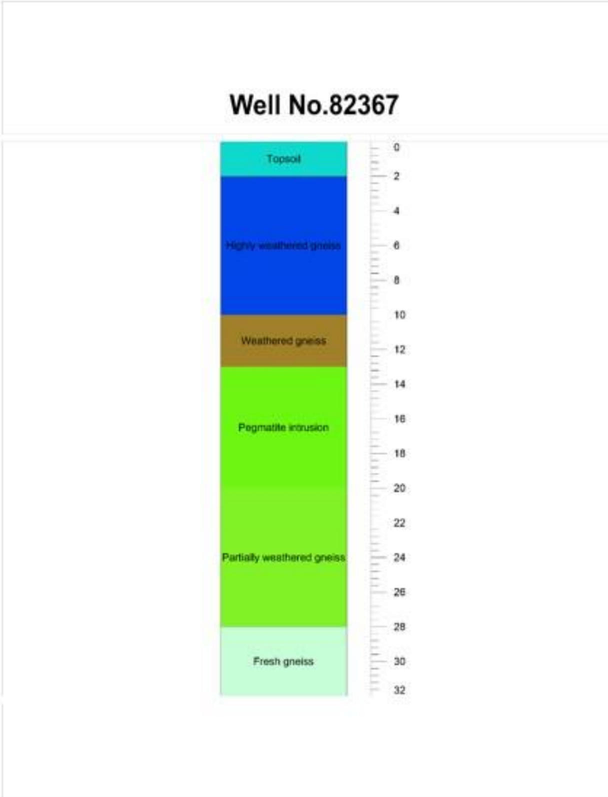

Well No.73129
Top clayey soil
Weathered biotite gneiss
Partially weathered biotite gneiss
0
1
2
3
4
5
6
7
8
9
10
11
12

Well No.73142



Well No.73165




Well No.82367
Topsoil
Highly weathered gneiss
Weathered gneiss
Pegmatite intrusion
Partially weathered gneiss
Fresh gneiss
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2
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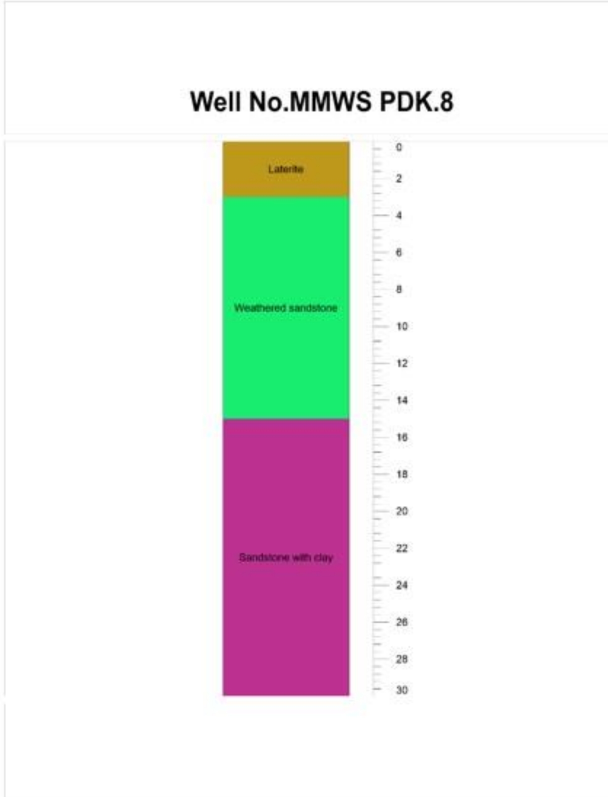
24
26
28
30
32


Well No.MMWS PDK.8
Laterite
Weathered sandstone
Sandstone with clay
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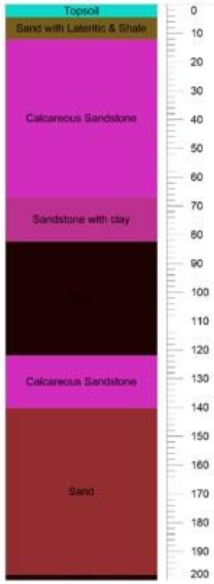
4
6
8
10
12
14
16
18
20
22
24
26
28
30

Well No.SW 1A



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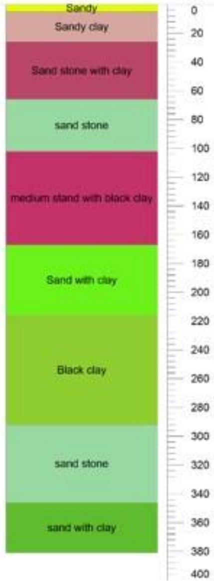


2.6. Geomorphology

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.

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 four major landforms were identified in the Agniyar basin, based on its genesis. (Plate AG-19) is prepared and its percentage of area covering by each landform is given in fig.2.6.1

I Landforms of Structural Origin

II Landforms of Denudation Origin

III Landforms of Fluvial Origin

IV Landforms of Coastal Origin

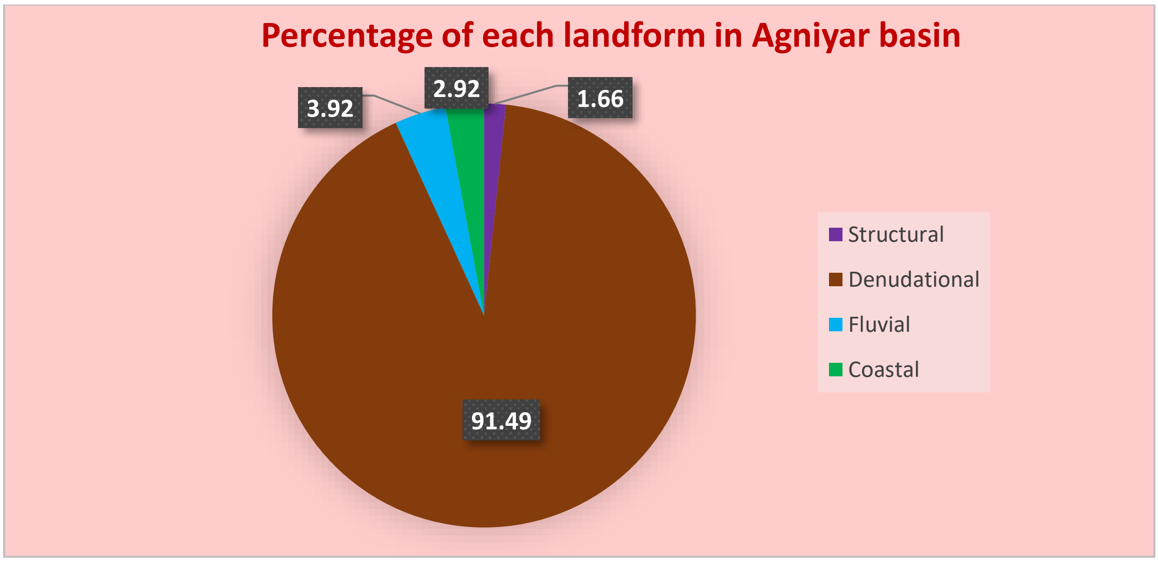


Fig 2.6.1 Percentage of area covering by each landform

Landforms of Structural origin

The landforms of Structural origin includes 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. The relevence to groundwater prospects is moderate along its valleys, subject to weathering. Structural hills are in the sparsely distributed in the western basin around Kottaippatti, Maniyankurichchi, Karadippatti, Palaikurrichchi, Marungapuri, Kanjanayakanpatti, Kurumbur etc.

Landforms of Denudation origin

The Denudational landforms are ocurred in western and middle part of the basin and divided into various geomorphic units such as denudational hills/residual hills, buried pediment -deep, shallow and moderate , pediment -inselberg complex, sedimentary grounds with level >80 m and level <80 m, badland topography, pediment-dissected/undissected, erosional plain surface, tertiary plains and sedimentary sloping lands. The denudation process is active in these landforms of landforms. The description and its significance to grounwater resources are explained below.

The Denudational hills are formed, due to differential erosion and weathering, so that, a more resistant formation stand as mountains or hills with varying hard rock lithology. Denudational hills are located mainly in the western basin in and around Karisalpatti, Adikaram, and Karadipatti etc. The prospects for groundwater is poor to nil.

Pediment-Inselbergs complex are found scattered in the western parts of basin in and around Palaikurrichchi, Kudumiyamalai, Marungapuri, Alavayal, Marudanpatti, Panaiyapatti, Nartamalai etc. They are also residual, isolated hill, stand above the ground level with surrounding vast pediplain. They are normally barren and rocky with varying hard rock lithology. The groundwater prospects in Inselberg is very poor.

Pediment is gently sloping, smooth surface of erosional bed rock between hill and plain with thin. The lithology comprise of different hard rock formations. The significance to groundwater is moderate to poor; varies with underlying lithology and depends on fracture / lineaments.

Shallow pediment covers entire western basin area and spreads up to the central part of the basin. It is a flat and smooth surface, with shallow overburden of 0-5 m thickness. 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.

Moderate Pediment is shallow than deep pediment area and have high relief than shallow pediment with moderately thick over burden of 5-20 m thickness. Weathered thickness of this landform is appreciable. Moderate pediment scatters in and around the western and north-western basin area and spreads upto the central part of the basin.

Deep Pediment have high relief than moderate pediment zone. It will have deep weathering with thick over burden of >20 m thickness 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. Deep pediment is found in the south-western basin near Tirugokarnam and Perumanadu.

Erosional plains are plain surfaces formed by continuous long time erosion activities. The surface of such plain is hard. It is found sparsely distributed in western basin around Melataniyam, Virappatti, Kilakkudi and Rappusal.

Sedimentary grounds with level >80 m and level <80 m covers majority of basin area. Sedimentary grounds with level <80 m is the major geomorphic unit of the basin which extensively covers entire eastern basin except the coastal stretch. 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.

Badland topography are erosion based dry terrains characterized by steep slopes and minimal vegetation. It is intensely dissected landscapes mainly by fluvial erosion. The prospects for groundwater is poor to nil.It is mainly located near Ganapathipuram and Raghunathapuram.

Dissected/undissected terrain are erosive terrain formed at the surface of plain lands or plateaus. These scatters in and around the western and north-western basin. Ground water potential of this landform is poor.

Tertiary uplands are found significantly near Gandarvakottai, Nayakkarpatti, Kurungulam, Mudukulam etc. It is elevated plain compared with adjacent landforms. Infiltration and recharge is moderate to poor.

Sedimentary sloping lands are found south-eastern region of the basin in and around Avudaiyarkovil, Paramandur, Memangalam, Perandani etc. The prospects for groundwater is moderate.

Landforms of Fluvial origin

Fluvial landforms are produced by the action of rivers. The main agent is stream water. The landforms are developed due to various destructive and constructive fluvial processes such as erosion and deposition.

Alluvial plain is formed by extensive deposition of alluvium by major river systems.This unit is normally flat/gently undulating surface.These units constitute gravels,sand, silt and clay of varying lithology of sedimentary origin. The groundwater prospects will be excellent due to its porosity and proximity to water sources. The alluvial plain, is located in south and south eastern part towards the coastal region of the basin and located in and around Puvattakudi, Arantangi, Pinnavasal, and Arasarkulam.

The flood plain exists along the rivers, such Agniyar and Vellar. It is a flat surface adjacent to a stream / river composed of unconsolidated fluvial sediments, normally subject to periodic flooding by parent river.The lithology will primarily comprise of unconsolidated materials like gravel, sand, silt. Sand will be thedominaing lithology in flood plain.

Deltaic plain with backwater is a gently sloping plain of large extent of area with thick sediments in fan shape,normally formed atthe mouth of river course.These units consist of material from river borne sediments mostly alluvium.The groundwater potential in these units are very good to good. Deltaic plain is seen in the southern part of the basin around Vadakku Ammapattinam.

Palaeochannel is found as thin stretch near Memangalam. This unit consist of material deposits of varying lithology and size.

Landforms of Coastal origin

The landforms are developed due to various destructive and constructive forces by the wave actions of seawater in the coastal belt.

The Coastal plain is a regional land of low relief bounded seaward by the shore and landward by highlands, mainly formed due to coastal action.The lithology in coastal plain are sand ,silt and clay. Groundwater prospects is promising. However in some places, salinity is a problem.

Beach is a narrow strip of land along sea shore, generally consisting of sand or un consolidated material.Sometimes it can be formed of boulders or shingles.The quality of ground water will be saline .

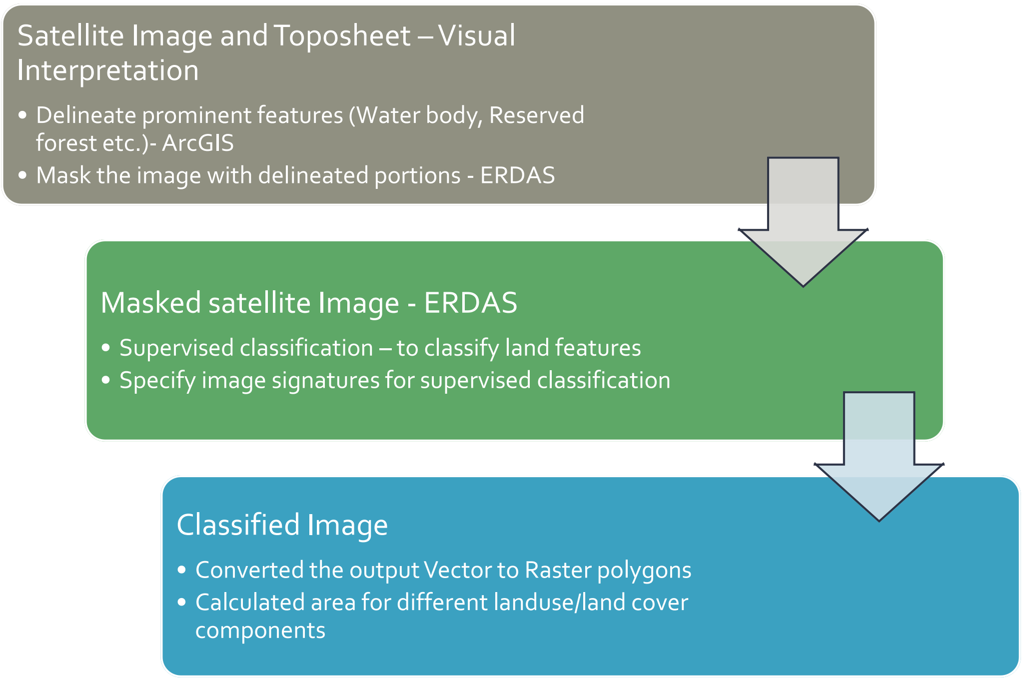
Salt flat is a flat land, bordering the sea estuaries with thin veneer of salt. Fine grained material like clay dominates in this area.The quality of water is saline.

Marshes are greasy wet areas with standing or slow moving water. It is found towards the western basin region.

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 and to identify the water stress 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 way 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 serve as an indicator on basin's land use scenario.

For Agniyar Basin land use study, satellite imageries of LISS III acquired on March 2004 and of March 2021 have been interpreted. Land use maps were prepared and shown in **Plate** AG-**20 and Plate** AG- **21** 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 Agniyar Basin have been tabulated and shown in **Table 2.7.1 and 2.7.2** for the respective years. The land use pattern of the basin is discussed below.

2.7.1. Land use/ Land cover in 2004

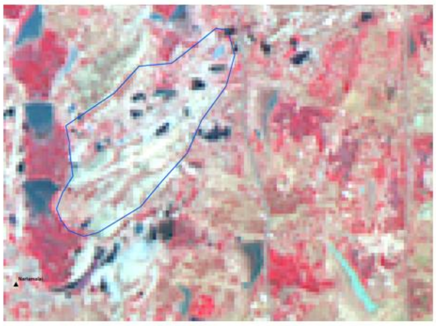
In the Agniyar basin, the settlement area covers 1.06 %. This includes dwellings, factory and quarrying locations. The dwellings occupy 42.10 Sq Km, major among them are Pattukottai and Pudukkottai. The factories have taken 3.89 Sq Km, this includes Thanjavur Air Force Station. Quarrying gneissic rocks for blue metals is taking place around Kiranur, Narthamalai, Virapatti and Kudumiyanmalai. Figure 2.7.1 shows the satellite image of the respective settlement areas.

Table 2.7.1. Land use pattern for the year 2004

Sl. No.	Land use Category			Area in 2004	Percentage Area in 2004
	I Level	II Level	III Level		
1	Built up Land	Settlement and others	Dwelling	42.10	0.895
			Factory	3.89	0.083
			Quarry	3.83	0.082
2	Agriculture	Wet Crop / Irrigated Land	Paddy, Sugar Cane etc.	633.40	13.471
		Dry crop/Rain fed land	Groundnut, Grams, Millets etc.	420.30	8.939
		Plantation	Cashews	75.90	1.614
		Groves	Coconut	184.02	3.914
		Fallow/Harvested	Current fallow/ harvested Land	2502.12	53.214
3	Forest	Reserved Forest	Reserved Forest	144.93	3.082
			Hills / Reserved Forest	66.78	1.420
		Forest	Mangroves	3.95	0.084
4	Barren/Waste Land	Barren land	Barren land/ Rocky Outcrop	43.70	0.929
			Shrubs	15.77	0.335
			Scrub	8.01	0.170
		Hills	Hills	16.69	0.355
5	Water body	Inland wet land	Saltpan	21.20	0.451
		Water body	Tank	465.89	9.908
			River	49.53	1.053
			Aqua Culture	-	-
Total Area				4702.02	100.00

Airport

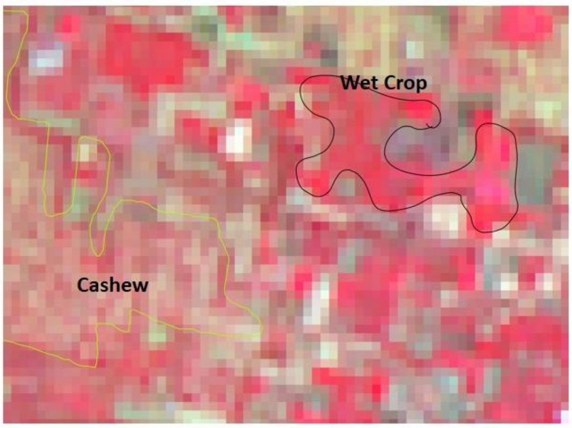
Settlement



Quarry

Fig 2.7.1 Satellite view of settlement area – Agniyar Basin

Agricultural activity is major in the study area and it occupies 81.15 % of the total area. In the agricultural land, wet crops like paddy and sugar cane have covered 633.4 Sq km which is 13.47 % of the total area of the basin. Dry crops like ground nuts, grams, millets have been grown for 5420.3 Sq Km. Cashew plantations are other type of crops that are raised in the area around Kurungulam, Andanur and Malayur and it covers 75.9 Sq Km. Casuarina and coconut groves are cultivated in the region and it covers 184.02 Sq Km. Most of the agricultural land were either left out as fallow or harvested at the time of march 2004. This category covers 2502.12 Sq km which is 53.21% of the total agriculture land of Agniyar basin. Figure 2.7.2 and 2.7.3 show the satellite view of agriculture land with different crops and fallow and harvested respectively.



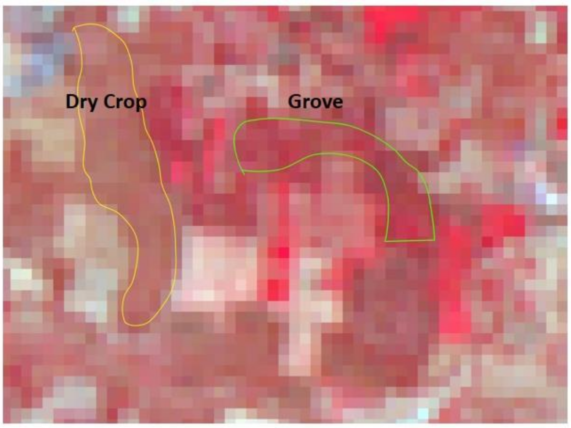


Fig 2.7.2 Satellite view of Agricultural Land with different crops

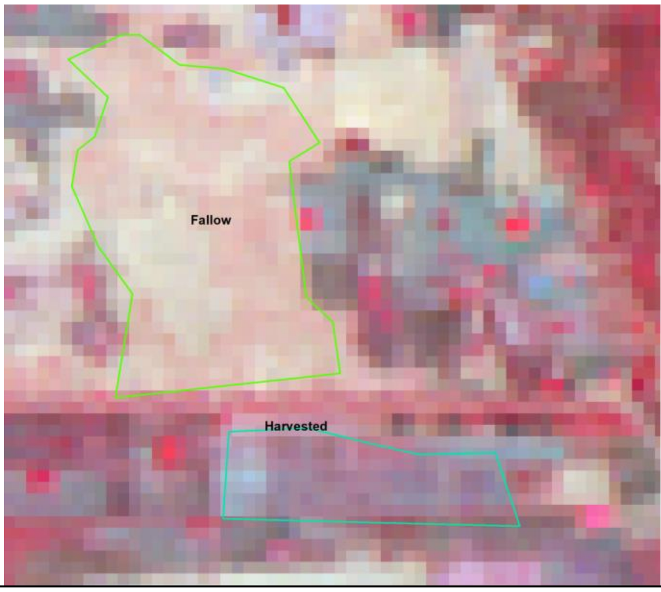


Fig 2.7.3 Satellite view of Agricultural Land – Fallow and Harvested

The forest portions cover 4.94 % i.e 232.35 Sq Km of the agniyar basin. The reserved forest in the plain terrain and on the hills cover 144.93 Sq km and 66.78 Sq Km respectively. Some of the major reserved forests are Marungapuri and Varappur, however this is already discussed in chapter 2.2 - Physiography. The Mangroves occupy 3.95 Sq km.

As most of the area is adapted for cultivation, the barren/waste land spread is only 84.17 sq km. In this category, barren land in plain terrain is 43.7 Sq km extent. Scrubs and shrubs are extended over 23.78 sq. km. Barren rocky hills take 16.69 Sq km in the basin.

Water bodies include rivers, inland wet land i.e salt pan and other water body viz., tanks, rivers and Aqua culture activities. The inland wet land describes the salt pan activity in the coastal region for which 21.2 sq km of the area is used. Tanks include WRD tanks and other tanks which are around 6000 in nos. and they are spread over 465.89 Sq Km. The Rivers in the basin covers 49.53 Sq km.

Figure 2.7.4 presents the appearance of salt pan, aquaculture and mangroves in satellite imagery.

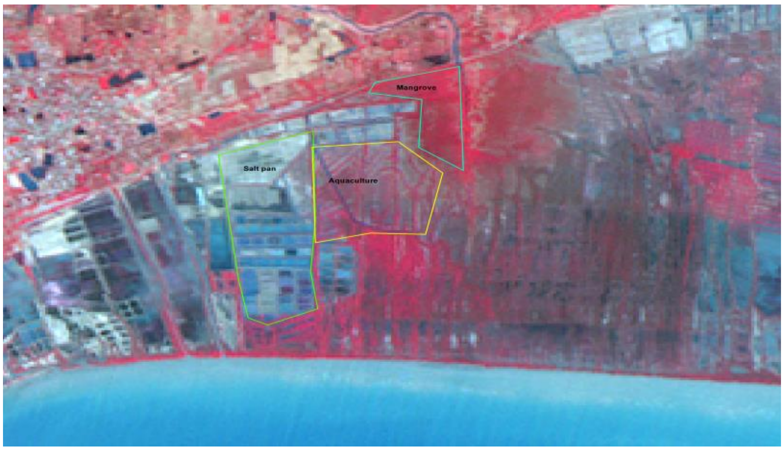


Fig 2.7.4 Satellite view of Salt Pan, Aquaculture and Mangroves

2.7.2 Land use/ Land cover in 2021

Table 2.7.2 Land use pattern for the year 2021

Sl. No.	Land use Category I Level	II Level	III Level	Area in 2021	Percentage Area in 2021
1	Built up Land	Settlement and others	Dwelling	97.11	2.065
			Factory	4.24	0.090
			Quarry	6.27	0.133
2	Agriculture	Wet Crop / Irrigated Land	Paddy, Sugar Cane etc.	652.87	13.885
		Dry crop/Rainfed land	Groundnut, Grams, Millets etc.	592.40	12.599
		Plantation	Cashews	37.80	0.804
		Groves	Coconut, casuarina	297.87	6.335
		Fallow/Harvested	Current fallow/ harvested Land	2193.75	46.655
3	Forest	Reserved Forest	Reserved Forest	144.93	3.082
			Hills / Reserved Forest	66.78	1.420
		Forest	Mangroves	4.12	0.088
4	Barren/Waste Land	Barren land	Barren land/ Rocky Outcrop	35.92	0.764
			Shrubs	4.30	0.091
			Scrub	6.51	0.138
		Hills	Hills	16.69	0.355
5	Water body	Inland wet land	Saltpan	18.69	0.397
		Water body	Tank	465.89	9.908
			River	49.53	1.053
			Aqua Culture	6.35	0.135
			Total Area	4702.02	100.00

In 2021, majority of the area is used for agricultural activity (**Plate** AG-**21)**. The total area of the agricultural land is 3774.69 sq.km, which is 80.27 % in the total area **(Table 2.7.2).** Fallow and wet crop covers much of the agricultural land, followed by dry crop, groves and cashews. The settlement area has been spread for 107.62 sq. km (2.295%). Whereas the habitation is 97.11 sq. km and factory and Quarry are 4.24 sq. km and 6.27 sq. km respectively.

The area covered by reserved forest is 211.71 sq. km and that of the barren land portion is 35.92 sq. km. The shrubs and scrubs cover 10.81 sq. km and the water bodies such as rivers and tanks is about 515.42 sq.km. Over the period, aqua cultural activities have been started in the coastal regions and it covers 6.35 Sq km.

2.7.3 Land Use/ Land cover comparison of 2004 and 2021

The comparison of changes in the settlement area for the two different periods **(Fig.2.7.5),** supports the increased spread of the habitation as well as factories and quarries in the Agniyar basin.

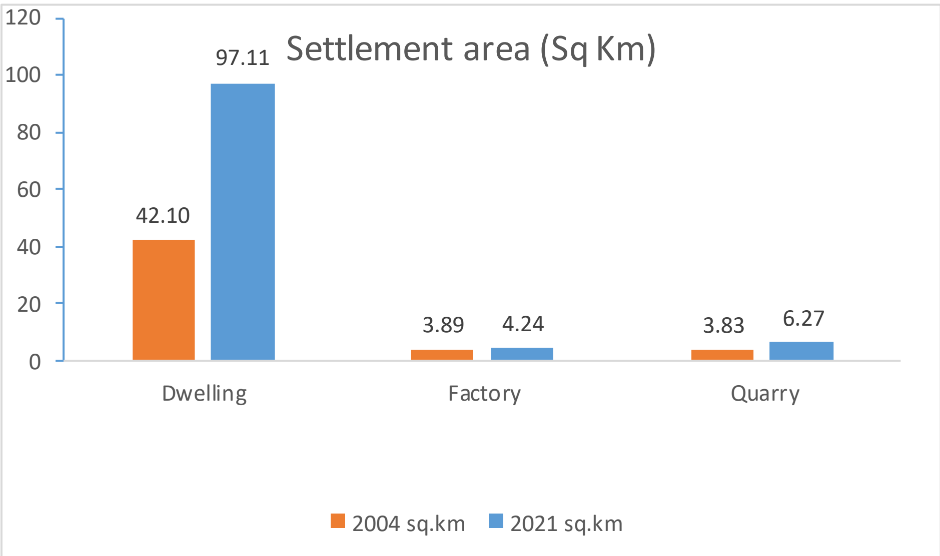


Fig. 2.7.5. Comparison of settlement area

Most 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 Perungalur and Kudumiyanmalai are converted in to quarry now.

The agricultural land has been reduced to 3774.69 sq. km from 3815.75 sq. km, which is only 0.87% 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 2004 have been adapted for quarrying in 2021 **(Fig.2.7.6).**

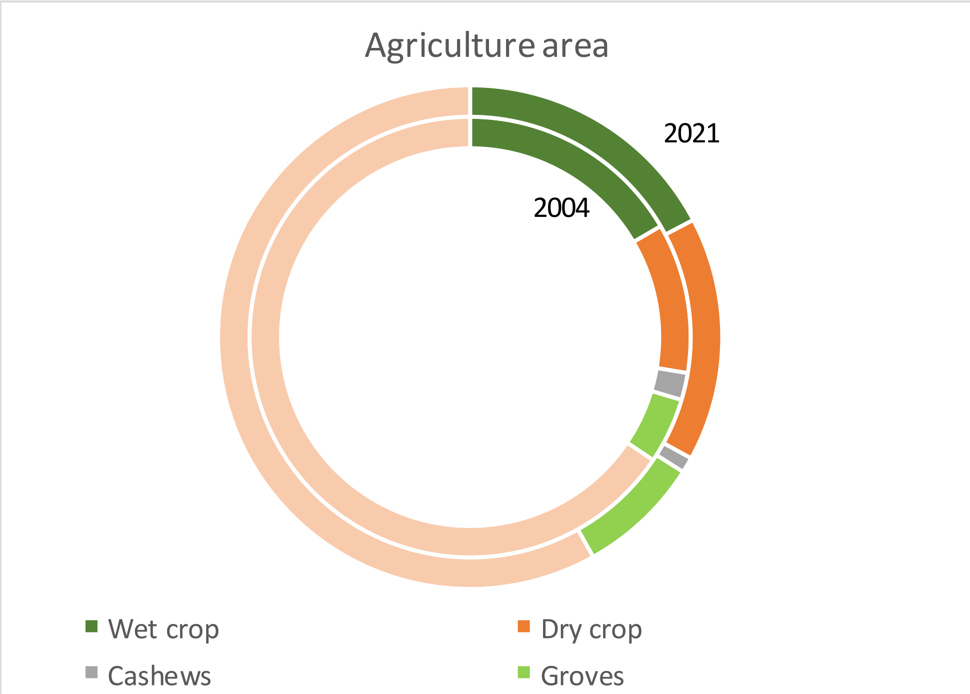


Fig. 2.7.6. Comparison of agriculture area

The variation in the magroves is noticeable at east of Amasinhendrapuram (Fig. 2.7.7).

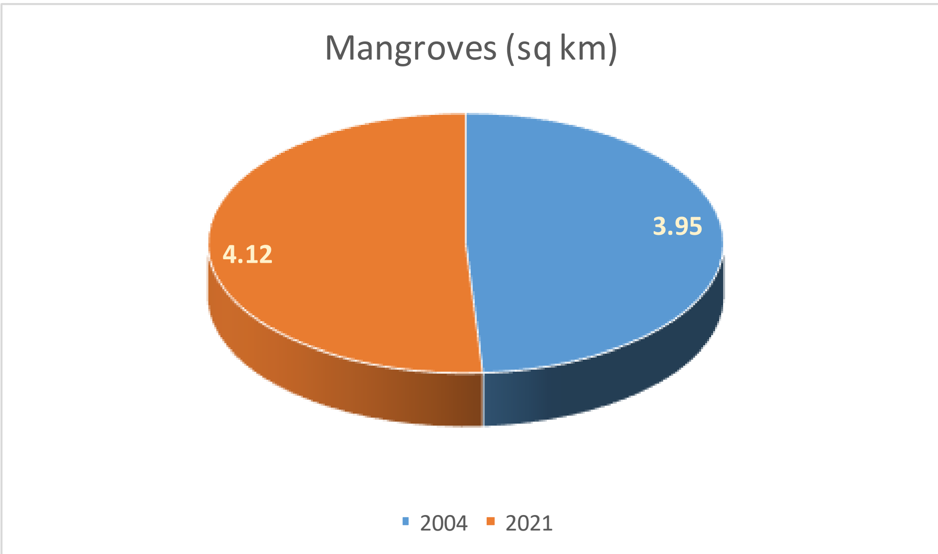


Fig. 2.7.7. Comparison of mangroves spread

Land cover of barren, scrub and shrub was 1.43 % in 2004 which has been reduced to 0.99 % in 2021. The changes in this category is attributed to the development of dwellings and quarry. Figure 2.7.8 depicts the variation of the categories in two periods.

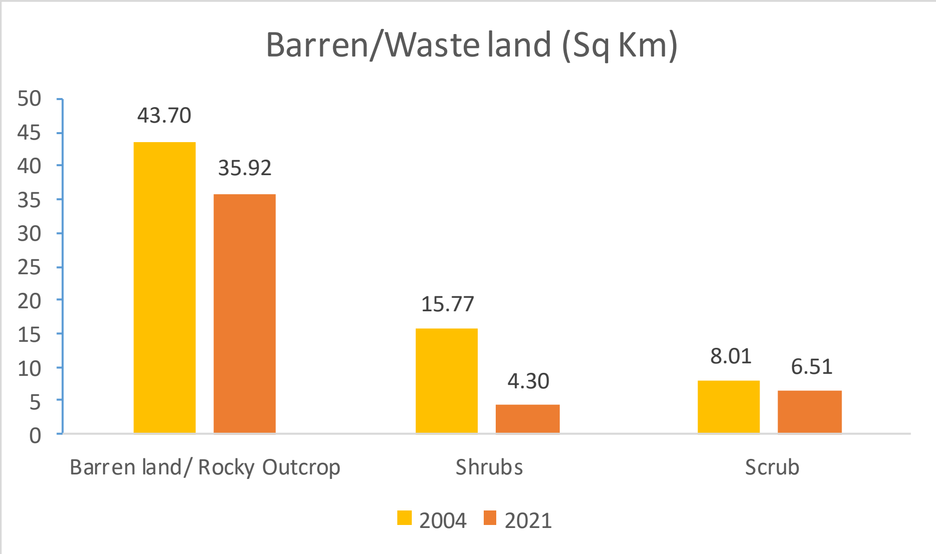


Fig. 2.7.8. Comparison of barren/waste lands

Salt pan activities in the coastal regions are reduced from 21.2 Sq Km to 18.69 sq Km. how ever, some portions of salt pan were converted for aquaculture. Aquacultural activity, not existed in 2004 has occupied 6.35 sq Km in 2021 (Fig 2.7.9). This is seen south east of Pallathur and at east of Amasinhendrapuram.

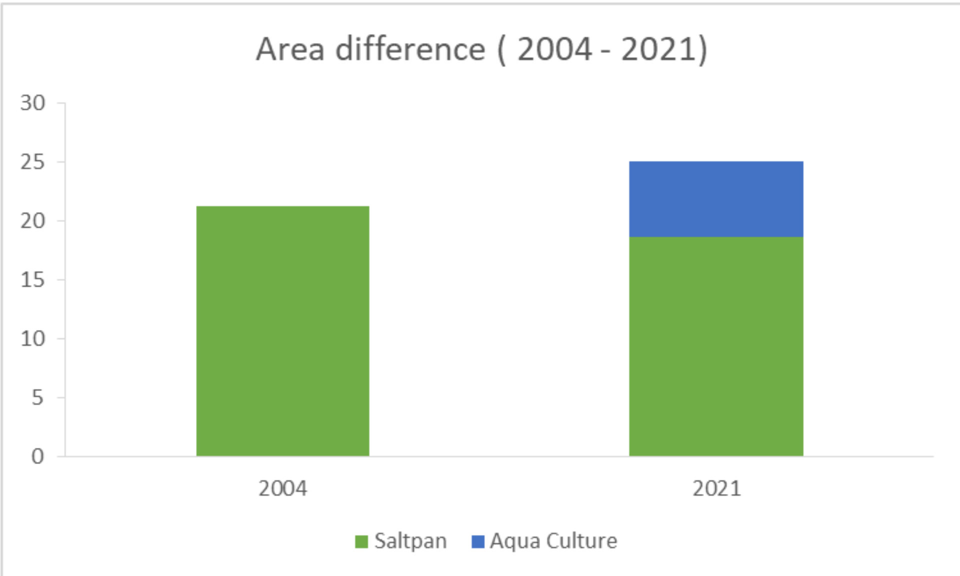


Fig. 2.7.9. Comparison of salt pan and aquaculture

Figure 2.7.10 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 consumption of agriculture and barren land for quarrying and encroachment. Salt pan activity has been reduced a little but the mangroves have been increasad over time.

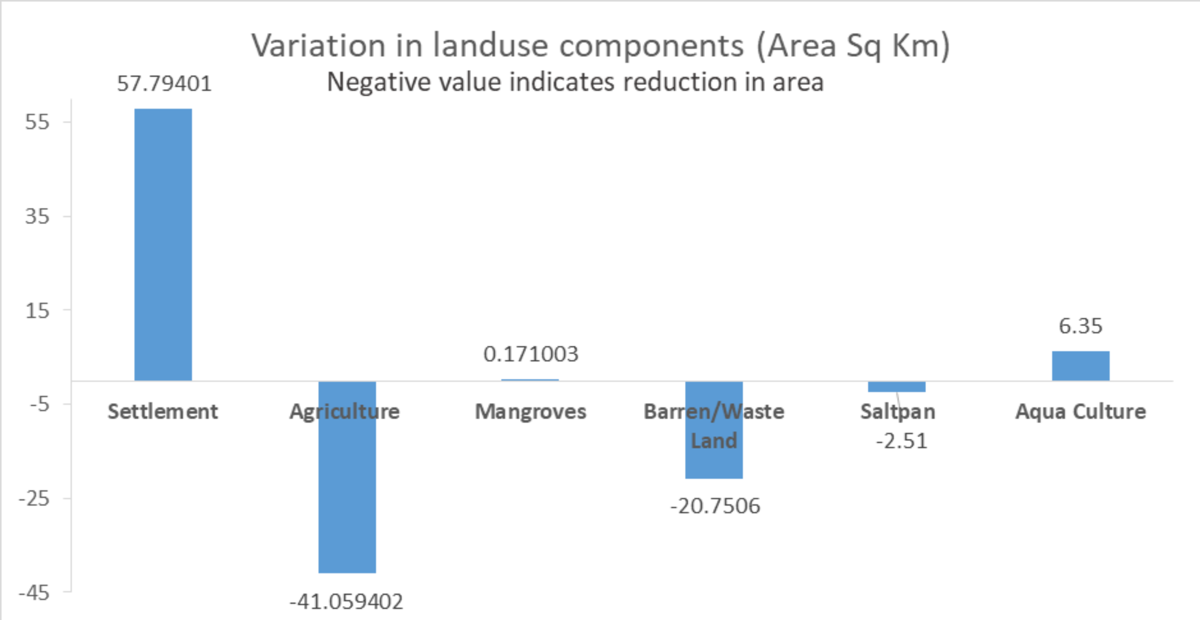


Fig. 2.7.10. Variation in landuse components

2.8 Lineament

Lineament is a linear feature in a land surface that express an underlying geological structure such as a fault, fracture, or joint. The landforms and the lineaments have considerable influence on the aquifer characteristics. The wells located along the lineaments / faults / fractures / shear zones give higher discharge and transmissivity values.

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 (Hard castle). Therefore, mapping of lineaments closely related to groundwater occurrence and yield which lead to groundwater development and management.

2.8.1 Data used for interpretations

Satellite Images of Indian Remote Sensing Satellite – IRS P6 2A sensor LISS III with date of pass on March 2021 is used for the study. 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 scale were interpreted for deciphering the lineaments. These lineament analysis has been effectively done in GIS environment and final interpretation is given as map in Plate AG-22- .The basin has numerous linear features which are probable fault or fractures. The length of the lineaments vary from 5.4 km to 49.2 km. Directions of lineaments are represented here under in the form of Rose Diagram.

2.8.2 Rose diagram

Rose diagram has been prepared with the lineament data to understand the orientation of the linear features in the basin area **(Fig. 2.8.1).** It is a circular histogram plot which displays directional data and the frequency of each class.

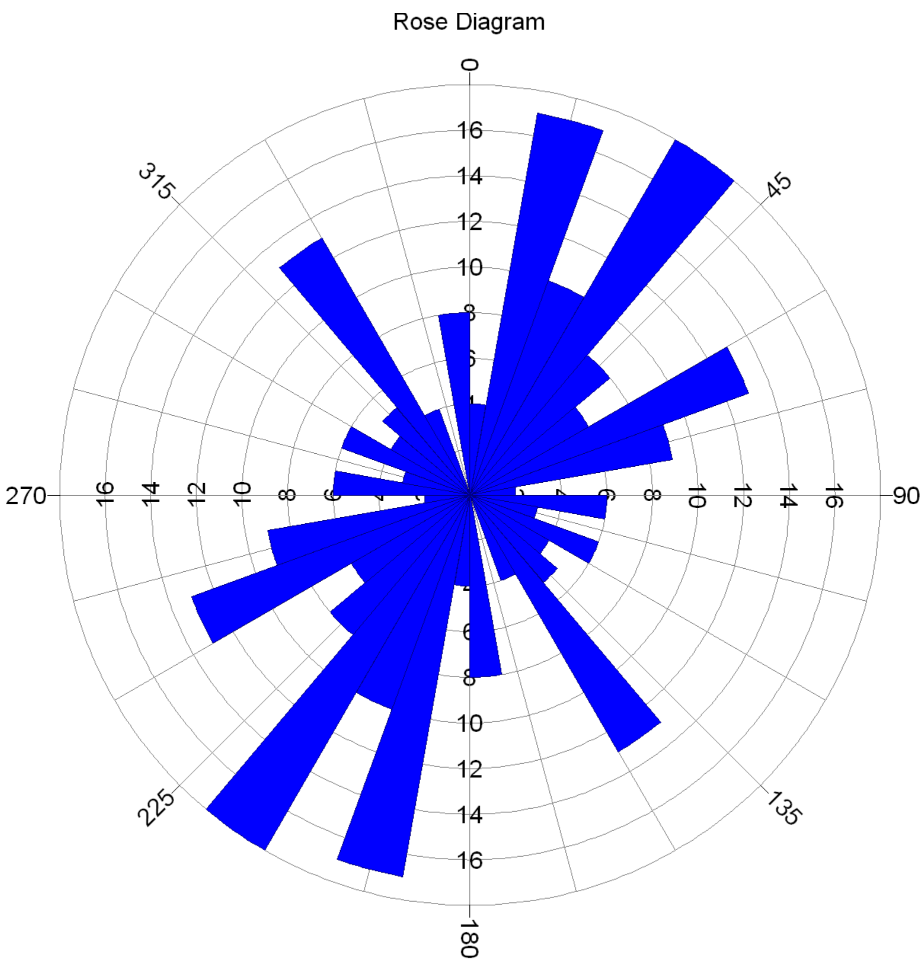


Fig. 2.8.1 Rose diagram for lineaments

The Rose diagram of the basin indicates that high frequency of lineaments are trending from NNE –SSW. The trend of the lineaments is in all directions.

2.8.3 Lineament Intersection

The zone on which two or more lineaments will have more impact resulting to disintegration of formations. Normally the bore wells located in the intersection of lineament zones will yield copious water.ie lineament intersections represent nodal point for two or more lineament lines (Bayowa et al., 2014). The nodes of intersections are the point of interest which indicate site for appreciable groundwater accumulation. Intensity of lineament intersection points is reasonably high towards the middle of the basin area in and around Tavalapallam, Varappur, Varappur, Alangudi, Kottamangalm, and Malayur etc. Moderate intersection intensity is found towards the western basin region in and around Marudanpatti, Valanadu, Melataniyam, Annavasal, Oliyamangalam, Palaikurrichchi etc. The eastern and southern basin area is devoid of any prominent lineaments and intersection points.

2.8.4 Lineament Density

A lineament density layer was generated using GIS which shows three classes such as low, medium and high lineament zones and is given in **Plate** AG-**23** . Regions with moderate-high lineament density may indicate shattered ground which leads to presence of loose formation and thus have good groundwater prospects. Major portion of the basin has low lineament density. Medium – high density zones are found in very limited region towards the central and western portion. As eastern and southern basin is devoid of lineaments, it comes under low density zone.

Presence of about six lineaments are confirmed by Geological Survey of India for Pudukkottai district. Other lineaments mapped and shown in map are probable ones that are subject to validation through field verification.

2.9 Geo Physics

Electrical Resistivity methods are widely used to delineate the subsurface formations including aquifer. This method involves measurement of resistances of different layers of sub surface by sending current into earth through metal electrodes using different 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 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 and Fractured / Jointed rocks.

2.9.1 Methodology

The Agniyar basin is predominantly composed of soft, unconsolidated Quaternary and Tertiary sediments towards eastern, north-eastern and south-eastern reaches of the basin. The western basin area is traversed by hard crystalline rocks of Proterozoic and Archaean era. The basin can be divided into hard and soft rock regions by a contact zone traversing in the middle of the basin. Hornblende biotite gneiss is the predominant rock type among hard rocks which covers most of the western region of the basin. The eastern part of the study area is covered by soft, unconsolidated sediments and gentle rocks. Laterite and lateritic soil of Tertiary period covers vast stretches of the sedimentary region in the eastern basin area within which isolated patches of Cuddalore sand stone is found. Sandstone (Cuddalore Formation) is another prominent lithology which is found towards south of lateritic formation. According to these geological information, the available data of VES are verified and correlated. The top soil and unconsolidated top layers are identified and demarcated by low resistivity zones. Similarly the thickness of weathered and fractured/ jointed formations are demarcated by moderate and high resistivity values respectively. The geophysical data pertaining to Agniyar basin were collected from State Ground and Surface Water Resource Data Centre of WRD were 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. 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 AG-24, Plates AG-25& Plate AG-26).

The hard rock area of this basin is comprised mainly of Gneiss and Granite and sedimentary rock comprised mainly of laterite and sandstone formations. 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.

2.9.2 Topsoil/ Unconsolidated Formation

Plate AG-24 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 0 -5 m below ground level, **2.** Layers from 5-10 m bgl, **3.** Layers from 10-15 m bgl, **4.** Layers from 15-20 m bgl.

The shallow layer of 0-5 m bgl covers majority of the western area of the basin in and around Kottaippatti, Maniyankurichchi, Marungapuri, Virapatti, Oliyamangalam and Kiranur where hard rock makes the major lithology and extends towards the central region of the basin. Another shallow layer of 5-10 m bgl occurs in hard rock region closely associated to the shallow 0-5 m layer in the central basin in locations such as Pudukkottai, Perungalur, Vattanakkotai, Kurumbur etc. The moderately deeper layers of 10-15 m bgl covers most of the basin sedimentary area towards north-easte in and around Tulukkampatti, Gandarvakottai, Vettikkadu, Kurungulam etc., towards east in and around Tiruchitrambalam , Avanam etc., and towards south-eastern basin area in and around Amarasimhendrapuram, Memengalam etc. The deep layer of unconsolidated formations of 15-20 m bgl is mainly observed in limited area in south- southeast basin nearer to the coast at Kiranur and Karakkottai.

2.9.3 Weathered Formation

Spatial distribution and depth of occurrence of weathered formation is represented on Plate AG- 25. These formation may form shallow to moderate aquifers on the basis of the depth of formation. This layer is further sub divided into 5 sub layers based on depth of occurrence and thickness of layer in the basin. They are **1**. Layers from 10-20m bgl **2.** Layers from 20-30m bgl **3**.Layers from 30-40m bgl **4**.Layers from 40-50m bgl **5**.Layers from 50-65 m bgl. The shallow depth layer of weathered rock, which is 10-20 m bgl is found in the western area of the basin in and around Kottaippatti, Maniyankurichchi, Marungapuri, Virapatti, Oliyamangalam and Kiranur where hard rock is prominent lithology. The formations having moderate depth and thickness of weathering ie.20-30 m bgl and 30-40 m bgl exists parallel to each other in the central basin in and around Pudukkottai, Perungalur, Vattanakkotai, Kurumbur Malayur etc. The deep weathered formation of 40-50 m bgl covers most of the eastern basin towards the coast in and around Amarasimhendrapuram, Memengalam, Avanam, Uranikkadu etc. The deepest weathered depth of

50-65 m bgl occur in limited area in and around Kurungulam and Andanur in north-northeastern region and in Karakkottai in the south east.

2.9.4 Fractured / Jointed Formations

Spatial distribution and depth of occurrence of fractured formation is presented on Plate AG-26.

This zone underlies weathered formation and overlies the basement fresh rocks. Based on depth of occurrence below ground level, this formation is further sub divided in to 6 sub layers. They are **1**. Layers from 30-50m bgl **2.** Layers from 50-70m bgl **3**.Layers from 70-100m bgl **4**.Layers from 100-200m bgl **5**.Layers from 200-300 m bgl **6**.Layers from 300-600 m bgl. The shallow fractured depth layers of 30-50m and 50-70 m covers the western and north western basin region completely in major locations such as Kottaippatti, Maniyankurichchi, Marungapuri, Virapatti, Oliyamangalam, Kiranur, Pudukkottai and Kudimiyamalai which comprise of hard rock lithology. The moderately fractured depth layer of 70-100 m occurs at the central basin in and around Perungalur, Vattanakkotai and limited area in eastern boundary near Pallathur and Pattukkottai. The deep fractured zones of 100-200 m and 200-300 m covers most of the eastern basin area in places such as Tiruchitrambalam , Avanam , Uranikkadu, Malayur etc., north-eastern basin in and around Tulukkampatti, Gandarvakottai, Vettikkadu, Kurungulam etc., and south-eastern area in Amarasimhendrapuram. The deepest fracture zone of 300-600 m is found in limited area in south- southeast basin nearer to the coast in Kiranur and Memengalam.

2.9.5 Depth to Bed Rock

Generally bed rocks are observed below fractured formations. 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 30 m to 70 m below ground level which is considered as depth to bed rock in western region of the basin and 100 m to 300 m below ground level in eastern area. Generally the depth to bottom of aquifer (depth to bedrock) of this basin extends to deeper depths.In the regions where the depth to bedrock is shallow, dug well would be 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, borewell would be the suitable structure for tapping groundwater.

Shallow aquifer generally made up of weathered rock widely exists in the western and central parts of the basin. In the shallow aquifer area the depth to bedrock is found to occur between 30-70 m bgl (below ground level).

The aquifer occurring at moderate depth exists in the central parts of the basin, here the depth to bedrock is expected at a depth of 70-100 m bgl. The spatial extent of this moderate depth aquifer of this basin, present in the central part of the basin exhibits the sedimentary-crystalline contact.

The aquifer occurring at deeper depth exists in the eastern part of the basin. Here the depth to bedrock ranges between 100 and 600 m bgl

2.10 Soils

Soil is one of the natural resources and also a medium for growth of crop plants. Soil has layers or horizon of mineral and organic constituents of variable thickness which differ from parent material in morphological, physical, chemical, mineralogical and biological characteristics.

As Agriculture is very much production oriented in the states like Tamilnadu it is necessary to take steps for its proper conservation and management. Soil survey provides information on the nature of soil, depth, their extent, physical and chemical characteristics which have greater impact on irrigability of the soil and thereby on agricultural production.

The soil map of Agniyar river basin has been shown in plate 27,28. The major soil order found in this basin belong to Alfisols, Vertisols and Entisols.

ALFISOLS

In Agniyar river basin this type of soil is found in majority of the area. These soils are well developed deep to very deep red or brown in colour with alluvial concentration of clay in sub horizon. This soil is well suited for commonly growing crops. This type of soil is noted in Pudukkottai, Alangudi, Gandarvakottai, Kulathur, Pudukkottai, Orathanad and Thanjavur Taluks. There are 9 sub groups under this category and are described below.

1. **Typic Haplustalfs:**

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

2. **Udic Haplustalfs:**

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

3. **Ultic Haplustalfs:**

These resemble Typic Haplustalfs except that they have base saturation less than 75% in the textural horizon.

4. **Vertic Haplustalfs:**

These are also like Typic Haplustalfs but are heavy textured and develop cracks.

5. **Typic Rhodustalfs:**

These are comparatively dark, red soils than Typic Halplustalfs and have secondary; carbonates at moderate depth.

6. **Udic Rhodustalfs:**

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

7. **Udic Paleustalfs:**

The textural B horizon has a colour hue of 5 YR or yellowed in some part or has a value moist of 4 or more. They do not have secondary carbonates in the sub surface.

8. **Vertic Natrudalfs:**

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

9. **Plinthustalfs:**

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

INCEPTISOL

This comprises of immature soils having profile features more weakly expressed. All the pathogenic 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.

ENTISOL:

This order is found in very few locations in Manaparai taluks. 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 materials like quartzite , bedrock etc, prolongs the period of undistinguished horizonations. The following are the 4 sub groups identified under Entisols.

1. **Typic Ustorthents:**

These are reddish brown to red, light to medium textured and mostly non-calcareous soils. They are well drained externally 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.

2. **Lithic Ustorthents:**

These soils resemble like Topic Ustorthents but their depth is within 50cm followed by bedrock.

3. **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 conditions.

4. **Typic Ustipsamments:**

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

SOIL TYPES AND THEIR SERIES

The soils in the area have been classified on the basis of soil series that occurs in that area. The different type of soil series are described below. The soil series for each station is identified and the group is assigned to the station on the basis of the description of the group.

1. **Vayalogam soil series (Vyg)**

This consists of moderately deep medium textured and acidic brown soil. They are non – calcareous in nature derived from laterite parent material. They are sandy clay loams acidic and well draind.

2. **Mangalathupatti soil series (Mng)**

This series consists of dark yellowish brown deep acidic light textured and soil derived from laterite parent material. They are coarse sandy loams mixed and excessively drained.

3. **Illupur soil series**

This is extremely deep brownish yellow mildly alkaline and calcareous soil derived from laterite over gneissic rock. They are fine sandy loams mixed and poorly drained.

4. **Pattukottai soil series (Pst)**

It comprises extremely deep yellowish brown acidic to neutral and sandy loams occupying the upper portion of the catenary sequence. They are fine loamy and well drained.

5. **Madukkur soil series (Mdk)**

This group consists of very deep brown and natural soil with conspicuously reduced mottles in the sub soil. They are sandy loam acidic and excessively drained.

6. **Avadaiyarkoil series (Avk)**

It comprises very deep and medium textured yellowish brown soil developed from laterite parent materials. Lime concentrations are very common in this soil and the soils are mildly alkaline.

7. **Vallam soil series (Vlm)**

It comprises moderately deep light texture and reddish yellow soils occupying top most portion of laterite cap. It is fine sandy loam acidic and excessively drained.

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, Tamilnadu. The list of mapping units falling in the Agniyar river basin is shown in the following Table 2.10.1.

Table 2.10.1 Soil Classification

Mapping Unit	Description	Classification
27	Deep, well drained, gravelly clay soils on gently sloping lands, moderately eroded, associated with deep well drained, clayey soils.	Clayey- skeletal, mixed, Typic Rhodustalfs Fine, mixed, Typic Rhodustalfs
66	Shallow, somewhat excessively drained, gravelly loam soils on moderately sloping, low hills, severely eroded, associated with moderately shallow, well drained, gravelly clay soils	Loamy – skeletal, mixed Typic Ustropepts Clayey-skeletal, mixed, Typic Ustropepts
103	Moderately shallow, well drained, calcareous, clayey soils of gently sloping, interhill basins, slightly eroded, associated with very deep, well drained, stratified, loamy soils	Fine, mixed, Typic Ustropepts Fine-loamy, mixed, Typic Ustifluvents
156	Very deep, moderately well drained, loamy soils on gently sloping lands, moderately eroded associated with very deep, moderately well drained, clayey soils	Fine – loamy, mixed, Kandic Paleustalfs Fine, Kaolinitic, Kandic Paleustalfs
159	Very deep, well drained, clayey soils on nearly level lands, slightly eroded, associated with very deep, well drained, loamy soils with moderate erosion	Fine Kaolinitic, Kandic Paleustalfs Fine-Loamy, mixed, Oxic Ustropepts
177	Deep, well drained, gravelly clay soils on very gently sloping lands, severely eroded, associated with shallow somewhat excessively drained, loamy soils.	Clayey-skeletal, Kaolinitic, Kandic Rhodustalfs Fine- loamy, mixed, oxic ustropepts

Mapping Unit	Description	Classification
179	Moderately deep, well drained, gravelly loam soils on very gently sloping lands, moderately eroded, associated with deep, well drained, calcareous, gravelly loam soils with severe erosion.	Loamy-skeletal, mixed, Typic Haplustalfs Loamy-skeletal, mixed, Typic ustropepts
187	Moderately shallow, somewhat excessively drained, gravelly loam soils on undulating lands, moderately eroded, associated with moderately shallow, well drained, gravelly clay soils on gently sloping lands	Loamy-skeletal, mixed, Kanhaplic Haplustalfs Clayey-skeletal, Kaolinitic, Kandic Rhodustalfs
188	Moderately shallow, well drained, gravelly clay soils on undulating lands, moderately eroded, associated with deep, well drained, gravelly clay soils with slight erosion	Clayey-skeletal, Kaolinitic, Kanhaplic Haplustalfs Clayey-skeletal, Kaolinitic, Kandic Rhodustalfs
189	Shallow, well drained, gravelly clay soils on gently sloping laterite land, moderately eroded, associated with moderately shallow, well drained, gravelly loam soils	Clayey-skeletal, Kaolinitic, Kanhaplic Haplustalfs Loamy-skeletal, mixed, Oxic Ustropepts
190	Moderately shallow, somewhat excessively drained, gravelly clay soils on gently sloping lands, moderately eroded, associated with moderately deep, well drained, loamy soils on very gently sloping lands	Clayey-skeletal, Kaolinitic, Kanhaplic Haplustalfs Fine-Loamy, mixed, Oxic Ustropepts

Mapping Unit	Description	Classification
191	Deep, well drained, loamy soils on gently sloping lands, moderately eroded, associated with deep, well drained, loamy soils.	Fine –loamy, mixed, Kanhapic Haplustalfs Fine – loamy, mixed Kandic Rhodustalfs.
192	Deep, very poorly drained, strongly saline, clayey soils on nearly level marshy lands, slightly eroded	Fine, mixed, Typic Tropaquents Fine, mixed, Typic Halaquepts
195	Very deep, excessively drained, sandy soils on very gently sloping lands, moderately eroded.	Mixed, Typic Ustipsamments
198	Very deep, moderately well drained, sandy soils on gently sloping sand ridges, moderately eroded, associated with deep, moderately well drained, loamy soils on very gently sloping lands.	Mixed, Typic Ustipsamments Coarse- loamy, mixed, Typic Ustifluvents
210	Deep, somewhat excessively drained, loamy soils very gently sloping lands, moderately eroded, associated with moderately shallow, somewhat excessively drained, loamy soils	Coarse – loamy, mixed, Typic Ustropepts Fine- Loamy, mixed, Typic Ustropepts.
212	Deep moderately well drained calcarious loamy soils on nearly level tank irrigated lands slightly eroded associated with deep moderately well drained, clayey soils	Fine loamy mixed Typic Ustropepts Fine mixed Typic Ustropepts

Mapping Unit	Description	Classification
215	Deep imperfectly drained calcareous loamy soils on nearly level tank irrigated lands slightly eroded associated with deep imperfectly drained calcareous cracking clay soils	Fine-Loamy, mixed, Typic Ustropepts Fine, Montmorillonitic, Vertic Ustropepts
221	Very deep, moderately well drained, clayey soils of nearly level valleys, slightly eroded, associated with moderately deep, well drained, loamy soils with moderate erosion.	Fine, mixed, Typic Ustropepts Fine-loamy, mixed, Typic Ustropepts
230	Very deep, well drained, clayey soils of nearly level valleys, slightly eroded, associated with very deep, poorly drained, cracking clay soils	Fine, mixed, Typic Ustropepts Fine, montmorillonitic, Vertic Ustropepts
235	Deep, moderately well drained, clayey soils on nearly level valleys, slightly eroded, associated with deep, imperfectly drained, clayey soils of gently sloping valleys	Fine, mixed, Typic Ustropepts, Fine, mixed, Aquic Haplustalfs
236	Deep, well drained, clayey soils of nearly levels valleys, slightly eroded, associated with moderately deep moderately well drained stratified loamy soils	Fine, mixed, Typic Ustropepts Fine-loamy, mixed, Typic Ustifluvents
246	Moderately shallow, well drained, gravelly loam soils on very gently sloping lands, moderately eroded, associated with deep, well drained, loamy soils	Loamy-skeletal, mixed, Oxic Ustropepts Fine-loamy, mixed, Kanhaplic Haplustalfs

Mapping Unit	Description	Classification
248	Moderately deep, somewhat excessively drained, gravelly clay soils on very gently sloping lands, moderately eroded, associated with deep well drained gravelly clay soils on nearly level lands with slight erosion	Clayey-skeletal, Kaolinitic, Oxic Ustropepts Clayey-skleletal, Kaolinitic, Kandic Rhodustalfs
250	Moderately shallow, somewhat excessively drained, gravelly clay soils on very gently sloping laterite land, severely eroded, associated with shallow, well drained, gravelly clay soils	Clayey-skeletal, Kaolinitic, Oxic Ustopepts Clayey- skeletal, Kaolinitic, Lithic Ustrothents
254	Very deep, imperfectly drained, calcareous, cracking clay soils on nearly level, tank irrigated, lands slightly eroded	Fine montmorillonitic Vertic Ustropepts.

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 map the irrigable soils of the Agniyar basin were identified. The irrigable soil's main properties are summarized in Table 2.10.2 and their interpretative classifications for land capability for crop production irrigability and suitability for rice, sugarcane groundnut and cotton are given in the Table 2.10.3

Table 2.10.2 Major Properties of Soil

Type	Unit (*)	Drainage	Ground Water Depth (m)	Surface Texture	Available Water (mm/m) (**)	Depth (cm)	Slope
I	27	WD	4	sl-scl	50-100	100-150	M
	156	MWD	4	sl-ls	100-150	>150	M
	159	WD	4	sl-sel	100-150	>150	NTS-M
	177	WD-SWeD	4	scl	50-100	100-150	S
	179	WD	4	ls-sl	50-100	75-100	M-S
	187	SWeD-WD	4	ls-scl	50-100	50-75	M
	188	WD	4	sl	50-100	50-75	M-NTS
	189	WD	4	scl	50-100	100-150	M
	190	SWeD-WD	4	sl-scl	50-100	50-75	M
	191	WD	4	sl	100-150	100-150	M
II	66	SWeD-WD	4	scl-sc	<50	25-50	S
	103	WD	4	sl	100-150	50-75	NTS
	210	SWeD	4	ls	100-150	100-150	M
	212	MWD	3 to 4	sl-scl	150-200	100-150	NTS
	215	ID	4	cl	150-200	100-150	NTS
	221	MWD-WD	3	sl-scl	150-200	>150	NTS-M
	230	WD-PD	5	c	150-200	>150	NTS
	235	ID-MWD	2	sl-scl	150-200	100-150	NTS
	236	WD-MWD	2 to 3	cl	100-150	100-150	NTS
	246	WD	4	sl-ls	<50	50-75	M

Type	Unit (*)	Drainage	Ground Water Depth (m)	Surface Texture	Available Water (mm/m) (**)	Depth (cm)	Slope
II	248	SWeD-WD	4	scl-sl	<50	75-100	M-NTS
	250	SWeD- WD	4	sc	<50	50-75	S
	254	ID	4	cl	150-200	>150	NTS
III	192	VPD	1	cl-sl	150-200	100-150	NTS
	195	ED	1	s	<50	>150	M-NTS
	198	MWD	3	s	<50	>150	M-NTS

Drainage	Texture	Erosion
WD-Well Drained	scl=sandy-clay-loam	NTS=None To Slight
MWD= Moderately Well Drained	ls=loamy –sand	M=Moderate
SWeD =Some What excessively Drained	sl=sandy loam	S=Severe
(M)- Miscellaneous land	c=clay	N = None
ID –Imperfectly Drained	cl=clay loam	(M) = Misc land
MWD- Moderately Well Drained		

* - Soil association according to NBSS Publication No.46/b, 1997

** - Per 1 m of soil depth or the entire column if the soil is shallower

Table 2.10.3 Land Classification

Type	Unit (*)	Capability	Irrigability	Rice	Groundnut	Cotton	Sugarcane
I	27	llles	3s	NR	S2g-S1	S2gs-S1	NR
	156	llle	3s	NR	S2ng	S2n	NR
	159	llles-llls	2s	NR	S2ng	S2n	NR
	179	llles-lVes	3s	NR	S2g	S3gs	NR
	187	llles	4s	NR	S2ng	N1	NR
	188	llles-llls	4s-3s	NR	S2ng	S3ge	NR
	189	lVes-lVe	4s	NR		N1	NR
	190	llles	4s-3s	NR	S2ng	S3ge	NR
	191	lle	2s	NR	S2ng	S3c	NR
II	66	Vles	6s-6t	NR	NR	NR	NR
	103	llls-lls	3s-2s	S2-dt	SI	S2g-S2gt	S2t-S2s
	210	llle	3s	NR	SI	S2g-S2gt	NR
	212	lls	2s	S2xt-S1	S2xt-S3xt	S2tx-S1	S2xt-S1
	215	lls	2s	S2xt	S3xd	S3xd	S3xd
	221	lls	2s	S2dt	S2dt-S1	S2t	S1
	230	llw	2d	S2dt	S2d-S3d	S2d-S3ds	S2t-S2td
	235	llw	2d	S1	S2d-S3d	S3c	S1-S2d
	236	lls-llw	2s-3s	S2d-S1	S1-S2xd	S2t	S1-S2d
	246	llles	4s-3s	NR	S2ng	S3sg-S2nt	NR
	248	llles-llls	3s	NR	S2ng	S2ng	NR
	250	lVes-lVe	3s-4s	NR	N1	N2	NR
	254	lls	2d	S2xt	S3xd	S3c	S2x-S2xd

Type	Unit (*)	Capability	Irrigability	Rice	Groundnut	Cotton	Sugarcane
III	192	lVes-lVe	3d	N2	N2	N2	N2
	195	lVes-lVe	4s	N2	N2	N2	N2
	198	lVes-lVe	6s-6t	N2	N2	N2	N2

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

Type – I Soils: In this type the soils mostly with medium texture well and moderately well drained gravelly clay and loamy soils on gently sloping lands, moderately eroded. These soils are classified for irrigation mainly as moderate (2s, 3s) and moderately suitable for cultivation of Cotton and Groundnut Paddy and Sugarcane crops are not relevant for cultivation in these type of soils . The soils are irrigable and suitable for crops like Groundnut, Cotton, Pulses, Millets and Tree crops.

Type – II Soils: These are of fine texture imperfectly to moderately well drained moderately deep to deep with 1-3% slope with none to moderate erosion problems. These soils are classified for irrigation as 2S.3S,&2D for Land capability as IIs, IIw, IIIe & IIIs. In these soils the crops like Rice Sugarcane Groundnut and Cotton etc, are suitable for cultivation.

Type – III Soils: In this type, the soils are very deep moderate to very poorly drained, strongly saline clayey soils on nearly level marshy lands, moderately eroded and in some places having sandy soil excessively drained. In these type of soils Paddy, Sugarcane Cotton and Groundnut crops are not suitable for cultivation.

The different mapping unit numbers related with different soil category of the basin are given in the following Table 2.10.4.

Table 2.10.4 Mapping Unit of Soil

Sl No	Soil Category	Mapping Unit Numbers
1	Alfisol	27,156,159,179,187,188,189,190 & 191
2	Entisol	192,195, & 198
3	Inceptisol	66,103,210,212,215,221,230,235,236,246,248,250 & 254

Note:

Capability	**Irrigability**	**Land Suitability**
II Good cultivable land	2,3 moderate	NR: Not Relevant
III Moderately good cultivable land	4 severe	N2: Permanently not suitable
IV Fairly good cultivable land	6 not suitable	S1 :Highly suitable
VI Land suited for grazing	s: soil limitations	S2: Moderate
VII Fairly suited for grazing	d:drainage problem	S3:Moderate with limitations
VIII Land suited for wild life	t: Topographic and rock exposure	t: soil texture limitations
e:erosion problem		d: drainage problem
s:soil problem		g: gravelliness
w:drainage problem		e: erosion
		n: moderate limitations of Fertility
		s: soil depth limitations
		c:climate limitations

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 Agniyar River Basin covers part of Dindigul, Pudukkottai, Sivagangai, Thanjavur and Trichirapalli districts. An analysis of Social and demographic characteristics of above two districts gives an idea about such characteristics in the Agniyar River Basin.

2.11.1 Population in Agniyar Basin

0.21 % of total area of Dindigul District (12.99 sq.km out of 6068.82 sq.km) , 66.32 % of total area of Pudukkottai District (3083.53 sq.km out of 4648.13 sq.km), 1.51 % of total area of Sivagangai District (63.81 sq.km out of 4236.69 sq.km), 35.17 % of total area of Thanjavur District (1201.35 sq.km out of 3416.08 sq.km) and 7.62 % of total area of Trichirapalli District (340.33 sq.km out of 4467.2 sq.km) covers the Agniyar River Basin and population of districts covered in Agniyar River Basin within the Basin as per census 2011 is given below in Table 2.11.1

Table 2.11.1. District wise population details of Agniyar River Basin (in million)

Sl.No.	Name of the District	Population in 2011			Population during 2021		
		Rural	Urban	Total	Rural	Urban	Total
1	Dindigul	0.003	0	0.003	0.003	0.000	0.003
2	Pudukkottai	0.989	0.254	1.243	1.071	0.307	1.378
3	Sivagangai	0.018	0	0.018	0.020	0.000	0.020
4	Thanjavur	0.426	0.112	0.538	0.462	0.136	0.598
5	Trichirapalli	0.069	0	0.069	0.075	0.000	0.075
Total		**1.505**	**0.366**	**1.871**	**1.631**	**0.443**	**2.074**

There are 3 (Three) sub Basins in Agniyar 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 Agniyar River Basin are given in **Appendix 2.11.1 to 2.11.3.** The Sub Basin wise population of Agniyar River Basin is given in the **Table 2.11.2**. The population of Agniyar River Basin is projected for the targeted years 2021, 2022, 2030, 2040 & 2050 which is detailed in Chapter 7.

Table 2.11.2 Sub Basin wise Population in Agniyar River Basin

S. No	Name of Sub basin	As per census 2011 (in million)			As projected to 2021 (in million)		
		Rural	Urban	Total	Rural	Urban	Total
1	Agniyar	0.749	0.235	0.984	0.811	0.284	1.095
2	Ambuliyar	0.298	0.055	0.353	0.323	0.066	0.389
3	South Vellar	0.458	0.076	0.534	0.496	0.092	0.587
	Total	**1.505**	**0.366**	**1.871**	**1.630**	**0.442**	**2.071**

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 Agniyar 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 Agniyar River Basin based on census 2011 is projected to the present year 2022. The average annual exponential growth rate is used to find out the growth of urban and rural population and projecting the population.

The Geometric Increase 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,

Sl.No	Census Period	Average Annual Exponential growth rate	
		Rural	Urban
1	**2001-2011**	**0.8%**	**1.9%**

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 0.8% for Rural population and 1.9% for Urban Population. The projected population in Agniyar River Basin for 2021 is given below in **Table 2.11.3**

Table 2.11.3 Projected population in Agniyar River Basin for 2021

Sl. No	Name of Sub basin	Area in Sq.km	Total Rural Population in million		Total Urban Population in million		Total	
			2011	2021	2011	2021	2011	2021
1	Agniyar	2106.43	0.749	0.811	0.235	0.284	0.984	1.095
2	Ambuliyar	825.69	0.298	0.323	0.055	0.066	0.353	0.389
3	South Vellar	1769.90	0.458	0.496	0.076	0.092	0.534	0.588
	Total	**4702.02**	**1.505**	**1.630**	**0.366**	**0.442**	**1.871**	**2.072**

Source: Census 2011

From the above table it is inferred that about 80.45% and 19.55% of people live in Rural and Urban area in this Agniyar River Basin.

2.11.3 Population Density

Population density is a measurement of population per unit area. The Sub Basin wise population density of Agniyar River Basin is given in Table **2.11.4.** The population density is higher in Agniyar sub basin (468 persons per sq.km) and lower in South Vellar sub basin (302 Persons per sq.km).

Table 2.11.4 Sub basin wise Population density in Agniyar River Basin

Sl.No	Name of the sub Basin	Area (Sq.km)	Total population 2011	Density (Person/Sq.km)
1	Agniyar	2106.43	984782	468
2	Ambuliyar	825.69	353630	428
3	South Vellar	1769.90	533801	302
Total		**4702.02**	**1872213**	**1198**
Average population Density				**399**

2.11.4 Population by Sex

The sex wise distribution of population in Agniyar River Basin as per census 2011 is given in **Table 2.11.5**

Table 2.11.5 District wise Population by sex in Agniyar 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	Dindigul	12.99	2602	1303	50%	1299	50%
2	Pudukkottai	3083.53	1243324	616010	50%	627315	50%
3	Sivagangai	63.81	18463	9284	50%	9179	50%
4	Thanjavur	1201.35	538619	263378	49%	275241	51%
5	Trichirapalli	340.33	69206	34502	50%	34703	50%
	Total		**1872214**	**924477**	**49%**	**947737**	**51%**

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 Agniyar River Basin is given below in **Table 2.11.6**

Table 2.11.6 Sex wise Population distribution in Agniyar River Basin

Sl. No	Name of the Sub Basin	Population(in million)			Male %	Female %	Total %	Sex Ratio
		Male	Female	Total				
1	Agniyar	0.49	0.50	0.98	49.47	50.53	100	1021 females for 1000 males
2	Ambuliyar	0.17	0.18	0.35	48.86	51.14	100	1046 females for 1000 males
3	South Vellar	0.26	0.27	0.53	49.55	50.45	100	1018 females for 1000 males
	Total	**0.92**	**0.95**	**1.86**	**49.30**	**50.70**	**100**	1025 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 Agniyar River basin is worked out sub basin wise and is given in **Table 2.11.7.** The overall literacy rate in Agniyar River Basin is found to be 61.56%.

Table 2.11.7 Details of Literacy level in Agniyar 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	Agniyar	0.255	0.233	0.488	0.487	0.498	0.985	52.34	46.90	49.59
2	Ambuliyar	0.125	0.112	0.237	0.173	0.181	0.354	72.58	61.73	67.03
3	South Vellar	0.200	0.163	0.363	0.265	0.269	0.534	75.78	60.46	68.05
	Total	**0.580**	**0.508**	**1.088**	**0.925**	**0.948**	**1.873**	**66.90**	**56.36**	**61.56**

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 Agniyar River Basin is given in **Table 2.11.8**

Table 2.11.8 Details of Births and Deaths Registered in Districts covered in Agniyar Basin

Sl.No	Name of the District	Mid-Year Estimated Populaion for 2021	As on Year 2020				
			Births	Deaths	Infant Deaths	Still Births	Maternal Deaths
1	Dindigul	2347789	25693	19948	291	212	15
2	Pudukkottai	1753465	18162	14520	296	87	13
3	Sivagangai	1453917	18871	13159	164	19	14
4	Thanjavur	2614352	40311	24797	366	12	18
5	Trichirapalli	2965633	42298	29442	361	380	30

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 Agniyar River Basin for the period of 2019-2020 is given in **Table 2.11.9**

Table 2.11.9 Details of Family Welfare Programme in Districts of Agniyar River Basin

Name of the District	2019-20			
	Sterilisation	IUCD	Oral Pill Users	Conventional Contraceptives Users
Dindigul	7859	13461	838	3817
Pudukkottai	4450	10297	431	1910
Sivagangai	5392	9584	969	1004
Thanjavur	8258	14447	1295	2381
Trichirapalli	8189	17279	882	1312

Source: Director of family welfare, Chennai – 6

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 Agniyar River Basin is given in **Table 2.11.10.**

Table 2.11.10 Number of Households in Agniyar River Basin (2011)

Sl.No	Name of the SubBasin	Total Population In million	Number of House Holds
1	Agniyar	0.985	235720
2	Ambuliyar	0.354	88753
3	South Vellar	0.534	128054
4	**Total**	1.872	452527

Source: Census of India 2011

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

There are 606 small scale industries, 15 large & medium scale industries in Agniyar River Basin. The water requirement for the industrial purpose for large & medium and small scale industries are estimated as 0.131 Mcum and 1.532 Mcum respectively. The projected future water demand for large & medium scale industries for the targeted year 2022, 2030, 2040 & 2050 are estimated as 0.142 Mcum, 0.232 Mcum, 0.418 Mcum & 0.752 Mcum respectively. The projected future water demand for small scale industries for the targeted year 2022, 2030, 2040 & 2050 are estimated as 1.654 Mcum, 2.713 Mcum, 4.884 Mcum & 8.790 Mcum respectively.

Dindigul District

Major employment in the city is provided by industrial estates, hand loom, trading and commerce activities. Approximately 90 percent of the workforce is employed in the tertiary sector. The district at large has only two industrial estates, with one of them located in the city. Oddanchatram is one of the important town in Dindigul district. Oddanchatram Vegetable market (also known as Gandhi market) is the largest vegetable market in Tamil Nadu. As of 2001, there were approximately 60 tanneries, 165 lock manufacturing units and large number of cotton spinning mills.

Locks and steel safes are manufactured in Dindigul and operated as a co-operative sector. Locks manufactured in Dindigul are sold in national and international markets and is well known all over India for its quality. Dindigul locks received geographical indication on 30 August 2019. A decline in lock industry is observed in modern times and other industries like leather, handloom, and aggro opportunities have gained significance. Silk, muslin and blanket manufacturing is common in Dindigul and after Coimbatore, the city has the second largest textile spindling capacity in the State. Chinnalapatti silk, a brand of silk saree is produced out of Chinnalapatti located 11 km (6.8 mi) from the city. The climate condition of the region is conducive for horticulture and agriculture. The district at large produce non-food crops like coffee, flowers, tobacco, and eucalyptus. Dindigul is the center for wholesale trading of fruits like orange, pineapple, sapota and guava, and vegetables like onion.

Pudukkottai District

The economy is primarily agrarian, supplemented by gradually growing industrial and service sectors. Paddy is the major crop of this district. Other than Paddy, Groundnut is the major crop in this district which is mainly cultivated under rainfed conditions. Under irrigated condition. Millet, pulse, cotton, sugarcane, gingelly are the other crops cultivated in this district.

Sivagangai District

The economy is primarily agrarian , the principal crop of Sivagangai district is paddy rice. Most of the district has red soil. The other crops grown are sugarcane, groundnuts, pulses, millet and cereals. Tamil Nadu Agricultural University plans to set up the State's first Red Soil Dryland Research Centre in Sivagangai district.

Sakthi sugar factory is also located in Padamathur, Sivagangai. It has the capacity to produce more than 5000 tons of sugar per day. It provides employment to more than 1000 labourers, directly and indirectly. Moser Baer Clean Energy Limited has commissioned a 5 MW grid connected solar PV project at Sivagangai, Tamil Nadu. The project was awarded to Sapphire Industrial Infrastructure Pvt. Ltd., a wholly owned subsidiary of MBCEL, through a competitive bidding process conducted by the Tamil Nadu Renewable Development Agency. The project is implemented under the 50 MWp generation based incentive scheme of the Ministry of New and Renewable Energy, Government of India.

Thanjavur District

The major occupation of the inhabitants of the city is tourism and service-oriented industry, while the traditional occupation is agriculture. Thanjavur is known as the "Rice bowl of Tamil Nadu". Paddy is the crop and the other crops grown are blackgram, banana, coconut, gingelly, ragi, redgram, greengram, sugarcane and maize. The total percentage of land fit for cultivation is 58%. There are three seasons for agriculture in Thanjavur – *Kuruvai* (June to September), *Samba* (August to January) and Thaladi (September, October to February, March). The total rice production has been maintained at 10.615 L.M.T and 7.077 L.M.T. The city acts as a focal point for food grains transported from the adjoining areas of the Cauvery Delta. Organic farming is gradually becoming known to the farmers of Thanjavur. To maximise agricultural produce, organic farming is being implemented. Though agriculture is the main economic activity, only 7% of the population is involved in it. There is a lot of agricultural related trading that forms the key economic activity in the city.

Thanjavur is an important centre of silk weaving in Tamil Nadu. There were 200 silk weaving units in the city in 1991 with around 80,000 people working in them. Thanjavur is also famous for the 'Thalaiyatti bommai' or 'Dancing dolls' which is a doll made from clay, wood or plastic. The sarees produced in the villages surrounding Thanjavur are sold in Thanjavur and neighbouring towns. Increasing production costs and competition from large-scale producers have reduced the number of people involved in the production. The city produces bell metal craft like Thanjavur metal plates, bronze images bowls, napkins and powder boxes made of copper and bronze. The city is a major manufacturer of pith works consisting of models of Hindu idols, mosques, garlands and other bird figurines.

Manufacture of musical instruments like veena, tambura, violin, mrithangam, thavil and kanjira is another economic activity in the city.

Trichirapalli District

Tiruchirappalli is a major engineering equipment manufacturing and fabrication hub in India. The Golden Rock Railway Workshop, which moved to Tiruchirappalli from Nagapattinam in 1928, is one of the three railway workshop–cum–production units in Tamil Nadu. The workshops produced 650 conventional and low-container flat wagons during 2007–2008.

A high-pressure boiler manufacturing plant was set up by Bharat Heavy Electricals Limited (BHEL), India's largest public sector engineering company. This was followed by a seamless steel plant and a boiler auxiliaries plant. BHEL contribute nearly 60 per cent of India's steel fabrication, earning the city the title, "Energy equipment and fabrication capital of India". Other important industries in Tiruchirappalli include Trichirapalli Distilleries and Chemicals Limited (TDCL), which was established at Senthaneerpuram in the former Golden Rock municipality in 1966 and the Trichirapalli Steel Rolling Mills, which was started as a private limited company on 27 June 1961. The Trichirapalli Distilleries and Chemicals Limited manufactures rectified spirit, acetaldehyde, acetic acid, acetic anhydride and ethyl acetate. It is one of the biggest private sector distilleries in Tamil Nadu.

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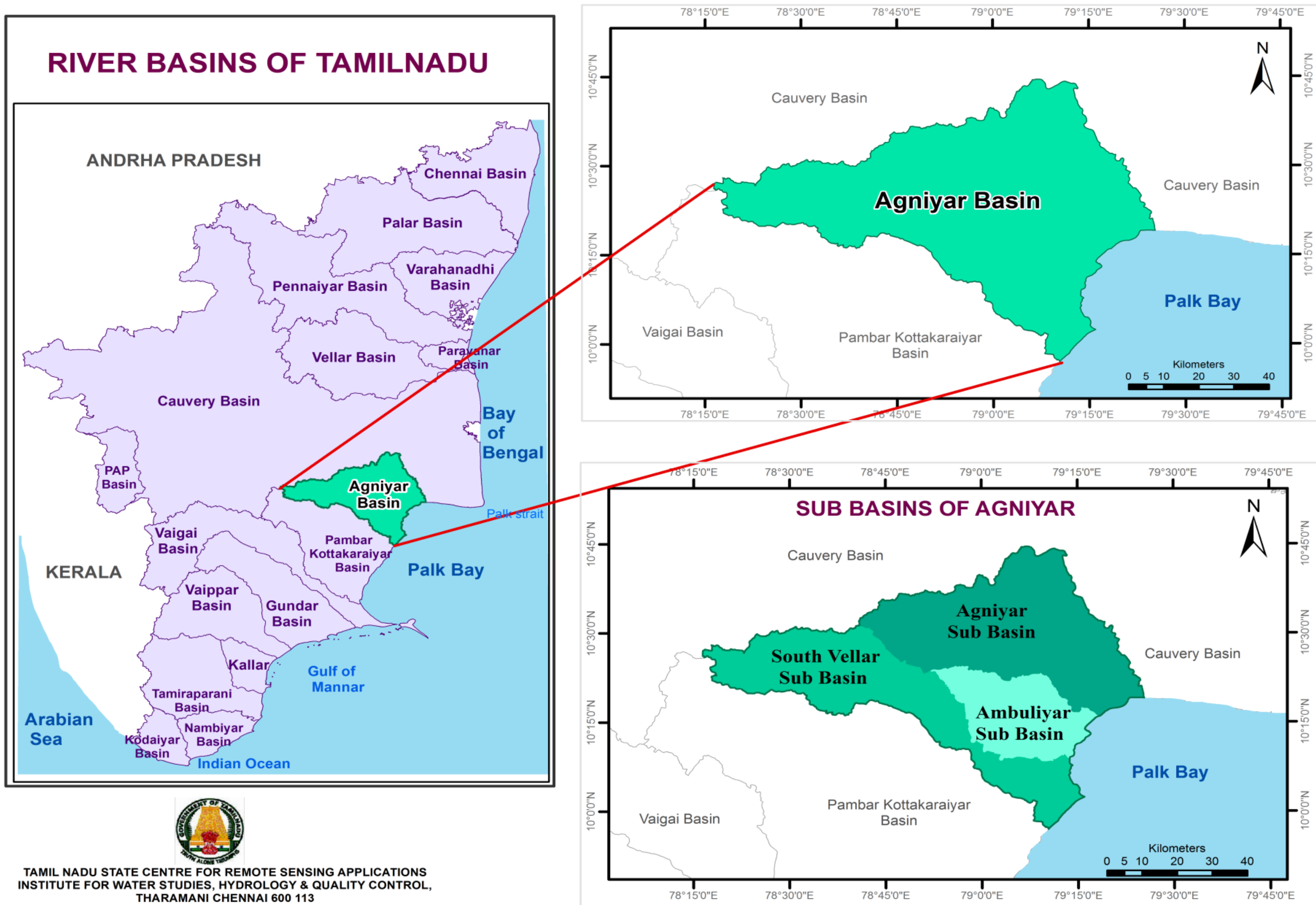
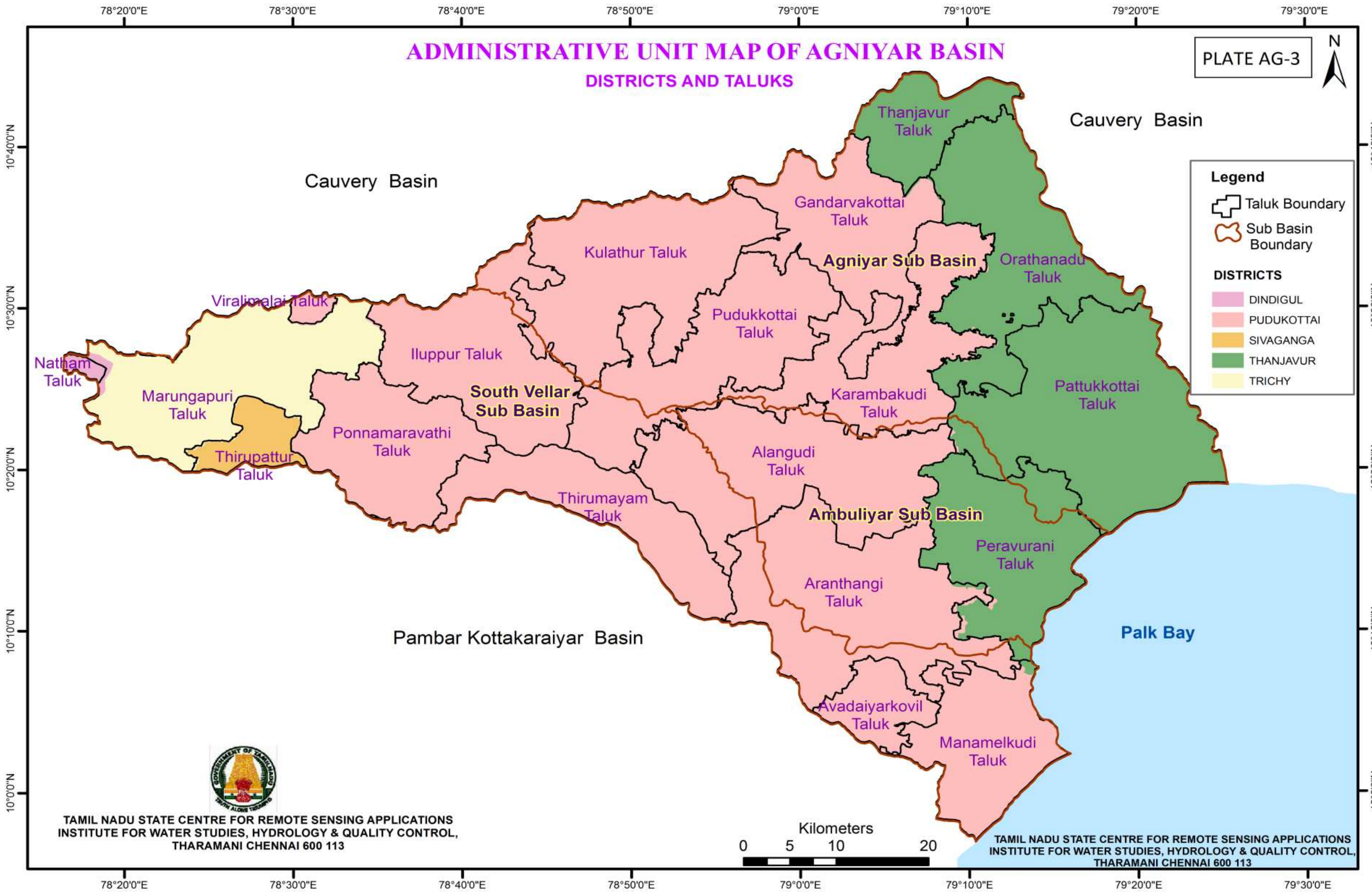
INDEX MAP OF AGNIYAR BASIN

PLATE AG - 2




ADMINISTRATIVE UNIT MAP OF AGNIYAR BASIN
DISTRICTS AND TALUKS
PLATE AG-3
N
Cauvery Basin
Cauvery Basin
Pambar Kottakaraiyar Basin
Palk Bay
Legend
Taluk Boundary
Sub Basin Boundary
DISTRICTS
DINDIGUL
PUDUKOTTAI
SIVAGANGA
THANJAVUR
TRICHY
Thanjavur Taluk
Gandarvakottai Taluk
Kulathur Taluk
Agniyar Sub Basin
Orathanadu Taluk
Viralimalai Taluk
Pudukkottai Taluk
Natham Taluk
Iluppur Taluk
Marungapuri Taluk
South Vellar Sub Basin
Karambakudi Taluk
Pattukkottai Taluk
Ponnamaravathi Taluk
Alangudi Taluk
Thirupattur Taluk
Thirumayam Taluk
Ambuliyar Sub Basin
Peravurani Taluk
Aranthangi Taluk
Avadaiyarkovil Taluk
Manamelkudi Taluk
Kilometers
0 5 10 20
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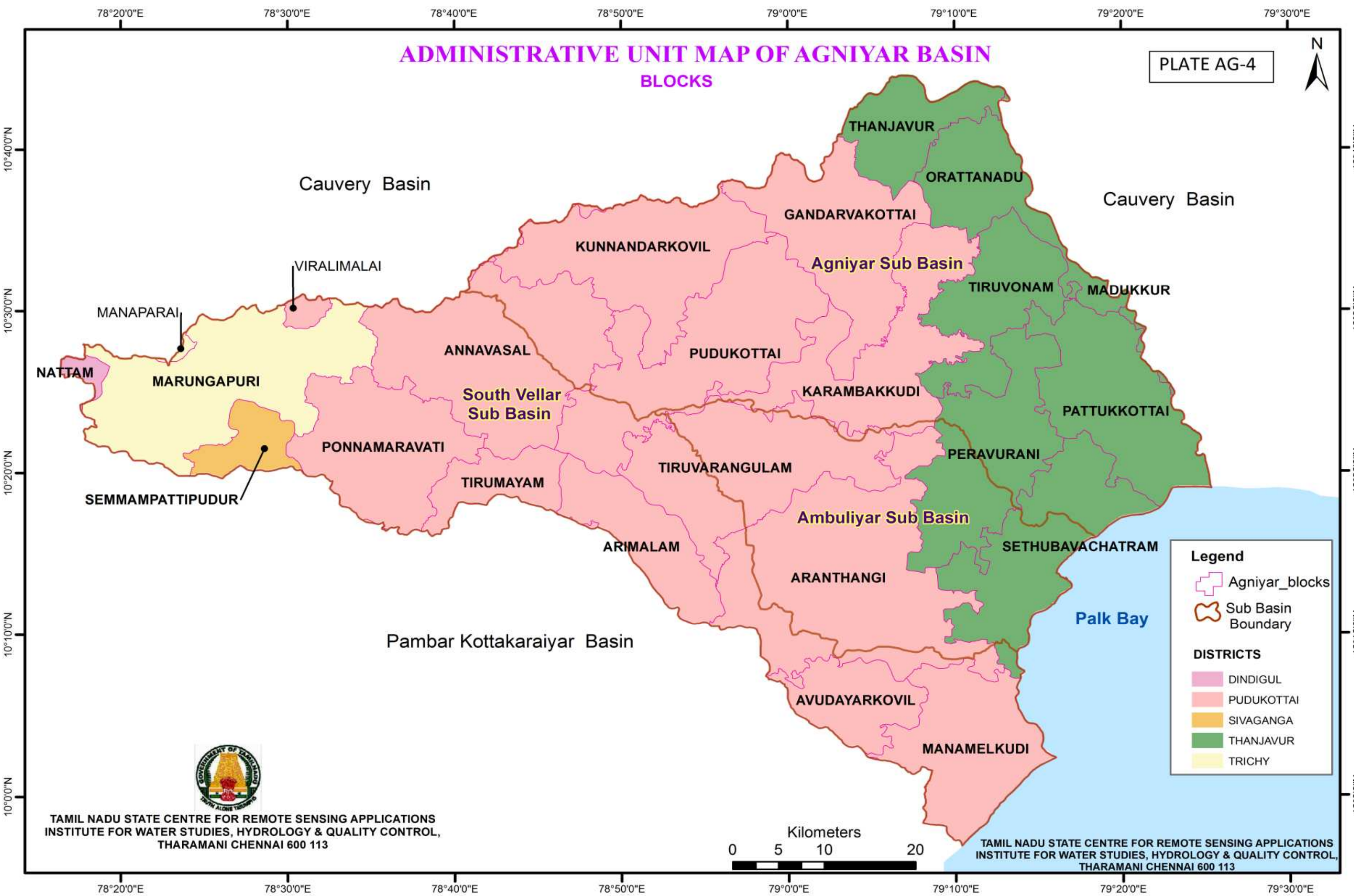
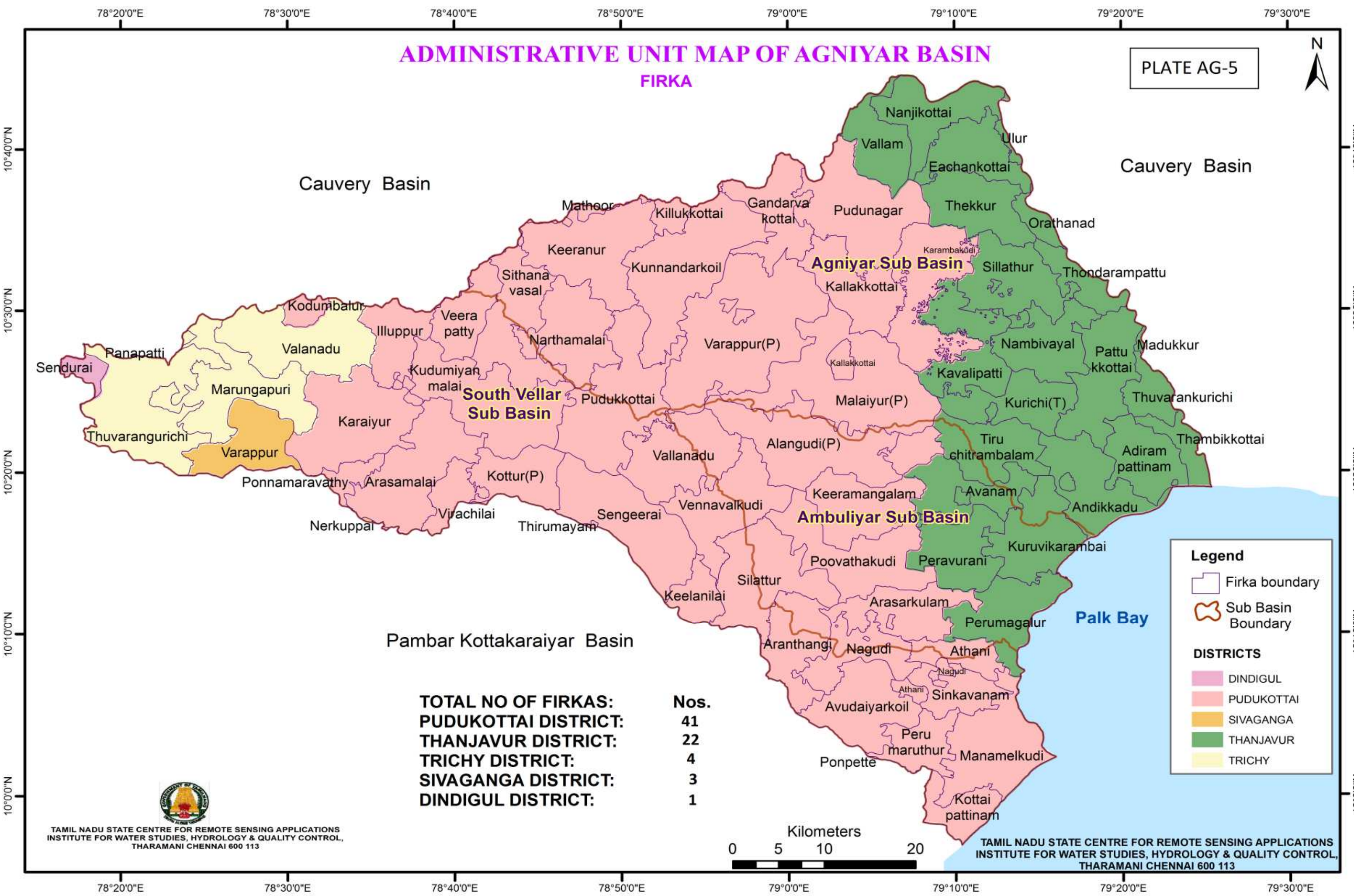
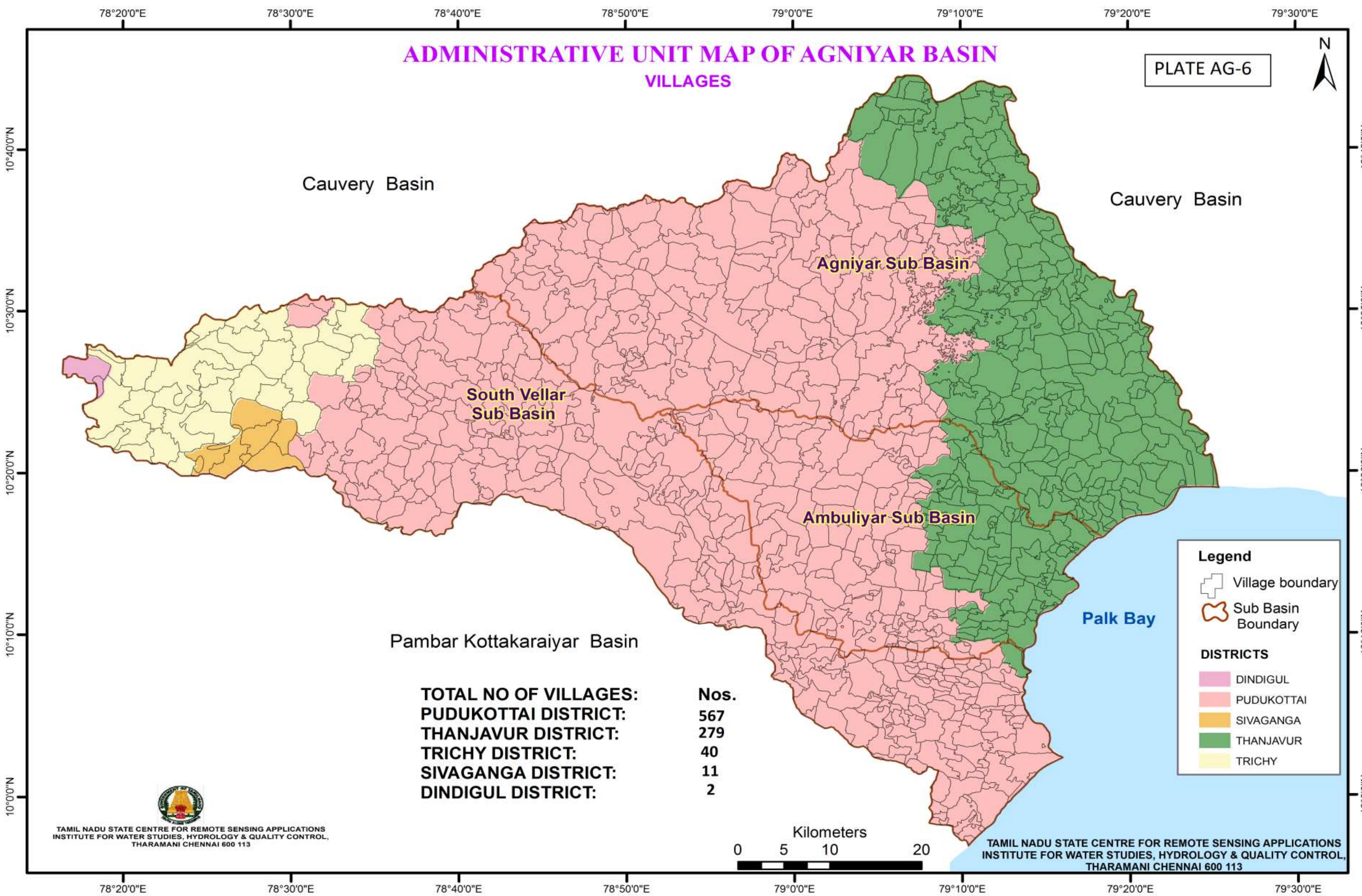
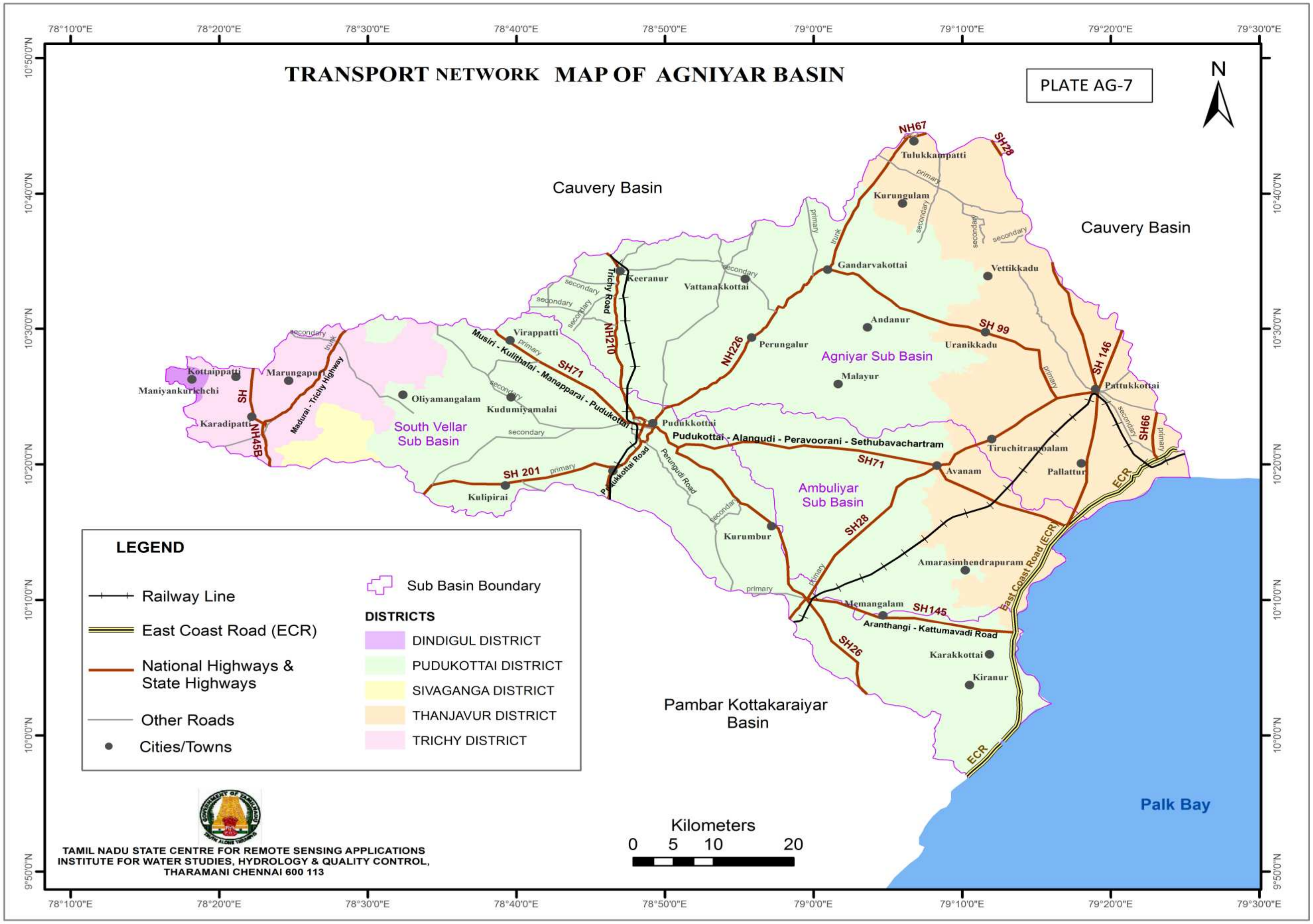
THARAMANI CHENNAI 600 113
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATIONS
INSTITUTE FOR WATER STUDIES, HYDROLOGY & QUALITY CONTROL,
THARAMANI CHENNAI 600 113
78°20'0"E
78°30'0"E
78°40'0"E
78°50'0"E
79°0'0"E
79°10'0"E
79°20'0"E
79°30'0"E
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
10°0'0"N


ADMINISTRATIVE UNIT MAP OF AGNIYAR BASIN
BLOCKS
PLATE AG-4
N
78°20'0"E
78°30'0"E
78°40'0"E
78°50'0"E
79°0'0"E
79°10'0"E
79°20'0"E
79°30'0"E
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
10°0'0"N
Cauvery Basin
Cauvery Basin
Pambar Kottakaraiyar Basin
Palk Bay
Agniyar Sub Basin
South Vellar Sub Basin
Ambuliyar Sub Basin
THANJAVUR
ORATTANADU
GANDARVAKOTTAI
KUNNANDARKOVIL
TIRUVONAM
MADUKKUR
VIRALIMALAI
MANAPARAI
NATTAM
MARUNGAPURI
ANNAVASAL
PUDUKOTTAI
KARAMBAKKUDI
PATTUKKOTTAI
PONNAMARAVATI
TIRUMAYAM
TIRUVARANGULAM
PERAVURANI
SEMMAMPATTIPUDUR
ARIMALAM
SETHUBAVACHATRAM
ARANTHANGI
AVUDAYARKOVIL
MANAMELKUDI
Legend
Agniyar_blocks
Sub Basin Boundary
DISTRICTS
DINDIGUL
PUDUKOTTAI
SIVAGANGA
THANJAVUR
TRICHY
Kilometers
0 5 10 20
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATIONS
INSTITUTE FOR WATER STUDIES, HYDROLOGY & QUALITY CONTROL,
THARAMANI CHENNAI 600 113
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATIONS
INSTITUTE FOR WATER STUDIES, HYDROLOGY & QUALITY CONTROL,
THARAMANI CHENNAI 600 113

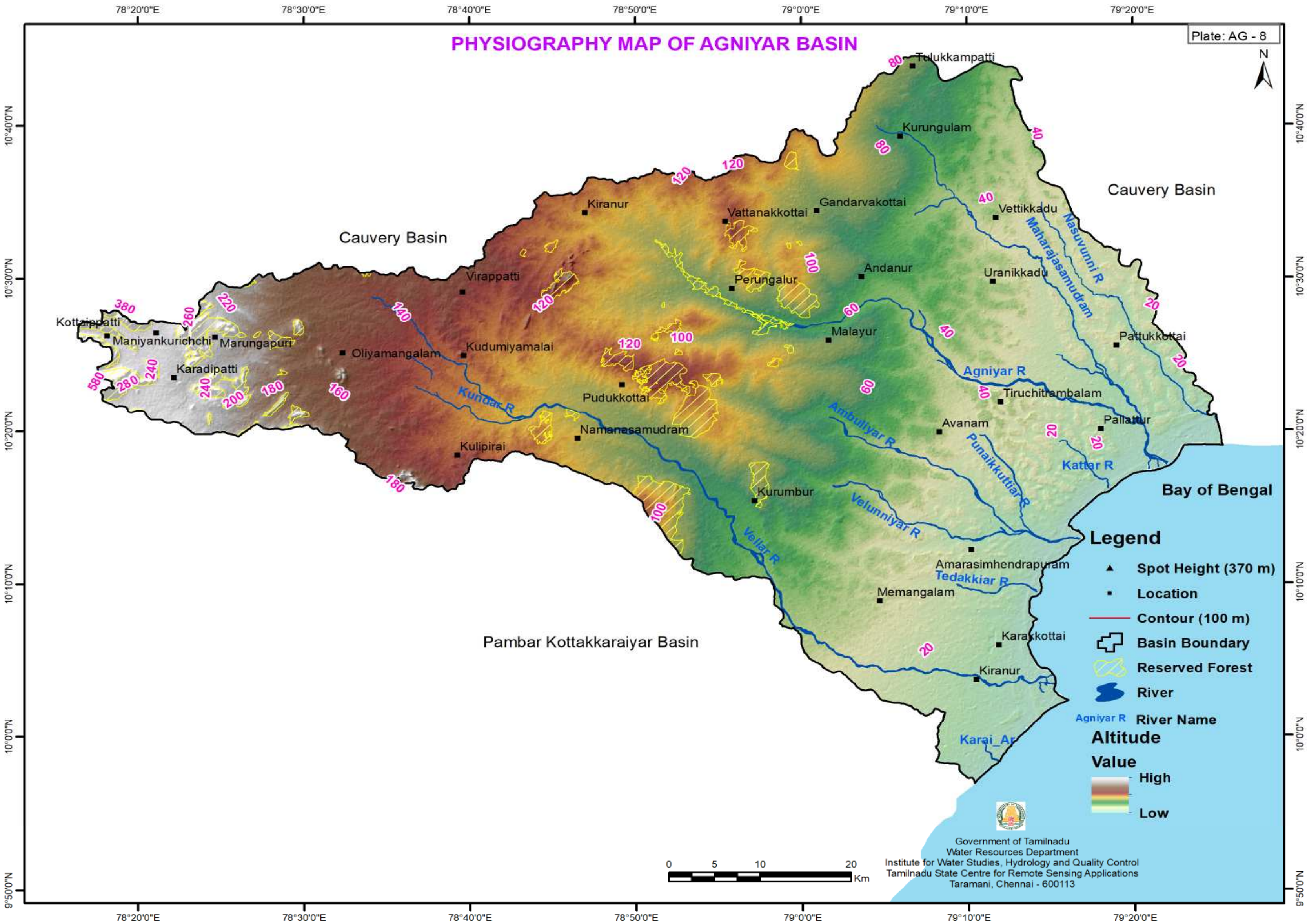

ADMINISTRATIVE UNIT MAP OF AGNIYAR BASIN
FIRKA
PLATE AG-5
N
Cauvery Basin
Cauvery Basin
Pambar Kottakaraiyar Basin
Palk Bay
Agniyar Sub Basin
South Vellar Sub Basin
Ambuliyar Sub Basin
Nanjikottai
Vallam
Ulur
Eachankottai
Thekkur
Orathanad
Pudunagar
Gandarva kottai
Killukkottai
Mathoor
Keeranur
Kunnandarkoil
Sithana vasal
Karambakudi
Sillathur
Thondarampattu
Kallakkottai
Kodumbalur
Veera patty
Illuppur
Narthamalai
Varappur(P)
Nambivayal
Pattu kkottai
Madukkur
Panapatti
Sendurai
Valanadu
Kudumiyan malai
Kallakkottai
Kavalipatti
Marungapuri
Pudukkottai
Malaiyur(P)
Kurichi(T)
Thuvarankurichi
Karaiyur
Thiru chitrambalam
Thambikkottai
Thuvarangurichi
Varappur
Alangudi(P)
Adiram pattinam
Vallanadu
Ponnamaravathy
Arasamalai
Kottur(P)
Avanam
Keeramangalam
Vennavalkudi
Andikkadu
Virachilai
Sengeerai
Nerkuppai
Thirumayam
Kuruvikarambai
Poovathakudi
Peravurani
Silattur
Keelanilai
Arasarkulam
Perumagalur
Aranthangi
Nagudi
Athani
Nagudi
Athani
Sinkavanam
Avudaiyarkoil
Peru maruthur
Manamelkudi
Ponpette
Kottai pattinam
TOTAL NO OF FIRKAS: Nos.
PUDUKOTTAI DISTRICT: 41
THANJAVUR DISTRICT: 22
TRICHY DISTRICT: 4
SIVAGANGA DISTRICT: 3
DINDIGUL DISTRICT: 1
Legend
Firka boundary
Sub Basin Boundary
DISTRICTS
DINDIGUL
PUDUKOTTAI
SIVAGANGA
THANJAVUR
TRICHY
Kilometers
0 5 10 20
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATIONS
INSTITUTE FOR WATER STUDIES, HYDROLOGY & QUALITY CONTROL,
THARAMANI CHENNAI 600 113
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATIONS
INSTITUTE FOR WATER STUDIES, HYDROLOGY & QUALITY CONTROL,
THARAMANI CHENNAI 600 113
78°20'0"E
78°30'0"E
78°40'0"E
78°50'0"E
79°0'0"E
79°10'0"E
79°20'0"E
79°30'0"E
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
10°0'0"N

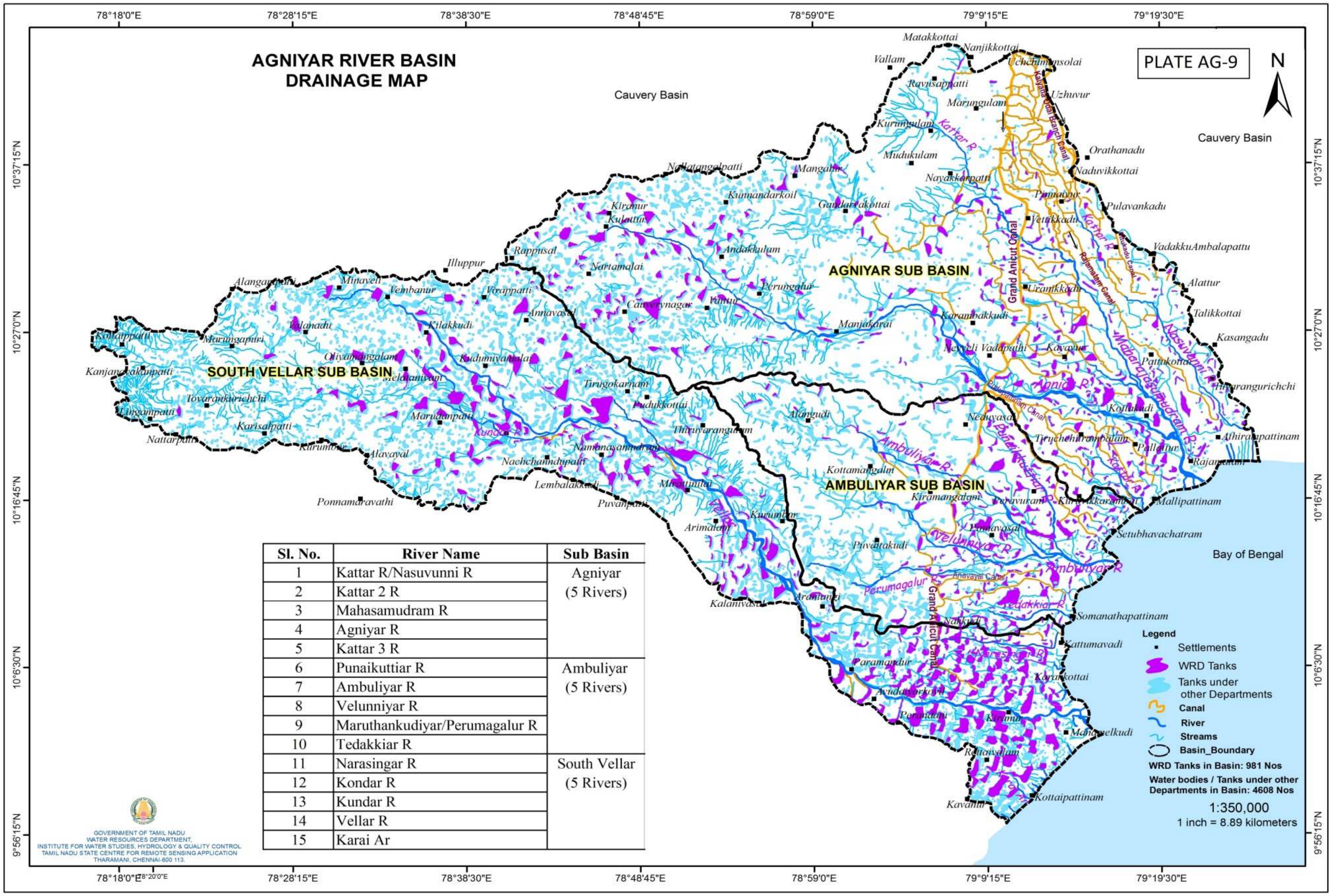


ADMINISTRATIVE UNIT MAP OF AGNIYAR BASIN
VILLAGES
PLATE AG-6
N
Cauvery Basin
Cauvery Basin
Agniyar Sub Basin
South Vellar Sub Basin
Ambuliyar Sub Basin
Pambar Kottakaraiyar Basin
Palk Bay
TOTAL NO OF VILLAGES: Nos.
PUDUKOTTAI DISTRICT: 567
THANJAVUR DISTRICT: 279
TRICHY DISTRICT: 40
SIVAGANGA DISTRICT: 11
DINDIGUL DISTRICT: 2
Legend
Village boundary
Sub Basin Boundary
DISTRICTS
DINDIGUL
PUDUKOTTAI
SIVAGANGA
THANJAVUR
TRICHY
Kilometers
0 5 10 20
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATIONS
INSTITUTE FOR WATER STUDIES, HYDROLOGY & QUALITY CONTROL,
THARAMANI CHENNAI 600 113
78°20'0"E
78°30'0"E
78°40'0"E
78°50'0"E
79°0'0"E
79°10'0"E
79°20'0"E
79°30'0"E
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
10°0'0"N

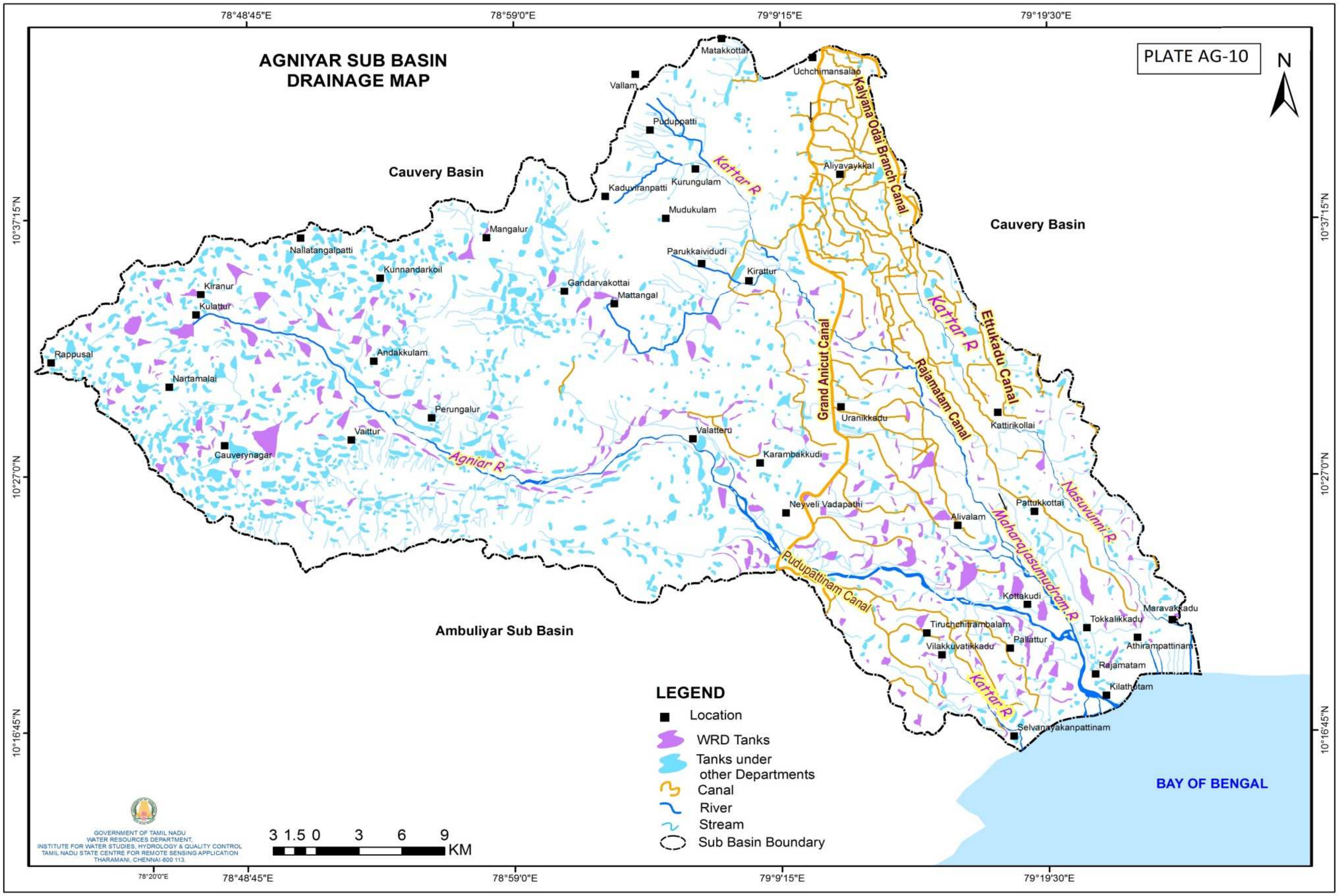


TRANSPORT NETWORK MAP OF AGNIYAR BASIN
PLATE AG-7
N
Cauvery Basin
Cauvery Basin
Agniyar Sub Basin
South Vellar Sub Basin
Ambuliyar Sub Basin
Pambar Kottakaraiyar Basin
Palk Bay
LEGEND
Railway Line
East Coast Road (ECR)
National Highways & State Highways
Other Roads
Cities/Towns
Sub Basin Boundary
DISTRICTS
DINDIGUL DISTRICT
PUDUKOTTAI DISTRICT
SIVAGANGA DISTRICT
THANJAVUR DISTRICT
TRICHY DISTRICT
Kilometers
0 5 10 20
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATIONS
INSTITUTE FOR WATER STUDIES, HYDROLOGY & QUALITY CONTROL,
THARAMANI CHENNAI 600 113
Tulukkampatti
Kurungulam
Gandarvakottai
Vettikkadu
Keeranur
Vattanakkottai
Andanur
Perungalur
Uranikkadu
Malayur
Pattukkottai
Virappatti
Oliyamangalam
Kudumiyamalai
Pudukkottai
Tiruchitrambalam
Pallattur
Avanam
Kulipirai
Kurumbur
Amarasimhendrapuram
Memangalam
Karakkottai
Kiranur
Kottaippatti
Marungapuri
Maniyankurichchi
Karadipatti
NH67
SH28
NH226
SH 99
SH 146
SH66
SH71
NH210
SH 201
NH45B
SH26
SH145
ECR
Trichy Road
Musiri - Kulithalai - Manapparai - Pudukottai
Madurai - Trichy Highway
Pudukottai Road
Perungudi Road
Pudukottai - Alangudi - Peravoorani - Sethubavachartram
Aranthangi - Kattumavadi Road
East Coast Road (ECR)
78°10'0"E
78°20'0"E
78°30'0"E
78°40'0"E
78°50'0"E
79°0'0"E
79°10'0"E
79°20'0"E
79°30'0"E
10°50'0"N
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
10°0'0"N
9°50'0"N

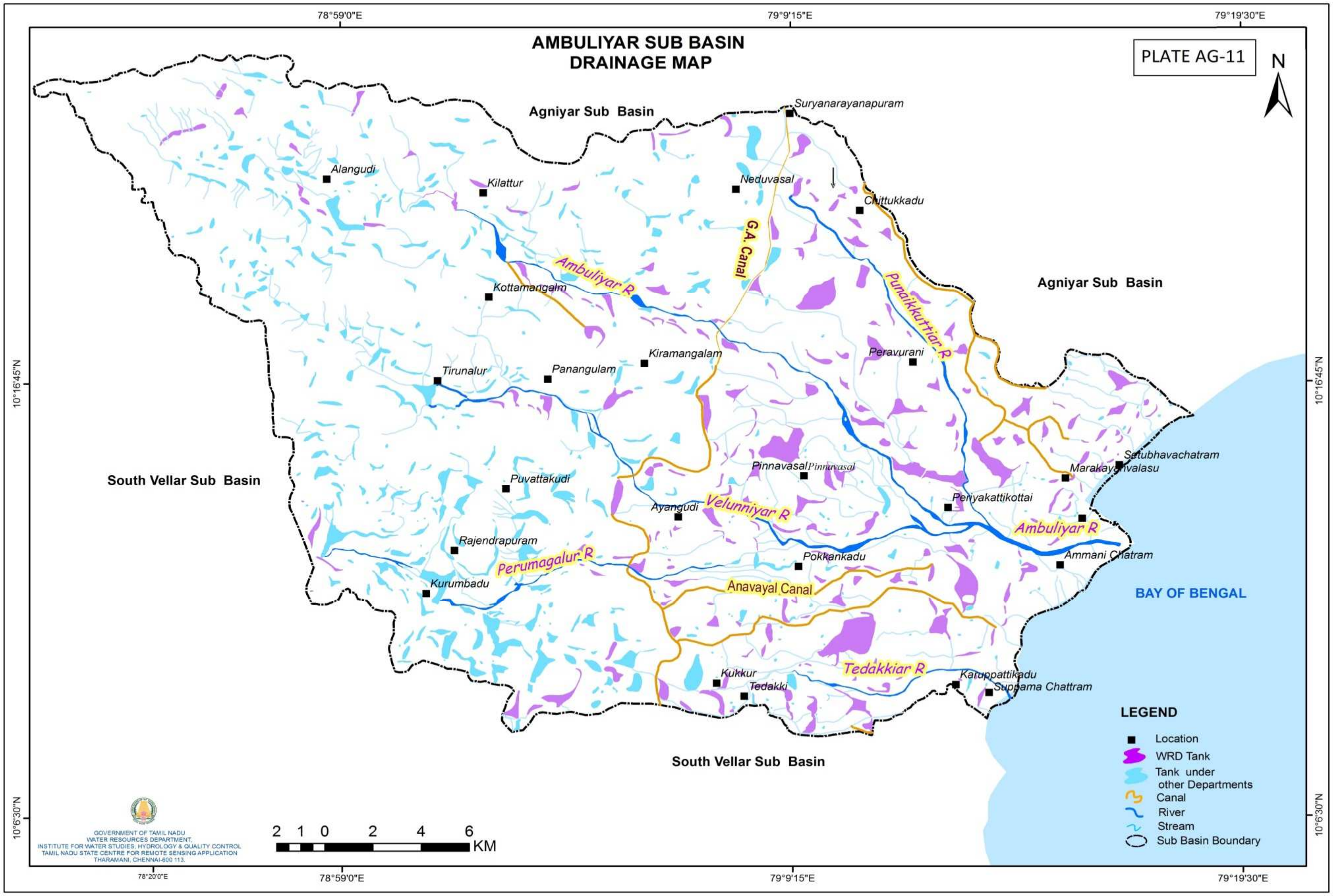

PHYSIOGRAPHY MAP OF AGNIYAR BASIN
Plate: AG - 8
N
Cauvery Basin
Cauvery Basin
Bay of Bengal
Pambar Kottakkaraiyar Basin
Tulukkampatti
Kurungulam
Kiranur
Vattanakkottai
Gandarvakottai
Vettikkadu
Virappatti
Perungalur
Andanur
Uranikkadu
Kottaippatti
Maniyankurichchi
Marungapuri
Oliyamangalam
Kudumiyamalai
Karadipatti
Malayur
Pattukkottai
Pudukkottai
Tiruchitrambalam
Namanasamudram
Avanam
Pallattur
Kulipirai
Kurumbur
Amarasimhendrapuram
Memangalam
Karakkottai
Kiranur
Kundar R
Agniyar R
Ambuliyar R
Punaikkuttiar R
Kattar R
Velunniyar R
Vellar R
Tedakkiar R
Maharajasamudram
Nasuvunni R
Karai_Ar
Legend
Spot Height (370 m)
Location
Contour (100 m)
Basin Boundary
Reserved Forest
River
Agniyar R River Name
Altitude
Value
High
Low
0 5 10 20 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



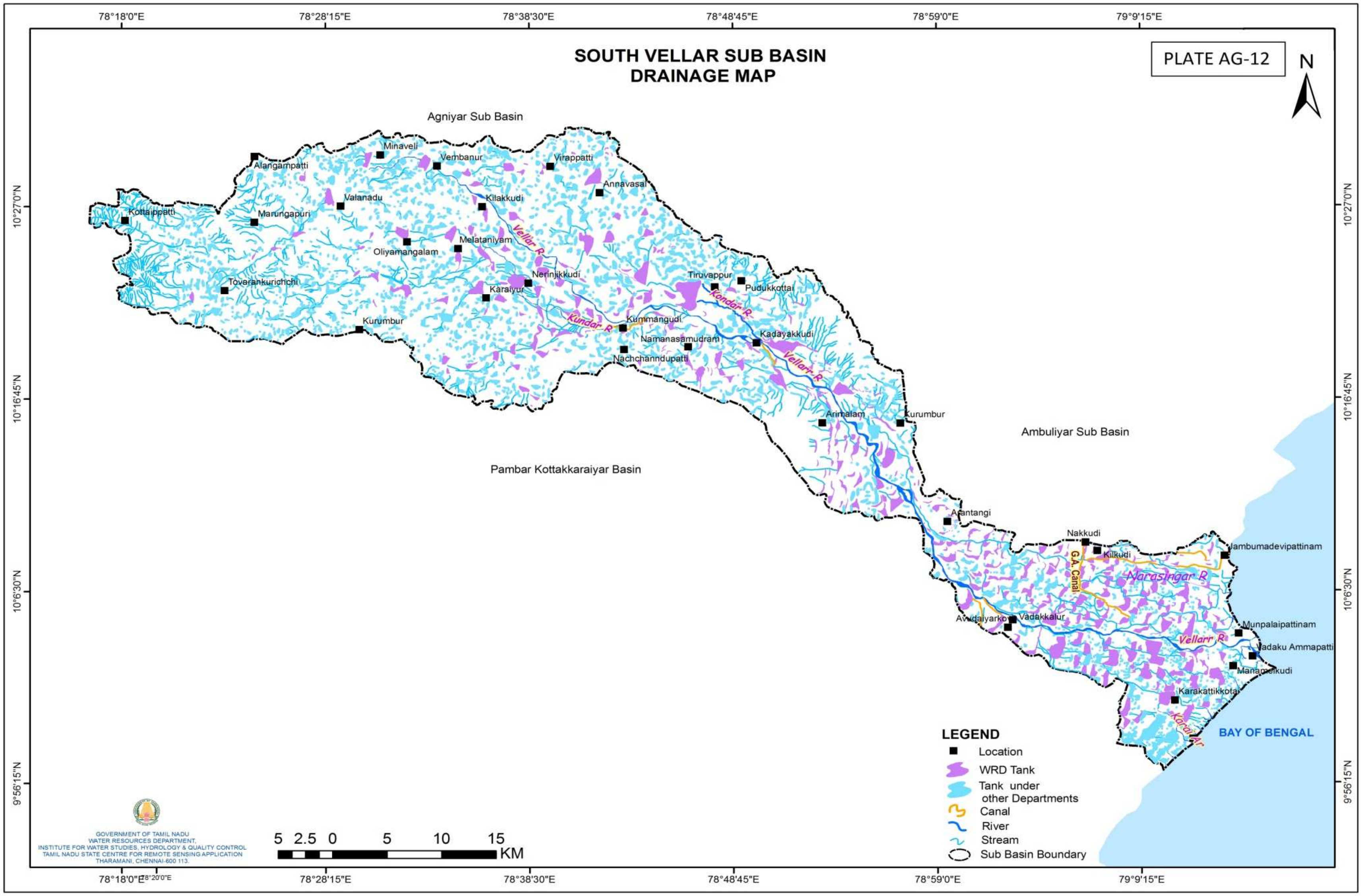
Sl. No.	River Name	Sub Basin
1	Kattar R/Nasuvunni R	Agniyar (5 Rivers)
2	Kattar 2 R	
3	Mahasamudram R	
4	Agniyar R	
5	Kattar 3 R	
6	Punaikuttiar R	Ambuliyar (5 Rivers)
7	Ambuliyar R	
8	Velunniyar R	
9	Maruthankudiyar/Perumagalur R	
10	Tedakkiar R	
11	Narasingar R	South Vellar (5 Rivers)
12	Kondar R	
13	Kundar R	
14	Vellar R	
15	Karai Ar	

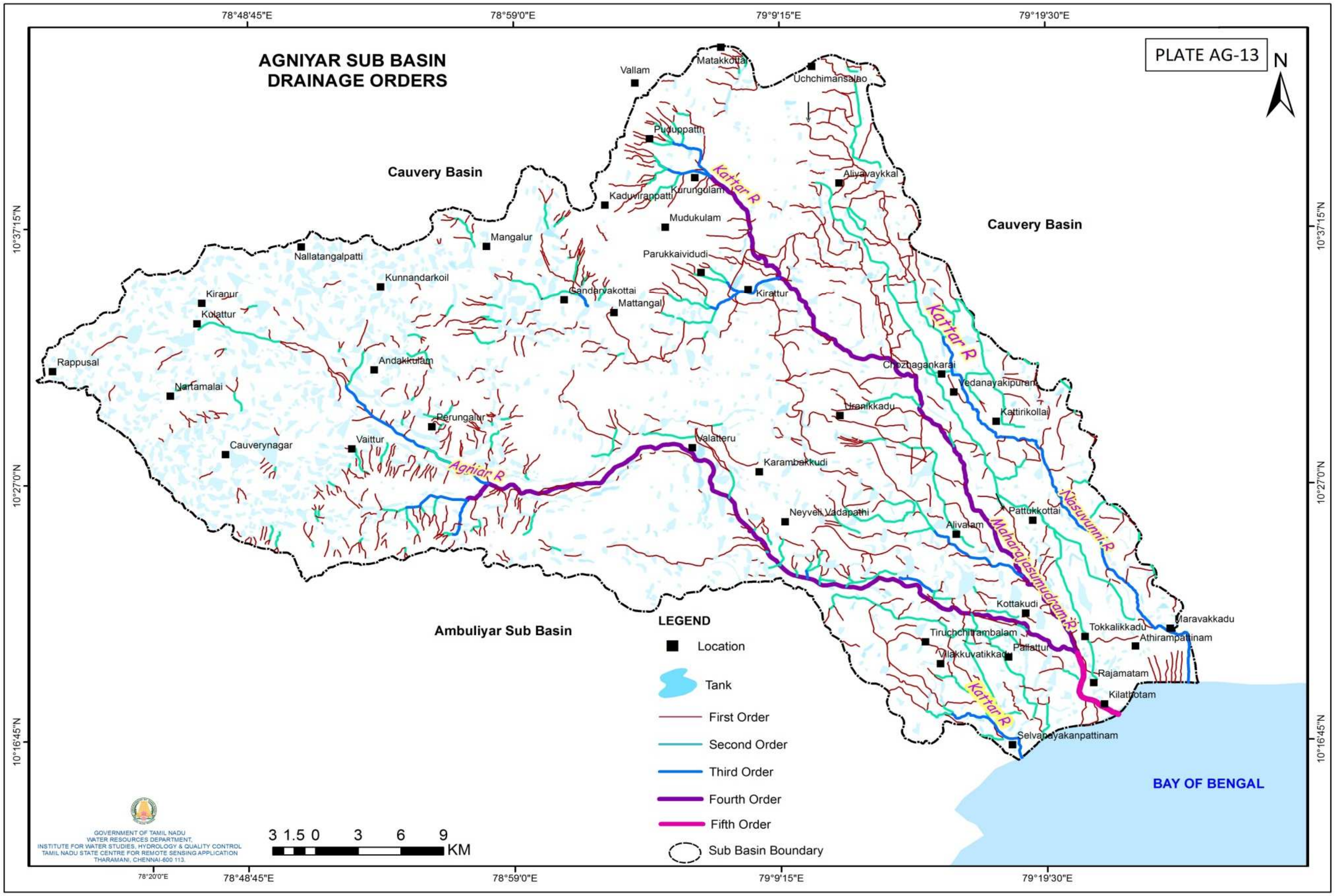


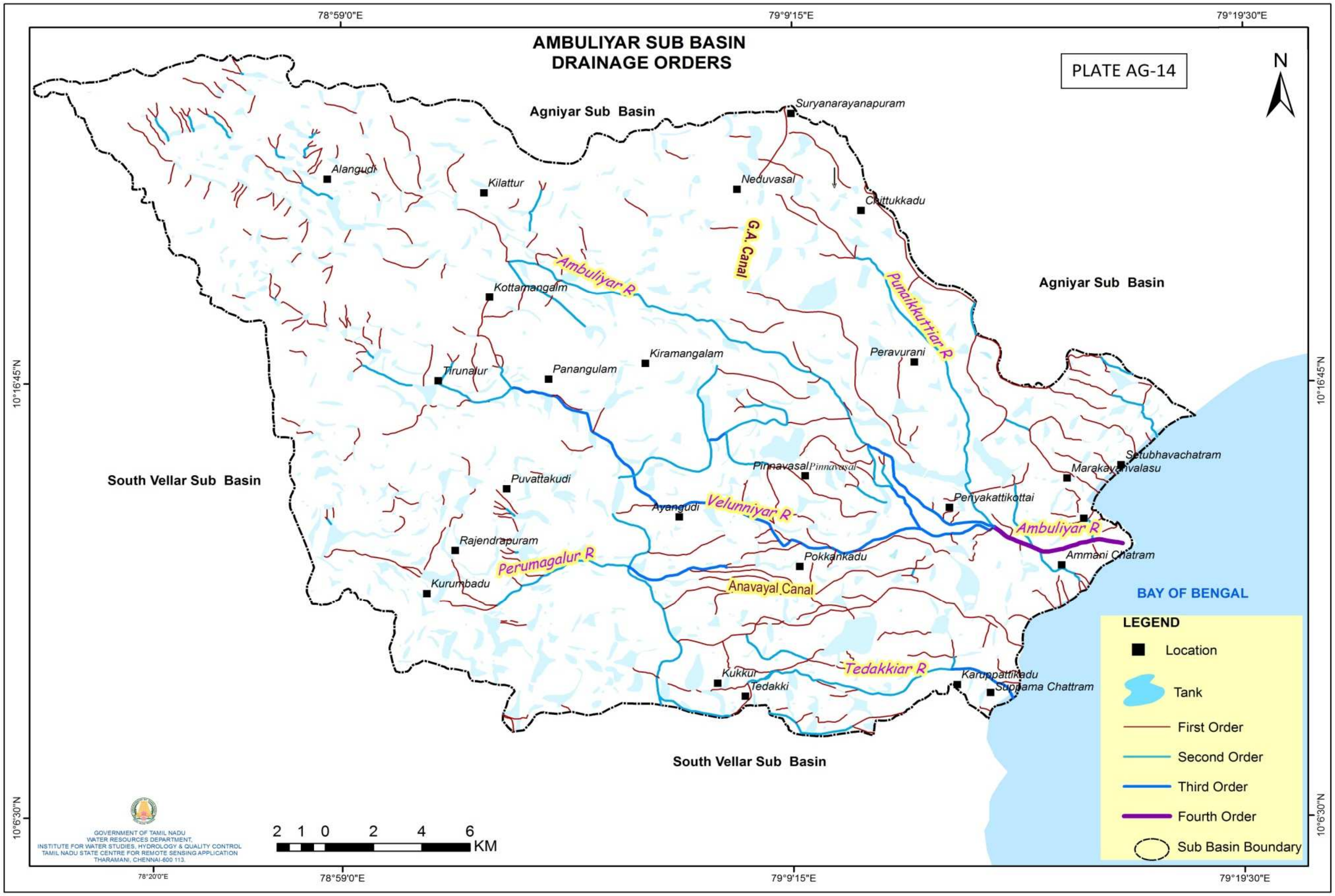
AGNIYAR SUB BASIN
DRAINAGE MAP
PLATE AG-10
N
Cauvery Basin
Cauvery Basin
Ambuliyar Sub Basin
BAY OF BENGAL
Kattar R
Agniar R
Grand Anicut Canal
Kalyana Odai Branch Canal
Rajamatam Canal
Ettukadu Canal
Nasuvunni R
Maharajasumudram R
Pudupattinam Canal
LEGEND
Location
WRD Tanks
Tanks under other Departments
Canal
River
Stream
Sub Basin Boundary
3 1.5 0 3 6 9 KM
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT.
INSTITUTE FOR WATER STUDIES, HYDROLOGY & QUALITY CONTROL
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI-600 113.
78°48'45"E
78°59'0"E
79°9'15"E
79°19'30"E
10°37'15"N
10°27'0"N
10°16'45"N

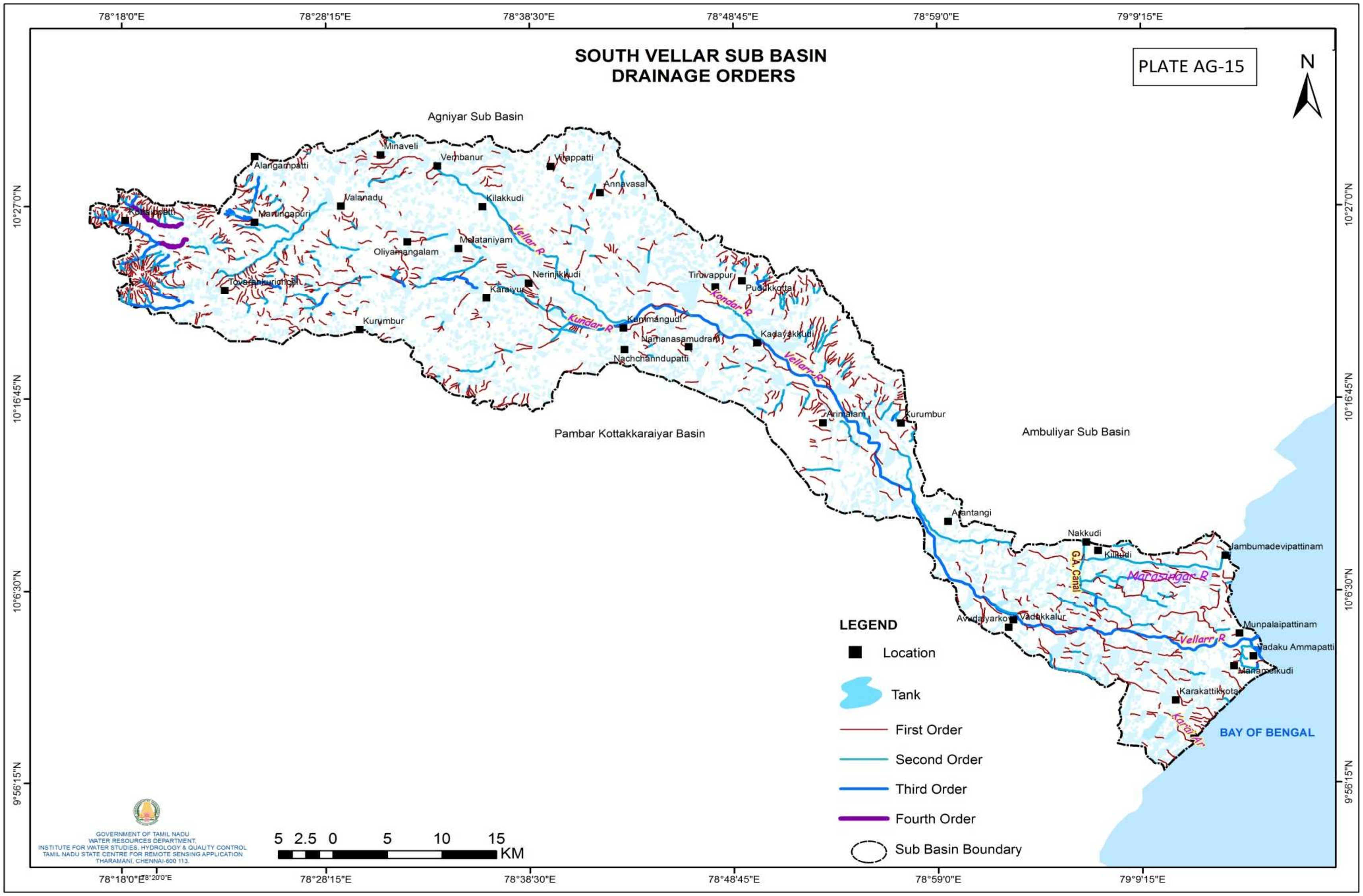


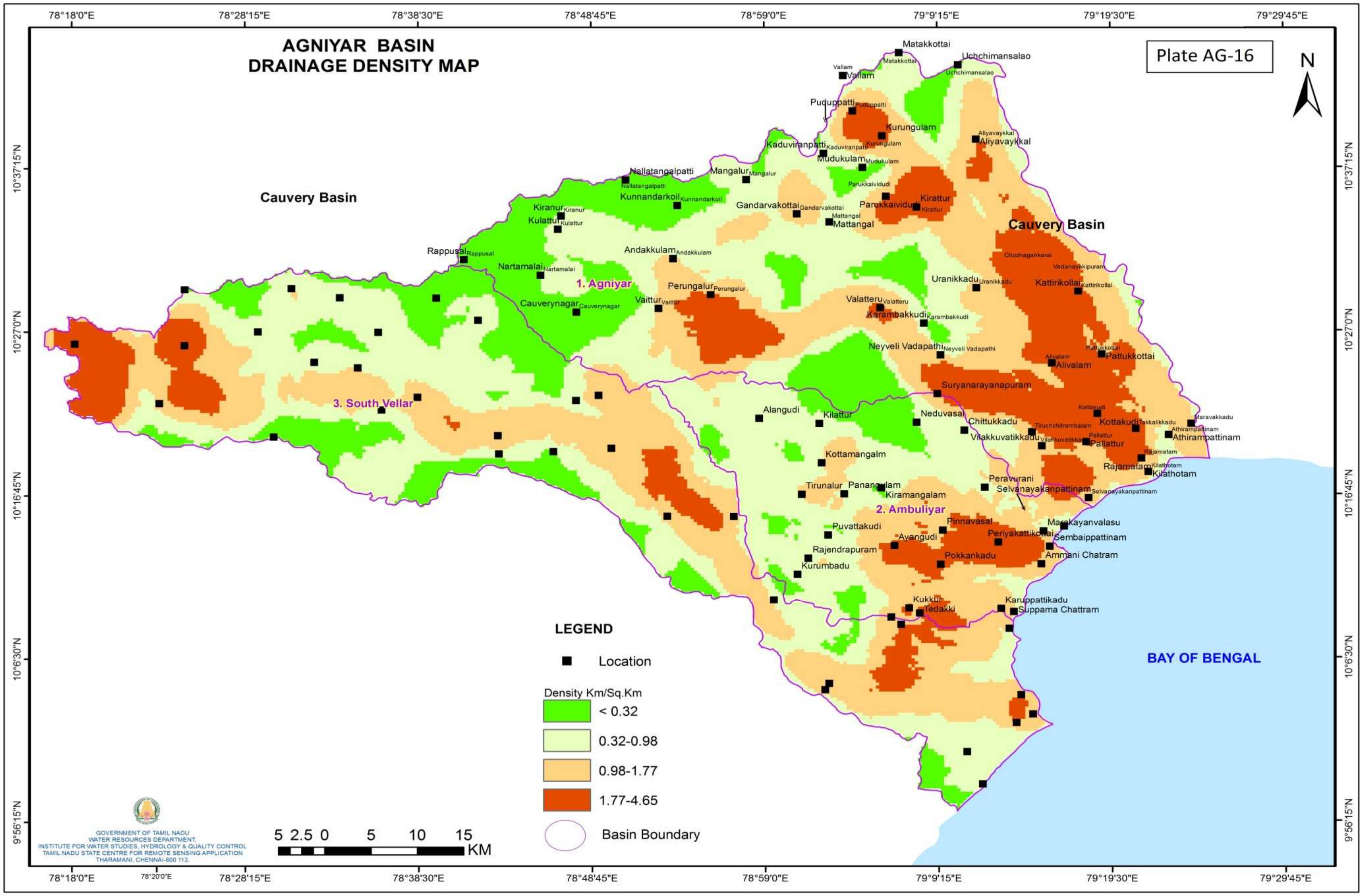
AMBULIYAR SUB BASIN
DRAINAGE MAP
PLATE AG-11
N
78°59'0"E
79°9'15"E
79°19'30"E
10°16'45"N
10°6'30"N
78°20'0"E
Agniyar Sub Basin
Agniyar Sub Basin
South Vellar Sub Basin
South Vellar Sub Basin
BAY OF BENGAL
Suryanarayanapuram
Alangudi
Kilattur
Neduvasal
Chittukkadu
G.A. Canal
Ambuliyar R
Punaikkuttiar R
Kottamangalm
Kiramangalam
Peravurani
Tirunalur
Panangulam
Pinnavasal
Setubhavachatram
Marakayarvalasu
Puvattakudi
Ayangudi
Velunniyar R
Periyakattikottai
Ambuliyar R
Rajendrapuram
Perumagalur R
Pokkankadu
Ammani Chatram
Kurumbadu
Anavayal Canal
Tedakkiar R
Kukkur
Tedakki
Karuppattikadu
Suppama Chattram
LEGEND
Location
WRD Tank
Tank under other Departments
Canal
River
Stream
Sub Basin Boundary
2 1 0 2 4 6
KM
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT,
INSTITUTE FOR WATER STUDIES, HYDROLOGY & QUALITY CONTROL
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI-600 113.

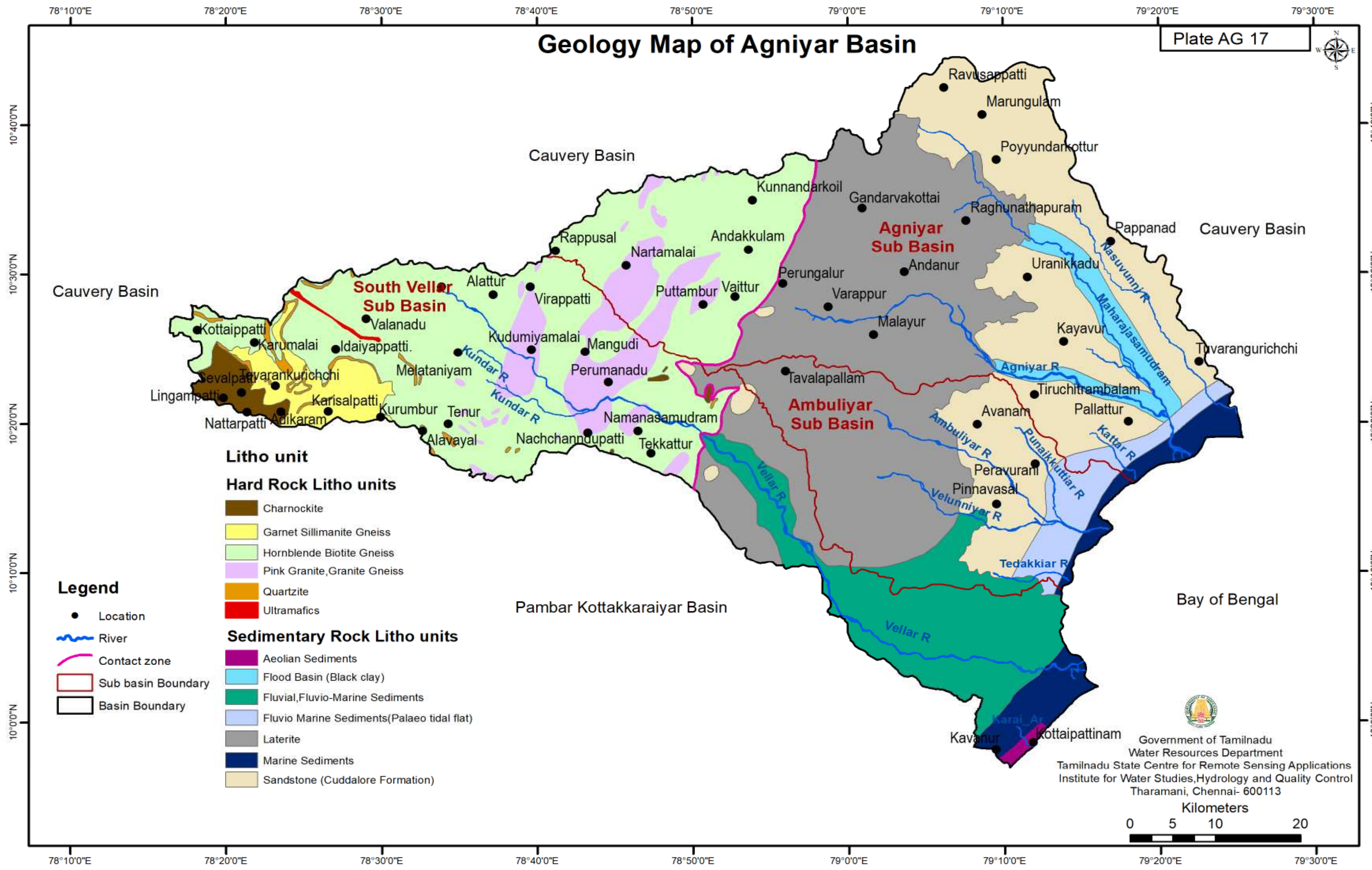

SOUTH VELLAR SUB BASIN
DRAINAGE MAP
PLATE AG-12
N
Agniyar Sub Basin
Ambuliyar Sub Basin
Pambar Kottakkaraiyar Basin
BAY OF BENGAL
Vellar R
Kundar R
Vellarr R
Narasingar R
G.A. Canal
LEGEND
Location
WRD Tank
Tank under other Departments
Canal
River
Stream
Sub Basin Boundary
5 2.5 0 5 10 15 KM
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT,
INSTITUTE FOR WATER STUDIES, HYDROLOGY & QUALITY CONTROL
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI-600 113.
78°18'0"E
78°28'15"E
78°38'30"E
78°48'45"E
78°59'0"E
79°9'15"E
10°27'0"N
10°16'45"N
10°6'30"N
9°56'15"N

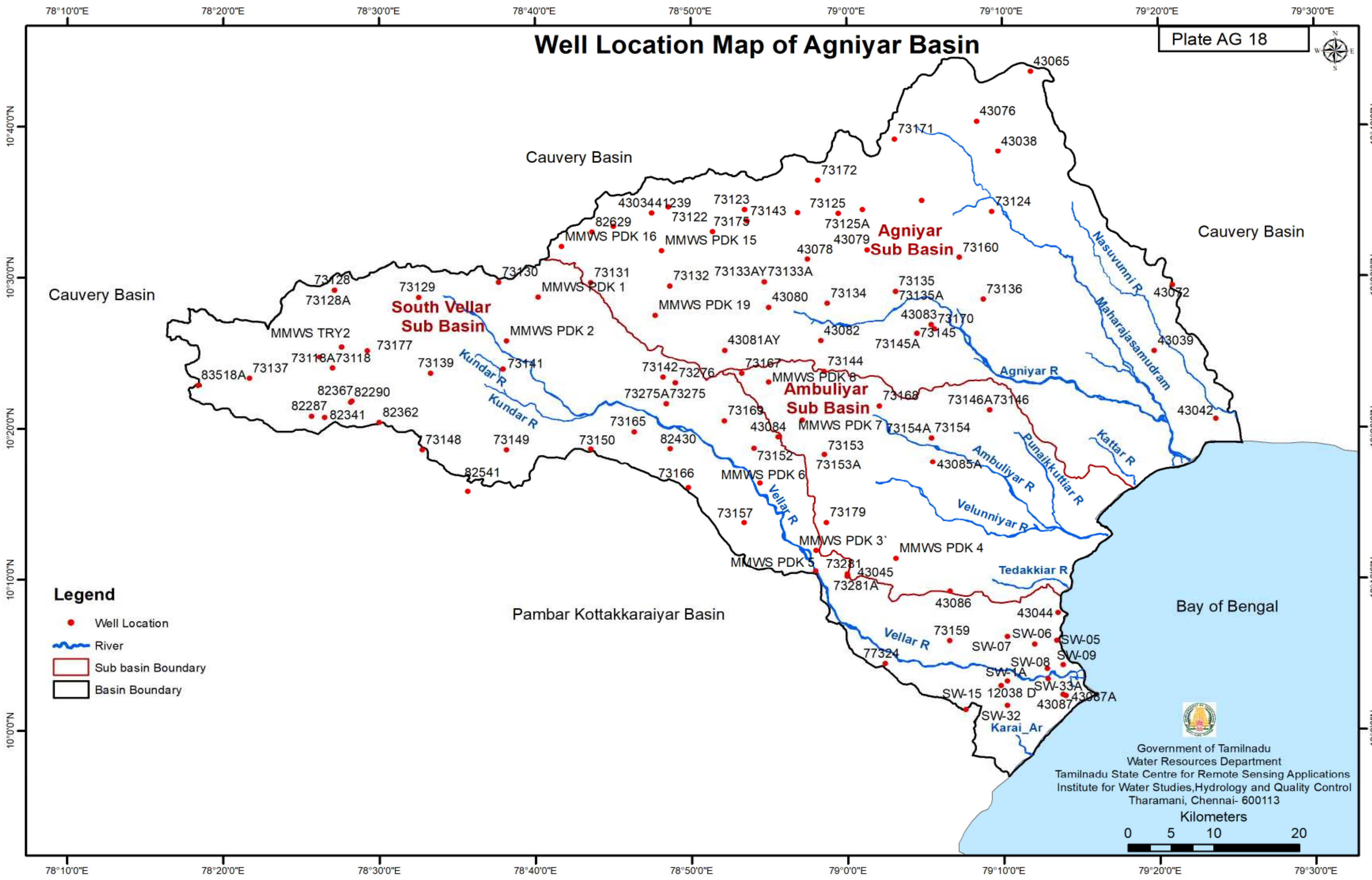

AGNIYAR SUB BASIN
DRAINAGE ORDERS
PLATE AG-13
N
78°48'45"E
78°59'0"E
79°9'15"E
79°19'30"E
10°37'15"N
10°27'0"N
10°16'45"N
Cauvery Basin
Cauvery Basin
Ambuliyar Sub Basin
BAY OF BENGAL
Vallam
Matakkottai
Uchchimansalao
Puduppatti
Kurungulam
Kaduvirappatti
Aliyavaykkal
Mudukulam
Mangalur
Nallatangalpatti
Parukkaividudi
Kunnandarkoil
Gandarvakottai
Kirattur
Mattangal
Kiranur
Kolattur
Andakkulam
Rappusal
Nartamalai
Perungalur
Vaittur
Cauverynagar
Valatteru
Karambakkudi
Uranikkadu
Chozhagankarai
Vedanayakipuram
Kattirikollai
Pattukkottai
Neyveli Vadapathi
Alivalam
Kottakudi
Tiruchchitrambalam
Vilakkuvatikkadu
Pallattur
Tokkalikkadu
Maravakkadu
Athirampattinam
Rajamatam
Kilathotam
Selvanayakanpattinam
Kattar R
Kattar R
Kattar R
Agniar R
Nasuvunni R
Maharajasamudram R
LEGEND
Location
Tank
First Order
Second Order
Third Order
Fourth Order
Fifth Order
Sub Basin Boundary
3 1.5 0 3 6 9
KM
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT,
INSTITUTE FOR WATER STUDIES, HYDROLOGY & QUALITY CONTROL
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI-600 113.
78°20'0"E

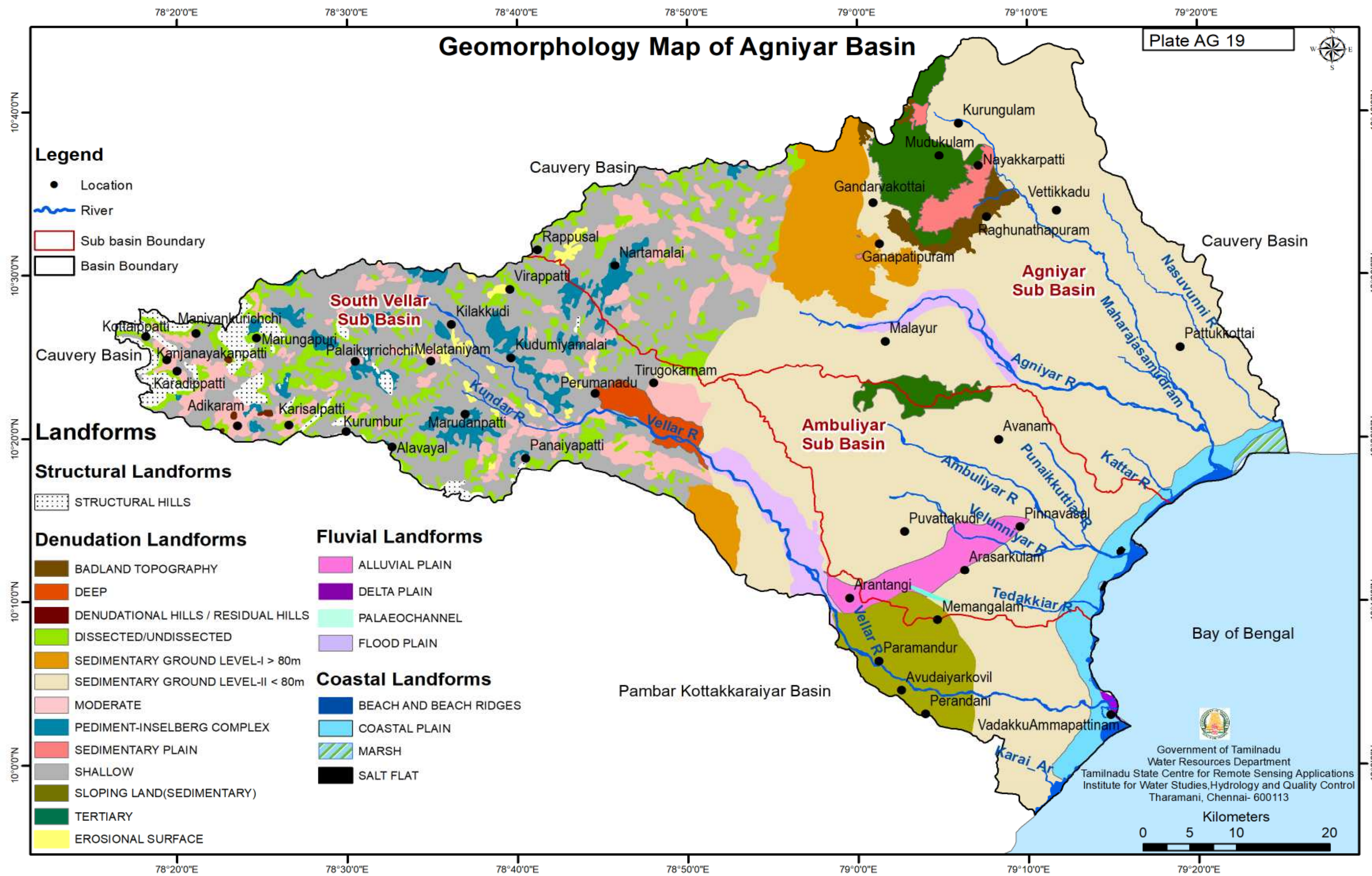

AMBULIYAR SUB BASIN
DRAINAGE ORDERS
PLATE AG-14
N
78°59'0"E
79°9'15"E
79°19'30"E
10°16'45"N
10°6'30"N
78°20'0"E
Agniyar Sub Basin
Agniyar Sub Basin
South Vellar Sub Basin
South Vellar Sub Basin
BAY OF BENGAL
Suryanarayanapuram
Alangudi
Kilattur
Neduvasal
Chittukkadu
G.A. Canal
Ambuliyar R
Punaikkuttiar R
Kottamangalm
Kiramangalam
Peravurani
Tirunalur
Panangulam
Setubhavachatram
Marakayarivalasu
Pinnavasal
Puvattakudi
Periyakattikottai
Ayangudi
Velunniyar R
Ambuliyar R
Rajendrapuram
Perumagalur R
Pokkankadu
Ammani Chatram
Kurumbadu
Anavayal Canal
Tedakkiar R
Kukkur
Tedakki
Karuppattikadu
Suppama Chattram
LEGEND
Location
Tank
First Order
Second Order
Third Order
Fourth Order
Sub Basin Boundary
2 1 0 2 4 6
KM
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT,
INSTITUTE FOR WATER STUDIES, HYDROLOGY & QUALITY CONTROL
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI-600 113.


SOUTH VELLAR SUB BASIN
DRAINAGE ORDERS
PLATE AG-15
N
Agniyar Sub Basin
Pambar Kottakkaraiyar Basin
Ambuliyar Sub Basin
BAY OF BENGAL
Vellar R
Kundar R
Kondar R
Vellarr R
Marasingar R
G.A. Canal
Minaveli
Alangampatti
Vembanur
Annavasal
Valanadu
Marungapuri
Kilakkudi
Oliyamangalam
Melataniyam
Nerinjikkudi
Karaiyur
Kurumbur
Kunnamangudi
Namanasamudram
Nachchanndupatti
Tiruvappur
Pudukkottai
Kadayakkudi
Arimalam
Arantangi
Nakkudi
Jambumadevipattinam
Avudaiyarkoil
Vadakkalur
Munpalaipattinam
Vadaku Ammapatti
Manamelkudi
Karakattikkotai
LEGEND
Location
Tank
First Order
Second Order
Third Order
Fourth Order
Sub Basin Boundary
5 2.5 0 5 10 15 KM
78°18'0"E
78°28'15"E
78°38'30"E
78°48'45"E
78°59'0"E
79°9'15"E
10°27'0"N
10°16'45"N
10°6'30"N
9°56'15"N
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT,
INSTITUTE FOR WATER STUDIES, HYDROLOGY & QUALITY CONTROL
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI-600 113.

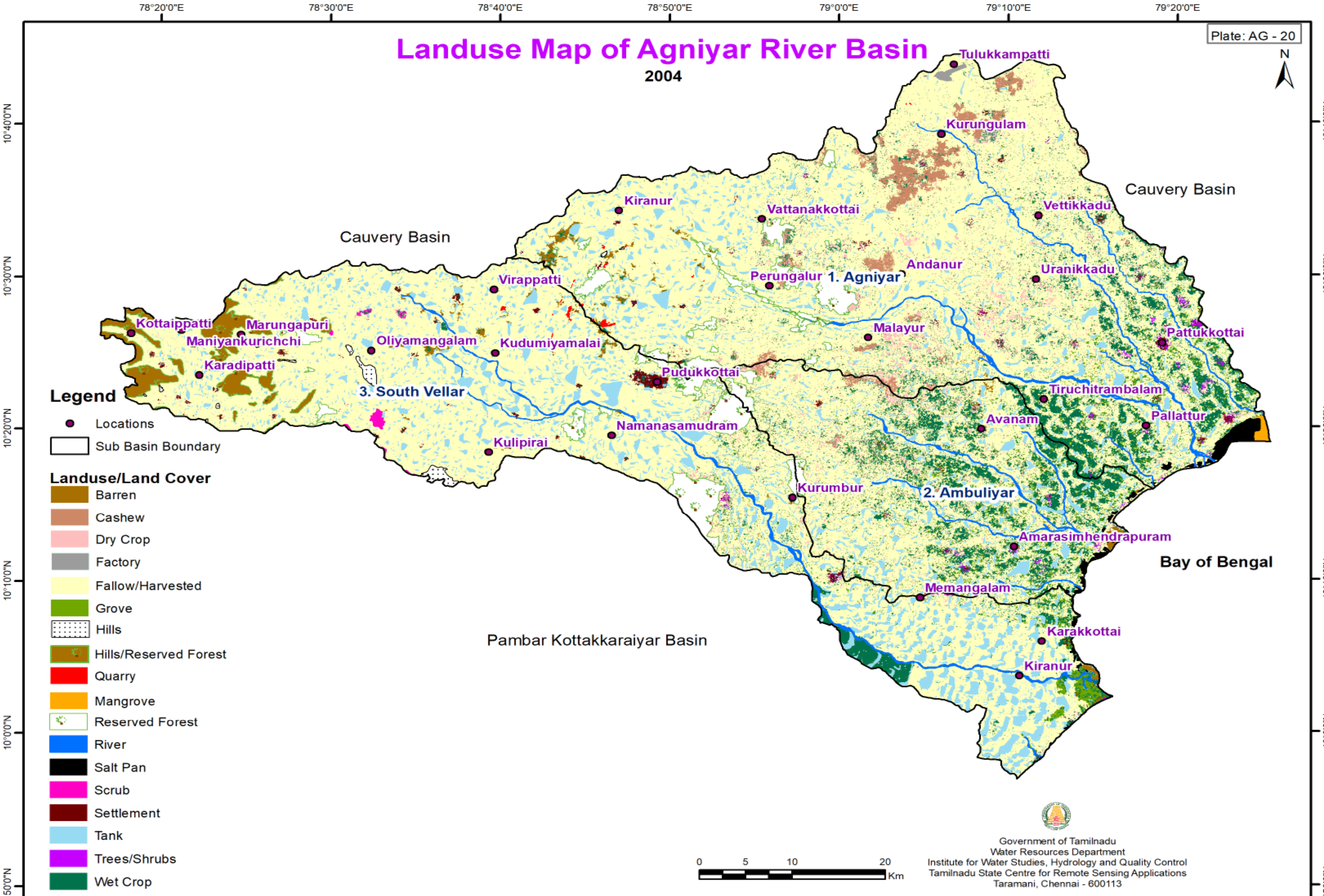

AGNIYAR BASIN
DRAINAGE DENSITY MAP
Plate AG-16
N
Cauvery Basin
Cauvery Basin
BAY OF BENGAL
1. Agniyar
2. Ambuliyar
3. South Vellar
LEGEND
Location
Density Km/Sq.Km
< 0.32
0.32-0.98
0.98-1.77
1.77-4.65
Basin Boundary
5 2.5 0 5 10 15 KM
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT,
INSTITUTE FOR WATER STUDIES, HYDROLOGY & QUALITY CONTROL
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI-600 113.
78°18'0"E
78°28'15"E
78°38'30"E
78°48'45"E
78°59'0"E
79°9'15"E
79°19'30"E
79°29'45"E
10°37'15"N
10°27'0"N
10°16'45"N
10°6'30"N
9°56'15"N
Matakkottai
Uchchimansalao
Vallam
Puduppatti
Kurungulam
Aliyavaykkal
Kaduviranpatti
Mudukulam
Nallatangalpatti
Mangalur
Kunnandarkoil
Gandarvakottai
Parukkaividuti
Kirattur
Mattangal
Kiranur
Kulattur
Rappusal
Andakkulam
Nartamalai
Perungalur
Uranikkadu
Kattirikollai
Valatteru
Karambakkudi
Cauverynagar
Vaittur
Neyveli Vadapathi
Alivalam
Pattukkottai
Suryanarayanapuram
Alangudi
Kilattur
Neduvasal
Chittukkadu
Vilakkuvatikkadu
Kottakudi
Maravakkadu
Athirampattinam
Pallattur
Kottamangalam
Rajamatam
Kilathotam
Peravurani
Selvanayakanpattinam
Tirunalur
Panangulam
Kiramangalam
Puvattakudi
Pinnavasal
Periyakattikottai
Marakayanvalasu
Sembaippattinam
Ayangudi
Rajendrapuram
Pokkankadu
Ammani Chatram
Kurumbadu
Kukkur
Tedakki
Karuppattikadu
Suppama Chattram

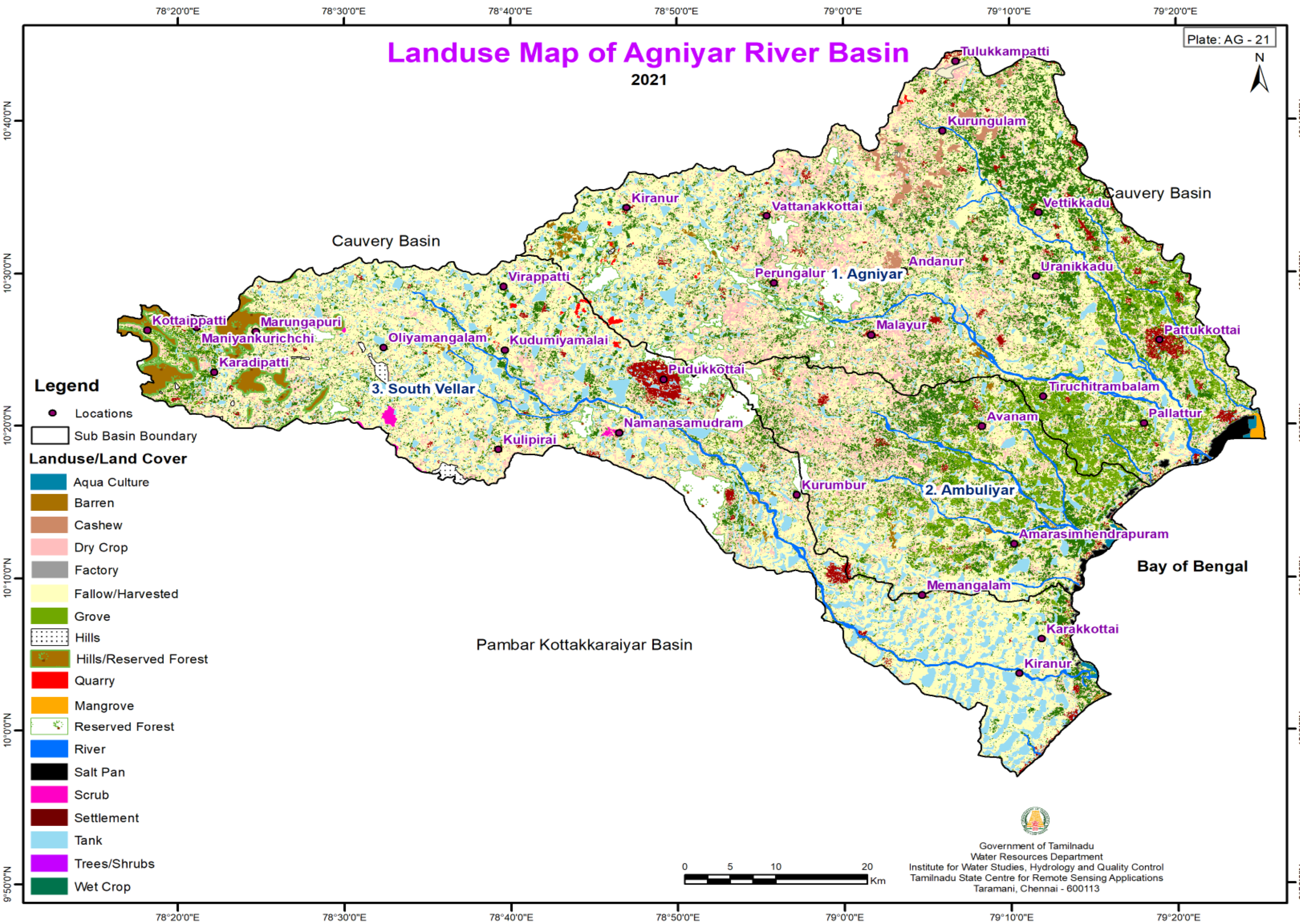

Geology Map of Agniyar Basin
Plate AG 17
Cauvery Basin
Cauvery Basin
Cauvery Basin
Pambar Kottakkaraiyar Basin
Bay of Bengal
South Vellar Sub Basin
Agniyar Sub Basin
Ambuliyar Sub Basin
Ravusappatti
Marungulam
Poyyundarkottur
Kunnandarkoil
Gandarvakottai
Raghunathapuram
Pappanad
Rappusal
Nartamalai
Andakkulam
Andanur
Uranikkadu
Perungalur
Varappur
Puttambur
Vaittur
Alattur
Virappatti
Valanadu
Kottaippatti
Karumalai
Idaiyappatti.
Kudumiyamalai
Mangudi
Malayur
Kayavur
Tavarangurichchi
Melataniyam
Perumanadu
Tavalapallam
Tiruchitrambalam
Pallattur
Avanam
Sevalpatti
Tavarankurichchi
Lingampatti
Karisalpatti
Nattarpatti
Adikaram
Kurumbur
Tenur
Namanasamudram
Alavayal
Nachchandupatti
Tekkattur
Peravurani
Pinnavasal
Kavanur
Kottaipattinam
Kundar R
Kundar R
Agniyar R
Nasuvunni R
Maharajasamudram
Ambuliyar R
Punaikkuttiar R
Kattar R
Vellar R
Vellar R
Velunniyar R
Tedakkiar R
Karai_Ar
Litho unit
Hard Rock Litho units
Charnockite
Garnet Sillimanite Gneiss
Hornblende Biotite Gneiss
Pink Granite,Granite Gneiss
Quartzite
Ultramafics
Sedimentary Rock Litho units
Aeolian Sediments
Flood Basin (Black clay)
Fluvial,Fluvio-Marine Sediments
Fluvio Marine Sediments(Palaeo tidal flat)
Laterite
Marine Sediments
Sandstone (Cuddalore Formation)
Legend
Location
River
Contact zone
Sub basin Boundary
Basin Boundary
Government of Tamilnadu
Water Resources Department
Tamilnadu State Centre for Remote Sensing Applications
Institute for Water Studies,Hydrology and Quality Control
Tharamani, Chennai- 600113
Kilometers
0 5 10 20
78°10'0"E
78°20'0"E
78°30'0"E
78°40'0"E
78°50'0"E
79°0'0"E
79°10'0"E
79°20'0"E
79°30'0"E
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
10°0'0"N

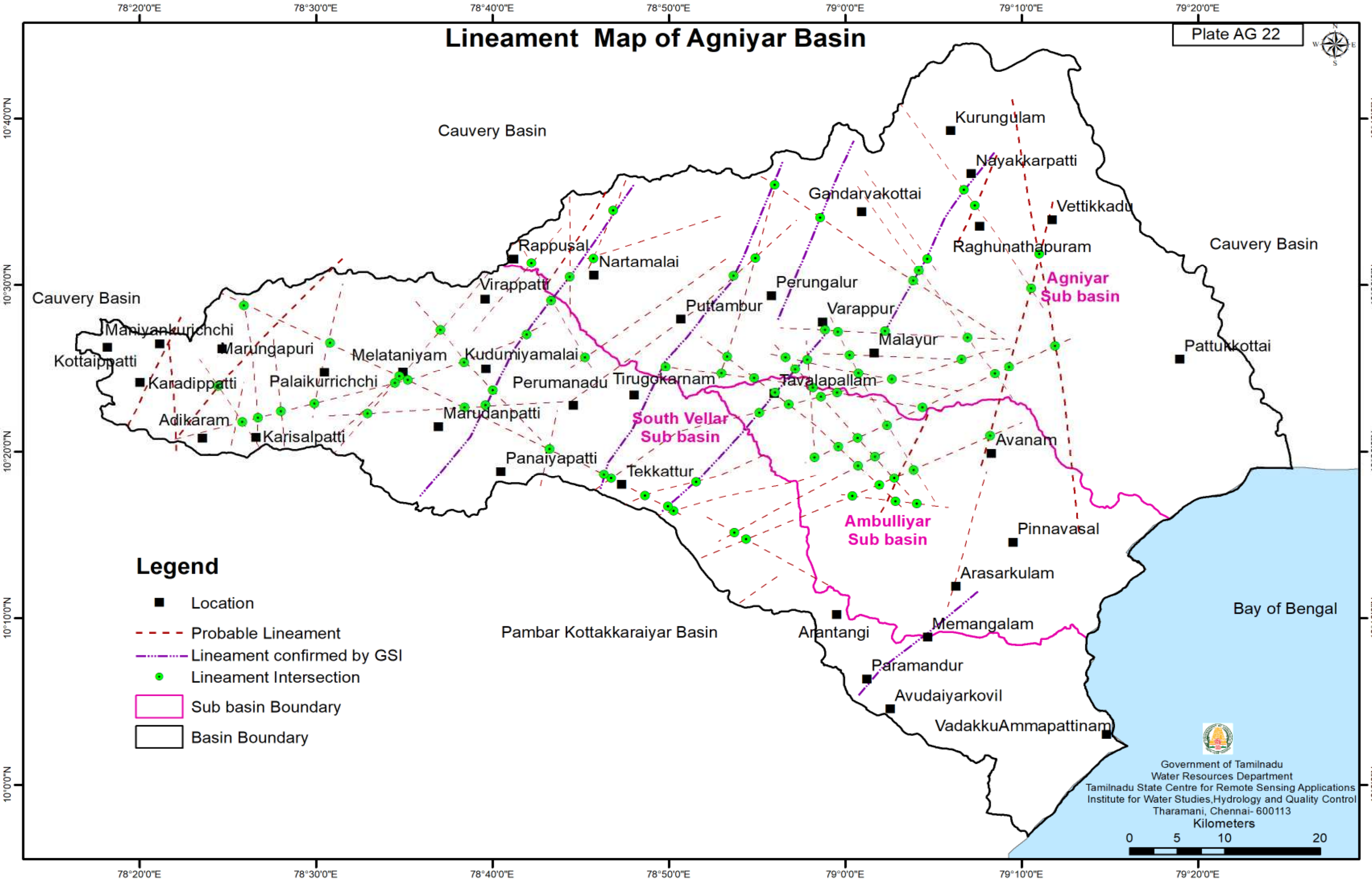

Well Location Map of Agniyar Basin
Plate AG 18
Cauvery Basin
Cauvery Basin
Cauvery Basin
Pambar Kottakkaraiyar Basin
Bay of Bengal
Agniyar Sub Basin
South Vellar Sub Basin
Ambuliyar Sub Basin
Nasuvunni R
Maharajasamudram
Agniyar R
Kattar R
Punaikkuttiar R
Ambuliyar R
Velunniyar R
Tedakkiar R
Vellar R
Kundar R
Karai_Ar
Legend
Well Location
River
Sub basin Boundary
Basin Boundary
Government of Tamilnadu
Water Resources Department
Tamilnadu State Centre for Remote Sensing Applications
Institute for Water Studies,Hydrology and Quality Control
Tharamani, Chennai- 600113
Kilometers
0 5 10 20
78°10'0"E
78°20'0"E
78°30'0"E
78°40'0"E
78°50'0"E
79°0'0"E
79°10'0"E
79°20'0"E
79°30'0"E
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
10°0'0"N



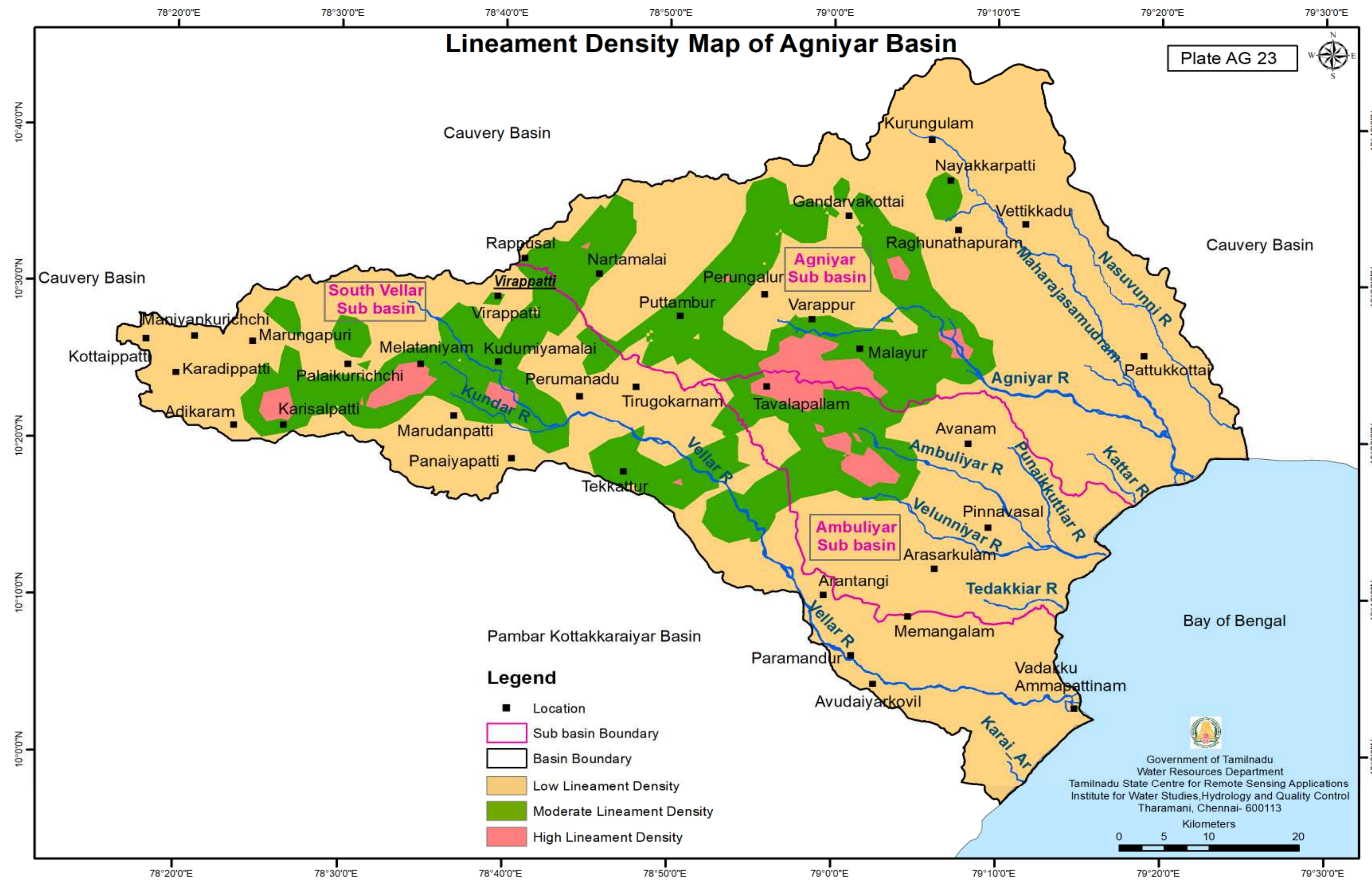
Geomorphology Map of Agniyar Basin
Plate AG 19
Legend
Location
River
Sub basin Boundary
Basin Boundary
Landforms
Structural Landforms
STRUCTURAL HILLS
Denudation Landforms
BADLAND TOPOGRAPHY
DEEP
DENUDATIONAL HILLS / RESIDUAL HILLS
DISSECTED/UNDISSECTED
SEDIMENTARY GROUND LEVEL-I > 80m
SEDIMENTARY GROUND LEVEL-II < 80m
MODERATE
PEDIMENT-INSELBERG COMPLEX
SEDIMENTARY PLAIN
SHALLOW
SLOPING LAND(SEDIMENTARY)
TERTIARY
EROSIONAL SURFACE
Fluvial Landforms
ALLUVIAL PLAIN
DELTA PLAIN
PALAEOCHANNEL
FLOOD PLAIN
Coastal Landforms
BEACH AND BEACH RIDGES
COASTAL PLAIN
MARSH
SALT FLAT
Cauvery Basin
South Vellar Sub Basin
Agniyar Sub Basin
Ambuliyar Sub Basin
Pambar Kottakkaraiyar Basin
Bay of Bengal
Government of Tamilnadu
Water Resources Department
Tamilnadu State Centre for Remote Sensing Applications
Institute for Water Studies,Hydrology and Quality Control
Tharamani, Chennai- 600113
Kilometers
0 5 10 20


Landuse Map of Agniyar River Basin
2004
Plate: AG - 20
N
78°20'0"E
78°30'0"E
78°40'0"E
78°50'0"E
79°0'0"E
79°10'0"E
79°20'0"E
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
10°0'0"N
9°50'0"N
Cauvery Basin
Cauvery Basin
Bay of Bengal
Pambar Kottakkaraiyar Basin
1. Agniyar
2. Ambuliyar
3. South Vellar
Tulukkampatti
Kurungulam
Vettikkadu
Kiranur
Vattanakkottai
Andanur
Perungalur
Uranikkadu
Virappatti
Malayur
Pattukkottai
Kottaippatti
Marungapuri
Maniyankurichchi
Oliyamangalam
Kudumiyamalai
Karadipatti
Pudukkottai
Tiruchitrambalam
Avanam
Pallattur
Namanasamudram
Kulipirai
Kurumbur
Amarasimhendrapuram
Memangalam
Karakkottai
Kiranur
Legend
Locations
Sub Basin Boundary
Landuse/Land Cover
Barren
Cashew
Dry Crop
Factory
Fallow/Harvested
Grove
Hills
Hills/Reserved Forest
Quarry
Mangrove
Reserved Forest
River
Salt Pan
Scrub
Settlement
Tank
Trees/Shrubs
Wet Crop
0 5 10 20
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

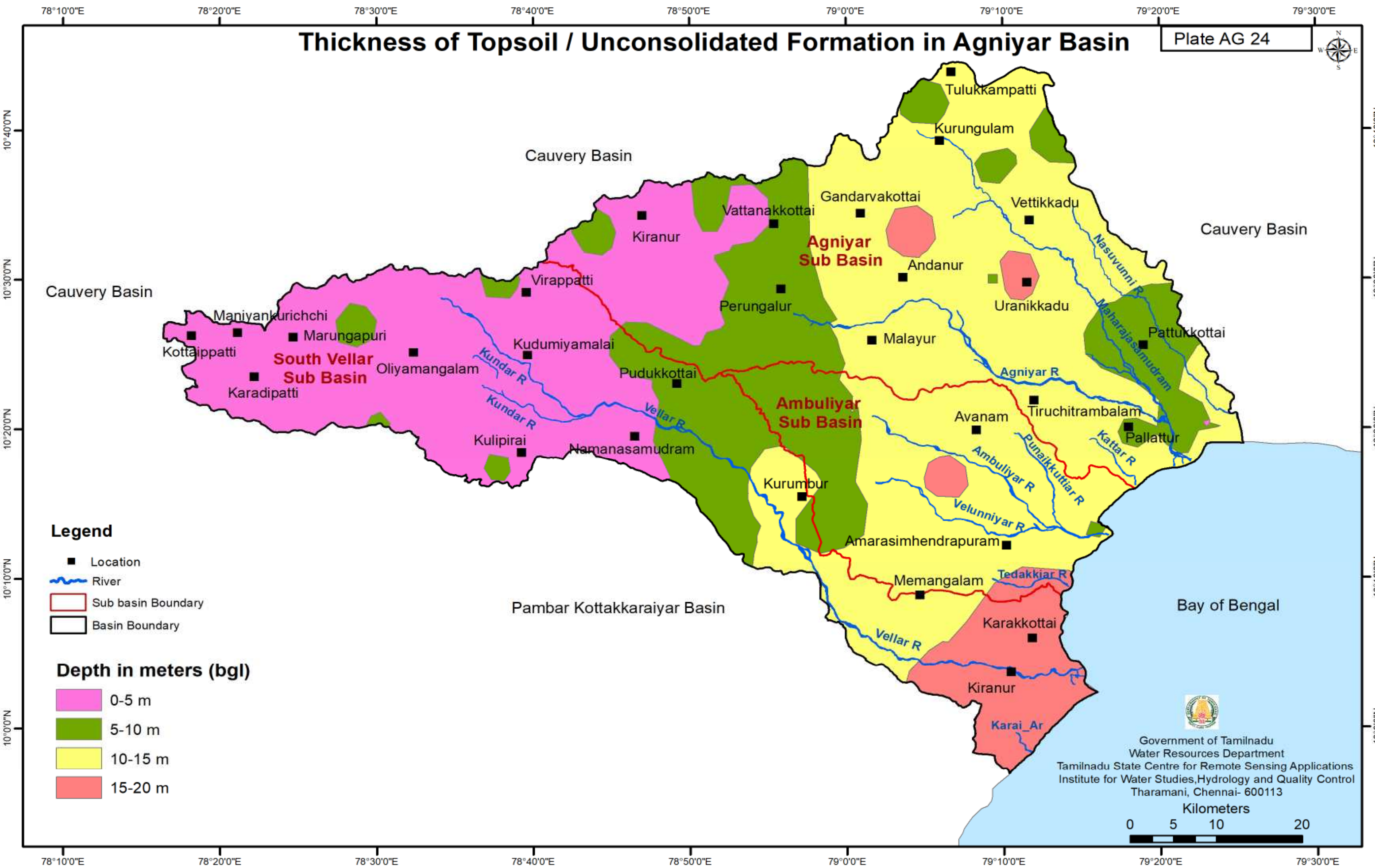

Landuse Map of Agniyar River Basin
2021
Plate: AG - 21
N
Cauvery Basin
Cauvery Basin
Bay of Bengal
Pambar Kottakkaraiyar Basin
1. Agniyar
2. Ambuliyar
3. South Vellar
Tulukkampatti
Kurungulam
Vettikkadu
Kiranur
Vattanakkottai
Andanur
Perungalur
Uranikkadu
Virappatti
Kottaippatti
Marungapuri
Maniyankurichchi
Oliyamangalam
Kudumiyamalai
Malayur
Pattukkottai
Karadipatti
Pudukkottai
Tiruchitrambalam
Avanam
Pallattur
Namanasamudram
Kulipirai
Kurumbur
Amarasimhendrapuram
Memangalam
Karakkottai
Kiranur
Legend
Locations
Sub Basin Boundary
Landuse/Land Cover
Aqua Culture
Barren
Cashew
Dry Crop
Factory
Fallow/Harvested
Grove
Hills
Hills/Reserved Forest
Quarry
Mangrove
Reserved Forest
River
Salt Pan
Scrub
Settlement
Tank
Trees/Shrubs
Wet Crop
0 5 10 20 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
78°20'0"E
78°30'0"E
78°40'0"E
78°50'0"E
79°0'0"E
79°10'0"E
79°20'0"E
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
10°0'0"N
9°50'0"N

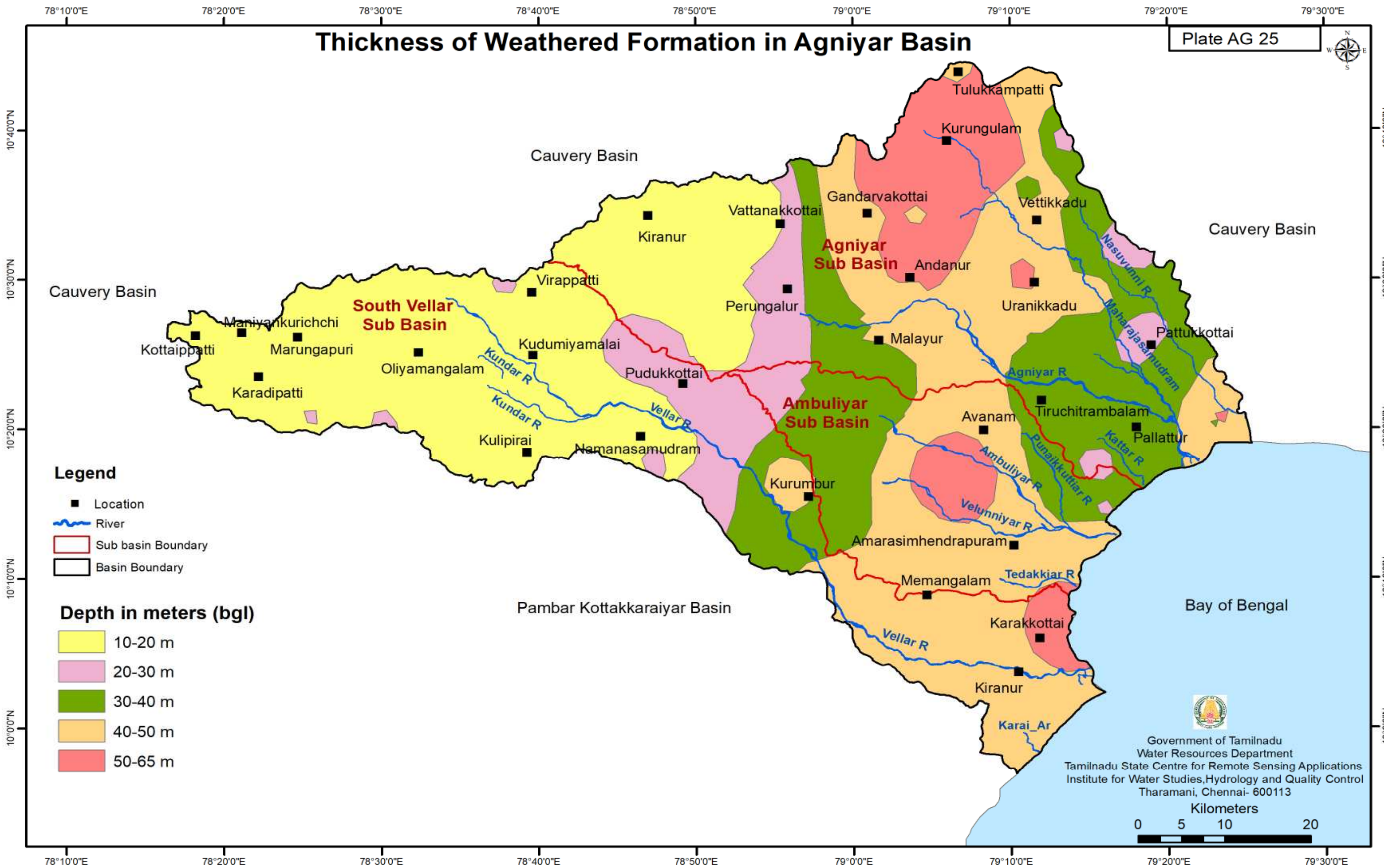


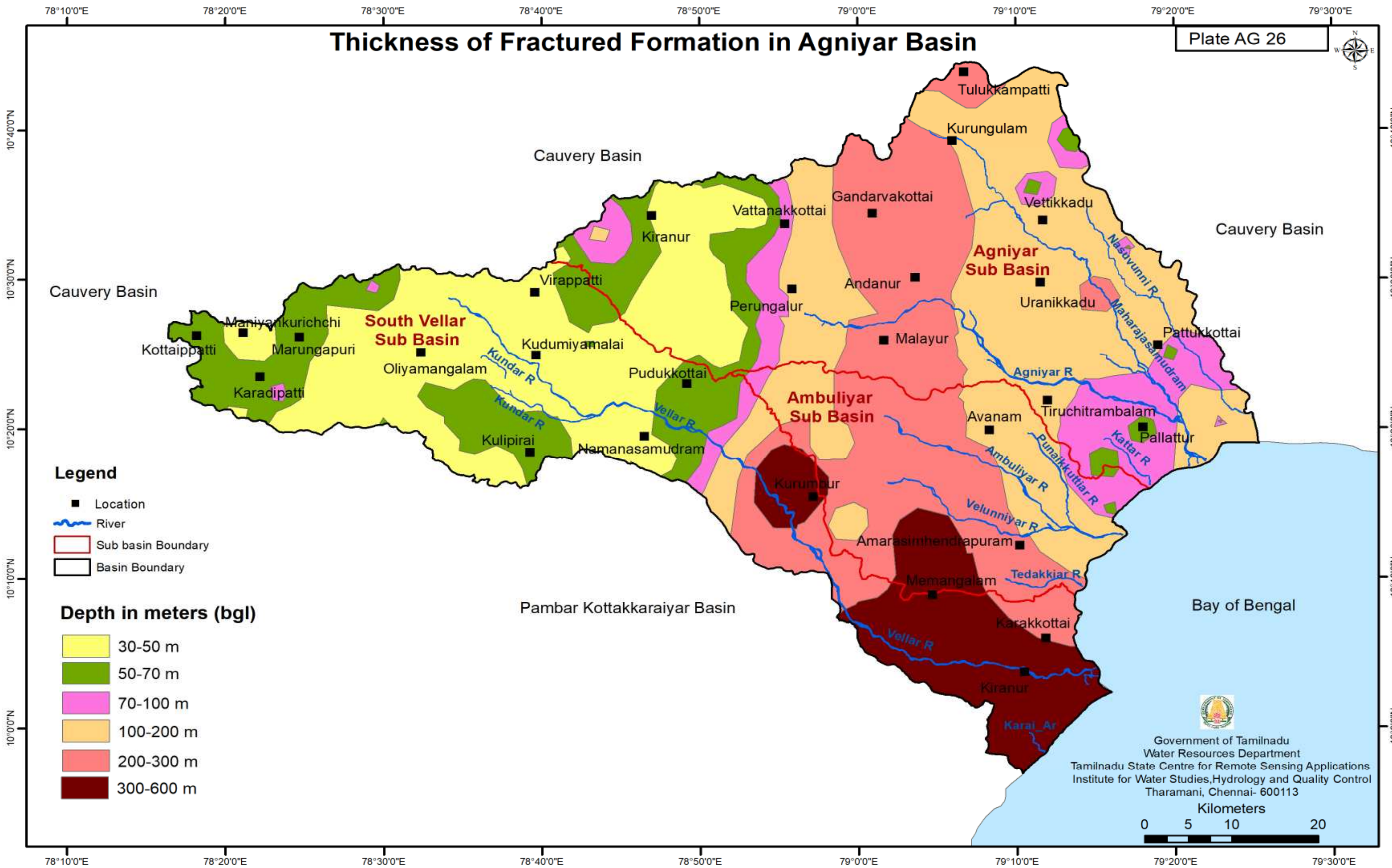
Lineament Map of Agniyar Basin
Plate AG 22
Cauvery Basin
Cauvery Basin
Cauvery Basin
Kurungulam
Nayakkarpatti
Vettikkadu
Gandarvakottai
Raghunathapuram
Rappusal
Nartamalai
Virappatti
Perungalur
Agniyar Sub basin
Puttambur
Varappur
Maniyankurichchi
Kottaippatti
Marungapuri
Melataniyam
Kudumiyamalai
Malayur
Pattukkottai
Karadippatti
Palaikurrichchi
Perumanadu
Tirugokarnam
Tavalapallam
Adikaram
Marudanpatti
South Vellar Sub basin
Karisalpatti
Avanam
Panaiyapatti
Tekkattur
Ambulliyar Sub basin
Pinnavasal
Legend
Location
Probable Lineament
Lineament confirmed by GSI
Lineament Intersection
Sub basin Boundary
Basin Boundary
Arasarkulam
Bay of Bengal
Pambar Kottakkaraiyar Basin
Arantangi
Memangalam
Paramandur
Avudaiyarkovil
VadakkuAmmapattinam
Government of Tamilnadu
Water Resources Department
Tamilnadu State Centre for Remote Sensing Applications
Institute for Water Studies,Hydrology and Quality Control
Tharamani, Chennai- 600113
Kilometers
0 5 10 20
78°20'0"E
78°30'0"E
78°40'0"E
78°50'0"E
79°0'0"E
79°10'0"E
79°20'0"E
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
10°0'0"N

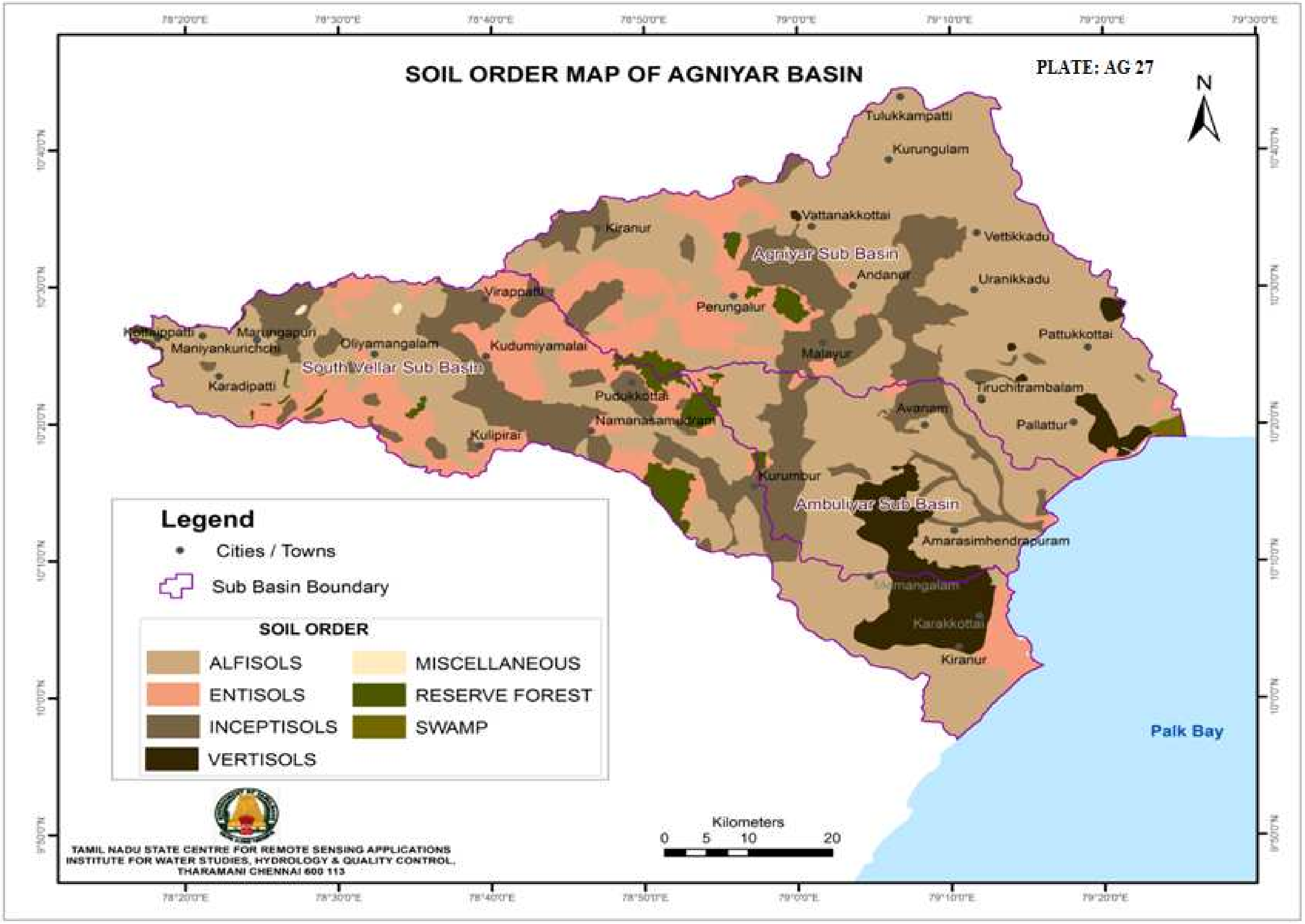


Lineament Density Map of Agniyar Basin
Plate AG 23
Cauvery Basin
Cauvery Basin
Cauvery Basin
Pambar Kottakkaraiyar Basin
Bay of Bengal
South Vellar Sub basin
Agniyar Sub basin
Ambuliyar Sub basin
Kurungulam
Nayakkarpatti
Gandarvakottai
Vettikkadu
Raghunathapuram
Rappusal
Nartamalai
Virappatti
Perungalur
Puttambur
Varappur
Maniyankurichchi
Marungapuri
Kottaippatti
Karadippatti
Palaikurrichchi
Melataniyam
Kudumiyamalai
Malayur
Pattukkottai
Perumanadu
Tirugokarnam
Tavalapallam
Adikaram
Karisalpatti
Marudanpatti
Panaiyapatti
Tekkattur
Avanam
Pinnavasal
Arasarkulam
Arantangi
Memangalam
Paramandur
Avudaiyarkovil
Vadakku Ammapattinam
Agniyar R
Kundar R
Vellar R
Ambuliyar R
Velunniyar R
Punaikkuttiar R
Kattar R
Tedakkiar R
Karai Ar
Maharajasamudram
Nasuvunni R
Legend
Location
Sub basin Boundary
Basin Boundary
Low Lineament Density
Moderate Lineament Density
High Lineament Density
Government of Tamilnadu
Water Resources Department
Tamilnadu State Centre for Remote Sensing Applications
Institute for Water Studies,Hydrology and Quality Control
Tharamani, Chennai- 600113
Kilometers
0 5 10 20
78°20'0"E
78°30'0"E
78°40'0"E
78°50'0"E
79°0'0"E
79°10'0"E
79°20'0"E
79°30'0"E
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
10°0'0"N


Thickness of Topsoil / Unconsolidated Formation in Agniyar Basin
Plate AG 24
Cauvery Basin
Cauvery Basin
Cauvery Basin
Pambar Kottakkaraiyar Basin
Bay of Bengal
South Vellar Sub Basin
Agniyar Sub Basin
Ambuliyar Sub Basin
Tulukkampatti
Kurungulam
Gandarvakottai
Vettikkadu
Vattanakkottai
Kiranur
Andanur
Uranikkadu
Perungalur
Virappatti
Maniyankurichchi
Marungapuri
Kottaippatti
Karadipatti
Oliyamangalam
Kudumiyamalai
Pudukkottai
Malayur
Pattukkottai
Tiruchitrambalam
Avanam
Pallattur
Kulipirai
Namanasamudram
Kurumbur
Amarasimhendrapuram
Memangalam
Karakkottai
Kiranur
Kundar R
Kundar R
Vellar R
Vellar R
Agniyar R
Nasuvunni R
Maharajasamudram
Ambuliyar R
Punaikkuttiar R
Kattar R
Velunniyar R
Tedakkiar R
Karai_Ar
Legend
Location
River
Sub basin Boundary
Basin Boundary
Depth in meters (bgl)
0-5 m
5-10 m
10-15 m
15-20 m
Government of Tamilnadu
Water Resources Department
Tamilnadu State Centre for Remote Sensing Applications
Institute for Water Studies,Hydrology and Quality Control
Tharamani, Chennai- 600113
Kilometers
0 5 10 20
78°10'0"E 78°20'0"E 78°30'0"E 78°40'0"E 78°50'0"E 79°0'0"E 79°10'0"E 79°20'0"E 79°30'0"E
10°40'0"N 10°30'0"N 10°20'0"N 10°10'0"N 10°0'0"N


Thickness of Weathered Formation in Agniyar Basin
Plate AG 25
Cauvery Basin
Cauvery Basin
Cauvery Basin
Pambar Kottakkaraiyar Basin
Bay of Bengal
South Vellar Sub Basin
Agniyar Sub Basin
Ambuliyar Sub Basin
Tulukkampatti
Kurungulam
Gandarvakottai
Vettikkadu
Vattanakkottai
Kiranur
Andanur
Virappatti
Perungalur
Uranikkadu
Maniyankurichchi
Kottaippatti
Marungapuri
Oliyamangalam
Kudumiyamalai
Malayur
Pattukkottai
Pudukkottai
Karadipatti
Tiruchitrambalam
Avanam
Pallattur
Kulipirai
Namanasamudram
Kurumbur
Amarasimhendrapuram
Memangalam
Karakkottai
Kiranur
Kundar R
Kundar R
Vellar R
Agniyar R
Nasuvunni R
Maharajasamudram
Ambuliyar R
Punakkuttiar R
Kattar R
Velunniyar R
Tedakkiar R
Vellar R
Karai_Ar
Legend
Location
River
Sub basin Boundary
Basin Boundary
Depth in meters (bgl)
10-20 m
20-30 m
30-40 m
40-50 m
50-65 m
Government of Tamilnadu
Water Resources Department
Tamilnadu State Centre for Remote Sensing Applications
Institute for Water Studies,Hydrology and Quality Control
Tharamani, Chennai- 600113
Kilometers
0 5 10 20
78°10'0"E
78°20'0"E
78°30'0"E
78°40'0"E
78°50'0"E
79°0'0"E
79°10'0"E
79°20'0"E
79°30'0"E
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
10°0'0"N


Thickness of Fractured Formation in Agniyar Basin
Plate AG 26
Cauvery Basin
Cauvery Basin
Cauvery Basin
Pambar Kottakkaraiyar Basin
Bay of Bengal
South Vellar Sub Basin
Ambuliyar Sub Basin
Agniyar Sub Basin
Tulukkampatti
Kurungulam
Gandarvakottai
Vattanakkottai
Vettikkadu
Kiranur
Virappatti
Andanur
Perungalur
Uranikkadu
Pattukkottai
Maniyankurichchi
Kottaippatti
Marungapuri
Kudumiyamalai
Oliyamangalam
Malayur
Karadipatti
Pudukkottai
Tiruchitrambalam
Avanam
Pallattur
Kulipirai
Namanasamudram
Kurumbur
Amarasimhendrapuram
Memangalam
Karakkottai
Kiranur
Kundar R
Vellar R
Agniyar R
Ambuliyar R
Punaikkuttiar R
Kattar R
Velunniyar R
Tedakkiar R
Karai_Ar
Nasuvunni R
Maharajasamudram
Legend
Location
River
Sub basin Boundary
Basin Boundary
Depth in meters (bgl)
30-50 m
50-70 m
70-100 m
100-200 m
200-300 m
300-600 m
Government of Tamilnadu
Water Resources Department
Tamilnadu State Centre for Remote Sensing Applications
Institute for Water Studies,Hydrology and Quality Control
Tharamani, Chennai- 600113
Kilometers
0 5 10 20
78°10'0"E
78°20'0"E
78°30'0"E
78°40'0"E
78°50'0"E
79°0'0"E
79°10'0"E
79°20'0"E
79°30'0"E
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
10°0'0"N


SOIL ORDER MAP OF AGNIYAR BASIN
PLATE: AG 27
N
Tulukkampatti
Kurungulam
Vattanakkottai
Kiranur
Vettikkadu
Agniyar Sub Basin
Andanur
Uranikkadu
Virappatti
Perungalur
Pattukkottai
Marungapuri
Maniyankurichchi
Oliyamangalam
Kudumiyamalai
Malayur
South Vellar Sub Basin
Karadipatti
Tiruchitrambalam
Pudukkottai
Avanam
Namanasamudram
Pallattur
Kulipirai
Kurumbur
Ambuliyar Sub Basin
Amarasimhendrapuram
Karakkottai
Kiranur
Palk Bay
Legend
Cities / Towns
Sub Basin Boundary
SOIL ORDER
ALFISOLS
ENTISOLS
INCEPTISOLS
VERTISOLS
MISCELLANEOUS
RESERVE FOREST
SWAMP
Kilometers
0 5 10 20
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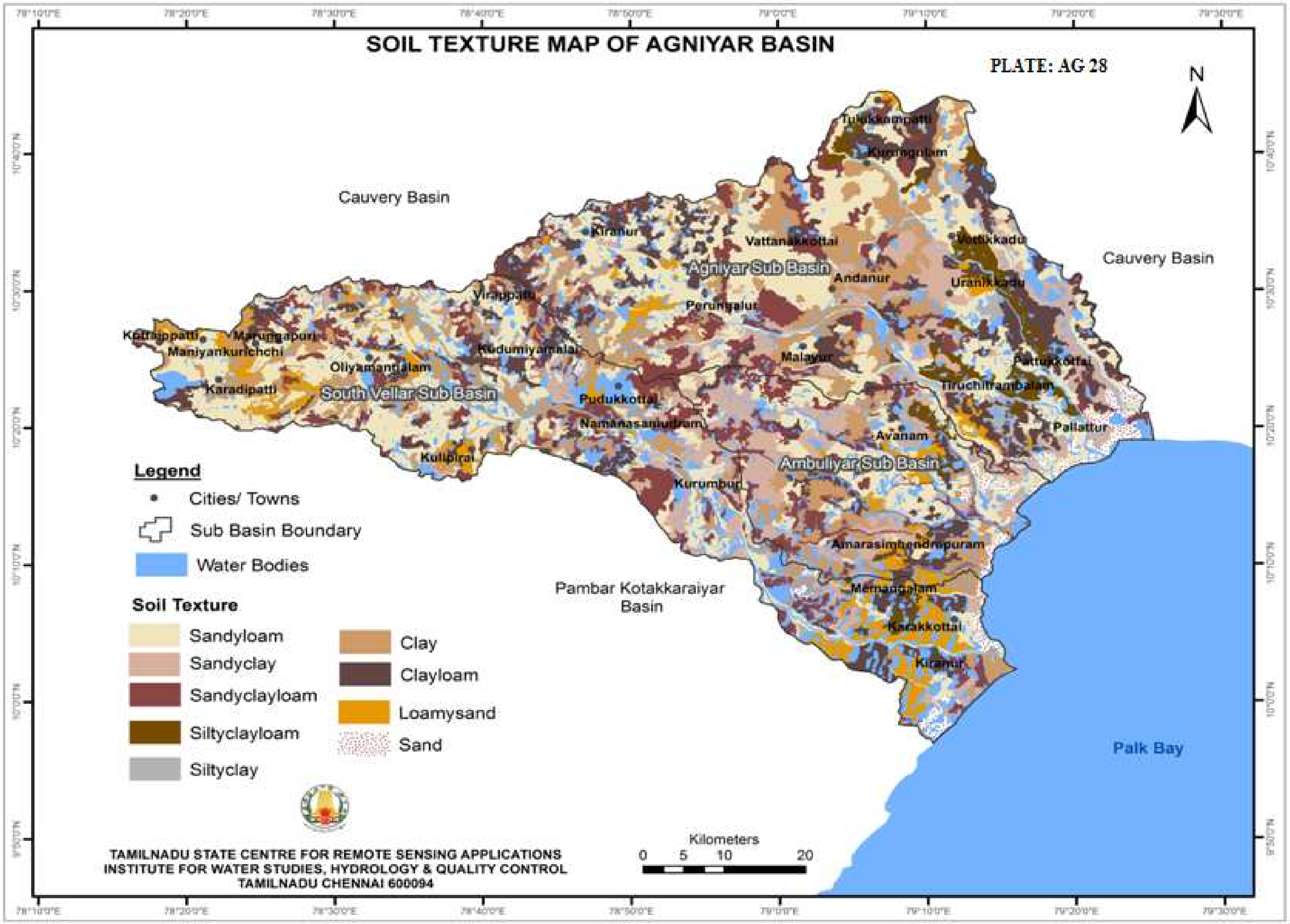
INSTITUTE FOR WATER STUDIES, HYDROLOGY & QUALITY CONTROL,
THARAMANI CHENNAI 600 113


SOIL TEXTURE MAP OF AGNIYAR BASIN
PLATE: AG 28
N
Cauvery Basin
Cauvery Basin
Pambar Kotakkaraiyar Basin
Palk Bay
Agniyar Sub Basin
South Vellar Sub Basin
Ambuliyar Sub Basin
Pudukkottai
Pattukkottai
Legend
Cities/ Towns
Sub Basin Boundary
Water Bodies
Soil Texture
Sandyloam
Sandyclay
Sandyclayloam
Siltyclayloam
Siltyclay
Clay
Clayloam
Loamysand
Sand
Kilometers
0 5 10 20
TAMILNADU STATE CENTRE FOR REMOTE SENSING APPLICATIONS
INSTITUTE FOR WATER STUDIES, HYDROLOGY & QUALITY CONTROL
TAMILNADU CHENNAI 600094

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, Agniyar 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 Agniyar River Basin lies in the districts of Dindigul, Pudukkottai, Thanjavur, Tiruchirappalli and Sivagangai of Tamil Nadu State. A detailed study report on the hydro meteorological parameters for Agniyar River Basin is furnished below.

3.2 Rainfall

3.2.1 Rain gauge Stations

There are 32 rain gauge stations in and around the Basin. Considering the distribution of rain gauge stations and the stations having long term records, out of 32 rain gauge stations, only 20 rain gauge stations were selected for detailed analysis. The details of influencing and non-influencing rain gauge stations in Agniyar River basin are given in the **Table 3.1 and 3.2**

Daily rainfall data for the period of 31 years from 1990 to 2021 has been collected from State Ground & Surface Water Resources Data Centre (SG&SWRDC), WRD 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 971.80 mm, (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 20 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: 29.** Dependable rainfall at 50% & 75% dependability and season wise 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: 30 to 34)** 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 31 years annual average rainfall of the basin is 937.17 mm.

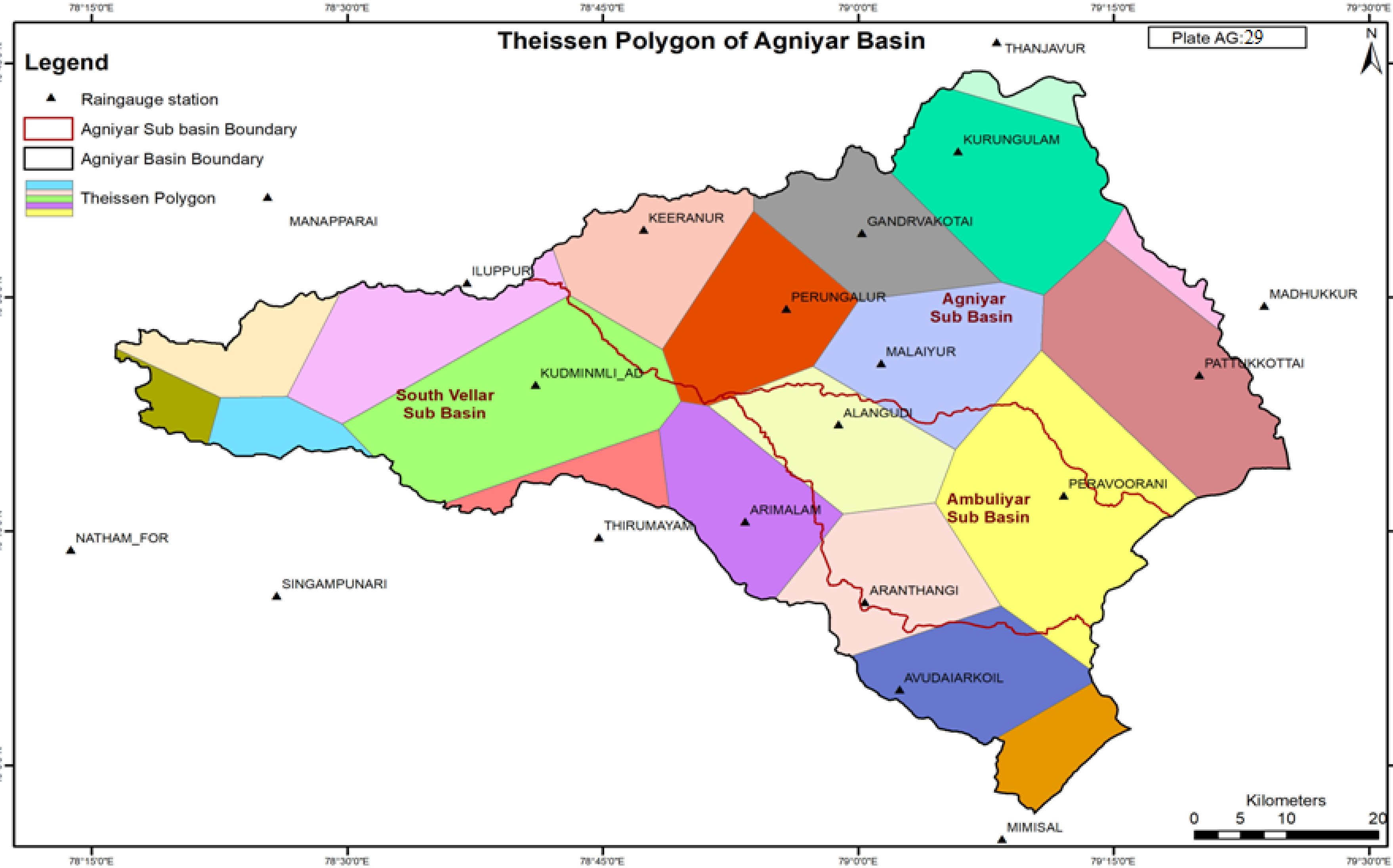
Table 3.1

Influencing Raingauge Stations of Agniyar River Basin

Sl.no	Station Code	District	Latitude	Longitude	Data Availability Period
1	Alangudi	Pudukkottai	10°21'52"	78°58'51"	1990-2019
2	Gandrvakotai	Pudukkottai	10°34'08"	79°00'14"	1990-2019
3	Keeranur	Pudukkottai	10°34'22"	78°47'24"	1990-2019
4	Kudminmli_AD	Pudukkottai	10°24'25"	78°41'04"	1990-2019
5	Kurungulam	Thanjavur	10°39'23"	79°05'53"	1990-2019
6	Iluppur	Pudukkottai	10°30'57"	78°37'01"	1990-2019
7	Malaiyur	Pudukkottai	10°25'47"	79°01'22"	1990-2019
8	Madhukkur	Thanjavur	10°29'29"	79°23'52"	1990-2019
9	Pattukottai	Thanjavur	10°18’04’’	76°52’47’’	1990-2019
10	Peravoorani	Thanjavur	10°52’31’’	77°11’47’’	1990-2019
11	Perungalur	Pudukkottai	10°29’13’’	77°10’00’’	1990-2019
12	Thanjavur	Thanjavur	10°28’16’’	76°50’39’’	1990-2019
13	Aranthangi	Pudukkottai	10°20’04’’	76°57’45’’	1990-2019
14	Arimalam	Pudukkottai	10°34’01’’	76°55’17’’	1990-2019
15	Avudaiarkoil	Pudukkottai	10°25’13’’	76°59’31’’	1990-2019
16	Manapparai	Pudukkottai	10°36'27"	78°25'20"	1990-2019
17	Mimisal	Thiruchirapalli	09°55'17"	79°08'27"	1990-2019
18	Natham_FOR	Dindigul	10°13'49"	78°13'45"	1990-2019
19	Singampunari	Sivagangai	10°10'52"	78°25'51"	1990-2019
20	Thirumayam	Pudukkottai	10°14'37"	78°44'46"	1990-2019

Table 3.2
Non - Influencing Raingauge Stations of Agniyar River Basin

Sl.no	Station Code	District	Lat	Long	Data Availability Period
1	Vettikadu	Thanjavur	10°34'16"	79°11'42"	1977-1979, 1983-2021
2	Adhirampattinam	Thanjavur	10°20'26"	79°23'06"	1992-2021
3	Adanakottai	Pudukkottai	10°31'36"	78°57'39"	1995-2021
4	Karambakkudi	Pudukkottai	10°27'26"	79°07'55"	1979-1993, 1998-2021
5	Udayalipatti	Pudukkottai	10°35'03"	78°53'43"	1986-1989, 2004-2021
6	Ayinkudi	Pudukkottai	10°13'13"	79°05'47"	1977-1995, 1997-2021
7	Kattumavadi	Pudukkottai	10°07'32"	79°13'35"	1971-2019
8	Nagudi	Pudukkottai	10°09'08"	79°06'21"	1977-1980, 1982-1986 1988-2021
9	Annavasal	Pudukkottai	10°27'40"	78°42'04"	1983-1984, 1992-1997, 2004-2021
10	Karaiyur	Pudukkottai	10°22'06"	78°36'03"	1971-1975, 1983, 1986-1996, 2003-2021
11	Pudukottai	Pudukkottai	10°22'37"	78°49'03"	1991-1996, 1998-2021
12	Marungapuri	Thiruchirapalli	10°26'00"	78°24'50"	1975-1999, 2002-2021

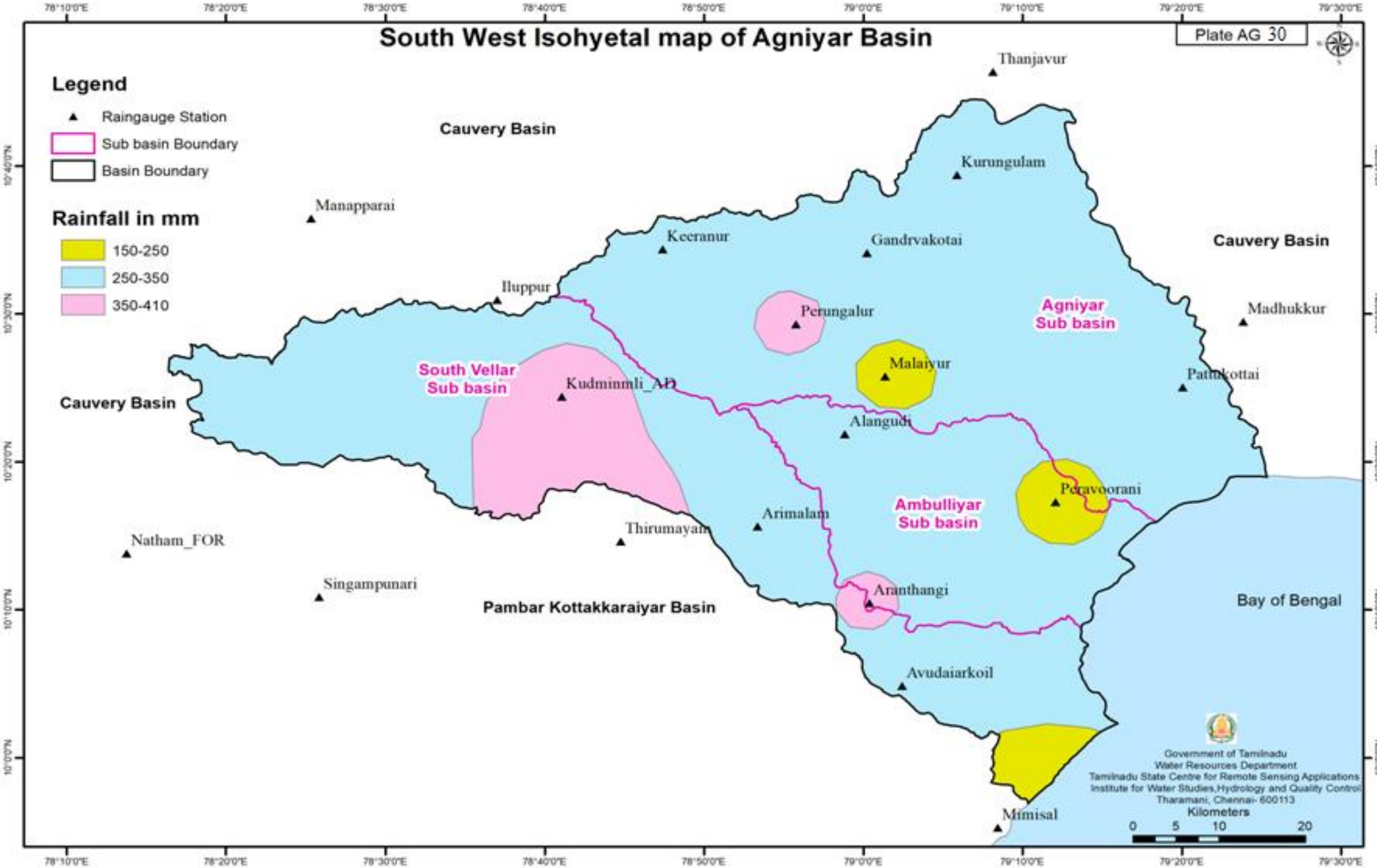


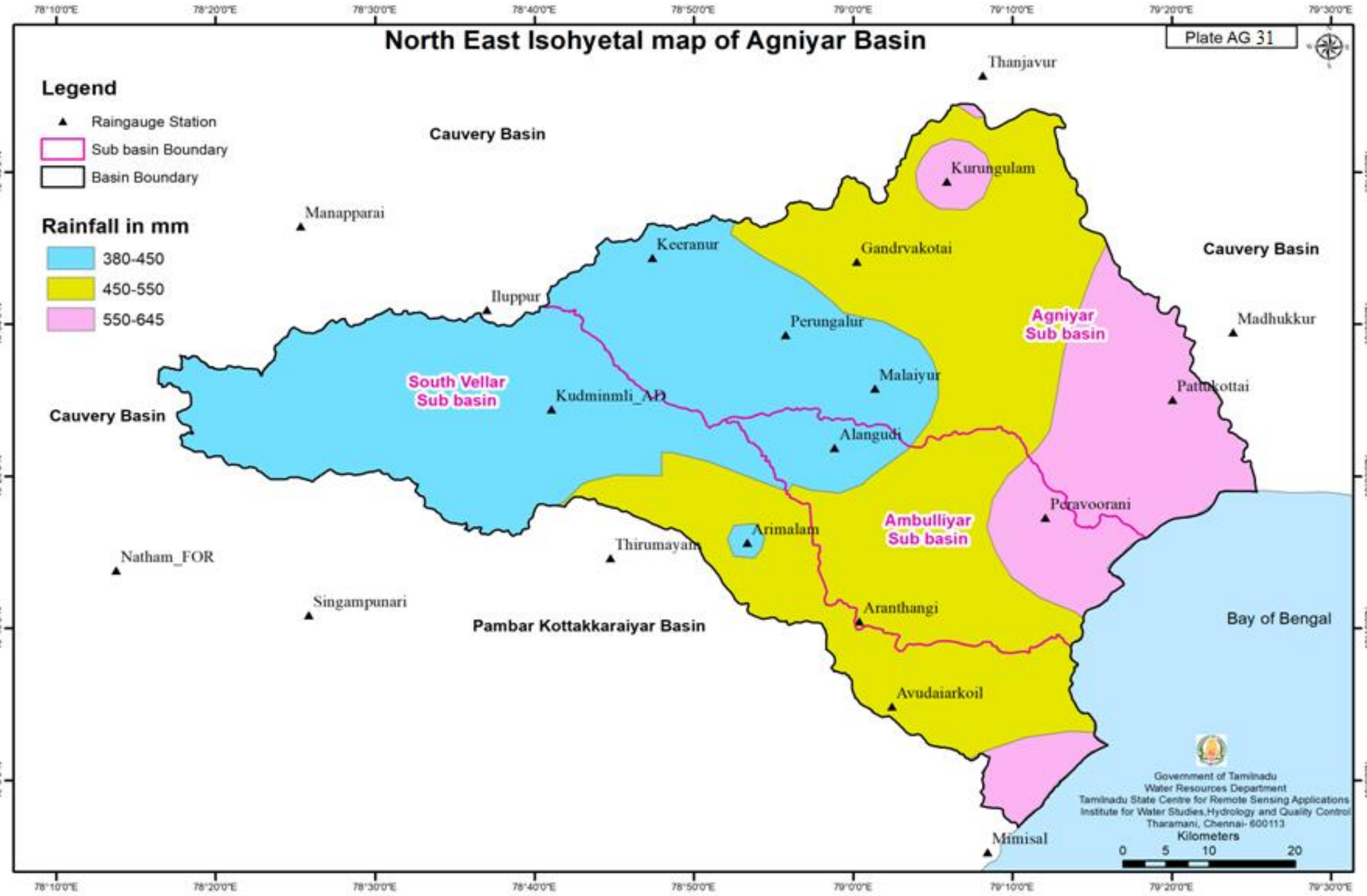
Theissen Polygon of Agniyar Basin
Plate AG:29
Legend
Raingauge station
Agniyar Sub basin Boundary
Agniyar Basin Boundary
Theissen Polygon
THANJAVUR
KURUNGULAM
GANDRVAKOTAI
KEERANUR
MANAPPARAI
ILUPPUR
PERUNGALUR
Agniyar Sub Basin
MADHUKKUR
MALAIYUR
PATTUKKOTTAI
KUDMINMLI_AD
South Vellar Sub Basin
ALANGUDI
PERAVOORANI
Ambuliyar Sub Basin
ARIMALAM
THIRUMAYAM
NATHAM_FOR
SINGAMPUNARI
ARANTHANGI
AVUDAIARKOIL
MIMISAL
Kilometers
0 5 10 20
78°15'0"E
78°30'0"E
78°45'0"E
79°0'0"E
79°15'0"E
79°30'0"E
10°45'0"N
10°30'0"N
10°15'0"N
10°0'0"N
N

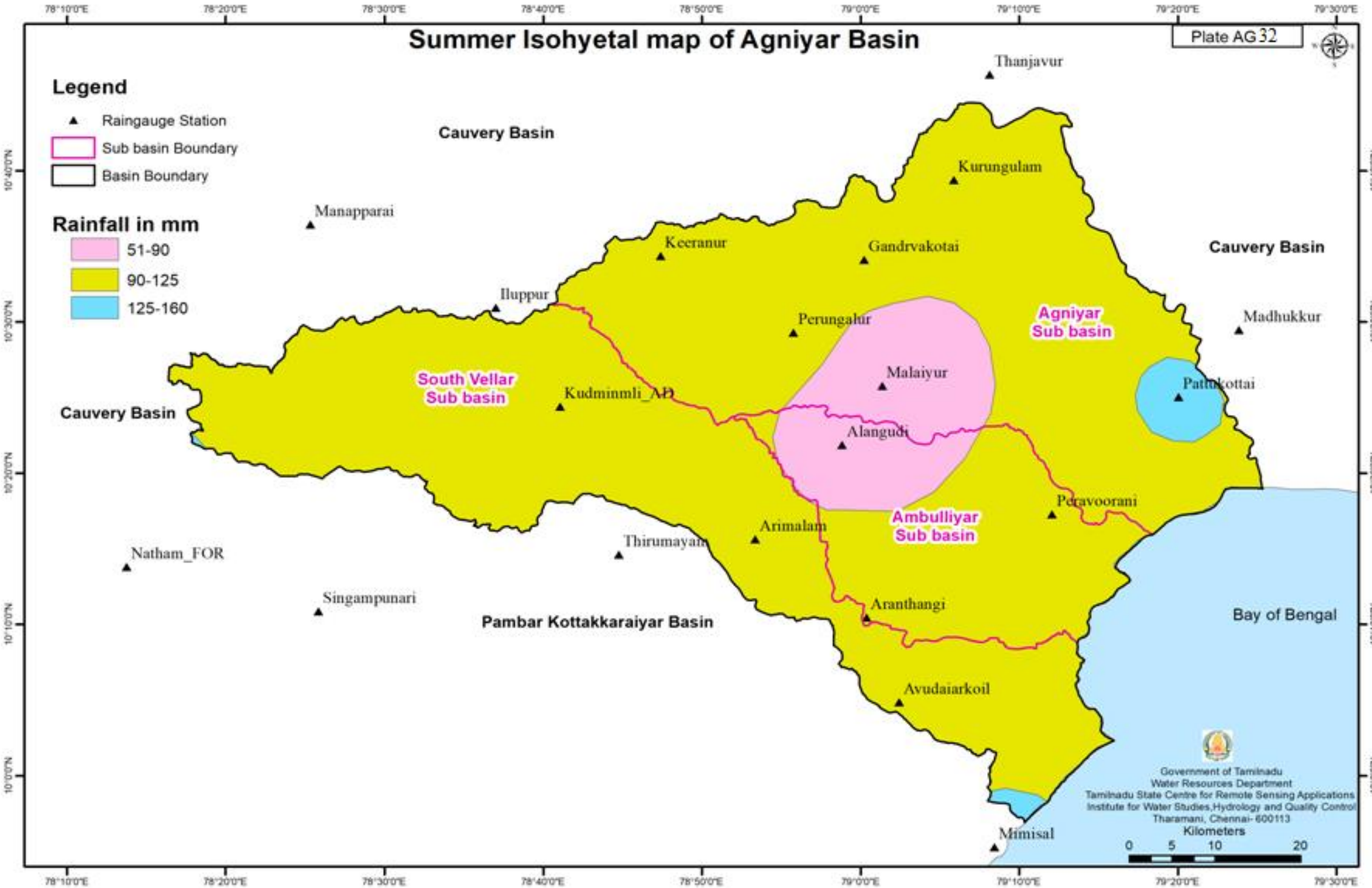
Table 3.3 Annual Average Weighted Rainfall for the Basin

S.NO	SUB-BASIN	S.NO	Raingauge Station	RG Station Influencing Area in Sq.km	Sub basin Area in Sq.km	Weight in %	Annual average rainfall for the Stations in mm	Annual average weighted rainfall for the sub-basin in mm
1	**AGNIYAR**	1	Alangudi	14.96	**2106.43**	0.007	852.92	934.92
		2	Gandrvakotai	246.17		0.117	885.19	
		3	Keeranur	237.22		0.113	896.44	
		4	Kudminmli_AD	28.89		0.014	955.64	
		5	Kurungulam	373.43		0.177	954.35	
		6	Iluppur	9.81		0.005	847.03	
		7	Madhukkur	39.62		0.019	1011.17	
		8	Malaiyur	284.02		0.135	688.88	
		9	Pattukottai	420.63		0.200	1107.05	
		10	Peravoorani	146.94		0.070	985.10	
		11	Perungalur	262.97		0.125	937.73	
		12	Thanjavur	41.77		0.020	981.70	
2	**AMBULIYAR**	1	Alangudi	221.04	**825.69**	0.268	852.92	954.25
		2	Aranthangi	184.37		0.223	1050.75	
		3	Arimalam	9.09		0.011	892.55	
		4	Avudaiarkoil	11.90		0.014	938.43	
		5	Malaiyur	23.38		0.028	688.88	
		6	Peravoorani	375.10		0.454	985.10	
		7	Perungalur	0.82		0.001	937.73	

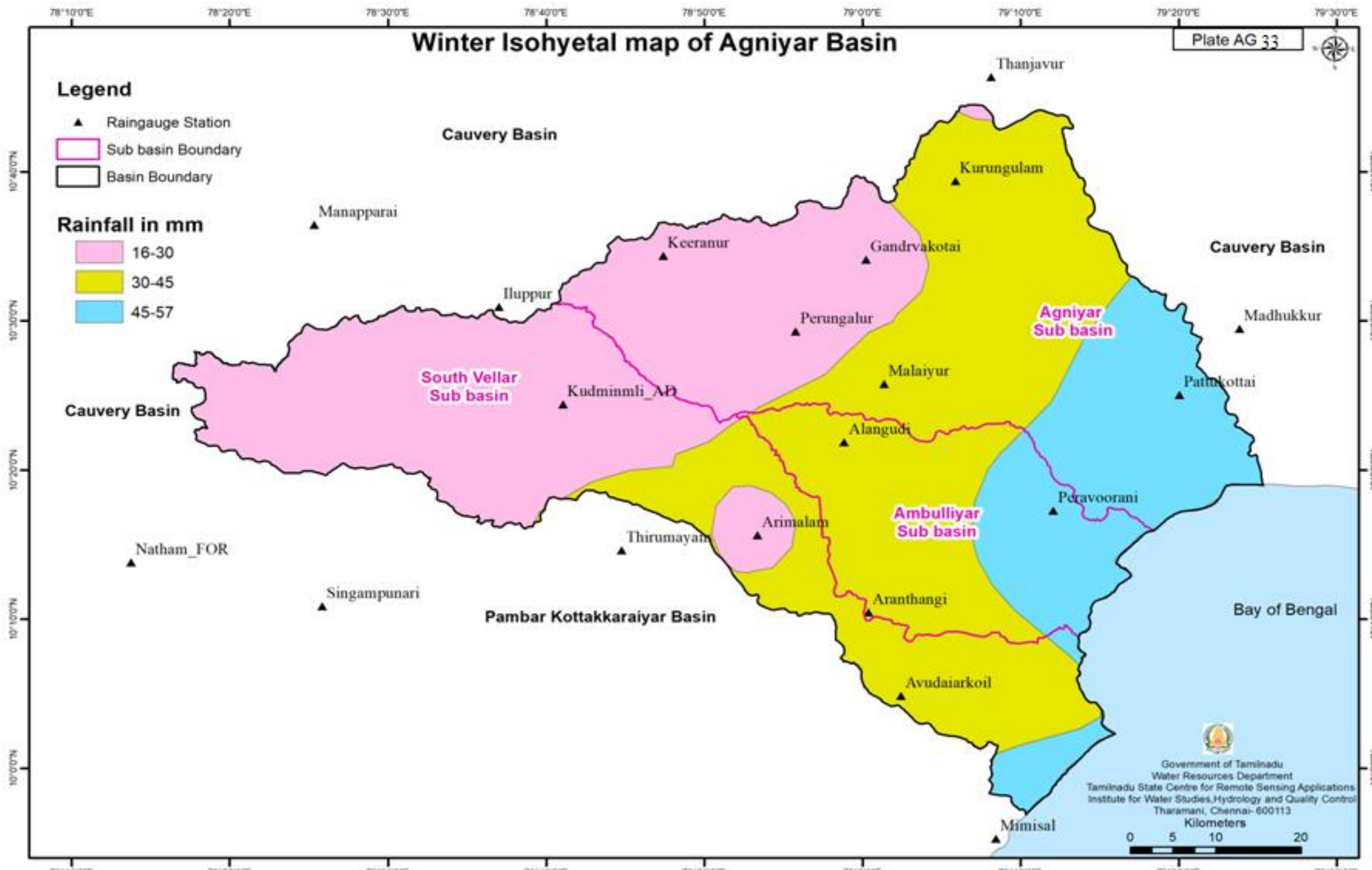
3	**SOUTH VELLAR**	1	Alangudi	16.43	**1769.90**	0.009	852.92	922.35
		2	Aranthangi	71.37		0.040	1050.75	
		3	Arimalam	243.13		0.137	892.55	
		4	Avudaiarkoil	228.82		0.129	938.43	
		5	Keeranur	0.05		0.000	896.44	
		6	Kudminmli_AD	460.03		0.260	955.64	
		7	Iluppur	251.44		0.142	847.03	
		8	Manapparai	143.08		0.081	812.23	
		9	Mimisal	112.42		0.064	971.72	
		10	Natham_FOR	52.70		0.030	1075.04	
		11	Peravoorani	18.80		0.011	985.10	
		12	Perungalur	5.77		0.003	937.73	
		13	Singampunari	85.03		0.048	828.14	
		14	Thirumayam	80.83		0.046	1022.16	
Basin Total Area				**4702.021**	**4702.021**			**937.17**

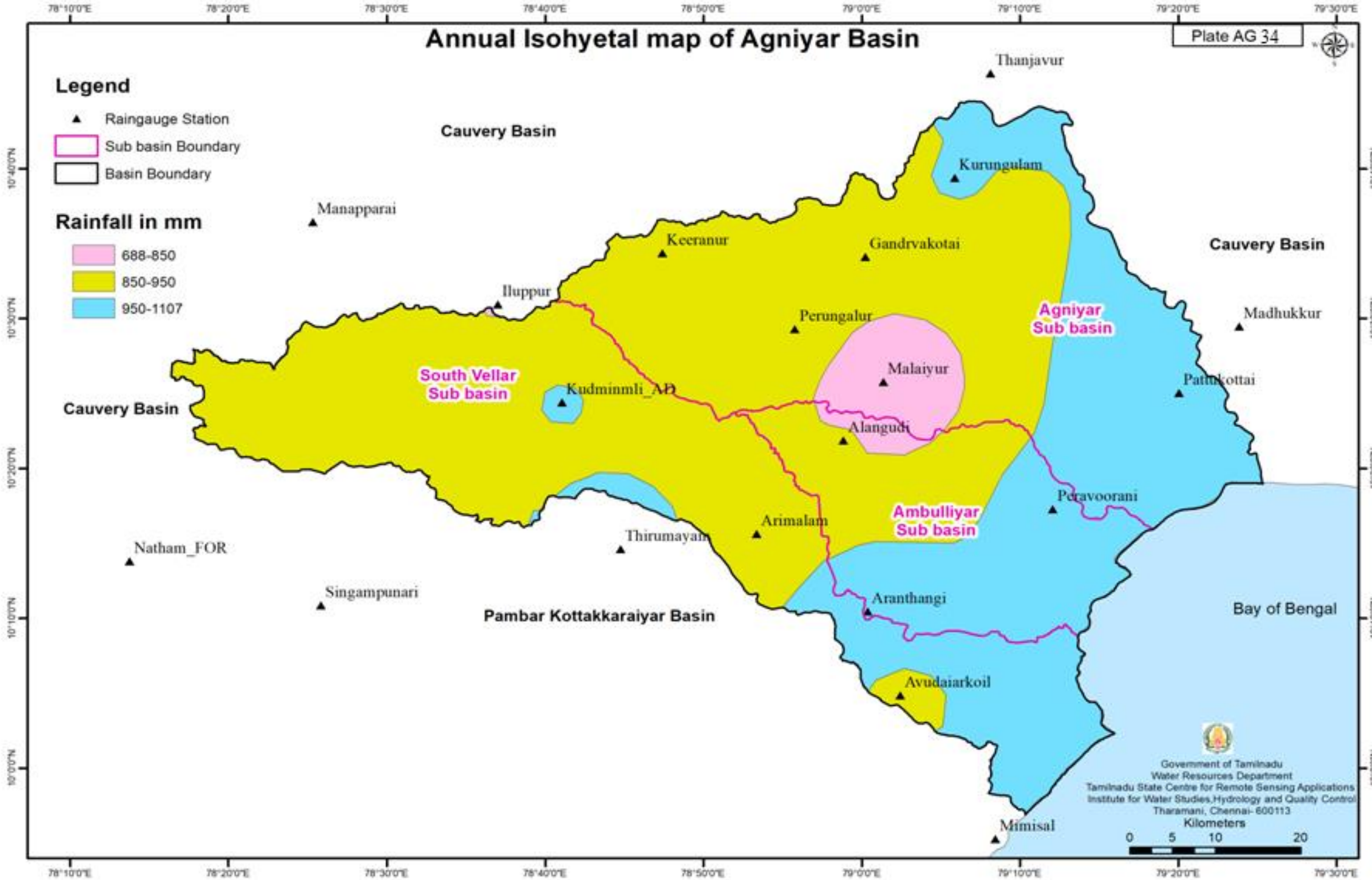

South West Isohyetal map of Agniyar Basin
Plate AG 30
Legend
Raingauge Station
Sub basin Boundary
Basin Boundary
Rainfall in mm
150-250
250-350
350-410
Cauvery Basin
Thanjavur
Kurungulam
Manapparai
Keeranur
Gandrvakotai
Cauvery Basin
Iluppur
Perungalur
Agniyar Sub basin
Madhukkur
Malaiyur
South Vellar Sub basin
Kudminmli_AD
Pattukottai
Cauvery Basin
Alangudi
Peravoorani
Arimalam
Ambulliyar Sub basin
Thirumayam
Natham_FOR
Singampunari
Aranthangi
Pambar Kottakkaraiyar Basin
Bay of Bengal
Avudaiarkoil
Government of Tamilnadu
Water Resources Department
Tamilnadu State Centre for Remote Sensing Applications
Institute for Water Studies,Hydrology and Quality Control
Tharamani, Chennai- 600113
Kilometers
0 5 10 20
Mimisal


North East Isohyetal map of Agniyar Basin
Plate AG 31
Legend
Raingauge Station
Sub basin Boundary
Basin Boundary
Rainfall in mm
380-450
450-550
550-645
Cauvery Basin
Cauvery Basin
Cauvery Basin
Pambar Kottakkaraiyar Basin
Bay of Bengal
South Vellar Sub basin
Agniyar Sub basin
Ambulliyar Sub basin
Thanjavur
Kurungulam
Manapparai
Gandrvakotai
Keeranur
Iluppur
Perungalur
Madhukkur
Malaiyur
Pattukottai
Kudminmli_AD
Alangudi
Peravoorani
Arimalam
Thirumayam
Natham_FOR
Singampunari
Aranthangi
Avudaiarkoil
Mimisal
Government of Tamilnadu
Water Resources Department
Tamilnadu State Centre for Remote Sensing Applications
Institute for Water Studies,Hydrology and Quality Control
Tharamani, Chennai- 600113
Kilometers
0 5 10 20



Summer Isohyetal map of Agniyar Basin
Plate AG 32
Legend
Raingauge Station
Sub basin Boundary
Basin Boundary
Rainfall in mm
51-90
90-125
125-160
Cauvery Basin
Cauvery Basin
Cauvery Basin
Pambar Kottakkaraiyar Basin
Bay of Bengal
South Vellar Sub basin
Agniyar Sub basin
Ambulliyar Sub basin
Thanjavur
Kurungulam
Manapparai
Keeranur
Gandrvakotai
Iluppur
Perungalur
Madhukkur
Malaiyur
Kudminmli_AD
Pattukottai
Alangudi
Peravoorani
Arimalam
Thirumayam
Natham_FOR
Singampunari
Aranthangi
Avudaiarkoil
Mimisal
Government of Tamilnadu
Water Resources Department
Tamilnadu State Centre for Remote Sensing Applications
Institute for Water Studies,Hydrology and Quality Control
Tharamani, Chennai- 600113
Kilometers
0 5 10 20


Winter Isohyetal map of Agniyar Basin
Plate AG 33
Legend
Raingauge Station
Sub basin Boundary
Basin Boundary
Rainfall in mm
16-30
30-45
45-57
Cauvery Basin
Cauvery Basin
Cauvery Basin
Pambar Kottakkaraiyar Basin
Bay of Bengal
South Vellar Sub basin
Agniyar Sub basin
Ambulliyar Sub basin
Thanjavur
Kurungulam
Manapparai
Keeranur
Gandrvakotai
Iluppur
Perungalur
Madhukkur
Malaiyur
Kudminmli_AD
Pattukkottai
Alangudi
Peravoorani
Natham_FOR
Thirumayam
Arimalam
Singampunari
Aranthangi
Avudaiarkoil
Mimisal
Government of Tamilnadu
Water Resources Department
Tamilnadu State Centre for Remote Sensing Applications
Institute for Water Studies,Hydrology and Quality Control
Tharamani, Chennai- 600113
Kilometers
0 5 10 20



Annual Isohyetal map of Agniyar Basin
Plate AG 34
Legend
Raingauge Station
Sub basin Boundary
Basin Boundary
Rainfall in mm
688-850
850-950
950-1107
Cauvery Basin
Cauvery Basin
Cauvery Basin
Pambar Kottakkaraiyar Basin
Bay of Bengal
South Vellar Sub basin
Agniyar Sub basin
Ambulliyar Sub basin
Thanjavur
Kurungulam
Manapparai
Keeranur
Gandrvakotai
Iluppur
Perungalur
Madhukkur
Malaiyur
Kudminmli_AD
Pattukottai
Alangudi
Peravoorani
Arimalam
Thirumayam
Natham_FOR
Singampunari
Aranthangi
Avudaiarkoil
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Tharamani, Chennai- 600113
Kilometers
0 5 10 20

3.2.3 Maximum, minimum and average rainfall

The maximum, minimum and average annual rainfall for the 20 rain gauge stations have been analysed and tabulated in Volume II **Appendix-3.1.1 to 3.1.20**

- Maximum Annual average weighted Rainfall of this basin is 954.2 mm [in Ambuliyar Sub basin]
- Minimum Annual average weighted Rainfall of this basin is 922.3 mm[in South Vellar Sub basin]
- Average annual weighted rainfall of the Agniyar River Basin is 937.1 mm

And each sub basin rainfall ranges are tabulated below **in Table 3.4**

Table 3.4 Rainfall ranges of the Agniyar Basin

Sl. No.	Name of the Sub-basin	No. of influencing Raingauage Staions	Rainfall range in mm(1991 - 2021)					Annual Average Rainfall in mm
			Annual	NE	SW	Winter	Summer	
1	Agniyar	12	1481.9 To 547.7	895.4 To 161.3	510.9 To 171.7	277.6 To 0.0	293.2 To 16.3	934.9
2	Ambuliyar	7	1683.0 To 532.1	918.5 To 182.9	482.1 To 97.3	350.5 To 0.0	324.9 To 4.5	954.2
3	South Vellar	14	1375.1 To 481.8	799.5 To 177.8	609.8 To 204.2	199.3 To 0.0	239.5 To 20.1	922.3

3.2.4 Moving Average

The 5 years moving average data for the three sub basins are given in the **Appendix 3.2.1 to 3.2.3**. The 5 years moving average graph for the annual rainfall has been drawn for the three sub basins. A linear fit has also been shown along with moving average curve. The details are given in fig 3.2.1 to 3.2.3 of volume II respectively.

- **The Agniyar Sub Basin is showing the decreasing trend**
- **The Ambuliyar Sub Basin is showing the slightly decreasing trend**
- **The South Vellar sub basin is showing the decreasing trend**

3.3 Dependable Rainfall

The Dependable Rainfall is the value of period rainfall (monthly, seasonal, etc.,) that will be exceeded over that value of the time.

The 50% and 75% dependable rainfall for Agniyar River Basin are tabulated below in **Table 3.5, Table 3.6 & Table 3.7**

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

Name of the Sub basin	**Agniyar**		
Season	**50%**	**75%**	**Average**
SW	269.6	216.3	**281.9**
NE	490.4	415.3	**514.1**
Winter	11.9	3.2	**36.8**
Summer	92.0	60.6	**102.2**
Annual	924.8	786.2	**934.9**

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

Name of the Sub basin	**Ambuliyar**		
Season	**50%**	**75%**	**Average**
SW	281.3	230.9	**283.8**
NE	527.9	421.2	**527.9**
Winter	4.8	15.6	**46.5**
Summer	77.5	57.2	**96.1**
Annual	926.4	782.8	**954.2**

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

Name of the Sub basin	**South Vellar**		
Season	**50%**	**75%**	**Average**
SW	303.9	256.0	**323.8**
NE	476.3	351.9	**460.7**
Winter	10.9	3.5	**27.9**
Summer	107.5	72.8	**109.9**
Annual	931.1	780.5	**922.3**

Table 3.8- Agniyar River Basin - Dependable Rainfall (inmm)

Name of the basin	Agniyar Basin		
Season	Dependability		
	50%	75%	Average
SW	284.9	234.4	**296.5**
NE	498.2	396.1	**500.9**
Winter	12.8	3.1	**37.1**
Summer	92.3	63.5	**102.7**
Annual	927.4	783.2	**937.1**

3.4 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. From the table it is noticed that rainfall exceeding 1000mm is maximum (40% of the study period (1991-2021) in Natham_FOR, Aranthangi, Pattukottai, Thanjavur, Mimisal. Frequency of Rainfall in the range of 900-1000mm occurred nearly 12% and below of the study period in Pattukottai, Gandrvakotai, Madhukkur, Thirumayam. Frequency of Rainfall in the range of 800-900mm occurred a maximum of 12 % in the study period in Aranthangi, Thirumayam. Frequency of Rainfall in the range 600 to 800mm rainfall occurred 23% of the study period in most stations of the Basin. Frequency of Rainfall in the range 400 to 600mm rainfall occurred nearly 9% of the study period in Malaiyur, Avudaiarkoil, Singampunari. Frequency of Rainfall in the range 200 to 400mm rainfall occurred less than 2% of the study period in few stations. Less than 200 mm rainfall has occurred in Alangudi, Malaiyur and Manaparai.

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	Alangudi	31	9	3	5	9	4	0	1
2	Gandrvakotai	31	10	7	2	8	4	0	0
3	Keeranur	31	11	3	5	9	3	0	0
4	Kudminmli_AD	31	13	3	4	7	4	0	0
5	Kurungulam	31	13	5	3	7	2	1	0
6	Iluppur	31	11	3	3	7	4	3	0
7	Malaiyur	31	3	2	5	11	6	2	2
8	Madhukkur	31	14	7	3	6	1	0	0
9	Pattukottai	31	17	8	3	2	1	0	0
10	Peravoorani	31	14	5	3	6	3	0	0
11	Perungalur	31	14	3	3	9	2	0	0
12	Thanjavur	31	15	3	3	9	1	0	0
13	Aranthangi	31	17	4	8	1	1	0	0
14	Arimalam	31	12	1	4	10	4	0	0
15	Avudaiarkoil	31	14	3	5	6	3	0	0
16	Manapparai	31	9	0	2	11	5	3	1
17	Mimisal	31	15	4	4	6	1	1	0
18	Natham_FOR	31	18	3	3	7	0	0	0
19	Singampunari	31	8	3	5	10	5	0	0
20	Thirumayam	31	14	6	6	3	2	0	0

3.5 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 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 Agniyar Sub-basin is given below in **Fig 3.1**

Fig.3.1 (A) Statistical Parameters of Agniyar Sub-basin (1991 to 2021)

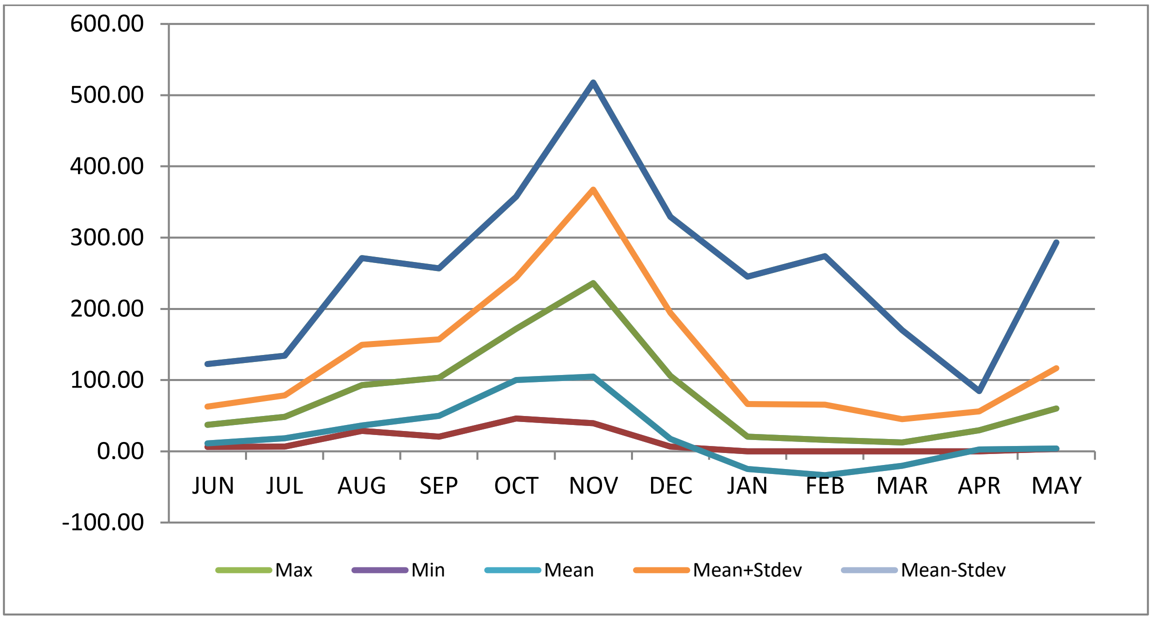


Fig.3.1 (B) Statistical Parameters of Ambuliyar Sub-basin (1991 to 2021)

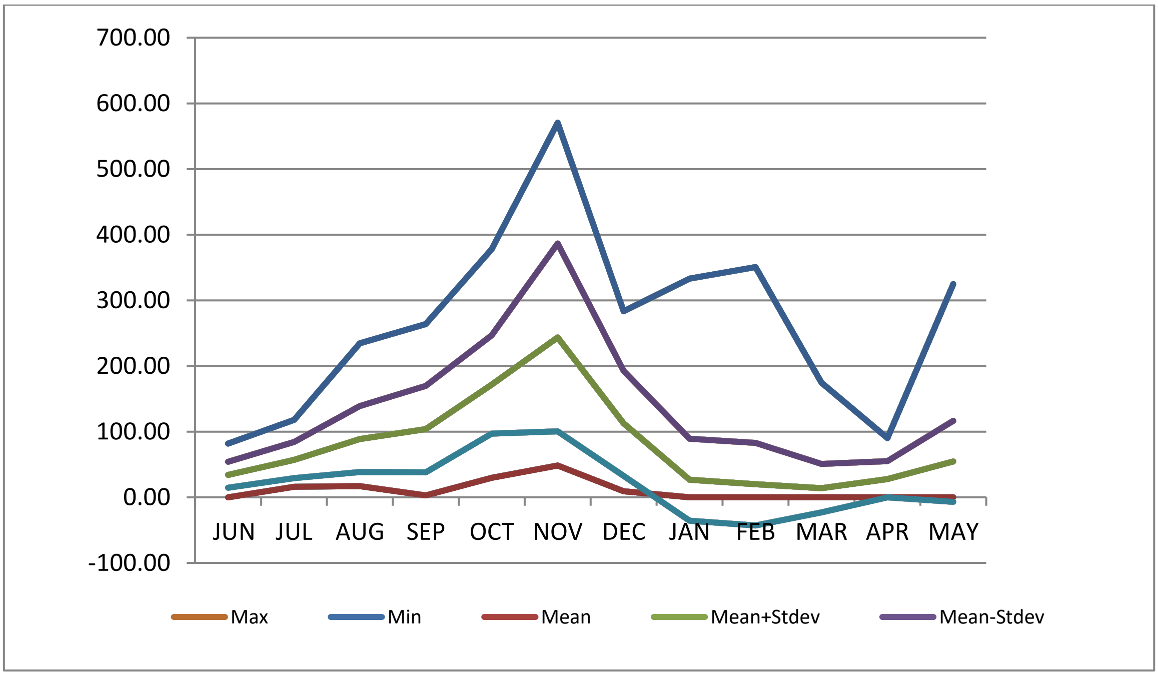
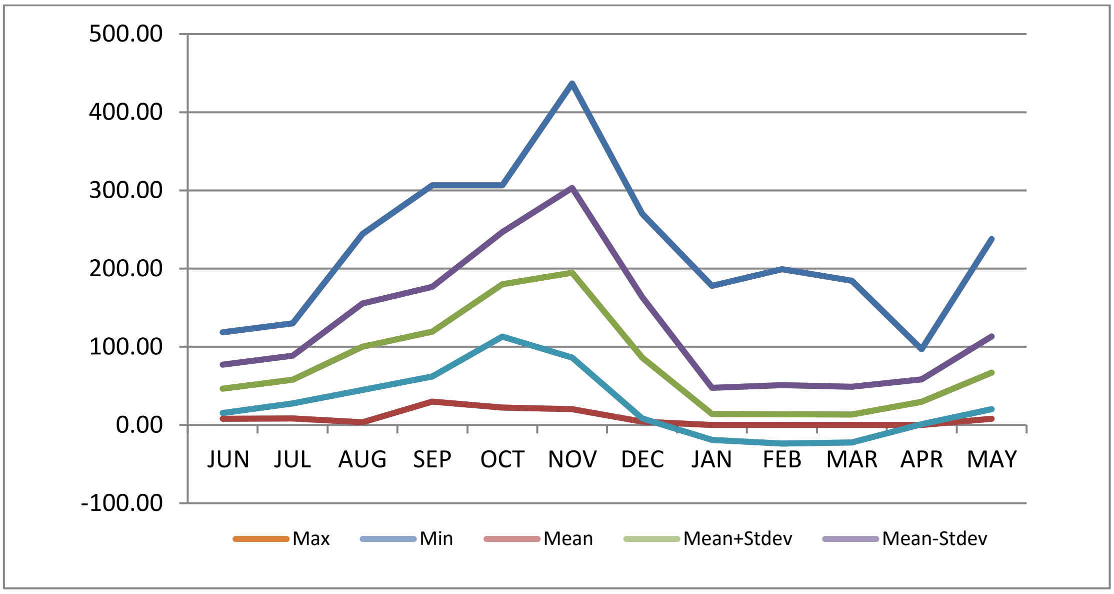


Fig.3.1 (C) Statistical Parameters of South Vellar Sub-basin (1991 to 2021)



3.6 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 for South West monsoon, North East monsoon and Annual Rainfall deviation from over the basin for 31 years is found to be of alternating sequences of wet (+ve- Deviation) and dry (-ve - Deviation) periods and are given in **Table 3.10, 3.11 & 3.12** as depicted from the **fig.3.2, 3.3 & 3.4** respectively

Table 3.10 – Details of deviation in South West monsoon Rainfall

Monsoon	Period of Years	No. of years	Deviation in mm	Deviation
South West Monsoon	1991-2021	18	10.6 to 110.3	Negative (-)
		13	7.3 to 229.0	Positive (+)

Table 3.11 – Details of deviation in North East monsoon Rainfall

Monsoon	Period of Years	No. of years	Deviation in mm	Deviation
North East Monsoon	1991-2021	17	2.9 to 352.7	Negative (-)
		14	21.7 to 381.3	Positive (+)

Table 3.12 – Details of deviation in Annual Rainfall

Monsoon	Period of Years	No. of years	Deviation in mm	Deviation
Annual Rainfall	1991-2021	16	10.0 to 387.2	Negative (-)
		15	28.8 to 547.0	Positive (+)

Fig.3.2 Deviation from mean South West monsoon Rainfall

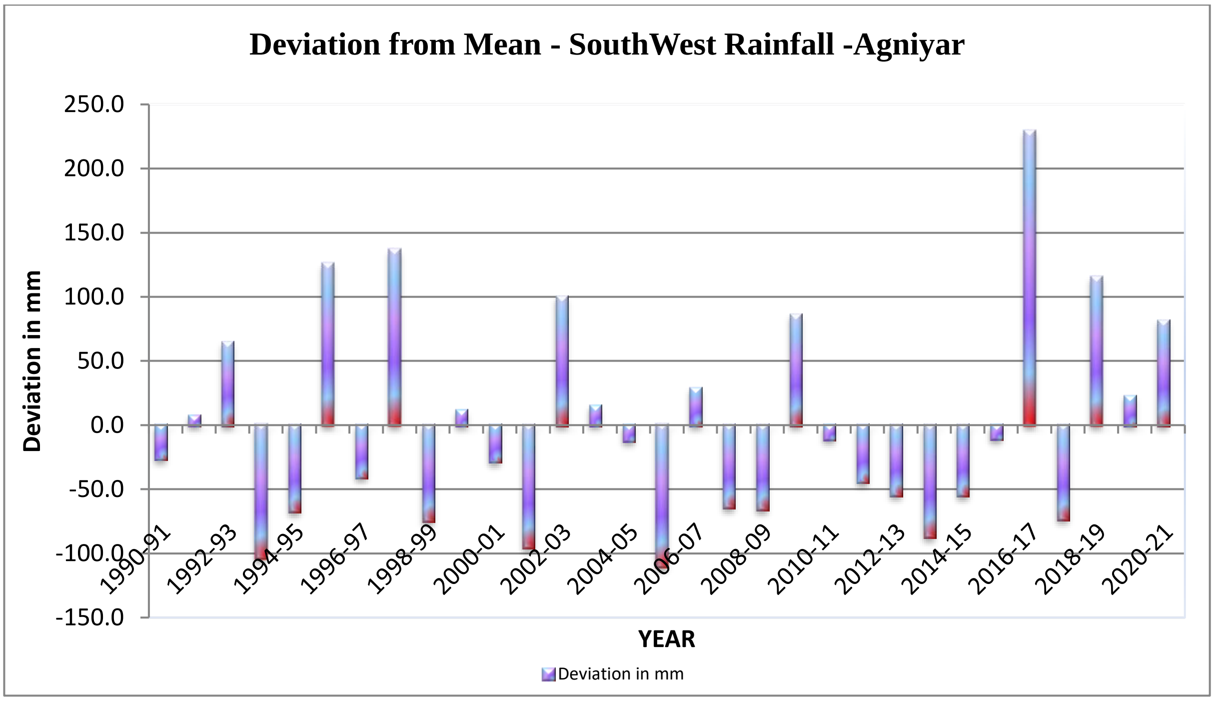


Fig.3.3 Deviation from mean North East monsoon Rainfall

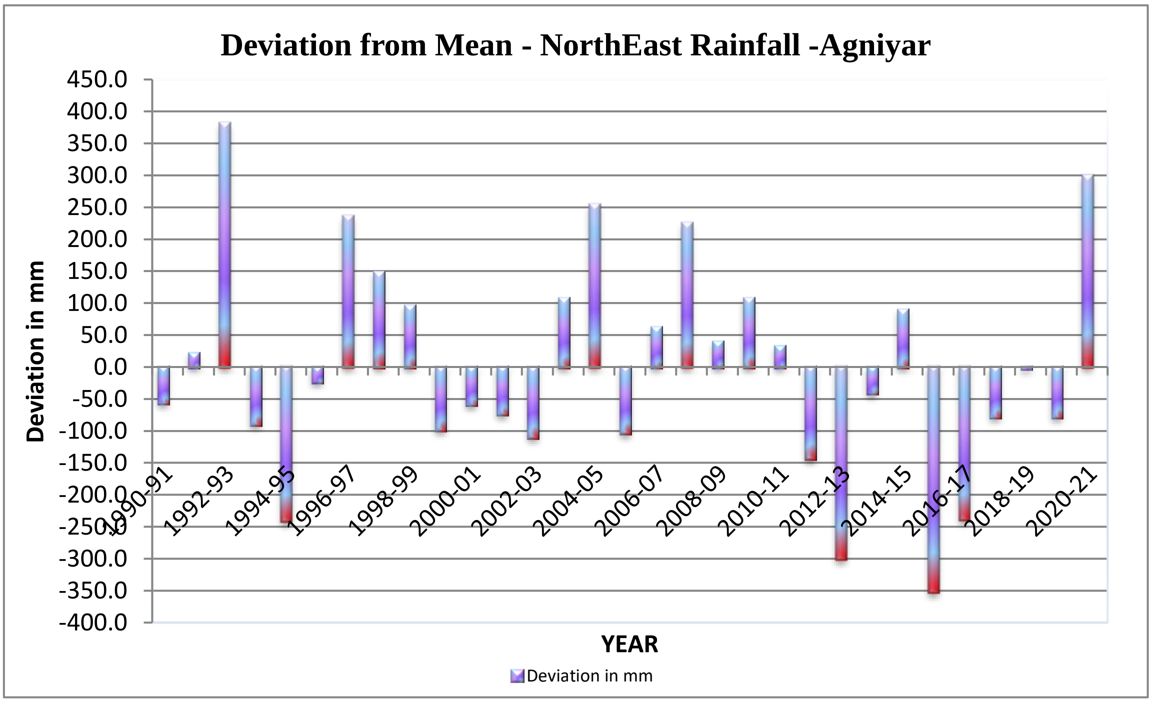
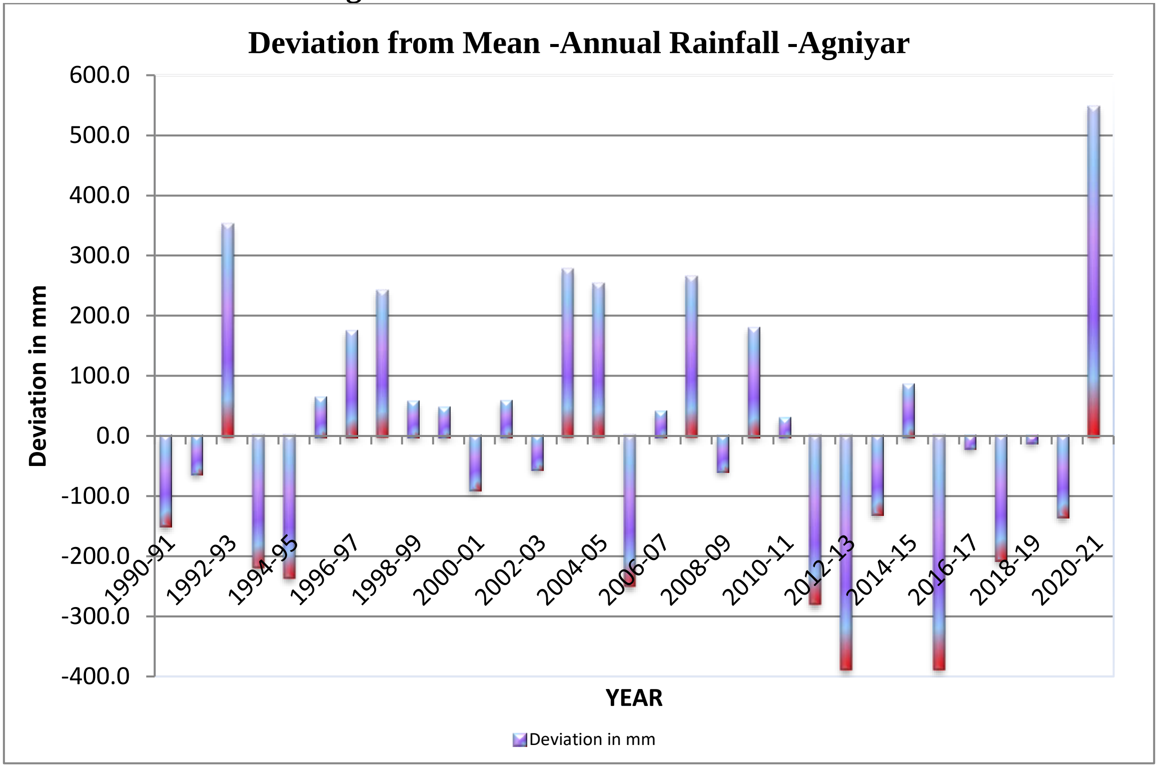


Fig.3.4 Deviation from mean - Annual rainfall



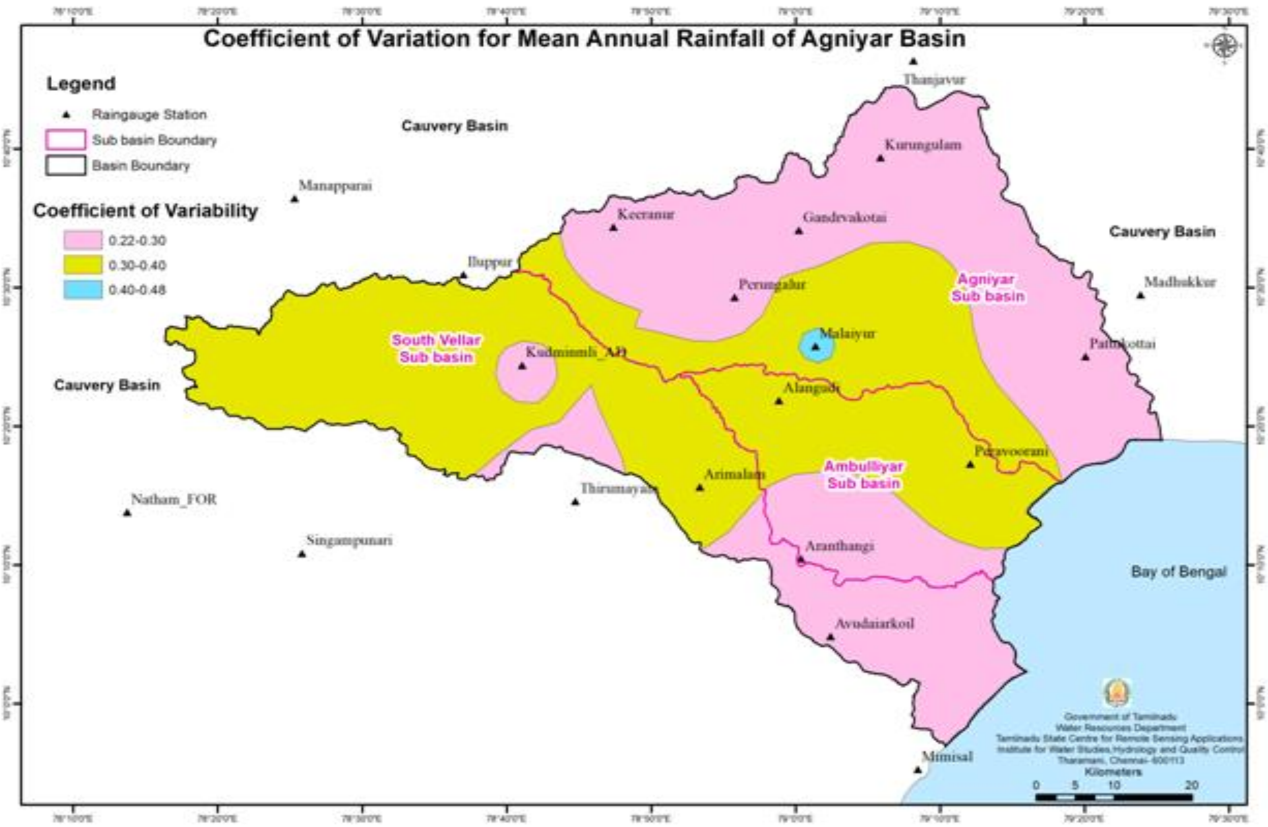
The above observations revealed the fact that the rainfall trend of south west monsoon is decreasing compare to that of north east monsoon over this basin. This trend influences on Annual rainfall pattern over this basin.

3.7 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 31 years from Rain gauge location points, using an inverse distance weighted technique, the Co-efficient of variation for Agniyar 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 937.17 mm. Cv value of the basin indicates the variation of annual rainfall is close to the mean. The 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



3.8 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.

Pudukkottai and Kurungulam weather station is situated inside Agniyar River Basin. Pudukkottai 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 3.13** and its climatological Parameters are listed in **Table 3.14.**

Table-3.13-Weather Stations

SI.No	Name of the weather station	Block	Sub-basin	Maintained by
1	Pudukkottai	Pudukkottai	South Vellar	WRD

Table-3.14-Climatological Parameters

SI. No	Climatological Parameter (Annual Average)	Pudukkottai
1	Average monthly temperature Maximum in ^{0} Celsius	35.15
2	Average monthly temperature Minimum in ^{0} Celsius	24.83
3	Average mean temperature in ^{0} Celsius	29.99
4	Average relative humidity in %	73.06
5	Average wind velocity in km/hour	37.70
6	Average Sunshine hours / day	5.50
7	Average Pan Evaporation in mm/month	86.04

3.8.1 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 Pudukkottai station is 42.11^0 Celsius (May-2019), 18.58^0 Celsius (Jan-2018)

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

3.8.2 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 monthly average relative humidity of the Pudukkottai station varies from 85.07 to 62.76 and tabulated in **Appendix-3.4.3**

3.8.3 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 Pudukkottai station varies from 6.16 km/hr to 0.09 km/hr and tabulated in **Appendix 3.4.4**

3.8.4. Sunshine

The monthly average sunshine hours of the Pudukkottai station varies from 9.18hrs/day to 0.11hrs/day are tabulated and given in Appendix **3.4.5**

3.8.5 Evaporation

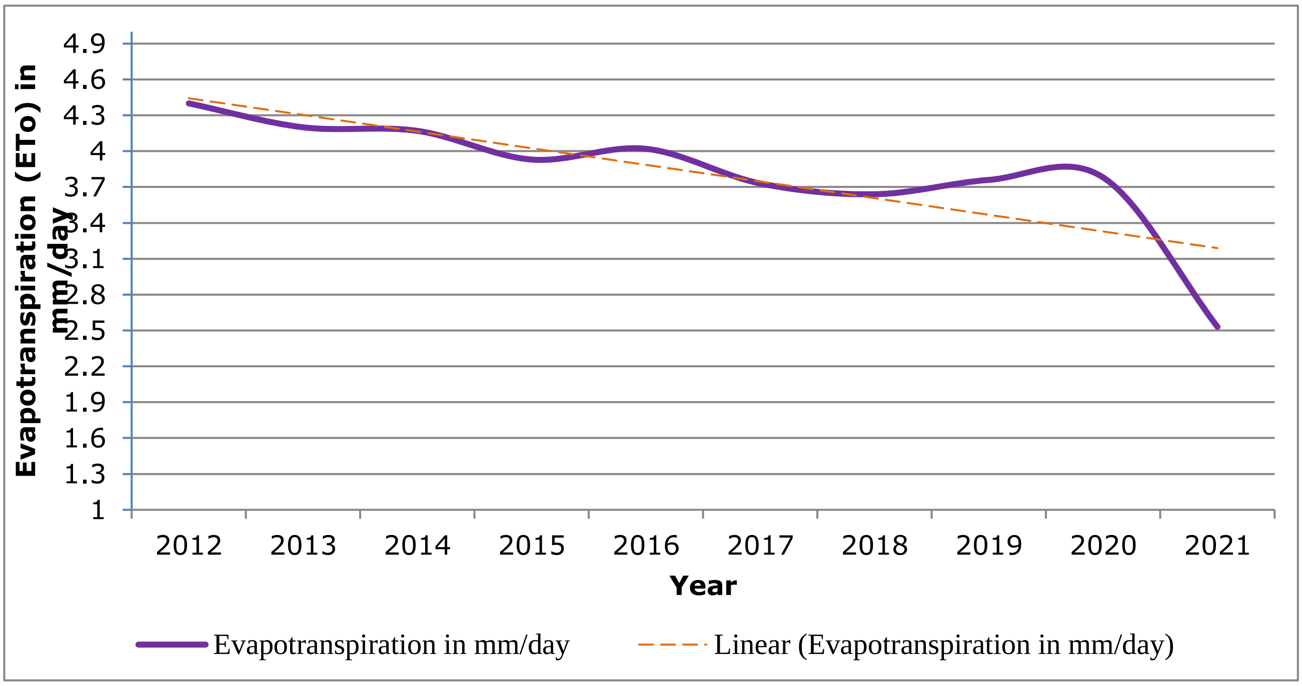
Evaporation is an essential part of the water cycle. The sun (solar energy) drives evaporation of water from oceans, lakes, moisture in the soil, and other sources of water. The estimation of evaporation in water body and transpiration from crop are important parameters to find out the crop water requirement 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.**

3.9 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 Pudukkottai weather station is estimated using Penman Montieth Method. The estimated values for this basin are given in **Appendix 3.4.7**. The Annual PET for Pudukkottai weather station is arrived as 1391.80 mm. The PET for 9 years (2012 to 2021) of daily average for each year for Pudukkottai weather station is shown in **Fig 3.6** .The trend line for 9 years data of Potential Evapotranspiration is decreasing.

Fig.3.6 Evapotranspiration of weather Station in Pudukkottai



The results of Annual Rainfall, Rainy Days, Maximum Temperature, and Minimum Temperature of Pudukottai Weather station are given in **fig 3.7.1 to 3.7.4**

The climatic change in Agniyar river Basin,over 10years (2012-2021) based on the weather station in Pudukkottai is summarised below:

- The trend of annual rainfall is increasing.
- The trend of number of rainy days shows increasing trend
- There is a slight decrease in summer and winter maximum temperature trend.
- There is a reasonable increase in summer and winter minimum temperature trend.

Fig 3.7.1 Annual Rainfall of Pudukkottai Weather Station – Agniyar (2012 – 2021)

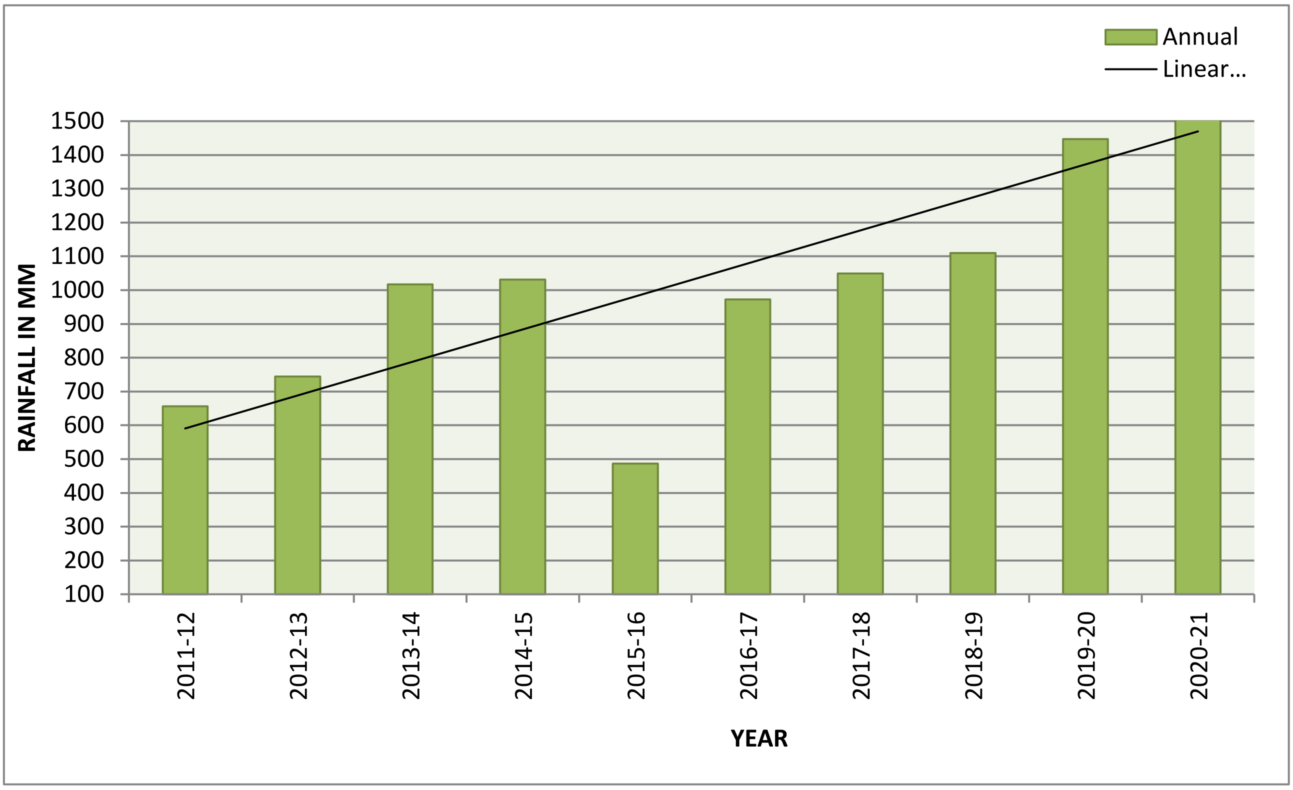


Fig 3.7.2 Rainy Days of Pudukkottai Weather Station – Agniyar (2012 – 2021)

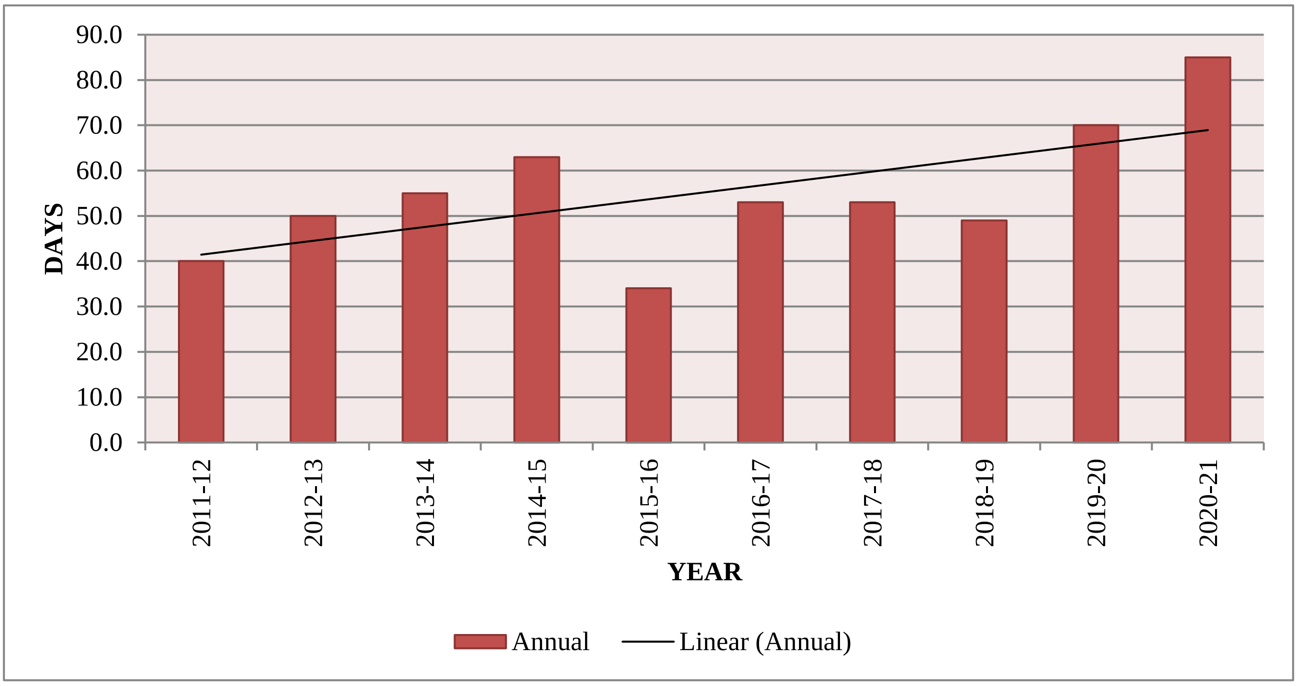


Fig 3.7.3 Maximum temperature of Pudukkottai Weather Station – Agniyar (2012 – 2021)

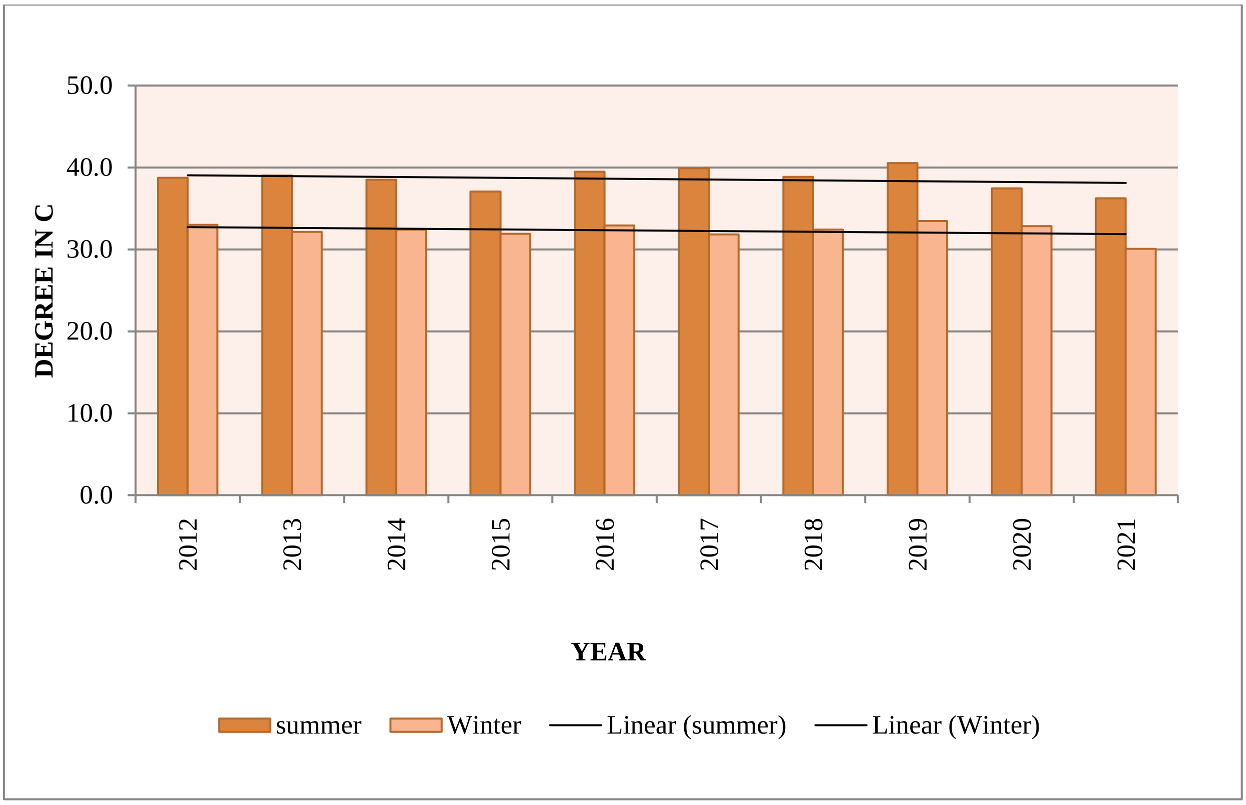
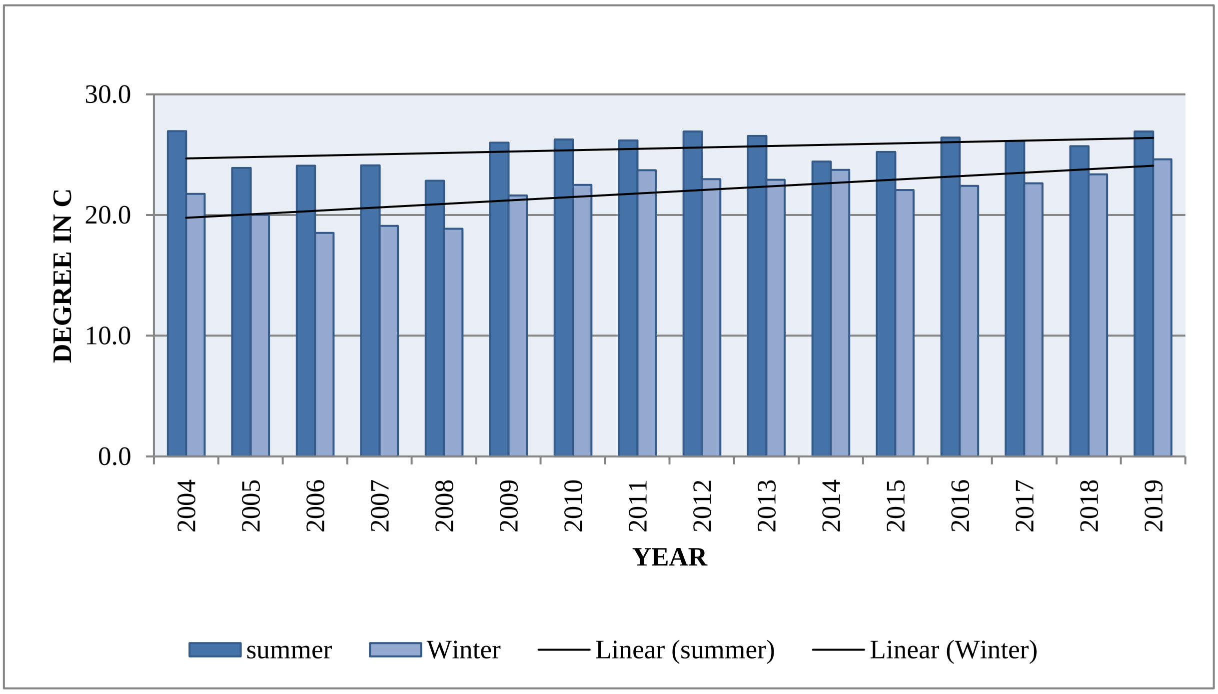


Fig 3.7.4 Minimum Temperature of Pudukkottai Weather Station – Agniyar (2012 – 2021)



3.10 Climatic Classification

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

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

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

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

The classification climate according to Moisture Index is given in**Table 3.15**

Table 3.15 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 Pudukkottai (1391.80 mm/year) weather Station is adopted for calculating moisture Index. The Moisture index (Im) and Climatic Classification for all the 20 rain gauge stations and for all the sub basins has been worked out in **Table 3.16 and 3.17** respectively.

Table 3.16 - 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	Alangudi	852.92	1392	538.9	0.0	38.7	-38.7	Semi-arid
2	Gandrvakotai	885.19	1392	506.6	0.0	36.4	-36.4	Semi-arid
3	Keeranur	896.44	1392	495.4	0.0	35.6	-35.6	Semi-arid
4	Kudminmli_AD	955.64	1392	436.2	0.0	31.3	-31.3	Dry Sub-humid
5	Kurungulam	954.35	1392	437.5	0.0	31.4	-31.4	Dry Sub-humid
6	Iluppur	847.03	1392	544.8	0.0	39.1	-39.1	Semi-arid
7	Malaiyur	688.88	1392	702.9	0.0	50.5	-50.5	Semi-arid
8	Madhukkur	1011.17	1392	380.6	0.0	27.3	-27.3	Dry Sub-humid
9	Pattukottai	1107.05	1392	284.8	0.0	20.5	-20.5	Dry Sub-humid
10	Peravoorani	985.10	1392	406.7	0.0	29.2	-29.2	Dry Sub-humid
11	Perungalur	937.73	1392	454.1	0.0	32.6	-32.6	Dry Sub-humid
12	Thanjavur	981.70	1392	410.1	0.0	29.5	-29.5	Dry Sub-humid
13	Aranthangi	1050.75	1392	341.1	0.0	24.5	-24.5	Dry Sub-humid
14	Arimalam	892.55	1392	499.3	0.0	35.9	-35.9	Semi-arid
15	Avudaiarkoil	938.43	1392	453.4	0.0	32.6	-32.6	Dry Sub-humid
16	Manapparai	812.23	1392	579.6	0.0	41.6	-41.6	Semi-arid
17	Mimisal	971.72	1392	420.1	0.0	30.2	-30.2	Dry Sub-humid
18	Natham_FOR	1075.04	1392	316.8	0.0	22.8	-22.8	Dry Sub-humid
19	Singampunari	824.14	1392	567.7	0.0	40.8	-40.8	Semi-arid
20	Thirumayam	1022.16	1392	369.6	0.0	26.6	-26.6	Dry Sub-humid

Table 3.17 - 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	Agniyar	934.9	1392	460.8	0.0	33.1	-33.1	Dry Sub-humid
2	Ambuliyar	954.3	1392	437.6	0.0	31.4	-31.4	Dry Sub-humid
3	South Vellar	922.4	1392	469.5	0.0	33.7	-33.7	Semi-arid

3.11 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

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

Where Pi is the annual rainfall in the year i and $\bar{P}$ 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 3.18**

Table-3.18 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 3.19**. It is observed from the **Table 3.19** 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 3.19 - Abstract of Drought Assessment (From 2001-02 to 2019-20)

Sl.No	STATION CODE	M0	M1	M2	M3
1	Alangudi	10	3	2	0
2	Gandrvakotai	5	4	6	0
3	Keeranur	6	4	4	1
4	Kudminmli_AD	6	5	4	0
5	Kurungulam	9	3	2	1
6	Iluppur	5	7	2	1
7	Malaiyur	8	4	2	1
8	Madhukkur	8	5	2	0
9	Pattukottai	6	6	3	0
10	Peravoorani	7	3	4	1
11	Perungalur	6	6	3	0
12	Thanjavur	7	4	4	0
13	Aranthangi	7	7	1	0
14	Arimalam	3	4	8	0
15	Avudaiarkoil	4	7	4	0
16	Manapparai	3	4	4	4
17	Mimisal	5	5	4	1
18	Natham_FOR	7	2	6	0
19	Singampunari	8	4	3	0
20	Thirumayam	5	8	2	0

3.12 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 Agniyar 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, Agniyar basin receives more rainfall in North East monsoon than South West monsoon. On viewing the climatic pattern, it is observed that there is increase in number of rainy days, further, trend line of annual rainfall shows inclination, a slight decrease in summer and winter maximum temperature trend, a reasonable increase in summer and in winter minimum temperature trend.

CHAPTER 4

IRRIGATION AND AGRICULTURE

CHAPTER – 4

IRRIGATION AND AGRICULTURE

4.1 Introduction

Tamil Nadu is classified under semi-dry sub-humid to dry humid tropics in the geographical system. It is the 11th largest State in India (with an area of 1.30 lakh Sq.km) and the seventh most populous State (7,21,47,000 according to the 2011 census). It comprises four percent of the total area, six percent of the population and three percent of the water resources at all India level.

93% of total land holdings are Marginal and Small farmers, operating 62% of the total cultivable lands. Remaining seven percent of land holdings are medium and large farmers operating 38% of the total culturable lands. Although the average land area of India is 1.08 Ha, the average land area of Tamil Nadu is only 0.75 hectare.

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 26.72 lakh hectares as per the season and crop report 2019-20. About 56.4% of the net area sown is benefitted by irrigation. The total Gross Irrigated area of Agniyar Basin is 1,99,603 Ha as per the Season and Crop report of 2019-20. The main crops cultivated in Agniyar Basin are Paddy, Coconut, Groundnut, Black Gram, Sugarcane, Fruits & Vegetables and Gingelly.

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 soils found in the Districts covering Agniyar Basin are as follows:

The soil types found in the Pudukkottai District are Black soil, Red soil and Alluvial soil. Alluvial soils consisting of blackish and brownish sandy and silty soils are observed in Agniyar river basin. The soil types found in the Thanjavur District are Clayey soils, Sandy soils and Mixed soils. In Sivagangai District the major soil types are Red soil, Laterite soil, Alluvial soil and Black cotton soil. The major soil types encountered in Tiruchirapalli District are Black cotton soils, Red sandy to loamy soils and Alluvial soils. In Dindigul District major soil types found are Red soil, Red sandy soil and Black cotton soil.

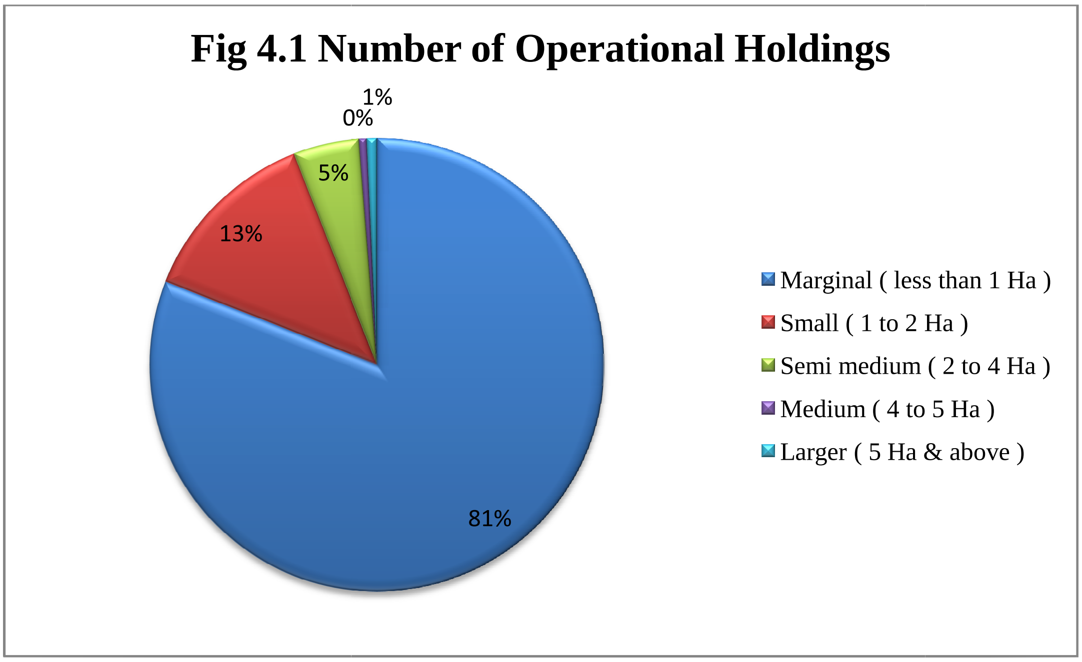
4.2 Land Holdings

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 2015-16, the State had 79.38 lakhs holdings with an operating area of 59.70 lakh Ha. The category of agriculturists / farmers in Agniyar Basin on the land holding size is given in Table 4.1. Marginal farmers account for 82.81%, Small farmers - 11.71%, Semi medium farmers - 4.27%, Medium farmers - 1.07% and Large Farmers - 0.14% in Agniyar Basin. (Source: Agriculture census 2015-16, Blockwise Number of Operational Holding and Area in Ha).Fig 4.1 explains the different category of farmers in Agniyar Basin.

Table -4.1 Sub Basin wise Number of Operational Holding

Social Group	Agniyar	Ambuliyar	South Vellar	Total	Total in %
Marginal (< 1 Ha)	118667	44396	61619	224682	82.81
Small (1 to 1.99 Ha)	16704	5240	9818	31762	11.71
Semi medium (2 to 3.99 Ha)	6563	1651	3379	11592	4.27
Medium (4 to 9.99 Ha)	1770	348	795	2914	1.07
Larger (>10 Ha)	221	47	108	376	0.14
Total	**143924**	**51682**	**75719**	**271325**	**100.00**



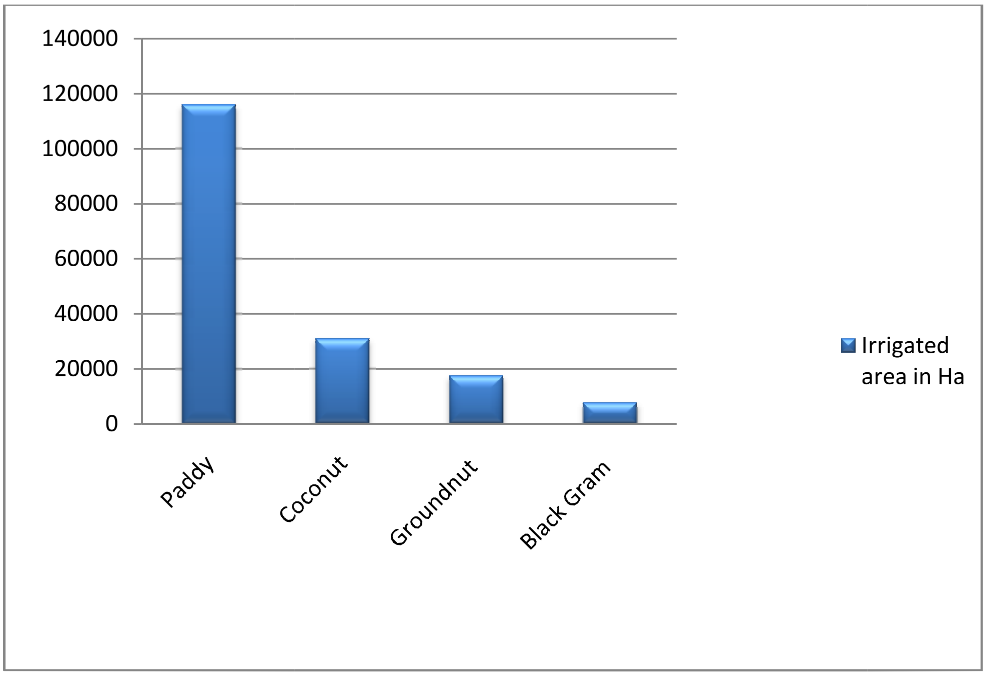
4.3 Irrigation Water Demand Calculation

Major crops and Irrigated area

Irrigated area details for various crops were collected from the Agricultural Department. Irrigated area data for the year 2020-21 was taken for computing Irrigation water demand. The block wise crop area cultivated during 2020-21 was transformed into sub basin area by its block area proportion. Present Sub basin wise irrigated area of crops in Agniyar 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 2020-21, gross irrigated area in the basin under different crops is 1,86,422 Ha. Under irrigated conditions, Paddy (1,16,057 Ha) is the main crop in this basin, followed by Coconut (31,023 Ha), Groundnut (17,533 Ha) and Blackgram (7,731 Ha). Irrigated area of major crops is given in **Fig 4.2.**

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



The total irrigated area in Agniyar Sub Basin is 1,03,698 Ha which accounts for 56% of basin area, Ambuliyar Sub Basin is 38,196 Ha which occupies 20% and South Vellar Sub Basin is 44,282 Ha which occupies 24% of the total Basin area.

Figure 4.3 Sub basin wise Irrigated area of crops in Agniyar Basin

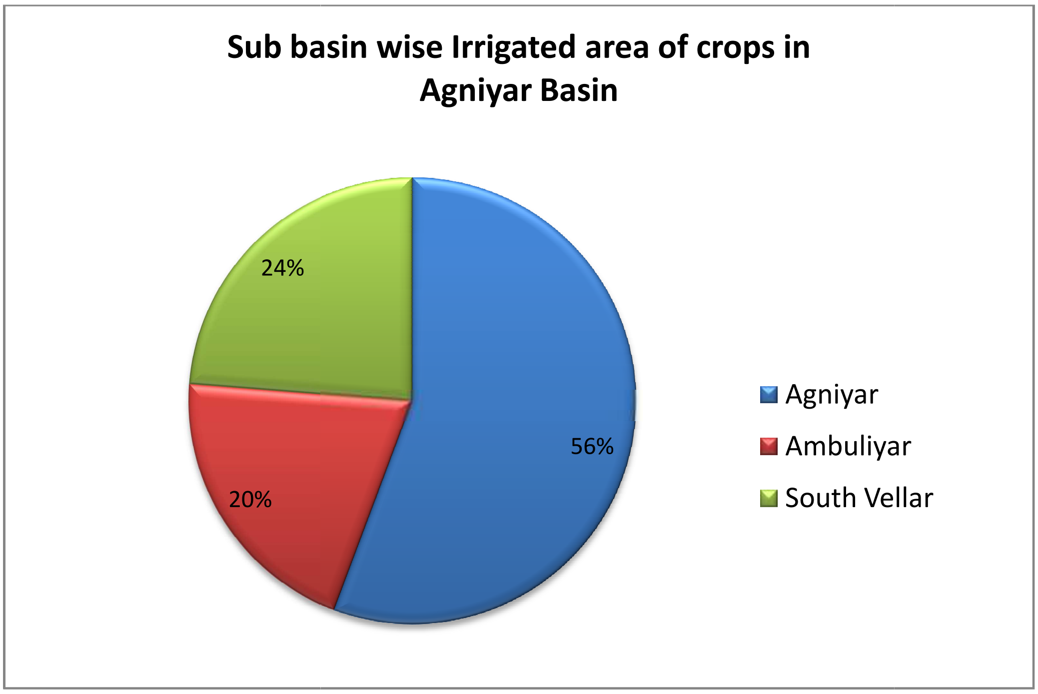
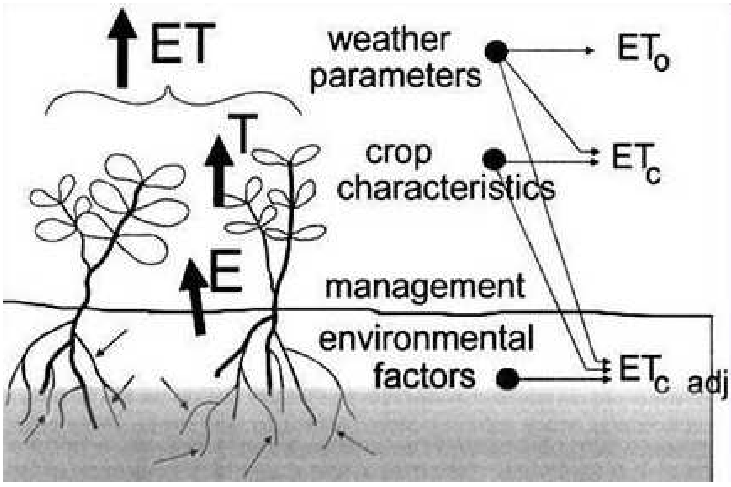


Table 4.2
Sub Basinwise Irrigated Area (Ha) of different crops in Agniyar Basin

Crop	Agniyar	Ambuliyar	South Vellar	Total
Coconut – Per - Jan	14510	11496	5017	**31023**
Paddy I - June	47847	15405	23791	**87043**
Paddy II - Oct	15949	5135	7930	**29014**
Cholam - Aug	0	0	70	**70**
Cumbu - Mar	2	3	4	**9**
Ragi - July	21	3	55	**79**
Maize - May	1409	408	263	**2080**
Red Gram - June	204	5	75	**283**
Black Gram - June	6325	652	755	**7731**
Green Gram - June	88	0	0	**88**
Other Cereals - July	0	0	0	**0**
Chillies - Feb	65	652	315	**1032**
Onion-Apr	0	0	0	**0**
Fodder - Mar	0	5	0	**5**
Condiments -Sep	0	0	0	**0**
Sugarcane - Jan	1024	246	289	**1313**
Banana - Apr	1419	411	346	**2176**
Groundnut - Nov	10998	3135	3400	**17533**
Cotton - Jan	17	1	15	**33**
Gingelly - Feb	1857	614	203	**2674**
Fruits & Vegetables - July	1856	193	1381	**3430**
Flowers - Per - June	107	80	372	**559**
Turmeric - Sep	0	0	0	**0**
Total	**103698**	**38446**	**44282**	**186422**

4.4 Crop Water Requirement

Crop water requirement (CWR) is defined as the depth of water [mm] needed to meet the water consumed through evapotranspiration ETc, 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 two 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 Pudukkottai station as discussed in section 3.9 of 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:

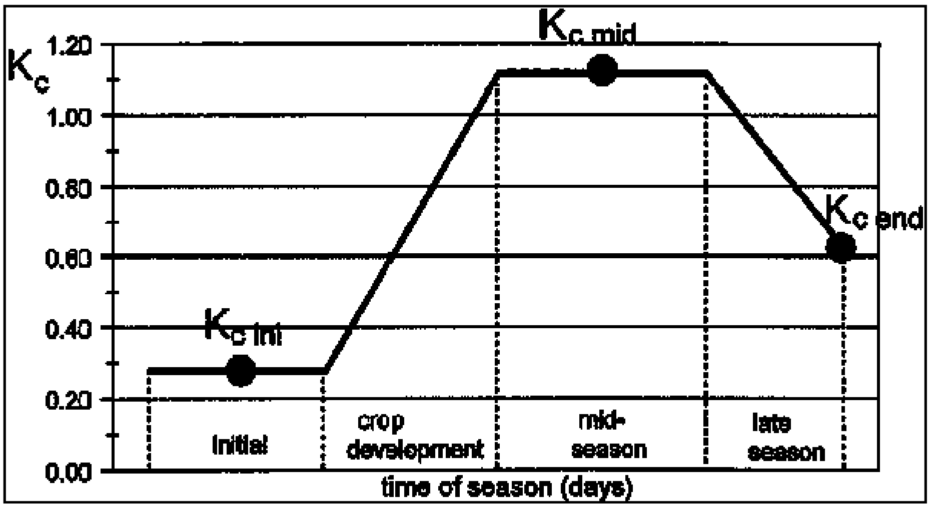
(i) The initial stage (from sowing to about 10% ground cover),

(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, 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 for 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 Agniyar Basin are given in **Table 4.3 & Table 4.4.**

4.5 Basin Net Irrigation Water Demand – Present situation

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

The monthly crop irrigation requirements as discussed above were applied to the crop area of the 3 sub basins for the two 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 Agniyar Basin is given in **Vol-II Appendix 4.8, 4.9, 4.10 and 4.11.** On the same line, Irrigation water demand for 50% and 75% dependable rainfall of the three sub basins were calculated and given in **Tables 4.5 and 4.6** respectively.

Figure 4.5 Methodology for calculating Irrigation Demand – Agniyar River Basin

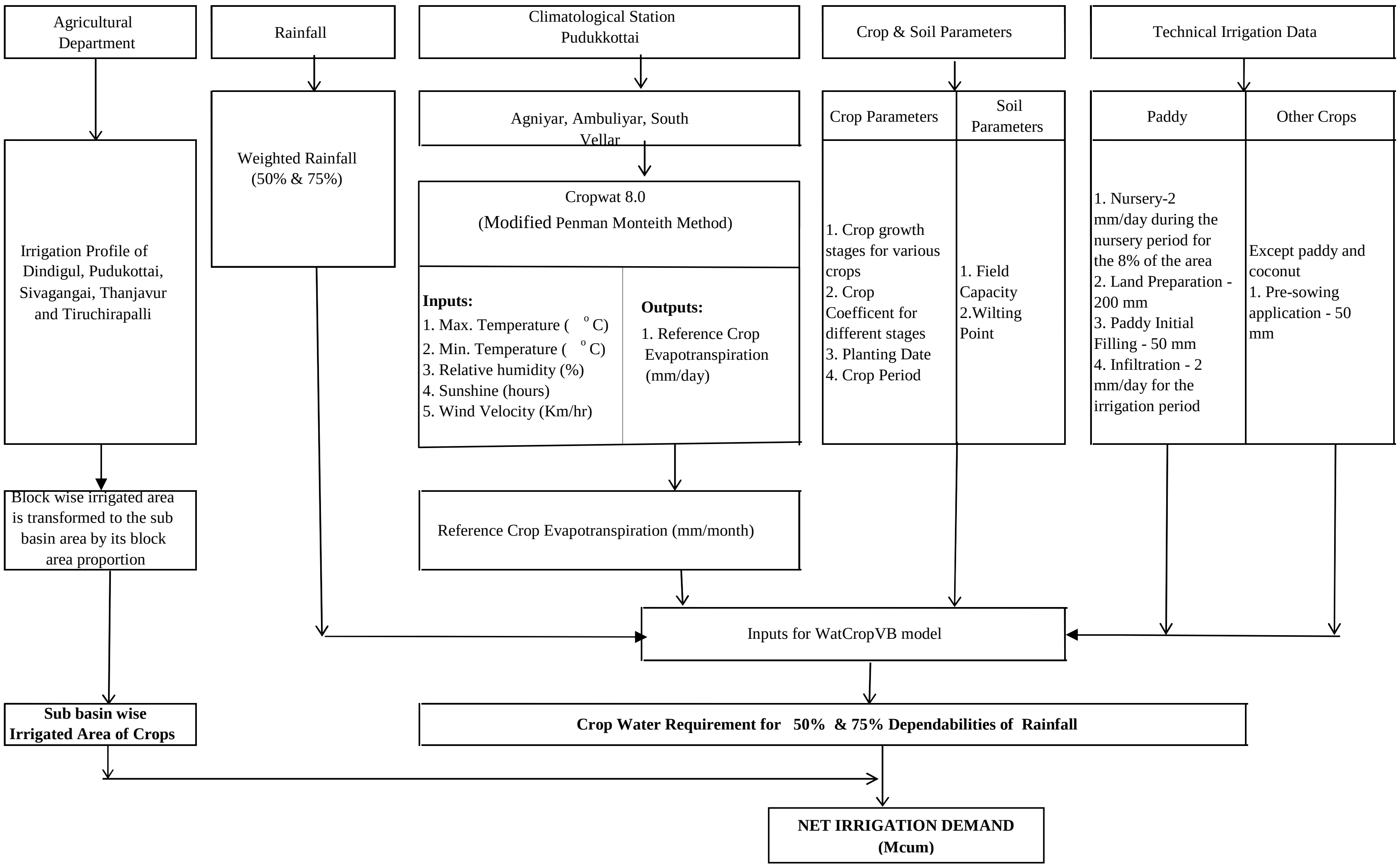


Table 4.3 Crop Parameters in Agniyar Basin

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 Agniyar 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 Agniyar Basin

Sl. No	Sub Basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	Agniyar	26.25	12.38	21.50	34.85	48.68	251.03	93.58	106.13	25.84	45.91	17.54	27.06	**710.74**
2	Ambuliyar	11.43	7.95	12.63	3.83	24.24	76.93	37.11	24.96	8.32	14.78	5.65	8.65	**236.48**
3	South Vellar	12.44	0.00	8.33	12.01	1.89	106.03	54.42	52.44	35.75	22.83	8.72	17.40	**332.27**
	TOTAL	**50.12**	**20.32**	**42.47**	**50.69**	**74.81**	**433.99**	**185.10**	**183.53**	**69.91**	**83.52**	**31.92**	**53.10**	**1279.49**

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

Sl. No	Sub Basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	Agniyar	9.81	10.65	21.59	35.11	47.97	205.18	128.68	116.77	27.04	45.91	17.54	36.16	**702.42**
2	Ambuliyar	12.74	7.93	10.42	12.18	16.24	91.19	17.46	24.96	38.86	14.78	5.65	21.15	**273.59**
3	South Vellar	12.35	5.59	8.44	10.71	15.51	117.89	27.35	69.91	12.85	22.83	8.72	13.16	**325.31**
	TOTAL	**34.92**	**24.21**	**40.44**	**58.00**	**79.72**	**414.26**	**173.49**	**211.64**	**78.75**	**83.52**	**31.92**	**70.47**	**1301.32**

The above table 4.6 shows the water requirement for the total crop cultivated during 2020-2021.

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 Agniyar Basin nearly 62% of the paddy area is raised only under irrigated condition. Considering this fact, the lower limit for the future irrigation demand is determined taking into consideration the cultivation of Paddy using SRI (System of Rice Intensification) 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 Agniyar 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 Agniyar Basin is listed in **Table 4.10.**

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

Crop	Agniyar	Ambuliyar	South Vellar	Total
Coconut- Per - Jan	14510	11496	5017	**31023**
Paddy I - June	14354	4622	7137	**26113**
SRI Paddy I - June	33493	10784	16653	**60930**
Paddy II - Oct	4785	1541	2379	**8704**
SRI Paddy II - Oct	11164	3595	5551	**20310**
Cholam - Feb	0	0	70	**70**
Cumbu - Mar	2	3	4	**9**
Ragi– Jan	21	3	55	**79**
Maize - Jul	1409	408	263	**2080**
Red Gram - June	204	5	75	**283**
Black Gram - Jan	6325	652	755	**7731**
Green Gram - Jan	88	0	0	**88**
Other Cereals - July	0	0	0	**0**
Chillies - Jan	65	652	315	**1032**
Onion-June	0	0	0	**0**
Fodder - Mar	0	5	0	**5**
Condiments -Sep	0	0	0	**0**
Sugarcane - Dec	1024	246	289	**1559**
Banana - Dec	1419	411	346	**2176**
Groundnut - Dec	10998	3135	3400	**17533**
Cotton - Feb	17	1	15	**33**
Gingelly - Feb	1857	614	203	**2674**
Fruits & Vegetables - June	1856	193	1381	**3430**
Flowers - Per - June	107	80	372	**559**
Turmeric - June	0	0	0	**0**
TOTAL	**103698**	**38196**	**44282**	**186422**

Lower Limit Scenerio

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

Sl.No	Sub Basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	Agniyar	21.71	11.43	20.22	33.25	46.88	189.78	71.66	76.17	18.60	33.06	12.63	19.31	**554.70**
2	Ambuliyar	9.82	7.24	11.59	3.23	23.36	59.03	30.59	17.97	5.99	10.64	4.07	6.32	**189.85**
3	South Vellar	10.07	0.00	7.60	11.09	1.89	78.45	41.80	38.03	27.66	16.44	6.28	12.68	**251.98**
	TOTAL	**41.60**	**18.67**	**39.40**	**47.58**	**72.13**	**327.25**	**144.05**	**132.17**	**52.26**	**60.13**	**22.98**	**38.31**	**996.53**

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

Sl.No	Sub Basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	Agniyar	8.26	9.47	20.20	33.48	46.20	151.60	100.58	85.61	18.60	33.06	12.63	26.14	**545.84**
2	Ambuliyar	11.01	7.26	9.49	11.38	15.53	71.42	13.06	17.97	32.30	10.64	4.07	17.73	**221.85**
3	South Vellar	10.01	5.00	7.60	9.85	14.61	87.84	20.18	52.20	9.25	16.44	6.28	9.42	**248.68**
4	TOTAL	**29.28**	**21.74**	**37.29**	**54.71**	**76.34**	**310.87**	**133.81**	**155.78**	**60.15**	**60.13**	**22.98**	**53.29**	**1016.37**

Table – 4.10 Net Irrigation Water Demand at 75 % Dependable Rainfall in Agniyar Basin

Sl. No.	Sub Basin	Present Irrigation Demand (Mcm)	Lower Limit Irrigation Demand (Mcm)	% of Savings in Demand
1	Agniyar	702.42	545.84	22.29
2	Ambuliyar	271.22	219.48	19.08
3	South Vellar	325.31	248.68	23.56
	Total	**1298.95**	**1014.00**	**21.94**

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 are predominantly of paddy, coconut, groundnut, blackgram 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 Agniyar basin and its crop water requirement is presented in the **Table 4.11**.

Fig 4.6 Irrigated area of various crops for the past 4 years

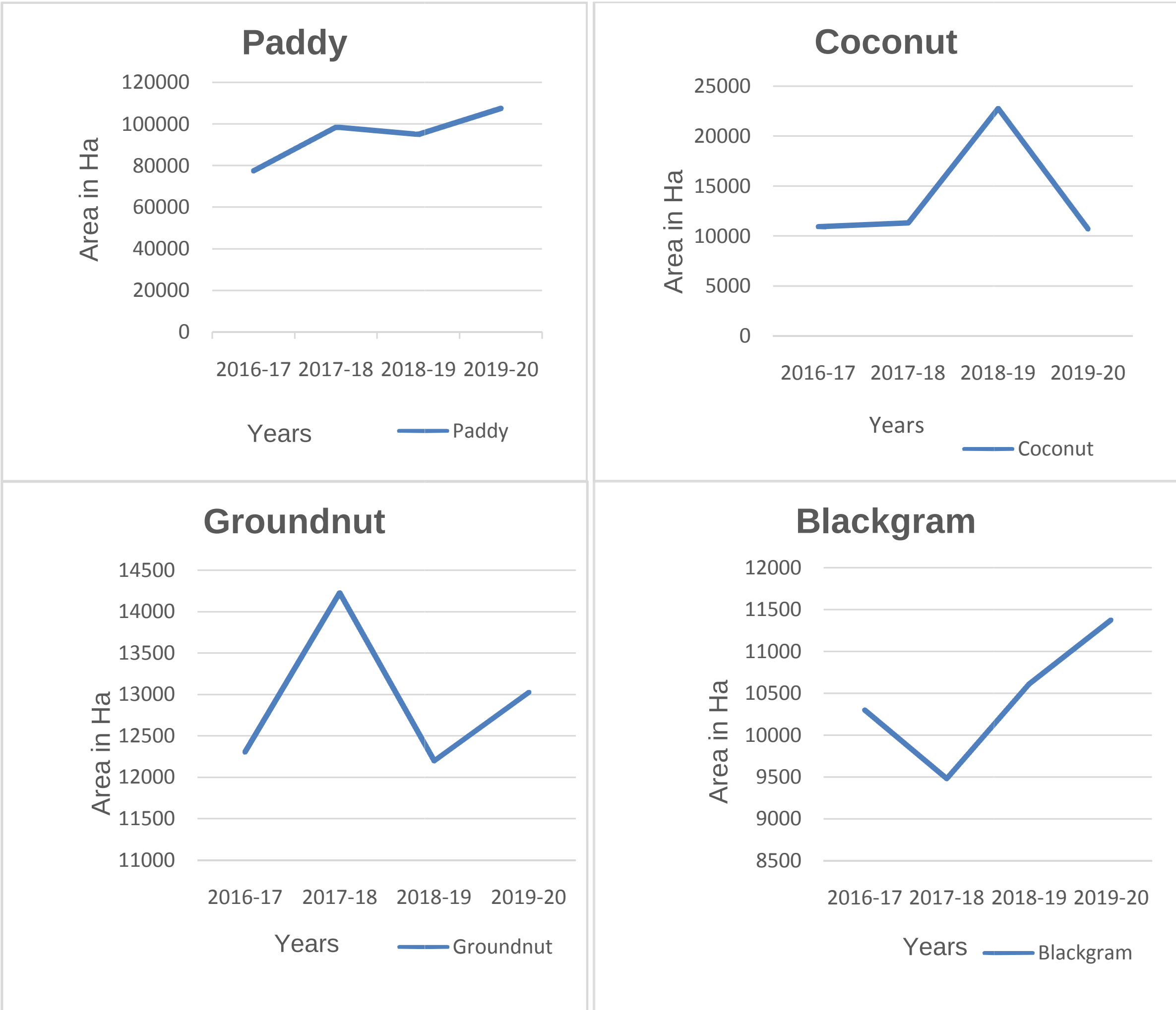


Table 4.11 Irrigated area (in Ha) of four major crops grown in the Agniyar basin and its crop water requirement

Paddy				
Year	Crop area in Ha	Crop water reqd. in MCM	Yield rate Kg/Ha	Production in thous. Qtl
2016-17	77439	639.02	1918	1485.39
2017-18	98530	813.01	3121	3075.34
2018-19	94946	783.72	3458	3283.60
2019-20	107461	929.16	3745	4024.21

Coconut				
Year	Crop area in Ha	Crop water reqd. in MCM	Yield rate Kg/Ha	Production in thous. Qtl
2016-17	31161	180.86	15016	467.92
2017-18	31775	162.08	14023	445.57
2018-19	22766	127.78	13473	306.71
2019-20	10718	135.63	10751	115.22

Groundnut				
Year	Crop area in Ha	Crop water reqd. in MCM	Yield rate Kg/Ha	Production in thous. Qtl
2016-17	12306	40.19	1986	244.43
2017-18	14225	46.57	3617	514.54
2018-19	12198	40.00	3305	403.16
2019-20	13026	50.64	3896	507.46

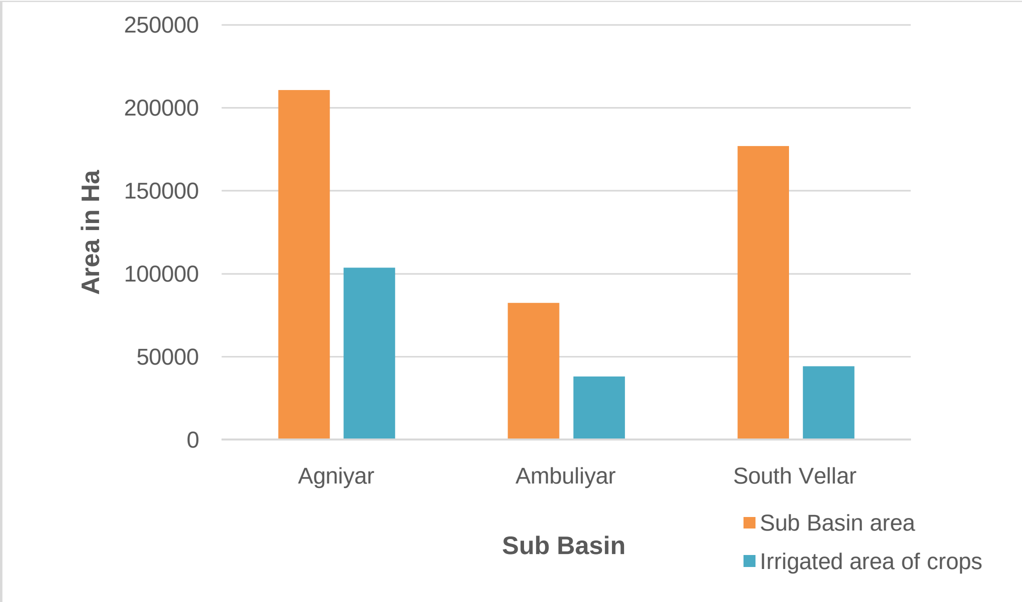
Blackgram				
Year	Crop area in Ha	Crop water reqd. in MCM	Yield rate Kg/Ha	Production in thous. Qtl
2016-17	10299	29.61	636	65.55
2017-18	9481	27.46	909	86.14
2018-19	10609	30.39	743	78.85
2019-20	11374	22.96	951	108.22

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 2016-17, 2017-18, 2018-19, 2019-20. Yield rate for the crops may vary with the type of agriculture practices adopted by the farmers.

Existing & Suggested Cropping Pattern in Agniyar Basin

The major crops cultivated in Agniyar Basin are Paddy, Coconut, Groundnut and Blackgram. The irrigated area for the year 2020-21 in Agniyar Basin under different crops is 1,86,176 Ha. Paddy is cultivated in 1,16,057 Ha, 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 three sub basins of Agniyar basin is presented in **Fig 4.7.**

Figure 4.7 Sub basin area vs Irrigated area of crops in Agniyar Basin



The distribution of rainfall 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 Agniyar Basin

Sl.No.	District	Block	Existing cropping pattern during normal rainfall year	Suggested cropping pattern during poor rainfall year
I	Dindigul	Nattam	Paddy – Pulses Paddy – Cholam Cholam - Pulses	Pulses Cholam Cholam - Pulses
II	Pudukkottai	Annavasal	Paddy-Groundnut Redgram – Groundnut / Blackgram	Kudhiraivali / Ragi – Groundnut Redgram + Groundnut
		Aranthangi	Paddy-Groundnut Paddy – Blackgram	Blackgram – Groundnut / Gingelly
		Arimalam	Paddy - Paddy – Blackgram / Groundnut	Blackgram – Groundnut / Gingelly
		Avudayarkovil	Paddy - Gingelly	Gingelly
		Gandarvakottai	Maize – Paddy - Blackgram / Groundnut Paddy - Paddy – Blackgram / Groundnut Sugarcane - Blackgram	Millets, Pulses and Oil seeds
		Karambakkudi	Paddy - Paddy – Paddy Paddy - Paddy – Blackgram / Groundnut	Paddy – Blackgram / Groundnut
		Kunnandarkovil	Maize – Paddy - Blackgram / Groundnut Redgram – Groundnut / Blackgram	Kudhiraivali / Ragi – Groundnut / Blackgram
		Manamelkudi	Paddy - Gingelly	Gingelly
		Ponnamaravati	Paddy – Cowbea / Mochai Paddy - Groundnut	Cowpea - Groundnut
		Pudukkottai	Maize – Paddy - Blackgram / Groundnut Paddy - Paddy – Blackgram / Groundnut	Paddy – Blackgram / Groundnut
		Tirumayam	Paddy - Paddy – Blackgram / Groundnut	Blackgram - Groundnut

Sl.No.	District	Block	Existing cropping pattern during normal rainfall year	Suggested cropping pattern during poor rainfall year
II	Pudukkottai	Tiruvarangulam	Paddy - Paddy – Blackgram / Groundnut Maize – Paddy - Blackgram / Groundnut	Paddy – Blackgram / Groundnut
		Viralimalai	Ragi / sorghum – Paddy - Blackgram	Ragi / sorghum – Blackgram - Groundnut
III	Sivagangai	Semmampattipudur	Blackgram – Groundnut Paddy – Pulses Gingelly – Cotton – Pulses Paddy – Pulses	Paddy – Pulses
		Tiruppattur	Blackgram – Groundnut Paddy – Pulses Gingelly – Cotton – Pulses Paddy – Pulses	Paddy – Pulses
IV	Thanjavur	Madukkur	Fallow – Paddy - Blackgram	Blackgram – Groundnut Blackgram - Gingelly
		Orattanadu	Paddy - Paddy – Blackgram Paddy - Paddy – Maize	Paddy - Paddy – Blackgram
		Pattukottai	Fallow – Paddy - Blackgram	Blackgram – Groundnut Blackgram - Gingelly
		Peravurani	Fallow – Paddy - Blackgram	Blackgram – Groundnut Blackgram - Gingelly
		Sethubavachatram	Fallow – Paddy - Blackgram	Blackgram – Groundnut Blackgram - Gingelly
		Thanjavur	Paddy - Paddy – Blackgram Paddy - Paddy – Maize	Paddy - Paddy – Blackgram
		Tiruvonam	Paddy - Paddy – Blackgram Paddy - Paddy – Maize	Paddy - Paddy – Blackgram

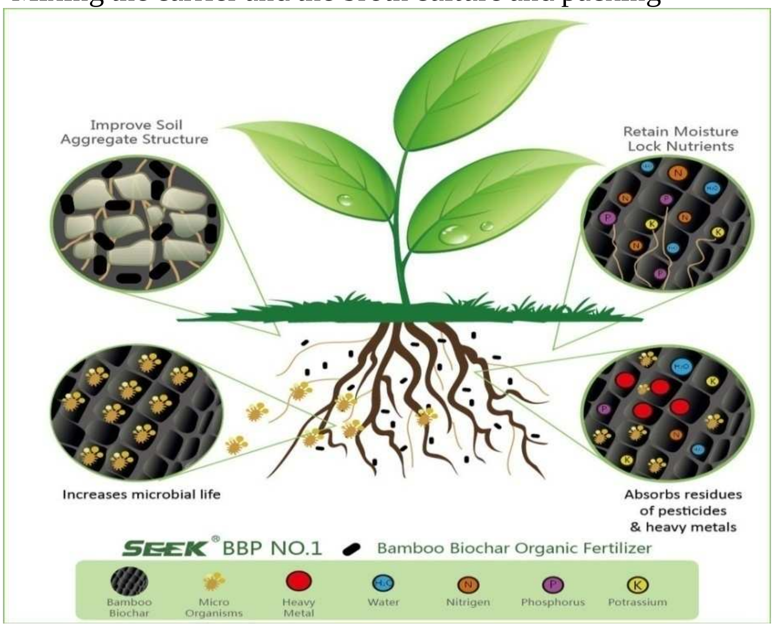
Sl.No.	District	Block	Existing cropping pattern during normal rainfall year	Suggested cropping pattern during poor rainfall year
V	Tiruchirapal li	Manaparai	Cholam – Pulses Groundnut – Pulses Paddy – Cumbu / Ragi, Pulses Groundnut – Pulses / Cumbu	Cholam – Pulses, Pulses Cumbu / Ragi, Pulses Groundnut – Pulses / Cumbu
		Marungapuri	Cholam – Pulses Groundnut – Pulses Paddy – Cumbu / Ragi, Pulses Groundnut – Pulses / Cumbu	Cholam – Pulses, Pulses Cumbu / Ragi, Pulses

4.8 Biofertilizers

Biofertilizers are defined as preparations containing living cells or latent cells of efficient strains of micro-organisms that help crops to 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: Organic 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 upto 20% and replaces chemical nitrogen and phosphorus by 25%.
- They stimulate plant growth.
- They activate 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 Ha for the year 2020-21 for the blocks in Agniyar Basin 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
Annavasal	4	10.534	0	10.534	2106
Madukkur	-	-	5.666	5.666	4722
Manaparai	-	-	5.05	5.05	1010
Marungapuri	-	-	5.03	5.03	1006
Nattham	-	-	8.5	-	850
Oratthanadu	-	-	7.490	7.490	6242
Pattukkottai	-	-	7.438	7.438	6198
Peravurani	-	-	5.374	5.374	4478
Semmampattipudur	-	-	3.58	3.58	716
Sethubavachatram	-	-	6.723	6.723	5603
Thanjavur	-	-	6.754	6.754	5628
Tiruppattur	-	-	4.44	4.44	888
Tiruvonam	-	-	8.435	8.435	7029

(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 of plants. 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 N - 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 Vermicompost usage in the blocks covered in Agniyar Basin are tabulated in **Table 4.14.**

Table 4.14 - Details of blocks where vermicompost utilized in Agniyar Basin

Sl. No.	Block	Vermi compost	
		No. of units for which subsidy given	Vermi compost utilized – Area in Ha
1	Annavasal	0	0
2	Aranthangi	0	0
3	Arimalam	0	0
4	Avudayarkovil	0	0
5	Gandarvakottai	0	0
6	Karambakkudi	0	0
7	Kunnandarkovil	0	0
8	Madukkur	1	187
9	Manamelkudi	0	0
10	Manaparai	0	120
11	Marungapuri	0	180
12	Nattham	0	0
13	Oratthanadu	1	1125
14	Pattukkottai	1	125
15	Peravurani	1	95
16	Ponnamaravati	100	200
17	Pudukkottai	0	0
18	Semmampattipudur	50	100
19	Sethubavachatram	1	26
20	Thanjavur	1	856
21	Tirumayam	0	0

Sl. No.	Block	Vermi compost	
		No. of units for which subsidy given	Vermi compost utilized – Area in Ha
22	Tiruppattur	70	140
23	Tiruvarangulam	100	200
24	Tiruvonam	1	962
25	Viralimalai	0	0
	Total	**327**	**4316**

(**Source**: Agriculture Department)

4.10 Major Schemes covered in Agniyar Basin by Agricultural Department

Tamil Nadu Irrigated Agriculture Modernization Project (TNIAMP)

TNIAMP is a Multi Disciplinary Project funded by World Bank and implemented by the Government of Tamil Nadu. The main objective of the programme is to accelerate crop diversification from more water requiring crops to less water requiring high remunerative horticultural crops, through promotion of hi-tech cultivation technologies and water conservation technologies in the proposed sub basins.

In 2021-2022, this scheme is being implemented at an outlay of Rs.35.62 crore to take up crop demonstration in an area of 5,486 Ha, micro irrigation installation in an area of 2,073 Ha and model villages.During the year 2022-23, this scheme is proposed to be implemented at a total outlay of Rs.45.57 crore.

Pradhan Mantri Krishi Sinchayee Yojana 2.0 (WDC - PMKSY 2.0)

Tamil Nadu Watershed Development Agency has been designated as the Nodal Agency for this scheme. Watershed Development Component -Pradhan Mantri Krishi Sinchayee Yojana 2.0 (WDC - PMKSY 2.0) is a programme for the development of rainfed and degraded land. The objectives of the scheme are as follows.

Economy – Improving income of village community in the watershed areas by increasing the productivity of various crops through optimal, integrated, sustainable and efficient use of natural resources and managing sustainability.

Ecology – Harnessing, Conserving, developing natural resources (to restore ecological balance) by way of building community organizations and promoting simple, affordable technologies and practices.

Equity - Improving the social and economic conditions of the poor, landless, physically challenged and women through equitable access to land, water, resources developed and by involving them in various community institutions.

The Government of India has sanctioned 275 Watersheds under 27 Projects in Perambalur, Thoothukudi, Dindigul, Krishnagiri, Ramnad, Dharmapuri & Virudhunagar districts to cover an area of 1.3033 lakh ha at an outlay of Rs.286.73 crore for implementation from 2021-22 to 2025-26.

Project Activities:

The project activities are to be taken up in three phases over the period of five years.

Phase I - Preparatory Phase (Planning, Institution Development, Entry Point activities & Detailed Project Report Preparation) - six months to one year -6% of the Total Project Cost.

Phase II - Work Phase - Two to Three years with 79% of the total project cost for Natural Resource Management, Farm Production System and Livelihood Activities for the asset less persons, Micro Enterprises and Business Development.

Under Natural Resource Management, the development of natural resources like Farm Ponds, Percolation Ponds, Minor, Medium and Major Check dams, Village Ponds, Desilting of Oorani and Supply Channels, Gabion Check Dams, Recharge Shafts, Rejuvenation of Wells and Sunken Ponds are taken up.

Under the Production System, activities like Horticulture Plantation, Agro-forestry, Floriculture, Fodder Cultivation, Crop Demonstrations, Vermicompost preparation, Supply of Power Sprayers, Hand Sprayers, Battery Sprayers, Tarpaulin, Chaff Cutter, Fish culture in farm ponds, Distribution of goats/ sheep, beehives and Poultry rearing are taken up for the improvement of the economy of the village community in the watershed areas.

Under Livelihood Activities for asset less person, Micro Enterprises and Business Development components like Readymade cloth and Tailoring, Distribution of Dairy Cows, Backyard poultry farm, Preparation of Food products and Bakery, Petty Shop, Charcoal making, Catering and event management, Handicraft, Goat rearing, Distribution of goats/ sheep, Supply of tailoring machines, Iron Box, beehives, Idly/ Dosa Batter Grinding Mill are taken up, besides Revolving Fund is also provided SHGs with an aim to improve the socio-economic conditions of the village community of the watershed area.

Phase III - Consolidation and Withdrawal Phase - supervision & Estimation works -six months to one year - 5% of Project Cost.

Action Plan for 2021-22 has been approved for an outlay of Rs.71.68 crore. Based on the release from GoI, sanction was accorded for Rs.17.92 crore for 2021-22 and proposed to be utilized for Preparation of Detailed Project Report, Entry Point Activity, Capacity Building, Livelihood Support System for landless, Natural Resources Management, Production System and administrative Expenditure. This scheme will be continued with allocation of Rs.125.44 crore during 2022-23.

Expected Outcome:

i. Increase in average productivity of crops, livestock and other agricultural enterprises,
ii. A rise in cumulative output of all agricultural produce in the project area,
iii. Minimizing the risks and uncertainties in both production and marketing stages through diversified production system.
iv. Increase in the average income of the farmers and
v. Popularity of sustained production technologies & farm management practices among the farmers.

Some of the Agricultural Schemes

Sl.No	Schemes
1.	**Kalaignarin All Village Integrated Agricultural Development Programme (KAVIADP)**
	KAVIADP is being implemented in 1,997 Village Panchayat at an outlay of Rs.227.059 crore from 2021-22 with an objective of attaining overall agricultural development and self sufficiency of the village in a period of five years. During 2021-22, bore well, tube well points were identified and works are being carried out. In 2022-23, this scheme will be converged and implemented in 3,204 of "Anaithu Grama Anna Marumalarchi Thittam" village panchayats with a Project Cost of Rs.300 crore.
2.	**Chief Minister's Dry land Development Mission**
	It was implemented at a total outlay of Rs.146.64 crore during 2021-22 for the development of 7.5 lakh acre of dryland area and 3.15 lakh Small and Marginal Farmers have been benefitted. This scheme will be continued in 2022-23 under which 3,000 Dryland Clusters will be formed covering an area of 7.5 lakh acre with a financial outlay of Rs.132 crore

Sl.No	Schemes
3.	**Tamil Nadu Mission for Sustainable Green cover in Farm Lands**
	During 2021-22, a budget of Rs.11.14 crore has been allocated and 73 lakh tree saplings are being distributed at 100% subsidy to farmers of all districts with Central and State fund. During 2022-23, 80 lakh Tree saplings will be distributed at 100% subsidy to Farmers at a Project cost of Rs.12 crore.
4.	**Integrated Farming System (IFS) for Sustainable Income**
	This scheme is being implemented in National Mission for Sustainable Agriculture-RainfedArea Development (NMSA-RAD) and National Agriculture Development Programme (NADP). 50% subsidy or Rs.45,000/- as assistance is provided for the package comprising Crop cultivation, Milch cow, Buffalo, Goats, Sheep, Poultry Birds, Fruit seedlings, Fodder crop, Vermicompost production and Apiary Units. About 13,300 integrated farming clusters have been formed during the year 2021-22 at an allocation of Rs.59.85 crore. This scheme will be continued during the year 2022-23.
5.	**Encouraging Organic Farming**
	The farmers interested in Organic farming will be provided with Green Manure Seeds with a financial allocation of Rupees Three crore and 100 farmers groups interested in production and sale of Vermicompost, Amirthakaraisal will be provided with Rupees One lakh / group with total allocation of Rupees One crore during the year 2022-23.
6.	**Special Package for Bringing Fallow land into Cultivation**
	This special scheme with an objective to increase the cultivable area by bringing the lands remaining fallow for more than one year into cultivation has been implemented by cultivation of Millets, Pulses and Oilseeds in an area of 6,929 Ha, 6,347 Ha and 1,728 Ha respectively with financial allocation of Rs.20.57 crore during the year 2021-22. This scheme will be continued during the year 2022-23.

Sl.No	Schemes
7.	**Scheme for judicious use of irrigation water**
	Tamil Nadu Government is taking concerted efforts to boost farmers" income and to increase productivity of crops through efficient usage of water. To supplement this, Micro Irrigation scheme is being implemented in the State to bring more area under cultivation and enhance production by judicious use of water. Also, to encourage the farming community 100% subsidy is provided to Small/Marginal farmers and 75% for other farmers for installation of Micro Irrigation Systems. During 2022-23, it has been programmed to implement the scheme in an area of 1.00 lakh Ha for Horticulture and Agriculture crops with a financial outlay of Rs.960 crore to enhance the productivity and increase the income of the farmers besides conserving water.
8.	**Mission for Integrated Development of Horticulture - National Horticulture Mission (MIDH-NHM)**
	National Horticulture Mission is being implemented as a sub-scheme under Mission for Integrated Development of Horticulture from 2014-15 with a fund sharing pattern of 60:40 between the Centre and State. The scheme focuses on the development of Fruits, Vegetables, Flowers, Plantation crops, Spices and Aromatic crops. The scheme also promotes additional income to the farmers by providing training and assistance in mushroom cultivation, vermi-compost production, apiculture etc., For the year 2021-22, the scheme is being implemented at an outlay of Rs.125 crore. During the year 2022-23, it has been proposed to implement the scheme at a total financial outlay of Rs.340.31 crore.
9.	**National Agriculture Development Programme (NADP)**
	National Agriculture Development Programme is being implemented during 2021-22 at an outlay of Rs.61.05 crore. Organic cultivation of Vegetables is being promoted in an area of 40,000 Ha by providing incentives to the farmers. In order to maximize quality production and productivity of Pandal type fruit and Vegetable crops, assistance is being provided for the establishment of Permanent Pandal structures (which is quite expensive for a small/marginal farmer to afford) in an area of 638 Ha. Moreover, the cultivation of vegetables in zero vegetable villages was encouraged in area of 1,250 Ha. During the year 2022-23, it has been proposed to implement this scheme at an outlay of Rs.86.39 crore which includes promotion of Organic farming in Horticultural crops in an area of 41,000 Ha, crop diversification, Promotion of traditional vegetable cultivars, etc

Sl.No	Schemes
10.	**National Mission on Sustainable Agriculture (NMSA) - Rainfed Area Development (RAD)**
	Rainfed Area Development (RAD) is implemented with the objective to introduce appropriate farming systems, by integrating multiple components of Agriculture such as Horticulture, livestock, fishery, forestry with agro based income generating activities and value addition. During the year 2021-22, Rainfed Area Development is being implemented at a total outlay of Rs.16.24 crore in 23 Districts. Integrated Farming System units (4,400 Nos) comprising Horticulture based farming, Rearing of Milch cows and Goats, Vermi beds, Training and Demonstration were implemented under this scheme. During the year 2022-23, it has been proposed to implement this scheme at a total outlay of Rs.25.45 crore.
11.	**State Horticulture Development Scheme (SHDS)**
	State Horticulture Development Scheme is implemented for area expansion under horticulture crops with a special focus on non-NHM districts. Under Chief Minister's Nutritive Vegetable Garden Scheme, two lakh Vegetable seed kits, one lakh Terrace garden kits and two lakh Nutritive garden kits have been provided at 75% subsidy to the beneficiaries in all districts who had registered online. During 2021-22, the scheme was implemented at an outlay of Rs.41.53 crore and for the year 2022-23, the scheme will be implemented at an outlay of Rs.33.38 crore.
12.	**Pradhan Mantri Fasal Bima Yojana (PMFBY)**
	Under this scheme, farmers can insure the notified horticulture crops in notified Firkas. The farmers have to pay 5% of sum insured as premium rate for availing insurance of Horticultural Crops under PMFBY. During the year 2021-22, a total number of 1,38,466 farmers insured their notified horticulture crops in a total area of 42,603 Ha. During 2022-23, the scheme implementation will be continued.

(**Source**: Agriculture Department)

4.11 Water Saving Techniques in Crop Production

For some of the major crops grown in Agniyar 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 highincome. The methodology involved is mat nursery method, young seedling transplantation (14 daysold 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 ofsugarcane 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)

- 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 ofone 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 advantageousto 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) 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 is adopted the 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 Agniyar Basin is given below.

Sl. No.	Crop	Cultivated area in Ha	Water requirement-conventional method(MCM)	% of saving byadopting saving technique	Savings (MCM)
1	SRI-Paddy	116057	957.68	40	383.07
2	SSI-Sugarcane	1559	14.77	50	7.38
3	Coconut - DRIP	31023	181.91	63	114.60
4	Groundnut-DRIP	17533	57.42	50	28.71
				Total	**533.77**

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 Agniyar Basin. The cost of cultivation of crops in Tamilnadu is also appended in **Appendix 4.1 to 4.7 of Volume-II.**

4.13 Summary

Conclusion

- The Gross irrigated area of crops in Agniyar Basin is reported to be 1,86,422 Ha.
- Irrigated area in Agniyar sub basin is 1,03,698 Ha, Ambuliyar sub basin is 38,196 Ha and South Vellar subbasin is 44,282 Ha.
- Out of the total area irrigated, about 62% is under Paddy cultivation and the remaining in Coconut, Groundnut, Blackgram, Fruits&Vegetables, Gingelly, Banana and Maize cultivation.
- Net Irrigation demand of this basin at 75% dependable rainfall is 1301.32 MCM.
- Net Irrigation demand of this basin at 50% dependable rainfall is 1279.49 MCM.
- Agniyar sub basin has the maximum irrigated area of 1,03,698 Ha which accounts

for about56% of the total irrigated area.

- Ambuliyar sub basin has the minimum irrigated area of 38,196 Ha which accounts for about 21% of the total irrigated area.
- Agniyar sub basin has the maximum irrigation demand of about 702.42 MCM (about 54%) and Ambuliyar sub basin has the minimum irrigation demand of about 273.59 MCM (about 21%).
- Organic farming practice is to be extended in greater manner in this Basin.
- As per 2008, Microlevel Study Report of Agniyar Basin, Net Irrigation demand was calculated as 1098 MCM at 75% dependable rainfall for an irrigated crop area of1,46.585 Ha in which Irrigated area of Paddy is 62% and Coconut is 17%.
- Presently irrigated area is adopted as 1,86,422 Ha based on good rainfall year 2020-21.On comparing the cultivated area of the present study, it is found that the total irrigated area has increased from 1,46,585 Ha to 1,86,422 Ha. Irrigated area of Paddy is increased from 1,08,747 Ha to 1,16,057 Ha and Coconut is increased from 12,180 Ha to 31,023 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 intensityof 1.
- Savings in Irrigation demand of about 383.07 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 (6.20 MCM) could be saved.
- Using DRIP and coir pith as soil mulch for coconut trees, 63% of irrigation water could be saved (114.60MCM).
- During poor rainfall years, suitable cropping pattern may be adopted with crops that requirelesser 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 Location

Agniyar Basin is the ninth River basin from North and located in the middle part of the east coast of Tamil Nadu, adjoining the Palk bay. Geographically it spreads from 10^{o} 44’ 32’’ N to 9^{o} 56’ 55’’ N latitudes to 79^{o}25’21’’ E to 78^{o} 16’22’’ E longitudes. The Agniyar river basin covers a Geographical extent of 4702 Sq km . The Agniyar River Basin spreads across 5 districts of Tamil Nadu namely Pudukkottai, Thanjavur, Tiruchirapalli, Sivagangai and Dindigul districts . The basin is bounded by Cauvery River basin in the North and West , Pambar -Kottakaraiyar River basin in the South and West and Bay of Bengal in the East.

5.2 River Systems

The three rivers viz., Agniyar, Ambuliyar and South Vellar are non-perennial rivers that start as small streams and then flows towards the south eastern direction and drain into the Palk Strait and Palk bay portions of the Bay of Bengal.

5.3 Gauging Sites in the Basin

There are two gauging sites in Agniyar sub basin namely Poovanam anicut in Agniyar river in Poovanam village located at an latitude of 10° 21’51’’N and longitude of 79°16’36’’E and Thokkalikkadu anicut in Maharajasamuthiram river in Thokkalikkadu village at an latitude of 10°20’54’’N and longitude of 79°20’24’’E. Now a days due to lack of man power, gauging readings are not recorded.

5.4 Assessment of Surface Water Potential

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.

The following influential rainfall stations having long term records are considered for analysis and tabulated in **Table 5.1**

Table 5.1 Details of the influencing Raingauge Stations

Sl.No	Name of sub basin	Sub basin area (sq.km.)	Sub Basin wise Name of Raingauge station	No.of Raingauge Stations
1	Agniyar	2106.43	Alangudi, Gandarvakottai, Keeranur, Kudiminmli_AD, Kurungulam, Iluppur, Madhukkur, Malaiyur, Pattukottai, Peravoorani, Perungalur, Thanjavur	12
2	Ambuliyar	825.69	*Alangudi*, Aranthangi, Arimalam, Avudaiarkoil, *Malaiyur*, *Peravoorani*, *Perungalur*	7
3	South Vellar	1769.90	*Alangudi*, *Aranthangi*, *Arimalam*, *Avudaiarkoil*, Keeranur, *Kudiminmli_AD*, *Iluppur*, Manapparai, Mimisal, Natham_FOR, *Peravoorani*, *Perungalur*, Singampunari, Thirumayam	14
Total		**4702.02**		

Sub basin wise average annual rainfall adopted in the analysis is given vide **Appendix 5.2** of **Vol II**, Based on the annual rainfall Surface Water Potential is assessed by the following two methods:

- Rainfall –Runoff Co-efficient Method
- Monthly Runoff Simulation Model (MRS Model)

5.4.1 Rainfall – Runoff Co-efficient Method

An empirical relationship between rainfall and runoff in terms of yield of the catchment is adopted by assuming a suitable Run-off Co-efficient.

Agniyar River Basin has a drainage area of 4702.02 Sq.Km. Accordingly the sub basin area is divided into hilly, forest and plain area and the yield of each sub basin is arrived.

Yield = C x A x P is used, where,

Y- Yield in MCM

A - area of catchment in Sq.Km

P - weighted rainfall arrived from Theisson Polygon

C - Run-off Co-efficient

In general, a runoff coefficient of 0.15 for the plains, 0.20 for hilly region and 0.12 for forest area is adopted. The yield from all the sub basins are cumulatively added to arrive at the basin yield. This gives the Surface water potential of the basin.

Adopting 75 % and 50 % dependable rainfall, the potential of the basin is calculated and tabulated in Tables 5.2 & 5.3 respectively. The surface water potential thus calculated for using this method at **75 % and 50 %** dependability is **548.25 MCM & 649.03 MCM** respectively.

Table 5.2 Surface Water Potential by Run off- co efficient method @ 75% dependability

Sl. No	Name of the Sub Basin	Total Area in Sq.Km	Hilly Area in Sq.Km	Forest Area in Sq.Km	Plain Area in Sq.Km	75% dependable Rainfall in mm	Surface Water Potential in MCM			Total Potential in MCM
							in hilly Area	in Forest area	in Plain Area	
1	Agniyar	2106.43	6.41	62.95	2037.07	786.2	1.01	5.94	240.22	247.17
2	Ambuliyar	825.69	0.00	12.29	813.40	782.8	0.00	1.15	95.51	96.66
3	South Vellar	1769.90	10.28	136.47	1623.15	780.5	1.60	12.78	190.03	204.42
Total		**4702.02**	206.79	151.67	4473.62	2349.49	28.05	19.88	525.77	**548.25**

Table 5.3 Surface Water Potential by Run off- co efficient method @ 50% dependability

Sl. No	Name of the Sub Basin	Total Area in Sq.Km	Hilly Area in Sq.Km	Forest Area in Sq.Km	Plain Area in Sq.Km	50% dependable Rainfall in mm	Surface Water Potential in MCM			Total Potential in MCM
							in hilly Area	in Forest area	in Plain Area	
1	Agniyar	2106.43	6.41	62.95	2037.07	924.8	1.19	6.99	282.60	290.77
2	Ambuliyar	825.694	0.00	12.29	813.40	926.4	0.00	1.37	113.03	114.39
3	South Vellar	1769.9	10.28	136.47	1623.15	931.1	1.91	15.25	226.71	243.87
Total		**4702.02**	**206.79**	**151.67**	**4473.62**	**2782.34**	**3.10**	**23.60**	**622.33**	**649.03**

5.4.2 Surface Water Potential by MRS Model:

(i) Development of MRS Model

There are different watershed models whose common base is the conservation of mass principle as applied to a watershed, requiring a balance between all the watershed water components, namely, rainfall, evaporation, surface runoff and groundwater replenishment. The models in existence differ in the inter-relationships between these components, and their computational time-steps. Generally speaking, the shorter the time-step, the larger are the number of watershed parameters operated by the model, and the more accurate is the model's output, subject to the availability of data.

Perhaps, the most reliable water shed model is that developed by Stanford University, U.S.A., in the nineteen-sixties, to which the author of the present MRS model being used, had the honour to contribute. The model operates at hourly time-steps, requiring hourly rainfall as input. The Sacramento model adopted by the U.S. National Weather Services operates at daily time-steps. Having applied these types of models in many parts of the world, it became apparent that for water resources projects in regions where the number of rainy days in a rainy month is fairly large, the model may replace the hourly and even the daily time-steps. Conversely, where the density of rain gauges is low the monthly model may even produce better results than the daily or hourly ones. These facts led to the development of the present monthly model, requiring easily accessible monthly rainfall as input. The Monthly Runoff Simulation (MRS) model and the related computer program were developed and prepared by Dr. Moshe Negev of TAHAL Consulting Engineers Ltd., Tel-Aviv, Israel ("TAHAL"). The Monthly Runoff Simulation (MRS) model belongs to the above class of water shed models. The model has since been successfully used and its applicability verified in many parts of the world having diverse climatic and geological conditions.

(ii) The MRS Model - Methodology

The MRS model is a conceptual, distributed, deterministic model in which hydrological water balance computations are carried out. The inputs to the model are monthly rainfall associated with catchment area, mean monthly potential evapotranspiration and several empirical parameters such as runoff coefficient and soil moisture retention capacity. The outputs of the model are the total flow in the river, its surface and base flow components, and the recharge to groundwater (see Schematic Flowchart of the MRS model in Diagram A and Diagram B in VOL–II). The MRS model incorporates several applications such as Reservoir Operation and Probability Analysis. Detailed MRS Model descriptions are given in **Appendix 5.1** of **Volume II**.

(iii) Model Calibration

Simulation by the MRS Model normally begins with evaluating the model parameters by way of reconstructing the model, the observed flows at a given location in the river. This process is called "model calibration". Its application requires the input of rainfall data, usually in accordance with the Thiessen polygon method and the input of mean monthly potential evapotranspiration determined by the Penman method or by an evaporation pan adjusted by an appropriate coefficient and observed flows.

The calibration process is the "trial and error", guided by following "best fit" criteria with respect to simulated and observed (sim/obs) flows and by visual comparisons of monthly sim/obs hydrographs.

The following are model parameters requiring evaluation, and their range as encountered in previous calibrations:

V	(evapo transpiration adjustment factor)	0.60 – 1.0
Z	(coefficient of runoff)	0.01 – 0.4
P	(fraction of impervious area)	0.00 – 1.0

M	SMAX (upper limit of SM)	20.00 – 300
C	(base flow recession rate)	0.50 – 0.98
G	GWMAX (upper limit of GW)	0.00 – 1000
B	(fraction of recharge becoming base flow)	0.00 – 1.0

It is a good practice to start calibration by fore-closing the water balance, adjust PET by way of V. If V fall out of range, the calibration should be stopped and the input data reconsidered.

In the Agniyar Basin there are no reservoirs found. Hence with the rainfall data the model parameters were adjusted within its range so that the surface water potential (the output of the model) was approximately in accordance with the output of above model discussed in section 5.4.1.

Now, the following model parameters are adopted in the model for Agniyar sub basin.

V	(evapo transpiration adjustment factor)	1
Z	(coefficient of runoff)	0.1
P	(fraction of impervious area)	0.08
M	SMAX (upper limit of SM)	200
G	GWMAX (upper limit of GW)	400
B	(fraction of recharge becoming base flow)	0

The details of the calculation are also furnished in **Appendix 5.2** of **Volume II**. Accordingly the 75 % and 50 % dependable surface water potential for the three sub basins for the monsoon and non monsoon periods are individually determined and corresponding annual value is calculated and tabulated in Tables 5.4 and 5.5 respectively.

Table 5.4 75% Dependable Surface Water Potential – MRS Model

in MCM

Sl.No.	Name of the Sub Basin	SW	NE	NM	Annual
1.	Agniyar	62.38	151.95	40.86	255.19
2.	Ambuliyar	34.67	62.38	11.59	108.63
3.	South Vellar	115.21	87.54	19.80	222.55
Total		212.26	301.87	72.25	586.37
South West Monsoon Potential		**212.26**			
North East Monsoon Potential		**301.87**			
Non Monsoon Potential		**72.25**			
Annual Potential		**586.37**			

The average quantity of water diverted through Grand Anicut Canal to Agniyar basin 505 MCM. The details are as follows.

G.A. canal ayacut in Agniyar basin = 50785 ha or 125488 acres.
Designed duty of G.A. canal = 1043.30 ha/ cumec (73 acres/ cusecs)
Discharge required = 125488/73 i.e., 1719 c/s or 48.68 cumec
Crop period = 135 days
Base period = 120 days
1 cusec flow per day = 0.0864 Mcft
Total quantity required = 1719 × 120 × 0.0864 i.e., 17,823 Mcft
Hence, diverted water from G.A. canal = 17823Mcft or **505 MCM**

Surface water potential generated within the basin = **586.37 MCM**
Surface water quantity diverted from Cauvery river = **505 MCM**
Total Surface water potential = 1,091.37 MCM

Table 5.5 50% Dependable Surface Water Potential – MRS Model

inMCM

Sl.No.	Name of the Sub Basin	SW	NE	NM	Annual
1.	Agniyar	138.52	185.16	5.91	329.59
2.	Ambuliyar	52.30	62.17	10.63	125.10
3.	South Vellar	89.36	155.75	16.46	261.56
Total		280.12	403.08	33.00	716.25
South West Monsoon Potential		280.12			
North East Monsoon Potential		403.08			
Non Monsoon Potential		33.00			
Annual Potential		716.25			

The Annual Surface Water Potential of Agniyar Basin at 75% dependability is 586.37MCM.

5.5 The Existing Surface Water Supply Systems

The basin is generally dominated by tanks. There are few independent rivers. There is no reservoir in this basin. The surface water is drawn from tanks. Most of the channels are surplus courses of tanks (or) supply channels.

5.5.1 Anicuts

There are totally 39 anicuts in the basin and is listed below Sub basin wise. The details of these are furnished in the **Appendix 5.4** of **Volume II**.

Agniyar Sub basin	
1	Neiveli Anicut
2	Madathikkadu Anicut
3	Poovanam Anicut
4	Rajamadam Check dam

Agniyar Sub basin	
5	Yoganayagipuram Anicut
6	Thokkalikkadu Anicut
7	Nariyar Anicut
8	Gangatharapuram and Pudirivayal
9	Kallukulam vari Anicut
10	Nadium Anicut
Ambuliyar Sub basin	
1	Chithathikkadu Anicut
2	Nelliyadikkadu Anicut
3	Adaikkathevan Anicut
4	Palayanagaram bed dam
5	Mavadukuruchi bed dam
6	Poonaikuthiyar Anicut
7	Arasarkulam No.I Anicut
8	Arasarkulam No.II Anicut
9	Amarasinmendrapuram Anicut
10	Ramasamypuram anicut
South Vellar Sub basin	
1	Nallampillai Anicut
2	Kilikudi Anicut
3	Pinangudy Anicut
4	Visalur Anicut
5	Keemanur Anicut
6	Sundarapatty Anicut
7	Senthamangalam Anicut
8	Holds Worth Anicut

South Vellar Sub basin	
9	Sethu Kanmoi Anicut
10	Narpavalakudi Anicut
11	Alappiranthan Anicut
12	Panchathi Anicut
13	Veeramangalam Anicut
14	Avudaiyarkovil Anicut
15	Karungadu Anicut
16	Manaloor Anicut
17	Keeranoor Anicut
18	Manamelkudy Anicut
19	Mumbalai Anicut

5.5.2 Tanks

This basin has about 1191 tanks. The non-system tanks use surface water of the direct run off from their own catchment. Whereas the system tanks are filled from the canal flow diverted by the anicuts across the rivers apart from the direct run off of their own catchment.

Out of the 1191 tanks in this basin, 600 are system tanks with a registered ayacut of 27,883.81 ha and 591 are non-system tanks with a registered ayacut of 31,829.39 ha. The total ayacut benefited by the tanks in the basin comes out to 59,713.20 ha. The total capacity of all tanks is 387.04 MCM.

The tank details are attached in the **Appendix 5.3** of **Volume II**

Table 5.6 Details of Tanks

Sl.No.	Name of the Sub Basin	System Tanks			Non System tanks		
		Number	Capacity in MCM	Ayacut in Ha	Number	Capacity in MCM	Ayacut in Ha
1	Agniyar	293	110.13	12452.54	189	57.56	10283.73
2	Ambuliyar	196	22.28	8990.98	57	17.49	2077.09
3	South Vellar	111	21.45	6440.29	345	158.12	19468.57
Total		**600**	**153.86**	**27,883.81**	**591**	**233.17**	**31,829.39**

Table 5.7 Details of Tanks – Capacity (MCM) & Ayacut (Ha)

Sl.No.	Name of the Sub Basin	Total Number of Tanks	Total Capacity in MCM	Total Ayacut in Ha
1	Agniyar	482	167.69	22,736.27
2	Ambuliyar	253	39.76	11,068.07
3	South Vellar	456	179.57	25,908.86
Total		**1191**	**387.04**	**59,713.20**

5.5.3 Grand Anicut Canal:

Eventhough there are no reservoirs in this basin the irrigation demand is met from Cauvery water received through the Grand Anicut Canal. It is supplementing the ayacut under 16 anicut located in Agniyar , Ambuliyar and their Tributaries.The total ayacut benifited by the canal is 50,785 Ha or 1,25,488 acre. There are 74 tanks in Pudukkotai district supplemented by G.A Canal irrigating 5997 Ha. In addition to this, the ayacut directly fed by G.A Canal is 17719 Ha. The ayacut is located in Pattukottai and Peravurani taluks of Thanjavur district and Alangudi, Aranthangi and Avudayarkoil taluks of Pudukkottai district.

5.6 Inter Basin Transfer of Water

There is Inter basin transfer of water from Cauvery river basin to Agniyar river basin through Grand Anicut Canal. This Grand anicut diverts the water released from Mettur reservoir to meet the irrigation requirements of Agniyar basin.

5.7 Outflow to Sea

As there are no gauging sites operative in the basin due to deficient man power, the surplus discharge through the river into the sea could not be assessed as such.

5.8 Issues in the Management of Surface Water Resources

Problems in Tank Irrigation

Tank irrigation, which is one of the most ancient systems in India, has a glorious history of extremely well organised governance and execution of all critical functions of water management such as maintenance, water sharing and arbitrating the conflicts that arise among users from time to time. This basin is predominantly irrigated by tanks throughout the year.

At present the efficiency of tank irrigation system is quiet low. There has been some reduction in storage capacity of tanks due to siltation and encroachment. Available water is further reduced due to losses in the distribution system.

Inadequate supplies to the command area produces soil moisture stress condition and reduces the yield, which in turn forces the farmers to go in for supplemental irrigation by using ground water through bore wells. Recharge of these wells depend upon the hydraulic head of anicut and tanks in the vicinity and aquifer tapped by these wells. Conjunctive use of tank and well water help in increasing the crop production and also improve performance of the system.

Most of the canals in this basin are unlined. This causes losses in conveyance of water. The losses may be evaluated by the field Engineers in future and it is hence recommended to line atleast the channels where the losses are appreciable and the canals leading to the ayacut.

Approach to the structural components of the tanks is difficult due to extensive weeding. The approach is difficult for frequent visits to inspect and maintain the structural components. This may cause deterioration and damage to them in due course of time.

5.9 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:

1. Improving the performance of the existing irrigation system by suitable structural measures.
2. Lining of canals to improve the efficiency by reducing conveyance loss of water.
3. Renovating old tanks and ponds, desilting of tanks and supply channels and constructing recharge structures to improve irrigation potential.
4. Equitable distribution of irrigation water by better water management.
5. Conjunctive use of surface and ground water wherever possible.
6. Introducing modern irrigation techniques like, drip and sprinkler irrigation.
7. Automatic flow measuring devices may be installed in anicuts, so as to quantify the flow.

8. Adopting preventive measures in reducing the sedimentation of tanks, supply channels from the take – off point itelf. (Anicuts, Head Sluices etc..)

5.10 New Schemes

Union Government in August 1980 formulated the National Perspective Plan (NPP) for Water Resources Development which envisaged transfer of water from surplus basins to deficit basins. National Water Development Agency (NWDA), which was set up by the Union Government, identified 16 river links under Peninsular rivers links based on field surveys and investigation and detailed studies. It includes Mahanadi – Godavari – Krishna – Pennar – Palar – Cauvery – Vaigai – Gundar links and prepared feasibility report for this link project in 2004.

Tamil Nadu has been urging the Union of India to have Mahanadi - Godavari – Krishna – Pennar - Palar - Cauvery - Gundar link to benefit the drought prone areas in Tamil Nadu, which was the only scope for increasing the surface water availability of Tamil Nadu. Due to the untiring efforts of Tamil Nadu, NWDA has decided to implement the Peninsular rivers link project under two phases. Phase – I is linking Godavari river with Krishna, Pennar and Cauvery, and prepared the DPR for the same in April, 2021 and now it is in the process of consensus building between the concerned States. NWDA has proposed to execute the Cauvery – Vaigai – Gundar link project under Phase-II.

However, Government of Tamil Nadu in order to meet the growing needs of water in the basins south of Cauvery has taken up the implementation of this project to divert the flood water of Cauvery river whenever occurs up to Gundar basin in three Phases in the same alignment as proposed by NWDA. This project of Tamil Nadu also helps to alleviate the floods in Cauvery delta area.

The Government of Tamil Nadu is proposing to form a new canal taking off from the Kattalai barrage to connect Cauvery, Agniyar, South Vellar, Manimuthar, Vaigai and Gundar Rivers in 3 phases for a total length of 262.190 km viz. Phase I - Cauvery (Kattalai Barrage) to South Vellar (L.S. 0 km – 118.45 km), Phase II - South Vellar to Vaigai (L.S. 118.45 km – 228.145 km) and Phase III - Vaigai to Gundar (L.S. 228.145 km – 262.190 km). This project envisages the transfer of the Mahanadi, Godavari waters in future as well as the diversion of flood water of Cauvery river occurring occasionally at Mettur dam and the flood surplus occurring in the catchment between Mettur and Kattalai barrage. Such flood surplus whenever occur would be diverted at Mayanur barrage for meeting drinking water, stabilizing the existing ayacut, being irrigated under open tanks/wells/bore wells in Karur, Tiruchirapalli and Pudukkottai districts as well as for recharging ground water to some extent on the en-route area.

The total cost of the interlinking project is Rs. 6940 Crores. This project comprises the following three phases.

1. Phase I (0.0 – 118.450 km : Slices 1 to 8)
2. Phase II (118.450 – 228.145 km : Slices 9 to 15)
3. Phase III (228.145 – 262.190 km : Slices 15 pt. & 16)

Now under Phase I, the work is in progress.

By implementing this scheme, drinking water needs, stabilizing the existing ayacut, and recharging ground water can be improved.

5.11 Conclusion

The Water Potential of a basin comprises of both Surface Water Potential and Ground Water Potential.

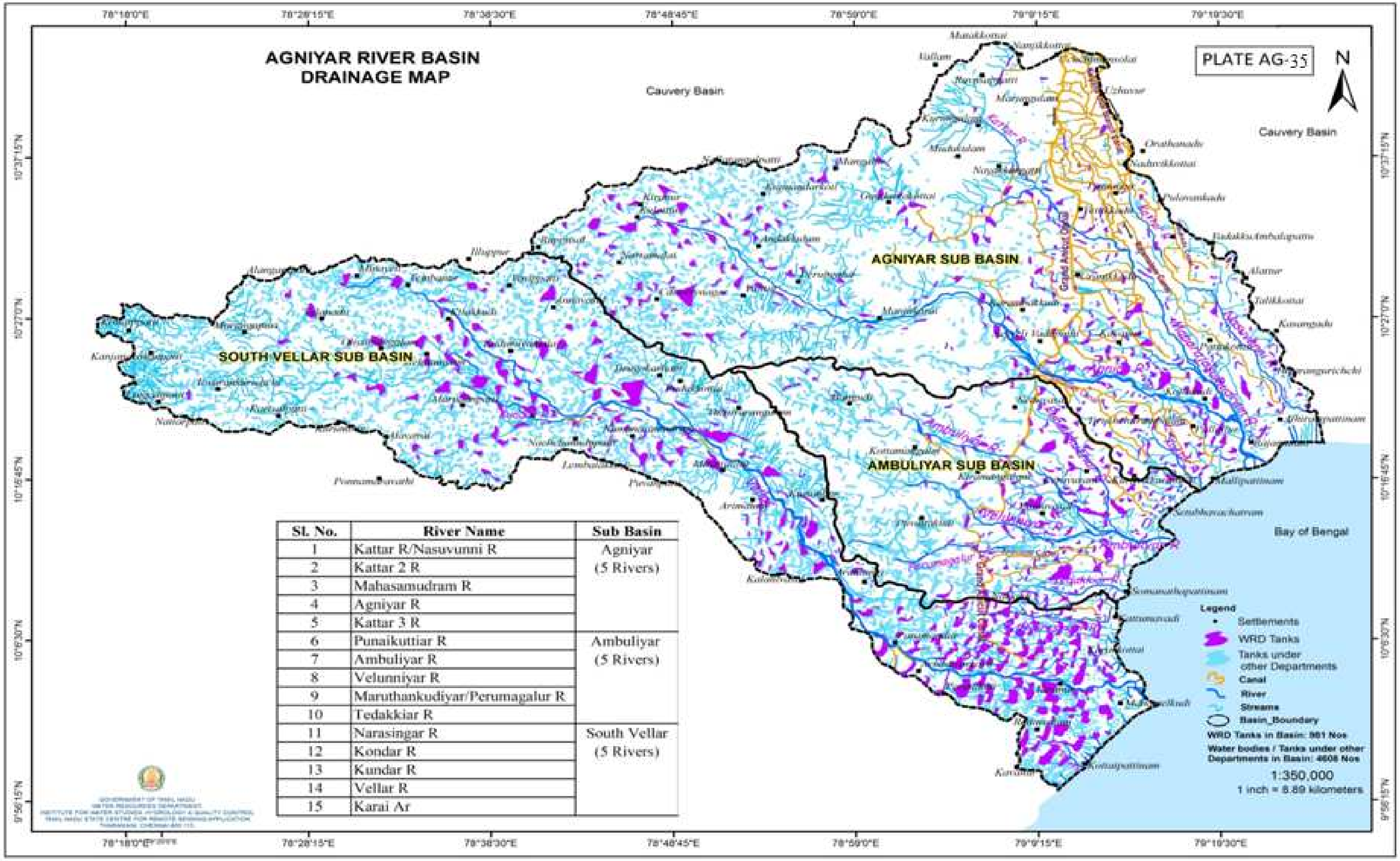
Sub Basin wise Surface Water Potential for the basin is assessed by the following two methods:

1. **Rainfall – Run-off Co-efficient Method**
2. **MRS Model**

The annual Surface Water Potential of Agniyar river basin calculated using Rainfall – Run-off Co-efficient Method is **548.26 MCM** at 75% dependability and that by using MRS Model is **586.37 MCM**.

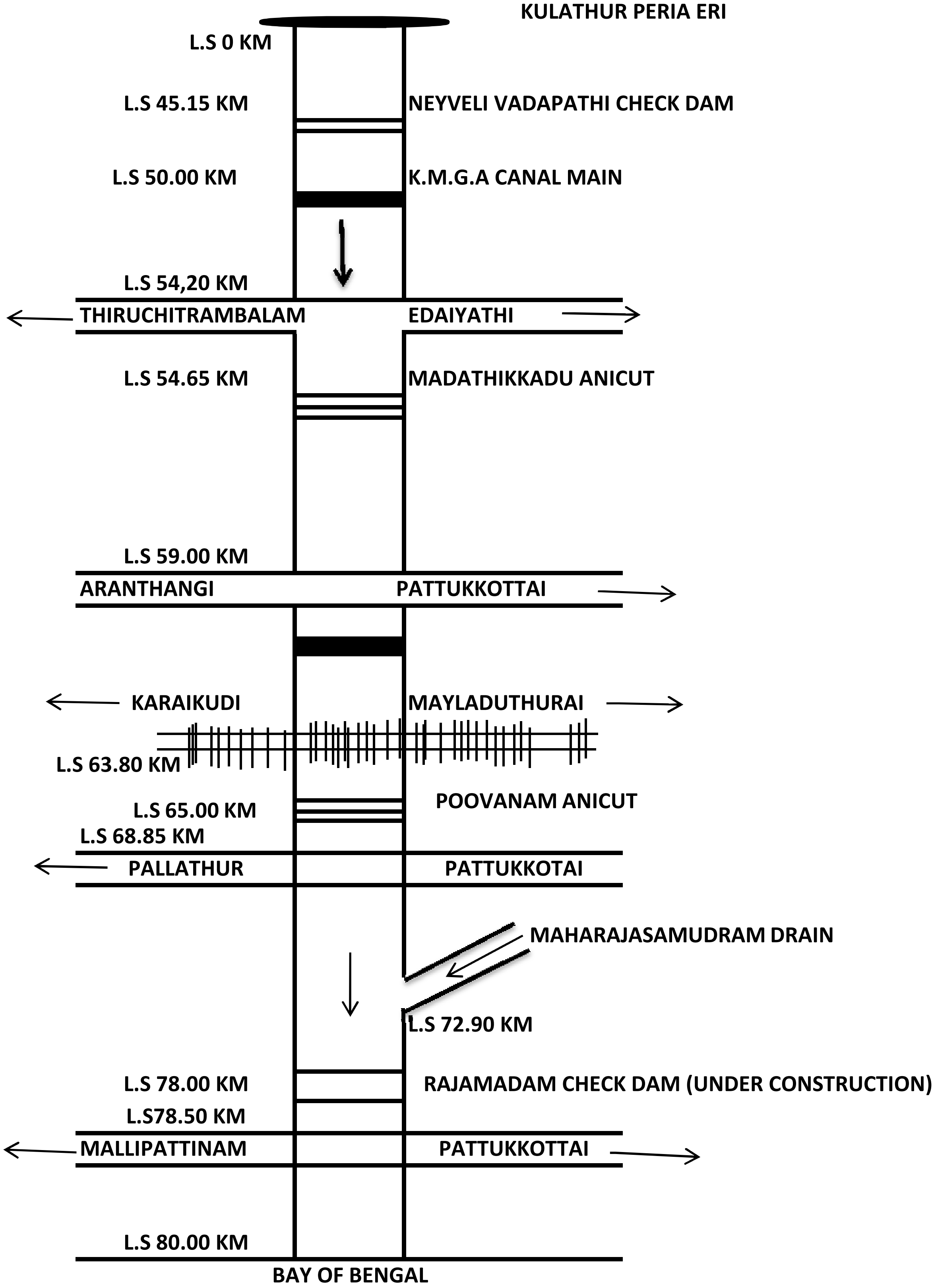
A quantum of water contribution from the Grand Anicut Canal into this basin is **505 MCM.**

The Surface Water Potential has decreased from **1136 MCM** during 2008 to **1091.37 MCM** during 2021 due to less precipitation for the past few years.

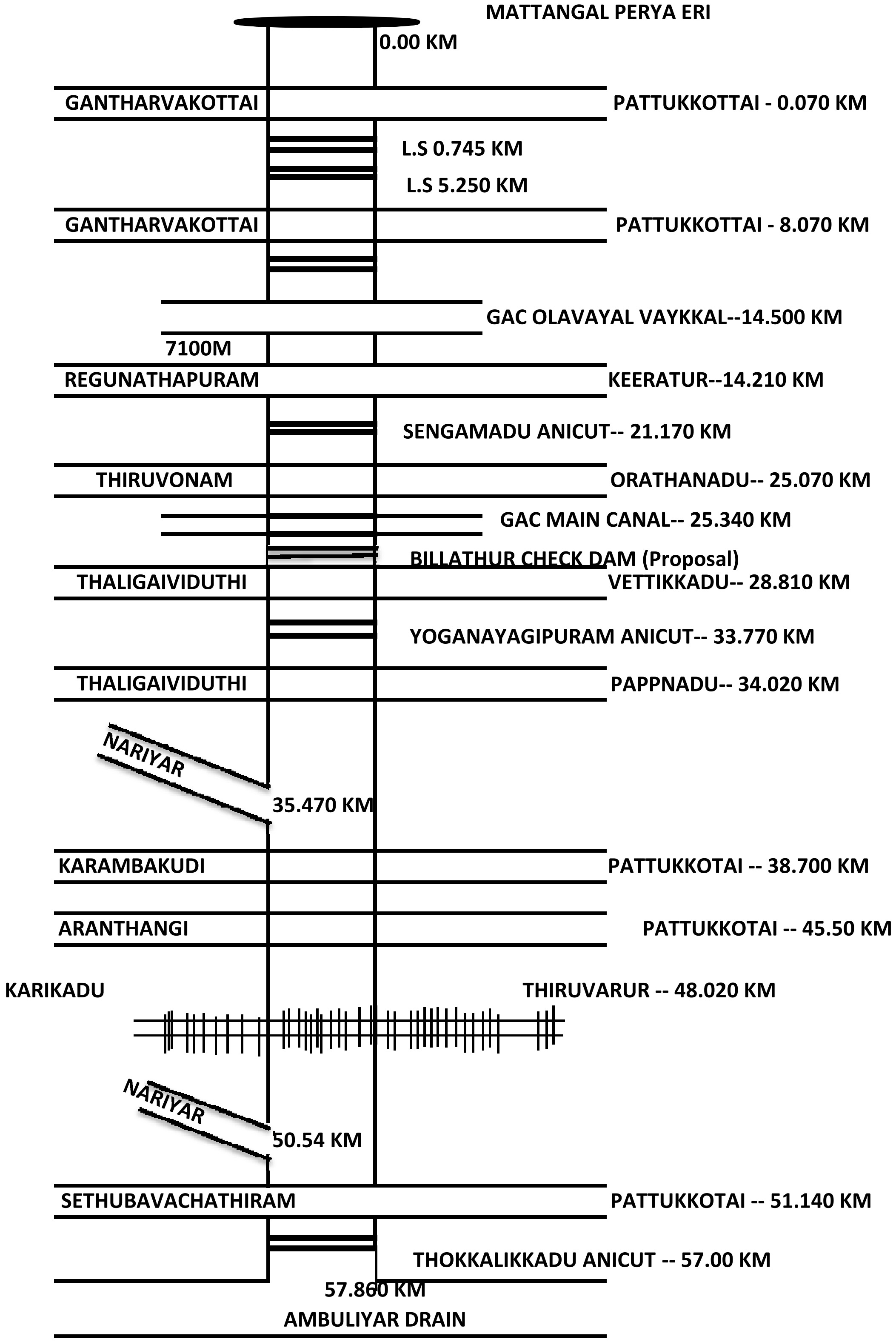


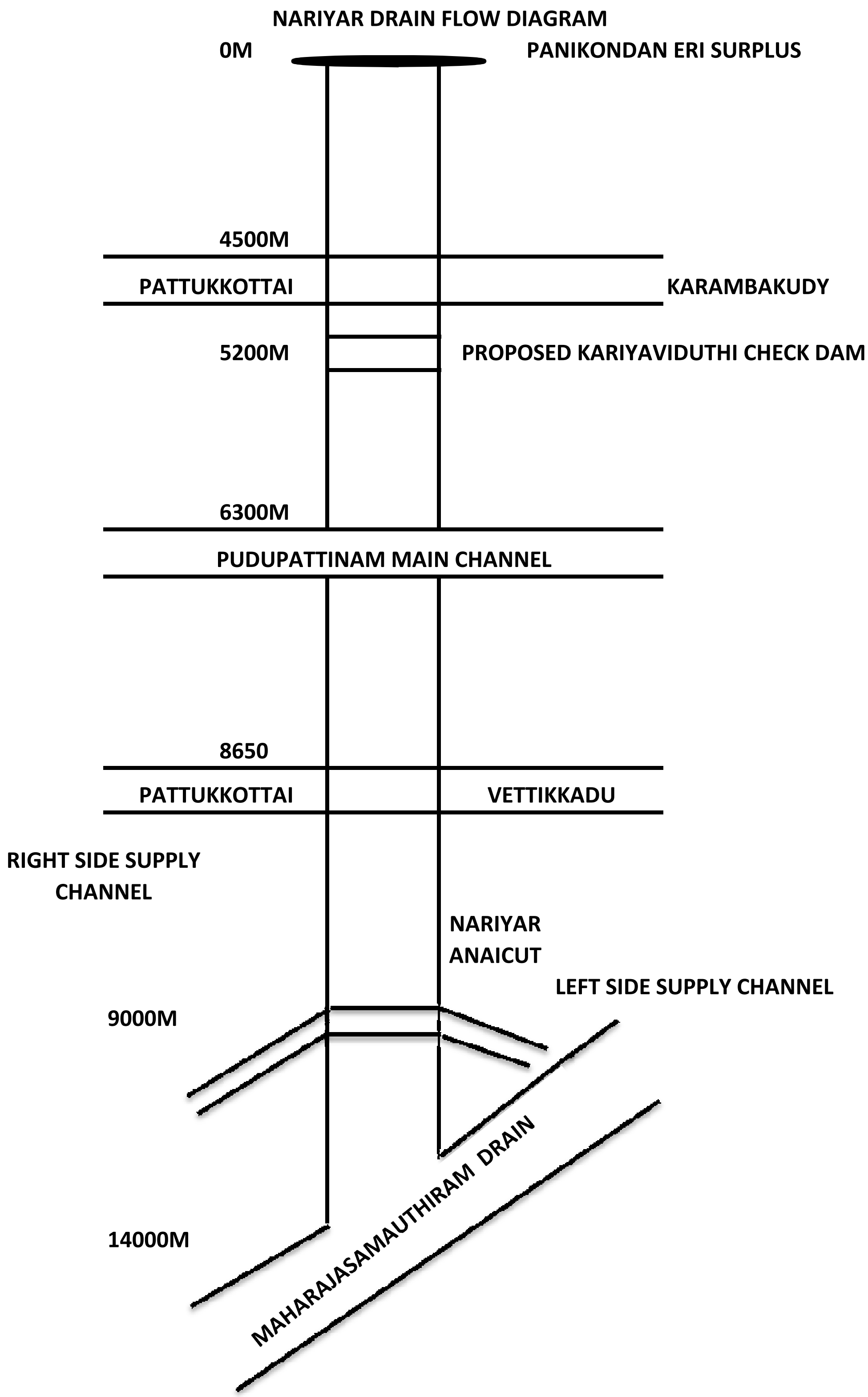
Sl. No.	River Name	Sub Basin
1	Kattar R/Nasuvunni R	Agniyar (5 Rivers)
2	Kattar 2 R	
3	Mahasamudram R	
4	Agniyar R	
5	Kattar 3 R	
6	Punaikuttiar R	Ambuliyar (5 Rivers)
7	Ambuliyar R	
8	Velunniyar R	
9	Maruthankudiyar/Perumagalur R	
10	Tedakkiar R	
11	Narasingar R	South Vellar (5 Rivers)
12	Kondar R	
13	Kundar R	
14	Vellar R	
15	Karai Ar	

FLOW DIAGRAM OF AGNIYAR DRAIN

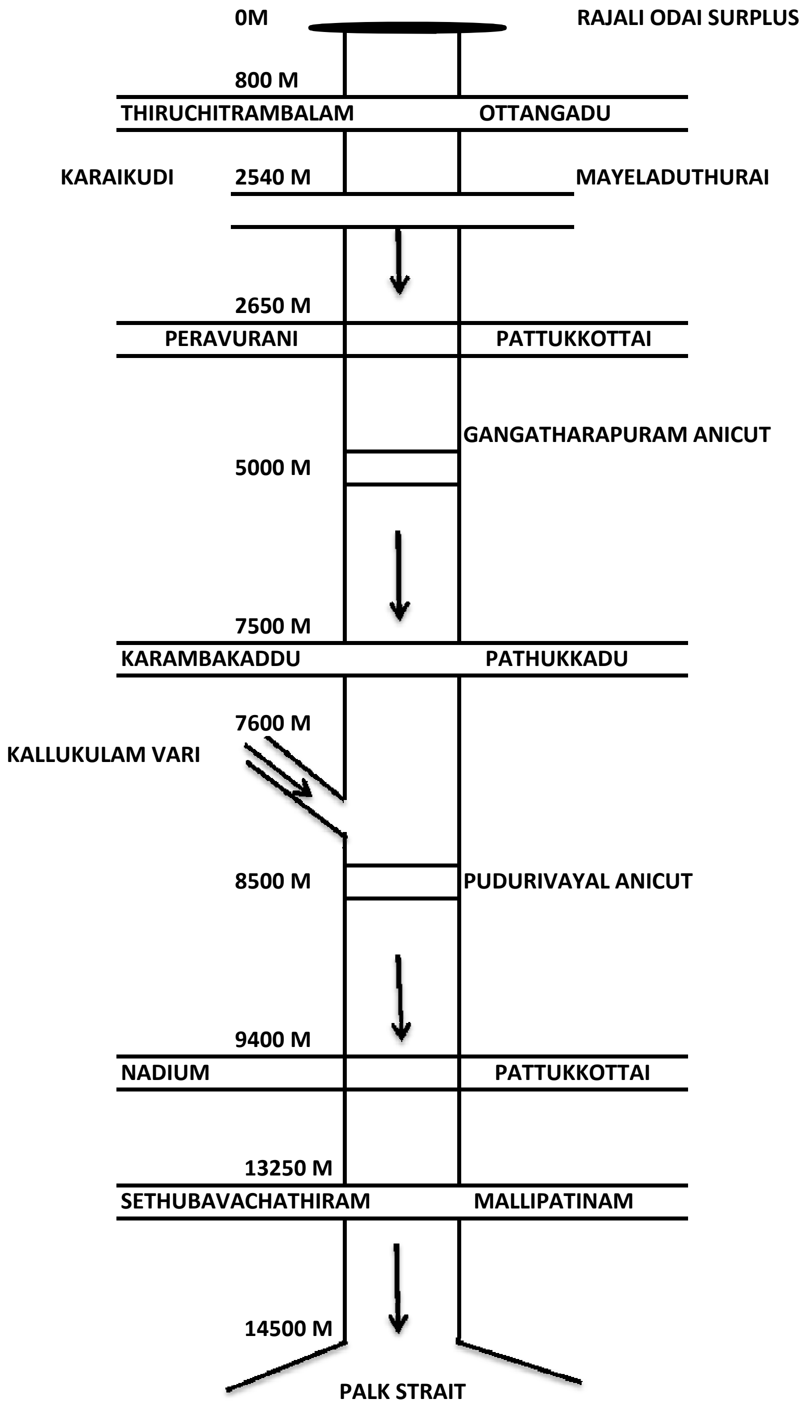


FLOW DIAGRAM OF MAHARAJASAMUDRAM DRAIN

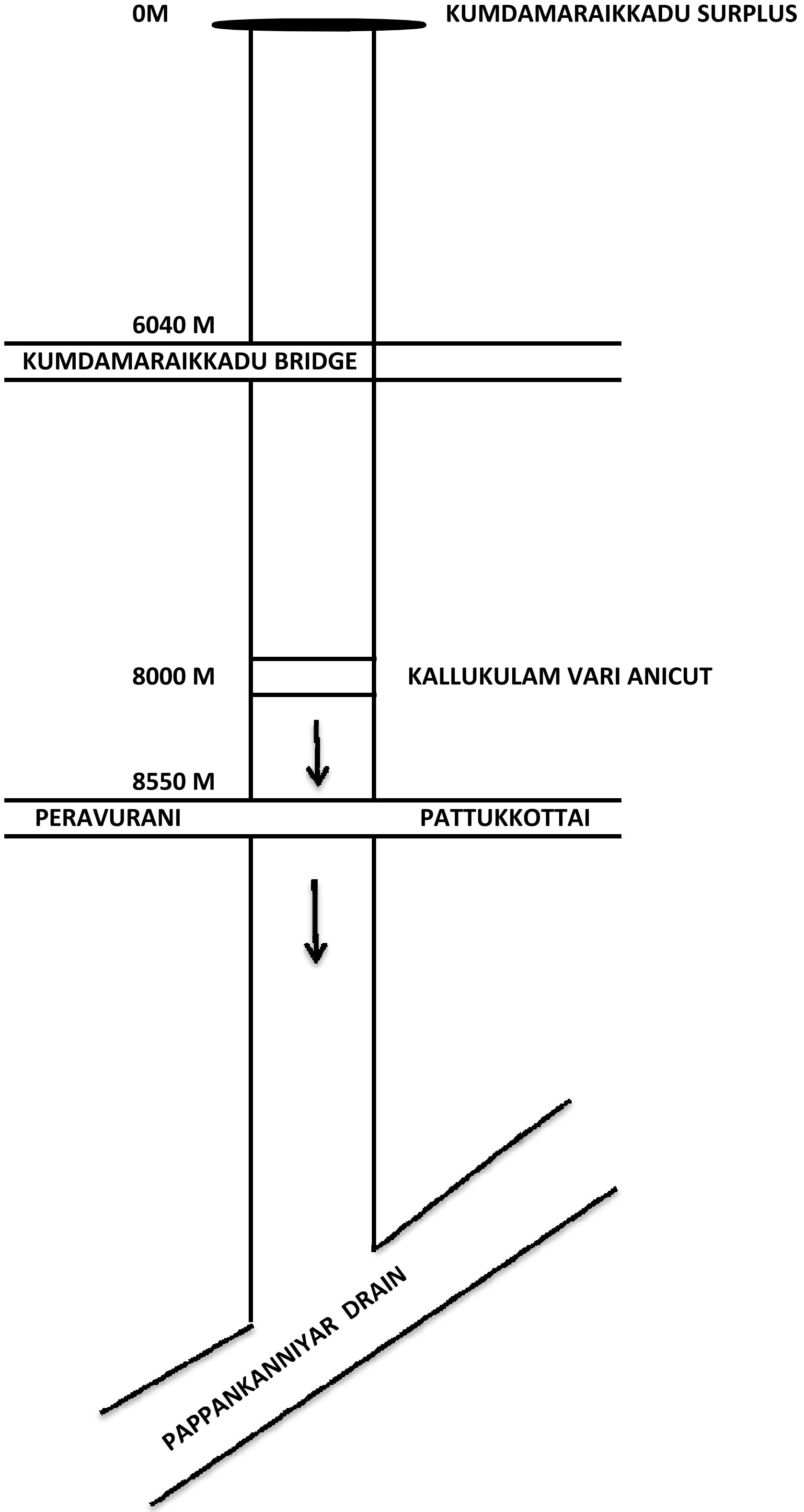



NARIYAR DRAIN FLOW DIAGRAM
0M
PANIKONDAN ERI SURPLUS
4500M
PATTUKKOTTAI
KARAMBAKUDY
5200M
PROPOSED KARIYAVIDUTHI CHECK DAM
6300M
PUDUPATTINAM MAIN CHANNEL
8650
PATTUKKOTTAI
VETTIKKADU
RIGHT SIDE SUPPLY
CHANNEL
NARIYAR
ANAICUT
LEFT SIDE SUPPLY CHANNEL
9000M
14000M
MAHARAJASAMAUTHIRAM DRAIN

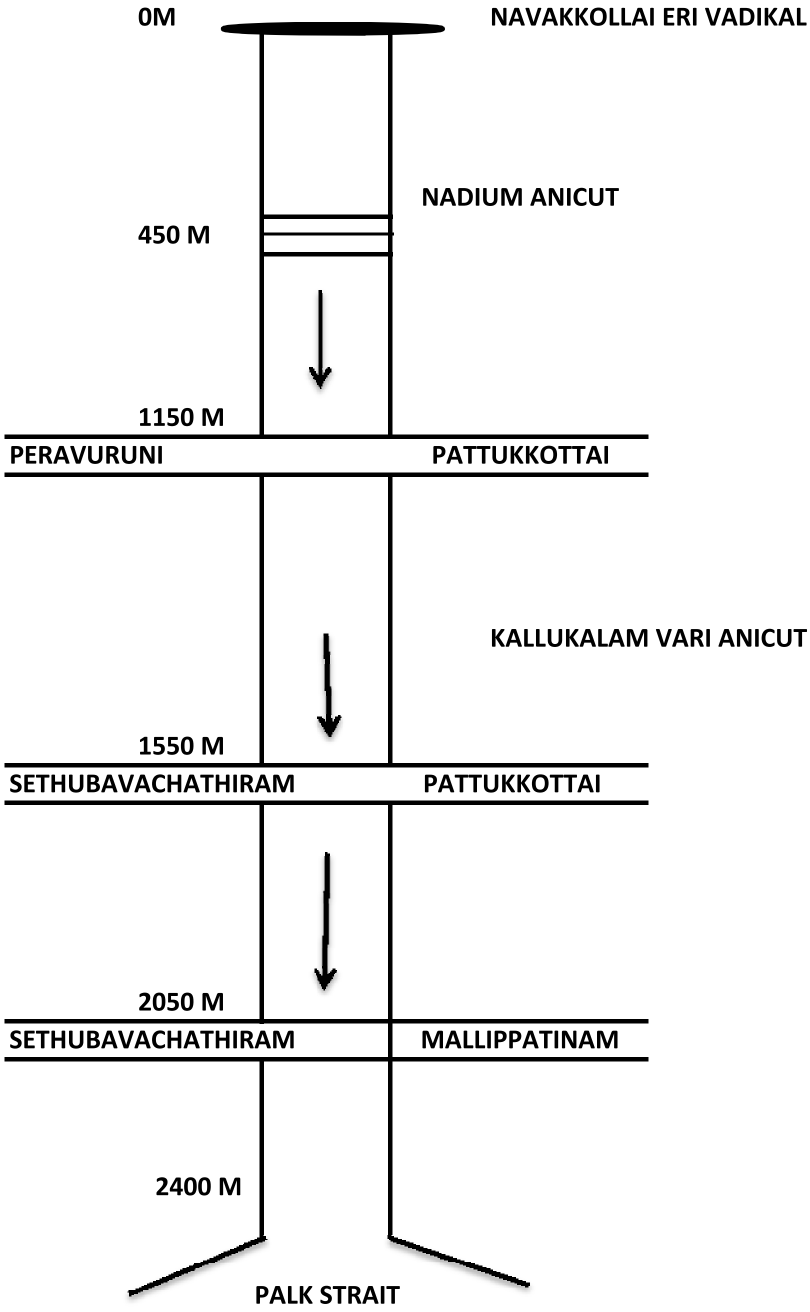
FLOW DIAGRAM OF PAPPANKANNIYAR DRAIN



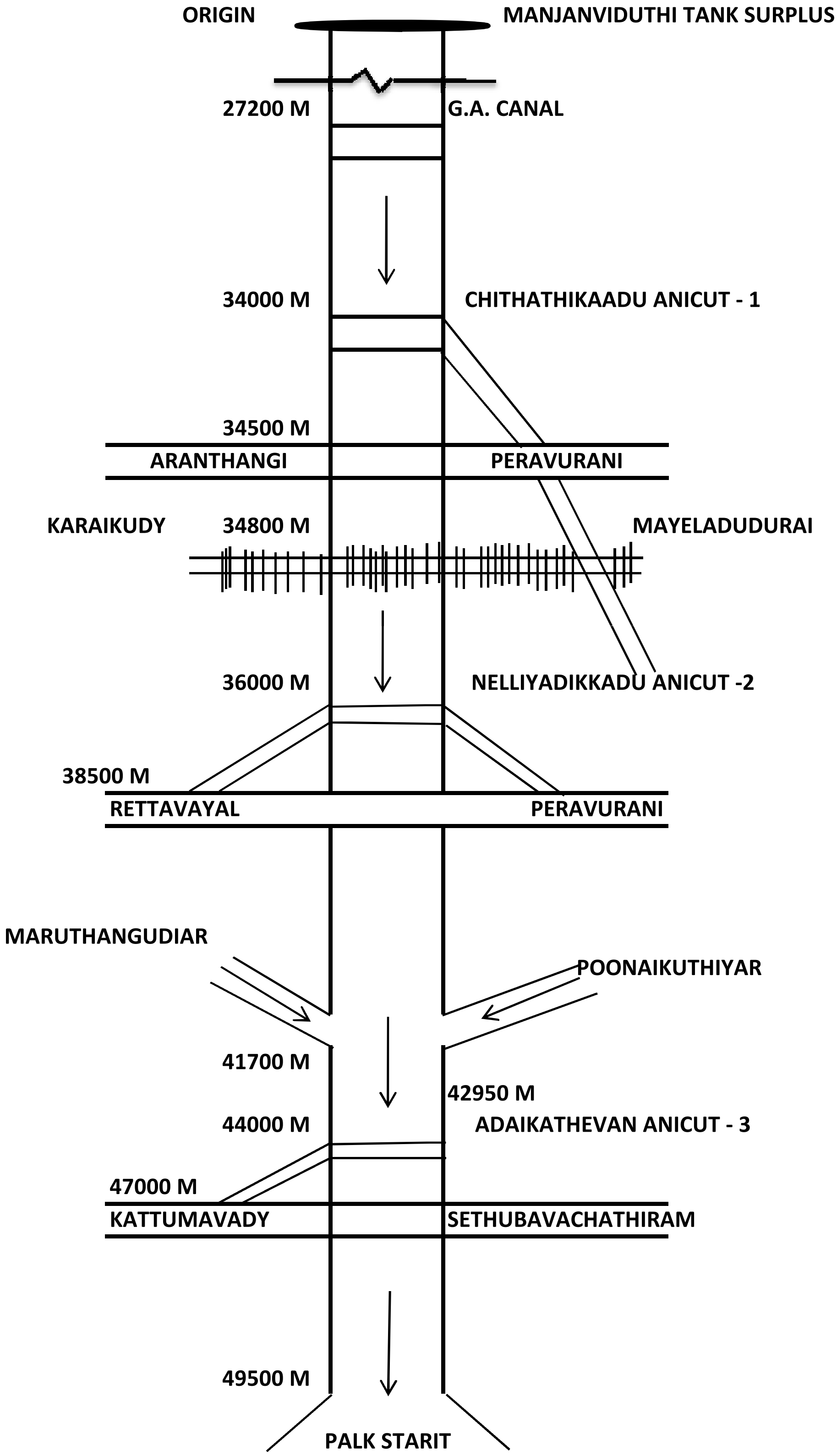
FLOW DIAGRAM OF KALLUKULAM VARI DRAIN

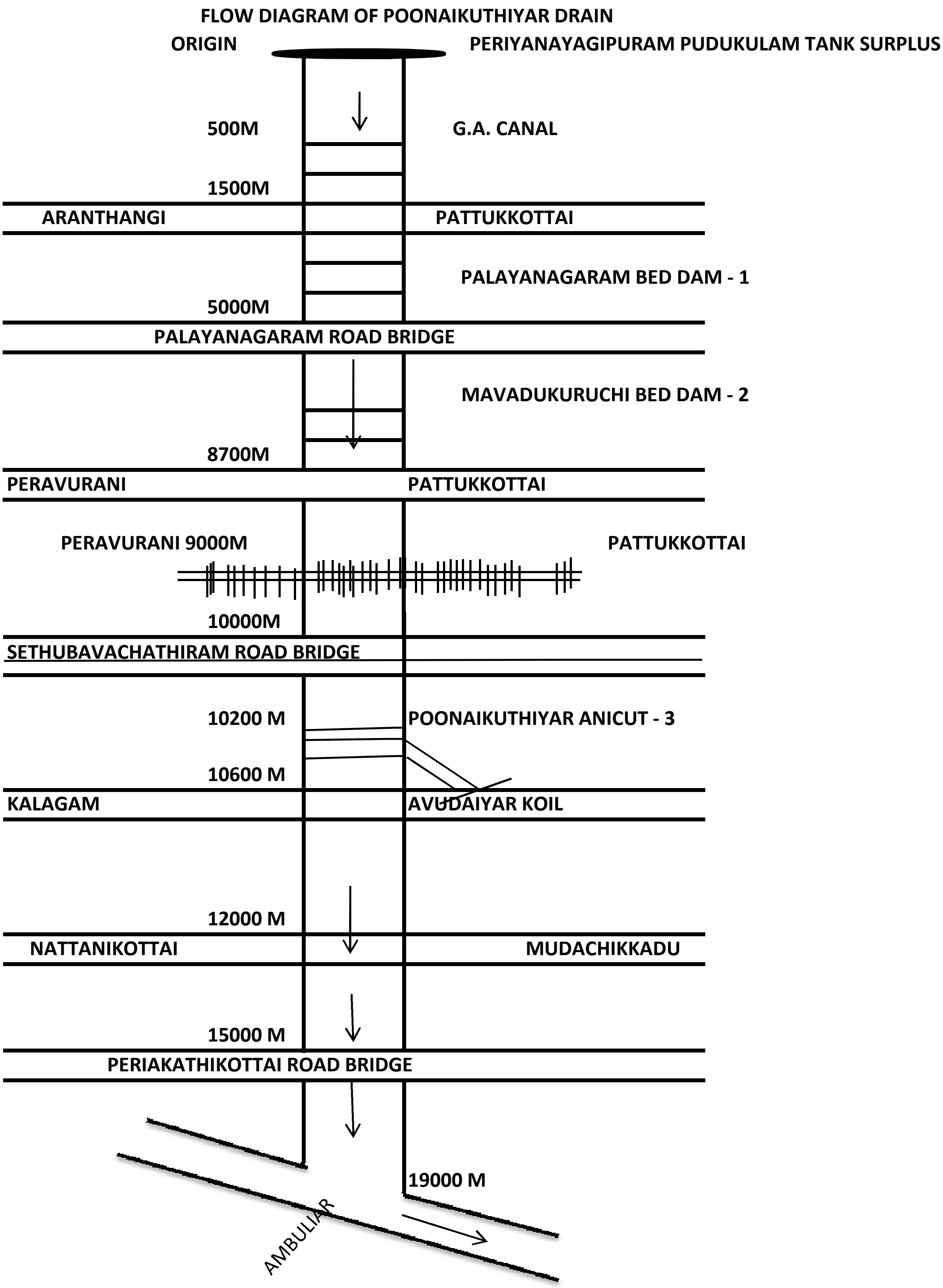


FLOW DIAGRAM OF NADIUM VARI DRAIN

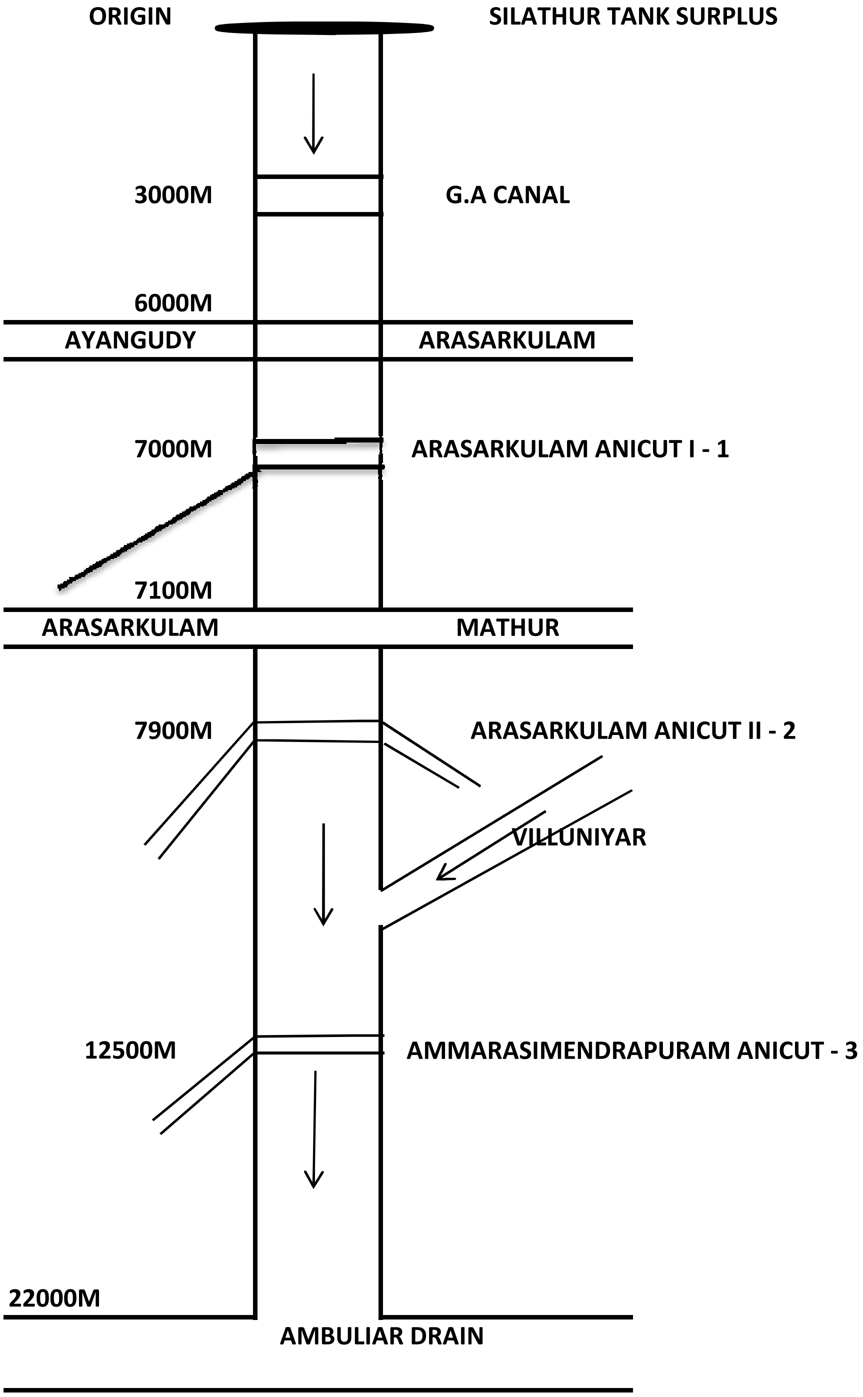


FLOW DIAGRAM OF AMBULIYAR DRAIN

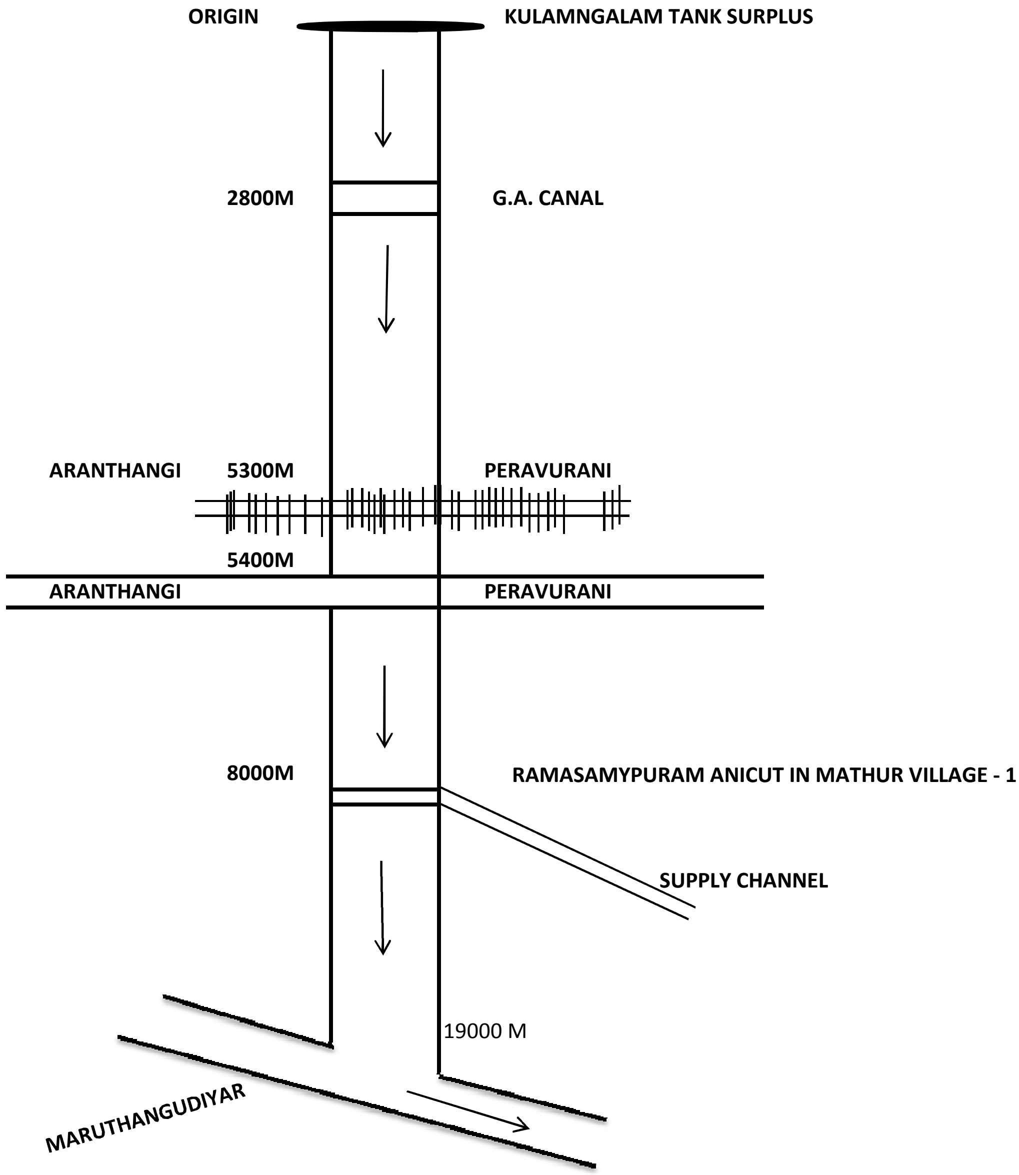



FLOW DIAGRAM OF POONAIKUTHIYAR DRAIN
ORIGIN
PERIYANAYAGIPURAM PUDUKULAM TANK SURPLUS
500M
G.A. CANAL
1500M
ARANTHANGI
PATTUKKOTTAI
PALAYANAGARAM BED DAM - 1
5000M
PALAYANAGARAM ROAD BRIDGE
MAVADUKURUCHI BED DAM - 2
8700M
PERAVURANI
PATTUKKOTTAI
PERAVURANI 9000M
PATTUKKOTTAI
10000M
SETHUBAVACHATHIRAM ROAD BRIDGE
10200 M
POONAIKUTHIYAR ANICUT - 3
10600 M
KALAGAM
AVUDAIYAR KOIL
12000 M
NATTANIKOTTAI
MUDACHIKKADU
15000 M
PERIAKATHIKOTTAI ROAD BRIDGE
19000 M
AMBULIAR

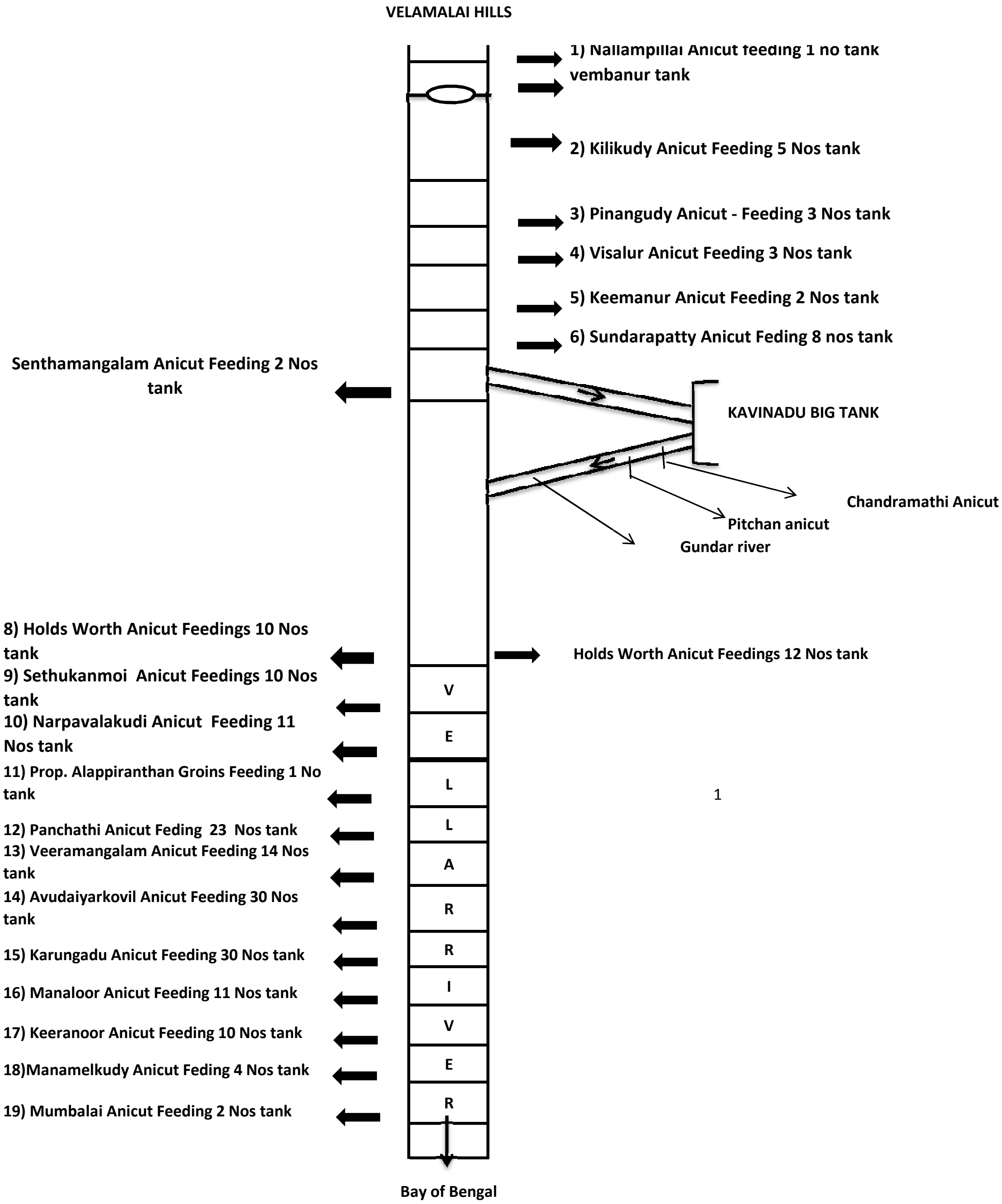
FLOW DIAGRAM OF MARUTHANGUDIYAR DRAIN



FLOW DIAGRAM OF VILLUNIYAR DRAIN



FLOW DAIGRAM OF SOUTH VELLAR



Poovanam Anicut Images

Adaikkadevan Anicut Images

Thiruvudayapatti Checkdam Images

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 2020,** the data on **DynamicGround Water Resources of India 2020** is as stated below:

- **Total Annual Ground Water Recharge : 436.15 BCM**
- **Annual Extractable Ground Water Resources : 397.62 BCM**
- **Annual Ground Water Extraction : 244.92 BCM**
- **Stage of Ground Water Extraction : 61.60 %.**

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 50% 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 2020,** the data on **Dynamic Ground Water Resources of the State of Tamilnadu** is as stated below:

- **Total Annual Ground Water Recharge : 19.59 BCM**
- **Annual Extractable Ground Water Resources : 17.70 BCM**
- **Annual Ground Water Extraction : 14.67 BCM**
- **Stage of Ground Water Extraction : 82.90 %**

The following sections explain the groundwater availability and status prevailing in Agniyar Basin.

6.2 Groundwater Estimation Methodology

As per Latest revised guidelines of Ground Water Resources estimation 482/7committee-2015, the firka wise dynamic Ground Water resources assessment of State of Tamil Nadu as on 2020has been carried out and completed by the State Ground and Surface Water Resources Data centre, WRD, 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 thepump test results, yield and recharge rate of aquifers are being predicted.

6.3.2 Aquifer Parameters

Geologically, Agniyar basin is comprised of hard rock formation such as Gneiss, Granite, Charnockite, Pink Granite, Migmatite and Pyroxene granite.

The aquifer parameters of the geological formations in Agniyar River Basin are given in the **Table 6.1.**

Table: 6.1 Aquifer parameter in Hard Rock

S. No	Parameters	Range
1.	Well Yield	300 lpm
2.	Transmissivity (T) in m^2/day	1 to 145 m^2/day
3.	Specific Yield	0.12%

Note : lpm = litre per minute

6.3.3 Groundwater Occurrence

There are 49 wells(29 Observation wells & 20 piezometric wells) spread over the entire Agniyar Basin and they have been analyzed, over the period of Seven years to Ten years. The wells analyzed fall in thanjavur, pudukkottai, Tiruchirapalli, dindugul, and sivagangai districts. The details of these wells in Agniyar basin arepresented in **Appendix 6.1 of Vol II** and it's spatial distribution are shown in **Plate:AG-36.** 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 3 sub basins is presented in **Table 6.2**. The ground water occurrence in the 3 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		
		South vellar Sub - Basin	Ambuliyar Sub-Basin	Agniyar Sub-Basin
1	Granitic Gneiss (GGN)	13	-	2
2	Gneiss (GNS)	4	1	-
3	(CRT)	-	-	3
4	(TSS)	6	2	3
5	(ALV)	9	-	-
6	(LTR)	1	2	-
7	(SDM)	1	-	2

(Source : SG&SWRDC, WRD, Chennai)

Table 6.3 Ground water occurrence

(a) 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	South Vellar	18	**8.91m** well no SW 1A (April 2012)	**34.4m** well no SW 1A (May 2013)	**8.71m** well no SW 1A (Jan 2016)	**25.4m** well no SW 1A (Feb 2019)
2	Ambuliyar	3	**10.11m** well no 73144 (March 2012)	**21.65 m** well no 73144 (April 2014)	**7.05m** well no 73144 (Jan 2012)	**18.62 m** well no 73144 (Feb 2014)
3	Agniyar	8	**5.71m** well no 73171 (March 2012)	**14.19 m** well no 73171 (May 2014)	**3.65m** well no 73171 (Jan 2012)	**12.71m** well no 73171 (Feb 2017)
	Total	29				

(b) 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	South Vellar	15	**14.24 m** well no 12038 D (April 2012)	**63.98m** well no 8037 (May 2018)	**14.24 m** well no 12038 D (Jan 2012)	**59.35m** well no 8037 (Feb 2017)
2	Ambuliyar	2	**7.68 m** well no 12032 D (March 2012)	**51.72m** well no 12032 D (May 2017)	**7.36 m** well no 12032 D (Feb 2012)	**46.2m** well no 12032 D (Feb 2017)
3	Agniyar	3	**10.78m** well no 12006 (March 2012)	**27.5m** well no 12031 D (May 2017)	**6.45m** well no 12031 D (Jan 2011)	**23.86m** well no 12031 D (Feb 2017)
	Total	20				

(Source : SG&SWRDC, WRD, Chennai)

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 datas, 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 2011 to January 2020 have been prepared and are presented in **Plate: AG-37 to AG-44** respectively. Groundwater levels of the 49 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 49 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 3 wells and high rise in water level is found in 3 wells. Moderate depletion is found in 5 wells and high depletion in water level is found in 13 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(a) (b) & 6.5(a) (b)**

Table 6.4

High Rise Wells

Sl.No	Well No	Sub-Basin	District
1	MMWS PDK 2	South Vellar	Pudukkottai
2	MMWS PDK 5		
3	12050		

Long term Rise Wells

Sl.No	Well No	Sub-Basin	District
1	73166	South Vellar	Pudukkottai
2	SW-1A		
6	MMWS PDK 14	Agniyar	Pudukkottai

Table 6.5

(a). High Depletion Wells

Sl.No	Well No	Sub-Basin	District
1	12010	South Vellar	Pudukkottai
2	12024 D		
3	12025 D		
4	12038 D		
5	8018		Thanjavur
6	8037		
7	11009 D		Tiruchirapalli
8	11010 D		
9	11034 D		
16	12032 D	Ambuliyar	Pudukkottai
17	24014		Sivaganga
26	12031 D	Agniyar	Pudukkottai
27	12006		

(b). Long term Depletion Wells

<table>
<tr><th>Sl.No</th><th>Well No</th><th>Sub-Basin</th><th>District</th></tr>
<tr><td>1</td><td>12032 D</td><td rowspan="3">South Vellar</td><td rowspan="3">Pudukkottai</td></tr>
<tr><td>2</td><td>12039 D</td></tr>
<tr><td>3</td><td>MMWS TRY 1</td></tr>
<tr><td>5</td><td>63715</td><td rowspan="2">Agniyar</td><td rowspan="2">Pudukkottai</td></tr>
<tr><td>6</td><td>63725</td></tr>
</table>

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 0.22m to 24.95m in South vellar sub-basin, 0.52m to 11.65m in Ambuliyar sub-basin, 0.39m to 14.30m in Agniyar sub-basin and Annual water level fluctuation in piezometric wells varies from 1.18m to 59.50 m in South vellar sub-basin, 1.30m to 23.63m in Ambuliyar sub-basin, and 3.18m to 21.21m in Agniyar sub-basin

i) Monsoon Groundwater Level Variation

a) In observation wells:

- In South vellar sub-basin, pre-monsoon groundwater level varies from 0.09m to 34.40m and post monsoon groundwater level varies from 0.10m to 13.62m.
- In Ambuliyar sub-basin, pre-monsoon groundwater level varies from 3.15 m to 21.65m andpost monsoon groundwater level varies from 2.08m to 18.62m
- In Agniyar sub-basin, pre-monsoon groundwater level varies from 1.1 m to 14.19m and post monsoon groundwater level varies from 0.40m to 12.71m.

b) In piezometric wells

- In South vellar sub-basin, pre-monsoon groundwater level varies from 1.43m to 63.98m and post monsoon groundwater level varies from 0.70m to 59.35m
- In Ambuliyar sub-basin, pre-monsoon groundwater level varies from 7.4m to 51.72m and post monsoon groundwater level varies from 4.6m to 46.2m
- In Agniyar sub-basin, pre-monsoon groundwater level varies from 5m to 27.50m andpost monsoon groundwater level varies from 4.25m to 23.86m.

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 Agniyar 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-2011 to Jan-2020 have been prepared based on the above data and presented in **Plates AG-37 to AG-44**

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, (1mto 20m) in middle reach and (1m to 75m) in tail reach.

ii) Pre-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 (3mto 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 middlereach 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 2020.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.

Agniyar basin encompasses 71 Firkas either fully or partially and all firkas are falling in Pudukkottai, Thanjavore, Trichirapalli, Dindugul and sivangai districts. Map showing the categorization of firkas falling in Agniyar Basin is presented in **Plate: AG-45**

The list of categorization of 71 firkas in Agniyar Basin based on Dynamic Ground Water Resources of the State of Tamil nadu as on March 2020 is presented in **Table 6.7 & Table 6.8**

Table 6.7 Categorization of Firkas in Agniyar basin

Sl.No	Firka	Sub-Basin	District	Categorisation of Firkas
1	Aranthangi	South Vellar	Pudukkottai	safe
2	Arasamalai		Pudukkottai	Semi Critical
3	Athani		Pudukkottai	safe
4	Avudaiyarkoil		Pudukkottai	safe
5	Illuppur		Pudukkottai	safe
6	Karaiyur		Pudukkottai	Semi Critical
7	Keelanilai		Pudukkottai	safe
8	Kodumbalur		Pudukkottai	Semi Critical
9	Kottaipattinam		Pudukkottai	salinity
10	Kottur(P)		Pudukkottai	Semi Critical
11	Kudumiyanmalai		Pudukkottai	safe
12	Manamelkudi		Pudukkottai	safe
13	Nagudi		Pudukkottai	safe
14	Narthamalai		Pudukkottai	Semi Critical
15	Perumaruthur		Pudukkottai	salinity
16	Ponnamaravathy		Pudukkottai	Semi Critical
17	Ponpette		Pudukkottai	safe
18	Pudukkottai		Pudukkottai	safe
19	Sengeerai		Pudukkottai	safe
20	Silattur		Pudukkottai	safe

Sl.No	Firka	Sub-Basin	District	Categorisation of Firkas
21	Sinkavanam	South Vellar	Pudukkottai	salinity
22	Sithanavasal		Pudukkottai	safe
23	Thirumayam		Pudukkottai	safe
24	Vallanadu		Pudukkottai	safe
25	Veerapatty		Pudukkottai	safe
26	Vennavalkudi		Pudukkottai	Semi Critical
27	Virachilai		Pudukkottai	safe
28	Marungapuri		Tricuchirapalli	Over Exploited
29	Panapatti		Tricuchirapalli	Over Exploited
30	Thuvarangurichi		Tricuchirapalli	Over Exploited
31	Valanadu		Tricuchirapalli	safe
32	Nerkuppai		Sivagangai	safe
33	Varappur		Sivagangai	safe
34	Perumagalur		Thanjavore	safe
35	Sendurai		Dindigul	Semi Critical
36	Alangudi(P)	Ambuliyar	Pudukkottai	safe
37	Aranthangi		Pudukkottai	safe
38	Arasarkulam		Pudukkottai	Semi Critical
39	Athani		Pudukkottai	safe
40	Keeramangalam		Pudukkottai	Semi Critical
41	Malaiyur(P)		Pudukkottai	safe
42	Nagudi		Pudukkottai	safe
43	Poovathakudi		Pudukkottai	safe
44	Pudukkottai		Pudukkottai	safe
45	Silattur		Pudukkottai	safe
46	Vallanadu		Pudukkottai	safe
47	Varappur(P)		Pudukkottai	safe
48	Vennavalkudi		Pudukkottai	Semi Critical
49	Andikkadu		Thanjavore	Over Exploited
50	Avanam		Thanjavore	Over Exploited
51	Kuruvikarambai		Thanjavore	Over Exploited
53	Peravurani		Thanjavore	Semi Critical
53	Perumagalur		Thanjavore	Safe
54	Tiruchitrambalam		Thanjavore	Over Exploited
55	Alangudi(P)	Agniyar	Pudukkottai	Safe
56	Gandarvakottai		Pudukkottai	Safe
57	Illuppur		Pudukkottai	Safe
58	Kallakkottai		Pudukkottai	Safe
59	Karambakudi		Pudukkottai	Safe
60	Keeranur		Pudukkottai	Safe
61	Killukkottai		Pudukkottai	Safe
62	Kudumiyanmalai		Pudukkottai	Safe
63	Kunnandarkoil		Pudukkottai	Safe
64	Malaiyur(P)		Pudukkottai	Safe

Sl.No	Firka	Sub-Basin	District	Categorisation of Firkas
65	Mathoor	Agniyar	Pudukkottai	Safe
66	Narthamalai		Pudukkottai	Semi Critical
67	Pudukkottai		Pudukkottai	Safe
68	Pudunagar		Pudukkottai	Safe
69	Sithanavasal		Pudukkottai	Safe
70	Varappur(P)		Pudukkottai	Safe
71	Veerapatty		Pudukkottai	Safe
72	Adirampattinam		Thanjavore	Over Exploited
73	Andikkadu		Thanjavore	Over Exploited
74	Avanam		Thanjavore	Over Exploited
75	Eachankottai		Thanjavore	Safe
76	Kavalipatti		Thanjavore	Over Exploited
77	Kurichi(T)		Thanjavore	Semi Critical
78	Kuruvikarambai		Thanjavore	Over Exploited
79	Madukkur		Thanjavore	Over Exploited
80	Nambivayal		Thanjavore	Critical
81	Nanjikottai		Thanjavore	Over Exploited
82	Orathanad		Thanjavore	Semi Critical
83	Pattukkottai		Thanjavore	Over Exploited
84	Sillathur		Thanjavore	Over Exploited
85	Thambikkottai		Thanjavore	Critical
86	Thekkur		Thanjavore	Semi Critical
87	Thondarampattu		Thanjavore	Over Exploited
88	Thuvarankurichi		Thanjavore	Over Exploited
89	Tiruchitrambalam		Thanjavore	Over Exploited
90	Ulur		Thanjavore	Critical
91	Vallam		Thanjavore	Over Exploited

Table 6.8 Summary of Categorization of Firkas

Sl.No	Category	2020 Assessment
1	Safe	35
2	Semi Critical	14
3	Critical	3
4	Over Exploited	16
5	Salinity	3
	Total	71

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 isignored 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	South vellar	506.58	263.25	260.02	51.97
2	Ambuliyar	211.70	139.53	76.40	65.91
3	Agniyar	618.60	507.26	147.51	82
	TOTAL	**1336.88**	**910.04**	**483.93**	**199.88**

(Source: Dynamic Ground Water Resources of the State of Tamilnadu as on March 2020, SG&SWRDC, WRD, Chennai)

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

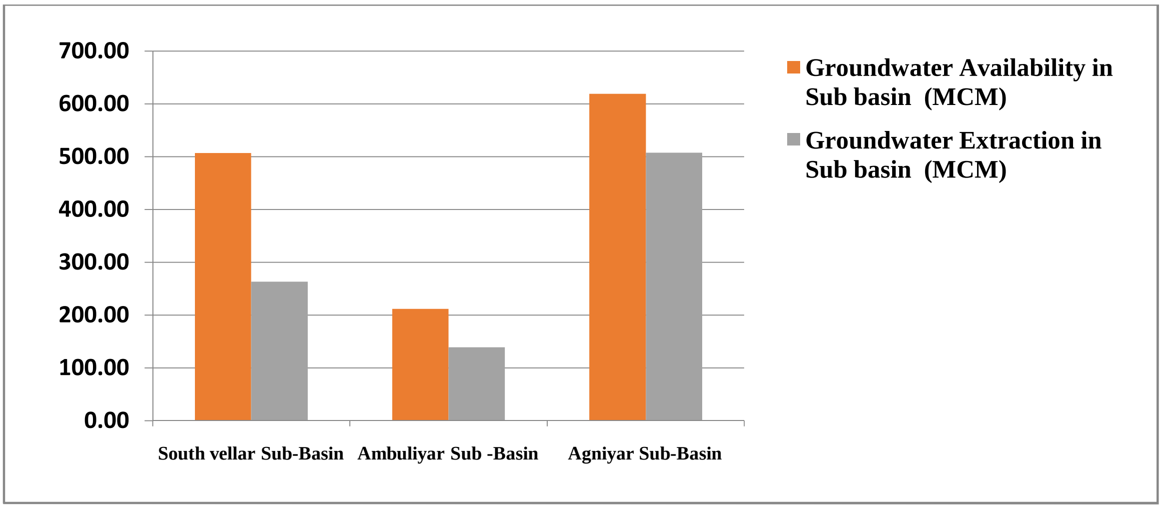


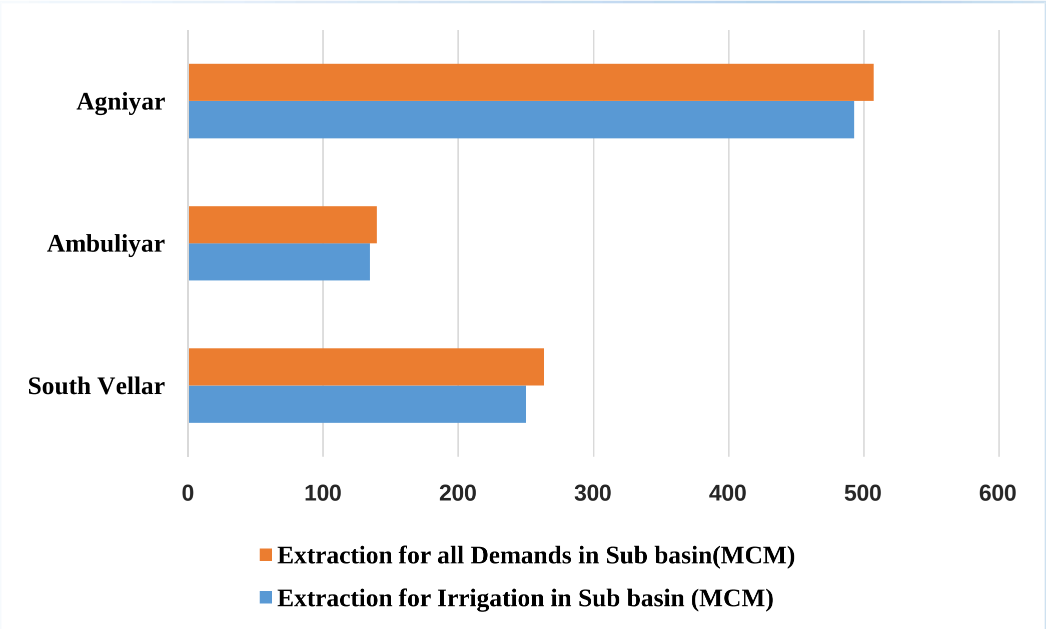
Table 6.10 shows the comparison of groundwater extraction for irrigation demand with respect to total extraction for all demands, based on 2020 assessment. The same is shown pictorially in **Fig: 6.2**.

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	South vellar	263.25	250.27	**95.07**
2	Ambuliyar	139.53	134.56	**96.44**
3	Agniyar	507.26	492.96	**97.18**
	TOTAL	**910.04**	**877.79**	**96.5**

(Source: Dynamic Ground Water Resources of the State of Tamilnadu as on March 2020, SG&SWRDC, WRD, Chennai)

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 Agniyar earlier in 2008 based on assessment done during 2003 with Block as unit. Presently it is calculated with latest assessment done in March 2020 with Firka as unit. The comparison of the above is presented in **Table 6.11**

Table: 6.11 Comparison of groundwater assessment: 2008 and 2020

Sl. No	Sub-Basin	Annual Groundwater Availability (MCM)		Annual Groundwater Extraction (MCM)		Balance Annual Groundwater Availability (MCM)		Stage of Development (%)	
		2008	2020	2008	2020	2008	2020	2008	2020
1	South vellar	331.82	506.58	83.17	263.25	249.31	260.02	25.06	51.97
2	Ambuliyar	108.31	211.70	58.70	139.53	49.61	76.40	54.20	65.91
3	Agniyar	388.73	618.60	170.33	507.26	218.40	147.51	43.81	82
	TOTAL	**828.86**	**1336.88**	**312.20**	**910.04**	**509.32**	**483.93**	**123.07**	**199.88**
	Change	**Increased by 61.29%**		**Increased by 191.50%**		**Decreased by 5%**		**Increased by 62.41%**	

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 116 observation wells and bore wells **(Plate : AG 46)** were taken for the study, for the pre monsoon period of the year 2020 (July 2020).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

Sl.No	Parameter	BIS Standards		WHO Guideline
		Desirable Limit	Permissible limit	Maximum allowable Concentration
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 Agniyar river basin of Tamilnadu.

6.7.3 Groundwater quality scenario in Agniyar River Basin

Water quality data of Pudukkottai, Trichy, Thanjavur, Dindigul and Sivagangai districts coming under the jurisdiction of Agniyar river basin were collected from the Office of the Chief Engineer, State Ground & Surface Water Resources Data Center, Tharamani, Chennai. A total of

116 wells (Observations wells and Bore wells) were analyzed for the study for the pre monsoon period of 2020. The list of wells is listed in **Table 6.14.**

Table 6.14 Groundwater sampling locations in Agniyar Basin

Well No	District	Village	Lat	Long	Source
43077	Pudukkottai	Mudukulam	10.5842	79.0806	CW
43078	Pudukkottai	Adanakkottai	10.5194	78.9583	CW
43079	Pudukkottai	Ganapathipuram	10.5300	79.0222	CW
43044	Pudukkottai	Kattumavadi	10.1292	79.2250	CW
43045	Pudukkottai	Aranthangi Jail	10.1722	79.0000	CW
43086	Pudukkottai	Nagudi	10.1531	79.1097	CW
43087	Pudukkottai	Manamelkudi	10.0389	79.2306	CW
12002D	Pudukkottai	Vilappatti	10.5667	78.7125	BW
12010	Pudukkottai	Maravamadurai	10.3958	78.5528	BW
12018D	Pudukkottai	Rappoosal	10.5264	78.6875	BW
12023D	Pudukkottai	Peraiyur	10.3403	78.7542	BW
12024D	Pudukkottai	Nagarappatti	10.3569	78.5236	BW
12025D	Pudukkottai	Sevalur	10.2944	78.6333	BW
12027D	Pudukkottai	Thekkattur	10.2986	78.7903	BW
12055	Pudukkottai	Keeranur	10.5719	78.7833	BW
12011D	Pudukkottai	Thuthur	10.3133	78.5431	BW
73130	Pudukkottai	Idaiyappatti	10.4947	78.6278	CW
73132	Pudukkottai	Muttukkadu	10.4903	78.8108	CW
73149	Pudukkottai	Mekkinipatti	10.3100	78.6361	CW
73150	Pudukkottai	Lembalakudy	10.3106	78.7261	CW
73165	Pudukkottai	Namanasamudiram	10.3294	78.7725	CW
73166	Pudukkottai	Menampatti	10.2681	78.8306	CW
73177	Pudukkottai	Aanaipatti	10.4194	78.4872	CW
73372	Pudukkottai	Sithanavasal - 1	10.4667	78.7169	CW
73373	Pudukkottai	Sithanavasal - 2	10.4669	78.7169	CW
73374	Pudukkottai	Kunnandarkoil	10.5836	78.8853	CW
73378	Pudukkottai	Virachilai - 1	10.2847	78.7003	CW
73401	Pudukkottai	Kunnandarkovil 2	10.5833	78.8853	CW
PDK MWS 2	Pudukkottai	Parambur	10.4372	78.6381	BW
12028	Pudukkottai	Mullur	10.4208	78.8597	BW
12029	Pudukkottai	Cholagampatti	10.6528	78.9556	BW
12032D	Pudukkottai	Alangudi	10.3639	78.9833	BW
12033D	Pudukkottai	Kilangadu	10.5639	79.1542	BW
12035D	Pudukkottai	Echanviduthi	10.3972	79.1472	BW
12036D	Pudukkottai	Vembanpatti	10.5417	79.0806	BW
12037D	Pudukkottai	Melpanaikkadu	10.2625	79.1250	BW
12038D	Pudukkottai	Manalur	10.0486	79.1639	BW
12039D	Pudukkottai	Manamelkudi	10.0375	79.2333	BW
12040D	Pudukkottai	Manamelkudi	10.0375	79.2333	BW
12042D	Pudukkottai	Arayappatti	10.3028	78.9694	BW

Well No	District	Village	Lat	Long	Source
12047D	Pudukkottai	Perungalur	10.4917	78.9306	BW
12056	Pudukkottai	Perumaruthur - 2	10.1053	79.1733	BW
12057	Pudukkottai	Thilargalthidal	10.3858	78.8156	BW
12076	Pudukkottai	Nagudi	10.1517	79.1053	BW
73144	Pudukkottai	Mangottai	10.3958	78.9758	CW
73160	Pudukkottai	Maruthakon Viduthi	10.5167	79.1219	CW
73168	Pudukkottai	Keelathur	10.3575	79.0347	CW
73171	Pudukkottai	Punalkulam	10.6522	79.0517	CW
73172	Pudukkottai	Manganoor	10.6103	78.9644	CW
73281A	Pudukkottai	Aranthangi	10.1694	79.0000	CW
73368	Pudukkottai	Poovathakudi	10.2356	79.0636	CW
73369	Pudukkottai	Silattur	10.2350	78.9933	CW
73375	Pudukkottai	Kottaipattinam	9.9786	79.1986	CW
73377	Pudukkottai	Sinkavanam	10.1053	79.1906	CW
73381	Pudukkottai	Valanadu	10.3336	78.8792	CW
73383	Pudukkottai	Mattangal	10.5672	79.0361	CW
73388	Pudukkottai	Kallakottai	10.5289	79.1031	CW
73394	Pudukkottai	Arasarkulam Vadapathi	10.2111	79.1075	CW
73395	Pudukkottai	Aadudayarkovil	10.0753	79.0431	CW
73397	Pudukkottai	Manjagudi	9.9833	79.1711	CW
MMWS PDK 3`	Pudukkottai	Aliyanilai	10.1986	78.9667	BW
PDK MWS 6	Pudukkottai	Palaiyur	10.2725	78.9069	BW
PDK MWS8	Pudukkottai	Manjanviduthi	10.3844	78.9144	BW
12051	Pudukkottai	Manamelkudi Pwd	10.0406	79.2325	BW
73380	Pudukkottai	Kothamangalam	10.3114	79.0503	CW
PDKMWS19	Pudukkottai	Vellanur	10.4689	78.7950	BW
11034D	Thiruchirapalli	Kiranippatti	10.4056	78.5083	BW
MMWS TRY1	Thiruchirappalli	Chinnagoundanpatti	10.4236	78.4597	BW
11009D	Thiruchirapalli	Palayapalayam	10.3556	78.3486	BW
11010D	Thiruchirapalli	Pudupatti	10.4667	78.5472	BW
11053	Thiruchirapalli	Sevanthanpatti	10.3231	78.3858	BW
11055	Thiruchirapalli	Piranpatti	10.4800	78.4714	BW
08010D	Thanjavur	Thiruchitrambalam	10.3639	79.2028	BW
08014D	Thanjavur	Eachankottai	10.6625	79.1694	BW
8016	Thanjavur	Poyyundarkottai	10.6167	79.1472	BW
8018	Thanjavur	Peravurani	10.2833	79.2028	BW
8035	Thanjavur	Kurungulam	10.6569	79.1011	BW
8036	Thanjavur	Orathanadu	10.6108	79.2578	BW
8037	Thanjavur	Thiruvonam	10.5061	79.1594	BW
8038	Thanjavur	Pattukkotai	10.4200	79.3281	BW
8042	Thanjavur	Vallam	10.7183	79.0619	BW
8044	Thanjavur	Kurungulam Fcs	10.7000	79.0917	BW
43009	Thanjavur	Vallam	10.7183	79.0611	CW
43038	Thanjavur	Thiruvonam	10.6383	79.1622	CW
43065	Thanjavur	Puthur	10.7264	79.1972	CW

Well No	District	Village	Lat	Long	Source
43069	Thanjavur	Orathanadu	10.6292	79.2542	CW
43072	Thanjavur	Alathur	10.4903	79.3486	CW
43076	Thanjavur	Marungulam	10.6775	79.1394	CW
43116	Thanjavur	Avanam	10.3281	79.1369	CW
43117	Thanjavur	Chittathikadu	10.2714	79.1636	CW
43118	Thanjavur	Alivalam	10.4136	79.2764	CW
43119	Thanjavur	Ottankadu	10.3475	79.2467	CW
43120	Thanjavur	Enadhi	10.4664	79.2844	CW
43123	Thanjavur	Panchanathikottai	10.6753	79.1931	CW
43124	Thanjavur	Thekkur	10.5669	79.1908	CW
43157	Thanjavur	Melaponnapur	10.6769	79.2375	CW
43183	Thanjavur	Krishnapuram	10.5697	79.1931	CW
43184	Thanjavur	Periyanayagipuram	10.3422	79.1617	CW
43186	Thanjavur	Veppankadu	10.4883	79.2719	CW
43188	Thanjavur	Avidanallavijayapuram	10.5636	79.1719	CW
43213	Thanjavur	Konavallundanpatttu	10.7117	79.1414	CW
43214	Thanjavur	Samipatti	10.6414	79.1283	CW
43215	Thanjavur	Karukkadi Patti	10.5867	79.1850	CW
43218	Thanjavur	Uranipuram	10.4936	79.1925	CW
43220	Thanjavur	Thennankadi	10.3144	79.2136	CW
43221	Thanjavur	Peravurani	10.2881	79.2017	CW
43222	Thanjavur	Orathanadu	10.6397	79.2433	CW
43223	Thanjavur	Vettikadu	10.5728	79.1936	CW
43226	Thanjavur	Vattathi Kottai Kollukadu	10.4058	79.1944	CW
43227	Thanjavur	Punavasal	10.3544	79.2153	CW
43228	Thanjavur	Naduvikottai	10.4064	79.2775	CW
43230	Thanjavur	Pattukkottai	10.4244	79.3000	CW
43231	Thanjavur	Ullur	10.6917	79.2328	CW
43125	Thanjavur	Vellore	10.5669	79.2908	CW
43127	Thanjavur	Vettikadu	10.5697	79.1931	CW
24014	Sivagangai	Varappur	10.3500	78.4750	BW

Note: BW – Bore Well; CW – Control Well

The groundwater quality of the Agniyar River basin 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 2020 were collected and analyzed 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 Agniyar river basin is detailed below sub basinwise:

Agniyar Sub basin

Total Dissolved Solids (TDS) is the most important deciding factor for water quality determination and represents the total concentration of dissolved substances in water. TDS value in the sub basin rages from 69 mg/l to 4099 mg/l. The lowest value is observed in Punalkulam village in Pudukkottai district and the highest value is observed in Mudukulam village in Pudukkottai district. Generally the value is within the desirable limit of 500 mg/l in most of the wells while a few wells have a moderate value of TDS in the range of 2000 mg/l.

Total Hardness is another important parameter for water quality determination. Total Hardness value is good (<300 mg/l) in almost all the wells in the sub basin. Only a few wells have TH value greater than 300 mg/l and falls under moderate category. Highest value of TH (2200mg/l) is observed in Mudukulam village in this sub basin.

Apart from TDS and TH, chloride is also an important parameter for water quality. Good to moderate quality of chloride (250 - 1000 mg/l) is observed in all the blocks of the sub basin whereas a few part of Gandarvakottai block shows poor quality of chloride.

Generally the water quality is good in most of the blocks and moderate in a few blocks of this sub basin. Poor quality is observed in Mudukulam village in this sub basin.

Ambuliyar Sub basin

TDS value in the basin ranges from 129 mg/l to 6062 mg/l in the basin. Lowest value is observed in Poovathakudi village and the highest value is observed in Nagudi village of Pudukkottai District. Generally the TDS value in the basin ranges from good (<500 mg/l) to moderate value (500 – 2000mg/l) in the basin. Poor quality of TDS is observed in Nagudi village in the sub basin.

TH value is within the desirable limit of 300 mg/l in almost all the wells in this sub basin except Nagudi village where the value observed is 3000mg/l which is of poor quality.

Chloride value is also within the standards (<250 mg/l) specified for drinking purposes. Moderate quality 250 – 1000 mg/l is observed in a few wells while poor quality is observed in Nagudi village in the sub basin.

South Vellar Sub basin

Generally the TDS value in the sub basin ranges from good (<500mg/l) to moderate value (500 – 2000mg/l) in most of the blocks except parts of Avudaiyarkoil, Manamelkudi, Aranthangi and Sethubavachatram blocks where the value of TDS is above the permissible limit of 2000 mg/l.

TH value in the sub basin ranges from 50 mg/l (Aanaipatti village) to 1560 mg/l (Manjakudi village). Poor quality of TH is observed in fewer parts of Ponnamaravathi and

Pudukkottai blocks and considerably larger parts in Aranthangi, Avudaiyarkoil, Manamelkudi and Sethubavachatram blocks.

Generally the chloride value ranges from good (<250 mg/l) to moderate value (250 -1000 mg/l) in the sub basin while the tail end of the sub basin shows poor quality of chloride which is above the permissible limit of 1000 mg/l.

Table 6.15 Groundwater quality observation and % sample violation with respect to drinking water standards in Agniyar 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 116 samples)	Observation
1	pH value	7.1 - 8.8	6.5 – 8.5	88 % within desirable limit while 12% has pH value higher than 8.5	Most of the wells falls within the desirable limit of 6.5 – 8.5.
2	Total Hardness (as $CaCO_3$)	35 - 3000	300-600	80% within DL while 10% exceeds the DL but are within the permissible limit. 10% exceeds the permissible limit.	Value of TH is good to moderate in most of the blocks while poor quality is observed in Aranthangi, Avudaiyarkoil & Manamelkudi blocks in the basin.
3	Chloride	18 - 3914	250 - 1000	77% within DL while 16% within PL. 7% exceeds the permissible limit.	Chloride value is good to moderate except parts of Gandarvakottai and south eastern part of the basin where the quality is poor.
4	Total Dissolved Solids	69 - 6062	500-2000	62 % within DL while 30 % within PL. 8% falls under poor category.	TDS value is generally good to moderate. Parts of south eastern blocks show poor quality in the basin.
5	Calcium	6 - 192	75-200	91 % of samples comes under DL and 9% comes under PL .	All the values fall within the permissible limit.

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 116 samples)	Observation
6	Sulphate	1 - 572	200-400	94 % of water samples fall within the DL. 3% of water samples fall within permissible limit and 3% of water samples fall under poor category.	Most of the samples fall within desirable to permissible limit.
7	Nitrate	0.1 - 42	45	100 % of samples fall within the desirable limit.	All the samples are well within the desirable limit of drinking water.
8	Fluoride	0.1 – 1.9	1.0-1.5	93 % of samples fall within the desirable limit. 5% of samples fall under permissible limit and 2 % of samples show slightly higher range.	Generally the fluoride value is good to moderate in the basin.
9	Sodium	2 – 1438	200(WHO limit)	83 % comes under WHO limit while 17 % exceeded the WHO limit.	Sodium concentration above 1000mg/l is observed in Manjagudi, Kattumavadi, Nagudi and Sinkavanam villages. High sodium concentration is not suitable for irrigation purpose due to sodium sensitivity of crops / plants.
10	Potassium	0.1 - 141	Not prescribed	75 % of samples have potassium value below 10 mg/l while 25 % of samples have potassium value above 10 mg/l	The BIS has not included potassium in drinking water standards.
11	Magnesium	5 - 612	30 - 100	56 % falls within DL ; 33% falls within PL ; 11% falls under poor category	Higher magnesium values are observed in Mudukulam and Nagudi villages.

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 116 samples)	Observation
12	Electrical Conductivity (µS/cm)	120 - 11000	1000	69 % comes within DL; 22% comes within PL and 9 % comes under poor category.	Higher EC values are observed in Kattumavadi, Mudukulam, Manjagudi, Sinkavanam and Nagudi villages in Pudukkottai district.
13	Alkalinity (as HCO3)	29 - 445	200-600	84 % falls within DL; 16 % 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 69 mg/l (Punalkulam village) to 6062 mg/l (Nagudi village). Poor quality is observed in parts of Gandarvakottai, Aranthangi, Manamelkudi, Avudaiyarkoil and Sethubavachatram blocks in the basin.
   (**Plate :AG 47**)
2. The TH value in the basin ranges from 35 mg/l to 3000 mg/l in the basin. Poor quality of TH which is above the permissible limit is observed in the tail end of the basin.
   (Plate :AG 48)
3. The chloride value in the basin ranges from 18 mg/l to 3914 mg/l. Generally the Chloride value above the permissible limit is observed in Manamelkudi, Kattumavadi, Mudukulam, Manjagudi, Sinkavanam and Nagudi villages in Pudukkottai district.
   (Plate :AG 49)
4. pH value is within the desirable limit of the BIS standards in most of the wells in the basin.
5. Nitrate value is within the desirable limit of 45 mg/l in all the wells in the sub basin.
6. Fluoride value is good to moderate in the basin.
7. Generally the water quality is good to moderate in the basin while in the south eastern part of the basin the quality is poor in some of the blocks 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

Sl.No	Nature of soil	Crop growth	Upper permissible limit of EC in water µmhos/cm at 25˚C
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
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

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
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
8	Total residual chlorine	1.0	-	-	1.0
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

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
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.

Sl.No.	Parameters	Prescribed limits IS:10500, 1991		Probable effects
		Desirable limit	Permissible limit	
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 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.
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

Sl.No.	Parameters	Prescribed limits IS:10500, 1991		Probable effects
		Desirable limit	Permissible limit	
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 greatimportance 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 augmentationof 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 ingresseffectively. In case of urban areas and hilly terrains with high rainfall, roof top rain water structures are most useful.

Data on Artificial Recharge Structures (ARS) constructed in the recent years were obtained from the office of Chief Engineer, Madurai Region, WRD. The list of ARS constructed in Agniyar basin is listed in **Table 6.22**.

Table 6.22 List of ARS already Constructed in Agniyar Basin

Sl. No	Name of the work	G.O.No & Date	Project Cost (In Crores)	Name of Sub basin	Location (Lat & Long)	Funded By	Project Status
1	Construction of check dam across S.F.No. 156 of Mattangal tank surplus course in Gandarvakottai Talukof Pudukkottai District.	G.O.Ms.No . 49 / PW / R2 / Dept / Dated: 23.02.2011	0.29	Agniyar	**10 36' 4.79" / 78 28' 32.51"**	State Fund	work completed
2	Construction of Checkdam across S.F.No. 153 of Punakulam Odai in Gandarvakottai Taluk of Pudukkottai District.	G.O.Ms.No . 51 / PW / R2 / Dept / Dated: 23.02.2011	0.22	Agniyar	**10 38'55" / 79 03'00"**	State Fund	work completed
3	Construction of Check dam across South Vellar river in Thiruvudaiyarpatti Village of Alangudi taluk in Pudukkottai District.	State Planning commission, Chennai. Proc. No. 545 / 2014 / IPT / SPC / date: 14.10.2014	2.27	South Vellar	**10 18'07" / 78 51'45"**	SBG Fund	work completed

(Source : South Vellar Basin Division, WRD, Pudukkottai)

Table 6.23 List of Irrigation Schemes already Executed in Agniyar Basin

Sl. No	Name of the Scheme	Name of the Sub basin	Estimate Amount (In Crores)
1	Traditional Water Bodies - Phase - II	South Vellar	0.09
2	Traditional Water Bodies - Phase - II	Agniyar	0.098
3	TN - IAMWARM - Left out works	South Vellar	4.04
4	TN - IAMWARM - Additional DPR (South Vellar Phase I)	South Vellar	11.99
5	TN - IAMWARM - Additional DPR (Agniyar Phase I)	Agniyar	7.00
6	Kudimaramath Scheme 2016-2017	Agniyar	0.82
	Kudimaramath Scheme 2016-2017	South Vellar	1.37
7	Kudimaramath Scheme 2017-18	Agniyar	2.71
	Kudimaramath Scheme 2017-18	South Vellar	3.44
8	Kudimaramath Scheme 2019-2020	Agniyar	3.5
	Kudimaramath Scheme 2019-2020	South Vellar	9.62
9	Kudimaramath Scheme 2020-2021	Agniyar	0.26
	Kudimaramath Scheme 2020-2021	South Vellar	7.32
10	State Fund Scheme	South Vellar	2.98
11	NABARD Funded Scheme	Agniyar	1.13
12	RRR - Phase VI	Agniyar	6.83
13	RRR - Phase VI	South Vellar	7.25
14	RRR - Phase VII	South Vellar	5.05
15	RRR - Phase VII	Agniyar	4.51
16	RRR - Phase VII	Ambuliyar	1.46
17	RRR - Phase VIII	Agniyar	6.95
18	RRR - Phase VIII	South Vellar	5.78

(Source : South Vellar Basin Division, WRD, Pudukkottai)

6.8.2 Demand-side Management of Groundwater

In Agniyar basin, the total groundwater extraction is **910.04 MCM** out of which the extraction for irrigation sector is **877.79 MCM.**

Table: 6.24 Groundwater Availability and Extraction as per 2020 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	South vellar	506.58	250.27	12.98	263.25	**95.07**
2	Ambuliyar	211.70	134.56	4.97	139.53	**96.44**
3	Agniyar	618.60	492.96	14.30	507.26	**97.18**
	Total	**1336.88**	**877.79**	**32.25**	**910.04**	**96.5**

It is observed that the Ground water Extraction in Agniyar basin for irrigation is 96.5% whereas the total ground water extraction for all demands in Tamilnadu is 83%. 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

49 wells spread over the entire Agniyar 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.

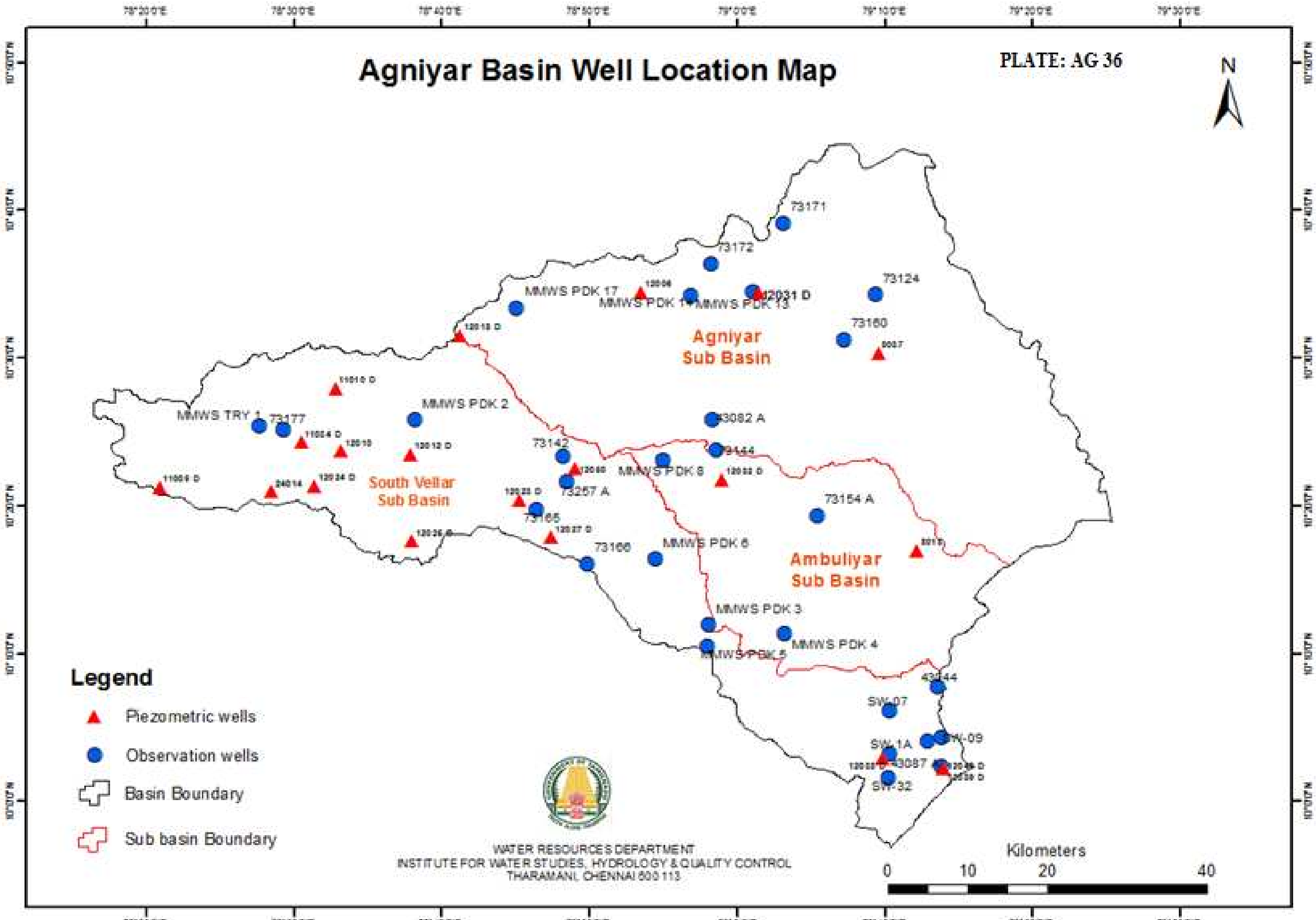
- ❖ Net annual groundwater availability in Agniyar Basin is 1336.88 MCM and total annual groundwater extraction in the basin is 910.04 MCM (68.07%). The balance groundwater available for further development is 483.93 MCM.
- ❖ Whilst comparing the groundwater resources of Agniyar Basin calculated in Appraisal report prepared in 2008 with this Reappraisal report, it is observed that the total annual groundwater availability has increased by **61.29%** (from 828.86

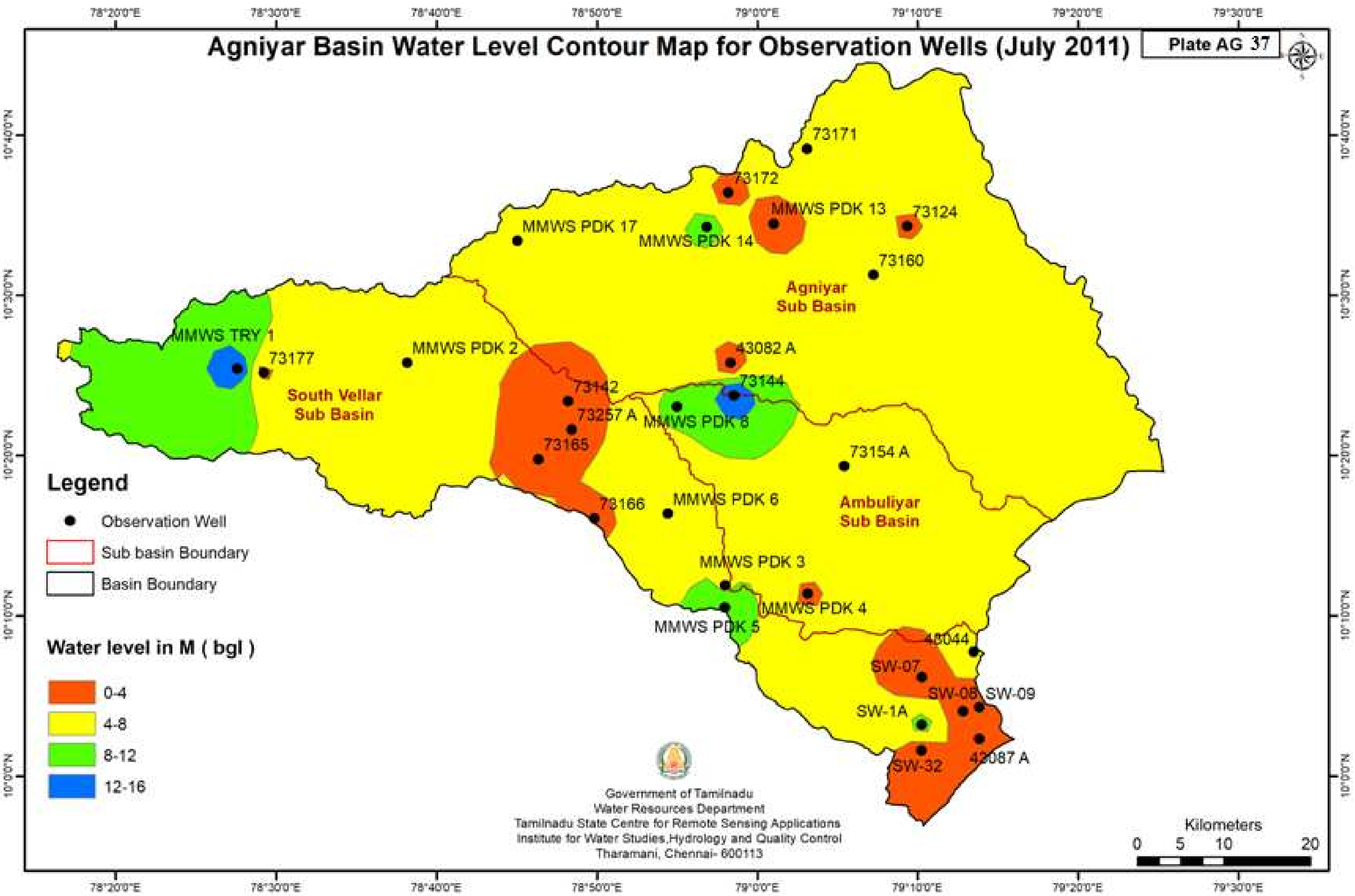
MCM to 1336.88 MCM) and total annual groundwater extraction has also increased by **191.50%** (from 312.20 MCM to 910.04 MCM). The balance annual groundwater availability of is decreased by **5 %** (from 509.32 MCM to 483.93 MCM)

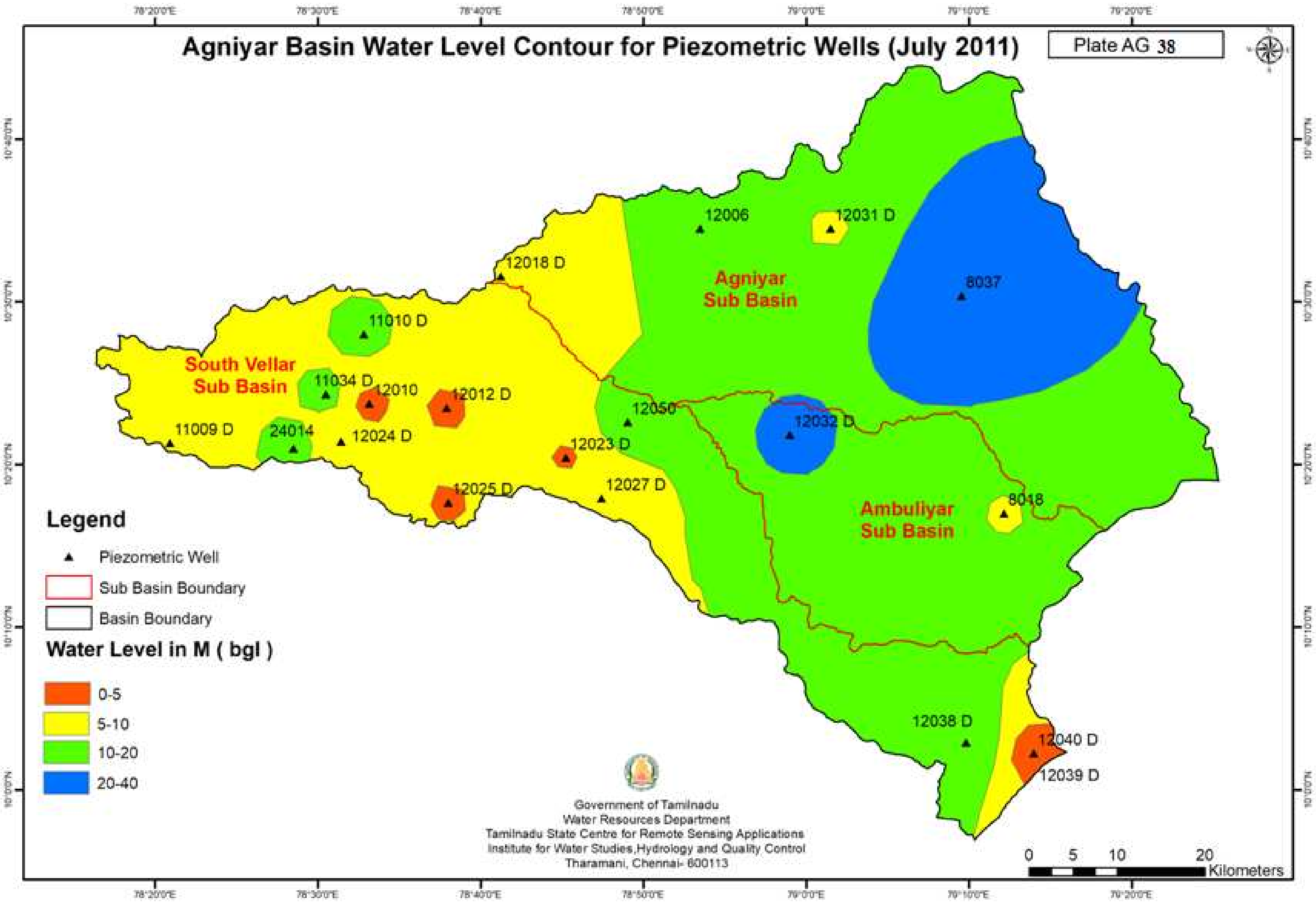
- Annually groundwater extracted for irrigation in Agniyar basin is **877.79** MCM which is 96.50 % in total annual groundwater extraction of **910.04** MCM for all sectoral demands.

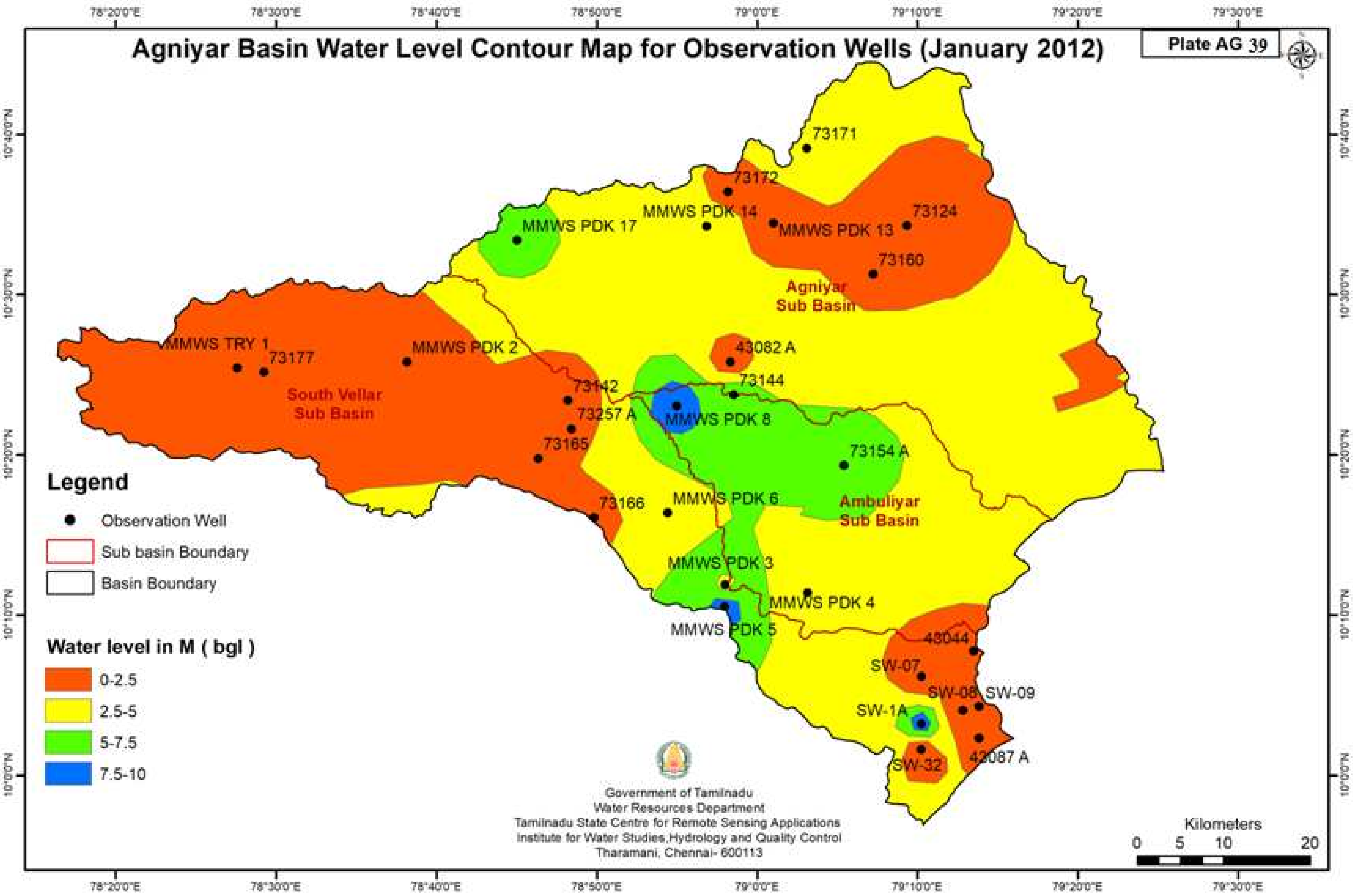
Recommendations:

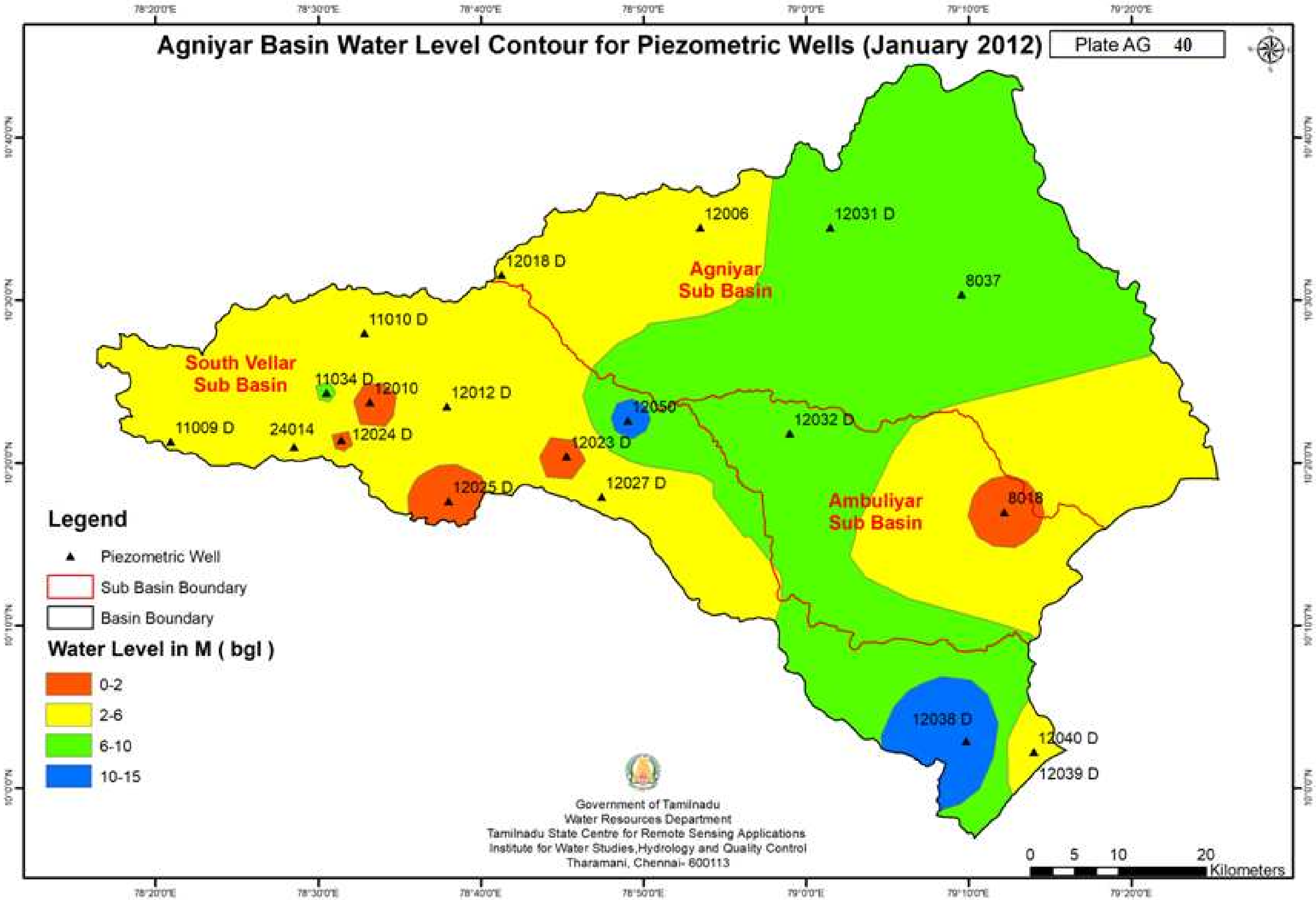
- Even though the Groundwater extraction for all demands is 68.07%, the extraction for
- irrigation sector in Agniyar basin is high at 96.50% in total extraction. In order to reduce the groundwater extraction for irrigation, modern irrigation method like drip and sprinkler irrigation and latest cultivation practices like System of Rice Intensification (SRI) and Sustainable Sugarcane Initiative (SSI) have to be implementedin large scale.

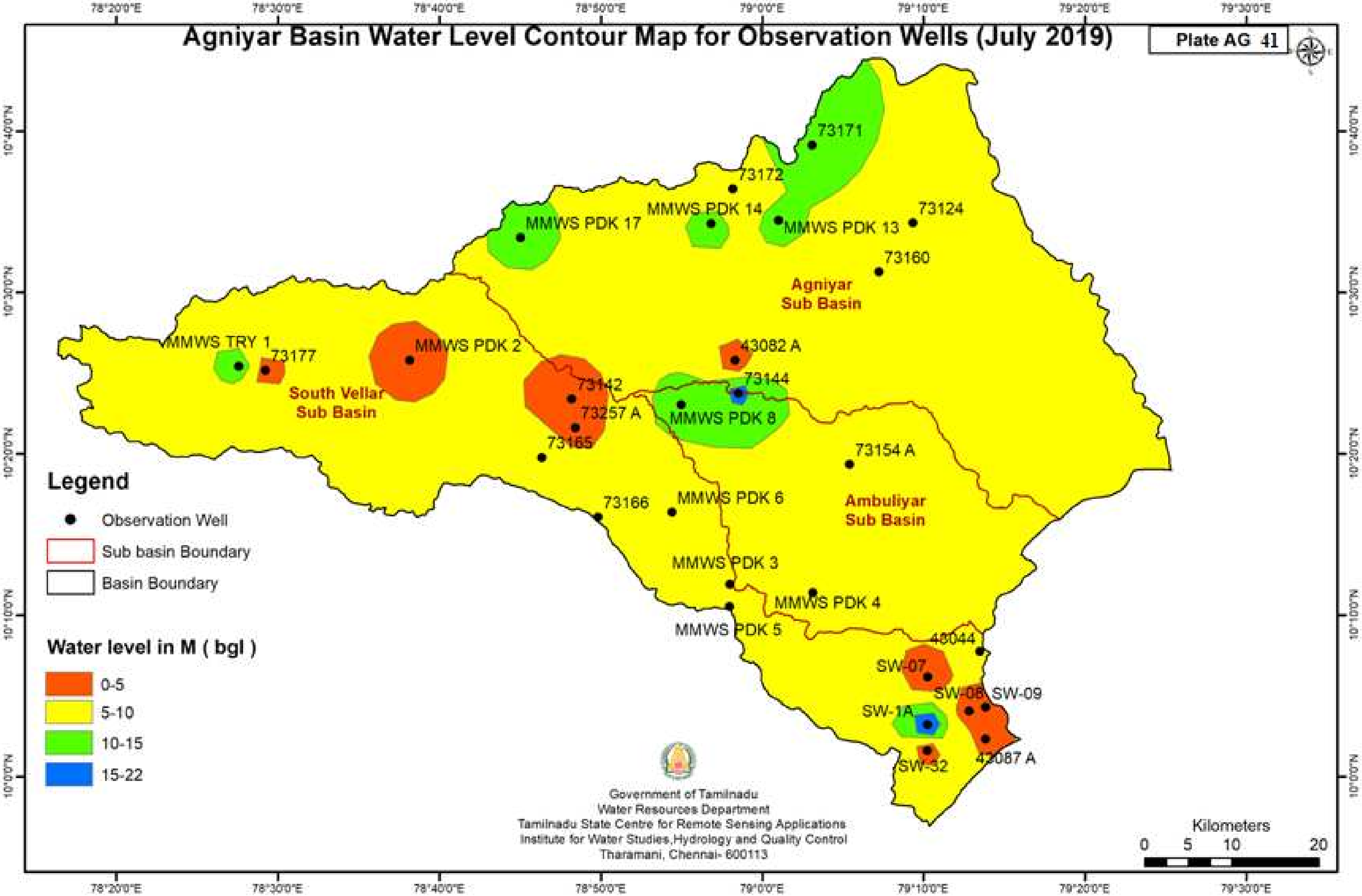

Agniyar Basin Well Location Map
PLATE: AG 36
N
Agniyar Sub Basin
South Vellar Sub Basin
Ambuliyar Sub Basin
73171
73172
73124
73160
MMWS PDK 17
MMWS PDK 2
MMWS TRY 1
73177
73142
73257 A
73165
73166
MMWS PDK 6
MMWS PDK 3
MMWS PDK 4
73154 A
SW-07
SW-1A
SW-09
SW-32
Legend
Piezometric wells
Observation wells
Basin Boundary
Sub basin Boundary
WATER RESOURCES DEPARTMENT
INSTITUTE FOR WATER STUDIES, HYDROLOGY & QUALITY CONTROL
THARAMANI, CHENNAI 600 113
Kilometers
0
10
20
40

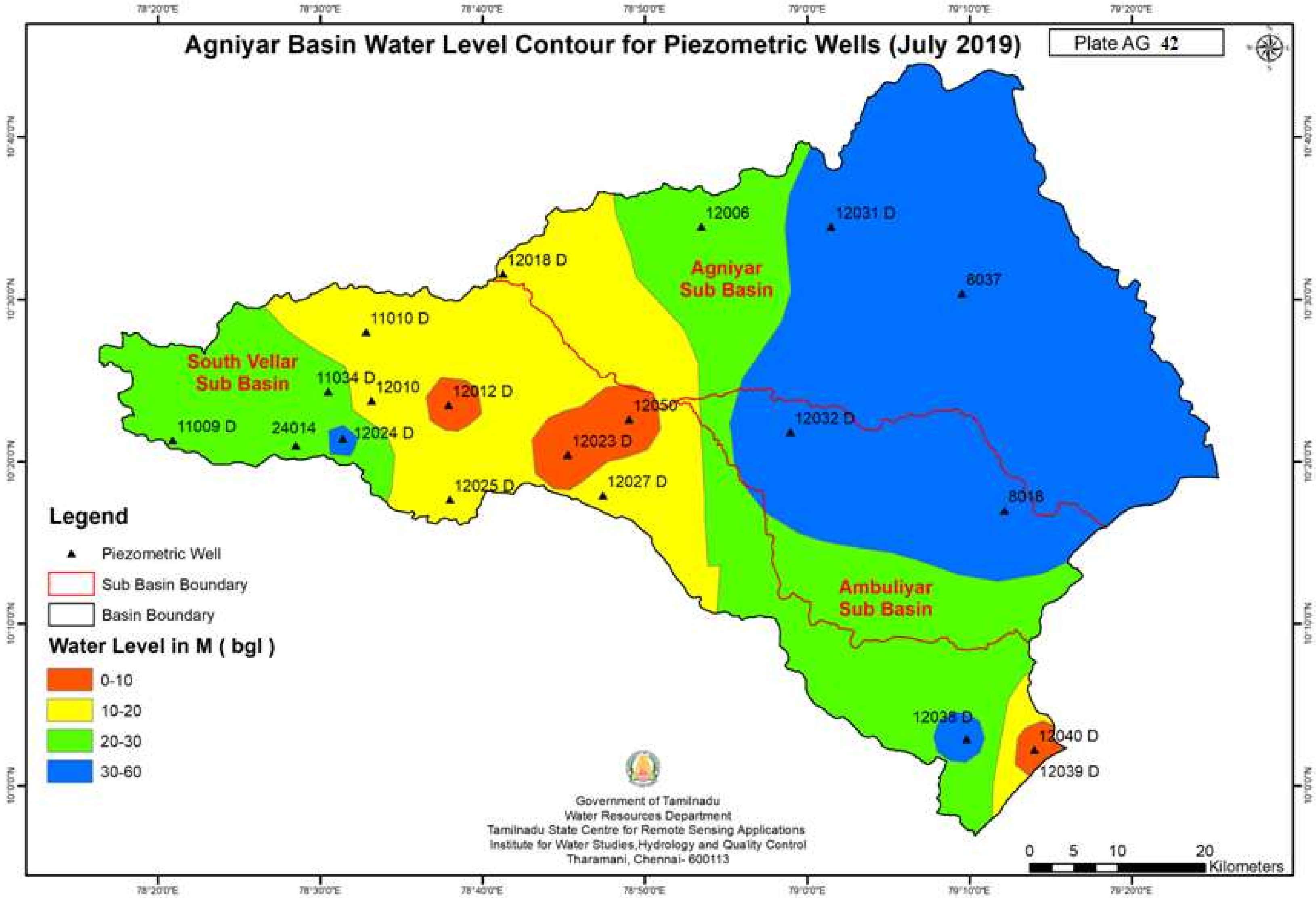

Agniyar Basin Water Level Contour Map for Observation Wells (July 2011)
Plate AG 37
78°20'0"E
78°30'0"E
78°40'0"E
78°50'0"E
79°0'0"E
79°10'0"E
79°20'0"E
79°30'0"E
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
10°0'0"N
73171
73172
MMWS PDK 13
73124
MMWS PDK 17
MMWS PDK 14
73160
Agniyar Sub Basin
MMWS TRY 1
73177
MMWS PDK 2
43082 A
South Vellar Sub Basin
73142
73144
73257 A
MMWS PDK 8
73165
73154 A
73166
MMWS PDK 6
Ambuliyar Sub Basin
MMWS PDK 3
MMWS PDK 4
MMWS PDK 5
43044
SW-07
SW-08
SW-09
SW-1A
SW-32
42087 A
Legend
Observation Well
Sub basin Boundary
Basin Boundary
Water level in M (bgl)
0-4
4-8
8-12
12-16
Government of Tamilnadu
Water Resources Department
Tamilnadu State Centre for Remote Sensing Applications
Institute for Water Studies,Hydrology and Quality Control
Tharamani, Chennai- 600113
Kilometers
0 5 10 20


Agniyar Basin Water Level Contour for Piezometric Wells (July 2011)
Plate AG 38
12006
12031 D
12018 D
8037
Agniyar Sub Basin
11010 D
South Vellar Sub Basin
11034 D
12010
12012 D
12050
12032 D
11009 D
24014
12024 D
12023 D
12027 D
12025 D
8018
Ambuliyar Sub Basin
Legend
Piezometric Well
Sub Basin Boundary
Basin Boundary
Water Level in M (bgl)
0-5
5-10
10-20
20-40
12038 D
12040 D
12039 D
Government of Tamilnadu
Water Resources Department
Tamilnadu State Centre for Remote Sensing Applications
Institute for Water Studies, Hydrology and Quality Control
Tharamani, Chennai- 600113
0 5 10 20
Kilometers

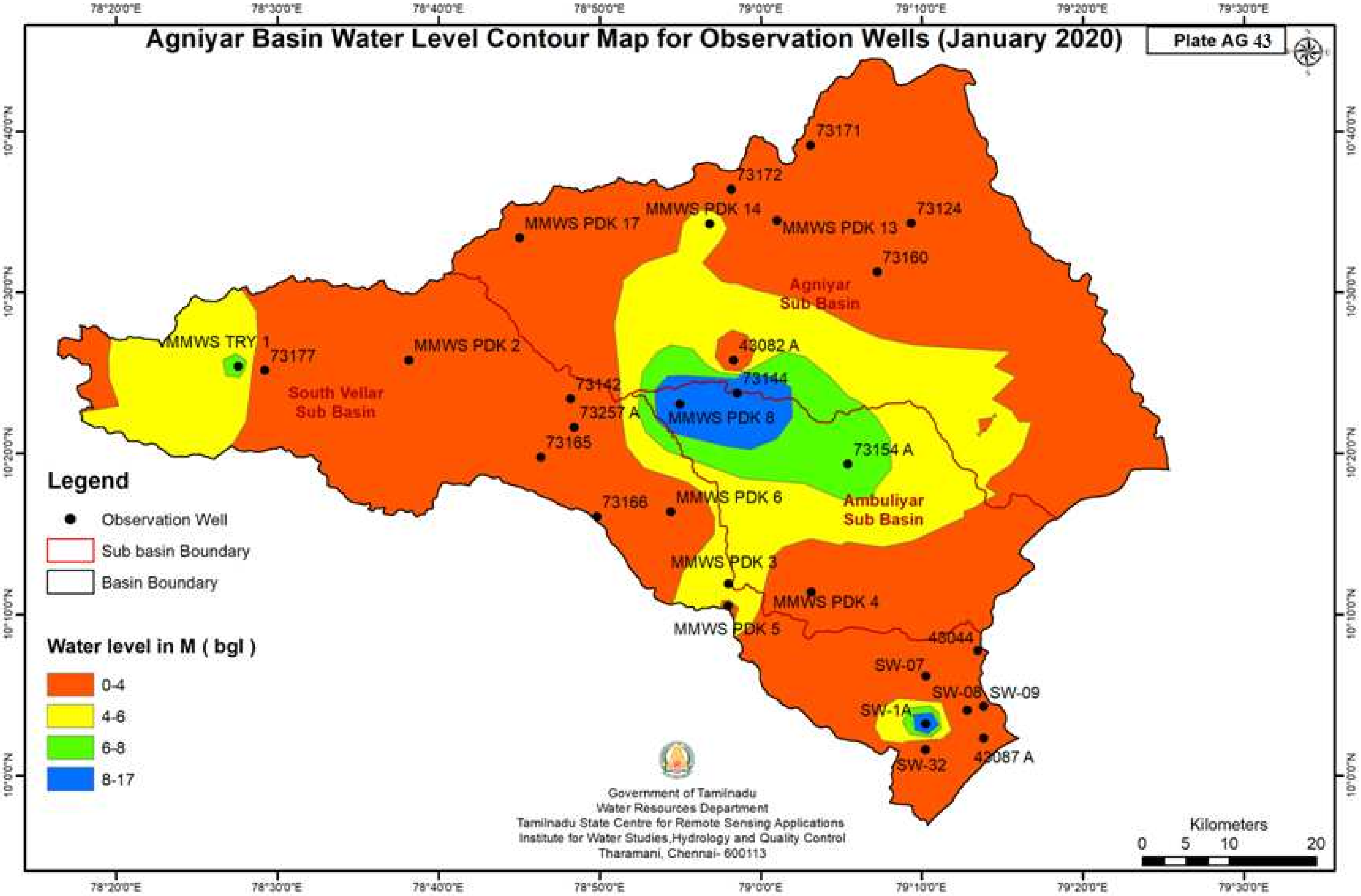

Agniyar Basin Water Level Contour Map for Observation Wells (January 2012)
Plate AG 39
Legend
Observation Well
Sub basin Boundary
Basin Boundary
Water level in M (bgl)
0-2.5
2.5-5
5-7.5
7.5-10
South Vellar Sub Basin
Agniyar Sub Basin
Ambuliyar Sub Basin
73171
73172
MMWS PDK 14
MMWS PDK 13
73124
MMWS PDK 17
73160
MMWS TRY 1
73177
MMWS PDK 2
43082 A
73144
73142
73257 A
MMWS PDK 8
73165
73154 A
73166
MMWS PDK 6
MMWS PDK 3
MMWS PDK 4
MMWS PDK 5
43044
SW-07
SW-08
SW-09
SW-1A
SW-32
42087 A
Government of Tamilnadu
Water Resources Department
Tamilnadu State Centre for Remote Sensing Applications
Institute for Water Studies,Hydrology and Quality Control
Tharamani, Chennai- 600113
Kilometers
0 5 10 20
78°20'0"E
78°30'0"E
78°40'0"E
78°50'0"E
79°0'0"E
79°10'0"E
79°20'0"E
79°30'0"E
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
10°0'0"N


Agniyar Basin Water Level Contour for Piezometric Wells (January 2012)
Plate AG 40
Agniyar Sub Basin
South Vellar Sub Basin
Ambuliyar Sub Basin
12006
12031 D
12018 D
8037
11010 D
11034 D
12010
12012 D
12050
12032 D
11009 D
24014
12024 D
12023 D
12025 D
12027 D
8018
12038 D
12040 D
12039 D
Legend
Piezometric Well
Sub Basin Boundary
Basin Boundary
Water Level in M (bgl)
0-2
2-6
6-10
10-15
Government of Tamilnadu
Water Resources Department
Tamilnadu State Centre for Remote Sensing Applications
Institute for Water Studies,Hydrology and Quality Control
Tharamani, Chennai- 600113
0 5 10 20
Kilometers

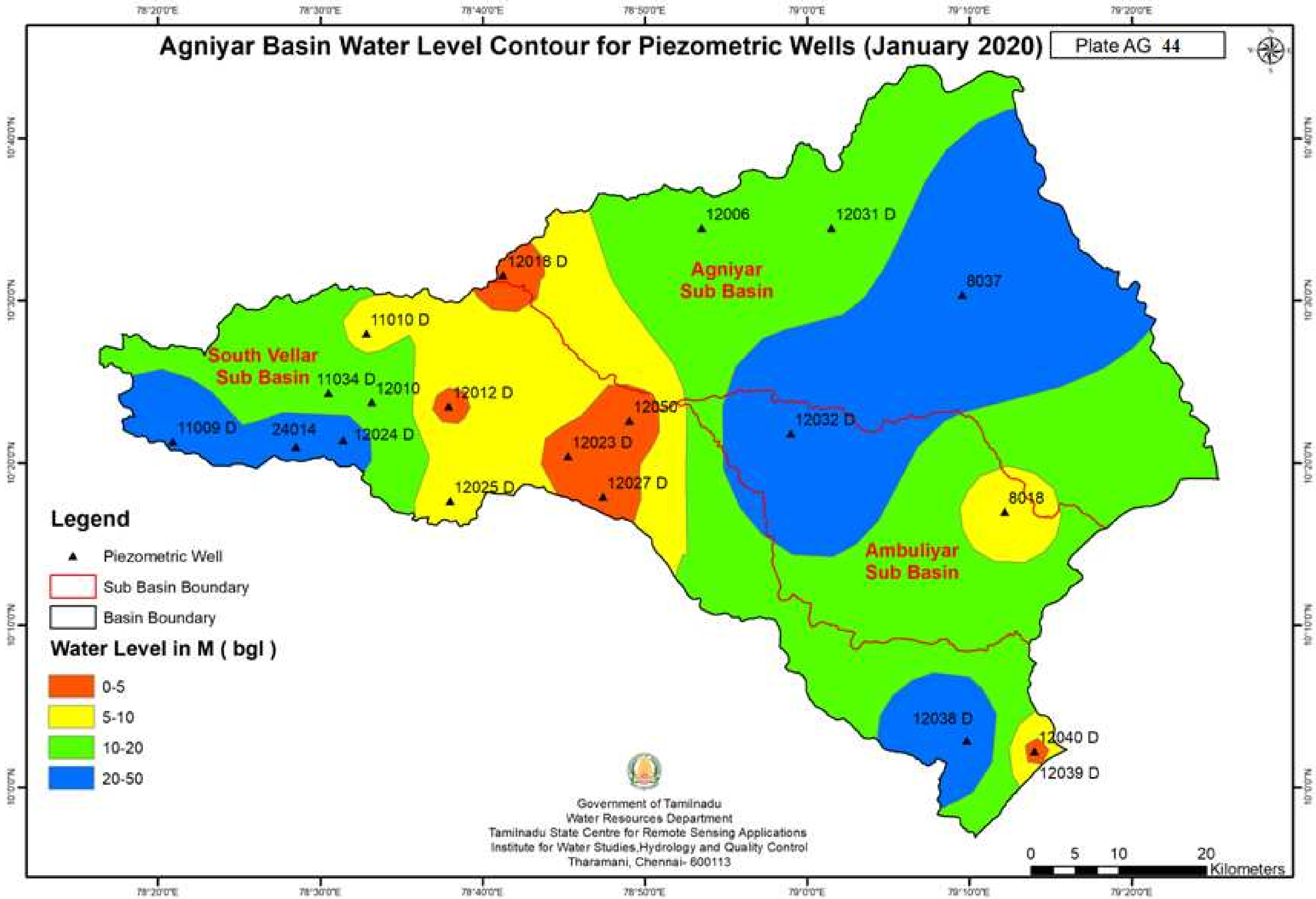

Agniyar Basin Water Level Contour Map for Observation Wells (July 2019)
Plate AG 41
73171
73172
MMWS PDK 14
MMWS PDK 17
MMWS PDK 13
73124
73160
Agniyar Sub Basin
MMWS TRY 1
73177
MMWS PDK 2
South Vellar Sub Basin
43082 A
73144
73142
73257 A
MMWS PDK 8
73165
73154 A
73166
MMWS PDK 6
Ambuliyar Sub Basin
MMWS PDK 3
MMWS PDK 4
MMWS PDK 5
43044
SW-07
SW-08
SW-09
SW-1A
SW-32
43087 A
Legend
Observation Well
Sub basin Boundary
Basin Boundary
Water level in M (bgl)
0-5
5-10
10-15
15-22
Government of Tamilnadu
Water Resources Department
Tamilnadu State Centre for Remote Sensing Applications
Institute for Water Studies,Hydrology and Quality Control
Tharamani, Chennai- 600113
Kilometers
0 5 10 20
78°20'0"E
78°30'0"E
78°40'0"E
78°50'0"E
79°0'0"E
79°10'0"E
79°20'0"E
79°30'0"E
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
10°0'0"N



Agniyar Basin Water Level Contour for Piezometric Wells (July 2019)
Plate AG 42
South Vellar Sub Basin
Agniyar Sub Basin
Ambuliyar Sub Basin
12006
12031 D
12018 D
8037
11010 D
11034 D
12010
12012 D
12050
11009 D
24014
12024 D
12023 D
12032 D
12025 D
12027 D
8018
12038 D
12040 D
12039 D
Legend
Piezometric Well
Sub Basin Boundary
Basin Boundary
Water Level in M (bgl)
0-10
10-20
20-30
30-60
Government of Tamilnadu
Water Resources Department
Tamilnadu State Centre for Remote Sensing Applications
Institute for Water Studies,Hydrology and Quality Control
Tharamani, Chennai- 600113
0 5 10 20
Kilometers



Agniyar Basin Water Level Contour Map for Observation Wells (January 2020)
Plate AG 43
78°20'0"E
78°30'0"E
78°40'0"E
78°50'0"E
79°0'0"E
79°10'0"E
79°20'0"E
79°30'0"E
10°40'0"N
10°30'0"N
10°20'0"N
10°10'0"N
10°0'0"N
73171
73172
MMWS PDK 14
MMWS PDK 13
73124
MMWS PDK 17
73160
Agniyar Sub Basin
MMWS TRY 1
73177
MMWS PDK 2
43082 A
73144
73142
73257 A
MMWS PDK 8
South Vellar Sub Basin
73165
73154 A
73166
MMWS PDK 6
Ambuliyar Sub Basin
MMWS PDK 3
MMWS PDK 4
MMWS PDK 5
43044
SW-07
SW-08
SW-09
SW-1A
SW-32
42087 A
Legend
Observation Well
Sub basin Boundary
Basin Boundary
Water level in M (bgl)
0-4
4-6
6-8
8-17
Government of Tamilnadu
Water Resources Department
Tamilnadu State Centre for Remote Sensing Applications
Institute for Water Studies,Hydrology and Quality Control
Tharamani, Chennai- 600113
Kilometers
0 5 10 20



Agniyar Basin Water Level Contour for Piezometric Wells (January 2020)
Plate AG 44
12006
12031 D
12018 D
Agniyar
Sub Basin
8037
11010 D
South Vellar
Sub Basin
11034 D
12010
12012 D
12050
11009 D
24014
12024 D
12023 D
12032 D
12027 D
12025 D
8018
Ambuliyar
Sub Basin
12038 D
12040 D
12039 D
Legend
Piezometric Well
Sub Basin Boundary
Basin Boundary
Water Level in M (bgl)
0-5
5-10
10-20
20-50
Government of Tamilnadu
Water Resources Department
Tamilnadu State Centre for Remote Sensing Applications
Institute for Water Studies,Hydrology and Quality Control
Tharamani, Chennai- 600113
0 5 10 20
Kilometers

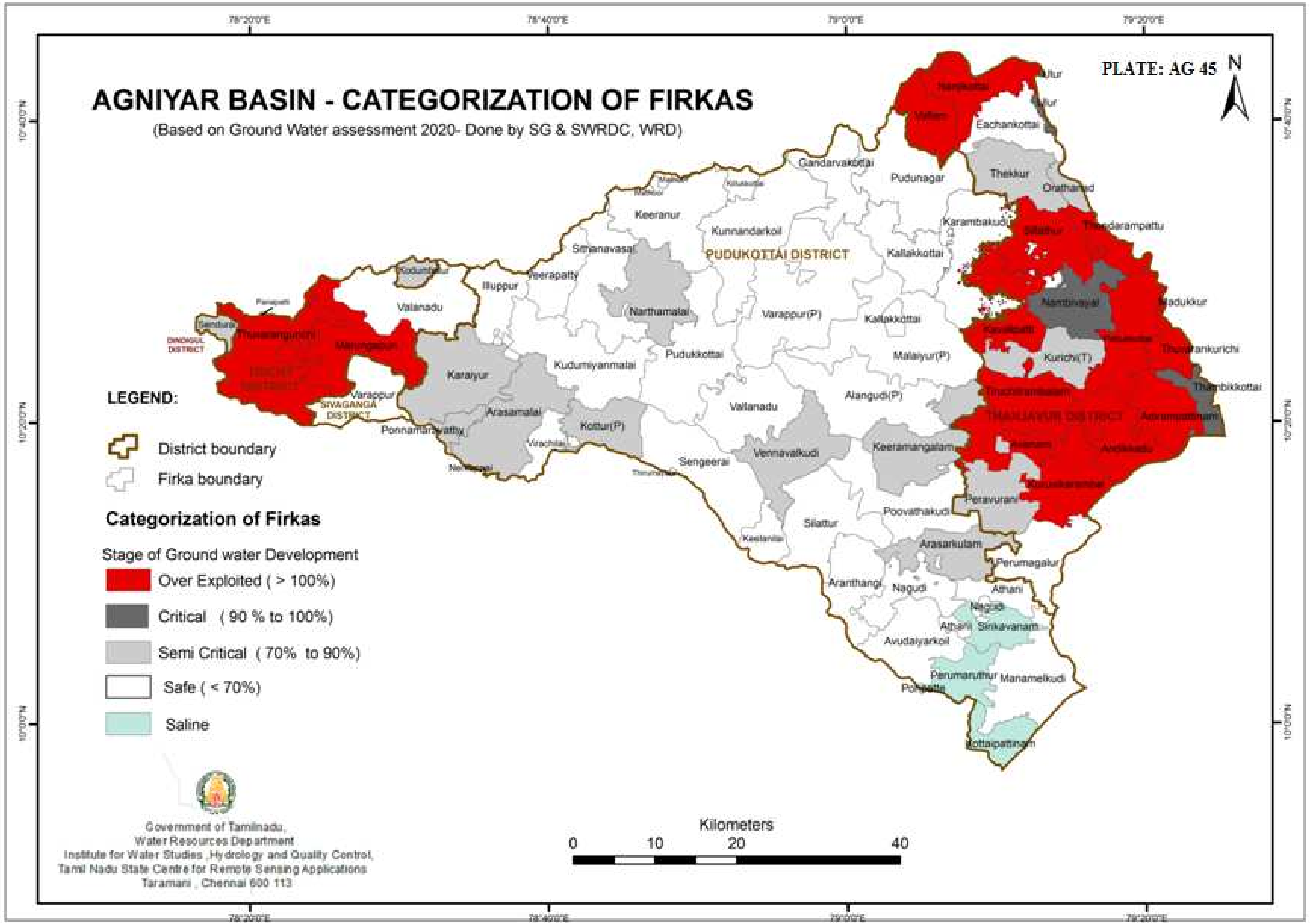
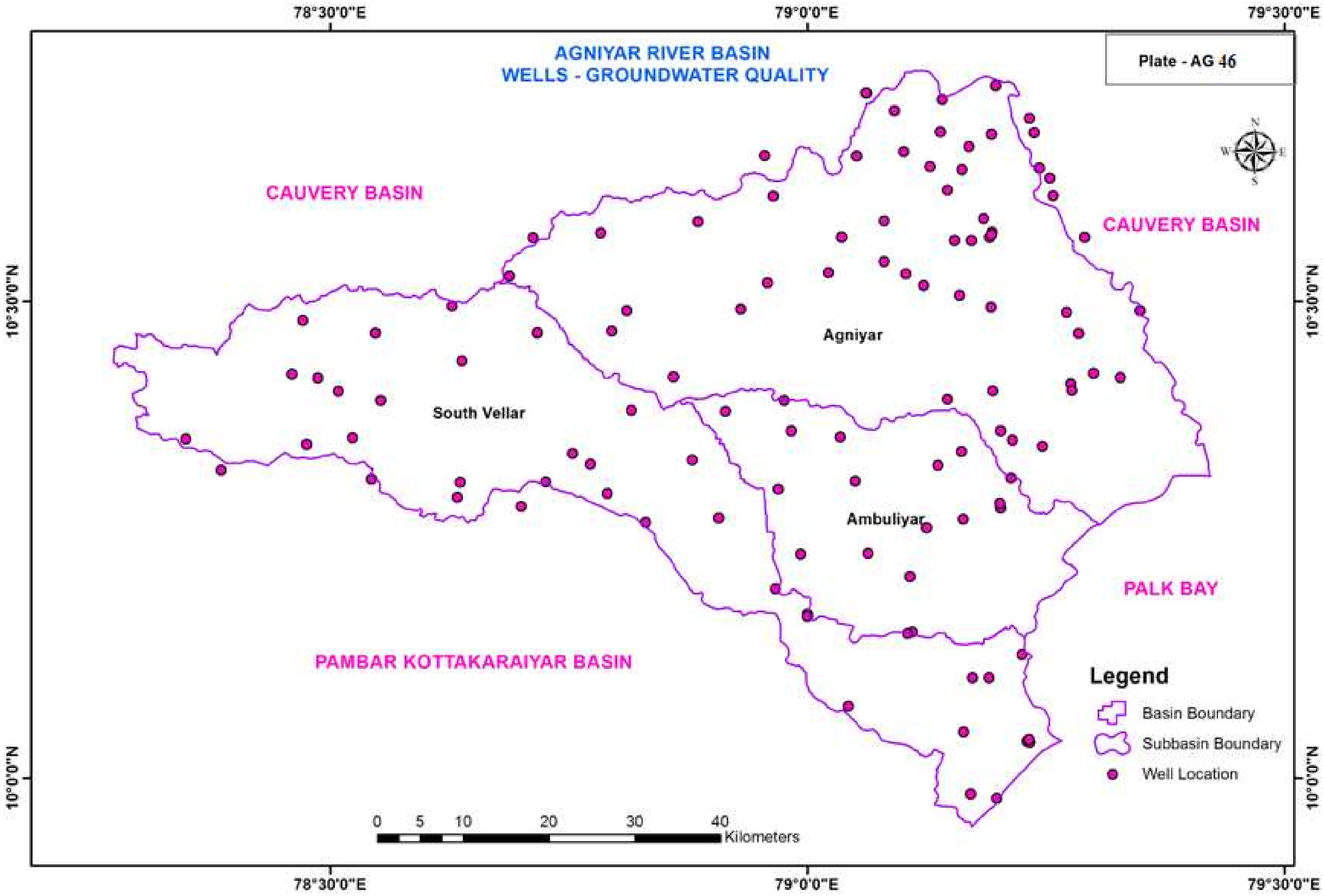
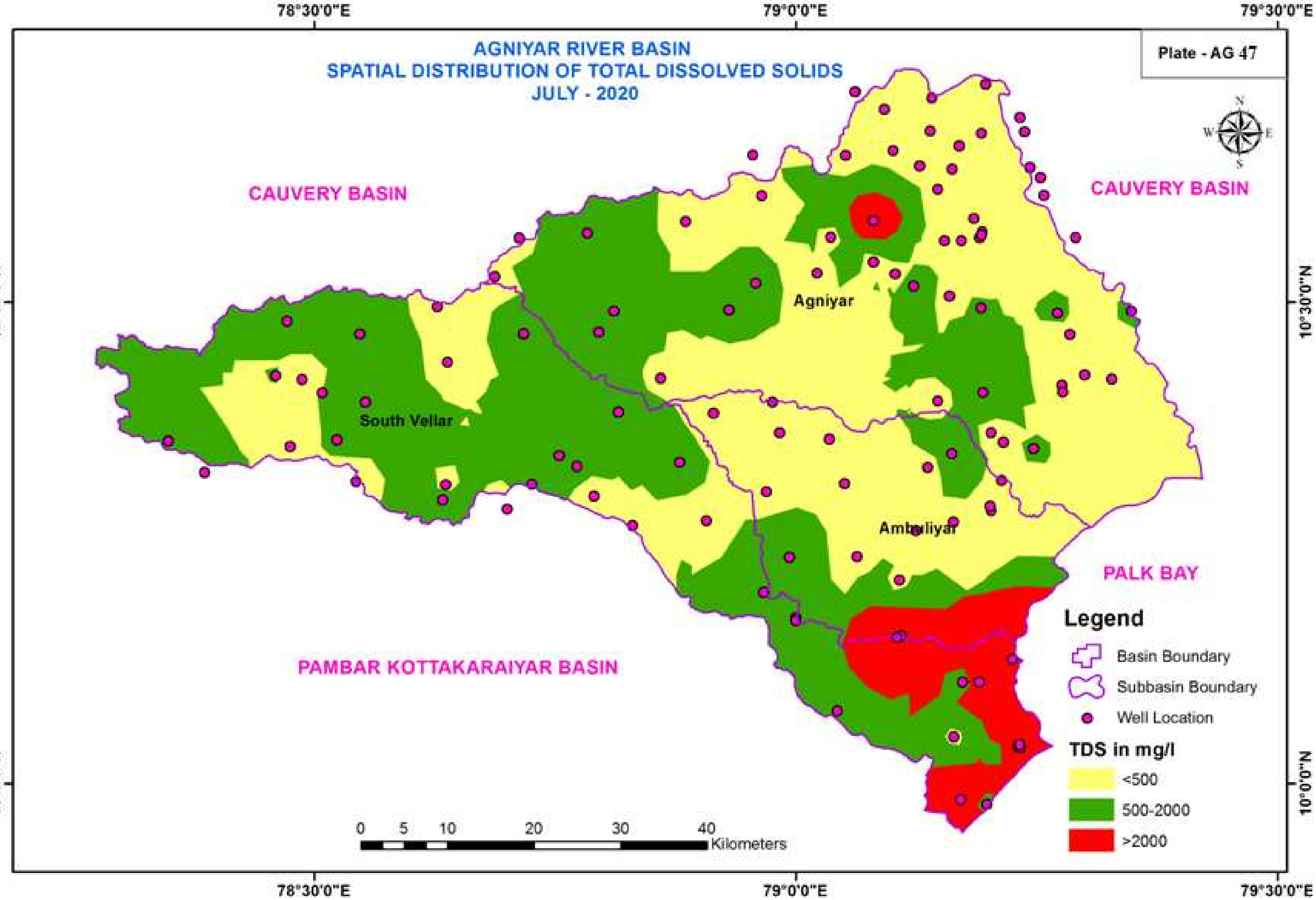
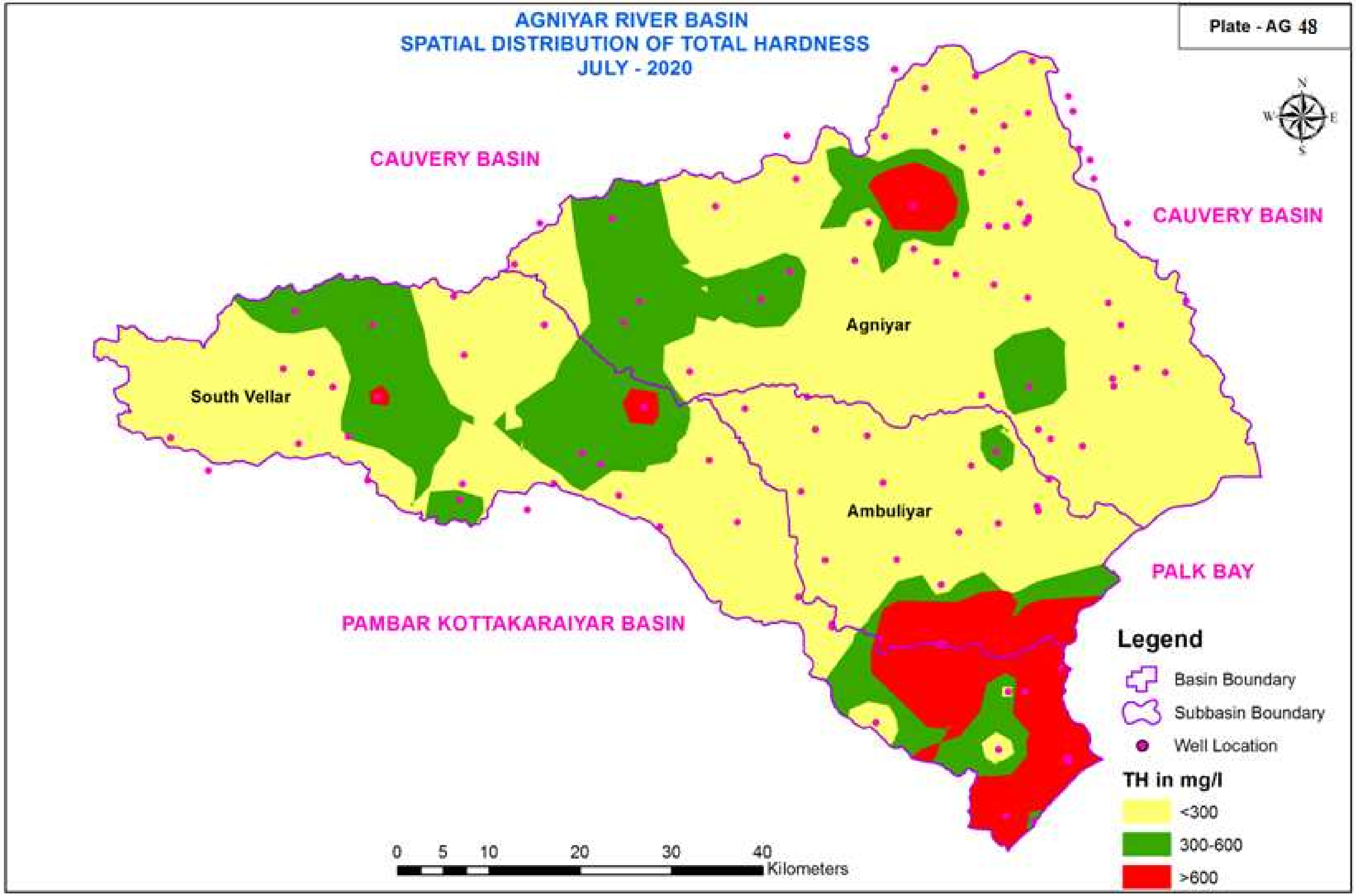


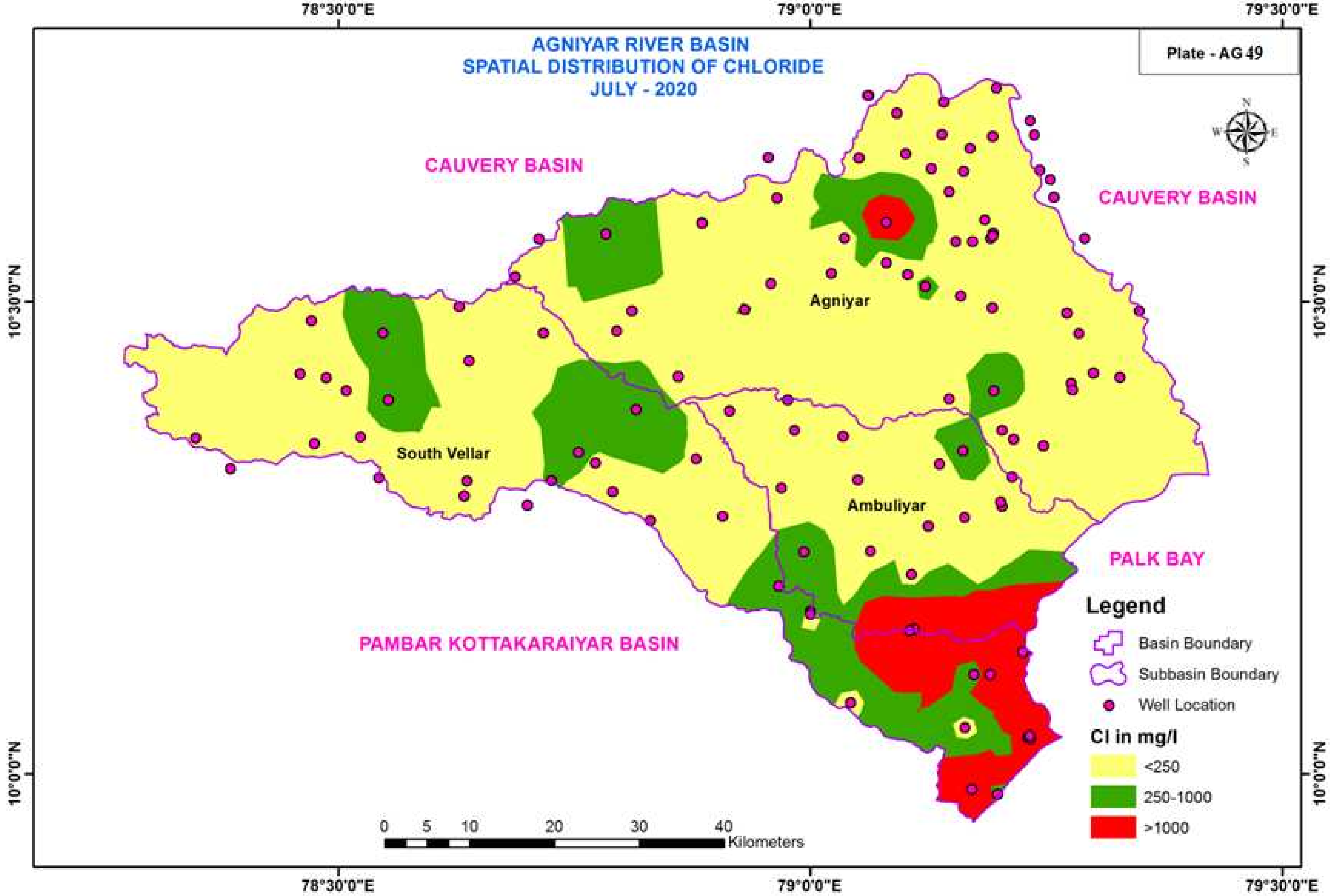
PLATE: AG 45
AGNIYAR BASIN - CATEGORIZATION OF FIRKAS
(Based on Ground Water assessment 2020- Done by SG & SWRDC, WRD)
LEGEND:
District boundary
Firka boundary
Categorization of Firkas
Stage of Ground water Development
Over Exploited (> 100%)
Critical (90 % to 100%)
Semi Critical (70% to 90%)
Safe (< 70%)
Saline
PUDUKOTTAI DISTRICT
THANJAVUR DISTRICT
SIVAGANGA DISTRICT
DINDIGUL DISTRICT
Kilometers
0 10 20 40
Government of Tamilnadu,
Water Resources Department
Institute for Water Studies ,Hydrology and Quality Control,
Tamil Nadu State Centre for Remote Sensing Applications
Taramani , Chennai 600 113


78°30'0"E
79°0'0"E
79°30'0"E
AGNIYAR RIVER BASIN
WELLS - GROUNDWATER QUALITY
Plate - AG 46
N
S
E
W
CAUVERY BASIN
CAUVERY BASIN
10°30'0"N
10°0'0"N
Agniyar
South Vellar
Ambuliyar
PALK BAY
PAMBAR KOTTAKARAIYAR BASIN
Legend
Basin Boundary
Subbasin Boundary
Well Location
0 5 10 20 30 40
Kilometers



AGNIYAR RIVER BASIN
SPATIAL DISTRIBUTION OF TOTAL DISSOLVED SOLIDS
JULY - 2020
Plate - AG 47
78°30'0"E
79°0'0"E
79°30'0"E
10°30'0"N
10°0'0"N
CAUVERY BASIN
CAUVERY BASIN
PALK BAY
PAMBAR KOTTAKARAIYAR BASIN
Agniyar
South Vellar
Ambuliyar
Legend
Basin Boundary
Subbasin Boundary
Well Location
TDS in mg/l
<500
500-2000
>2000
0 5 10 20 30 40
Kilometers


AGNIYAR RIVER BASIN
SPATIAL DISTRIBUTION OF TOTAL HARDNESS
JULY - 2020
Plate - AG 48
CAUVERY BASIN
CAUVERY BASIN
South Vellar
Agniyar
Ambuliyar
PALK BAY
PAMBAR KOTTAKARAIYAR BASIN
Legend
Basin Boundary
Subbasin Boundary
Well Location
TH in mg/l
<300
300-600
>600
0 5 10 20 30 40
Kilometers



78°30'0"E
79°0'0"E
79°30'0"E
AGNIYAR RIVER BASIN
SPATIAL DISTRIBUTION OF CHLORIDE
JULY - 2020
Plate - AG 49
CAUVERY BASIN
CAUVERY BASIN
10°30'0"N
Agniyar
South Vellar
Ambuliyar
PALK BAY
PAMBAR KOTTAKARAIYAR BASIN
Legend
Basin Boundary
Subbasin Boundary
Well Location
Cl in mg/l
<250
250-1000
>1000
10°0'0"N
0 5 10 20 30 40
Kilometers

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 Agniyar 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 Agniyar River Basin is projected to the years 2022, 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 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 acquifer.
- 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

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 7.1**

Table 7.1: 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.

7.2.1 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	1.9 % per year
Rural	0.8 % per year

Geometrical Increase Method is adopted for the population growth in the present study.

Geometrical Increase Method

$$\mathbf{P_n = P_o\,(1+r/100)^{n}}$$

Where,

P_0 = Initial population: i.e. the population at the end of last known census.

P_n = Future population after n decades.

r = Growth rate in %

n = 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 Agniyar River Basin arrived in Chapter 2 sub basin wise is projected for the present year 2021 and the target years 2022, 2030, 2040 & 2050. The sub-basin wise population projection for the Agniyar River Basin for the present year 2021 as **2.072 million,** and the target years 2022, 2030, 2040 & 2050 are arrived as **2.093 million, 2.274million, 2.528 million & 2.816 million** respectively and is given in **Table No. 7.2.**

Accordingly, the domestic water demand for the present year 2021 and the target years 2022, 2030, 2040 & 2050 are obtained as **72.586MCM, 73.441MCM, 80.738Mucm, 91.110MCM & 103.104MCM** respectively and are given in **Table No.7.3.**

Table 7.2 Sub basin wise Projected Population for Agniyar River Basin

Population in Million

Sl. No	Name of the Sub Basin	Population during 2021			Population during 2022			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	Agniyar	0.811	0.284	1.095	0.818	0.289	1.107	0.871	0.336	1.207	0.944	0.406	1.349	1.022	0.490	1.512
2	Ambuliyar	0.323	0.066	0.389	0.325	0.068	0.393	0.347	0.079	0.425	0.375	0.095	0.470	0.407	0.115	0.521
3	South Vellar	0.496	0.092	0.588	0.500	0.093	0.593	0.533	0.109	0.642	0.577	0.131	0.708	0.625	0.158	0.783
Total		**1.63**	**0.442**	**2.072**	**1.643**	**0.45**	**2.093**	**1.751**	**0.523**	**2.274**	**1.896**	**0.632**	**2.528**	**2.054**	**0.763**	**2.816**

Table 7.3 Sub basin wise Domestic Water Demand of Agniyar River Basin

Water Demand in MCM

Sl. No	Name of the Sub Basin	Water Demand 2021			Water Demand 2022			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	Agniyar	23.685	16.048	39.733	23.874	16.353	40.228	25.446	19.011	44.457	27.556	22.948	50.504	29.842	27.700	57.542
2	Ambuliyar	9.423	3.756	13.179	9.499	3.827	13.326	10.124	4.449	14.573	10.964	5.371	16.334	11.873	6.483	18.356
3	South Vellar	14.483	5.190	19.673	14.599	5.289	19.887	15.560	6.148	21.708	16.850	7.421	24.272	18.248	8.958	27.206
Total		**47.591**	**24.995**	**72.586**	**47.972**	**25.470**	**73.441**	**51.129**	**29.608**	**80.738**	**55.370**	**35.740**	**91.110**	**59.963**	**43.142**	**103.104**

7.3 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 Agniyar River Basin is tabulated in **Table 7.4** and the season wise Irrigation water demand (MCM) at 75 % rainfall dependability in Agniyar River Basin is tabulated in **Table 7.5**

The major crops cultivated in Agniyar River Basin are Paddy, Coconut, Groundnut & Black gram. The irrigated area for the year 2008 in Agniyar River Basin under different crops was 1,46,585 ha with paddy as the main crop of the basin cultivated in 1,08,747 ha. At present the irrigated area based on the good rainfall for the year 2020-21 is 186176 ha and has been consider for deriving the demand.

Table 7.4 Irrigation Water Demand (MCM) At 75 % Rainfall Dependability in Agniyar River Basin (Month Wise)

Sl.No	SUB BASIN	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	Agniyar	9.81	10.65	21.59	35.11	47.97	205.18	128.68	116.77	27.04	45.91	17.54	36.16	**702.42**
2	Ambuliyar	12.75	7.96	10.42	12.18	16.24	91.19	17.46	24.96	38.86	14.78	5.65	21.15	**273.59**
3	South Vellar	12.35	5.59	8.44	10.71	15.51	117.89	27.35	69.91	12.85	22.83	8.72	13.16	**325.31**
TOTAL		34.92	24.21	40.44	58.00	79.72	414.26	173.49	211.64	78.75	83.52	31.92	70.47	**1301.32**

Table 7.5 Irrigation Water Demand (MCM) At 75 % Rainfall Dependability in Agniyar River Basin (Season Wise)

Sub basin	Winter	Summer	Southwest	Northeast	Total
Agniyar	20.47	104.66	477.68	99.61	**702.42**
Ambuliyar	20.71	38.84	172.46	41.58	**273.59**
South Vellar	17.95	34.65	227.99	44.72	**325.31**
Total	59.13	178.16	878.13	185.91	**1301.32**

7.4 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 Dindigul, Pudukkottai, Sivagangai, Thanjavur, Tiruchirapalli 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 Agniyar River Basin are listed out and given in appendix 7.1 to 7.6. At present in the Agniyar River Basin there are 15 numbers of large and medium industries and 606 numbers of small scale industries. Accordingly, the yearly requirement of water for Large & Medium and small scale industries at present is estimated as 0.131 MCM&1.532MCM respectively.

7.4.1 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 Agniyar River Basin for the year 2021 for the small scale industries is assessed as **1.532 MCM** and for the target years 2022, 2030, 2040 and 2050 also and is given in **Table 7.6 (a).**

The Industrial Water Demand in Agniyar River Basin for the year 2021 for the Large & Medium scale industries is assessed as **0.131 MCM** and for the target years 2022, 2030, 2040 and 2050 also and is given in **Table7.6 (b)**

Table 7.6 (a) Water Demand of Small Scale Industries in Agniyar River Basin

Sl.No.	Name of the Sub Basin	2021		2022		2030		2040		2050	
		Number of Industries	Water Demand in MCM	Number of Industries	Water Demand in MCM	Number of Industries	Water Demand in MCM	Number of Industries	Water Demand in MCM	Number of Industries	Water Demand in MCM
1	Agniyar	381	1.220	411	1.317	675	2.161	1215	3.889	2186	7.001
2	Ambuliyar	108	0.198	117	0.214	191	0.351	344	0.632	620	1.138
3	South Vellar	117	0.114	126	0.123	207	0.201	373	0.362	671	0.652
Total		**606**	**1.532**	654	**1.654**	**1073**	**2.713**	**1932**	**4.884**	**3478**	**8.790**

Table 7.6 (b) Water Demand of Large & Medium Scale Industries in Agniyar River Basin

Sl.No.	Name of the Sub Basin	2021		2022		2030		2040		2050	
		Number of Industries	Water Demand in MCM	Number of Industries	Water Demand in MCM	Number of Industries	Water Demand in MCM	Number of Industries	Water Demand in MCM	Number of Industries	Water Demand in MCM
1	Agniyar	10	0.108	11	0.117	18	0.192	32	0.346	57	0.622
2	Ambuliyar	1	0.001	1	0.002	2	0.003	3	0.005	6	0.008
3	South Vellar	4	0.021	4	0.023	7	0.038	13	0.068	23	0.122
Total		**15**	**0.131**	**16**	**0.142**	**27**	**0.232**	**48**	**0.418**	**86**	**0.752**

Table 7.7 Total Industrial Water Demand in Agniyar River Basin

Sl. No	Name of the Sub Basin	2021			2022			2030			2040			2050		
		L&MI	SSI	Total	L&MI	SSI	Total	L&MI	SSI	Total	L&MI	SSI	Total	L&MI	SSI	Total
1	Agniyar	0.108	1.220	1.328	0.117	1.317	1.435	0.192	2.161	2.353	0.346	3.889	4.235	0.622	7.001	7.623
2	Ambuliyar	0.001	0.198	0.200	0.002	0.214	0.216	0.003	0.351	0.354	0.005	0.632	0.637	0.008	1.138	1.146
3	South Vellar	0.021	0.114	0.135	0.023	0.123	0.146	0.038	0.201	0.239	0.068	0.362	0.430	0.122	0.652	0.774
Total		**0.131**	**1.532**	**1.663**	**0.142**	**1.654**	**1.796**	**0.232**	**2.713**	**2.945**	**0.418**	**4.884**	**5.301**	**0.752**	**8.790**	**9.542**

7.5 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 census on livestock, poultry is conducted once in 5 years since 1951. The 20th livestock census 2019, 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 Agniyar River Basin. To predict the future livestock water demand in the basin, the present livestock population needs to be projected Likewise, the sub-basin wise livestock population projection and Livestock water demand for the Agniyar River Basin for the present year 2021 and the target years 2030, 2040 & 2050 are arrived and is given in **Appendix 7.9 and 7.10**

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 7.8 Water Requirement for Live Stock (Source: Indian council of Agriculture and Research)

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
11	Ducks	15

Table 7.9 Sub basin wise Growth rate for forecasting future Livestock Population

(Formula used for X = $\{e^{(\ln(pt/po)/t)}-1\}100\%$

Sub basin	Name	Growth Rate in %
Agniyar	Cattle	29
	Buffalo	-4
	Duck	14
	Sheep	18
	Goat	25
	Fowl	30
	Pigs	10
Ambuliyar	Cattle	-19
	Buffalo	-47
	Duck	-12
	Sheep	-25
	Goat	-10
	Fowl	-4
	Pigs	38
South Vellar	Cattle	10
	Buffalo	-46
	Duck	-1.02
	Sheep	-0.10
	Goat	2.17
	Fowl	7.48
	Pigs	-23

Table 7.10 Sub Basin wise Projected Livestock Population in Agniyar River Basin

Sl. No	Year	Livestock	Livestock Population			Total
			Agniyar	Ambuliyar	South Vellar	
1	2019	Cattle	366791	94992	189544	651327
		Buffalo	657	138	162	957
		Duck	3538	212	2416	6166
		Sheep	78631	14318	176409	269358
		Goat	518896	161012	332337	1012245
		Fowl	1093986	693213	1340874	3128073
		Pigs	194	52	419	665
2	2021	Cattle	610377	62324	229348	902049
		Buffalo	605	39	47	691
		Duck	4598	164	2367	7129
		Sheep	109486	8054	176056	293596
		Goat	810775	130420	346917	1288112
		Fowl	1848836	638865	1548971	4036672
		Pigs	157	20	248	426
3	2030	Cattle	6038172	40891	277511	6356574
		Buffalo	419	11	14	444
		Duck	5976	127	2319	8422
		Sheep	485619	4530	175704	665854
		Goat	6040744	105640	362136	6508521
		Fowl	19605984	588778	1789364	21984125
		Pigs	61	8	147	216
4	2040	Cattle	77055313	26829	335789	77417930
		Buffalo	279	3	4	286
		Duck	22154	98	2272	24524
		Sheep	2541651	2548	175353	2719553
		Goat	56258817	85568	378024	56722409
		Fowl	270285136	542618	2067064	272894818
		Pigs	21	3	87	112
4	2050	Cattle	85633458	17602	406304	86057365
		Buffalo	185	1	1	187
		Duck	82130	76	2226	84432
		Sheep	13302584	1433	175003	13479021
		Goat	523951063	69310	394608	524414982
		Fowl	3726110120	500077	2387862	3728998059
		Pigs	7	1	52	60

Table 7.11 Sub Basin wise Livestock Water Demand in Agniyar River Basin

Sl. No	Year	Livestock	Standard Norms in lpcd	Live Stock Water Demand in MCM			
				Agniyar	Ambuliyar	South Vellar	Total
1	2019	Cattle	110	14.727	3.814	7.610	26.151
		Buffalo	150	0.036	0.008	0.009	0.052
		Duck	15	0.019	0.001	0.013	0.034
		Sheep	20	0.574	0.105	1.288	1.966
		Goat	20	3.788	1.175	2.426	7.389
		Fowl	0.25	0.100	0.063	0.122	0.285
		Pigs	40	0.003	0.001	0.006	0.010
Total				**19.25**	**5.17**	**11.47**	**35.89**
2	**2021**	Cattle	110	24.51	2.50	9.21	36.22
		Buffalo	150	0.033	0.002	0.003	0.038
		Duck	15	0.025	0.001	0.013	0.039
		Sheep	20	0.799	0.059	1.285	2.143
		Goat	20	5.919	0.952	2.532	9.403
		Fowl	0.25	0.169	0.058	0.141	0.368
		Pigs	40	0.002	0.000	0.004	0.006
Total				**31.45**	**3.57**	**13.19**	**48.22**
3	2030	Cattle	110	242.433	1.642	11.142	255.216
		Buffalo	150	0.023	0.001	0.001	0.024
		Duck	15	0.033	0.001	0.013	0.046
		Sheep	20	3.545	0.033	1.283	4.861
		Goat	20	44.097	0.771	2.644	47.512
		Fowl	0.25	1.789	0.054	0.163	2.006
		Pigs	40	0.001	0.000	0.002	0.003
Total				**291.92**	**2.50**	**15.25**	**309.67**
4	2040	Cattle	110	3093.771	1.077	13.482	3108.330
		Buffalo	150	0.015	0.000	0.000	0.016
		Duck	15	0.121	0.001	0.012	0.134
		Sheep	20	18.554	0.019	1.280	19.853
		Goat	20	410.689	0.625	2.760	414.074
		Fowl	0.25	24.664	0.050	0.189	24.902
		Pigs	40	0.000	0.000	0.001	0.002
Total				**3547.81**	**1.77**	**17.72**	**3567.31**
5	2050	Cattle	110	3438.183	0.707	16.313	3455.203
		Buffalo	150	0.010	0.000	0.000	0.010
		Duck	15	0.450	0.000	0.012	0.462
		Sheep	20	97.109	0.010	1.278	98.397
		Goat	20	3824.84	0.51	2.88	3828.23
		Fowl	0.25	340.008	0.046	0.218	340.271
		Pigs	40	0.000	0.000	0.001	0.001
Total				**7700.60**	**1.27**	**20.70**	**7722.57**

7.6. Total Water Demand

The total water demand of four sectors, i.e., Domestic, Irrigation, Livestock and Industries of Agniyar River Basin for the present year 2021 and the projected target years 2030, 2040 & 2050 are worked out as 1423.78MCM, 1694.672MCM, 4965MCM & 9137MCM respectively and are given in Table No.7.12.

Table 7.12 Total Water Demand in Agniyar River Basin (Water Demand in (MCM)

Sl. No	Name of the Sub Basin	2021					2030				
		Domestic	**Irrigation**	**livestock**	**Industries**	**Total**	**Domestic**	**Irrigation**	**livestock**	**Industries**	**Total**
1	Agniyar	39.733	702.42	31.45	1.328	774.94	44.457	702.42	291.921	2.353	1041.150
2	Ambuliyar	13.179	273.59	3.575	0.200	290.54	14.573	273.59	2.501	0.354	291.018
2	South Vellar	19.673	325.31	13.19	0.135	358.30	21.708	325.31	15.247	0.239	362.504
Total		**72.586**	**1301.32**	**48.22**	**1.663**	**1423.78**	**80.738**	**1301.32**	**309.669**	**2.945**	**1694.672**

Sl. No	Name of the Sub Basin			2040					2050		
		Domestic	**Irrigation**	**livestock**	**Industries**	**Total**	**Domestic**	**Irrigation**	**livestock**	**Industries**	**Total**
1	Agniyar	50.504	702.42	3548	4.235	4305	57.542	702.42	7701	7.623	8468.187
2	Ambuliyar	16.334	273.59	1.771	0.637	292.332	18.356	273.59	1.27	1.146	294.361
2	South Vellar	24.272	325.31	17.724	0.430	367.736	27.206	325.31	20.70	0.774	373.992
Total		**91.110**	**1301.32**	**3567**	**5.301**	**4965**	**103.104**	**1301.32**	7723	**9.542**	**9137**

The Comparison between the reappraisal study of Agniyar River Basin carried out during 2007 and 2021 is presented in the T**able 7.12**

Table 7.13 Comparison between the reappraisal studies of Agniyar River Basin carried out during 2008 and 2021 (Water Demand in MCM)

SI.No	**Water Demand**	**Year**	
		2007	**2021**
1.	Domestic Demand	64.337	72.586
2.	Irrigation Demand	1098.030	1301.32
3.	Industrial Demand	61.000	1.663
4.	Livestock Demand	65.052	48.22
Total demand		**1288.419**	**1423.78**

The total water demand of our sectors, i.e., Domestic, Irrigation, Livestock, and Industries of Agniyar River Basin for the present year 2021 was worked out as **1423.78MCM.** But the water demand in 2007 was **1288.419MCM**. This shows that there is 9.6% increase in water demand within 14 years for the present year, when compared to the water demand during 2008.

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 optimallyin a river basin.

8.1 Water Potential of Agniyar basin

Total water potential is the sum of surface water potential and ground water potential. In this Agniyar Basin inflow and outflow datas are incorporated for assessment of surface water potential. The surface water potential of Agniyar basin is estimated and is furnished in **Table 5.4 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 Agniyar basin is 2428.25 MCM calculated as below:

Surface water potential assessed from Rainfall	= 586.37 MCM
Surface water potential assessed from Inter basin transfer (Grand Anicut canal)	= 505.00 MCM
Ground water availability	= 1336.88 MCM
Total Water Potential of the basin	= 2428.25 MCM

8.2 Water Demand of Agniyar 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 2022, 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 0.5% of Surface Water Potential for 2021 and at 1% for 2022, 2030, 2040 and 2050. This is added to total water demand. The total water demand in Agniyar basin for different years is tabulated in **Table 8.1**.

Table 8.1
Total Sectoral Water Demand in Agniyar Basin (75% Dependability)

Sl. No.	Type of Demand	Total Demand in MCM				
		2021	2022	2030	2040	2050
1	Domestic	72.586	73.441	80.738	91.110	103.104
2	Irrigation (including losses)	2173.20	2173.20	2173.20	2173.20	2173.20
3	Live Stock	35.885	35.885	35.885	35.885	35.885
4	Industries	1.663	1.796	2.945	5.301	9.542
5.	Ecological	2.94	5.89	5.89	5.89	5.89
	Total	**2286.27**	**2290.21**	**2298.65**	**2311.38**	**2327.62**

Table 8.2
Total Sectoral Water Demand in Agniyar Basin (50% Dependability)

Sl. No.	Type of Demand	Total Demand in MCM				
		2021	2022	2030	2040	2050
1	Domestic	72.586	73.441	80.738	91.110	103.104
2	Irrigation (including losses)	2136.73	2136.73	2136.73	2136.73	2136.73
3	Live Stock	35.885	35.885	35.885	35.885	35.885
4	Industries	1.663	1.796	2.945	5.301	9.542
5.	Ecological	3.58	7.16	7.16	7.16	7.16
	Total	**2250.44**	**2255.01**	**2263.45**	**2276.18**	**2292.42**

8.3 Water Balance at 75% Dependability

Water Potential for the year 2021 = 2428.25 MCM

Water demand for the year 2021 (75% dependability) = 2286.27 MCM

Water Balance = 141.98 MCM

% Water Balance with respect to potential = 5.84 %

Agniyar basin as such shows a water balance by 141.98MCM (5.84%) for the year 2021 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 2022, 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 8.3**

Table 8.3
Water Balancing for Agniyar Basin
Water Potential (75 % dependability), Demand and Deficit (Both long & short term)

Sector	2021	2022	2030	2040	2050
Total Water Potential in MCM	2428.25	2428.25	2428.25	2428.25	2428.25
Total Water Demand in MCM	2286.27	2290.21	2298.65	2311.38	2327.62
Total water balance in MCM	**141.98**	**138.04**	**129.60**	**116.87**	**100.63**
Percentage of water balance with respect to potential	**5.84%**	**5.68 %**	**5.34 %**	**4.81%**	**4.14 %**

From the table, it is observed that the Agniyar basin for the year 2021 appears surplus by 5.84% of total water potenial available in the basin.

8.4 Water Balance at 50% Dependability

Water balance is also worked out for 50% dependable values so that it could be adopted for years having good rainfall. For this purpose, Surface water potential value at 50% dependability obtained from MRS model, inter basin transfer and return flow is 2558.13 MCM,. Similarly, the irrigation demand values at 50% dependable rainfall obtained from the CROPWAT model is already given in Section 4.70 and it is adopted for calculation. The corresponding values for different years are tabulated In **Table 8.4**. This also shows a surplus value of 12.03 %.

Table 8.4

Water Balancing for Agniyar Basin
Water Potential (50 % dependability), Demand and Deficit (Both long & short term)

Sector	2021	2022	2030	2040	2050
Total Water Potential in MCM	2558.13	2558.13	2558.13	2558.13	2558.13
Total Water Demand in MCM	2250.44	2255.01	2263.45	2276.18	2292.42
Total water balance in MCM	**307.69**	**303.12**	**294.68**	**281.95**	**265.71**
Percentage of water balance with respect to potential	**12.03 %**	**11.85 %**	**11.52 %**	**11.02 %**	**10.39 %**

8.5 Water Balance for Different scenarios:

The following different planning scenarios for Agniyar basin are considered:

1. **Existing scenario**

The water balance in the above sections 8.3 and 8.4 has considered the surface water potential arrived due to rainfall alone. In this scenario, tanks in Agniyar 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 consideredfor planning purpose.

The net irrigation Water Demand at 50% and 75% dependable Rainfall of Improved Agricultural method Scenario are tabulated in **Tables 4.12 and 4.13**. To account for the losses, the net Irrigation demand is multiplied by a factor of 1.67 as discussed above.

Now the water balance for this scenario is calculated for 75 % dependability for the years 2021, 2022, 2030, 2040 and 2050 and presented in the **Appendix 8.1 to 8.5** of **Volume II.** Similarly, the water balance for this scenario is calculated for 50 % dependability for the years 2021, 2022, 2030, 2040 and 2050 and presented in the **Appendix 8.11 to 8.15** of **Volume II**.

3. **Improved Efficiency**

This scenario represents an irrigation system with an improved efficiency where the existing system is rehabilated and modernised to improve the efficiency of the system. Accorrding to the report the efficiency of the surface water potential has been improved by 30% of the existing system. Hence the overall efficiency of the system is 70 % on an average as the surface water potential is 70% and ground water potential as 70% as discussed earlier. Hence a factor of 1.43 is multiplied to counter the irrigation losses in the field.

Now the water balance for this scenario is calculated for 75 % dependability for the years 2021, 2022, 2030, 2040 and 2050 and presented in the **Appendix 8.6 to 8.10** of **Volume II**. Similarly, the water balance for this scenario is calculated for 50 % dependability for the years 2021, 2022, 2030, 2040 and 2050 and presented in the **Appendix 8.16 to 8.20**.

The bar charts for 75% & 50% dependabiliites for the years 2021, 2022, 2030, 2040 & 2050 for various scenerios are also presented in the **Figure 8.1 to Figure 8.5**.

8.6 Conclusion

Thus the Water Balance study of Agniyar basin for the existing scenario for the current year shows that the irrigation demand value accounts for about 95% 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.

Table 8.5

AGNIYAR BASIN - Sub Basin wise water balance at 75% dependability (Existing scenario)

2021

Details of Water Potential and Demand		**Agniyar**	**Ambuliyar**	**South vellar**	**Total**
Water potential in MCM	Surface water potential assessed from rainfall	255.19	108.63	222.55	586.37
	Water diverted from Grant Anicut	168.33	168.33	168.34	505.00
	Ground water potential	618.60	211.70	506.58	1336.88
	Total water potential	**1042.12**	**488.66**	**897.47**	**2428.25**
Water demand in MCM	Domestic demand	39.733	13.179	19.673	72.59
	Irrigation demand	1173.04	456.89	543.26	2173.19
	Livestock demand	19.250	5.161	11.475	35.89
	Industrial demand	1.328	0.200	0.135	1.66
	Ecological demand	1.28	0.54	1.11	2.93
	Total water demand	**1234.63**	**475.97**	**575.66**	**2286.26**
Total water potential in MCM	Total water potential after considering the reuse of waste water	**1042.12**	**488.66**	**897.47**	**2428.25**
Total Demand in MCM	Total water demand	**1234.63**	**475.97**	**575.66**	**2286.26**
Water Balance in MCM		**-192.51**	**12.69**	**321.81**	**141.99**
Percentage		**-18.5%**	**2.6%**	**35.9%**	**5.8%**
Water Balance in Agniyar basin		=	**141.99**	**MCM**	**5.8%**

Table 8.6

AGNIYAR BASIN - Sub Basin wise water balance at 75% dependability (Existing scenario)

2022

Details of Water Potential and Demand		**Agniyar**	**Ambuliyar**	**South vellar**	**Total**
Water potential in MCM	Surface water potential assessed from rainfall	255.19	108.63	222.55	586.37
	Water diverted from Grant Anicut	168.33	168.33	168.34	505.00
	Ground water potential	618.60	211.70	506.58	1336.88
	Total water potential	**1042.12**	**488.66**	**897.47**	**2428.25**
Water demand in MCM	Domestic demand	40.228	13.326	19.887	73.44
	Irrigation demand	1173.04	456.89	543.26	2173.19
	Livestock demand	19.250	5.161	11.475	35.89
	Industrial demand	1.435	0.216	0.146	1.80
	Ecological demand	0.26	0.11	0.22	0.59
	Total water demand	**1234.21**	**475.70**	**574.99**	**2284.90**
Total water potential in MCM	Total water potential after considering the reuse of waste water	**1042.12**	**488.66**	**897.47**	**2428.25**
Total Demand in MCM	Total water demand	**1234.21**	**475.70**	**574.99**	**2284.90**
Water Balance in MCM		**-192.09**	**12.96**	**322.48**	**143.35**
Percentage		**-18.4%**	**2.7%**	**35.9%**	**5.9%**
Water Balance in Agniyar basin		=	**143.35**	**MCM -**	**5.9%**

Table 8.7

AGNIYAR BASIN - Sub Basin wise water balance at 75% dependability (Existing scenario)

2030

Details of Water Potential and Demand		Agniyar	Ambuliyar	South vellar	Total
Water potential in MCM	Surface water potential assessed from rainfall	255.19	108.63	222.55	586.37
	Water diverted from Grant Anicut	168.33	168.33	168.34	505.00
	Ground water potential	618.60	211.70	506.58	1336.88
	Total water potential	**1042.12**	**488.66**	**897.47**	**2428.25**
Water demand in MCM	Domestic demand	44.457	14.573	21.708	80.74
	Irrigation demand	1173.04	456.89	543.26	2173.19
	Livestock demand	19.250	5.161	11.475	35.89
	Industrial demand	2.353	0.354	0.239	2.95
	Ecological demand	0.26	0.11	0.22	0.59
	Total water demand	**1239.35**	**477.09**	**576.90**	**2293.34**
Total water potential in MCM	Total water potential after considering the reuse of waste water	**1042.12**	**488.66**	**897.47**	**2428.25**
Total Demand in MCM	Total water demand	**1239.35**	**477.09**	**576.90**	**2293.34**
Water Balance in MCM		**-197.23**	**11.57**	**320.57**	**134.91**
Percentage		**-18.9%**	**2.4%**	**35.7%**	**5.6%**
Water Balance in Agniyar basin		=	**134.91**	**MCM -**	**5.6%**

Table 8.8

AGNIYAR BASIN - Sub Basin wise water balance at 75% dependability (Existing scenario)

2040

Details of Water Potential and Demand		**Agniyar**	**Ambuliyar**	**South vellar**	**Total**
Water potential in MCM	Surface water potential assessed from rainfall	255.19	108.63	222.55	586.37
	Water diverted from Grant Anicut	168.33	168.33	168.34	505.00
	Ground water potential	618.60	211.70	506.58	1336.88
	Total water potential	**1042.12**	**488.66**	**897.47**	**2428.25**
Water demand in MCM	Domestic demand	50.504	16.334	24.272	91.11
	Irrigation demand	1173.04	456.89	543.26	2173.19
	Livestock demand	19.250	5.161	11.475	35.89
	Industrial demand	4.235	0.637	0.430	5.30
	Ecological demand	0.26	0.11	0.22	0.59
	Total water demand	**1247.28**	**479.13**	**579.66**	**2306.07**
Total water potential in MCM	Total water potential after considering the reuse of waste water	**1042.12**	**488.66**	**897.47**	**2428.25**
Total Demand in MCM	Total water demand	**1247.28**	**479.13**	**579.66**	**2306.07**
Water Balance in MCM		**-205.16**	**9.53**	**317.81**	**122.18**
Percentage		**-19.7%**	**2.0%**	**35.4%**	**5.0%**
Water Balance in Agniyar basin		=	**122.18**	**MCM -**	**5.0%**

Table 8.9

AGNIYAR BASIN - Sub Basin wise water balance at 75% dependability (Existing scenario)

2050

Details of Water Potential and Demand		**Agniyar**	**Ambuliyar**	**South vellar**	**Total**
Water potential in MCM	Surface water potential assessed from rainfall	255.19	108.63	222.55	586.37
	Water diverted from Grant Anicut	168.33	168.33	168.34	505.00
	Ground water potential	618.60	211.70	506.58	1336.88
	Total water potential	**1042.12**	**488.66**	**897.47**	**2428.25**
Water demand in MCM	Domestic demand	57.542	18.356	27.206	103.10
	Irrigation demand	1173.04	456.89	543.26	2173.19
	Livestock demand	19.250	5.161	11.475	35.89
	Industrial demand	7.623	1.146	0.774	9.54
	Ecological demand	0.26	0.11	0.22	0.59
	Total water demand	**1257.71**	**481.66**	**582.94**	**2322.31**
Total water potential in MCM	Total water potential after considering the reuse of waste water	**1042.12**	**488.66**	**897.47**	**2428.25**
Total Demand in MCM	Total water demand	**1257.71**	**481.66**	**582.94**	**2322.31**
Water Balance in MCM		**-215.59**	**7.00**	**314.53**	**105.94**
Percentage		**-20.7%**	**1.4%**	**35.0%**	**4.4%**
Water Balance in Agniyar basin		=	**105.94**	**MCM -**	**4.4%**

Table 8.10

AGNIYAR BASIN - Sub Basin wise water balance at 50% dependability (Existing scenario)

2021

Details of Water Potential and Demand		**Agniyar**	**Ambuliyar**	**South Vellar**	**Total**
Water potential in MCM	Surface water potential assessed from rainfall	329.59	125.10	261.56	716.25
	Water diverted from Grant Anicut	168.33	168.33	168.34	505.00
	Ground water potential	618.60	211.70	506.58	1336.88
	Total water potential	**1116.52**	**505.13**	**936.48**	**2558.13**
Water demand in MCM	Domestic demand	39.733	13.179	19.673	72.59
	Irrigation demand	1186.94	394.91	554.89	2136.74
	Livestock demand	19.250	5.161	11.475	35.89
	Industrial demand	1.328	0.200	0.135	1.66
	Ecological demand	1.65	0.63	1.31	3.58
	Total water demand	**1248.90**	**414.08**	**587.48**	**2250.45**
Total water potential in MCM	Total water potential after considering the reuse of waste water	**1116.52**	**505.13**	**936.48**	**2558.13**
Total Demand in MCM	Total water demand	**1248.90**	**414.08**	**587.48**	**2250.45**
Water Balance in MCM		**-132.38**	**91.05**	**349.00**	**307.68**
Percentage		**-11.9%**	**18.0%**	**37.3%**	**12.0%**
Water Balance in Agniyar basin		=	**307.68**	**MCM**	**12.0%**

Table 8.11

AGNIYAR BASIN - Sub Basin wise water balance at 50% dependability (Existing scenario)

2022

Details of Water Potential and Demand		Agniyar	Ambuliyar	South Vellar	Total
Water potential in MCM	Surface water potential assessed from rainfall	329.59	125.10	261.56	716.25
	Water diverted from Grant Anicut	168.33	168.33	168.34	505.00
	Ground water potential	618.60	211.70	506.58	1336.88
	Total water potential	**1116.52**	**505.13**	**936.48**	**2558.13**
Water demand in MCM	Domestic demand	40.228	13.326	19.887	73.44
	Irrigation demand	1186.94	394.91	554.89	2136.74
	Livestock demand	19.250	5.161	11.475	35.89
	Industrial demand	1.435	0.216	0.146	1.80
	Ecological demand	0.33	0.13	0.26	0.72
	Total water demand	**1248.18**	**413.74**	**586.66**	**2248.58**
Total water potential in MCM	Total water potential after considering the reuse of waste water	**1116.52**	**505.13**	**936.48**	**2558.13**
Total Demand in MCM	Total water demand	**1248.18**	**413.74**	**586.66**	**2248.58**
Water Balance in MCM		**-131.66**	**91.39**	**349.82**	**309.55**
Percentage		**-11.8%**	**18.1%**	**37.4%**	**12.1%**
Water Balance in Agniyar basin		=	**309.55**	**MCM**	**12.1%**

Table 8.12

AGNIYAR BASIN - Sub Basin wise water balance at 50% dependability (Existing scenario)

2030

Details of Water Potential and Demand		**Agniyar**	**Ambuliyar**	**South Vellar**	**Total**
Water potential in MCM	Surface water potential assessed from rainfall	329.59	125.10	261.56	716.25
	Water diverted from Grant Anicut	168.33	168.33	168.34	505.00
	Ground water potential	618.60	211.70	506.58	1336.88
	Total water potential	**1116.52**	**505.13**	**936.48**	**2558.13**
Water demand in MCM	Domestic demand	44.457	14.573	21.708	80.74
	Irrigation demand	1186.94	394.91	554.89	2136.74
	Livestock demand	19.250	5.161	11.475	35.89
	Industrial demand	2.353	0.354	0.239	2.95
	Ecological demand	0.33	0.13	0.26	0.72
	Total water demand	**1253.33**	**415.12**	**588.57**	**2257.02**
Total water potential in MCM	Total water potential after considering the reuse of waste water	**1116.52**	**505.13**	**936.48**	**2558.13**
Total Demand in MCM	Total water demand	**1253.33**	**415.12**	**588.57**	**2257.02**
Water Balance in MCM		**-136.81**	**90.01**	**347.91**	**301.11**
Percentage		**110.9%**	**78.3%**	**40.9%**	**11.8%**
Water Balance in Agniyar basin		=	**301.11**	**MCM**	**11.8%**

Table 8.13

AGNIYAR BASIN - Sub Basin wise water balance at 50% dependability (Existing scenario)

2040

Details of Water Potential and Demand		**Agniyar**	**Ambuliyar**	**South Vellar**	**Total**
Water potential in MCM	Surface water potential assessed from rainfall	329.59	125.10	261.56	716.25
	Water diverted from Grant Anicut	168.33	168.33	168.34	505.00
	Ground water potential	618.60	211.70	506.58	1336.88
	Total water potential	**1116.52**	**505.13**	**936.48**	**2558.13**
Water demand in MCM	Domestic demand	50.504	16.334	24.272	91.11
	Irrigation demand	1186.94	394.91	554.89	2136.74
	Livestock demand	19.250	5.161	11.475	35.89
	Industrial demand	4.235	0.637	0.430	5.30
	Ecological demand	0.33	0.13	0.26	0.72
	Total water demand	**1261.26**	**417.17**	**591.33**	**2269.75**
Total water potential in MCM	Total water potential after considering the reuse of waste water	**1116.52**	**505.13**	**936.48**	**2558.13**
Total Demand in MCM	Total water demand	**1261.26**	**417.17**	**591.33**	**2269.75**
Water Balance in MCM		**-144.74**	**87.96**	**345.15**	**288.38**
Percentage		**-13.0%**	**17.4%**	**36.9%**	**11.3%**
Water Balance in Agniyar basin		=	**288.38**	**MCM**	**11.3%**

Table 8.14

AGNIYAR BASIN - Sub Basin wise water balance at 50% dependability (Existing scenario)

2050

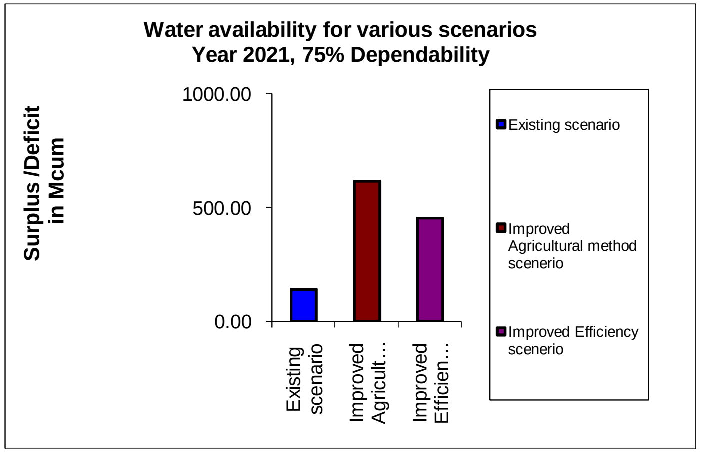
Details of Water Potential and Demand		Agniyar	Ambuliyar	South Vellar	Total
Water potential in MCM	Surface water potential assessed from rainfall	329.59	125.10	261.56	716.25
	Water diverted from Grant Anicut	168.33	168.33	168.34	505.00
	Ground water potential	618.60	211.70	506.58	1336.88
	Total water potential	**1116.52**	**505.13**	**936.48**	**2558.13**
Water demand in MCM	Domestic demand	57.542	18.356	27.206	103.10
	Irrigation demand	1186.94	394.91	554.89	2136.74
	Livestock demand	19.250	5.161	11.475	35.89
	Industrial demand	7.623	1.146	0.774	9.54
	Ecological demand	0.33	0.13	0.26	0.72
	Total water demand	**1271.68**	**419.70**	**594.61**	**2285.99**
Total water potential in MCM	Total water potential after considering the reuse of waste water	**1116.52**	**505.13**	**936.48**	**2558.13**
Total Demand in MCM	Total water demand	**1271.68**	**419.70**	**594.61**	**2285.99**
Water Balance in MCM		**-155.16**	**85.43**	**341.87**	**272.14**
Percentage		**-13.9%**	**16.9%**	**36.5%**	**10.6%**
Water Balance in Agniyar basin		=	**272.14**	**MCM -**	**10.6%**

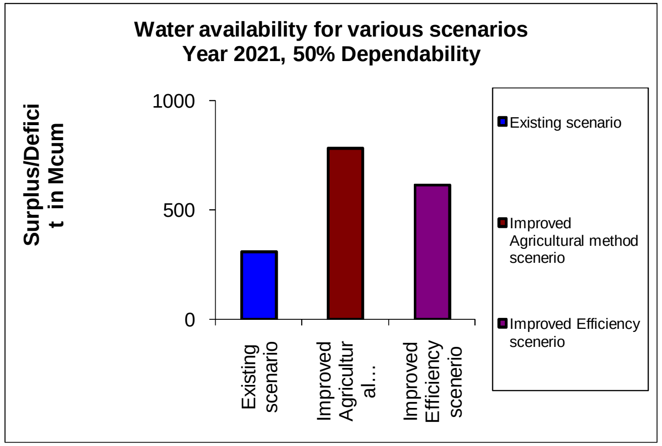
Figure - 8.1

Agniyar river basin - Water availability at 75% & 50% dependabilities during 2021 for various Scenarios

Water availability during 2021 at 75% dependability		
Sl.No.	Scenario	Surplus/Deficit in Mcum
1	Existing scenario	141.99
2	Improved Agricultural method scenerio	617.85
3	Improved Efficiency scenerio	454.30

Water availability during 2021 at 50% dependability		
Sl.No.	Scenario	Surplus/Deficit in Mcum
1	Existing scenario	308
2	Improved Agricultural method scenerio	782
3	Improved Efficiency scenerio	614





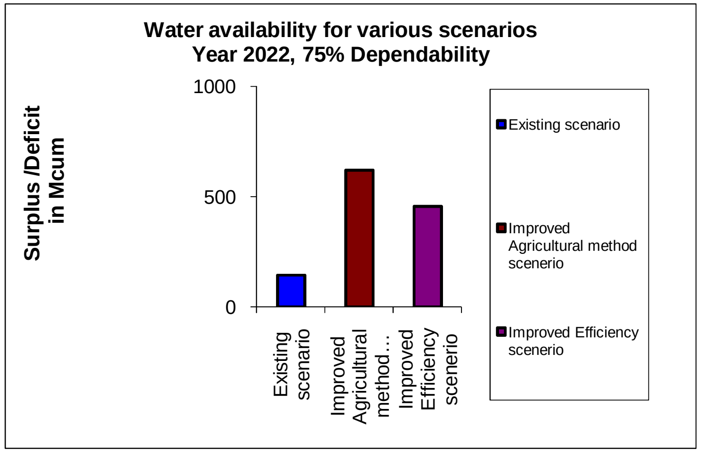
Description of Scenarios	
Existing Scenario	Present condition
Improved Agricultural method scenerio	Changes in the present cropping or cultivation pattern for Paddy by using SRI (System of Rice
Improved Efficiency scenerio	Condition where efficiency is increased to 75%

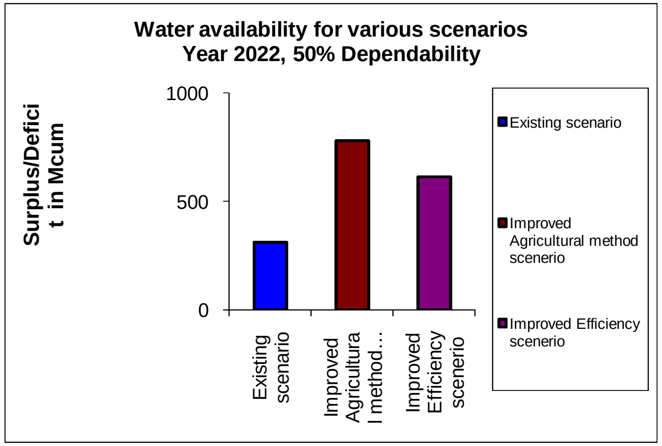
Figure - 8.2

Agniyar river basin - Water availability at 75% & 50% dependabilities during 2022 for various Scenarios

Water availability during 2022 at 75% dependability		
Sl.No.	Scenario	Surplus/Deficit in Mcum
1	Existing scenario	143
2	Improved Agricultural method scenerio	619
3	Improved Efficiency scenerio	456

Water availability during 2022 at 50% dependability		
Sl.No.	Scenario	Surplus/Deficit in Mcum
1	Existing scenario	310
2	Improved Agricultural method scenerio	782
3	Improved Efficiency scenerio	616





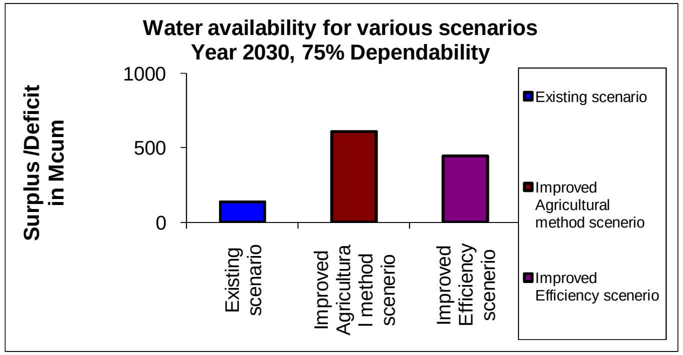
Description of Scenarios	
Existing Scenario	Present condition
Improved Agricultural method scenerio	Changes in the present cropping or cultivation pattern for Paddy by using SRI (System of Rice
Improved Efficiency scenerio	Condition where efficiency is increased to 75%

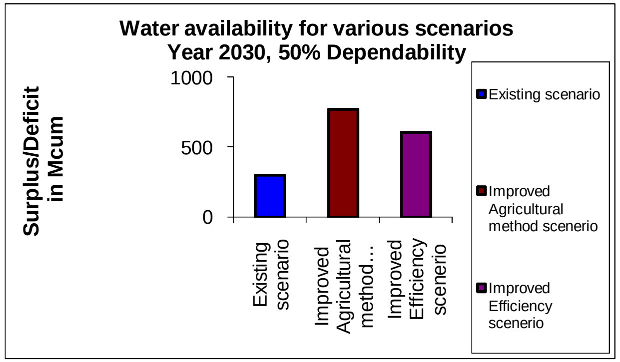
Figure - 8.3

Agniyar river basin - Water availability at 75% & 50% dependabilities during 2030 for various Scenarios

Water availability during 2030 at 75% dependability		
Sl.No.	**Scenario**	**Surplus/Deficit in Mcum**
1	Existing scenario	135
2	Improved Agricultural method scenerio	611
3	Improved Efficiency scenerio	447

Water availability during 2030 at 50% dependability		
Sl.No.	**Scenario**	**Surplus/Deficit in Mcum**
1	Existing scenario	301
2	Improved Agricultural method scenerio	774
3	Improved Efficiency scenerio	608





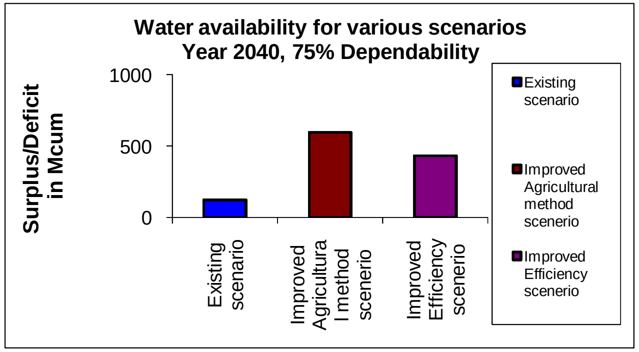
Description of Scenarios	
Existing Scenario	Present condition
Improved Agricultural method scenerio	Changes in the present cropping or cultivation pattern for Paddy by using SRI (System of Rice Intensification) method
Improved Efficiency scenerio	Condition where efficiency is increased to 75%

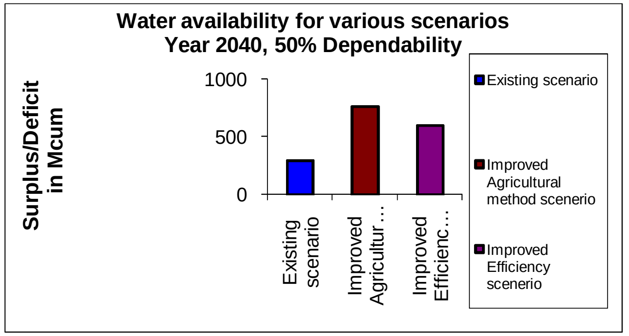
Figure - 8.4

Agniyar river basin - Water availability at 75% & 50% dependabilities during 2040 for various Scenarios

Water availability during 2040 at 75% dependability		
Sl.No.	**Scenario**	**Surplus/Deficit in Mcum**
1	Existing scenario	122
2	Improved Agricultural method scenerio	598
3	Improved Efficiency scenerio	434

Water availability during 2040 at 50% dependability		
Sl.No.	**Scenario**	**Surplus/Deficit in Mcum**
1	Existing scenario	288
2	Improved Agricultural method scenerio	761
3	Improved Efficiency scenerio	595





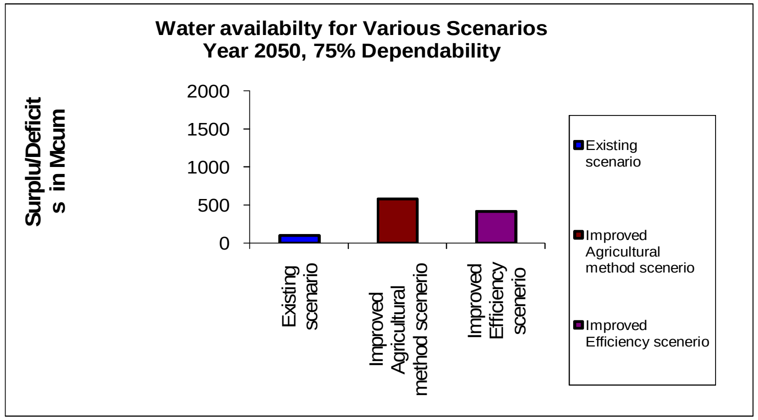
Description of Scenarios	
Existing Scenario	Present condition
Improved Agricultural method scenerio	Changes in the present cropping or cultivation pattern for Paddy by using SRI (System of Rice Intensification) method
Improved Efficiency scenerio	Condition where efficiency is increased to 75%

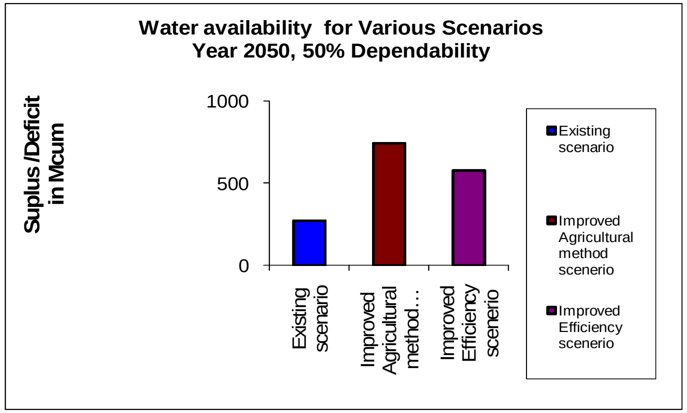
Figure - 8.5

Agniyar river basin - Water availability at 75% & 50% dependabilities during 2050 for various Scenarios

Water availability during 2050 at 50% dependability		
Sl.No.	Scenario	Surplus/Deficit in Mcum
1	Existing scenario	106
2	Improved Agricultural method scenerio	582
3	Improved Efficiency scenerio	418

Water availability during 2050 at 50% dependability		
Sl.No.	Scenario	Surplus/Deficit in Mcum
1	Existing scenario	272
2	Improved Agricultural method scenerio	745
3	Improved Efficiency scenerio	579





Description of Scenarios	
Existing Scenario	Present condition
Improved Agricultural method scenerio	Changes in the present cropping or cultivation pattern for Paddy by using SRI (System of Rice Intensification) method
Improved Efficiency scenerio	Condition where efficiency is increased to 75%

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 Agniyar 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.

The Pollution Index (PI) of any industrial sector is a number from 0 to 100 and the increasing value of PI denotes the increasing degree of pollution load from the industrial sector.

The following criteria on 'Range of Pollution Index' for the purpose of Categorization of industrial sectors has been finalized.

- Industrial Sectors having Pollution Index score of 60 and above - **Red** category
- Industrial Sectors having Pollution Index score of 41 to 59 - **Orange** category
- Industrial Sectors having Pollution Index score of 21 to 40 - **Green** category
- Industrial Sectors having Pollution Index score incl. & upto 20 - **White** category

Based on the revised criteria, the 'Final Report on revised Categorization of Industrial Sectors under Red/Orange/Green/White' has been evolved. The 'Categorization' is based on the relative pollution potential of the industrial sectors and grouping of the industrial sectors based on the use of raw materials, manufacturing process adopted and pollutants likely to be generated.

9.1.1.1 Industries in Agniyar river Basin

In Agniyar basin, the highly polluting, medium and less polluting industries are as shown in **Table 9.1.**

Table 9.1 Polluting Industries in Agniyar river Basin

Sl. No.	Name of sub basin	Highly polluting industries **PI ≥60 (Red)**	Medium polluting industries **PI 41 to 59 (Orange)**	Less polluting Industries **PI 21 to 40 (Green)**	**PI<20 (White)**	**Total**
1	Agniyar	79	197	84	31	**391**
2	Ambuliyar	12	57	28	12	**109**
3	South Vellar	43	54	16	8	**121**

(Source: Chapter7)

The details of the large, medium & small scale industries in the basin along with the waste water generated is given below in **Table 9.2 & Table 9.3**

Table 9.2 Waste Water generated in Large & Medium Industries in MCM/year

Sl. No.	Name of sub basin	Number of large & medium industries	Water demand in MCM per year	Waste water generated in MCM per year (80 % of water demand)
1	Agniyar	10	0.108	0.086
2	Ambuliyar	1	0.001	0.001
3	South Vellar	4	0.021	0.017
Total		**15**	**0.130**	**0.104**

(Source: Chapter7)

Table 9.3 Waste water generated in Small Scale industries in MCM/year

Sl. No.	Name of sub basin	Number of small scale industries	Water demand in MCM per year	Waste water generated in MCM Per year (80% of water demand)
1	Agniyar	381	1.220	0.976
2	Ambuliyar	108	0.198	0.158
3	South Vellar	117	0.114	0.091
Total		**606**	**1.532**	**1.225**

(Source:Chapter-7)

Waste water from Large & medium Scale Industries = 0.104 MCM per year

Waste water from Small Scale Industries = 1.225 MCM per year

Total = 1.329 MCM 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 along 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, petrochemical, 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 been courage 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 Agniyar 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 2021 in million	Water Demand 2021 in MCM	Volume of sewage generated in MCM/year (80% of Water Demand)
1.	Agniyar	0.811	23.685	18.948
2.	Ambuliyar	0.323	9.423	7.538
3.	South Vellar	0.496	14.483	11.586
TOTAL		**1.630**	**47.591**	**38.072**

(*Source: Chapter-7*)

Table 9.5 Generation of Sewage in Urban Areas

Sl. No.	Name of the Sub basin	Projected Population in 2021 in million	Water Demand 2021 in MCM	Volume of sewage generated in MCM/year (80% of Water Demand)
1.	Agniyar	0.284	16.048	12.838
2.	Ambuliyar	0.066	3.756	3.005
3.	South Vellar	0.092	5.190	4.152
TOTAL		**0.442**	**24.995**	**19.995**

(Source:Chapter-7)

Sewage from Rural Areas = **38.072** Mcum per year

Sewage from Urban Areas = **19.995** Mcum per year

Total = **58.067** 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 Agniyar river Basin, the sewage treatment plants have been implemented in Dindigul, Pudukkottai, Sivagangai, Thanjavur and Tiruchirapalli 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 Dindigul, Pudukkottai, Sivagangai, Thanjavur and Tiruchirapalli districts are given below in **Table 9.6**

Table 9.6 Sewage Treatment Plant in Dindigul, Pudukottai , Sivagangai, Thanjavur and Tiruchirapalli Districts

Sl. No.	Name of the District	Name of the UGSS (Underground Sewerage System)	STP location	Technology	STP Capacity in MLD	Population benefited (lakhs)	Sewage generated in MLD as on 31.01.2022
1.	Dindigul	Nil					
2.	Pudukottai	UGSS to Pudukottai Municipality	Marupini Grass Farm Pudukottai Municipality	Activated Sludge Process(ASP)	10.62	1.37	6.13
3.	Sivagangai	UGSS to Sivagangai Municipality	Arasani group in Muthhappati village	Extended Activated Sludge Process (EASP)	4.92	0.62	5.50
		UGSS to Karaikudi Municipality	Opposite to Solid waste disposal at Devakottai road	Extended Activated Sludge Process(EASP)	16.00	1.76	CS-99% &STP-83% completed
4.	Thanjavur	UGSS to Orathanadu Treatment Plant	Muthuambalpuram village	Activated Sludge Process(ASP)	1.50	0.13	1.28
		UGSS to Vallam Treatment Plant	Vallam Therkku	Extended Activated Sludge Process(EASP)	2.35	0.23	Completed. For generation of sewage houses to be linked by ULB.
5.	Tiruchirapalli	UGSS to Manachallur Treatment Plant UGSS to S.Kannanur Treatment Plant	Mela Sri Devi Mangalam	Extended Activated Sludge Process(EASP)	6.41	0.64	Completed. For generation of sewage houses to be linked by ULB.

(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 Agniyar river Basin

In Agniyar basin, the main elements of agricultural pollution are phosphates, nitrates, potassium etc. The year wise consumption of fertilizers and Pesticides in Agniyar Basin is furnished in **Table 9.7 and 9.8.**

Table 9.7 Consumption of Fertilizers in Agniyar Basin

Year	COMPLEX (NPK) in MT
2016-17	**75087**
2017-18	**71427**
2018-19	**78827**
2019-20	**87239**
2020-21	**101819**
Total	**414399**

(Source: Joint Director of Agriculture, Dindigul, Tiruchirapalli, Thanjavur, Pudukottai and Sivagangai)

Table 9.8 Consumption of Pesticides in Agniyar river Basin

Year	Liquid(litres)	Dust /Solid(kgs)
2016-17	281262	274449
2017-18	316072	288993
2018-19	342913	307916
2019-20	305945	286924
2020-21	328712	301998
Total	**1574904**	**1460280**

(Source: Joint Director of Agriculture, Dindigul, Tiruchirapalli, Thanjavur, Pudukottai and Sivagangai)

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 Agniyar river Basin

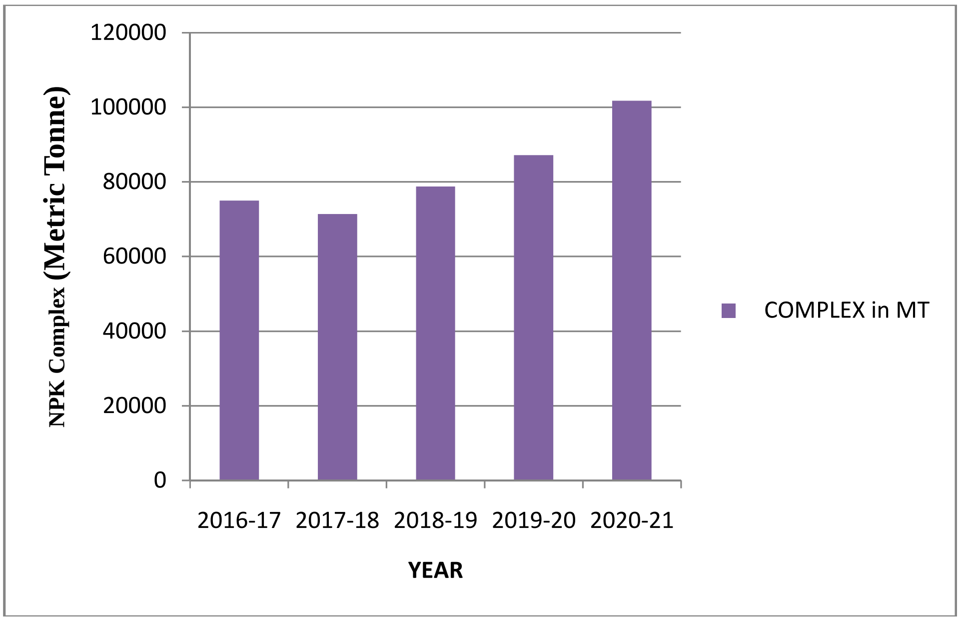
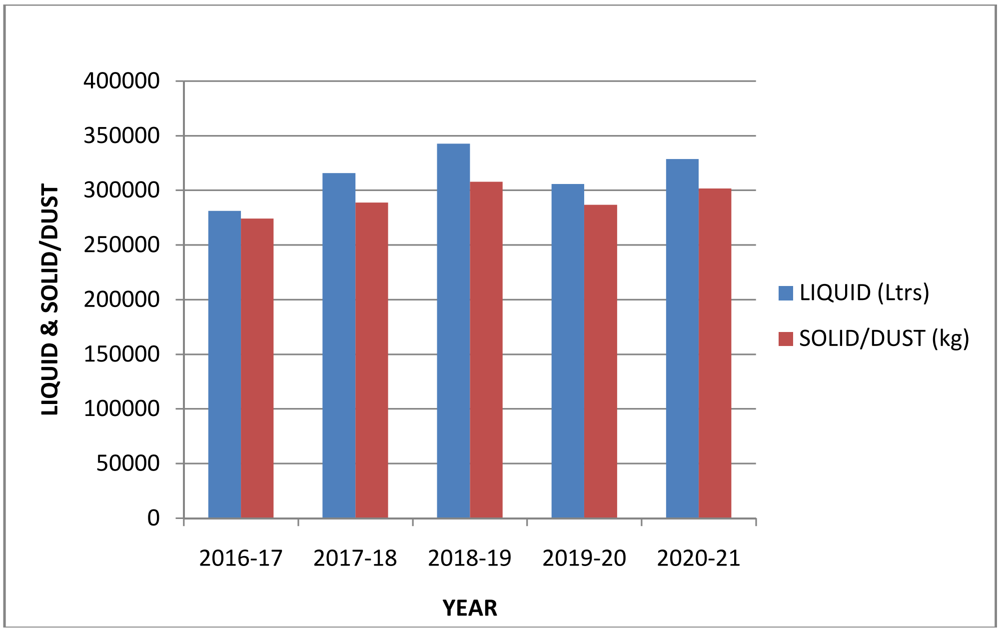


Fig 9.2 Consumption of Pesticides in Agniyar river Basin



From the above graphs, it is inferred that the consumption of Complex fertilizer and consumption of pesticides (in liquid form) were getting increased in the years 2017,2018,2020 and 2021.

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 into the sub-soil and reaches the ground water making it more saline. Again when there is water logging problem, the ground water 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 village.
- 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 micro nutrients).
- 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

As there are no irrigation reservoirs in this basin, conducting sedimentation studies in irrigation source does not arise.

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 Weeds growth

Almost all the states in India are having the problem of aquatic weeds. Irrigation tanks located in many suburban areas receive solid and liquid wastes from point and non-point sources. They contaminate not only the water quality but also encroach the conveyance systems. The nutrients are generally utilized for the abundant growth and proliferation of floating aquatic weeds such as Eichhormia Grassips, Ipomea aquatic, Pistia Sp and Salvinia

Sp. Such weeds emerge to cover the entire surface area of the tank making the system worse and unsuitable for irrigation. A major concern is that macophytes increase mosquito population by providing stagnant water.

Impact of Prosopis Juliflora

Impact of Prosopis Juliflora DC (Velikkaruvai) is an exotic evergreen tree native of arid regions of Mexico, South America and Caribbean. Prosopis Juliflora is a fast spreading weed at every place in wasteland (Poramboku land) Tank beds and farmlands also. The farmers, the charcoal producers and the traders are responsible for Prosopis Juliflora cultivation.

Merits in Growing Prosopis Juliflora

1. It was found to add maximum phosphorous and potassium through litter fall.
2. Soils under Prosopis Juliflora were found two or three times richer in organic matter and nitrogen than the soil, which is at distance from the trees.
3. The population of bacteria, fungi, actinomycetes and nitrogen fixing bacteria were found to be higher beneath the Prosopis Juliflora tree.

Demerits in Growing Prosopis Juliflora

1. The water quality of both surface and groundwater were affected by Prosopis Juliflora
2. It does not allow any plants to grow in and around. Hence this would be avoided in the places where cultivation is in practice.
3. It absorbs atmospheric moisture.

9.4 Encroachment

Rivers, streams, supply channels and tanks are becoming the easiest prey 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 9.9.**

Table 9.9 Details of Encroachments in Water Bodies

Sl. No	Description of Water body	Total Extent as per memoir in Acres	Extent of Encroachment in Acres	Action Taken	Remarks
1	2	3	4	5	6
	THANJAVUR DISTRICT				
1	Ayyanar Eri	4.90.0	0.81.0	Encroachment will be removed for the surveyed and demarcated areas after getting the fund from Government.F orthe balance which are not demarcated,to be surveyed and demarcated by the Revenue department and issue to form-I notification	
2	Kanakankulam	4.03.0	2.30.0		
3	Karungulam	2.84.0	0.40.0		
4	Kurumbaikulam	14.05.0	4.05.0		
5	Panayakulam	7.81.0	0.19.0		
6	Vadugankulam	7.81.0	0.95.0		
7	Otteri	12.09.0	1.85.0		
8	Sendan Eri	9.69.0	2.02.0		
9	Vendakottai Periya Eri	11.71.0	0.04.0		
10	Pudukulam	0.87.0	0.05.0		
11	Vannathiodai	3.79.0	1.21.0		
12	Thammankulam	15.61.0	3.65.0		
13	Parathatchanodai	12.09.0	0.74.0		
14	Silabakkanodai	8.87.0	0.78.0		
15	Sendan Odai	4.90.0	1.94.0		
16	Adidravidarkulam	51.34.5	7.99.0		
17	Arankulam	13.40.0	4.20.0		
18	Chettikulam	11.92.5	1.20.0		
19	Chettiuranikulam	7.95.0	0.77.0		
20	Edayankulam	2.88.0	0.40.0		

Sl. No	Description of Water body	Total Extent as per memoir in Acres	Extent of Encroachment in Acres	Action Taken	Remarks
21	Edayathi Eri	12.30.0	0.06.5	Encroachment will be removed for the surveyed and demarcated areas after getting the fund from Government. For the balance which are not demarcated,to be surveyed and demarcated by the Revenue department and issue to form-I notification	
22	Eduthanivayal Eri	17.32.0	0.81.4		
23	Ennanivayal Eri	4.42.0	0.75.0		
24	Eramarikulam	2.35.5	2.32.0		
25	Kadambangal	49.14.5	0.48.0		
26	Kadapirai Eri	8.66.5	4.148		
27	Kallakulam	13.11.5	2.94.0		
28	Karugavayal Eri	7.65.0	0.00.5		
29	Karuppanviduthi Eri	22.97.5	0.20.0		
30	Kasankulam	30.28.5	1.42.0		
31	Katchakulam	36.42.5	1.59.0		
32	Koothadivayal Eri	23.20.0	1.30.0		
33	Kuruchi Eri	7.25.5	0.60.0		
34	Kuthagaikulam	24.85.5	0.80.0		
35	Manavayalkulam	28.00.0	4.98.0		
36	Melamarichikatti Eri	32.65.0	0.30.0		
37	Mudapallikulam	23.70.0	6.09.2		
38	Nallikulam	4.9.15	5.26.0		
39	Navakulam	2.66.5	0.43.0		
40	Neppugaikulam	10.36.5	5.81.0		
41	NochiOdai	2.52.5	0.16.0		
42	Pallavarayan Eri	11.28.5	0.82.0		

Sl. No	Description of Water body	Total Extent as per memoir in Acres	Extent of Encroachment in Acres	Action Taken	Remarks
43	Pannavayal Eri	41.40.0	0.35.0	Encroachment will be removed for the surveyed and demarcated areas after getting the fund from Government. For the balance which are not demarcated,to be surveyed and demarcated by the Revenue department and issue to form-I notification	
44	PoovalurPeriya Eri	21.85.0	0.54.0		
45	PillanguzhiEri	19.50.0	0.41.0		
46	Salakulam	14.19.0	0.00.5		
47	SeethambalpuramEri	28.88.5	2.38.2		
48	SendaKkottai eri	4.56.0	0.81.0		
49	Senniakulam	33.06.5	0.01.5		
50	SevIdiyakulam	6.22.5	0.05.0		
51	Thalangulam	11.25.0	5.68.0		
52	Thuvaramadi	39.23.5	0.31.0		
53	Ullakulam	22.95.0	0.05.2		
54	Valasamudram Eri	5.50.0	3.245		
55	Vannan Odai	16.50.0	-		
56	Vannankulam	26.05.0	0.08.2		
57	Vattathikkottai Periya Eri	4.27.0	6.57.0		
58	Punavasal Eri	51.34.5	7.99.0		
59	Perandaikulam	11.92.5	1.20.0		
60	Sevanikkankulam	7.65.0	0.01.0		
61	Velivayal Tank	39.23.5	0.31.0		
62	Vavilankulam	41.40.0	0.35.0		
63	Nattarasankulam	4.56.0	0.81.0		
64	Seppankulam	27.00.0	2.87.0		
65	Thandamaraikadu Eri	28.04.0	0.61.0		
66	Palliodaivayal Eri	60.00.0	1.01.0		

Sl. No	Description of Water body	Total Extent as per memoir in Acres	Extent of Encroachment in Acres	Action Taken	Remarks
67	Velavadikulam Eri	25.20.0	0.20.0	Encroachment will be removed for the surveyed and demarcated areas after getting the fund from Government. For the balance which are not demarcated,to be surveyed and demarcated by the Revenue department and issue to form-I notification	
68	Nadiyam Eri	10.42.0	0.57.0		
69	Padayandankulam	1.98.0	0.20.0		
70	Venkitankulam	17.50.0	0.81.0		
71	Karayanvayal	28.00.0	0.61.0		
72	Villunivayal	16.85.0	1.82.0		
73	Maravanvayal	4.59.0	0.49.0		
74	Pethanachivayal	27.65.0	0.81.0		
75	Ravuthanvayal Eri	5.18.0	1.20.0		
76	Mudachankulam	3.96.0	0.10.0		
77	Kurukkalkulam	8.07.0	0.84.0		
78	M.Odaikulam	4.35.0	3.85.0		
79	Andikulam	5.35.0	0.81.0		
80	Senthalaivayal Eri	29.55.0	3.01.0		
81	Athanur	76.61.0	0.58.0		
82	Vembakulam	24.00.0	0.75.0		
83	KoratturEri	48.00.0	3.00.0		
84	Periyathikottai Eri	28.90.0	3.00.0		
85	Rettavayal Eri	79.00.0	0.53.0		
86	Pinnakulam	51.00.0	0.50.0		
87	Koothandarkulam	27.00.0	2.50.0		
88	Thevarkulam	27.00.0	3.00.0		
89	Nannavayal Eri	34.74.0	16.89.0		

Sl. No	Description of Water body	Total Extent as per memoir in Acres	Extent of Encroachment in Acres	Action Taken	Remarks
90	Palukkadu Eri	64.92.0	3.12.0	Encroachment will be removed for the surveyed and demarcated areas after getting the fund from Government. For the balance which are not demarcatedto be surveyed and demarcated by the Revenue department and issue to form-I notification	
91	Vellalankadu Eri	21.75.0	6.00.0		
92	VilankulamPeriya Eri	111.75.0	2.51.0		
93	Poosamadathan Eri	29.10.0	0.00.0		
94	Perumadathaneri	35.40.0	1.51.0		
95	Perumagalore Periya Eri	98.70.0	2.04.0		
96	Rajakulam	64.05.0	10.06.0		
97	Kolagudy Eri	52.92.0	5.38.0		
98	Veerakondan eri	27.00.0	3.31.0		
99	Mudian Eri	4.00.0	3.18.0		
100	Seventhanayaki Eri	7.00.0	0.05.0		
101	Karupattikadu Eri	4.00.0	0.03.0		
102	Kalakkamangalam	32.90.0	0.14.0		
103	Pichanendal Eri	7.00.0	0.49.0		
104	Puduppattinam Main Channel, Pattukkottai, Madathikkadu,				
105	Puduppattinam No:2 Channel, Pattukkottai,				
106	Puduppattinam No:5 Channel, Pattukkottai, Kattaiyankadu'		0.00.7		
107	Puduppattinam No:6 Channel, Pattukkottai,		0.29.0		
108	Puduppattinam No:8 Channel, Pattukkottai, Ettivayal		0.00.3		
109	Puduppattinam No:9 Channel, Pattukkottai, Andikadu		0.00.3		
110	Karisavayal Channel, Pattukkottai,		0.03.6		
111	PoovanamChannel, Pattukkottai,		0.00.3		
112	Ottangadu Channel, Pattukkottai, Ottangadu		0.09.6		

Sl. No	Description of Water body	Total Extent as per memoir in Acres	Extent of Encroachment in Acres	Action Taken	Remarks
113	Koravayal Channel, Pattukkottai,Koravayal		0.00.3	Encroachment will be removed for the surveyed and demarcated areas after getting the fund from Government. For the balance which are not demarcated to be surveyed and demarcated by the Revenue department and issue to form-I notification	
114	Ettivayal Supply Channel, Pattukkottai,Ettivayal		0.11.9		
115	Vettikulam Surplus Course, Pattukkottai, Punalvasal		0.41.0		
116	Perandakulam Surplus Course, Pattukkottai, Punalvasal		0.25.0		
117	Ammamadam Eri Surplus Course		0.03.0		
118	KannakulamSurplusCourse, Pattukkottai,Thiruchitrambal		0.20.0		
119	Uppukulam Surplus Course, Pattukkottai, Madathikkadu,		0.02.0		
120	Poonachikulam Surplus Course,Pattukkottai, Ambalapuram		0.02.0		
121	Mathanpatttakulm Surplus Course, Pattukkottai, Ambalapuram		0.02.0		
122	Mathanpattavur Eri Surplus Course, Pattukkottai, Mathanpattavur		0.10.0		
123	Valaiyankulam Surplus Course, Pattukkottai, Chokkanathapuram		0.15.0		
124	Vellankulikulam Surplus Course, Pattukkottai, Alagiyanayakipuram		0.09.0		
125	Eralivayal Eri Surplus Course, Pattukkottai, Eralivayal		0.16.0		
126	Anukkankulam Vaari Course, Pattukkottai,		0.10.0		
127	Maruthangavayal Eri Surplus Course, Pattukkottai, Maruthangavayal		0.20.0		
128	Kottaikadu Eri Surplus Course, Pattukkottai, Kottaikadu		4.74.0		
129	Mithiyakudi Eri Surplus Course,Pattukkottai, Ottangadu		0.03.0		

Sl.No	Description of Water body	Total Extent as per memoir in Acres	Extent of Encroachment in Acres	Action Taken	Remarks
	PUDUKOTTAI DISTRICT				
1	Meli kanmoi	10.95	0.030	Evicted	
2	Kattupiramanavayal	81.00	0.100	Evicted	
3	Melasuriyapuram	8.00	0.120	Evicted	
4	Samanthavayal	10.83	0.079	Evicted	
5	Sundaram periyakanmoi	52.55	2.500	To be Evicted	
6	Perunavalur	56.00	8.820	To be Evicted	
7	Parambur periyakulam	61.60	0.250	To be Evicted	
8	Kotti kanmoi	43.34	0.013	To be Evicted	
9	Thekkattur periyakanmoi	15.39	0.014	To be Evicted	
10	Siruvani kanmoi	26.20	0.015	To be Evicted	
11	Maravamadurai	87.00	0.030	To be Evicted	
12	Sirayan kanmoi	26.40	0.012	To be Evicted	
13	Thatachankulam	39.60	0.014	To be Evicted	
14	Isugukanmoi	207.30	0.013	To be Evicted	
15	Kavinadu kanmoi	29.00	0.023	To be Evicted	
16	Mirrattunilai periyakanmoi	216.50	0.013	To be Evicted	
17	Vembanmugunathankanmoi	40.00	0.014	To be Evicted	
18	Agarakulam	32.00	0.032	To be Evicted	
19	Otakulam	23.00	0.012	To be Evicted	
20	Paramanthur Keela Eri	35.00	0.031	To be Evicted	

Sl.No	Description of Water body	Total Extent as per memoir in Acres	Extent of Encroachment in Acres	Action Taken	Remarks
21	Nattumangalam	10.00	0.014	To be Evicted	
22	Rethinakottai	31.00	0.015	To be Evicted	
23	Puduvakadu	17.00	0.023	To be Evicted	
24	Payamariyanendal	35.00	0.010	To be Evicted	
25	Neduvakulam	112.00	1.100	Evicted	
26	Avudaiyanikulam	2.97	2.970	Evicted	
27	Periyathalurani	99.90	24.000	To be Evicted	
28	Kaya Eri	26.00	0.032	To be Evicted	
29	Sathinikulam	5.72	0.001	To be Evicted	
30	Keeranur periyakulam	44.60	0.005	To be Evicted	
31	Kulathur periyakulam	142.00	0.003	To be Evicted	
32	Mosakudi periyakulam	65.30	0.002	To be Evicted	
33	Ammankulam	16.10	0.004	To be Evicted	
34	Erayakulam	85.70	0.003	To be Evicted	
35	Mootankulam	19.21	0.021	To be Evicted	
36	Perakulam	42.53	0.023	To be Evicted	
37	Aranikulam	27.40	0.015	To be Evicted	
38	Pungankulam	16.00	0.014	To be Evicted	
39	Kalumuthikulam	160.40	0.013	To be Evicted	
40	Varappur periyakulam	22.06	0.012	To be Evicted	
41	Malaiyadikulam	52.90	0.020	To be Evicted	
42	Soorakadu pudukulam	9.80	0.020	To be Evicted	

Sl.No	Description of Water body	Total Extent as per memoir in Acres	Extent of Encroachment in Acres	Action Taken	Remarks
43	Chinnapudaiyankulam	11.50	0.003	To be Evicted	
44	Petherikulam	15.20	0.032	To be Evicted	
45	Punniyakulam	23.00	0.010	To be Evicted	
46	Neppiyarurani	22.00	0.002	To be Evicted	
47	MattangalPeriya Eri	8.68	0.015	To be Evicted	
48	Kattunavalperiya Eri	148.00	0.002	To be Evicted	
49	Karaikulam	14.30	0.015	To be Evicted	
50	Samanthavayal	10.83	0.001	To be Evicted	
	Total	**2398.76**	**40.535**		
	Agniyar basin division				
1	Agniyar Drain, Orathanadu Taluk, Neiveli Vadapathi		0.06		Burial ground
2	Neiveli Periya Eri, Orathanadu Taluk, Neiveli Vadapathi Village	128.41 Ac	0.14	Details called from Thasilthar orathanadu in form-I	Government School, Cultivation area
3	Senniyaviduthi Pudukulam, Orathanadu Taluk, Senniyaviduthi Village	36.01 Ac	0.182	Details called from Thasilthar orathanadu in form-I	Burial ground shed, Cultivation area

Sl.No	Description of Water body	Total Extent as per memoir in Acres	Extent of Encroachment in Acres	Action Taken	Remarks
4	Maharajasamuthiram Drain, Pattukkottai Taluk, Kargavayal Village		0.41	Awaited for judgment	The advocate of encroacher promised before the judge that encroaches says that the encroachment will be cleared our self. The cowshed & tin shed only have been removed by the encroacher. The balance encroachment of temple small & big size (cement construction) have not been removed till date.

Sl.No	Description of Water body	Total Extent as per memoir in Acres	Extent of Encroachment in Acres	Action Taken	Remarks
5	Keeniyakulam, Orathanadu Neyveli South	22.34.0	10.10.0	Details called from Tahsildar Orathanadu in form -I	
6	Padarakulam, Orathanadu Neyveli North	15.20.0	1.20.0		
7	Panikondanviduthi Eri Panikondanviduthi , Neyveli North	42.97.5	3.01.0		
	Ambuliyar basin division				
8	Poonaikuthiyar Drain		0.79.0	Details called from Thasilthar Peravurani in form-I	Huts, Houses
9	Ambuliyar Drain		11.35.50	Details called from Thasilthar Peravurani in form-I	Huts, House, Cultivation (Paddy, Coconut)
10	Maruthangudiyar Drain		9.30.06	Details called from Thasilthar Peravurani & Aranthangi in form-I	Huts, House, Cultivation (Paddy, Coconut)

9.4.1 Impact due to Encroachment

- The carrying capacity of the system is reduced due to the encroachment in river banks 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 level sand 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 quality threat to groundwater in coastal regions. It is the movement of seawater landwards as a result of weak groundwater supply from freshwater aquifers. At normal conditions, in coastal land, fresh water floats above salt water due to the difference in its density. When freshwater extracted above its potential, the groundwater level lowers and causes sea water intrusion. This is a very common phenomenon along the coastal cities as population explosively increases and in turn fresh water demand increases. Under above circumstances, lowering of groundwater table is clearly visible along coastal areas of Tamil Nadu. It stimulates sea water intrusion. Episodic changes in the land use pattern, pumping, climate change and sea level fluctuations also cause saltwater intrusion. Certain areas show salinity due to marine depositional environment.

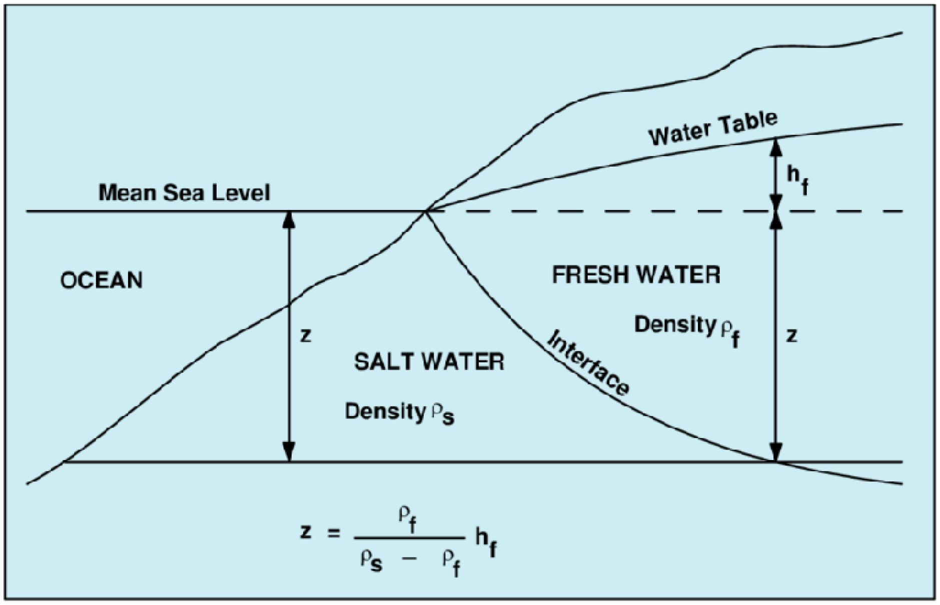
According to the variation of hydraulic pressure, the interface of freshwater and saline water moves landward or seaward. The width of this mixing zone varies in different regions. Mechanical dispersion, molecular diffusion, freshwater discharge, porosity of aquifer and the density contrast cause the variation of this thickness. Hydraulic continuity of seawater with coastal aquifers determines the extent of saltwater intrusion. Saltwater intrusion facilitated by the channels and canals which brings saline water to the distant portions of fresh water aquifer system. Hurricanes and storm surges make this process faster.

Scientific approaches, such as periodic observation on water level fluctuation, water samples collection and technical involvements such as interpretation of hydrographs and chemistry of water samples in these areas are being carried out. In addition, a detailed geophysical resistivity survey is necessary to delineate the Seawater – Freshwater interface.

Impacts of Sea water intrusion are:

1. Rising of saline water level in coastal aquifers
2. Depletion of freshwater in coastal areas
3. Loss of coastal vegetation
4. Lead to salt pan formation

The Ghyben- Herzberg formulae gives the behaviour of seawater intrusion



Here the thickness of fresh water zone above sea level is represented as h and the below sea level is represented as z.Density of saltwaterisρs and ρf is that of fresh water. If we take the density of water as 1 g/cm3 at 20o and density of salt water is ab out 1.025 g/cm3. The equation can be simplified to

z = 40h

For every meter of fresh water in an unconfined aquifer above sea level, there is 40 meter of fresh water in the aquifer below sea level.

In the Agniyar basin, Thanjavur and Pudukkottai districts are having coastal area.Thanjavur situates at the north-eastern side of the basin while Pudukkottai situates towards the south side.The coastline is around 62 Km long.To study the possibility of seawater intrusion along the coastline 10 Km of buffer zone h as been taken for study. There are 29 no of observation wells exclusively meant for seawater intrusion study, which are being monitored by SG&SWRDC. The samples collected and analysed by SG&SWRDC were obtained and analysed to ascertain the threat of seawat er intrusion along the coast of Agniyar basin and the results are discussed below.

Sodium Absorption Ratio (SAR) Values

During post monsoon period SAR values indicate that the seawater intrusion is severe than pre monsoon period. During pre monsoon time above permissible limit of

SAR values (>10) are observed at the isolated pockets of southern coastal areas. But in post monsoon time above permissible limit of SAR value observed all along the coastal region of Agniyar basin. Most of the coastal region is sodic as the SAR value is >3. This indicates that the water is hazardous for irrigation.

Chloride Values

Chloride value is a main parameter of seawater intrusion. The desirable limit is <250 mg/L and permissible limit is 1000 mg/L. Coastal area of Thanjavur district marked with ground water of desirable Cl values. The value continuously rises towards south and beyond permissible values are observed at southern most part of the basins coastal area. Kottaipattanam, Gopalapuram and Manamelkudi 1 villages reported with excess Cl values during both pre and post monsoon periods. Most of the coastal region have Chloride value within the permissible limit. During post monsoon period excess Chloride is common along the southern coast.

Electrical Conductivity

Electrical conductivity of water represents its ion content. This is a good indicator of seawater intrusion. Pre and post monsoon values are indicating above permissible limit of electrical conductivity in the southern part of the coastal region. During pre-monsoon time, the entire southern coastal region get affected by saline water intrusion as indicated by higher electrical conductivity reported at that region. Gopalapuram, Attani regions also heavily affected by the seawater intrusion. Desirable limit is noticed only at certain points. Most of the region is coming under above desirable limit of Electrical conductivity.

Considering the parameters such as SAR value, Chloride value and Electrical conductivity it can be inferred that the entire coastal region is affected by saline water. Poor quality of ground water is contributed by sedimentation in marine environment. Seawater intrusion can also be the reason behind this salinity and site specific studies are needed to find the reason behind this salinity and to confirm the seawater intrusion.

9.6 Salinity

Salinity issue is a major challenge to the quality of groundwater. Salinization of groundwater resources may have natural causes, arising from weathering, atmospheric deposition and saltwater intrusion, but rising salinity also occurs due to human activities, such as land alterations and irrigation return flows. Salinity originate from Marine sources and terrestrial sources. There are three major types of groundwater salinity

Natural / Primary – Due to the accumulation of salt over time or dissolution of minerals from bed rock

Dryland / Secondary – Due to rising water level as a result of rain or flooding especially in arid regions.

Irrigated /Tertiary – Due to repeated irrigation in agriculture fields.

For analyzing the salinity of groundwater in Agniyar basin, TDS along with Electrical conductivity are taken as the major parameters along with Ca and Mg ions. The data has been collected from the wells monitored SG&SWRDC, Tharamani, Chennai and compared the pre monsoon and post monsoon water quality data of 2015-16 and 2019-20. The districts of Thanjavur and Pudukkottai have coastal areas and salinity issues related with ground water mostly arises from seawater intrusion.

Salinity status	Salinity(TDS mg/L)
Fresh to Marginal	<500-1000
Brackish	1000-2000
Saline to highly saline	2000-35000
Brine	>35000

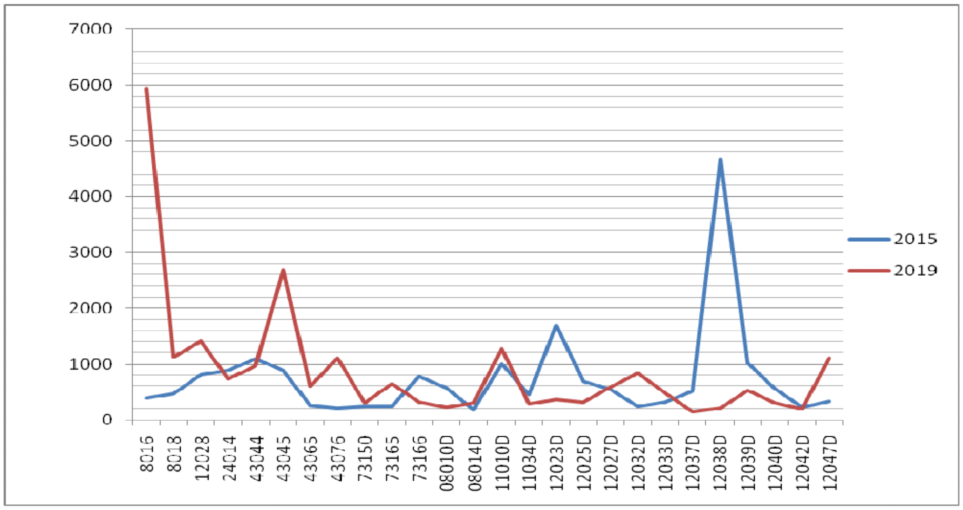
Higher TDS values are observes in the Agniyar and South Vellar sub basins of Agniyar basin. In Agniyar sub Basin saline water observed in wells towards the North and Northwest, while in the South Vellar sub basin presence of saline water is around the coastal region. The availability of fresh to brackish water is uniformly distributed across the basin.Highly saline and brackish water are observed in some isolated pockets of Pudukkottai district. Fresh water is available in the inland regions of the basin. Around 92 percent of the samples analyzed fall under the permissible limit for drinking purpose.

Sample wells with higher electrical conductivity (3000µS/cm) distributed in the same locations of high TDS value. Poyyundarkottai village, situates in the northern parts of Agniyar sub basin marked the highest value of electrical conductivity (10170µS/cm) in 2019.

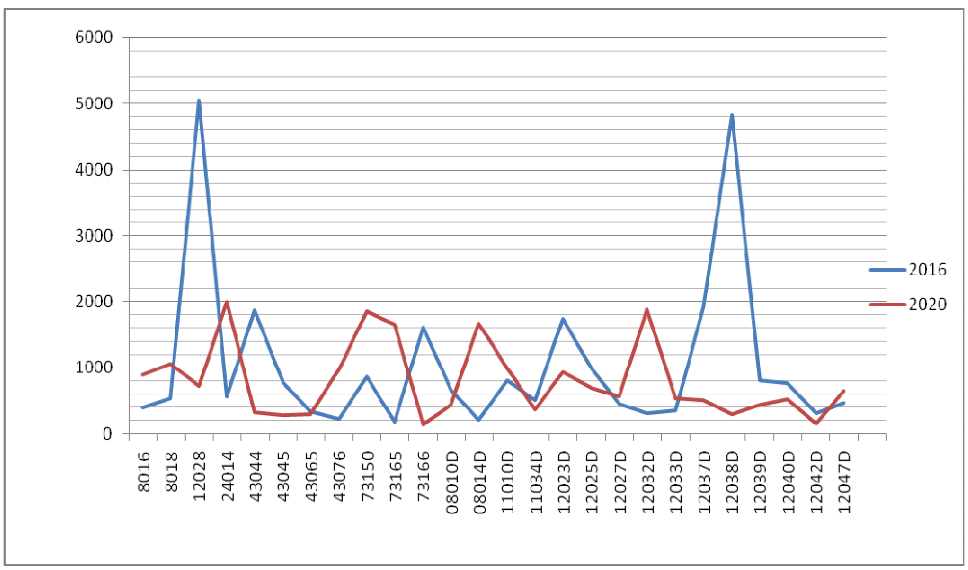
While comparing the post monsoon TDS values of the years 2016 and 2020, Mullur and Manalur villages of the Pudukkottai district marked TDS values above permissible limit during 2016. In 2020 the TDS value of the location showed within permissible and desirable limits respectively. Mullur village situates near to Agniyar and South Vellar sub basin boundary and Manalur situates near to the coast of Thanjavur district. During pre monsoon time of 2015, Manalur villages marked high TDS value of groundwater. The value has been improved to the desirable limit in 2019. In 2019, Poyyandarkottai village in Agniyar sub basin and Nagaram village of South Vellar sub basin are marked with high TDS value as the water quality worsen from 2015. Locations where saline water observed in the South Vellar sub basin are located close to the coastal area. In Agniyar sub basin it is distributed towards western and north western part of the basin.

Four locations in the Agniyar basin marked with above permissible limit of Calcium concentration of 300 mg/L. These locations fall in the Agniyar and South Vellar sub basins. Above desirable limit of Mg content(30mg/L) is observed in half of the samples. Ca comes under the permissible limit in almost all samples except Mullur village in the Agniyar sub basin which marked above permissible limit of Ca content.

Graph showing TDS value of groundwater in different locations during Pre Monsoon period



Graph showing TDS value of groundwater in different locations during Post Monsoon period



9.6.1 Mitigation Measures

- It is essential to enhance sustainable land use and water management.
- Proper irrigation management can prevent salt accumulation by providing adequate drainage water to leach added salts from the soil.
- Rainwater Harvesting structures should be made mandatory.

- Additional costs may include surface leveling, lining drainage channels, sub soil drainage schemes, pumping to lower water table s and mixing saline water with water of better quality.
- Drainage should be de-silted once a year before rainy season.
- Garbage should not be dumped in ponds and channels.

  Artificial recharge structures such as sub surface dyke, check dams may be constructed at vulnerable points to prevent sea water intrusion.

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.

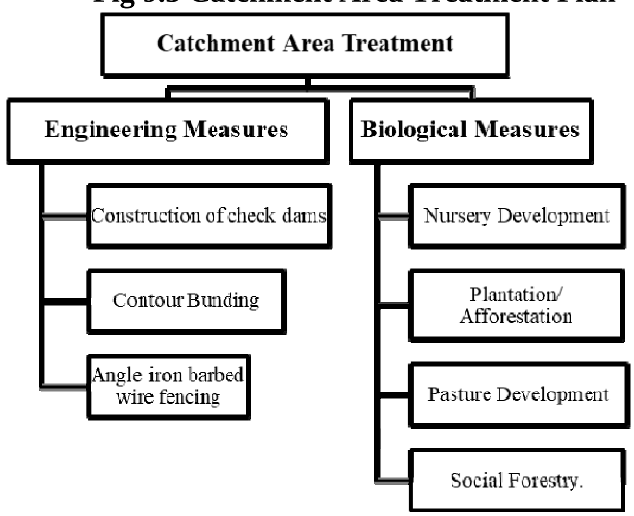
9.7.2 Catchment Area in Agniyar basin

The total area of Agniyar basin is 4702.02 sq.km out of which reserved forest is 211.71 sq.km and Mangrove forest is 4.12 sq.km. The percentage of forest area in this basin is very low as 4.59%. This basin is bounded in north and north eastern by Cauvery basin, Pambar Kottakaraiyar basin in South , South eastern side it is bordered by the Palk Strait and Palk Bay.

9.7.3 Catchment Area Treatment Plan

The basis for formulating appropriate Catchment Area Treatment Plan depends upon the parameters of the water shed such as geology, geomorphology, topography, soil, landuse/landcover, 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 9.10** below.

Table 9.10 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 grass lands.
- Afforestation in the degraded forest areas.
- Construction of contour stone walls (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 indifferent aquatic environment. The fishery in the state is one of the vital sources for food security. Climate

Change has affected in land and off shore 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 (158000ha.) and Brackish water areas, swamps, estuaries (63,000ha.) which are amenable to culture fisheries.

9.8.1.2 Marine Fisheries

Tamil Nadu 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. Tamil Nadu 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 Agniyar river Basin

District wise details of Inland fisheries, Fishermen population and schemes implemented in the Agniyar river basin is given in **Tables 9.11, 9.12 and 9.13** respectively**.**

From the tables, it is confirmed that inland fish production has almost increased every year from the year 2011-12 to 2021-22 in Thanjavur and Tiruchirapalli districts. The fishermen population has also increased in all the districts except Sivagangai from the year 2011-12 to 2021-2022.

Table 9.11 Year wise Inland Fish production (in Tonnes)

Sl.No	Districts	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
1	Dindigul	120	102	110	30	410	457	516	622	838	936	
2	Thanjavur	17115	17315	17825	18325	20385	25835	28959	35240	43152.59	43721	46125
3	Tiruchirapalli	128.50	145	13.04	150.50	140.459	348.39	368	510.18	878.56	791.45	
4	Sivagangai	10			3.2	14.30			3		80	
5	Pudukkottai				3047	4121	1616	3898	4721	3937	2853	3173

(Source: Fisheries Department,Chennai)

Table 9.12 Year wise Fishermen Population (in numbers)

Sl.No	Districts	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
1	Dindigul	2012	2124	2652	2974	3058	3149		3251	3438	3565	
2	Thanjavur	7560	7810	7960	8210	8320	8550	8712	8845	8925	9565	
3	Tiruchirapalli		1435	1638	1700	1935	2010	2135	2437	2417	2450	
4	Sivagangai	78	78	78	78	78	78	60	60	60	60	
5	Pudukkottai	1955	2354	2540	2884	3038	3721	4002	4220	4565	4950	5190

(Source: Fisheries Department,Chennai)

9.13 Schemes implemented for Inland fisheries and aquaculture

1. DINDIGUL DISTRICT

Year	Scheme	Subsidy	Amount	Component	Remark
2014-15	NADP	50%	7500/-	Dragnet and Gillnet	Benefited to 80 Fishermen
			7,03,100/-	Cage culture in Rural Development Tanks	Carry out in 2 Tanks (Tanks Name: Oddanchathiram block- verupaatchi kulam and Palani block- veerakulam
2015-16	NADP	50%	7500/-	Dragnet and Gillnet	Benefited to 86 Fishermen
			6250/-	Coracle	Benefited to 13 Fishermen
2016-17	**Blue Revolution (CSS)**	40%	3.50 Lakhs per ha	Construction of New fish farm	Benefited to 6 Beneficiaries
			1.75 Lakhs per ha	Renovation of Fish Farm	Benefited to 9 Beneficiaries
2017-18	NADP	50%	40000/-	Multipurpose farm pond	Benefited to 10 Beneficiaries
			10000/-	Gillnet and Dragnet	Benefited to 50 Fishermen
			7200/-	Coracle	Benefited to 14 Fishermen
	NFDB	40%	136000/-	Construction of new ornamental fish farm	Benefited to 4 Beneficiaries
			60000/-	Renovation of old ornamental fish farm	Benefited to 10 Beneficiaries
2019-20	TNIAMP	100%	15000/-	Cage culture in Manjalaru sub basin and distribution of nets	2 Unit Benefited to 10 Fishermen

Year	Scheme	Subsidy	Amount	Component	Remark
2019-20	**NADP**	40%	8000/-	Gillnet and Dragnet	Benefited to 60 Fishermen
		40%	7200/-	Coracle	Benefited to 35 Fishermen
2020-21	**NADP**	40%	122000/-	Seed stocked in Panchayat tanks	1,90,000 seeds stocked in 4 Panchayat tanks (30 ha)
			39100/-	GIFT construction of new farm ponds	Benefited to 5 Beneficiaries

2. THANJAVUR DISTRICT

1. TN-IAMP (Tamil Nadu Irrigated Agriculture Modernization Project)

S.No	Year	Name of the Project/Scheme	Name of the Intervention	Area/Unit
1	2018-19	TN-IAMP	Fish culture in long Seasonal tanks	600 ha
2	2018-19	TN-IAMP	Fish culture in Short Seasonal tanks	100 ha
3	2018-19	TN-IAMP	Aquaculture in farm ponds	25 units
4	2018-19	TN-IAMP	Cage farming of Fishes	3 units
5	2018-19	TN-IAMP	Fish seeds Rearing in cages	5 units
6	2018-19	TN-IAMP	Earthen fish seed rearing and culture farms	2 units
7	2019-20	TN-IAMP	Fish culture in short seasonal tanks	300 ha
8	2019-20	TN-IAMP	Aquaculture in farm ponds	25 units
9	2019-20	TN-IAMP	Fish seed rearing in cages	5 units
10	2019-20	TN-IAMP	Earthen fish seed rearing and culture farms	2 units
11	2019-20	TN-IAMP	Distribution of fishing implements (Drag nets)	30 units
12	2020-21	TN-IAMP	Fish culture in short seasonal tanks	200 ha
13	2021-22	TN-IAMP	Aquaculture in Farm ponds	25 units

2. NADP (National Agriculture Development Programme)

S.No	Year	Name of the Project/Scheme	Name of the Intervention	Area/Unit
1	2019-20	NADP	Distribution of fishing implements (Gill Nets)	33 Units
2	2020-21	NADP	Input subsidy assistance to the DFFDA registered fish farmers	10 ha
3	2020-21	NADP	Enhancement of fish production in Panchayat tanks by stocking of fish seeds	80 ha
4	2020-21	NADP	Promotion of GIFT Tilapia culture in farm ponds	20 Nos
5	2021-22	NADP	Subsidy assistance for expansion of fish culture	4 ha
6	2021-22	NADP	Promotion of fish seed rearing by providing subsidy assistance	2 ha
7	2021-22	NADP	Promotion of poly culture of Indian major carps and Scampi in existing Multipurpose Farm ponds	14 Nos
8	2021-22	NADP	Provision of Input assistance for Murrel Fish culture	12 Nos

3.PMMSY (Pradhan Mantri Matsya Sampada Yojana)

S.No	Year	Name of the Project/Scheme	Name of the Intervention	Area/Unit
1	2020-21	PMMSY	Establishment of new freshwater finfish hatcheries	1 No
2	2020-21	PMMSY	Construction of new seed rearing ponds and inputs for culture	3 ha
3	2020-21	PMMSY	Construction of new grow out fish ponds	10 ha
4	2020-21	PMMSY	Establishment of Re-circulatory Aquaculture System (RAS)	1 No

3. TIRUCHIRAPALLI DISTRICT

Year	Scheme	Subsidy	Amount	Component	Remark
2013-14	**NADP**	25%	1,12,600/-	Fish culture farm pond construction	Benefited to 1 Beneficiary
		100%	1000/-	Input subsidy in fish culture farmer	Benefited to 255 Farmers.,
2013-14	**NFDB**	100%	2000/-	Input subsidy in fish culture farmer	Benefited to 75 Farmers
2014-15	**NADP**	50%	7500/-	Dragnet and Gillnet	Benefited to 29Fishermen
	NFDB	100%	42000/-	Seed stocked in Panchayat tanks	25.53 ha area covered this scheme
		100%	7500/-	GIFT seed in farm ponds	Benefited to 94 Fishermen
2015-16	**NADP**	50%	7500/-	Dragnet and Gillnet	Benefited to 49 Fishermen
			6250/-	Coracle	Benefited to 2 Fishermen
2016-17	**Blue Revolution(CSS)**	40%	3.50 Lakhs per ha	Construction of New Fish Farm	Benefited to 1 Beneficiary
2016-17	**NADP**	50%	3.50 Lakhs per ha	Construction of New Fish Farm	Benefited to 2 Beneficiaries
2017-18	**NADP**	50%	40000/-	Multi Purpose Farm pond	Benefited to 12 Beneficiaries
	NFDB	40%	3,80,000/-	Construction of new Backyard ornamental fish farm	Benefited to 3 Beneficiaries
			9,78,000/-	Construction of New medium scale Ornamental Fish farm	Benefited to 1 Beneficiary
			1,60,000/-	Renovation of old ornamental fish farm	Benefited to 1 Beneficiary

Year	Scheme	Subsidy	Amount	Component	Remark
2019-20	**TNIAMP-PHASE-I**	100%	4,00,000/-	Seed Stocking in Short Seasonal Tanks in Ponnaniyar sub basin	100 ha area covered
		100%	4,00,000/-	Seed Stocking in Short Seasonal Tanks in Ponnaniyar sub basin	100 ha area covered
		100%	15,000/-	Dragnet and Gillnet	Benefited to 5 Beneficiaries
		100%	33,000/-	GIFT Seed & feed issued to 15 Farmers	Benefited to 15 Beneficiaries
2020-21	**NADP**	50%	1 ha	Input subsidy for DFFDA Members	Benefited to 5 Beneficiaries distributed to Rs.75,000
		100%	2,50,000/-	Seed stocked in Panchayat Tanks	125000 seeds stocked in 9 Panchayat Tanks (25 ha)
		40%	39,100/-	GIFT Construction of new farm Ponds	Benefited to 3 Beneficiaries
		40%	8,000/-	Gillnet	Benefited to 35 Beneficiaries
		100%	4,00,000/-	Seed stocking in short seasonal tanks in Ponnaniyar sub basin	100 ha area covered
		100%	4,00,000/-	Seed stocking in short seasonal tanks in Nanthiyar Koozhiyar	100 ha area covered
		100%	8,00,000/-	Seed stocking in short seasonal tanks in Ayyar sub basin	100 ha area covered
		100%	33,000/-	GIFT Seed & feed issued to 20 farm ponds	Benefited to 20 Beneficiaries
		100%	15,000/-	Dragnet and Gillnet	Benefited to 15 Beneficiaries

4. SIVAGANGAI DISTRICT

1. CSS (Centrally Sponsored Scheme)

S.No	Year	Name of the Intervention	Area/Unit
1	2016-17	Renovation of farm pond with 50% subsidy	1.8 ha

2. NFDP (National Fisheries Development Board)

S.No	Year	Name of the Intervention	Area/Unit
1	2017-18	Ornamental Pilot Project 1. Integrated ornamental fish unit- 1 2. New backyard Rearing unit-1 3. New medium scale rearing unit-1 4. Aquarium fabrication cum retail unit-2	5 Nos

3.NADP (National Agriculture Development Programme)

S.No	Year	Name of the Intervention	Area/Unit
1	2020-21	Input subsidy assistance to the DFFDA registered fish farmers in Tamil Nadu	3 Beneficiaries (0.36 ha)

4.ATMA (Agriculture Technology Management Agency)

S.No	Year	Name of the Intervention	Area/Unit
1	2020-21	Training related to Fish Growth for beneficiaries under ATMA Scheme	20 Beneficiaries

5. PMMSY (Pradhan Mantri Matsya Sampada Yojana)

S.No	Year	Name of the Intervention	Area/Unit
1	2020-21	Stakeholders awareness programme under PMMSY & FIDF Schemes	17 Beneficiaries attended awareness programme

5. PUDUKKOTTAI DISTRICT

1. TNIAMWARM

S.No	Year	Name of the Activity	Area/Unit
1	2008-2011	Aquaculture in Farm ponds	64
2	2009	Supplying of fishing implements	5
3	2014	Earthen fish seed rearing unit	4
4	2014	Government Earthen fish seed rearing unit	1
5	2010	Fish seed rearing centre	1
6	2015	Seed rearing in farm ponds	15
7	2014	Short seasonal fish culture in farm ponds	2
8	2014	Short seasonal fish culture in fixed cages in irrigation tanks	4
9	2014	Aqua culture in irrigation tanks-Direct stocking	280 ha

2. CSS Blue Revolution – Construction of New Grow out Pond

S.No	Year	Name of the Project/Scheme	Name of the Intervention	Area/Unit
1	2016-17	CSS	Construction of New Grow out Pond	1.9 ha

3. NFDP (National Fisheries Development Board)

S.No	Year	Name of the Project/Scheme	Name of the Intervention	Area/Unit
1	2014-15	NFDP	GIFT Tilapia fish culture in farm pond	36

4. NADP (National Agriculture Development Programme)

S.No	Year	Name of the Project/Scheme	Name of the Intervention	Area/Unit
1	2014-15	NADP	Fish culture in multipurpose farm ponds	4.5 ha
2	2015-16	NADP	Upgradation of fishing efficiency	5 Nos
3	2016-17	NADP	Expansion of fish culture	1 ha
4	2020-21	NADP	Input subsidy assistance to the DFFDA registered fish farmers	1 ha
5	2020-21	NADP	Enhancement of fish production in Panchayat tanks by stocking of fish seeds	10 ha
6	2020-21	NADP	Promotion of GIFT Tilapia culture in farm ponds	2 ha
7	2021-22	NADP	Expansion of fish culture	1 ha

(Source:FisheriesDepartment,Chennai)

From the above tables, it is inferred that various schemes implemented with subsidy for inland fisheries and aquaculture in the districts of Dindigul, Tiruchirapalli, Thanjavur and Sivagangai from the year 2011-21 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 Multi 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, Amurcarp, 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 tare 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 check up 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 water borne 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 block wise details of diseases prevailing in Agniyar river basin is depicted in **Table 9.14 to Table 9.21.**

Table 9.14 LEPTOSPIROSIS																								
SL. NO	**DISTRICT**	**BLOCK**	**2011**		**2012**		**2013**		**2014**		**2015**		**2016**		**2017**		**2018**		**2019**		**2020**		**2021**	
			C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**
1	Dindigul	Natham	1	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	Sivagangai	S.Pudur	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Thirupathur	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Thanjavur	Orathanadu	0	0	0	0	0	0	0	0	0	0	3	0	1	0	1	0	0	0	1	0	2	0
		Madukkur	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		Pattukottai	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		Sethubavachitram	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		Peravurani	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		Thiruvonam	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
		Thanjavur	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
4	Tiruchirapalli	Manaparai	3	0	0	0	0	0	0	0	2	0	4	0	1	0	0	0	0	0	2	0	2	0
		Marungapuri	2	0	0	0	0	0	0	0	0	0	6	0	2	0	3	0	3	0	0	0	0	0
5	Pudukkottai	Gandarvakottai	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
		Karambakudi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SL. NO	DISTRICT	BLOCK	2011		2012		2013		2014		2015		2016		2017		2018		2019		2020		2021	
			C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**
		Thiruvarangulam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Aranthangi	2	0	3	0	1	0	4	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
		Avudaiyarkoil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Manamelkudi	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Ponnamaravathy	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0
		Arimalam	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
		Thirumayam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Viralimalai	0	0	0	0	0	0	3	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
		Kunnandarkovil	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		Annavasal	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Pudukkottai	0	0	1	0	0	0	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	**11**	**0**	**9**	**0**	**6**	**0**	**13**	**0**	**2**	**0**	**20**	**0**	**11**	**0**	**5**	**0**	**4**	**0**	**3**	**0**	**10**	**0**

(Source: Public Health Department, Chennai).

Table 9.15 JAPANESE ENCEPHALITIS																								
SL. NO	**DISTRICT**	**BLOCK**	**2011**		**2012**		**2013**		**2014**		**2015**		**2016**		**2017**		**2018**		**2019**		**2020**		**2021**	
			C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**
1	Dindigul	Natham	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0
2	Sivagangai	S.Pudur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
		Thirupathur	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Thanjavur	Madukkur	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		Pattukottai	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		Sethubavachitram	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Peravurani	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		Thiruvonam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
		Thanjavur	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	3	0	1	0
4	Tiruchirapalli	Manaparai	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
		Marungapuri	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Pudukkottai	Gandarvakottai	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0
		Karambakudi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SL. NO	DISTRICT	BLOCK	2011		2012		2013		2014		2015		2016		2017		2018		2019		2020		2021	
			C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**
		Thiruvarangulam	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
		Aranthangi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Avudaiyarkoil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Manamelkudi	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
		Ponnamaravathy	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Arimalam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Thirumayam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Viralimalai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Kunnandarkovil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Annavasal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Pudukkottai	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
		TOTAL	**1**	**0**	**0**	**0**	**2**	**0**	**5**	**0**	**2**	**0**	**3**	**0**	**5**	**1**	**4**	**0**	**2**	**0**	**3**	**0**	**4**	**0**

(Source: Public Health Department, Chennai).

Table 9.16 CHIKUNGUNYA																									
SL. NO	**DISTRICT**	**BLOCK**	**2011**		**2012**		**2013**		**2014**		**2015**		**2016**		**2017**		**2018**		**2019**		**2020**		**2021**	
			C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**
1	Dindigul	Natham	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
2	Sivagangai	S.Pudur	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
		Thirupathur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Thanjavur	Orathanadu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Madukkur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Pattukottai	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		Sethubavachitram	0	0	0	0	0	0	1	0	2	0	3	0	0	0	2	0	0	0	0	0	0	0
		Peravurani	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Thiruvonam	0	0	10	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Thanjavur	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Tiruchirapalli	Manaparai	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	2	0	1	0	0	0
		Marungapuri	0	0	0	0	0	0	4	0	2	0	0	0	0	0	16	0	5	0	0	0	0	0
5	Pudukkottai	Gandarvakottai	0	0	0	0	0	0	6	0	3	0	0	0	0	0	16	0	7	0	1	0	0	0
		Karambakudi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SL. NO	DISTRICT	BLOCK	2011		2012		2013		2014		2015		2016		2017		2018		2019		2020		2021	
			C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	0	**D**	0	**D**	**C**	**D**	**C**	**D**
		Thiruvarangulam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Aranthangi	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Avudaiyarkoil	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Manamelkudi	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Ponnamaravathy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Arimalam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Thirumayam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Viralimalai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0
		Kunnandarkovil	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
		Annavasal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Pudukkottai	0	0	0	0	3	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
		TOTAL	**1**	**0**	**11**	**0**	**8**	**0**	**29**	**0**	**10**	**0**	**3**	**0**	**0**	**0**	**37**	**0**	**22**	**0**	**2**	**0**	**0**	**0**

(Source: Public Health Department, Chennai).

Table 9.17 DENGUE																								
SL. NO	DISTRICT	BLOCK	2011		2012		2013		2014		2015		2016		2017		2018		2019		2020		2021	
			C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**
1	Dindigul	Natham	0	0	0	0	16	0	4	0	5	0	0	0	33	0	7	0	26	0	5	0	14	0
2	Sivagangai	S.Pudur	0	0	13	0	24	0	8	0	12	0	3	0	22	0	2	0	10	0	2	0	7	0
		Thirupathur	0	0	52	0	35	0	12	0	34	0	10	0	70	0	10	0	11	0	18	0	18	0
3	Thanjavur	Orathanadu	4	0	244	0	33	0	17	0	27	0	24	0	121	0	25	0	43	0	17	0	16	0
		Madukkur	2	0	55	0	21	0	10	0	17	0	8	0	233	0	14	0	26	0	0	0	8	0
		Pattukottai	2	0	284	0	46	0	30	0	42	0	17	0	275	0	18	0	46	0	4	0	14	0
		Sethubavachitram	0	0	152	0	54	0	74	0	26	0	11	0	209	0	17	0	19	0	1	0	10	0
		Peravurani	2	0	248	0	42	0	21	0	22	0	45	0	352	0	14	0	20	0	3	0	5	0
		Thiruvonam	17	0	277	0	12	0	9	0	14	0	9	0	104	0	15	0	13	0	2	0	15	0
		Thanjavur	4	0	960	0	57	0	24	0	63	0	74	0	325	0	45	0	90	0	21	0	72	0
4	Tiruchirapalli	Manaparai	1	1	45	0	12	0	29	0	41	0	12	0	160	0	9	0	62	0	46	0	58	0
		Marungapuri	0	0	21	1	7	0	7	0	21	0	24	0	70	0	7	0	18	0	9	0	18	0
5	Pudukkottai	Gandarvakottai	1	0	99	0	8	0	3	0	15	0	13	0	45	0	28	0	38	0	7	0	22	0
		Karambakudi	15	0	175	0	16	0	5	0	20	0	26	0	106	0	26	0	37	0	4	0	20	0

SL. NO	DISTRICT	BLOCK	2011		2012		2013		2014		2015		2016		2017		2018		2019		2020		2021	
			C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**
		Thiruvarangulam	1	0	250	0	81	0	5	0	53	0	84	0	224	0	63	0	73	0	8	0	28	0
		Aranthangi	0	0	172	0	75	0	109	0	39	0	200	0	555	0	53	0	86	0	11	0	29	0
		Avudaiyarkoil	0	0	41	0	28	0	19	0	28	0	17	0	195	0	26	0	42	0	3	0	13	0
		Manamelkudi	0	0	67	0	42	0	56	0	26	0	23	0	319	1	30	0	36	0	12	0	35	0
		Ponnamaravathy	0	0	39	0	22	0	13	0	9	0	2	0	1	0	4	0	0	0	5	0	15	0
		Arimalam	0	0	54	0	26	0	9	0	2	0	1	0	0	0	3	0	1	0	3	0	19	0
		Thirumayam	0	0	26	0	17	0	4	0	9	0	0	0	3	0	6	0	1	0	2	0	9	0
		Viralimalai	4	0	46	0	20	0	13	0	26	0	5	0	43	0	6	0	5	0	22	0	69	0
		Kunnandarkovil	4	0	161	0	12	0	8	0	15	0	1	0	59	0	17	0	5	0	2	0	25	0
		Annavasal	0	0	92	0	39	0	19	0	14	0	0	0	13	0	13	0	2	0	11	0	38	0
		Pudukkottai	0	0	159	0	22	0	3	0	11	0	0	0	5	0	34	0	1	0	0	0	25	0
		TOTAL	**57**	**1**	**3732**	**1**	**767**	**0**	**511**	**0**	**591**	**0**	**609**	**0**	**3542**	**1**	**492**	**0**	**711**	**0**	**218**	**0**	**602**	**0**

(Source: Public Health Department, Chennai).

Table 9.18 MALARIA																								
SL. NO	**DISTRICT**	**BLOCK**	**2011**		**2012**		**2013**		**2014**		**2015**		**2016**		**2017**		**2018**		**2019**		**2020**		**2021**	
			C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**
1	Dindigul	Natham	4	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
2	Sivagangai	S.Pudur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Thirupathur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Thanjavur	Orathanadu	7	0	12	0	3	0	4	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0
		Madukkur	3	0	6	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		Sethubavachitram	1	0	2	0	3	0	7	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		Peravurani	1	0	0	0	5	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
		Thiruvonam	3	0	4	0	7	0	2	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0
		Thanjavur	12	0	13	0	8	0	5	0	0	0	5	0	0	0	2	0	2	0	1	0	0	0
4	Tiruchirapalli	Manaparai	4	0	0	0	2	0	0	0	1	0	2	0	1	0	3	0	1	0	0	0	1	0
		Marungapuri	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Pudukkottai	Gandarvakottai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Karambakudi	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0

SL. NO	DISTRICT	BLOCK	2011		2012		2013		2014		2015		2016		2017		2018		2019		2020		2021	
			C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**
		Thiruvarangulam	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	0	0	0	0	0	0	0
		Aranthangi	0	0	2	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
		Avudaiyarkoil	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	1	0	2	0
		Manamelkudi	1	0	6	0	1	0	49	0	37	0	4	0	0	0	1	0	0	0	0	0	0	0
		Ponnamaravathy	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
		Arimalam	0	0	2	0	0	0	4	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
		Thirumayam	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
		Viralimalai	5	0	0	0	0	0	1	0	0	0	0	0	2	0	1	0	1	0	0	0	0	0
		Kunnandarkovil	1	0	0	0	0	0	1	0	0	0	1	0	5	0	2	0	1	0	0	0	0	0
		Annavasal	3	0	11	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Pudukkottai	0	0	0	0	0	0	2	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0
		TOTAL	**46**	**0**	**59**	**1**	**30**	**0**	**83**	**0**	**45**	**0**	**15**	**0**	**13**	**0**	**21**	**0**	**7**	**0**	**2**	**0**	**3**	**0**

(Source: Public Health Department, Chennai).

Table 9.19 CHOLERA																									
SL. NO	**DISTRICT**	**BLOCK**	**2011**		**2012**		**2013**		**2014**		**2015**		**2016**		**2017**		**2018**		**2019**		**2020**		**2021**	
			C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**
1	Dindigul	Natham	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	Sivagangai	S.Pudur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Thirupathur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Thanjavur	Orathanadu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Madukkur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Sethubavachitram	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Peravurani	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Thiruvonam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Thanjavur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Tiruchirapalli	Manaparai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Marungapuri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Pudukkottai	Gandarvakottai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Karambakudi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Thiruvarangulam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SL. NO	DISTRICT	BLOCK	2011		2012		2013		2014		2015		2016		2017		2018		2019		2020		2021	
			C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**
		Thiruvarangulam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Aranthangi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Avudaiyarkoil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Manamelkudi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Ponnamaravathy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Arimalam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Thirumayam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Viralimalai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Kunnandarkovil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Annavasal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Pudukkottai	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**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

(Source: Public Health Department, Chennai).

Table 9.20 ACUTE DIARRHOEA DISEASES																								
SL. NO	**DISTRICT**	**BLOCK**	**2011**		**2012**		**2013**		**2014**		**2015**		**2016**		**2017**		**2018**		**2019**		**2020**		**2021**	
			C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**
1	Dindigul	Natham	903	0	994	0	394	0	626	0	850	0	766	0	546	0	453	0	427	0	164	0	99	0
2	Sivagangai	S.Pudur	178	0	96	0	100	0	175	0	108	0	36	0	35	0	33	0	30	0	32	0	36	0
		Thirupathur	315	0	130	0	201	0	216	0	356	0	116	0	81	0	88	0	122	0	112	0	114	0
3	Thanjavur	Madukkur	0	0	0	0	0	0	0	0	162	0	264	0	181	0	162	0	43	0	98	0	0	0
		Orathanadu	0	0	0	0	0	0	0	0	738	0	904	0	488	0	882	0	145	0	380	0	13	0
		Peravurani	0	0	0	0	0	0	0	0	64	0	725	0	568	0	705	0	497	0	873	0	122	0
		Sethubavachitram	0	0	0	0	0	0	0	0	305	0	69	0	8	0	11	0	1	0	0	0	0	0
		Thanjavur	0	0	0	0	0	0	0	0	1894	0	2098	0	2609	0	1964	0	355	0	1477	0	3	0
		Thiruvonam	0	0	0	0	0	0	0	0	658	0	366	0	996	0	603	0	210	0	460	0	36	0
4	Tiruchirapalli	Manaparai	624	0	745	0	455	0	416	0	409	0	416	0	410	0	461	0	424	0	343	0	228	0
		Marungapuri	752	0	850	0	613	0	776	0	628	0	641	0	565	0	883	0	572	0	457	0	126	0
5	Pudukkottai	Gandarvakottai	209	0	145	0	249	0	4	0	53	0	179	0	151	0	351	0	216	0	12	0	5	0
		Karambakudi	1223	0	990	0	325	0	474	0	162	0	145	0	269	0	264	0	585	0	72	0	12	0

SL. NO	DISTRICT	BLOCK	2011		2012		2013		2014		2015		2016		2017		2018		2019		2020		2021	
			C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**
		Thiruvarangulam	1902	0	2818	0	239	0	654	0	1645	0	884	0	514	0	653	0	871	0	46	0	14	0
		Aranthangi	340	0	237	0	128	0	63	0	34	0	58	0	156	0	234	0	172	0	10	0	13	0
		Avudaiyarkoil	275	0	890	0	198	0	175	0	69	0	52	0	77	0	119	0	55	0	16	0	11	0
		Manamelkudi	98	0	50	0	60	0	171	0	96	0	46	0	5	0	0	0	0	0	0	0	12	0
		Ponnamaravathy	637	0	941	0	318	0	895	0	1113	0	1124	0	969	0	988	0	1339	0	401	0	22	0
		Arimalam	3846	0	3834	0	471	0	990	0	887	0	1452	0	501	0	355	0	177	0	17	0	7	0
		Thirumayam	574	0	887	0	243	0	649	0	797	0	1066	0	787	0	688	0	687	0	406	0	31	0
		Viralimalai	943	0	780	0	145	0	303	0	602	0	510	0	589	0	253	0	247	0	10	0	2	0
		Kunnandarkovil	1480	0	1266	0	776	0	647	0	967	0	1309	0	1516	0	1638	0	1309	0	860	0	6	0
		Annavasal	266	0	1001	0	468	0	976	0	1402	0	1543	0	1817	0	2245	0	2327	0	1164	0	10	0
		Pudukkottai	198	0	205	0	57	0	81	0	49	0	35	0	187	0	160	0	156	0	77	0	5	0
		TOTAL	**14763**	**0**	**16859**	**0**	**5440**	**0**	**8291**	**0**	**14048**	**0**	**14804**	**0**	**14025**	**0**	**14193**	**0**	**10967**	**0**	**7487**	**0**	**927**	**0**

(Source: Public Health Department, Chennai).

Table 9.21 COVID-19

SL. NO	DISTRICT	BLOCK	2011		2012		2013		2014		2015		2016		2017		2018		2019		2020		2021	
			C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D
1	Dindigul	Natham																			615	12	774	16
2	Sivagangai	S.Pudur																			78	0	160	4
		Thirupathur																			304	5	1007	1
3	Thanjavur	Orathanadu																			797	7	5737	29
		Madukkur																			272	2	1157	16
		Pattukottai																			657	13	2625	33
		Sethubavachitram																			307	2	1183	10
		Peravurani																			502	4	1315	18
		Thiruvonam																			255	5	898	6
		Thanjavur																			2298	29	8739	92
4	Pudukkottai	Gandarvakottai																			484	3	501	4
		Karambakudi																			587	5	592	11
		Thiruvarangulam																			1093	13	1615	32
		Aranthangi																			432	6	1305	21
		Avudaiyarkoil																			392	3	592	4

SL. NO	DISTRICT	BLOCK	2011		2012		2013		2014		2015		2016		2017		2018		2019		2020		2021	
			C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**
		Manamelkudi																			427	7	600	11
		Ponnamaravathy																			487	7	526	17
		Arimalam																			289	4	365	13
		Thirumayam																			598	11	654	25
		Viralimalai																			423	2	351	14
		Kunnandarkovil																			369	12	320	9
		Annavasal																			469	12	477	19
		Pudukkottai																			982	55	1623	57
		TOTAL																			**13117**	**219**	**33116**	**462**

(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 over use 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:

1. Based on their sources of origin (Residential wastes, Industrial wastes, Commercial wastes, Institutional wastes, Municipal wastes and Agricultural wastes).

2. Based on physical nature (Garbage, Ashes, Combustible and non-Combustible wastes, Demolition & Construction wastes and Hazardous wastes).

Table 9.22 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, card board, 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 upon 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 Agniyar 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 Agniyar river basin, the collection, transportation and disposal of solid wastes is done by the local bodies. The details of Solid Waste Management in Agniyar river basin is given in the **Table 9.23**.

9.10.4 Impact of solid waste to the Environment

- Ground water 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 9.23 Solid waste management for blocks covered in Dindigul, Pudukkottai , Sivagangai, Thanjavur and Tiruchirapalli District

District	BLOCK	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
Pudukkottai	Pudukkottai	70	70	65	63	1)Wet waste- MCC,OCC, Vermi composting 2)Saleable dry waste sold to local vendors 3)Non Saleable Dry waste sent to Cement Factory 4)Inert and silt filled in low lying areas
	Aranthangi	14	14	12	12	1)Wet waste- MCC,OCC, Vermicomposting , Organic Carbon Centre 2)Saleable dry waste sold to local vendors 3)Non Saleable Dry waste sent to Cement Factory 4)Inert and silt filled in low lying areas
Thanjavur	Pattukottai	30	30	28	28	1)Wet waste- MCC,OCC, Vermicomposting 2)Saleable dry waste sold to local vendors 3)Non Saleable Dry waste sent to Cement Factory 4)Inert and silt filled in low lying areas
Tiruchirapalli	Manaparai	11	11	9	9	1)Wet waste- MCC,OCC 2)Saleable dry waste sold to local vendors 3)Non Saleable Dry waste sent to Cement Factory 4)Inert and silt filled in low lying areas

(Source: Director of Municipal Administration, Chennai *)*

9.10.5 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 land fill, 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 7,072.95 sq.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 26,364 sq.km which is 20.27% of the state's geographical area. There is an increase of 83.02 sq.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 earth moving machinery the conversion of wetland to farm land has become particularly profitable. The draining of wetlands not only eliminates wild life and also lowers the water tables.

9.11.1 Forest and Wild life scenario in Agniyar basin

The Reserved forest of 211.71 sq.km and Mangrove forest of 4.12 sq.km covered in Agniyar river basin is about 215.83 sq.km which accounts to 4.59% of the total basin area. The total area of Agniyar basin is 4702.02 sq.km.

There is no Wildlife sanctuary in this basin.

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 pictures que 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.

Thiruvengaivasal

The Vyagapuriswar-Brahadambal Temple, a Chola architecture built in the 11th century is 6 Kms on the Pudukkottai-Tiruchirapalli road. It was subsequently renovated by the Pandiya emperors during 13th – 14th century. The epigraphy with **six Chola inscriptions, seven Pandya, one each of the Vijayanagara and Pallava-rayar periods** provides an important source of information on the socio-political history of the area. Beautiful statue of **Dakshinamoorthy [God for Wisdom]** is found inside this temple.

Fig 9.4 Vyagapuriswar Temple

Avudayarkoil

It is also **called as *Tiruperunthurai,* located about 50 Km from Pudukkottai** and 13 Km from Aranthangi . The presiding deity is not in the form of ***Siva Lingam.*** Only a ***pedestal*** [***Avudai***] is found and worshipped here, **hence it is called *Avudaiyar Koil.*** Lord Siva's *Consort* and *Nandi* here is without an icon. Saint Manickavasagar who wrote Tiruvacakam here realized the truth of formlessness and Lord siva is called as **Atmanathar too.** Attractive murals and the **stone cornice called *Kodunkai*** are wonderful aspects of the temple.

Fig 9.5 Avudayarkoil

Narthamalai

It is located at 18th Km from Pudukkottai and 31 Kms from Tiruchirapalli. The structural Vijayalaya Choliswaram in veera style of architecture [10th Century AD], the Cave temples, Paliyili Isvaram, Samanar Kudagu, Kadambar Koil are the important monuments here. **The Mariamman Temple is very popular** in this region attracts a large crowd during the **car and Poochoriyal [flower dedication] festival** in the Month of April.

Fig 9.6 Narthamalai Cave temple

Kudumianmalai

This is at a distance of 20km from Pudukkottai, 50 km from Tiruchirapalli and 59 km from Thanjavur. ***Sika Nathar* or *Shikagireeshwarar –Akilandeswari*** are the presiding deities of the siva temple, The outer Mandapam and its beautiful sculptures are the main tourist attractions. One can reach the **Cave Temple of Kugai Jayanthavanesvarar temple [Cave Temple] through the prakarams [courts] of Sikanathar / Sikagiriswarar temple.** Musical Notes' inscriptions on the right side of the Cave temple is a remarkable piece of attraction. Temple of Lord Subramaniya Swami is located on top of the Kudumiyanmalai hill.

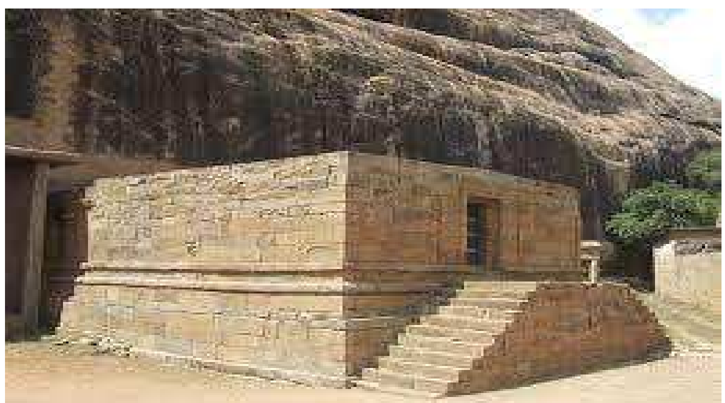


Fig 9.7 Kugai Jayanthavanesvarar Cave temple

Sittanvasal

It is 15 Km from Pudukkottai. Number of megalithic dolmens of the 1st century attest the antiquity of the area. The Sittanavasal Cave, also known as Arivar Kovil, is a Jain monastery of the 7th century. The earliest Brahmi Tamil script of 2nd century is found in the Jain Natural Cavern called Ezhadipattam. We still find stone beds used by Jain monks around 2000 years ago.

Fig 9.8 Sittanavasal Cave

Government Museum

Thirukogarnam, a suburb of this district houses the Government Museum which is the second largest of its kind next to Chennai Government Museum. Rare and exotic collections of Geology, Zoology, Anthropology, Archaeology are exhibited for public viewing. Exhibits of Sculpture, bronze images, weapons, paintings, copper plates, wood carvings, musical instruments , coins manuscripts and historical records are a part of the collection of the past. This museum is open to all public on all days except Fridays, Second Saturdays and three National Holidays.

Fig 9.9 Government Museum

Manora

It is a town located near Peravurani town. The word '*Manora*' was derived from the word 'Minar'. Manora is known for the eight-storied miniature fortress built by Rajah Serfoji in 1814. This 75-foot tower is hexagonal in shape and guarded by a moat. It was built in honor of Britain's victory over Napoleon Bonaparte at Waterloo. It is an excellent show case of Chola architecture. **UNESCO has declared Manora as World Heritage Site.** Cool Sea, Sailing Boats, breezy coconut groves around makes Manora a popular picnic spot and a coastal town in Thanjavur.

Fig 9.10 Manora

9.12.1 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.

9.12.2 Mitigation measures

The mitigation measures recommended to reduce the negative impact of tourism are as follows

1. Putting increased focus on Eco-tourism ie. Tourism which is ecologically sustainable and encouraging, Green tourism ie. Responsible, sustainable and ethical tourism.
2. Total ban on non-biodegradable products such as plastics have an enormous positive impact on the planet's environment.
3. Utilization of revenue from parks and other tourist spots for the overall development and management of environmentally sensitive areas.
4. Providing environmental information and raising awareness among tourists about the environmental consequences and their remedial actions.

9.13 Socio Economic Aspects

Socio Economic refers to society related economic factors. These factors relate to and influence one another.

In Agniyar Basin, the total population is about 2.072 million (as projected to 2021) out of which Urban population is about 0.442 million and Rural population is about 1.630 million. Overall literacy rate of the basin is found to be 61.56 %.

Agriculture is the major occupation of the people in this basin. In this basin Paddy is predominant followed by coconut, Groundnut, Black gram, and Cotton. The Agniyar basin area more than 80% of the land holdings are involved in Agricultural works and remaining residential houses or flats, commercial establishments and Government buildings. The farmers find employment during off season in town limits as construction labourers or other unskilled labourers, agro based industries like rice mills and small scale industries or other unskilled labourers. Fishing is another important source of livelihood in this basin and occupies a prime place in acceleration of socio-economic development in the basin.

Certain trends in the conversion of agricultural lands into industrial lands are also happening. Hence the agricultural labourers and land owners have a tendency to sell the lands for industrial purposes. 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.

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.

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 safeguard the forests and wild life 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 wildlife and to have compassion for living creatures.

Acts related to Water Resources, Environment & Encroachment.

Some of the major Acts / rules is given below in the **Table 9.24**

Table 9.24 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	Tamil Nadu Land encroachment Act,1905
4	Tamil Nadu Protection of Tanks and Eviction of Encroachment Act,2007
5	Tamil Nadu Farmer's Management of Irrigation Systems-Act,(TNFMIS),2000
6	The Environment (Protection) Rules,1986
7	The Tamil Nadu 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

9.13.2 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.

9.13.2.1 Environmental Awareness in Agniyar 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

District Collector Walk In Thanjavur For World Heritage Week To Enhance The Tourist For Heritage Landmarks On The Event Of World Heritage Week

Tiruchirapalli District Collector started Covid Awareness programme on 01.08.2021

Covid 19 –Awareness Campaign Conducted By District Collector, Pudukkottai In Gandhi Park On 07.08.2021

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.

9.14 Summary

In Agniyar 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. Introduction of fish culture in Multi Purpose farm ponds/water recharge ponds and promoting ornamental fish culture as a commercial activity.
3. Payer pays policy (Make the industries pay taxes for the environmental harm).
4. Organizing Environmental awareness campaign.
5. Waste Minimization which includes reducing waste at source, reusing materials and recycling waste materials(3R).
6. Proper waste disposal methods such as sanitary land fill, incineration, composting and pyrolysis.
7. Integrated Solid Waste Management can be adopted to mitigate the effects of solidwaste.
8. Chemical fertilizers should be replaced with organic fertilizers in a phased manner.
9. 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 (TWAD) 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. Agniyar River Basin falls under the jurisdiction of the Chief Engineer, TWAD Board, Thanjavur, Madurai, Superintending Engineer, Madurai, Tiruchirapalli, Sivagangai and Thanjavur, under the control of Engineering Director, Chennai implements the various schemes in Agniyar River Basin with the assistance of their Executive Engineers. Details of water supply schemes implemented in urban and rural areas of Agniyar River Basin are collected from the TWAD Board.

10.1.2 Tamil Nadu Pollution Control Board (TNPCB)

Tamil Nadu Pollution Control Board (TNPCB) is functioning with the Chairman as its head, Member Secretary, 3 Chief Environmental Engineers, 12 Joint Chief Environmental Engineers, 38 District Environmental Engineers and 3 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 8 Advanced Environmental Laboratories, 8 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 Dindigul, Pudukkottai, Sivagangai, Thanjavur and Tiruchirapalli. The District Environmental Engineer monitors and controls the Industrial Pollution in Agniyar 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.

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 and Preventive Medicines) at Chennai. The Deputy Director of Health Services at Dindigul, Pudukkottai, Sivagangai, Thanjavur and Tiruchirapalli districts covers Agniyar River Basin area. The details of Registered birth and death, Infant death and Maternal death in districts falling under Agniyar River Basin as per the Statistical Handbook of Tamil Nadu 2021 are collected from the Public Health and Preventive Medicines Department. These details are used to document the population dynamics in Agniyar River Basin.

10.1.4 Animal Husbandry & Veterinary Science Department

Animal Husbandry & Veterinary Science Department is headed and governed by the Commissioner, Animal Husbandry & Veterinary Science Department along with 4 Additional Directors at Chennai. The Regional Joint Director at Dindigul, Pudukkottai, Sivagangai, Thanjavur and Tiruchirapalli districts along with their Assistant Directors are responsible for all the activities of this Department in Agniyar 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 & Veterinary Science 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 zoonotic diseases of animals.

The district wise livestock census details in Agniyar 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 (WRD) 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 (WRD) 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's Association (WUA), 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 User's 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 (WUA) 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 Users 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 may 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 distributory 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 distributory 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 Water Users Association (WUA) details of Agniyar River Basin is as below in Table 10.1

AGNIYAR RIVER BASIN (WUA Details)

Table 10.1 Water User Association (WUA) Details under IAMWARM & WRCP

Sl. No.	Name of Division	No. of Water User's Association (WUA) Formed		
		Under IAMWARM	Under WRCP	To Be Formed
1	Grand Anicut Canal Division,Thanjavur.	32	-	-
2	Agniyar Basin Division,Pattukottai	1	-	9
3	Ariyaru Basin Division, Tiruchirapalli.	13	-	-
4	South Vellar Basin Division,Pudukkottai.	310	-	-
	Total	**356**	**-**	**9**

Table 10.2 Details of Water User's Association (WUA) President and T.C. Members

Sl. No	Name of the Sub - basin	Water User's Association (WUA) President - Details			Water User's Association (WUA) T.C. Members - Details		
		Total	Elected as on date	Balance left out	Total	Elected as on date	Balance left out
1.	Agniyar Sub- basin	93	93	-	434	434	-
2.	Ambuliyar Sub- basin	54	54	-	249	249	-
3.	South Vellar Sub- basin	209	209	-	959	959	-
	TOTAL	356	356	-	1642	1642	-

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 Board	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	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

As this chapter is an introductory one, water resources planning, river basin planning, river basin management, river basins in Tamil Nadu, purpose of the study methodology and data collection and validation were discussed elaborately.

The role of water resources planning is to develop a technical and engineering solution to meet those needs. The advantage of water resources planning is procedurally and relatively simple. It is usually undertaken by water resources planners supported by social, environmental and economic practitioners, and relies heavily on water resources system models. It is particularly applicable to systems that are flooding, or basins that have water resources available for further development.

River basin planning is the process of identifying the natural resources used to meet competing demands, while maintaining river health. It includes the allocation of scarce water resources between different users and purposes, choosing between environmental objectives and competing human needs, and choosing between competing flood risk management requirements. The need of strategic basin planning is not just to meet straightforward, externally set objectives, but to choose between a series of possible water management objectives that will best contribute to a range of competing economic, social and ecological goals.

With intensifying water use, climate change, and land use changes, achieving sustainable water management on the river basin scale is becoming more and more challenging. in river basin management. River basin management affects river basins in many ways. It may alter the natural physical processes in a river basin by constructing structures to store and carry water; regulate the use of water with the help of allocation rules, prices, water rights and permits; and apply economic instruments, such as taxes and subsidies to control the water usage.

Integrated River Basin Management (IRBM) emphasises cross-disciplinary coordination of water, land and related resources in a river basin, watershed or catchment to achieve long-term sustainability. Tamil Nadu is endowed with many rivers and 34 of them are classified as independent rivers which originates and confluence with Bay of Bengal independently. These 34 river basins are grouped into 17 major river basins and the river basins were further sub divided into 127 sub basins for the purpose of precise water resources planning and management.

For updation and bridging the gap of the data for 15 years (2006 to 2020) on climatological parameters, hydrology, hydrogeology, water quality and to carryout the statistical and spatial analysis to understand the dynamic variations over the period in the Agniyar basin, the Micro Level Reappraisal study is taken up. In this reappraisal study, IRS Resource Sat IIA LISS III Satellite data of the year 2021 is used for land use / land cover classification.

The micro level reappraisal of the study of Agniyar river basin is taken up to explore the current scenario of the basin and find out the changes in the hydro dynamics and geodynamic parameters so as to recommend judicious planning and management of water resources of the basin.

The Agniyar micro level reappraisal study adopted the new methodology , which includes the analysis of geospatial and non-spatial attributes collected to derive, Physiographic, drainage network. Sub basin wise drainage morphometric analysis carried out for qualitative assessment. Geophysical resistivity Vertical Electrical Sounding data used to explore the aquifer characters and to examine the spatial distribution and thickness of unconsolidated soil, weathered rock and fractured rock in the basin. Rainfall variation, distribution, intensity, frequency and evaluation of spatio temporal rainfall dynamics. season wise rainfall analysis was carried out and isohyets were generated using ArcGIS software to explore the rainfall spatial distribution and influence in the basin. Groundwater level data for pre and post monsoon periods were analyzed to examine the spatial distribution of subsurface water table and fluctuation in the basin. Monthly runoff simulation (MRS) model and Runoff coefficient methods were used for estimating the sub basin wise surface water potential. Estimation of sectorial water demands in sub basin wise carried out. Water balance based on available surface and groundwater potential and demand was determined. Environmental scenario in the basin including aqua culture, sea water intrusion, etc were brought out. The space technology data using Remote Sensing and GIS techniques were The space technology data using Remote Sensing and GIS techniques were employed wherever it requires to aid the study.

IRS Resource Sat IIA, LISS III of March, 2021, Aerial Photographs on 1:50000 scale and Shuttle Radar Tophography Mission (SRTM) 30 m DEM space technology data used for interpretation, analysis and mapping for this reappraisal micro level study The present report is the state-of-art for the year 2021 which is updated with latest data and analysed with modern technology tools available as on date , will be most useful for the field officers of WRD and all line departments in the Agniyar river basins.

11.1.2 Description of the Basin

In this chapter the geographical location of the basin, its boundaries, administrative details, physiography, drainage, drainage morphometry, geology, geomorphology, lineament, soil and sub surface lithology were discussed in details. The total area ofAgniyar basin is 4702 Sq km. Three main rivers namely Agniyar, Ambuliyar and SouthVellardraining in the basin and therefore this basin was named as Agniyar Sub Basin (2107 Sq km), Ambuliyar Sub Basin (826 Sq Km) and South Vellar Sub Basin (1770 Sq Km). Total number of water bodies are 5471 nos, out of which 1191 are being maintained by Water Resources Department. There is no Dam or reservoir in the basin.

The Agniyar river basin spreads across 5 districts namely Pudukkottai, Thanjavur, Tiruchirapalli, Sivagangai and Dindigul districts.Administrative units of Agniyar basin include **19 Taluks , 25 Blocks, 71 Firkas and 899 Revenue Villages.**

The elevation ranges in between +842 m AMSL and +1 m AMSL and the mean elevation is +422 m AMSL. The highest elevation (+842 m AMSL) is observed at Vellamalai reserved forest, and the lowest elevation (1 m AMSL) is observed near the coast of the river basin. Reserved forest/hills occupied by 225.40 Sq.Km of the basin.

The total length of G.A. Canal including its extension is 98.07 Km. The total length of the Rajamatam canal is 46.11 Km. Naduvikottai canal off-take from G.A.Canal distribute water in the basin by running a distance of 9.71 Km. Olavayal branch canal from G.A canal runs in this basin for a distance of 27.49 Km. Pudupattinam canal off-take from G.A. canal distribute water for a distance of 21.09 Km. Alivalam branch canal from G.A. canal carrying water for a distance of 16.56 Km.AmmaniChattram Canal is running from G.A. canal at a distance of 15.13 km. Anavayal canal from G.A. canal runs about 12.2 Km.

Kattar/Nasuvunni, Kattar, Maharajasamudram and Agniyar rivers drain in Agniyar sub basin. Punaikuttiyar, Ambuliyar, Velunniyar, PerumagalurAr and Tedakkiar are the five rivers wetted in Ambuliyarsub basin. Narasingar river, Kondarriver, Kundar river, Vellar river and Karaiyar river are drained in South Vellar sub basin.

The morphometry analysis shows that the drainage network in all the sub basins of the study area is well developed. It also shows the relatively greater degree of branching, lesser elongation, and higher flash flood potential. Generally the drainage density in the Agniyar basin is low due to the lithological disturbances and the presence of geomorphologic landforms such as shallow and moderate pediments and high infiltration formation. The drainage frequency in the upper part of the basin is higher than in the lower part of the basin. It clearly indicates that the drainage development in the basin is geologically controlled.

Geologically,Agniyar basin is predominantly composed of unconsolidated Quaternary and Tertiary sediments. Hard rock occupies 1603.12 sq.km (34.09%) and soft rock occupies 3098.90 sq.km (65.91%). Maximum area of 1323.04 sq.km occupied by Laterite.

The general yield of dug wells tapping crystalline formation is 5 lps for a pumping of 2-4 hrs, while the dug wells tapping in porous formations can sustain a yield of 5 lps for a pumping of 4-6 hrs. The transmisstivity value is less than 1 m^2/day - 145 m^2/day. The general specific yield is between 0.015- 0.12 %.

Geomorphologically, four major landforms such as structural, denudation, fluvial, and coastal were identified in the Agniyar basin, based on its genesis. The alluvial plain, is located in south and south eastern part towards the coastal region of the basin and located in and around Puvattakudi, Arantangi, Pinnavasal, and Arasarkulam.The flood plain exists along the rivers of Agniyar and Vellar. Deltaic plain is seen in the southern part of the basin around Vadakku Ammapattinam.Palaeo channel is found as thin stretch near Memangalam. Coastal plain is a regional land of low relief bounded seaward by the shore and landward by highlands, mainly formed due to coastal action. The lithology in coastal plain are sand,silt and clay. Marshes are found towards the western part of the basin.

Landuse of 2021, shows that majority of area is occupied by agricultural land (3774.69 sq.km), i.e 80.27 % in the total area. The settlement area has been spread over 107.62 sq. km (2.295%). The area covered by reserved forest is 211.71 sq. km and that of the barren land is 35.92 sq. km. The shrubs and scrubs covered by 10.81 sq. km and the water bodies spread over by 515.42 sq.km.

Comparison of landuse 2004 and 2021 reveals that most of settlements have been doubled in aerial extent. The quarry area have been expanded and new quarries are set up. The fallow and waste land then around Perungalur and Kudumiyanmalai are converted in to quarry land. Also the agricultural land has been reduced to 3774.69 sq. km from 3815.75 sq. km. Barren, scrub and shrub occupied 1.43 % in 2004 which has been reduced to 0.99 % in 2021.

Major portion of the basin has low lineament density. Medium to high density zones are found in very limited region towards the central and western portion. As eastern and southern parts of the basin is devoid of lineaments, it comes under low density zone. Presence of about six lineaments are confirmed by Geological Survey of India inPudukkottai district.

The depth of top soil/unconsolidated materials inferred from geophysical resistivity and bore well lithology data ranges from less than 5 m to 20 m bgl.The depth to weathered rock formation ranges from 10 m to 65 m. The deepest weathered depth of 50-65 m bgl is noticed in and around Kurungulam and Andanur in north-northeastern region and in Karakkottai in the south east.

The depth of fractured/jointed rock ranges in between 30 m and 600 m. The deepest fracture zone of 300-600 m is found in limited area in south- southeast basin nearer to the coast in Kiranurand Memengalam. The depth of bed rocks ranges between 30 m and 300 m. The aquifer occurring at deeper depth in the eastern part of the basin, in the range of 100 to 600 m bgl.

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 31 years from 1990 to 2021 has been collected from State Ground & Surface Water Resources Data Centre (SG&SWRDC), WRD, Chennai. This data is used for Yearly, Monthly and Seasonal Rainfall Probability analysis.

There are 33 rain gauge stations in and around the Basin. Considering the distribution of rain gauge stations and the stations having long term records, out of 33 rain gauge stations, only 20 rain gauge stations were selected for detailed analysis.

Details of 20 Selected Rain Gauge Stations

Sl.No	Name of sub basin	Sub basin area (sq.km.)	Sub Basin wise Name of Raingauge station
1	Agniyar	2106.43	Alangudi, Gandarvakottai, Keeranur, Kudiminmli_AD, Kurungulam, Iluppur, Madhukkur, Malaiyur, Pattukottai, Peravoorani, Perungalur, Thanjavur
2	Ambuliyar	825.69	*Alangudi*, Aranthangi, Arimalam, Avudaiarkoil, *Malaiyur, Peravoorani, Perungalur*
3	South Vellar	1769.90	*Alangudi, Aranthangi, Arimalam, Avudaiarkoil*, Keeranur, *Kudiminmli_AD, Iluppur*, Manapparai, Mimisal, Natham_FOR, *Peravoorani, Perungalur*, Singampunari, Thirumayam
Total		**4702.021**	

Dependable rainfall at 50% & 75% dependability and season wise average and annual rainfall for each of the sub basins have been analysed.

In general, Agniyar basin receives more rainfall in North East monsoon than South West monsoon. The highest Annual Average weighted rainfall of 954.2 mm was recorded in Agniyar sub basin. Similarly lowest Annual Average weighted rainfall of 922.3 mm was recorded in South Vellar sub basin .The 31 years annual average rainfall of the basin is 937.1 mm.

On viewing the climatic pattern, with reference to the Pudukkottai weather station, it is observed that there is increase in number of rainy days, further, annual rainfall shows increasing trend, a slight decrease in summer and winter maximum temperature trend, a reasonable increase in summer and winter minimum temperature trend.

11.1.4 Agriculture and Irrigation Demand

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 2019-20. About 56.4 % of the net area sown is benefitted by irrigation. The total Gross Irrigated area of Agniyar Basin is 1,99,603 Ha as per the season and crop report 2019-20 year crop area. The main crops cultivated in Agniyar Basin are Paddy, Coconut, Groundnut, Blackgram, Sugarcane, Fruits & Vegetables and Gingelly.

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 2015-16, 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) : 224682 (82.81%)**
- **Small farmers (1 to 1.99 Ha) : 31762 (11.71%)**
- **Semi-medium farmers (2 to 3.99 Ha) : 11592 (4.27%)**
- **Medium farmers (4 to 9.99 Ha) : 2914 (1.07%)**
- **Large farmers (more than 10 Ha) : 376 (0.14%)**
    - The Gross irrigated area of crops in Agniyar Basin is reported to be 1,86,422 Ha.

- Out of the total area irrigated, about 82% is under Paddy cultivation and the remaining in Coconut, Groundnut, Blackgram, Sugarcane, Fruits & Vegetables, Gingelly, Banana and Maize cultivation.
- Net Irrigation demand of this basin at 75% dependable rainfall is 1301.32 MCM.
- Net Irrigation demand of this basin at 50% dependable rainfall is 1279.49 MCM.
- Organic farming practice is to be extended in greater manner in this Basin.

As per 2008, Microlevel Study Report of Agniyar Basin, Net Irrigation demand was calculated as 1098 MCM at 75% dependable rainfall for an irrigated crop area of 1,46,585 Ha in which Irrigated area of Paddy is 62% and Coconut is 17%.

Presently irrigated area is adopted as 1,86,422 Ha based on good rainfall year 2020-21.On comparing the cultivated area of the present study, it is found that the total irrigated area has increased from 1,46,585 Ha to 1,86,422 Ha. Irrigated area of Paddy is increased from 1,08,747 Ha to 1,16,057 Ha and Coconut is increased from 12,180 Ha to 31,023 Ha.

Percentage of saving in water when water saving techniques are adopted on cultivation for the present cultivable area of different crops in Agniyar 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	116057	957.68	40	383.07
2	SSI-Sugarcane	1559	14.77	50	7.38
3	Coconut - DRIP	31023	181.91	63	114.60
4	Groundnut-DRIP	17533	57.42	50	28.71
				Total	**533.77**

- 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 383.07 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 (6.20 MCM) could be saved.
- Using DRIP and coir pith as soil mulch for coconut trees, 63% of irrigation water could be saved (114.60 MCM).
- 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.

Agniyar river system comprises of three rivers viz., Agniyar, Ambuliyar and South Vellar are non-perennial rivers that start as small streams and then flows towards the south eastern direction and drain into the Palk Strait and Palk bay portions of the Bay of Bengal.

There are two gauging sites in Agniyar sub basin namely Poovanam anicut in Agniyar river in Poovanam village located at an latitude of 10° 21’51’’N and longitude of 79°16’36’’E and Thokkalikkadu anicut in Maharajasamuthiram river in Thokkalikkadu village at an latitude of 10°20’54’’N and longitude of 79°20’24’’E. Now a days due to lack of man power, gauging readings are not recorded.

To know the actual quantity available to Tamil Nadu, the flow data from the year 1990-91 to 2020-21 and other available years are analysed. The quantity of average annual flows realized in the Agniyar system at each diversion structure are worked out.

The annual Surface Water Potential of Agniyar river basin is calculated for average annual flow is 1091.37 MCM.

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**

Agniyar basin encompasses 71 Firkas either fully or partially and all firkas are falling in Thanjavur, Pudukkottai, Tiruchirapalli, Dindigul and Sivagana districts and the categorization summary is as stated below:

Sl.No	Category	2020 Assessment
1	Safe	35
2	Semi Critical	14
3	Critical	3
4	Over Exploited	16
5	Salinity	3
	Total	71

As per the latest assessment, ie as on **March 2020,** the data on **Dynamic Ground Water Resources of the State of Tamilnadu** is as stated below:

- **Total Annual Ground Water Recharge : 19.59 BCM**
- **Annual Extractable Ground Water Resources : 17.70 BCM**
- **Annual Ground Water Extraction : 14.67 BCM**
- **Stage of Ground Water Extraction : 82.90 %**

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 49 wells (29 Observation wells & 20 Piezometric wells) spread over the entire Agniyar Basin and they have been analyzed, over the period of seven (7) years to ten (10) years. The wells analyzed fall in Thanjavur, Pudukkottai, Tiruchirapalli, Dindigul and Sivagana districts.

Hydrographs of groundwater level for the 49 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 3 wells and high rise in water level is found in 3 wells. Moderate depletion is found in 5 wells and high depletion in water level is found in 13 wells.

Generally the water quality is good to moderate in the basin while in the south eastern part of the basin the quality is poor in some of the blocks in the basin.

49 wells spread over the entire Agniyar 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 Agniyar Basin is 1336.88 MCM and total annual groundwater extraction in the basin is 910.04 MCM (68.07%). The balance groundwater available for further development is 483.93 MCM.
- ❖ While comparing the groundwater resources of Agniyar Basin calculated in Appraisal report prepared in 2008 with this Reappraisal report, it is observed that the total annual groundwater availability has increased by **61.29%** (from 828.86 MCM to 1336.88 MCM) and total annual groundwater extraction has also increased by **191.50%** (from 312.20 MCM to 910.04 MCM). The balance annual groundwater availability is decreased by **5%** (from 509.32 MCM to 483.93 MCM).

- Annually groundwater extracted for irrigation in Agniyar basin is **877.79** MCM which is 96.50 % in total annual groundwater extraction of **910.04** 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, industrial, livestock, aquaculture and power generation etc.

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:-

Sector	**Annual Growth rates**
Urban	1.9% per year
Rural	0.8% per year

The domestic water demand for the present year 2021 and the target years 2022, 2030, 2040 & 2050 are obtained as 72.586 MCM, 73.441 MCM, 80.738MCM, 91.110MCM & 103.104 MCM 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 Agniyar basin is 1301.32MCM and this quantity is maintained for the target years 2020, 2030, 2040 & 2050 without increasing the demand.

At present in the Agniyar River Basin there are 15 numbers of large and medium industries and 606 numbers of small scale industries. Accordingly, the yearly requirement of water for Large & Medium and small scale industries at present is estimated as 0.131MCM & 1.532 MCM 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 Agniyar basin is 50,68,891. Maintaining these values for the current year its current water demand is 35.885 MCM.

The total water demand of four sectors, i.e., Domestic, Irrigation, Livestock, and Industries of Agniyar River Basin for the present year 2021 was worked out as 1411.454 MCM. But the water demand in 2008 was 1287.419 MCM This shows that there is 8.78% increase in water demand within 14 years for the present year, when compared to the water demand during 2008.

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 optimallyin a river basin.

Different planning scenarios for Agniyar basin are considered:

1. Exisiting Scenario

2. Improved Agricultural Methods

Water Balance

- Water Potential for the year 2021 = 2428.25 MCM
- Water demand for the year 2019
  (75% dependability) = 2286.27 MCM
- Water Balance = 141.98 MCM
- % Water Balance with respect to potential = 5.84 %

Agniyar basin as such shows a water balance by 141.98MCM (5.84%) for the year 2021 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.

Thus the Water Balance study of Agniyar basin for the existing scenario for the current year shows that the irrigation demand value accounts for about 95% 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

"Environ" 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 facing 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 15 large & medium industries and 606 small scale industries in this basin and the waste water generated from the industries is 1.329 MCM per year

The generation of sewage in rural areas and urban areas in Agniyar River Basin is assumed as 80% of water demand. The volume of sewage generated in rural and urban areas of Agniyar River Basin is 58.067 MCM 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 Agniyar River Basin, the sewage treatment plants have been implemented in Dindigul, Pudukkottai, Sivagangai, Thanjavur and Tiruchirapalli 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 Agniyar Basin the main elements of agricultural pollution are phosphates, nitrates, potassium etc., The year wise consumption of fertilizers and pesticides in Agniyar Basin is furnished below,

- Consumption of fertilizers in Dindigul, Pudukkottai, Sivagangai, Thanjavur and Tiruchirapalli districts from 2016-17 to 2020-21: Total NPK - 4,14,399MT
- Consumption of pesticides in Dindigul, Pudukkottai, Sivagangai, Thanjavur and Tiruchirapalli districts from 2016-17 to 2020-21: Liquid- 15,74,904 Litres, Dust /Solid- 14,60,280 kgs

It is inferred that the consumption of complex fertilizer was sustainable and harmonious with the environment. The consumption of pesticides (in liquid form) were getting increased in the years 2017, 2018, 2020 and 2021.

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 Pudukkottai block in Pudukkottai district, The total solid waste generated per day is 70 tonnes and out of which 63 tonnes is cleared every day. In Pudukkottai block, wet wastes are disposed by MCC, OCC and Vermicomposting. In dry waste materials Saleable materials sold to local vendors and non saleable materials send to cement factories. Inert and silt filled in low lying areas.

In Aranthangi block in Pudukkottai district, The total solid waste generated per day is 14 tonnes and out of which 12 tonnes is cleared every day. In Aranthangi block, wet wastes are disposed by MCC, OCC and Vermicomposting. In dry waste materials Saleable materials sold to local vendors and non saleable materials send to cement factories. Inert and silt filled in low lying areas.

In Pattukottai block in Thanjavur district, The total solid waste generated per day is 30 tonnes and out of which 28 tonnes is cleared every day. In Pattukottai block, wet wastes are disposed by MCC, OCC and Vermicomposting. In dry waste materials Saleable materials sold to local vendors and non saleable materials send to cement factories. Inert and silt filled in low lying areas.

In Manaparai block in Tiruchirapalli district, The total solid waste generated per day is 11 tonnes and out of which 9 tonnes is cleared every day. In Manaparai block, wet wastes are disposed by MCC, OCC and Vermicomposting. In dry waste materials Saleable materials sold to local vendors and non saleable materials send to cement factories. Inert and silt filled in low lying areas.

The Reserved forest of 211.71 sq.km and Mangrove forest of 4.12 sq.km covered in Agniyar River Basin is about 215.83 Sq.km which accounts to 4.59% of the total basin area. No 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 Agniyar basin are Avudaiyarkoil, Narthamalai, Kudumianmalai, Sittanavasal, Government Museum, Manora and Thiruvengaivasal.

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 – R**educe **– R**euse - **R**ecycle).
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 (WRD) 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 Agniyar 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 Agniyar Basin 356 WUA's were formed under IAMWARM and 9 WUA committee is to be formed .

Even though Agniyar 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 by Water Resources Department in coordination with Tamil Nadu Water Supply and Drainage Board and Agriculture Department.

11.2 Action Plan

Developmental planning for any region is a complex process of decision- making based on information about the status of resources and socio-economic conditions. Reliability of database both spatial and non spatial is therefore crucial to the success of the developmental planning especially selection of recharge sites for construction of artificial recharge structures. The locale specific prescriptions could not be arrived through the effective scientific tools for selection of recharge site. Hence there is uncertainty of recharging groundwater in and aroundany structures constructed without scientific approach. Also the life of the structures recommended by unscientific approach is not sustainable.Hence in the Agniyar river basin, site suitable for recharge of groundwater is evaluated based on Remote Sensing and GIS techniques.

11.2.1 Preparing for base for scientific approach

Scientific methods, involving interpretation, integration and analyzing of resource data through relevant software are undoubtedly, a foremost important step in zonation of ground water recharge. The major advantage of adopting this scientific approach is to provide timely inflow of information to serve planning needs.

11.2.2 Remote Sensing and GIS Techniques

The scientific approach using remote sensing data from aircraft or satellite has become an indirect indicator for understanding the subsurface water conditions. As the satellite picture gives synoptic view of vast stretch of land and enables observer to see features which cannot be seen easily on the ground. Various surface features mapped using remotely sensed data that may be integrated with secondary data related to location specific information to develop thematic maps about the areas favourable for groundwater recharge and assessing the water harvesting mechanisms etc. using Geographical Information System(GIS) platform, a software with geodata based management system.

Study of hydrogeological aspects through remote sensing viz. lithology, structural and tectonic attributes of the area depicts the elements of terrain characteristics and land use pattern etc. This in turn greatly facilitates in deriving temporal qualitative assessment of the area of probable potential of water resources. The GIS has capability of conducting spatial searches and overlays and association of the spatial data with the non-spatial data to eventually generate new information. The Locale specific prescriptions could be arrived through the effective use of space based remote sensing data merged with other collateral data. Remote sensing data provide accurate spatial information that can be economically utilized over conventional techniques of groundwater investigation.

11.2.3 Considerations for Groundwater Recharge

The type of artificial recharge system that can be developed at any site is controlled to a large extent, by the geologic and hydrologic conditions. Site selection criteria, in addition to economic consideration, should include the following aspects.

1. Source of water to be used for recharge
2. Chemical and physical characteristics of recharge water
3. Availability of a geological formation suitable for artificial recharge
4. Thickness and permeability of the material overlying the geological formation considered suitable for recharge
5. Landuse
6. Water level in the study area
7. Infiltration rate of soil and hydraulic conductivities of water transmission are required to be considered for recharge system.

The present study envisages integration of spatial and non spatial data for analysing various hydrological attributes to classify the area in terms of ;

1. Good recharge zone
2. Moderate recharge zone
3. Poor recharge zone
4. Very poor recharge zone

11.2.4 Methodology

The most important/influencing thematic layers in groundwater recharge such as geology, geomorphology, soil, landuse, structure/lineament derived from remote sensing data have been prepared on 1:50000 scale. Secondary data such as drainage, average annual rainfall and pre monsoon water level have also been prepared into compatible digital formats in GIS environment. The selected layers and their role in recharge is given below.

i) Drainage – Conductance of surface water and source of potential
ii) Geology - Availability of a geological formation suitable for artificial recharge
iii) Geomorphology – Availability of favorable morphological/landform features
iv) Landuse/landcover – Classification of used lands for selection of recharge sites
v) Soil - Infiltration rate of soil & hydraulic conductivities of water transmission
vi) Lineament/fault - fracture / fault zones favourable for recharge

vii) Depth to Weathered rock/ Fractured rock/ Bed rock - Thickness and permeability of the material overlying the geological formation considered suitable for recharge

viii) Rainfall – Source for the recharge

ix) Water Level - Water level beneath the ground surface

11.2.5 Creation of Spatial Database

Digitization of existing data, conversion of raster to vector, correcting the boundary overlapping are done using Arc GIS software. Buffer analysis for lineament and lineament intersection were carried out. Point data such as rainfall, water level, water quality, depth to weathered rock/fractured rock and depth to bed rock were interpolated using Inverse Distance Weighted (IDW) method of spatial analysis. All spatial data were assembled in digital form and all the appropriate data were brought together into a geo database.

11.2.6 Spatial Analysis

The classes in each of the thematic layers were categorized depending upon the recharge characteristics by assigning suitable ranks to respective attributes. All layers are converted into raster with a defined cell size based on assigned ranks. These raster layers are brought into weighted analysis tool by assigning suitable weights to the individual layers considering its influence in recharging property and the total weights of the layers within 100 percent.

The weighted overlay analysis provides the ability to weight and combine multiple raster inputs, representing multiple factors can easily be combined incorporating weights or relative importance. The values of continuous raster are grouped into ranges and each range is assigned a single value to represent a class such as low, medium or high importance. The weighted overlay analysis works by multiplying the designed field values for each input raster by its specified weight. Each input raster can be assigned as percentage of influence, based on its importance. The cell values of each input raster are multiplied by raster's weight. The resulting cell values are added to final output raster.

The output raster gives, range of pixel values lowest to higher. Reclassification of the weighted raster layer brings three classes viz. poor suitable, moderately suitable and most Suitable.

11.2.7 Recharge Zones

By the weighted overlay method, using multiple thematic layers of influencing parameters by assigning scores for each feature and weightage of each layer suitability zones for groundwater recharge were identified wherein the classes with higher values indicate most suitable for recharge, moderately suitable for recharge and the lower value indicate as poor suitable for recharge as shown in **figure AG-xxx.** New structures may be selected in the good recharge zone and moderately recharge zones.

11.2.8 Recommended Structures

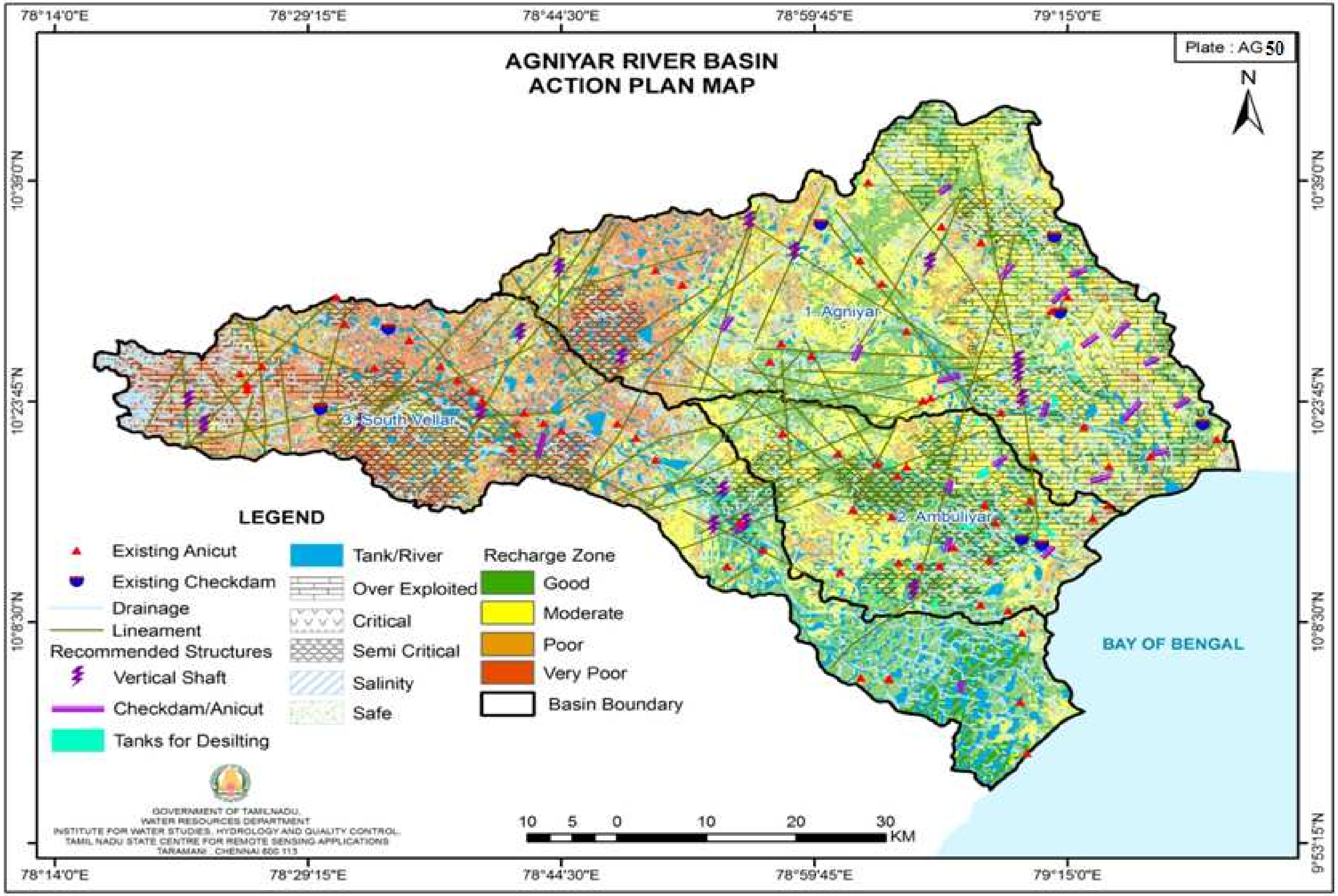
From the derived zones of suitable for recharge, firka wise categorisation as on 2020 and lineament layers were superimposed for selection of artificial recharge structures in the Over Exploited, Critical and Semi Critical firkas so as to improve the groundwater condition. Hence in the Agniyar river basin, new recharge structures such as check dam/anicut, vertical shaft and selection of tanks for desilting are recommended in the more groundwater extracted zones and presence of lineaments. For this basin, 15 vertical shafts, 21 check dams and 35 tanks for desilting were recommended. The recommended structures with location are given in **Table 11.1**

Table 11.1 Recommended Artificial Recharge Structures

Sl.No.	Location	Latitude	Longitude	Recharge Zone	Category	Sub Basin
I. Check Dam/Anicut						
1	Mattur	10.231	79.1292	Good	Semi Critical	Ambuliyar
2	Periyakalthi Kottai	10.2231	79.2293	Moderate	Over Exploited	Ambuliyar
3	Kilatheru	10.4233	79.1304	Good	Over Exploited	Agniyar
4	Malaiyur	10.4521	79.0375	Good	Safe	Agniyar
5	Nainakulam	10.3858	79.3139	Moderate	Over Exploited	Agniyar
6	Sillathur	10.5467	79.1879	Good	Over Exploited	Agniyar
7	Therkukottai	10.5193	79.2417	Good	Over Exploited	Agniyar
8	Enadhikarambai	10.2984	79.1304	Good	Semi Critical	Ambuliyar
9	Kalathur	10.3285	79.1813	Moderate	Over Exploited	Ambuliyar
10	Karisaivayal	10.308	79.2829	Moderate	Over Exploited	Agniyar
11	Chinavadayar Kovil	10.3383	79.3428	Good	Over Exploited	Agniyar
12	Punavasal	10.387	79.2262	Good	Semi Critical	Agniyar
13	Enadi,Adambai	10.4663	79.2712	Moderate	Critical	Agniyar
14	Athikottai	10.4434	79.3338	Good	Over Exploited	Agniyar
15	Thuvarangurichi	10.3953	79.3646	Good	Over Exploited	Agniyar
16	Sendakkadu	10.4789	79.3028	Moderate	Over Exploited	Agniyar
17	Sarkaranarkudikkadu	10.5459	79.2605	Good	Over Exploited	Agniyar

Sl.No.	Location	Latitude	Longitude	Recharge Zone	Category	Sub Basin
18	Marungulam	10.6414	79.1263	Good	Over Exploited	Agniyar
19	Perungalur	10.486	78.9067	Good	Safe	Agniyar
20	Vellur Siruvarai	10.0681	79.1443	Good	Salinity	South Vellar
21	Kothamangalam	10.2504	78.9187	Good	Semi Critical	South Vellar
II. Vertical Shaft						
1	Odakkur	10.548	78.7397	Moderate	Safe	Agniyar
2	Maravamadurai	10.3699	78.5421	Moderate	Semi Critical	South Vellar
3	Valuttaivattam	10.3976	79.2049	Moderate	Over Exploited	Agniyar
4	Temmavur	10.602	78.9309	Moderate	Safe	Agniyar
5	Sothupalai	10.5669	78.9766	Moderate	Safe	Agniyar
6	Pidarikkadu	10.1773	79.0961	Good	Semi Critical	Ambuliyar
7	Arimalam	10.2521	78.895	Moderate	Safe	Agniyar
8	Nallur	10.3807	78.6607	Moderate	Semi Critical	South Vellar
9	Alagapuri	10.3667	78.3834	Moderate	Over Exploited	South Vellar
10	Karaipatti	10.3959	78.368	Moderate	Over Exploited	South Vellar
11	Vellanur	10.4446	78.8026	Moderate	Semi Critical	Agniyar
12	Kothamangalam	10.2548	78.9272	Good	Semi Critical	South Vellar
13	Palaiyur	10.2917	78.9044	Good	Semi Critical	South Vellar
14	Vengarai	10.4413	79.2006	Moderate	Over Exploited	Agniyar
15	Vengarai	10.4252	79.2008	Moderate	Over Exploited	Agniyar
III. Tanks for Desilting						
1	Maravamadurai	10.3747	78.5372	Moderate	Semi Critical	South Vellar
2	Palaiyur	10.2856	78.9053	Good	Semi Critical	South Vellar
3	Kothamangalam	10.2505	78.9307	Good	Semi Critical	South Vellar
4	Mangadu	10.3224	79.0716	Good	Semi Critical	Ambuliyar
5	Ammayandi	10.3132	79.165	Moderate	Over Exploited	Ambuliyar
6	Pinnavasal	10.2542	79.1512	Good	Semi Critical	Ambuliyar
7	Alivalam	10.423	79.2572	Good	Semi Critical	Agniyar
8	Mullurpattikadu	10.511	79.3347	Good	Over Exploited	Agniyar
9	Nemelithippiakudi 2	10.5457	79.2756	Good	Over Exploited	Agniyar
10	Vettuvakottai	10.4824	79.1903	Good	Over Exploited	Agniyar
11	Inayathkanpettai	10.7051	79.1209	Good	Over Exploited	Agniyar
12	Vadakkur North	10.6351	79.181	Good	Semi Critical	Agniyar

Sl.No.	Location	Latitude	Longitude	Recharge Zone	Category	Sub Basin
13	Pinnayur	10.5879	79.2106	Good	Semi Critical	Agniyar
14	Poyyundarkudikadu	10.5685	79.2498	Moderate	Semi Critical	Agniyar
15	Adambai	10.4594	79.2478	Moderate	Critical	Agniyar
16	Atirampattinam	10.3498	79.3616	Good	Over Exploited	Agniyar
17	Saundaranayakipuram	10.368	79.3999	Good	Critical	Agniyar
18	Umathanadu	10.2475	79.2303	Moderate	Over Exploited	Ambuliyar
19	Korattur	10.2452	79.199	Moderate	Over Exploited	Ambuliyar
20	Korattur	10.2415	79.2133	Good	Over Exploited	Ambuliyar
21	Nelliyadikadu	10.2418	79.1684	Good	Semi Critical	Ambuliyar
22	Kukanur	10.1683	79.1181	Good	Semi Critical	Ambuliyar
23	Kukanur	10.1622	79.1166	Good	Semi Critical	Ambuliyar
24	Tuttakudi1	10.1681	79.0587	Good	Semi Critical	Ambuliyar
25	Memangalam	10.1859	79.0775	Good	Semi Critical	Ambuliyar
26	Ettiyathali	10.1862	79.0562	Good	Semi Critical	Ambuliyar
27	Rettaivayal Ukkadai	10.2234	79.1834	Good	Semi Critical	Ambuliyar
28	Kalatthur	10.3344	79.1792	Moderate	Over Exploited	Ambuliyar
29	Siruvavdudi Vadapadi	10.3725	79.1584	Moderate	Over Exploited	Ambuliyar
30	Kurichi	10.3955	79.2362	Moderate	Semi Critical	Agniyar
31	Kayavur	10.4158	79.2209	Moderate	Semi Critical	Agniyar
32	Kaduvettividuthy 1	10.4922	79.1695	Moderate	Over Exploited	Agniyar
33	Chinna Ammankudi	10.5305	79.1966	Moderate	Over Exploited	Agniyar
34	Sillathur	10.5431	79.2033	Moderate	Over Exploited	Agniyar
35	Vengarai	10.4428	79.2142	Good	Over Exploited	Agniyar



AGNIYAR RIVER BASIN
ACTION PLAN MAP
Plate : AG 50
N
1. Agniyar
2. Ambuliyar
3. South Vellar
BAY OF BENGAL
LEGEND
Existing Anicut
Existing Checkdam
Drainage
Lineament
Recommended Structures
Vertical Shaft
Checkdam/Anicut
Tanks for Desilting
Tank/River
Over Exploited
Critical
Semi Critical
Salinity
Safe
Recharge Zone
Good
Moderate
Poor
Very Poor
Basin Boundary
GOVERNMENT OF TAMILNADU,
WATER RESOURCES DEPARTMENT
INSTITUTE FOR WATER STUDIES, HYDROLOGY AND QUALITY CONTROL,
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATIONS
TARAMANI , CHENNAI 600 113
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78°59'45"E
79°15'0"E
10°39'0"N
10°23'45"N
10°8'30"N
9°53'15"N

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