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GOVERNMENT OF TAMILNADU
PUBLIC WORKS DEPARTMENT
WATER RESOURCES DEPARTMENT

MICRO LEVEL REAPPRAISAL STUDY

VARAHANADHI RIVER BASIN

VOLUME I

Vidur Reservoir

INSTITUTE FOR WATER STUDIES
TARAMANI, CHENNAI - 600113

MARCH 2018

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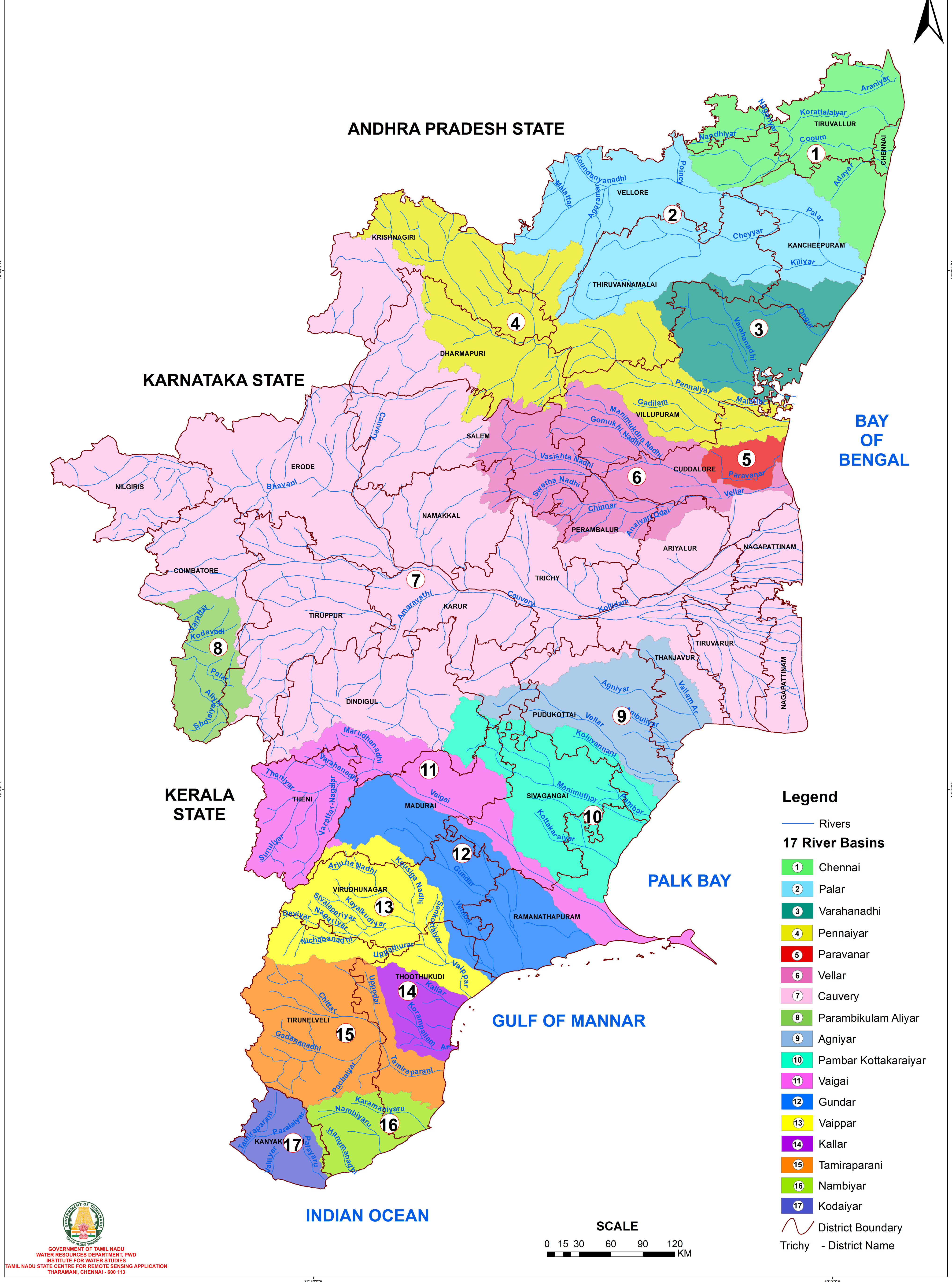
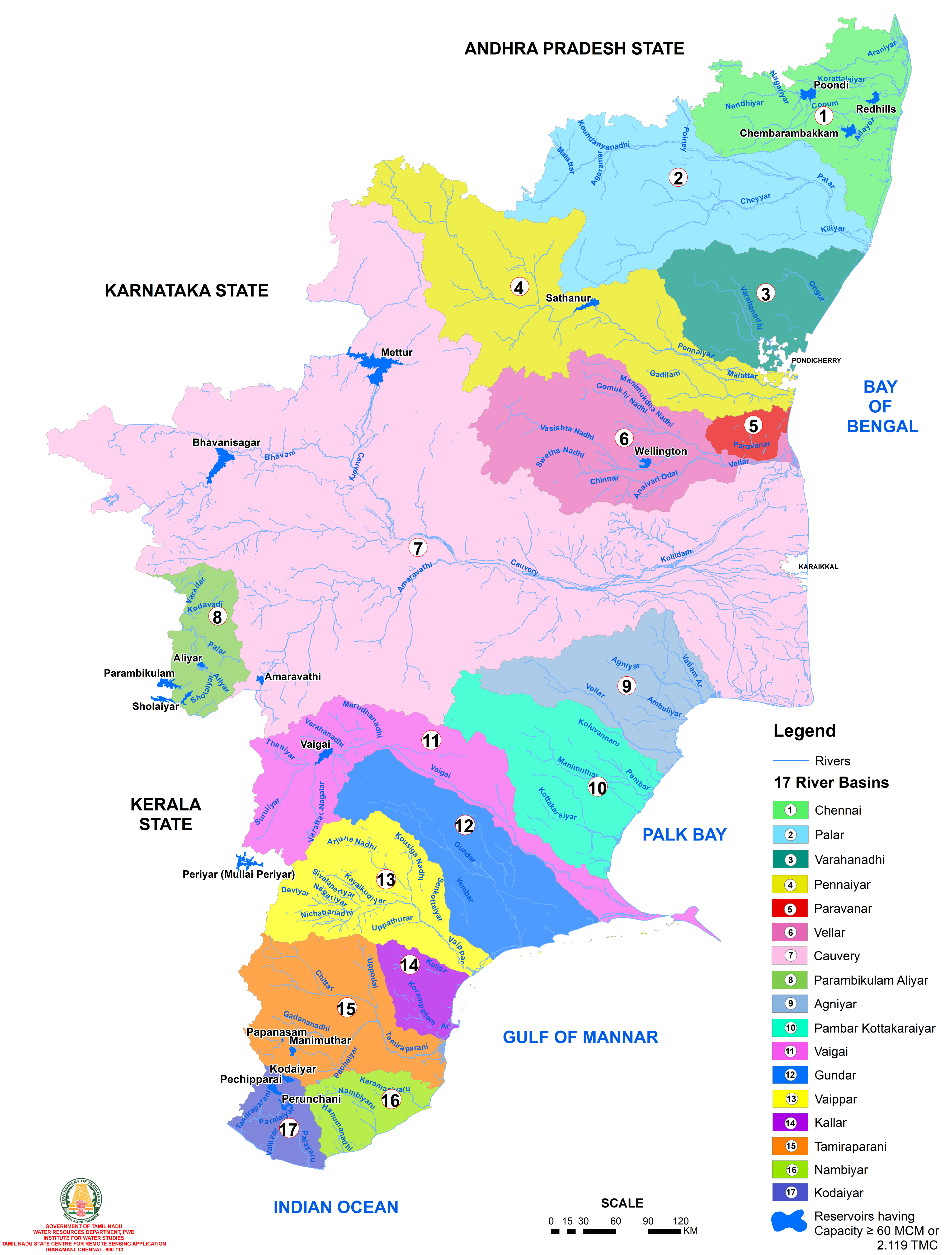
RIVER BASINS OF TAMIL NADU



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 of development of Principles for planning & management of Water Resources, Assistance in formulation of Water Management Policies, Research on Water Planning, Policy making and Remote Sensing applications, development of Training Programmes on Water Resources and to advise the Government on specific Policy matters.

The River Basin boundaries were delineated in **1:50,000 scale**. Micro level studies were completed for 16 River Basins except for Cauvery River basin. The Micro level study reports were disseminated to the concerned officers of Water Resources Department and other line departments.

In order to update the Micro Level study reports, incorporating the changes taken place thereafter with regard to land use and water demand of various sectors, with latest available data and using the River Basin boundaries in **1:50,000 scale**, Micro level Reappraisal studies for the River Basins were taken up. Accordingly, reappraisal studies for **Kodaiyar, Vaippar, Vaigai, Vellar, Palar, Tamiraparani, Pennaiyar and Paravanar River Basins** were completed. The Micro level Reappraisal study of **Varahanadhi River Basin** has been taken up for the year **2017 - 2018**.

The first report on Varahanadhi River Basin was prepared in the year 1984 under the UNDP project. The second report of Varahanadhi River Basin was modified in 1990 under the World Bank assisted project "Water Resources and Management Studies". The micro level appraisal report of Varahanadhi River Basin was prepared in the year 2005 using the latest tools, GIS data base and its simulations available at that time for river basin planning.

The Micro level Reappraisal study of Varahanadhi River Basin has been taken up in 2017-2018 to assess the present water potential, demand and balance prevailing in the basin, expected future water availability / balance, water demand for various sectors by taking into account the data upto 2017. The water balance of Varahanadhi River Basin is carried out in various scenarios to explore the availability of water for future. Various thematic maps of the Varahanadhi River Basin were prepared using

GIS and the developments required within the basin for effective utilization and management of Water Resources were analysed.

Necessary strategic action plan for improving the potential of Varahanadhi River Basin are recommended which may be considered for implementing in the State water plan and future planning of water resources in the State for the benefit of the society and better management of Water Resources in the Basin.

Chief Engineer & Director,
Institute for Water Studies,WRD,
Taramani, Chennai-113.

ACKNOWLEDGEMENT

We express our sincere thanks to the Principal Secretary to Government, Public Works Department for unrelenting support and encouragement for carrying out the Micro level reappraisal study of Varahanadhi River Basin.

We sincerely thank the Engineer-in-Chief, WRD, PWD for valuable support for carrying out the Micro level reappraisal study of Varahanadhi River Basin.

We express our deep sense of gratitude to Er.R.Subramanian, Chairman, Cauvery Technical Cell cum Inter State Waters Wing, Chennai for generously guiding us with effective, futuristic comments and opinions during the Micro level reappraisal study of Varahanadhi River Basin.

We thank the Chief Engineer, WRD, Chennai Region, 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 Varahanadhi River Basin.

We also thank, the Superintending Engineer, WRD, Pennaiyar Basin Circle, Tiruvannamalai, Superintending Engineer, WRD, Palar Basin Circle, Chennai, the Executive Engineer, WRD, Middle Pennaiyar Basin Division, Tiruvannamalai, the Executive Engineer, WRD, Lower Pennaiyar Basin Division, Villupuram and the Executive Engineer, WRD, Lower Palar Basin Division, Kancheepuram for their assistance and contributions for the preparation of this study report.

We acknowledge and thank the Agricultural Department, Agricultural Engineering Department, Department of Statistics and Economics, Tamil Nadu Water Supply and Drainage Board, Tamil Nadu Pollution Control Board, Directorate of Industries & Commerce, Department of Animal Husbandry & Veterinary Services, Directorate of Medical & Rural Health Services, Directorate of Census Operation, Department of Fisheries, 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 Varahanadhi River Basin.

I hope this effort on Water Resources planning in Varahanadhi River Basin will be useful to Water Resources Department and other line departments in taking necessary effective steps to improve the management of Water Resources in Varahanadhi River Basin.

Chief Engineer & Director,
Institute for Water Studies,WRD
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ABBREVIATIONS

ADD	Acute Diarrhoea Disease
AED	Agricultural Engineering Department
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
TWAD Board	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

VOLUME – I

MICROLEVEL REAPPRAISAL STUDY OF

VARAHANADHI RIVER BASIN

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5	Tmt.P.Indira Gandhi	Joint Director, Agriculture (01.04.2017 to 26.11.2017)
6	Thiru.P. Murugesan	Joint Director, Agriculture (09.11.2017 to 31.03.2018)
7	Er.S.Ayupkhan	Executive Engineer, Division II (01-04-2017 to 22-05-2017)
8	Er.T.Geetha Jayasree	Executive Engineer, Division II (28-09-2017 to 28.03.2018)
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	Name	Designation
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22	Er.A.Dhivya	Assistant Engineer, Division II
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24	Er. K. Priya	Assistant Engineer, Division IV (01-04-2017 to 28-02-2018)
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27	Er.J.Praveena	Assistant Engineer, Division V
28	Er.L.Umarani	Assistant Engineer, Division V
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32	Thiru.S.Mahalingam	Assistant Computer Programmer
33	Tmt. G.Lakshmi	Assistant Computer Programmer

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CHAPTER – 1

INTRODUCTION, SCOPE OF THE STUDY

AND

METHODOLGY

CHAPTER – 1

INTRODUCTION, SCOPE OF THE STUDY AND METHODOLOGY

1.1 Introduction

Water is, literally, the source of life on earth and is an essential commodity for the sustenance of all forms of life. As populations grow and per capita usage of water rises, demand for fresh water is soaring. Yet, the availability of fresh water is finite, that too threatened by pollution. Conservation of water, prevention from pollution and judicious management of its demand and supply are the need of the hour.

Being an agrarian State, Tamil Nadu depends upon its water resources for its need from the rivers, tanks and groundwater as well. At present Tamil Nadu is deficient in its water resources, both the surface and ground water. Due to frequent monsoon failures, unmindful extraction of groundwater, urbanization, inadequate water management and ever increasing population, the scenario has been aggravated and demand for water has increased in to many fold.

The surface water systems such as rivers, reservoirs and tanks depend only on monsoonal rains. Due to frequent failure of monsoons, these structures do not get adequate fillings and could not cater even their entire command areas. The capacity of these structures is also reduced due to various reasons resulting in poor storage conditions.

On the other hand, lowering of groundwater level is observed in many parts of the state in the last two decades, due to over exploitation. The number of wells and the number of energized pump sets have grown exponentially since the early 1950s (FAO, 2003).

Surging population, increasing industrialization and associated demands for freshwater, food and energy would be the areas of concern in the changing climate scenarios. Reduced precipitation in hilly regions affects the availability of water resource. Because of this, socio economic problems are cropping up, ultimately leaving the agricultural land unattended.

1.2 Scope of Reappraisal Study

Tamil Nadu occupies about 4 percent of the total geographical area of India and has about 3 percent of its water resources (State Planning Commission, Govt. of Tamil Nadu, 2006). As per 2011 census, about 6.40 percent of the total population of the country resides in Tamil Nadu.

Rivers of Tamil Nadu are ephemeral in nature, depends upon the seasonal rainfall except river Tamiraparani up to some extent. Hence the water potential of these rivers are strongly associated with the conditions of monsoons. A poor monsoon rainfall leads to drought conditions and the situation is further aggravated, if monsoon fails for consecutive years and successive drought occurs. Changes in the amount of rainfall, its pattern and intensity affects stream flow and the availability of water. Most of the rivers are interstate at its course and many interstate disputes on river water sharing is to be taken note of.

On the other hand, high flood levels can cause substantial damage to key economic sectors such as agriculture, infrastructure and housing. Flood and drought management through scientific approach are required by incorporating the possible effects of climate change in the design and management of water resources system.

Groundwater has, in the last few decades, emerged as the major alternate source of water supply to domestic, irrigation and industrial sectors in Tamil Nadu on account of the near-total utilization of surface water resources. The need to satisfy the requirements of an ever-increasing population have been exerts a severe stress on the limited groundwater resources in the State. Two decades back, the total number of agricultural wells were 5, 39,427. Now, it has been increased to 18,620,55 (Season and Crop Report of Tamil Nadu 2014-2015**)**. This alarming trend leads to groundwater mining in some parts of the State. This may become more dreadful due to the lack of knowledge among the users in recharging the aquifers in the overexploited areas and by poor water management. Hence, recharging the aquifers for sustainable ground water development is the need of the hour.

The sustainable development of water resources require precise quantitative assessment based on reasonably valid scientific principle. Quantification of the water potential of both surface water and groundwater is pre-requisite for efficient water resource development and management.

Quantification of water resources is often critical and no single comprehensive technique is yet to be identified which is capable of estimating accurate water resource assessment. The complexities of the processes governing the occurrence of groundwater, the capacity of the geological formations to store and transport groundwater makes the problem of assessment difficult, as it needs enormous data with a scientific, multidisciplinary approach for the space and time location of water, in quantity as well as quality.

In view of the factors mentioned above, it is necessary that suitable water management strategies be formulated and implemented in Tamil Nadu for optimal and sustainable management of its limited water resources. A detailed study, integrating various factors controlling the occurrence, development and management of water resources is a necessary pre-requisite for any such initiative. This study is an endeavor in this direction.

1.3 River Basins as Unit of Planning

River basin, the hydrological unit is an area which collects rain or stream waters and discharges it through a common outlet at its minimum elevation (the basin mouth). The divide represents the highest elevation points along the basin perimeters (Chandramohan, 1996). River basins, are delineated based on the drainage pattern, spot heights, contours and ridges using Survey of India topo sheets and Digital Elevation Model (DEM).

The rationale of choosing a river basin as the unit for the planning is to optimise the use of water resources in that basin, matching with supply and demand. An analysis of the water balance, water utilisation and allocation plan for different competing water users form the core of a river basin plan.

In Tamil Nadu, there are 34 major rivers including one west flowing river. All these 34 rivers are grouped into 17 river basins for the purpose of water resources planning activities. The Varahanadhi river basin is one of the 17 river basins **(Plate VAR - 01A).**

Sub-basin

A sub-basin is an area encompasses the tributaries of a major river. It includes all those areas which collect rain or stream waters and discharges it through a common outlet at its minimum elevation (the sub-basin mouth) as it is in the case of River basin.

Sub-basin is a logical unit for the efficient management of rainwater in the dry regions. In Tamil Nadu, the 17 River basins are further delineated in to 127 sub basins. **(The list of 17 River Basins and 127 basins are given in Table 1.1)** In the Varahanadhi basin there are three sub – basins viz. Nallavur, Varahanadhi and Ongur **(Plate VAR - 01B).**

The task of planning and management of water resources can be very effectively carried out on a basin wise structure for all intra and interstate rivers using scientific techniques. The main results of the river basin plan to be included in the State Water Plan are: (1) Inventory of development plans and attributes of the plans which are relevant to their prioritisation; (2) Institutional and legal deficiencies revealed in the basin with their proposed modifications. The feedback is schematically presented in **Figure. A.**

1.4 Objectives of Present Report and Its Updates

The main objective of this study is to carry out an integrated and holistic approach to assess the total (both surface and groundwater) water potential demand and balance water potential, apart from environmental issues to suggest suitable measures for better water resources management in Varahanadhi basin, based on the

- scenario of temperature and precipitation to assess the water potential
- different thematic layers utilizing IRS Satellite data
- aquifer characteristics based on geophysical resistivity data
- study of seasonal water level fluctuation from 1972 to 2016 and so the rainfall influence on groundwater
- groundwater quality variation with selected parameters
- changes in land use pattern for two periods i.e 1998 and 2016 using IRS Satellite data
- MRS model and NWDA approach for assessing Surface water potential
- groundwater potential assessment based on GEC 1997 norms
- sectoral demands
- water potential projected to future scenario
- identification of favorable groundwater potential zone and artificial recharge zone
- recommended measures to mitigate probable adverse scenario in connection with water resources.

1.5 Methodology

The Institute for Water Studies has completed Micro level study for 16 river basins, except Cauvery basin. Reappraisal study is being carried out and completed for Kodaiyar, Vaigai, Tamiraparani, Pennaiyar, Vellar, Palar and Paravanar river basins. At present the Varahanadhi river basin has been taken up for reappraisal micro level study to explore the water potential with current scenario by applying latest technology and comparing the outcome of the previous study during the year 2005.

Previously, a study under State Frame Work on the water resources plan for the Varahanadhi river basin has been carried out by the Institute for Water Studies during 1997, which was followed by Micro level study during the year 2005.

In the present report, assessment of water resources, water demand and water balance are estimated for this basin. The water balance of the basin indicates the level of utilisation of water resources for various sectoral demands and finally shows whether the basin is surplus or deficit. The assessment of water demand is as per the accepted development scenarios in all sectors, norms specified for per capita utilisation, the rate of growth of population and its standard of living etc. In this respect, there is a scope to make use of the decision- support systems like optimization models, and simulation models for judicious planning of the scarce water resources in the State. These models also include priority rules by sectors as prescribed in the National and State Water Policies, inter-basin and intra basin transfer capacities from source to users; basin wise local unmet demands and unused water are thus defined as problems to be solved in the planning process.

In addition to mismatch problems between demands and resources, other important problems that hamper the safe water availability such as water logging, salinity, pollution, environmental degradation, inefficient use of water, under utilisation of resources, seawater intrusion in coastal regions, natural calamities like floods and droughts, etc and health related problems are also considered. These problems are locally assessed and possible solutions are evaluated in the planning process for decision making at higher levels.

The planning process as demonstrated in this report is based on scientific tools such as Remote Sensing with Geo database and simulation models which have to be continuously updated with current data. According to the variations in results for the future-planning horizon, the recommended “Action Plan” will have to be revised and updated. The various models and database used have been revised accordingly for an adjustable scientific assessment of water resources and of sectoral water demands at present and for the future, under different socio-economic development scenarios.

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

At the outset, using Remote Sensing and the advanced concepts of GIS, Geo data bases were generated on the geosystems and there from the geodynamic model involving the following:

- ❖ Generation of GIS data base on geology, geomorphology, lineament using Satellite data and geophysical resistivity data from geophysical survey.
- ❖ GIS data bases on rainfall distribution and evaluation of rainfall dynamics.
- ❖ GIS data bases on water level distribution for evaluation of water level dynamics.
- ❖ GIS data bases on water quality variation for evaluation of water quality dynamics.
- ❖ GIS data bases on land use for 2 periods (1998 and 2016) and evaluation of landaus changes.
- ❖ Estimation of surface water by rainfall runoff method.
- ❖ Estimation of groundwater based on GEC 1997 norms.
- ❖ Water balance based on available surface & Groundwater potential.

1.6 Basin - Specific Data

For water resource planning, specific spatial and non-spatial data are required. Spatial data such as Geology, Soil, Geomorphology, Land use, Lineament, Hydrogeology, Climatology, Water level, Water quality etc., and non-spatial data such as environment, socio-economy, health, agriculture, population, livestock, industries, etc. were collected for analysis. Socio-economic, agricultural and livestock statistics are also collected and presented on the basis of administrative units, which generally, do not coincide with river basin boundaries. To obtain basin-specific data, one has to re-group / apportion the data of administrative units into river basins. For administrative units situated in two or more river basins, the value of the variables will be split between those basins in proportion to the area contained in the respective river basins.

1.6.1 Data Collection

The spatial and non spatial data pertaining to the Varahanadhi river basin have been collected from various organization such as Regional offices of WRD, SG & SWRDC (State Ground and Surface Water Resources Data Centre), Statistics Department, Commissioner of Revenue Administration, Survey and Settlements, Agricultural department, Forest department, respective District Collectorates, Census, Central Groundwater Board, TWAD Board, Tamil Nadu Pollution control Board etc.

District maps, Taluk maps, Survey of India Topo sheets on 1:50,000 scale and District Resource Map on Geology published by Geological Survey of India for Tiruvannamalai, Villupuram, Kancheepuram and Cuddalore districts, have been utilized.

The Climatological data including Rainfall for the basin were obtained from SG & SWRDC, PWD, WRD, Chennai.

Water level and Water quality data from the dedicated observation wells maintained and monitored by State Ground & Surface Water Resources Data Centre, PWD, WRD, Chennai were used. Geophysical resistivity data generated from the Resistivity survey were also obtained from State Ground & Surface Water Resources Data Centre, PWD, WRD.

Data on population has been collected from Directorate of census operations, Industries and livestock details are obtained from Tamil Nadu pollution control board and Department of Animal Husbandry and veterinary sciences respectively. Hydroelectric power generation details are collected from TNGEDCO.

Particulars about prevailing disease in the area of interest are collected from Public health department. Details on sewage generated are obtained from TWAD board. Information about tourists and fish production (inland and marine) are obtained from tourism and fisheries departments respectively. Sedimentation in the water bodies of the study area and particulars on the consumption of fertilizers and pesticide are received from Institute for Hydraulics & Hydrology and Agriculture department respectively.

1.6.2 Data Consistency and limitations

Regrouping of data according to river basins is to be done systematically in order to strike consistency between basin and administrative units of entire State. Many issues related to water demand could better be dealt for the whole State by dividing it into a number of basins. This would be better, to ensure consistency, more efficient data collection and analysis would avoid unnecessary repetition. There is limitation in the availability of data pertaining to climatic stations, water level monitoring observation wells as they are not evenly and adequately representing all part of the river basin.

1.7 Technologies Involved

Remote sensing techniques

Remote sensing and GIS technologies have been used to interpret the satellite imageries to prepare Geomorphology, Land use and Lineament maps. Imageries of satellite, sensors and year of acquisition are as follows

- IRS 1C LISS III data of 1998
- IRS P6, LISS III data of 2008
- IRS P6, LISS IV Mx 2015

1.7.1 Interpretation of Remote Sensing Data

Visual Interpretation

Identification of objects and classifieds by viewing the hard copies (Photos / imagery) based on the image characteristics, are commonly known as visual interpretation. Using visual interpretation techniques, different themes like Geomorphology, Lineament and Wasteland maps were prepared.

There are strong inter-linkages in various photo elements to derive information from remotely sensed data. This clearly shows that no single element can exclusively be used for full information extraction. It is the combination of all photo elements and change detection that maximize translation of raw data into information.

Digital / System Interpretation

The IRS P6 LISS III and PAN merged 1998 data was used to classify Land use / Land Classification.The digital satellite data was geo-rectified with ground control points (GCPs) obtained from rectified topo sheets. Radiometric corrections such as filtering, edge enhancement, histogram and PCA analysis were done to fine tune the digital image to analyse and derive the land use / land Classification information from the digital image using digital image processing software.

1.7.2 Map Preparation

Different thematic information were interpreted from satellite imageries and topographical data on 1:50,000 scale using film sheets and converted into raster format by scanning. These raster maps were geometrically rectified using Ground Control Points (GCP) and converted into vector format by "on screen digitization" method using GIS software. These vectorised themes were put into GIS environ with common projection coordinates so as to arrive results though overlay analysis.

1.7.3 Geo database Creation

Geo database using GIS software were created, organized, manipulated, analysed and displayed according to our defined specifications. The two kinds of databases under GIS environ, namely, spatial and non-spatial data were created. The spatial data are in the form of maps like, geology, soil, geomorphology, landuse, lineament wasteland etc were generated and stored as different layers. The non-spatial data are pertaining to attribute information in the form of statistics, tables and list, which are rainfall, water level, water quality population census, industries etc. Integrating the spatial and non-spatial data, querying and analysis were done in GIS environ. Theme maps generated precisely by integrating selected layers of data and manipulating them to evaluate relationships among the chosen elements in different layers under consideration to arrive the required results, which were organized in Geo database.

1.8 Analysis

Analysis on drainage pattern of this basin was done using the streams, rivers and its order taken from the topo sheet, satellite imageries and aerial photographs.

Satellite data analysis was carried out to delineate the different features for preparation of thematic maps by visual interpretation and digital classification methods using image processing software. Using the satellite data land use maps were prepared by adopting unsupervised classification method for the years 1998 and 2015. The changes in spatial distribution of each landuse category with aerial extent are arrived to know the changes in the landuse / Land Classification over these years and its causes.

Geophysical resistivity data were analyzed to study the subsurface lithological conditions of the basin.

Rainfall analysis was done by generating contours using GIS software to study the rainfall pattern and influence in the study area.

Water level data for Pre and Post monsoon periods collected from the control wells spread over entire basin were analysed. Water level Contour maps were generated using GIS software to study spatial distribution pattern of groundwater level and the fluctuation scenario of this basin.

Water quality data for Pre and Post monsoon periods were collected from the observation wells and analysed. Contours on selected water quality parameters were generated to know the spatial distribution of the water quality, its suitability with respect to domestic and irrigation purposes in the basin.

Using the derived information, GIS analysis were done to arrive favourable groundwater potential zones for further development and the area suitable for artificial recharging of groundwater with relevant recharge structures were identified and recommended.

MRS (Monthly Runoff Simulation) model, and NWDA (National Water Development Agency) method were used for surface water potential assessment. Assessment of groundwater potential as per GEC 1997 methodology done by SG&SWRDC were apportioned to sub basin wise to arrive the groundwater potential.

The inferences derived from the analysis were discussed and presented in various Chapters of this report.

Fig. 1.1 FLOWCHART OF WATER PLANNING – STATE AND RIVER BASIN PLANS

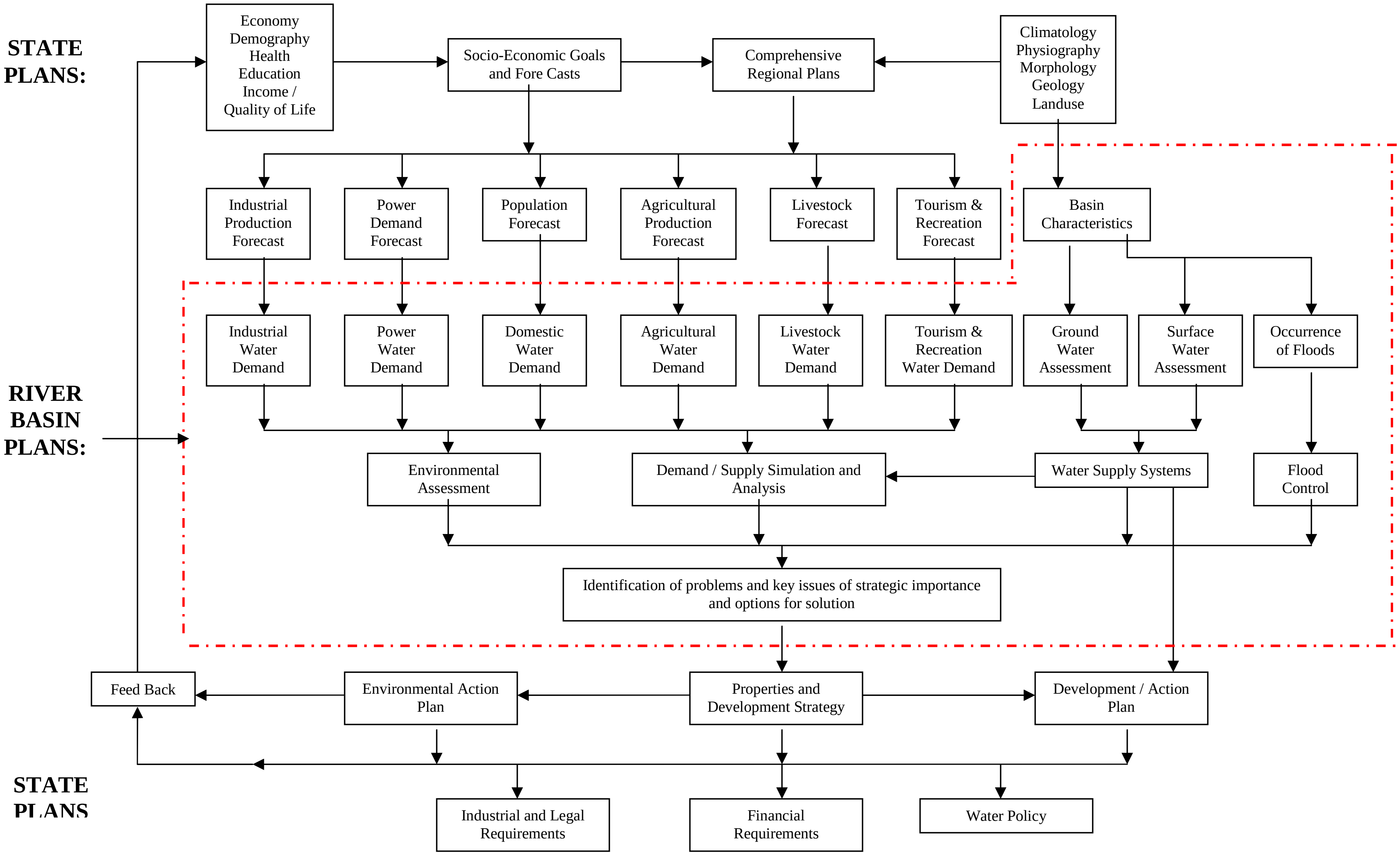


Fig. 1.2 FLOWCHART OF RIVER BASIN PLANNING

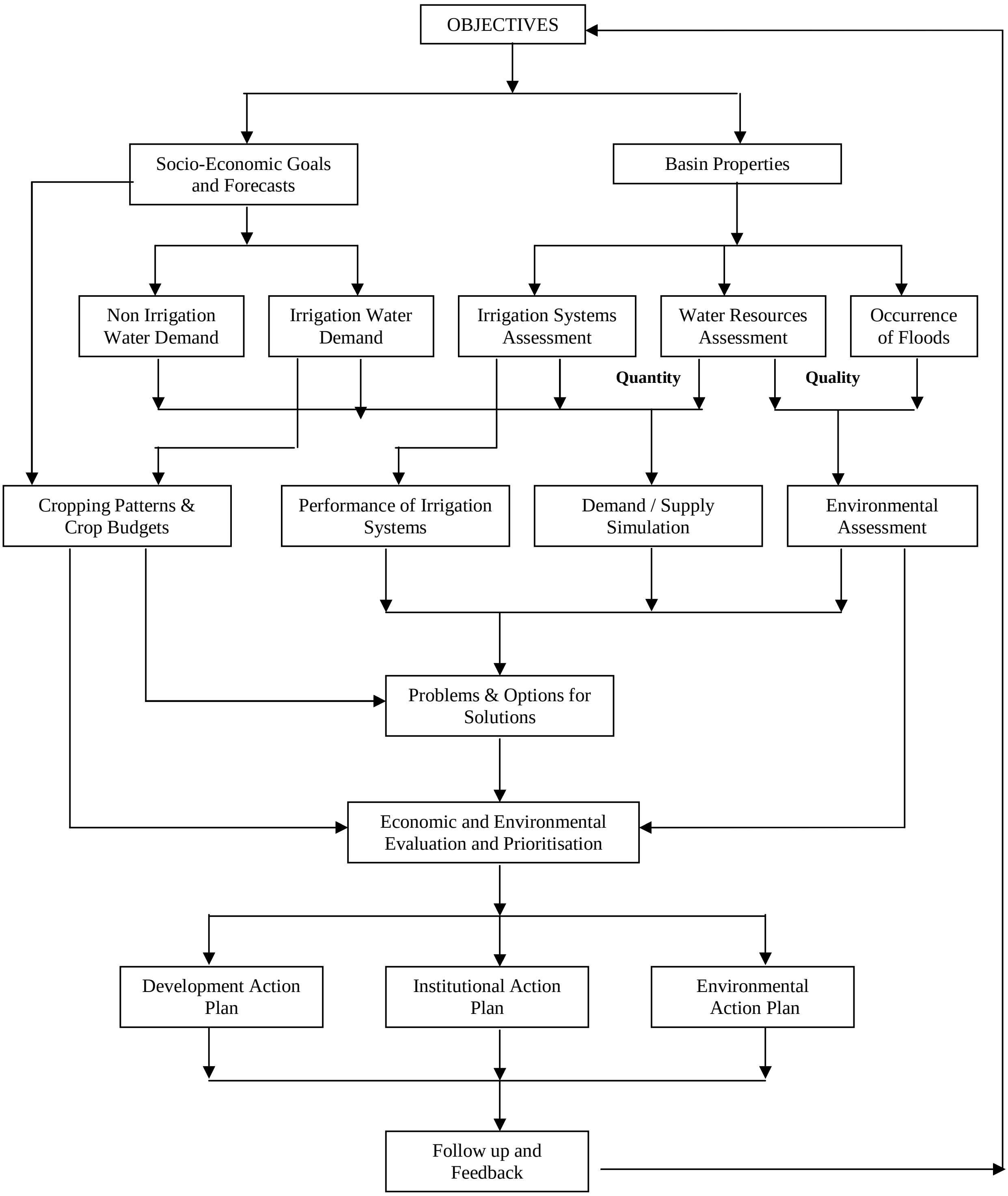


TABLE 1.1 127 SUB BASINS OF TAMIL NADU

Basin Name	Sub Basin No.	Sub Basin Name
1. CHENNAI BASIN		
	1	Gummidipoondi
	2	Araniar
	3	Nagariyar
	4	Nandhiyar
	5	Kosasthaliyar
	6	Cooum
	7	Adyar
	8	Kovalam
2. PALAR RIVER BASIN		
	9	Upper Palar
	10	Malattar
	11	Agramar
	12	Kavundinyanadhi
	13	Poiney
	14	Vegavathi
	15	Cheyyar
	16	Kiliyar
	17	Lower Palar
3. VARAHANADHI RIVER BASIN		
	18	Varahanadhi
	19	Nallavur
	20	Ongur
4. PENNAIYAR RIVER BASIN		
	21	1A Chinnar
	22	1 B Chinnar
	23	Markandanadhi
	24	Kambainallur
	25	Pambar
	26	Vanniar
	27	Mattuar
	28	Kottapattikallar(Kovilar)
	29	Valayar Odai
	30	Ramakal Odai

Basin Name	Sub Basin No.	Sub Basin Name
	31	Pambanar & Varattar
	32	Aliyar
	33	Musukundanadhi
	34	Thurinjalar
	35	Gadilam
	36	Upto Krishnagri Reservoir
	37	Krishnagri to Pambar
	38	Lower Ponnaiyar
	39	Pambar to Thirukovilur
5. PARAVANAR RIVER BASIN		
	40	Paravanar
	41	Uppanar
6. VELLAR RIVER BASIN		
	42	Upper Vellar
	43	Sweta Nadi
	44	Chinnar
	45	Anaivari Odai
	46	Gomukhi
	47	Maniukdha Nadi
	48	Lower Vellar
7. CAUVERY RIVER BASIN		
	49	Chinnar
	50	Dodda Halla
	51	Mettur Reservoir to Noyyel Confluence
	52	Palar Tatta Halla
	53	Moyar
	54	Upper Bhavani
	55	Lower Bhavani
	56	Noyyel
	57	Tirumanimuthar
	58	Amaravathi
	59	Karaipottanar
	60	Pungar (Upper Coleroon)
	61	Ayiaar
	62	Ponnaniyar
	63	Nandiyar-Kulaiyar
	64	Marudaiyar

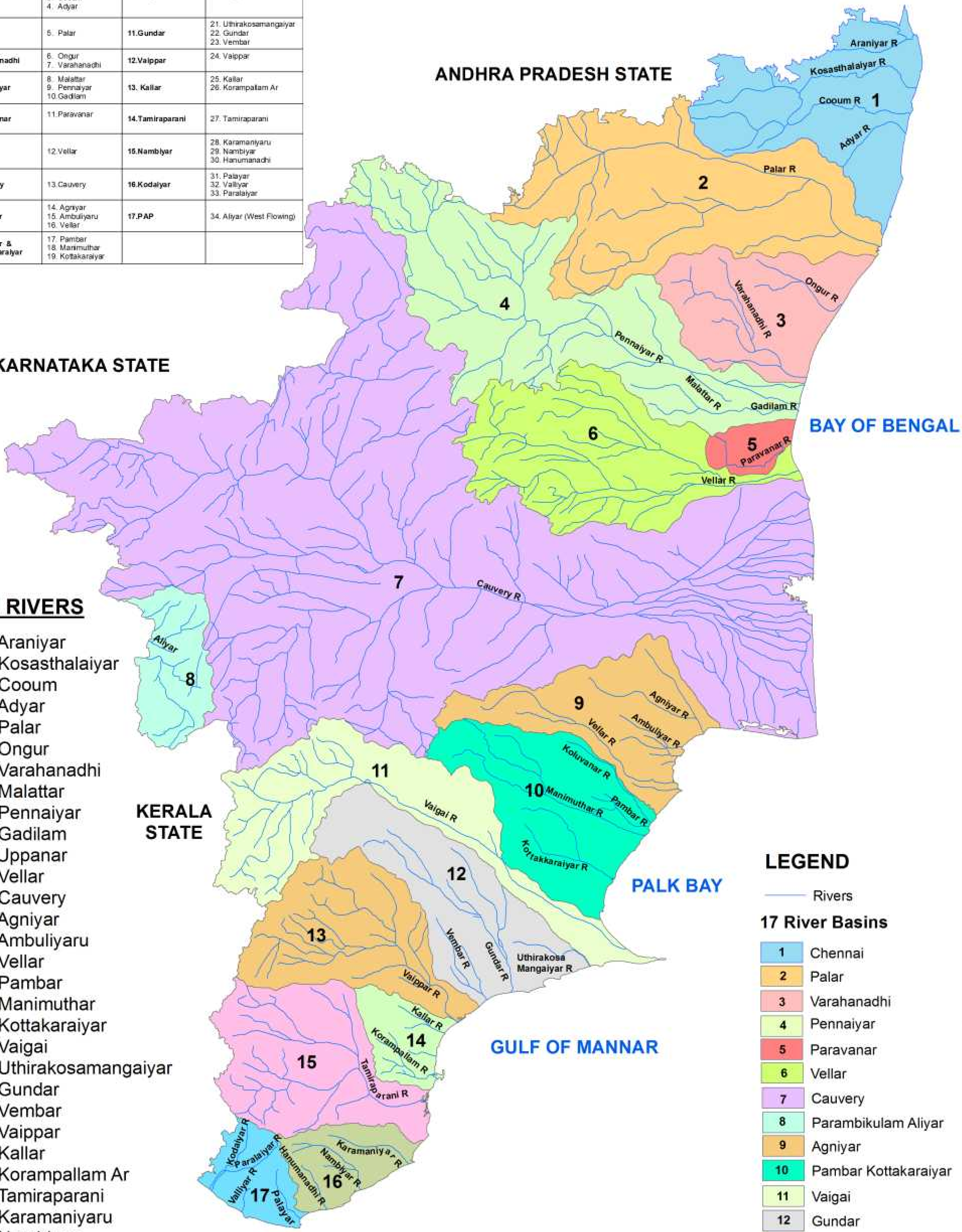
Basin Name	Sub Basin No.	Sub Basin Name
	65	Lower Coleroon
	66	Cauvery Delta
8.PAP BASIN		
	67	Walayar
	68	Palar
	69	Aliyar
	70	Sholayar
9. AGNIYAR RIVER BASIN		
	71	Agniyar
	72	Ambuliar
	73	South Vellar
10. PAMABR KOTTAKARAIYAR RIVER BASIN		
	74	Manimuttar
	75	Pambar
	76	Kottakariyar
11.VAIGAI RIVER BASIN		
	77	Upper Vaigai
	78	Suruliyar
	79	Theniyar
	80	Varattar-Nagalar
	81	Varahanadhi
	82	Manjalar
	83	Sirumalaiyar
	84	Sathaiyar
	85	Uppar
	86	LowerVaigai
12. GUNDAR RIVER BASIN		
	87	Upper Gundar
	88	Therkar
	89	Kanal Odai
	90	Gridhamal
	91	Paralaiyar
	92	Lower Gundar
	93	Uthirakosamangaiyar
	94	Palar
	95	Vembar

Basin Name	Sub Basin No.	Sub Basin Name
13. VAIPPAR RIVER 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 RIVER BASIN		
	109	Kallar
	110	Chalikulam
	111	Korampallam
15. TAMIRAPARANI RIVER BASIN		
	112	Upper Tamiraparani
	113	Manimuthar
	114	Gadana Nadhi
	115	Pachaiyar
	116	Chittar
	117	Uppodai
	118	Lower Tamiraparani
16. NAMBIYAR RIVER BASIN		
	119	Karumeniyar
	120	Nambiyar
	121	Hanumanadhi
17. KODAIYAR RIVER BASIN		
	122	Pechiparai
	123	Chittar(Kodayar)
	124	Perunchani
	125	Kuzhithurai
	126	Valliyar
	127	Pazhayar

34 RIVERS & 17 RIVER BASINSOF TAMIL NADU

Plate: VAR - 01A

Major River Basin / Basin group	Rivers in the group	Major River Basin / Basin group	Rivers in the group
1.Chennai Basin	1. Araniyar 2. Korattalaiyar 3. Cooum 4. Adyar	**10.Vaigai**	20. Vaigai
2.Palar	5. Palar	**11.Gundar**	21. Uthirakosamangaiyar 22. Gundar 23. Vembar
3.Varahanadhi	6. Ongur 7. Varahanadhi	**12.Vaippar**	24. Vaippar
4.Pennaiyar	8. Malattar 9. Pennaiyar 10.Gadilam	**13. Kallar**	25. Kallar 26. Korampallam Ar
5.Paravanar	11.Paravanar	**14.Tamiraparani**	27. Tamiraparani
6.Vellar	12.Vellar	**15.Nambiyar**	28. Karamaniyaru 29. Nambiyar 30. Hanumanadhi
7.Cauvery	13.Cauvery	**16.Kodaiyar**	31. Palayar 32. Valliyar 33. Paralaiyar
8.Agniyar	14. Agniyar 15. Ambuliyaru 16. Vellar	**17.PAP**	34. Aliyar (West Flowing)
9.Pambar & Kottakaraiyar	17. Pambar 18. Manimuthar 19. Kottakaraiyar		



34 RIVERS

1. Araniyar
2. Kosasthalaiyar
3. Cooum
4. Adyar
5. Palar
6. Ongur
7. Varahanadhi
8. Malattar
9. Pennaiyar
10. Gadilam
11. Uppanar
12. Vellar
13. Cauvery
14. Agniyar
15. Ambuliyaru
16. Vellar
17. Pambar
18. Manimuthar
19. Kottakaraiyar
20. Vaigai
21. Uthirakosamangaiyar
22. Gundar
23. Vembar
24. Vaippar
25. Kallar
26. Korampallam Ar
27. Tamiraparani
28. Karamaniyaru
29. Nambiyar
30. Hanumanadhi
31. Palayaru
32. Valliyar
33. Paralaiyar
34. Aliyar (West Flowing)

LEGEND

Rivers

17 River Basins

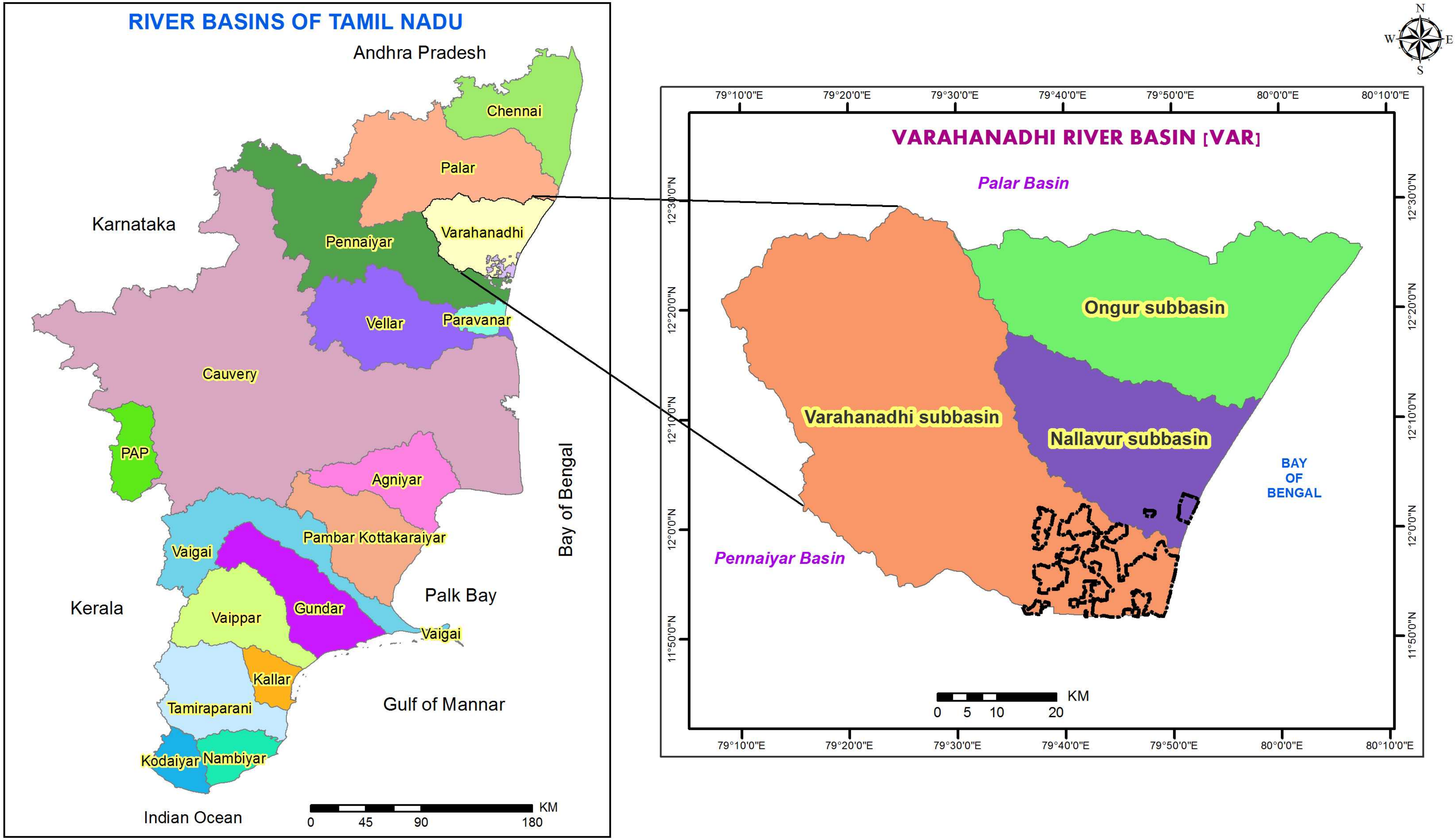
1 Chennai
2 Palar
3 Varahanadhi
4 Pennaiyar
5 Paravanar
6 Vellar
7 Cauvery
8 Parambikulam Aliyar
9 Agniyar
10 Pambar Kottakaraiyar
11 Vaigai
12 Gundar
13 Vaippar
14 Kallar
15 Tamiraparani
16 Nambiyar
17 Kodaiyar

0 15 30 60 90 120 KM

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

INDEX MAP OF VARAHANADHI RIVER BASIN

Plate: VAR-01B



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

CHAPTER - 2

DESCRIPTION OF THE BASIN

CHAPTER – 2

DESCRIPTION OF THE BASIN

2.1 General

Varahanadhi river basin is the third among the 17 river basins of Tamil Nadu having an aerial extent of 4536.51 sq.km in Tamil Nadu State and 220.119 sq.km in Union Territory of Puducherry. Geographically the basin is located between N.Latitude 11° 50’ 00” - 12° 31’ 51” and E.Longitude 79° 08’ 06” - 80° 08’ 42”and covered in Survey of India Topographic Sheets 57 P3, P4, P7, P8, P11, P12, P15, P16, 58 M5, M9, M12 and 66 D3&4 on 1:50000 scale.The basin is bounded by and Bay of Bengal in the east, Palar basin in the north and Pennaiyar basin in the south and west **(Plate VAR-01B).** The Varahanadhi basin spread over parts of Villupuram, Thiruvannamalai, Kancheepuram and Cuddalore districts of Tamil Nadu and Union Territory of Puducherry. The important towns/rural towns located in the basin are Gingee, Tindivanam, Olakkur, Mailam, Marakkanam, Vanur and Puducherry (Union Territory).

The basin is endowed with a good network of roads and railway lines **(Plate VAR-02).**The towns and villages are well connected with district roads, State highways and National highways. The National Highway-NH 45 is passing through Tindivanam town to southern districts of Tamil Nadu. Chennai to Tiruchirappalli broad gauge railway line passing through this basin.

There are 24 blocks with 13 taluks in this basin of which, only3 blocks are covered in full and the remaining blocks are partly covered **(Plate VAR-03).** In Varahanadhi basin 60 firkas partially/fully covered and the details of districts, taluks and blocks fall in the basin are furnished in **Table 2.1**and the sub basin wise aerial extent of the administrative units are given in **Table 2.2**.The basin encompasses a total of 1108 villages, out of which 782 villages are inVillupuram district, 230 villages in Kancheepuram district, 92 villages in Tiruvannamalai district and 4 villages in Cuddalore district (Appendix 2 of Volume II)

Table 2.1 Districts, Taluks and Blocks in Varahanadhi River Basin

<table>
<tr><th>State</th><th>District</th><th>Taluk</th><th>Block</th></tr>
<tr><td>Puduchery</td><td>1. Puduchery</td><td>1. Puduchery</td><td>1. Puduchery</td></tr>
<tr><td rowspan="4">Tamil Nadu</td><td>1. Cuddalore</td><td>1. Cuddalore</td><td>1. Cuddalore</td></tr>
<tr><td rowspan="3">2. Kancheepuram</td><td rowspan="2">1. Cheyyur</td><td>1. Chitamur</td></tr>
<tr><td>2. Lattur</td></tr>
<tr><td>2. Madurantakam</td><td>1. Maduranthagam</td></tr>
</table>

State	District	Taluk	Block
			2. Acharapakkam
	3. Tiruvannamalai	1. Kalasapakkam	1. Kalasapakkam
		2. Polur	2. Chetpet
		3. Tiruvannamalai	1. Turinjapuram
			2. Kilpennatur
		4. Vandavasi	1. Vandavasi
			2. Pernamallur
			3. Thellar
	4. Villupuram	1. Vikravandi	1. Vikravandi
			2. Kanai
			3. Kandamangalam
		2. Gingee	1. Gingee
			2. Melmalaiyanur
			3. Vallam
		3. Tindivanam	1. Mailam
			2. Marakkanam
			3. Olakkur
		4. Tirukkovilur	1. Mugaiyur
		5. Vanur	1. Vanur
		6. Viluppuram	1. Kannai
			2. Koliyanur
			Kandamangalam

Table 2.2: SUB BASIN WISE ADMINISTRATIVE DETAILS (ACCORDING TO FLOW PATTERN)

Sl. No	Sub Basin Name	Sub Basin Area Sq.Km.	District Name	District Area in Sq.Km.	Taluk Name	Taluk Area in Sq.Km.	Block Name	Block Area in Sq.Km.
1	Nalla-vur	800.973	Puduchery	12.196	Puduchery	12.196	Puduchery	12.196
			Villupuram	788.777	Tindivanam	442.087	Mailam	108.921
							Marakkanam	297.728
							Olakkur	35.439
					Vanur	346.689	Vanur	346.689
		Total		**800.973**		**800.973**		**800.973**
		Total in Tamil Nadu		**788.777**		**788.777**		**788.777**
2	Ongur	1274.731	Kancheepuram	753.810	Cheyyur	467.956	Chitamur	325.302
							Lattur	142.654
					Maduranthagam	285.854	Acharapakkam	187.59
							Maduranthagam	98.265

Sl. No	Sub Basin Name	Sub Basin Area Sq.Km.	District Name	District Area in Sq.Km.	Taluk Name	Taluk Area in Sq.Km.	Block Name	Block Area in Sq.Km.
			Tiruvanna-malai	154.349	Vandavasi	154.349	Thellar	117.464
							Vandavasi	36.886
			Villupuram	366.571	Gingee	1.401	Vallam	1.401
					Tindivanam	365.170	Mailam	0.192
							Marakka-nam	113.089
							Olakkur	251.889
		Total		**1274.731**		**1274.731**		**1274.731**
3	Varaha-nadhi	2473.003	Puduchery	**198.291**	Puduchery	**198.291**	Puduchery	**198.291**
			Cuddalore	13.809	Cuddalore	13.809	Cuddalore	13.809
			Tiruvanna-malai	327.052	Kalasa-pakkam	2.818	Kalasap-akkam	2.818
					Polur	14.606	Chetpet	14.606
					Tiruvanna malai	171.118	Turinja-puram	82.071
							Kilpenna-thur	89.047
					Vandavasi	138.510	Pernamallur	49.581
							Thellar	88.93
			Villupuram	2131.857	Gingee	1047.891	Gingee	383.664
							Melmalaiya nur	365.562
							Vallam	298.665
					Tindivanam	185.818	Mailam	179.711
							Olakkur	6.107
					Tirukovilur	66.491	Mugaiyur	66.491
					Vanur	115.136	Vanur	115.136
					Vikravandi	480.116	Kannai	150.368
							Kandamang alam	58.09
							Vikravandi	239.601
							Koliyanur	32.057
					Villupuram	236.406	Koliyanur	115.445
							Kannai	84.144
							Kandamang alam	36.816
		Total		**2671.009**		**2671.009**		**2671.009**
		Total in Tamil Nadu		**2472.718**		**2472.718**		**2472.718**

2.2 Physiography and Relief

A physiography map exhibiting the elevation contours, spot height and forest areas derived from Survey of India SRTM DEM and Toposheets are shown in **Plate VAR-04** and **Plate VAR-05** respectively**.**The right arm of Sankaraparani/VarahanadhiRiver originates from

MelmalaiyanurPeriyaEri and traverse towards south east upto the meeting point of Varahanadhi at north east of Turampundi. The left arm of Varahanadhi seems to be a small river originates in the Midapursonaimalai at an elevation of 485m above MSLsouth of Pakkamvillage. There are several hillocks having more than 350 m elevation above MSL and are noticed in the west, central and northwest and southwest part of the basin. Such hillocks arePakkammalai▲566m, Midapursonaimalai▲485m, Suralimalai▲535m, Elumalai ▲544m,Durgammalai ▲430m, Vilakkumalai ▲510m and Kannamalai ▲369 m. Pakkammalai reserved forest spread over these hillocks in the north western part of the basin.

Gengavaram reserved forest spread over the hillocks Konamalai▲456m, Matturmalai▲288m, Valasamalai▲276m and Konalurmalai ▲276mPurasonaimalai▲485m, Palapattumalai, ▲292m, Jambodimalai ▲329m and Konamalai▲249 m.

Muttakadu reserved forest located in the south west of Gingee town covered by hillocks such as Ettumalai▲299 m, Ukarimalai ▲302 m and Kusumalai▲349 m. The Siruvadi reserved forest located in the north west of Gingee town includes the hills of Durgamalai ▲319m and Rangaswamimalai ▲268 m.

Padipallam reserved forest located in south of Muttakadu reserved forest and in the right side of Gingee to Tiruvannamalai State highway road and spread over the hillocks Singidikolattumalai ▲431m, Redikolattumalai ▲384m and Ponnamudimalai ▲346m.

Kumaratattumalai ▲349m, Palappattumalai ▲292m, Jambodimalai ▲329m and Muttatturmalai ▲208m are also seen in this basin. The Achcharapakkam reserved forest spread over right side of NH-45 near Achcharapakka town. Badur, Rajapalayam and Nedunkunam reserved forests also seen in this basin.Konalurmalai ▲208 m is located in Tandavasamudram reserved forest and Kadayammalai ▲267 m located in Odayanattam reserved forest. The reserve forests such as Chengavaram, Karai, Ponnur, Turinjikadu, Adukkam, Badur, Rajapoalayam, Nedunkunam, Agaram, Kumalumpattu and Kurumpuram are also spread over in this basin. Other than hillocks almost the entire area is a plain terrain and the elevation is ranges from 10 m to 100 m above MSL. The general slope of the basin is towards east and southeast direction.

There are two swamps spread over in this basin on the northern and southern sides of Marakkanam. The Kaluveli (tank) swamp is a large lagoon having triangular shape. It is bounded by Marakkanam to Puduchery East Coast road on the eastern side, Brahmadesam to Kiliyanur road on the western side and Olundiyapattu to Pudupattuchavadi road on the southern and northern side by YeddeyantittuKaluveli. The Kaluveli tank is a major swampy area having its aerial extent of 72.40 sq.km located in the southern side of Marakkanam in Villupuram district.The river NallavurAr empty its water into this Kaluveli tank.It has a link with

Yeddeyantittu swamp on the north by a tidal creek of about 8 km in length which in turn opens into the sea at about 9.7 km north of Marakkanam. This large swamp is full of water during rainy season and remains dry for the most part of the year and is covered by shrub/scrub including ordinary grass. During the dry period, it shows an appearance of arid waste with patches of salt efflorescence.

The YeddeyantittuKaluveli located in the northern side of the Marakkanam having its aerial extent of 8.08 sq.km. OngurRiver empty its water into YeddeyantittuKaluveli. This Kaluveli gets back water of the sea as well as the surplus water of Kaluvelitank which gets water from Nallavur river. During monsoon periods, the excess water or flood waters of Nallavur and Ongur rivers flushed through these swamps and finally confluence with Bay of Bengal near Alamparai village. The Kaluveli swamp flows in the northeast direction. In this swampy area, water remains for about 4 to 5 months in a year. The whole basin area lies in the eastern part of Tamil Nadu.

2.3 Drainage

Three major rivers namely Ongur, Nallavur and Varahanadhi drain in this basin with individual catchment areas, flow independently. Sankaraparani/Varahanadhi river confluence with Bay of Bengal, the Ongur and Nallavur rivers flow into YedayantittuKaluveli.

NedungalAr, SaramAr and EdaiyalamAr are the tributories of Ongur river. KannalamOdai/AnnamangalamAr, TondiAr and PambaiAr, NariAr, AriyankuppamAr are the tributaries of Varahanadhi. Besides small to medium sizes of drainages drains water into tanks and rivers in this basin. All the rivers in this basin are seasonal.

The Buckingham canal from Andharapradesh used for navigation enters into this basin at west of Kodapattinam and endwith Yedayanthittu Kaluveli near Kadapakkamkuppam village. The total length of the Buckingham canal in this basin is 21.72 km.

A drainage map showing the rivers, drainages, tanks and reservoir is prepared from Survey of India toposheets on 1:50000 scale and shown in **Plate VAR-06.** Based on the physiographic and catchment areas of the major rivers, the Varahanadhi basin is sub divided into three sub basins namely Varahanadhi, Nallavur, and Ongur using Remote Sensing and GIS technologies on 1:50000 scale **(Plate VAR-07).**

2.3.1 Varahanadhi sub basin

Varahanadhi is the largest sub basin among the three sub basin having the geographical area of 2473.003 sq.km. The Puduchery U.T area covered by 207.923 sq.km in this sub basin. The main river Sankaraparani or Varahanadhi originates from MelmalaiyanurPeriyaEri and traverse through Sirukadambur, Gingee and Villiyanur. A small stream originates in MidapursonaiMalai at an altitude of 485 m called VarahaNadi traveling after 15.45 Km join with Sankaraparani main river at 1 Km north of Turampundi village and hence the river gets the name Sankaraparani or Varahanadhi. From Gingee onwards the river gets the name Gingeeriver or Varahanadhi river uptoVilliyanur and after that the river is called as ChunnambuAr upto the confluence point with Bay of Bengal at ChinnaVirampattinam.

Another tributary in the name of Pambaiyar originates from the surplus water of Dalavanur tank, draining through Vikiravandi carrying the name Varahanadhi and join the right side of Gingee river at west of Elaiyandapattu. The total length of this river is 29.47 km.

Tondi river an another tributary of Sankaraparani/Varahanadhi river originates from MelOlakkur tank and runs more or less parallel to the Varahanadhi from Vallam village and empties in Vidur reservoir near Vidur village in Tindivanam taluk. Total length of the river is 34.13 km.

Near Vallam village, the main Varahanadhi river takes a turn towards the south. After Vidur reservoir, the river turns towards southeast and enters into Villupuram Taluk.

Pambai river another tributary of Varahanadhi passes through north of Villupuram town originates from the surplus water of Madavilagam and Angarayanattam tanks. Angarayanattam tank receiving water through Pillaiyarkoilodai from Villakumalai in Chengavaram reserved forest and Madavilagam gets water from PulanjiMalai and Adakkam reserved forest. The river gets water also from Pennaiyarriver through PambaiVaykkal. The off take point of PambaiVaykkal at Pennaiyar river is located near Emapper village. The length of PambaiVaykkal is 20.75 Km. Total length of the Pambai river upto confluence point near Kandiyankuppam with Varahanadhi is 46.55 Km.

Total length of the Sankaraparani/Varahanadhi river uptoVidur reservoir is 53.08 km and from Vidur reservoir to its confluence point, the length is 40.75 km. Hence the total length of the river is 93.83 Km. The river runs towards south upto Elaiyandapattu and turn Suttakanni then again turn into south and south east in Tamil Nadu and Puduchery States alternately and finally confluence with the Bay of Bengal near ChinnaVirampattinam with the name of Chunnambu river.

A surplus course from Annamangalam tank called as KannalamOdai join in the right side of the Varahanadhi river near southeast of Sittattur. The total length of the Kannalamodai is 5.9 Km. A tributary, NariAr originate from Sennalur tank and join with the main river Varahanadhi near Uranitangal after travelling 14.80 km.

A small river called AriyankuppamAr originates from the Usteri tank drains through Villiyanur town and confluence with Bay of Bengal in the south of Virampattinam village in Tamil Nadu after travelling 13.11 Km.

The last tributary of Varahanadhi river called as SellangaiVaikkal originates from Valavanur tank drains through Pallacherry and Palliveriyanur and after that the Odai carrying the name of KuduvaiyarOdai and join with Varahanadhi river at the east of Pudumettukuppam. The total length of this tributary is 23.68 km.

2.3.2 Nallavur Sub Basin

Nallavursub basin having an aerial extent of 788.777Sq.Km is the smallest sub basin among the three, located in between Varahanadhi and Ongur sub basins. In this sub basin 12.196 Sq.Kmarea is covered by Union Territory of Puduchery. At the starting point it has two arms. The right arm of KondamurRiveroriginates from the surplus course of Singanur tank near south west of Tindivanam town and the left arm originates from the surplus water of Tindivanam tank which received the surplus water from upper tanks. The two arms join together and form a river Kodamurnear Karanavur village at about 3 kmsouth of Tindivanam town and the river turns towards south.

Another drainage course, starting from surplus of more than 10 tanks located in east of Mailam town join on the right hand side of the river at about 1.71Km southeast of Sittamur village. After this, the Kondamurriver traverses in the eastern direction in between Arovapakkam and Kondamur.The main river takes its name NallavurAr after it crossing Nallavur village. The Nallavurriverempties into Kaluvelitank (swamp) after travelling a distance of 36.85 Km near Anappakkam village. The surplus water of this Kaluveli swamp finds its way to feed YedayantittuKaluveli tank (where Ongurriver also enters) near Marakkanam before confluence with the Bay of Bengal.

2.3.3 Ongur sub basin

The Ongur sub basin having an aerial extent of 1274.731 sq.km located in the north and north eastern side of the basin. NedungalAr originates near Kallatur and Kattivakkam from a surplus course from nearly 15upper reach tanks including Embalam, Nallur, Mudur, Oratti and Kalattur tanks. The total length of the river is 9.84 km.

SaramAr originates near Saram from the surplus course of Saram tank which receive water from nearly 15 tanks in the upper reach including Puttanandal, Dadapuram, Meladanur, Ammanapakkam, Vairapuram and Evallur. The left arm of Saram river called as NariyarOdai or MurungaiOdai originates near Murangai at an altitude of 40m MSL from surplus course of Olakkur, Murungai and Allur tanks and it joins the Saram river about 1.3 Km in the east of Karasangal village.

Saramriver and Nedungal river join together at 1 km in the northwestern of Ongur and from this point onwards the river is called as Ongur river. Another river Edaiyalam originates from the surplus course of Velangadu tank and confluence with Ongurriver at 0.75 km south of Attur village.As the physiographic landscape of the eastern side of the Ongur basin is towards north western direction, the Ongur river confluence with Yedayantittu which is located in Nallavur sub basin. The total length of the Ongur riverupto the confluence point with YedayantittuKaluveli is 24.16 km.

The man made Buckingham canal from Andhrapradesh used for navigation in yester years enters into this basin at west of Kodapattinam and end with Yedayanthittu Kaluveli near Kadapakkamkuppam village. The total length of the Buckingham canal in this sub basin is 21.72 km. The waters will run bidirectional based on the ocean current in Bay of Bengal.

2.4 Drainage Morphometry

Remote Sensing and GIS techniques are the proven efficient tools in delineating, updation on the drainage basin and morphometric analysis. The drainage basin analysis is important in any hydrological investigation like, assessment of water potential and its management. Various important hydrologic phenomena can be correlated with the physiographic characteristics of drainage basins such as, size, shape, slope, drainage density, size and length of the tributaries (Rastogi*et al*. 1976). In morphometric analysis, remote sensing data can be used in conjunction with conventional data for delineation of ridgelines, characterization, priority evaluation, problem identification, assessment of potentials and management needs, identification of erosion prone areas, evolving water conservation strategies, selection of sites for artificial recharge (Dutta *et al*. 2002). It is felt that the study will be useful to understand hydrological behavior of basin.

2.4.1 Linear Aspects of the Stream System

The results of the linear aspects of drainage network such as, stream order (Nu), bifurcation ratio (Rb), stream length (Lu) for Varahanadhi basin are presented in **Table 2.3**.

2.4.1.1 Stream Order (Nu)

From the drainage of basin analysis, stream orders are derived. The channel segment of the drainage has been ranked according to Strahler’s stream ordering system. According to Strahler (1964), the smallest fingertip tributaries are designated as order 1. Where two first order channels join, a channel segment of order 2 is formed where two of order 2 joins, a segment of order 3 is formed and so on. The trunk stream through which water and sediment passes is therefore, the stream segment of highest order.

The study area is a 4th order drainage basin **(Plate VAR-08).** The total number of 6266 streams was identified of which 4415 are 1st order streams, 1732 are 2nd order, 115 are 3rd order and 4 in 4th order stream. Drainage patterns of stream network of the basin have been observed, mainly dendritic type which indicates the homogeneity in texture. This pattern is characterized by a tree like or fernlike pattern **(Fig. 2.1)** with branches that intersect primarily at acute angles. Dendritic drainage pattern is noticed in Malayantangal, Nallapalayam, Pudur, Gengavaram and Devadanampettai.

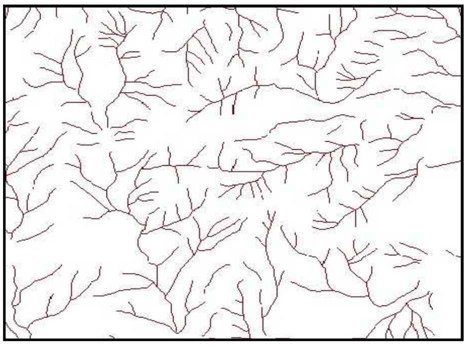


Fig. 2.1 Dendritic Drainage pattern in Varahanadhi Basin

In some parts of the basin, parallel pattern **(Fig. 2.2)**represent in and aroundNangattur, Muttattur, Nemur, Anantapuram and Senjikunnattur. A parallel drainage pattern consists of tributaries that flow nearly parallel to one another and all the tributaries join the main channel at approximately the same angle. Parallel drainage suggest that the area has a gentle, uniform slopes and with less resistant bed rock. In Varahandhi basin, the Sankaraparani and Tondi rivers running parallel uptoVidur reservoir. The Pambaiyarriver running parallel to Varahanadhi from Panchalam village to Vikravandi.

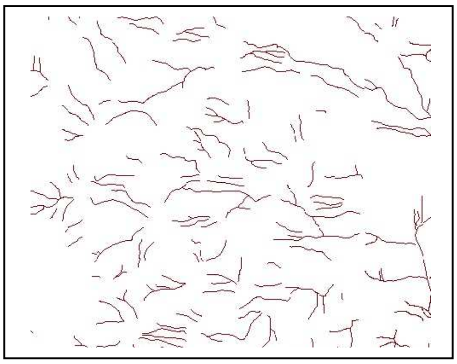


Fig. 2.2 Parallel Drainage pattern in Varahanadhi Basin

Radial pattern types **(Fig. 2.3)** noticed in and around Perumukkal, Munnur, Aranipur, Saram, Nallatur, Nalambur, Sevur and Tindivanamindicating that the topographical features are dipping, folded and highly jointed. A radial drainage pattern forms when water flows downward or outward from a hill or elevated area (Jensen 2006).

Fig. 2.3 Radial Drainage pattern in Varahanadhi Basin

The order wise total number of stream segment is known as the stream number. Horton's (1945) laws of stream numbers states that the number of stream segments of each order forms an inverse geometric sequence which when plotted against order, shows a linear relationship with small deviation from a straight line, for most of the drainage systems. The plot of logarithm of number of streams against stream order follows a straight line as proposed by Horton (**Fig.2.4)**. This means that the number of streams usually decreases in geometric progression as the stream order increases.

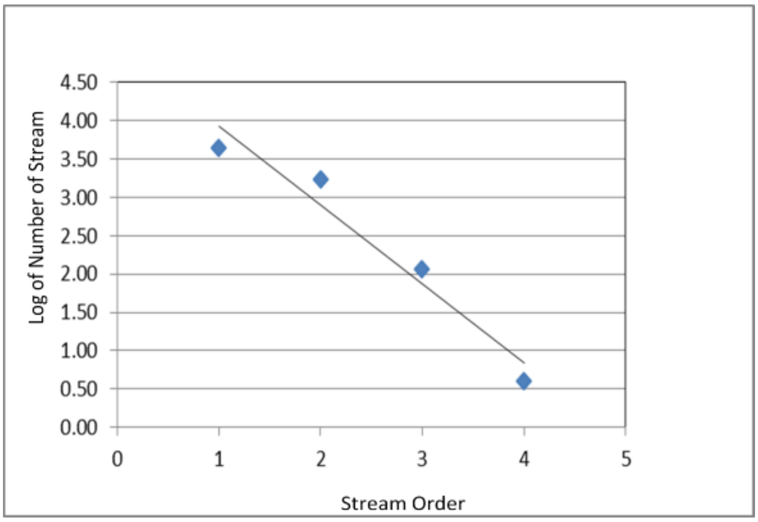


Fig. 2.4 Plots of number of streams Vs stream order

2.4.1.2 Bifurcation Ratio (Rb)

The term bifurcation ratio (Rb) is used to express the ratio of the number of streams of any given order to the number of streams in next higher order (Schumn 1956). Bifurcation ratios characteristically range between 3.0 and 5.0 for basins in which the geologic structures do not distort the drainage pattern (Strahler 1964). Strahler (1957) demonstrated that bifurcation ratio shows a small range of variation for different regions or for different environment dominates.The mean bifurcation ratio value is 15.45 for the basin (**Table 2.3**) which indicates that the geological structures are disturbing the drainage pattern.

Table 2.3 Linear aspects of the drainage network

Stream Order (u)	No. of Streams (Nu)	Total Length of Streams in Km (Lu)	Log (Nu)	Log (Lu)
1	4415	3016.74	3.64	3.48
2	1732	903.75	3.24	2.96
3	115	277.68	2.06	2.44
4	4	87.65	0.60	1.94
	Bifurcation ratio (Rb)			
	1st order /2nd order	2nd order/ 3rd order	3rd order/ 4th order	Mean Bifurcation ratio
	2.549	15.06	28.75	15.45

2.4.1.3 Stream Length (Lu)

Stream length is one of the most significant hydrological features of the basin. It reveals surface runoff characteristics of streams relatively smaller lengths and are characteristics of areas with larger slopes and finer textures. Longer streams are generally indicates the flatter gradients. Generally, the total length of stream segments is more in first order streams and decreases as the stream order increases. The number of streams of various orders in the basin is counted and their lengths from mouth to drainage divide are measured with the help of GIS software. The total stream length in all segments is 4285.85 km. Plot of the logarithm of stream length versus stream order **(Fig.2.5)** shows the linear pattern which indicates the homogenous roc material subjected to weathering and erosion characteristics of the basin.

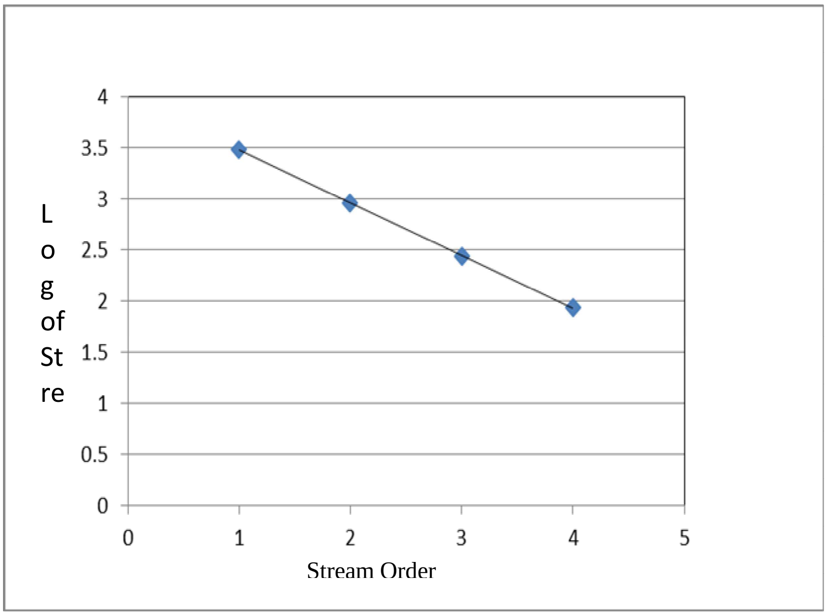


Fig. 2.5 Plots of stream length Vs stream order

2.4.1.4 Areal aspects of Drainage Basin

Area of a basin (A) and perimeter (P) are the important parameters in quantitative morphology. Perimeter is the length of the boundary of the basin which can be drawn 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. It is interesting that the maximum flood discharge per unit area is inversely related to size (Chorley *et al*. 1957). 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.**

Table 2.4 Results of morphometric analysis

Sl. No.	Aspect	Parameter	Unit	Value
1	Aerial	Area(Sq.km)	A	4536.51Sq.Km
2		Perimeter(km)	P	531.15 Km
3		Basin Length (km)	L_b(km)	94.64 Km
4		Stream Order	(u)	1,2,3,4
5		Stream Length of all order	L_u	4285.82 Km
6	Linear	Total number of stream segments in all order	N_u	6266
7		Total number of first order	N1	4415
8		Mean stream length (Km)	$Lsm=L_u/N_u$	0.68
9		Bifurcation Ratio	$R_b=N_u/(N_u+)1$	15.45
10		Basin relief	B_h	494
11	Relief	Relief Ratio	R_h	5.22
12		Ruggedness Number	Rn	464.36
13		Drainage density(km/km^2)	$D_d=L_u/A$	0.94 km/km^2
14		Stream frequency	$F_s=N_u/A$	1.38
15		Drainage texture	$R_t=N_u/P$	11.8
16		Circularity ratio	$Rc=4\Pi A/P^2$	0.2
17		Form factor ratio	$Rf=A/L_b^2$	0.51
18	Aerial	Constant channel maintenance	$C=1/D_d$	1.06
19		Elongation ratio	$R_e=2((\sqrt{(A/\Pi)})/L_b$	0.8
20		Texture raio	T=N1/P	8.31
21		Infiltration Number	If	1.3
22		Length of overland flow	Lg	0.47

2.4.1.5 Drainage Density (D)

Horton (1932) introduced the drainage density (D) as an important indicator of the linear scale of landform elements in stream-eroded topography. It is the ratio of total channel segment lengths cumulated for all orders within a basin, to the basin area, which is expressed in terms of km/sq km. The drainage density indicates the closeness of spacing of channels, thus, providing a quantitative measure of the average length of stream channel for the whole basin. It has been observed from drainage density measurements made over a wide range of geologic and climatic types, that a low drainage density is more likely to occur in regions which aremore resistant to highly permeable subsoil material under dense vegetative cover, and where relief is low. High drainage density is the resultant of weak or impermeable subsurface material, sparse vegetation and mountainous relief. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture (Strahaler 1964).

The drainage density (D) of the basin is 0.94 km/sq km indicating low drainage density. It is suggested that the low drainage density indicates the basin has highly permeable subsoil and thick vegetative cover (Nag 1998). The type of rock also affects the drainage density. Generally, lower values of drainage density tend to occur in granite and gneiss. The rock types in the study area are Migmatite, Epidote Hornblende Gneiss and Biotite Gneiss. This corroborates the low drainage density observed in the drainage basin.

2.4.1.6 Stream Frequency (Fs)

Stream frequency (Fs) is the total number of stream segments of all orders per unit area (Horton 1932). The stream frequency value of the basin is 1.38. The value of stream frequency (Fs) for the basin exhibit positive correlation with the drainage density value of the area indicating the increase in stream population with respect to increase in drainage density.

2.4.1.7 Texture Ratio (T)

Horton (1945) defined drainage texture is the total number of stream segments of all order in a basin per perimeter of the basin. It is important to geomorphology which means that the relative spacing of drainage lines. Drainage texture is based on the underlying lithology, infiltration capacity and relief aspect of the terrain. Smith (1950) has classified drainage texture into 5 different textures i.e., very coarse (<2), coarse (2 to 4), moderate (4 to 6), fine (6 to 8) and very fine (>8). More is the texture more will be dissection and leads more erosion. The texture ratio of the basin is 2.73 and categorized as coarse in nature.

2.4.1.8 Elongation Ratio (Re)

Schumm (1956) used an elongation ratio (Re) defined as the ratio of diameter of a circle of the same area as the basin to the maximum basin length. It is a very significant index in the analysis of basin shape which gives an idea about the hydrological character of a drainage basin. Values near to 1.0 are typical of regions of very low relief (Strahler 1964). Elongation ratio and Shape of basin:

<0.7	Elongated
0.8-0.7	Less elongated
0.9-0.8	Oval
>0.9	Circular

The value Re of the Varahanadhi basin is 0.8 which indicates the low relief of the terrain that is less elongated in shape.

2.4.1.9 Circularity Ratio (Rc)

Miller (1953) defined a dimensionless circularity ratio (Rc) as the ratio of basin area to the area of circle having the same perimeter as the basin. He described the basin of the circularity ratios range from 0.4 to 0.5 which indicates strongly elongated and highly permeable homogenous rocks. The circularity ratio value (0.2) of the basin corroborates the Miller's ranges which indicate that the basin is elongated in shape, low discharge of runoff and high permeability of the subsoil and also there is strong structural control on the drainage development. Therefore the structural control of drainage is probably responsible for the low values of circularity ratio.

2.4.1.10 Form Factor Ratio (Rf)

Quantitative expression of drainage basin outline form was made by Horton (1932) through a form factor ratio (Rf), which is the dimensionless ratio of basin area to the square of basin length. Basin shape may be indexed by simple dimensionless ratios of the basic measurements of area, perimeter and length (Singh 1997). The basin with high form factor, have high peak flows of shorter duration, whereas, elongated drainage basin with low form factors have lower peak flow of longer duration. The form factor value of the basin is 0.51 which indicate lower value of form factor and thus, represents less elongated shape. The less elongated basin with low form factor indicates that the basin will have a flatter peak of flow for longer duration. Flood flows of such less elongated basins are easier to manage than that of circular basin.

2.4.1.11 Infiltration Number (If)

The infiltration Number is defined as the product of Drainage Density (Dd) and drainage Frequency (Fs). The basin has the low infiltration number of ~ 1.3. The higher the infiltration number the lower will be the infiltration and consequently, higher will be run off. This leads to the development of higher drainage density. It gives an idea about the infiltration characteristics of the basin which reveals impermeable lithology and lower relief. Nearly 25% of the basin area underlined by alluvial plain thus it has a higher infiltration.

2.4.1.12 Ruggedness Number (Rn)

Ruggedness number is the product of maximum basin relief (H) and drainage density (Dd), where both parameters are in the same unit. An extreme high value of ruggedness number occurs when both variables are large and slope is steep (Strahler 1952). The value of ruggedness number in the basin is 464.36 (Schumm 1956).

2.4.1.13 Length of overland flow (Lg)

The Length of Overland Flow (Lg) is the length of water over the ground surface before it gets concentrated into definite stream channel (Horton 1945). Lg is one of the most important independent variables affecting hydrologic and physiographic development of drainage basins. The length of overland flow is approximately equal to the half of the reciprocal of drainage density. This factor is related inversely to the average slope of the channel and is quiet synonymous with the length of sheet flow to a large degree. Smaller the value of overland flow the quicker surface runoff will enter the streams represents well developed drainage network with higher slope. In a relatively homogeneous area, therefore less rainfall is required to contribute a significant volume of surface runoff to stream discharge when the value of overland flow is smaller than when it is large**.**

The Lg value of study area is 0.47, which represents long time flow in the basin. The length of overland flow bears an effective relationship with the drainage density and constant channel maintenance.More the value represents long time of flow in the basin. The alluvial plain parts of the basin have a high length of course. In the basin of the central part runoff is more but they have short course of flow.

2.4.1.14 Constant of Channel Maintenance (C)

This parameter indicates the requirement of units of watershed surface to bear one unit of channel length. Schumn (1956) has used the inverse of the drainage density having the dimension of length as a property termed constant of channel maintenance. The drainage basin having higher values of this parameter, there will be lower value of drainage density. This constant, in units of square feet per foot, has the dimension of length and therefore, increases in magnitude as the scale of the land-form unit increases.Especially, the constant C provides information on the number of square feet of watershed surface required to sustain one linear foot of stream. The value C of basin is 1.06. It means that on an average of 1.06sqft surface is needed in the basin for creation of one linear foot of the stream channel. Higher value of constant channel Maintenance reveals strong control of lithology with a surface of high permeability.

The drainage morphometric analysis of Varahanadhi basin reveals that dendritic, parallel and radial drainage patterns are exhibit. The number of streams decreasing while increasing in the drainage order. Drainage patterns are disturbed by the geological structures. The basin has low drainage density since the drainages are controlled by hard rock formation in the upper part of the basin. The texture ratio of the basin is 2.73 and categorized as coarse in nature which indicate that the basin has very good infiltration capacity with low relief and has very good potential zones. Based on the shape of the basin, Varhanadhi is a less elongated indicating low discharge of runoff and high permeability of the subsoil and will have a flatter peak of flow for longer duration. Flood flows of such less elongated basins are easier to manage.

2.5 Geology

Geology of an area defines the geo units, the rocks and its structure. It is important to understand the geology to carry out a detailed integrated study since the rock units in an area impacts the external and internal form of a land. Hence, prior to the detailed study of the basin, Geology is need to be understood. Geology map **(Plate VAR-09)** of the basin is prepared by digitizing the district geology maps of Cuddalore, Thiruvannalamai, Villupuram and Kancheepuram published by Geological Survey of India and 72 borehole lithologs **(Table 2.5A)** collected from SG&SWRDC as well as field knowledge have been incorporated.

The Varahanadhi basin is composed of hard (Igneous and Metamorphic) and soft (Sedimentary) rocks. The northern, southern and western parts of the basin are made of hard rocks of older age dated from 2500 to 570 Million Annum (Ma). The sedimentary rocks aged from 360 Ma to the recent occupies the eastern portion of the basin. The stratigraphic and lithologic units of the rocks in the basin are shown in the figure and the same is detailed as follows.

Bore hole data: - the deepest boreholes are 150 m and are drilled through sedimentary formations whereas the maximum depth of boreholes in hard rock is 60m and many of the logs reach up to the fresh rock. The borehole logs are used to prepare fence diagram for the basin. Fence Diagram is the geologic cross section in a network form to understand the changes in the geology. To make a fence diagram for the study, 12 bore hole logs are selected among 72 logs in the study area. The 12 bore wells are selected based on their location, crosscutting diverse lithology. Among the 12 bore wells, 9 are drilled through hard rock and the rest are on soft rock. The locations of the bore holes are shown in **Plate VAR-10**. The fence diagram prepared with the bore hole logs penetrated through hard rock is shown in **Plate VAR- 11A** and the view of the fence diagram on hard rock has changed and shown in **Plate VAR-11B**. Cross section of the lithology connecting 3 boreholes of hard rock and another cross section cutting two different litho units are shown in **Plate VAR-12**.

Some of the borehole data used for the study are plotted as lithologs using dedicated software and shown in **Plate VAR-13**.

Table 2.5A Borhole Lithology									
Well No	Well Type	District	Tahsil / Taluk	Block / Mandal	Village	Latitude	Longitude	Depth	Lithiology
HP31517	Bore Well	Villupuram	Villupuram	Kanai	Mambalapattu	11.95972	79.37778	3	Topsoil
								20	Gneiss weathered
								35	Partly Weathered Gneiss
								40	Jointed mica Gneiss
HP31517A	Bore Well	Villupuram	Villupuram	Kanai	Mambalapattu	11.95694	79.37611	2	Topsoil
								15	Gneiss weathered
								45	Gneiss fractured
								60	Gneiss hard
HP31518	Bore Well	Villupuram	Chenji	Vallam	Kilmampattu	12.18083	79.48167	1	Topsoil
								13	Gneiss highly weathered
								25	Gneiss weathered
								40	Gneiss fractured
HP31519	Bore Well	Villupuram	Tindivanam	Olakkur	Vairapuram	12.31111	79.66444	0.5	Topsoil
								8.5	Charnokite fractured
HP31520	Bore Well	Villupuram	Chenji	Gingee	Alampoondi	12.24750	79.33444	1.5	Topsoil
								10	Gneiss highly weathered
								25	Gneiss weathered
								40	Gneiss fractured
HP31521	Bore Well	Villupuram	Chenji	Vallam	Melolakkur	12.33750	79.48889	1.5	Topsoil
								35	Charnokite fractured
HP31522	Bore Well	Villupuram	Tindivanam	Mailam	Alagramam	12.16472	79.57306	1.5	Topsoil

Well No	Well Type	District	Tahsil / Taluk	Block / Mandal	Village	Latitude	Longitude	Depth	Lithiology
								38	Charnokite fractured
HP31523	Bore Well	Villupuram	Tindivanam	Marakkanam	Omandur	12.15917	79.69528	1.5	Topsoil
								10	Gneiss highly weathered
								20	Gneiss weathered
								40	Gneiss fractured
HP31524	Bore Well	Villupuram	Villupuram	Kanai	Sangeethamangalam	12.10972	79.40417	1	Topsoil
								4	Gneiss highly weathered
								24	Granite weathered
								35	Granite fractured
								40	Gneiss
HP31526	Bore Well	Villupuram	Chenji	Melmalaiyanur	Sathampadi	12.37361	79.35861	2	Topsoil
								18	Charnokite fractured
								43	Charnokite
HP31527	Bore Well	Villupuram	Chenji	Gingee	Thiruvathikunnam	12.15556	79.44444	2.5	Topsoil
								23	Charnokite fractured
								43	Charnokite
HP31528	Bore Well	Villupuram	Tindivanam	Olakkur	Avanipur	12.27722	79.81722	3	Topsoil
								12	Charnokite fractured
								43	Charnokite
HP31529	Bore Well	Villupuram	Tindivanam	Olakkur	Saram	12.27944	79.70167	1.5	Topsoil

Well No	Well Type	District	Tahsil / Taluk	Block / Mandal	Village	Latitude	Longitude	Depth	Lithiology
								27	Charnokite fractured
								43	Charnokite
HP31530	Bore Well	Villupuram	Vanoor	Vanur	Kiliyanur	12.10583	79.74361	1.5	Topsoil
								19	Charnokite fractured
								43	Charnokite
HP31531	Bore Well	Villupuram	Villupuram	Vikkiravandi	Esalam	12.11139	79.50361	2	Topsoil
								6	Gneiss highly weathered
								9	Gneiss weathered
								32	Gneiss weathered/fractur ed
								43	Gneiss
HP31532	Bore Well	Villupuram	Villupuram	Koliyanur	Kilperumpakka m	11.94306	79.50750	8	Clay with interbeds of sand
								30	Charnokite fractured
								50	Charnokite
HP31533	Bore Well	Villupuram	Villupuram	Kanai	Athanurvinaya gapuram	12.00583	79.45250	3	Topsoil
								12	Gneiss highly weathered
								18	Gneiss weathered
								32	Gneiss fractured
								43	Gneiss hard

Well No	Well Type	District	Tahsil / Taluk	Block / Mandal	Village	Latitude	Longitude	Depth	Lithiology
HP31555	Bore Well	Villupuram	Vanoor	Vanur	Bommayapala yam	11.99167	79.85000	12	Laterite verigated / wuggy
								45	Sandstone
								46	Sandstone
HP31556	Bore Well	Villupuram	Villupuram	Kandamangalam	Kanda-mangalam	11.91389	79.68889	3	Topsoil
								21	Sand
								30	Clay
								45	Sand
								51	Clay
HP31561	Bore Well	Villupuram	Villupuram	Kandamangalam	Arpisam-palayam	11.89833	79.58417	16	Sand
								20	Clay
								25	Sand
								33	Clay
								42	Sand
								50	Sandstone
HP31563	Bore Well	Villupuram	Tindivanam	Marakkanam	Alappakkam	12.16056	79.92917	1	Topsoil
								12	sand Fine
								24	Clay
								36	Clay
								50	Sandstone
HP31564	Bore Well	Villupuram	Tindivanam	Marakkanam	Ekkiyakuppam	12.18389	79.96056	6	Fine Sand
								18	Fine -Medium Sand
								30	Sandstone
HP31565	Bore Well	Villupuram	Tindivanam	Marakkanam	Kandhadu	12.20583	79.91417	1	Topsoil
								6	Fine Sand

Well No	Well Type	District	Tahsil / Taluk	Block / Mandal	Village	Latitude	Longitude	Depth	Lithiology
								18	Very Coarse Sand
								24	Fine Sand
								50	Coarse Sand with Pebbles
HP31566	Bore Well	Villupuram	Tindivanam	Marakkanam	Nadukkuppam	12.21500	79.88222	1	Topsoil
								4	Fine Grained Sand
								12	Medium Coarse Sand
								18	Clay with interbeds of sand
								24	Coarse to Fine Sandstone
								30	Clay
								54	Coarse to Medium Sandatone
								56.6	Charnokite fractured
HP31567	Bore Well	Villupuram	Tindivanam	Marakkanam	Kaippani-kuppam	12.21778	79.98167	6	Fine Grained Sand
								18	Fine to Medium Sand
								24	Clay with interbeds of sand
								30	Medium to Coarse Sand
								33	Fine Grained sand
								44	Fine to Medium Sand

Well No	Well Type	District	Tahsil / Taluk	Block / Mandal	Village	Latitude	Longitude	Depth	Lithiology
								50	Very Coarse Sand
HP31568	Bore Well	Villupuram	Villupuram	Koliyanur	Valavanur	11.92972	79.58611	1	Topsoil
								42	Sandstone
								51	Sandstone
HP31569	Bore Well	Villupuram	Vanoor	Vanur	Thiruchitr-ambalam	12.00306	79.79861	15	Clay
								45	Clay with interbeds of sand
								60	Clay with interbeds of sand
								75	Sandstone
								80	Clay with interbeds of sand
								150	Sandstone
HP31570	Bore Well	Villupuram	Vanoor	Vanur	Kottakkarai	12.01111	79.79861	15	Clay
								40	Clay
								150	Sandstone
HP31571	Bore Well	Villupuram	Tindivanam	Marakkanam	Nesal	12.05833	79.81222	15	Topsoil
								25	Clay
								60	Calcarious Sand Stone
								65	Clay
								150	Calcarious Sandstone
HP31573	Bore Well	Villupuram	Vanoor	Vanur	Koluvari	12.05944	79.81222	5	Topsoil
								10	Sandstone
								15	Sandstone with Clay

Well No	Well Type	District	Tahsil / Taluk	Block / Mandal	Village	Latitude	Longitude	Depth	Lithiology
								20	Clay with interbeds of sand
								40	Clay
								55	Calcarious Sandstone
								90	Sandstone fractured
								100	Calcarious Sandstone
HP31574	Bore Well	Villupuram	Vanoor	Vanur	Kilputhu-ppattu	12.05000	79.87222	10	Topsoil with fine medium sand
								20	Clay with thin gravel layer
								40	Calcarious Sandstone
								50	Sandstone with pebbles
HP33050A	Tube Well	Villupuram	Tirukkoilur	Thirukoilur	T.Elram-pattu	12.39111	79.38667	2	Topsoil
								6	Granite highly weathered
								10	Gneiss weathered
								16	Jointed Granite Gneiss
								22	Hard jointed Granite Gneiss
								30	Pegmatites
								50	Hard is jointed Granite Gneiss
								60	Hard jointed Granite Gneiss

Well No	Well Type	District	Tahsil / Taluk	Block / Mandal	Village	Latitude	Longitude	Depth	Lithiology
INV - 31347	Tube Well	Villupuram	Villupuram	Kandamangalam	Rampakkam	11.96028	79.61083	1.5	Topsoil
								12	Sand
								21	Clayey sand
								30	Sand
								45	Sandstone
								60.5	Sandstone
								66	Clay mixed sandstone
INV - 31458	Bore Well	Villupuram	Villupuram	Vikkaravandi	Kayathur	12.01667	79.57528	3	Topsoil
								12	Clay with interbeds of sand
								24	Gneiss highly weathered
								36	Gneiss fractured
								45	Charnokite
								50	Charnokite fractured
MWS - 31595	Bore Well	Villupuram	Villupuram	Koliyanur	Asarankuppam	11.98722	79.45250	3	Topsoil
								15	Gneiss highly weathered
								23	Gneiss weathered
								34	Gneiss fractured
								50	Gneiss
MWS - 31596	Bore Well	Villupuram	Villupuram	Kanai	Viramur	12.01639	79.41833	2	Topsoil
								15	Gneiss highly weathered

Well No	Well Type	District	Tahsil / Taluk	Block / Mandal	Village	Latitude	Longitude	Depth	Lithiology
								22	Gneiss fractured
								43	gneiss less jointed
								50	Gneiss
MWS - 31597	Bore Well	Villupuram	Villupuram	Vikkravandi	Kottiyampundi	12.03417	79.50000	0.5	Topsoil
								12	Gneiss highly weathered
								31	Gneiss fractured
								50	Gneiss
MWS - 31598	Bore Well	Villupuram	Chenji	Gingee	Sirunampundi	12.20833	79.40778	0.5	Topsoil
								8	Gneiss weathered
								19	Gneiss fractured
								50	Gneiss fractured
MWS - 31599	Bore Well	Villupuram	Chenji	Vallam	Mel Kalavay	12.27972	79.43639	3	Topsoil
								12	Gneiss highly weathered
								19	Gneiss weathered
								38	Gneiss fractured
								50	Gneiss
MWS - 31600	Bore Well	Villupuram	Chenji	Vallam	Aviyur	12.30500	79.48556	1	Topsoil
								13	Gneiss weathered
								24	Gneiss fractured
								50	Gneiss
MWS - 31601	Bore Well	Villupuram	Villupuram	Kanai	Perumgalampundi	12.08111	79.40139	1	Topsoil

Well No	Well Type	District	Tahsil / Taluk	Block / Mandal	Village	Latitude	Longitude	Depth	Lithiology
								13	Gneiss highly weathered
								18	Gneiss weathered
								29	Gneiss fractured
								50	Gneiss
MWS - 31602	Bore Well	Villupuram	Villupuram	Kanai	Hanumanathapuram	12.05111	79.37972	0.5	Topsoil
								14	Gneiss highly weathered
								22	Gneiss weathered
								36	Gneiss fractured
								50	Gneiss
MWS - 31603	Bore Well	Villupuram	Villupuram	Vikkravandi	Vikkravandi	12.04000	79.54500	2.5	Top clayey soil
								14	Gneiss highly weathered
								36	Gneiss fractured
								50	gneiss less jointed
MWS - 31604	Bore Well	Villupuram	Chenji	Gingee	Semmedu	12.24111	79.28306	1	Topsoil
								9	Gneiss highly weathered
								17	Gneiss weathered
								32	Gneiss fractured
								48	gneiss less jointed
								50	Gneiss hard
MWS - 31605	Bore Well	Villupuram	Chenji	Melmalaiyanur	Sethavarai	12.16361	79.25583	0.5	Topsoil

Well No	Well Type	District	Tahsil / Taluk	Block / Mandal	Village	Latitude	Longitude	Depth	Lithiology
								8	Gneiss highly weathered
								24	Gneiss weathered
								33	gneiss jointed
								50	Gneiss fractured
MWS - 31606	Bore Well	Villupuram	Chenji	Gingee	Periyamur	12.20167	79.44361	2.5	Topsoil
								14	Gneiss highly weathered
								22	Gneiss weathered
								38	Gneiss fractured
								50	Gneiss less jointed
MWS - 31607	Bore Well	Villupuram	Villupuram	Kanai	Karungalipattu	11.94694	79.39472	3	Topsoil
								18	Gneiss weathered
								40	Gneiss fractured
								50	gneiss less jointed
MWS - 31610	Bore Well	Villupuram	Chenji	Melmalaiyanur	Kappalambadi	12.37306	79.27417	1.5	Topsoil
								12	Gneiss highly weathered
								26	Gneiss weathered
								36	Gneiss fractured
								50	Gneiss highly weathered
MWS - 31611	Bore Well	Villupuram	Chenji	Melmalaiyanur	Sevalapurai	12.28806	79.35778	3.5	Topsoil

Well No	Well Type	District	Tahsil / Taluk	Block / Mandal	Village	Latitude	Longitude	Depth	Lithiology
								16	Gneiss highly weathered
								28	Gneiss weathered
								39	Gneiss fractured
								50	gneiss jointed
MWS - 31612	Bore Well	Villupuram	Chenji	Vallam	Illodu	12.31750	79.42417	1	Topsoil
								12	Gneiss weathered
								26	Gneiss fractured
								50	Gneiss
MWS - 31613	Bore Well	Villupuram	Tindivanam	Mailam	Kollar	12.24639	79.59500	2	Topsoil
								11	Gneiss highly weathered
								19	Gneiss weathered
								32	Gneiss fractured
								44	Gneiss less jointed
								50	Gneiss
MWS - 31614	Bore Well	Villupuram	Tindivanam	Mailam	Veliyanur	12.12250	79.65056	1	Topsoil
								9	Gneiss highly weathered
								18	Gneiss weathered
								35	Gneiss fractured
								50	Gneiss
MWS - 31615	Bore Well	Villupuram	Tindivanam	Marakkanam	Vada Alapakkam	12.23028	79.67000	1	Topsoil

Well No	Well Type	District	Tahsil / Taluk	Block / Mandal	Village	Latitude	Longitude	Depth	Lithiology
								7	Gneiss highly weathered
								12	Gneiss weathered
								24	Gneiss fractured
								32	Gneiss less jointed
								50	Gneiss hard
MWS - 31622	Bore Well	Villupuram	Tindivanam	Marakkanam	Vannipper	12.18417	79.79056	1.5	Topsoil
								7	Charnokite weathered
								28	Charnokite fractured
								41	Charnokite less jointed
								50	Charnokite
MWS - 31623	Bore Well	Villupuram	Tindivanam	Olakkur	Andappattu	12.25806	79.76000	1.5	Topsoil
								10	Charnokite weathered
								22	Charnokite jointed
								46	Charnokite less jointecd
								50	Charnokite
MWS - 31624	Bore Well	Villupuram	Tindivanam	Olakkur	Kambur	12.30889	79.77167	1.5	Topsoil
								12	Charnokite weathered

Well No	Well Type	District	Tahsil / Taluk	Block / Mandal	Village	Latitude	Longitude	Depth	Lithiology
								25	Charnokite fractured
								42	Charnokite jointed
								50	Charnokite
MWS - 31625	Tube Well	Villupuram	Vanoor	Vanur	Katrambakkam	12.05500	79.75167	4	Topsoil
								18	Sandy Clay
								32	Sandstone
								54	Sand
								78	Sandstone
								100	Sandstone
MWS - 31626	Bore Well	Villupuram	Tindivanam	Olakkur	Vadampundi	12.30528	79.61472	1.5	Topsoil
								8	Charnokite weathered
								27	Charnokite fractured
								39	Charnokite fractured
								50	Charnokite
MWS - 31627	Bore Well	Villupuram	Chenji	Melmalaiyanur	Mel Karanai	12.39056	79.38472	1.5	Topsoil
								9	Charnokite weathered
								20	Charnokite fractured
								37	Charnokite jointed

Well No	Well Type	District	Tahsil / Taluk	Block / Mandal	Village	Latitude	Longitude	Depth	Lithiology
								50	Charnokite
MWS -31594	Bore Well	Villupuram	Kallakurichi	Thiyagadurgam	Chithathur	12.18417	79.79056	1.5	Topsoil
								8	Gneiss weathered
								35	Gneiss fractured
								50	Gneiss
PZ12180379 5753	Bore Well	Kancheepur am	Cheyyur	Chittamur	Vedal	12.30000	79.96667	3	Topsoil
								13	high weath grant gneiss
								24	well jntd grant gneiss
								35	Fractured grantic gneiss
PZ12181879 5408	Bore Well	Kancheepur am	Cheyyur	Chittamur	Puthirankottai	12.30833	79.89722	1.5	Red soil
								6	Highly weathered sandy soil
								9	Highly weathered charnokite
								14	Weathered charnokite
								33	Jointed charnokite
								40	Less jointed charnokite
PZ12205279 5138	Bore Well	Kancheepur am	Cheyyur	Chittamur	Kayappakkam	12.34583	79.86111	3	Topsoil
								12	High weath grant gneiss

Well No	Well Type	District	Tahsil / Taluk	Block / Mandal	Village	Latitude	Longitude	Depth	Lithiology
								27	Well jntd grantic gneiss
								30	Fractured grantic gneiss
PZ122131795703	Bore Well	Kancheepuram	Madhuranthagam	Madhuran-thagam	Salaiyur	12.35861	79.95083	3	Topsoil
								10.5	High weath grant gneiss
								24	Well jntd grant gneiss
								34	Well fract grant gneiss
								35	Fractured grantic gneiss
PZ122250794129	Bore Well	Kancheepuram	Madhuranthagam	Acharapakkam	Orathi	12.38056	79.69139	1.4	Topsoil
								7.5	High weathered charnokite
								21.5	Weathered charnokite
								40	Part weath jntd char with peg
PZ122331800033	Bore Well	Kancheepuram	Cheyyur	Lattur	Sengattur	12.38889	80.00833	3.5	Topsoil
								14	Highly weathered charnokite
								21	Well jointed charnokite
								32	Jointd & fract charnokite

Well No	Well Type	District	Tahsil / Taluk	Block / Mandal	Village	Latitude	Longitude	Depth	Lithiology
								33	fractured charnokite
PZ122420795707	Bore Well	Kancheepuram	Madhuranthagam	Madhuranthagam	Chittamur	12.40556	79.95194	2	Topsoil
								13	high weath grant gneiss
								28	jointed grantic gneiss
								40	fractured grantic gneiss
HP21515	Bore Well	Thiruvannamalai	Thiruvannamalai	Kilpennathur	Kilpennathur	12.24167	79.22917	2.9	Topsoil
								14	Charnockite
								39	Fresh Charnockite
HP21562	Bore Well	Thiruvannamalai	Chengam	Pudupalayam	Vasudevan-pattu	12.32083	79.93333	1.8	Topsoil
								13.6	Weathered Charnockite
								19.6	Jointed Charnockite
								40	Less jointed charnockite
								46	Fresh Charnockite
HP21565	Bore Well	Thiruvannamalai	Thiruvannamalai	Thurinjapuram	Mangalam	12.32778	79.17778	3	Topsoil
								20	Weathered Gr. Gn
								40	Jointed Gr.Gn
								46	Fresh Gr.Gn

Well No	Well Type	District	Tahsil / Taluk	Block / Mandal	Village	Latitude	Longitude	Depth	Lithiology
HP21566	Bore Well	Thiruvanna malai	Thiruvannamalai	Thurinjapuram	Poyyandal	12.38333	79.19583	2.2	Topsoil
								8.2	Weathered granite gneiss
								38	Jointed Gr.gn
								48	Fresh Gr. Gn
HP21568	Bore Well	Thiruvanna malai	Thiruvannamalai	Kilpennathur	Keekkalur	12.30556	79.26944	1.8	Topsoil
								9.4	weathered granite gneiss
								18	Jointed Granite Gn
								37	Less Jointed Gr.Gn
HP21575	Bore Well	Thiruvanna malai	Vandavasi	Thellar	Thellar	12.40000	79.55417	2.8	Topsoil
								5.6	Weathered Gr.Gn
								21	Highly Jointed Gr.Gn
								33.5	Jointed Gr.Gn
								46	Less Jointed Gr.

2.5.1 Precambrian - Archaean Eon

This oldest group of rocks is dated back to 2500 Million Annum (Ma) and is of Precambrian Eon. Arachean groups are oldest rock types in the geologic time scale **(Table 2.5B)** and comprisesof crystalline rocks. In the Varahanadhi basin the Archaean charnockite and migmatite complexes are found to be the basement formation.

The charnockite complex constitutes charnockites, pyroxene granulite, Quartz feldspathic granulite and quartz- magnetite granulite. The charnockites cover most part of the study area and it is spread widely in Nallavur and Ongur sub basins comparatively. The pyroxene granulite considered to represent mafic volcanic whereas the Quartz feldspathic granulite and quartz- magnetite granulite represents acid volcanism and volcanic exhalation.

The term migmatite represents any rock of mixed appearance, being an intimate mixture of granite and older rock, specifically from intense metamorphism which partially melts the rock, causing it to re-crystallize in a state intermediate between igneous and metamorphic. Hence, the above mentioned charnockites have undergone migmatisation and resulted in migmatised charnockite, Gingee granite (2250 Ma) and biotite gneiss, epidote hornblende gneiss and granitoid gneiss. Most of the Varahanadhi subbasin is covered by this complex rock group.

2.5.2 Precambrian - Proterozoic Rocks

During the late Proterozoic, the dykes, quartz veins and pegmatites are intruded in the Archaean group of rocks. Most of the intrusions are minor and are not possible to be shown on map. These intrusions are dated back to 570 Ma.

This is followed by an unconformity between Precambrian and Phanerozoic rocks.

2.5.3 Phanerozoic Eon

2.5.3.1 Paleozoic Era

Unconformity represents gaps in the geological record, periods of time that are not presented by any rock. Unconformity in the study area is identified by conglomerates (showing erosion) occurred in Cambrian, Ordovician, Silurian and Devonian periods of Paleozoic era.

After the unconformity, the deposition of sandstone belong to Lower Gondwana stage, carboniferous to Permian period (245 – 360 Ma) is recorded. In the study area, the sandstone and conglomerate occur as small patch at north of Ongursubbasin near Orathi.

2.5.3.2 Mesozoic Era - Upper Cretaceous period

The Mesozoic, upper cretaceous rocks representing Ariyalur group are made of argillaceous sandstone, shelly limestone, calcareous sandstone, clay sandy clay and siltstone. These are divided into lower Vanur formations and upper Nesal formations (Sundaram, 1980). Vanur sandstone is fossiliferous and fragments of lamellibranches are seen variably.

The upper cretaceous rocks occur in alternate sequences, parallel to the coast at south of Kaluveli.

2.5.3.3 Cenozoic Era

Tertiary period - Paleocene sub period (65 -23.7 Ma)

The Palaeocene rocks of Varahanadhi show Cuddalore, Manaveli and Karasur formations. Comparatively, the Cuddalore formations covers a large area along the coast, exposing the sandstone. The Manaveli formation having clay and sandstone is found at south of Kaluveli. The Karasur formation comprises of Limestone intercalated with calcareous shale is distributed at south of Kaluveli and shows NE-SW trending.

Tertiary period - Neogene sub period (23.7 - 1.6Ma)

Laterites are of rusty red colored, high iron oxide containing soil or rock. They are rich in iron and aluminum. In the study area, laterite is found near Pondicherry and it has low level of bauxite (an ore of aluminum).

Quaternary period (1.6 Ma - recent)

These quaternary formations are not grouped lithostratigraphically but are classified genetically into fluvial, marine and eolian in origin. The alluvial clay and sand are deposited along west of Pondicherry and along the coast of Varahanadhi sub basin.

The Thiruvakkarai wood fossil park is a notified National Geo-heritage Monument located in Villupuram district within the Varahanadhi basin. The wood fossils are dated to 20 Ma and are interpreted as transported through flood to the location before they are petrified. Photograph of a petrified wood taken during one of the field visits to the basin is shown in **Figure 2.6**.

2.5.4 Geological Impact on Water Resources

The groundwater occurrence in any area is influenced by geology of the area. The origin of the geological formations, degree of weathering, orientation affects the groundwater potential as well as the quality of the same.

In the Varahanadhi basin, the groundwater occurs in unconfined condition i.e. the water table pressure is equal to the atmospheric pressure. The weathered and fractured portion of the hard rocks of Archaean and Proterozoic Eon forms the unconfined aquifer in the Northern, western and central portion of the basin whereas the pore spaces in the sedimentary rocks viz. limestone, sandstone and shale forms the aquifer system in southern and eastern portion.

Fig 2.6 Photograph of a petrified wood

YOUNGER ↑

OLD

Table 2.5B Stratigraphy and Geological Time scale

EON	ERA	PERIOD / SUBPERIOD		STRATIGRAPHY		LITHOLOGY
Phanerozoic	Cenozoic	Quaternary				Alluvium and soil
		Tertiary	Neogene			Laterite
			Paleocene		Cuddalore formation	Sandstone
					Manaveli formation	Clay and sandstone
					Karasur formation	Limestone and calcareous shale
	Mesozoic	Upper cretaceous		Ariyalur Group	Nesal formation	Clay, shale, argillaceous sandstone with shell limestone or calcareous sandstone.
					Vanur formation	Argillaceous sandstone with shell limestone or calcareous sandstone.
Unconformity						
Phanerozoic	Paleozoic	Carboniferous to Permian		Lower Gondwana		Sandstone and conglomerate (basal)
Unconformity						
Precambrian	Proterozoic					Basic dykes, Quartz vein, Pegmatite
	Archaean			Migmatite complex		Biotite Gneiss Epidote Hornblende Gneiss Granitoid Gneiss Gingee granite (migmatite) Migmatite -Charnockite
				Charnockite group		Magnetite quartzite Granulite Pyroxene Granulite Quartzo feldspathic Granulite Charnockite.

2.6 Geological Structure - Lineaments

A lineament is a linear feature on a landscape which is an expression of the underlying geological structure such as fractures, fault etc. Typically a lineament will comprise a fault-aligned valley, a series of fault or fold-aligned hills, a straight coastline or indeed a combination of these features.Study of the lineaments in an area is vital as such structures are the possible conduits for transportation of groundwater, suitable sites for groundwater exploration and artificial recharge structure development as well.

Aerial photographs and satellite image of LISS III acquired on 30th August 2015 **(Plate 14)** were analysed in order to identify the linear features of the area. Mirror stereoscope is being used to study the aerial photographs. After processing the satellite image, lineaments can be identified by naked eye however a good experience in the field is necessary. By combining the results that are obtained from aerial photo and satellite image study, the map on geological structures of Varahanadhi Basin is prepared and displayed in **Plate 15A**.

The lineaments map show that most of the linear features are NW-SE trending, some are NE-SW while very few are NNW-SSE direction. As the direction of the groundwater flow is towards east and south east, the orientation of the lineaments does not affect the groundwater flow. This in turn depicts that the NW-SE lineaments does not hold groundwater and may not be a probable locations for groundwater exploration. Whereas the NE-SW trending lineaments fall across the groundwater flow. However the groundwater gradient may not show significant change, the lineaments itself may act as a good aquifer and holds a substantial amount of water. This makes such area desirable for groundwater prospecting.

2.6.1 Geology and lineament

On comparing the lineaments in the area with its geology **(Plate 15B)**, it is understood thatdensity of the lineaments and the intensity of occurrence of the intersection points is more in hard rock region when compared with the sedimentary rocks. This is attributed to the fact that the hard rocks of the region are subjected to many structural activities like faults and fractures. This in turn increases the secondary porosity of the unconfined aquifer of hard rock region and thus the storativity increases. Hard rocks in such region may exhibit more groundwater potential.

The sandstone located around Kaluveli swamp shows high level of lineaments and intersections. This increases the storativity of the unconfined aquifers of sedimentary rocks. However the other sedimentary rocks show lineaments, they are subdued in many places because of the thickness of sedimentary deposits. Anyhow this will neither affect nor benefit the groundwater potential zones in sedimentary rock region.

2.7 Geomorphology

The study of the land / landforms constitutes Geomorphology which deals with the origin and morphological characteristics of the surface of the earth's crust.

Mapping any terrain requires good understanding of the Geomorphology. It forms the basic input for understanding the basic information on land and water resources. It plays vital role in the disciplines like hydrology, groundwater prospecting, in the field of mineral, oil and natural gas explorations, environmental studies, mitigation of natural disasters etc.

Landforms develop through the combined influence of exogenous and endogenous processes. Climate has a pronounced effect on the development of landforms. Aerial photos and satellite Imageries provide the best means of identifying landforms and processes. Landforms of various genetic type are identified on the Satellite / aerial photos based on the different recognition elements **(Plate -16A).** But a thorough knowledge of the various genetic aspects of landforms and experience in identifying and the landforms on the aerial photo or satellite imagery or in the field is a must.

Geomorphically, 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.

Based on the genesis, the land forms are broadly classified in to Structural, Denudational, Fluvial, Aeolian and marine origin.

In the Structural origin, geological processes are operational. In Denudational origin, weathering and deposition are operational and are prevalent in the Central plains and Eastern Ghats region. Aeolian origin are the landforms formed due to wind action. Marine origin are as indicated by the term itself, the formations formed due to the constructive and destructive action of waves. These forms are observed in the coastal region of Tamil Nadu.

The synoptic view of satellite imagery facilitates better appreciation of the geomorphology of the Terrain and helps in mapping of different landforms and their assemblages.

Varahanadhi River basin falls in the Central and Eastern Coastal part of Tamil Nadu. Hence the landforms of Denudational and Coastal origin are noticed in the Varahanadhi Basin.

Geologically, the western and central part of the basin is occupied by hard rock formations and the geomorphic units were derived from the hard rock terrain only. These landforms vary from one rock type to the other, but the common feature of these rocks is the massive characteristic and homogeneity which is reflected in the morphology. Various forms of hill, such as structural hills, Denudational hills / Residual hills and Inselbergs found in this region.

Structural hills are the high or low relief hills which exhibit structures such as folds, faults, joints, ridges and escarpments. Whereas Residual hills are structure less hills which have been detached from the main ranges by the later stages of denudational process. Inselbergs are the remains of the original mountain mass which are now isolated surrounded by vast plain. Infiltration and groundwater recharge are very meagre and depends upon the weathering in such landforms. Whereas plateau regions and valley portions have more potential for groundwater than the ridges and hill slopes

Other Geomorphic units of hard rock terrain noticed in this basin are Pediment, shallow pediment, moderate pediment and deep pediments. Pediments are the eroded bedrock surface with thin veneer of soil located in close proximity with hills. Shallow, moderate and deep pediment are classified based on the thickness of overburden of weathered materials. These units will occur away from the mountains and the thickness of soil cover increases with weathered mantle and more so in areas of low relief bordering the streams or tanks. Ground water potential will be dependent upon the weathered thickness. The weathered thickness will be more in deep pediment / buried pediment when compared to the moderate and shallow pediments. The possibility of groundwater potential in deep pediment will be high when compared to the moderate and shallow pediment. In Varahanadhi basin, a patch of deep pediment is occurring in the southern border of the basin. The moderate pediment scattered throughout the hard rock terrain of the basin. A major part of the basin is moderate pediment zone and the groundwater potential will be good. However the shallow pediment occurs in the north eastern, central and south-western part of the basin and scope of groundwater exploration and recharge is relatively low when compared to the deep and moderate pediment.

The sedimentary landforms comprises fluvial landforms such as alluvial plain and flood plain, land form developed under sedimentary condition and coastal land forms. The alluvial plains and flood plains were formed due to river actions. The Alluvial plain is a land form produced by river action by depositing the alluvium when there is a change in the gradient. The smooth flat plain areas bordering the streams and rivers are favourable zone for groundwater targeting. The alluvial plain is noticed in the southern part of the basin in and around Villupuram, Valavanur, and Mundiyampakkam. Flood plains are formed when the river spills over on either banks of the river and dumps lot of sediments. Certain rivers show development of such flood plains only on one side of the banks which indicates the preferential shifting of the river in one direction. However the flood plains are noticed along either side of Varahanadhi river located north of Mundiyambakkam and along either side of Ongur River, located south of Toluppedu to north of Alattur. During the course of flood plain development river dumps coarser sand grains close to the river as heaps of sand bodies and owing to their more resistance to erosive action, these sand bodies stand out prominently in flood plain. Due to the inherent porosity, they form favourable zones of potable groundwater.

The landforms of sedimentary origin, depends upon its relative elevation factors and are classified as sedimentary low land, sedimentary plain and sedimentary high ground. These landforms are formed in Cretaceous, Tertiary and Quaternary age, and comprising laterite, sand and sandstone. These geomorphic units are considered as very good aquifers and suitable for groundwater exploration and recharge.

The coastal land forms are found in the eastern coastal side of the basin and they are Beach and Beach Ridges, Coastal plain, Coastal High ground, Lagoon / Back water, Mud flat, Swamp and Salt Flat/Pans.

Beach is the temporary veneer of rock debris ie the sands which accumulate along the coast. They are linear and may extend for hundreds of miles or may be patches. The beach ridges are the low linear or arcuate ridges located adjacent to the coast or in coastal plain. In Varahandhi basin beach and beach ridges are noticed in the eastern part of the basin and run up to 3/4th length of entire coastal length of the basin. To the west of the beach and beach ridges, nearly level coastal plain formed by marine action along the coast, mainly containing brackish water sediments. The relatively elevated coastal plain is called coastal high ground.

An elongated body of water lying parallel to the coast line and separated from the open sea by barrier islands are called lagoon. Lagoon is noticed in Varahanadhi basin in between South West of Cheyyur and north of Mudaliyarkuppam, south of Edayanthittu and west of Alappakam.

Mud Flat are nothing but the mud deposited in the back swamps and along tidal creeks. The lagoon area in the long run can be reduced to a mudflat. The Mud Flat are noticed in the Varahanadhi basin in north eastern direction of Chunampet.

Swamps are features of areas with very low relief which gets brackish water or water from sea as backwater. There are three such swamps are located in the coastal belt of this basin in eastern side. Swampy / backwater topography are seen in the north and north western side of Mudaliarkuppam village, in the southern side of Edayanthittu and north of Marakkanam, which locally called as EdayanthittuKazhuveli and the third one is located southwest of Alappakkam village. The latter is the biggest among the three and gets fresh water at the time of low tide season and gets sea water through Edayanthittukazhuveli. Nallavur River empties its flow in to this swamp before confluence with the sea.

Saltpan/saltflat is the deposition of salt in the waterbody by evaporation. In the Varahanadhi basin, the swamp near Marakkanam is associated with saltflat.

In general according to the geomorphic conditions prevailing in the basin, eastern sedimentary part is the only promising zone with regard to water resources, whereas the central and western part due to its hard rock origin, the scope for water resources depends upon the deformity of the formation only.

2.7.1 Geomorphology and lineament

The lineaments are compared with the geomorphology of the area and shown in **Plate-16B**.As similar to geology, the lineaments are more in landforms developed on hard rock regions compared to that of sedimentary rock areas. Most of the area with moderate pediments with considerable amount of weathered top layer in the central and western region of the study area are exhibiting lineaments.

Among the sedimentary landforms, the sedimentary high ground regions are highly dissected by lineaments and the intensity of intersections is also very high. As sedimentary rocks are naturally good aquifers, the presence of lineaments makes the locations most desirable for groundwater occurrence and prospecting.

The intersection points are striking about 135 revenue villages under Cheyyur, Gingee, Madurantakam, Vandavasi, Villupuram, Tirukovilur, Vanur, Vikiravandi and Tindivanam Taluks. The list of revenue villages with respective taluks is given in **Table 2.6.**

2.8 Land use

Land use of an area defines the physical pattern and engagement of the area and quantification of the same. To understand the land use of an area, remote sensing technique is of immense use since the method is time saving, cost effective and feasible to cover a vast area. In order to study the land use of an area of interest, vast field knowledge, as well as remote sensing data covering various field activities in the area are necessary. Processing and interpreting the satellite imageries of the study area is one of the best and ideal way to carry out land use study.

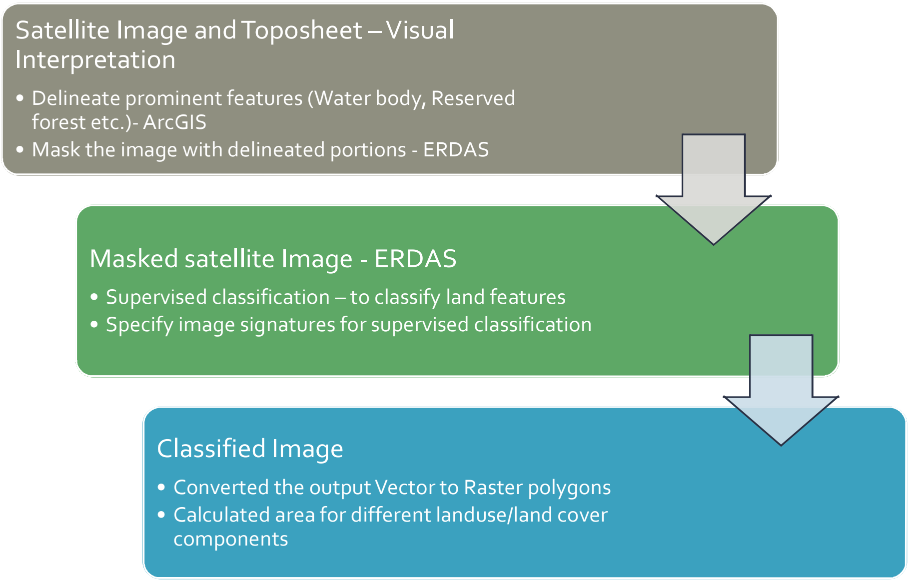
In the study of Varahanadhi basin, satellite image of LISS III acquired on 30th August 2015 is used. Visual interpretation and software aided supervised image classification technique are applied to understand and process the land use information of the basin **(Plate VAR -17).** In order to implement the techniques GIS tool and image processing tool are used. The steps involved in the image interpretation are shown in the following.

Table 2.6 Probable Location for further field investigation with regard to Groundwater Potential

Point of Intersection Cheyyur Taluk		Point of Intersection Gingee Taluk		Point of Intersection Vanur Taluk		Point of Intersection Tindivanam Taluk	
Village No	**Village name**	**Village No**	**Village name**	**Village No**	**Village name**	**Village No**	**Village name**
12	Chithamur	6	Gangavaram RF	6	Ulagapuram	0	Tindivanam
26	Puliyani	32	Vaduganpundi	19	Idaichcheri	17	Naduvanandal
35	Poongunam	43	Valatti	22	Kiliyanur	19	Nagavaram
51	Panaiyadivakkam	80	Sorattupperiyankuppam	23	Terkunam	21	Mavilangal(Kil)
63	Cheyyur	89	Odiyattur	25	Adanappattu	27	Kodiam
66	Sengattur	95	Padippallam	27	Perumbakkam	45	Rattanai
68	Perumbakkam	99	Tachchambattu	29	Murukkam	46	Peramandur
69	Pudupattu	104	Tandavasamudram	30	Kuttappakkam(Kil)	47	Mutttiyur
72	Iraniyasithi	109	Ponnankuppam	37	Mattur	50	Karanavur
114	Akkinambattu	110	Tuttippattu	45	Kattarambakkam	52	Pasiyar(Ten)
117	Atchivilagam	111	Chittarasur	46	Kenippattu	54	Aviyakuppam
118	Madayambakkam	114	Konalur	47	Semangalam	55	Pandamangalam
119	Pakkur	118	Karai	48	Ilavampattu	61	Kottamangalam(Se)
Madurantakam Taluk		120	Sittampundi	64	Tollamur	64	Periathachur
17	Dharmapuram	129	Kappai	66	Parangani	66	Perani
93	Kattugudalore	134	Kallalippattu	69	Vanur	68	Elay
96	Kilathivakkam	135	Dalavanur	**Vikravandi Taluk**		74	Kanniyam
98	Acharapakkam RF	137	Gudalur(Mel)	0	Gangavaram RF	75	Taludali
100	Nedungal	146	Sorattur	8	Kruvakshi	78	Kuralur
114	Vilangadu	147	Taiyur	17	Muttattur	79	Padirippuliyur
116	Thimmapuram	167	Annamangalam	26	Ealusempon	80	Palapattu

Point of Intersection Cheyyur Taluk		Point of Intersection Gingee Taluk	
Village No	**Village name**	**Village No**	**Village name**
181	Chinnavenmani	168	Amur
182	Nesapakkam	169	Devanur
184	Venmani	207	Karunguli
191	Neerpair	210	Pennagar
193	Budur	221	Ethanemeli
Villupuram Taluk		235	Kongarappattu
1	Ariyalur	240	Vailamur(Kil)
3	Palliyandur	**Vandavasi Taluk**	
4	Kedar	121	Korakkottai
5	Viramur	138	Embalam
13	Kangiyanur	195	Nallur
14	Malliyappattu		
52	Viluppuram		

Point of Intersection Vanur Taluk		Point of Intersection Tindivanam Taluk	
Village No	**Village name**	**Village No**	**Village name**
36	Ichchanguppam	81	Chendur
38	Narasinganur	91	Ariyankuppam
47	Kakkanur	105	Nerkunam(Ten)
51	Kasbakaranai	123	Vairapuram
54	Vembi	143	Kattalal
55	Tenper	145	Perumukkal
57	Enaviram	146	Palamukkal
63	V.Salai	147	Tenneri
65	Reddikuppam	151	Vannipper
66	Pilaiyarkuppam	185	Nerkunam(Vada)
67	Kayattur	203	Kulattur
68	Avadaiyarpattu	210	Marakkanam
73	Tumbur	220	Kesavanayakkenpalaiyam
74	Orattur	221	Nadukkuppam
87	Vakkur	**Tirukkovilur Taluk**	
104	Kodukkur	143	Karanai(Kasba)



Details on the landuse of Varahanadhi basin for 2015 are given in the following: the basin is dwelling for many people as the urban and rural settlements are spread all over the

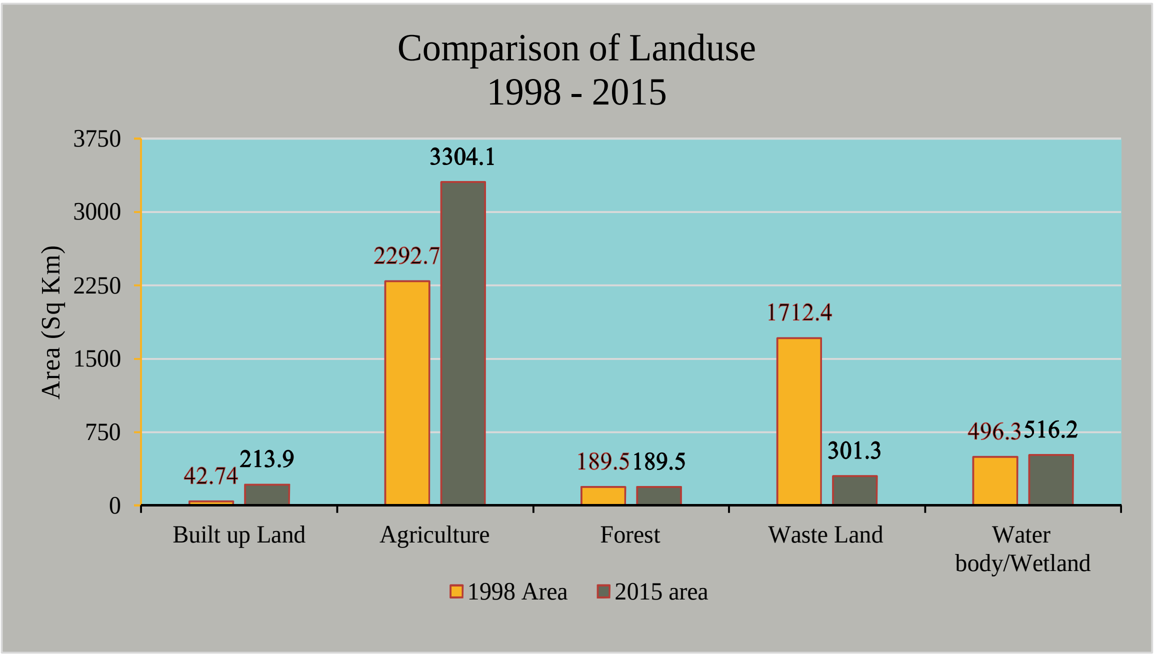
Table 2.7 Comparison of Landuse categories – 1998 and 2015

Sl. No.	Landuse Category			1998 Area (Sq Km)	2015 area (Sq Km)
	Ist Level	IInd Level	IIIrd Level		
1	Built up Land	Settlement	Urban	42.74	51.95
			Rural		161.20
			Industry		0.71
2	Quarry	Quarry	Quarry		11.29
3	Agriculture	Wet Crop / Irrigated Land	Paddy, Sugarcane, Banana and harvested Land	1687.48	1548.00
		Dry crop/Rainfed land	Cholam, Onion, Kambu and Groundnut	434.48	1467.58
		Plantation	Cashew plantation	94.5	31.50
		Groves	Groves - Coconut, Casuarina	76.21	257.06
4	Forest	Reserved forest/ hill	Reserved forest/ hill	189.5	184.93
		Forest Blanks	Forest Blanks		4.571
5	Barren/ Uncultivable/Waste Land	Barren land	Barren land	1474.98	137.53
		Scrub land	Shrubs	11.37	24.158
			Scrub land	67.27	52.73
		Salt affected / Sandy area	Alkaline	135.51	27.08
			Saltpan		34.83
			Sandy area	23.24	23.24
			Alkaline/Sand		1.687
6	Water body/Wetland	Water body	Tank	378.28	412.09
			River		21.24
		Wetland	Water logged area	118.04	82.84
PUDUCHEERY					210.49
TOTAL AREA				4733.6	4746.71

basin. Agriculture wise, the basin land is used for irrigated crop and dry crop cultivation, as well as cashew plantations and groves occupy a considerable area. Most of the western part of the basin is irrigated cultivation. Dry cropping is dominant around north and north east of the basin, whereas the cashews are planted in the east, near Pondy and Kaluveli.

The comparison of land use prepared for IRS ID & P6 False Colour Composite (FCC) LISS III data of January 1998 covering Varahanadhi Basin and the land use prepared for the current study is done and the same is tabulated below **(Table 2.7).**

The detailed discussion on variations in the various land use components over the period of 17 years in the Varahanadhi basin is comprised in the chapter. The graphical comparison of the major land forms of the study area in the past (1998) and in the present (2015) is shown in the following chart.



2.8.1 Built up land

The term built up land include human settlement area which is further classified in to urban (Town and Cities) and Rural (Village). In 2015 the total settlement area in the basin is 213.9 Sq Km whereas 51.95 Sq Km is urban includes Gingee, Tindivanam, Achcharapakkam, Ongur, Cheyyur, Vikiravandi and Villupuram towns and 161.2 Sq Km is rural area.

On comparing the urban settlements in 1998 to 2015, the towns are expanded in the present to about 171.1 Sq Km. This shows the development of the local sectors that increases the suitability of the basin for human activity. About 0.71 Sq Km of the basin is occupied for industrial purpose near Sikkinanakuppam. The type of the industry is unknown and it has to be concluded in the field.

2.8.2 Quarry

Quarry land is located near Vidur and between Molasur and Nallam in Villupuram district. Such quarries are developed in the agriculture land. The purpose of the quarries is unknown and this has to be clarified in the field.

2.8.3 Agriculture Land

The Varahanadhi basin is widely used for many agricultural purposes that are irrigated cropping, dry cropping, plantation and grooving.

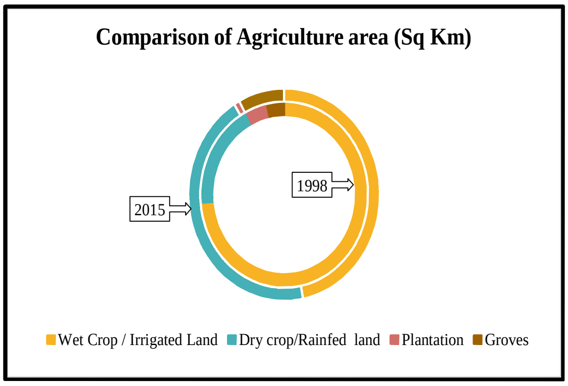
Wet crop: Comprises of Paddy, Sugarcane and Banana. As the study was carried out with the satellite image of August 2015 which is a pre-monsoon season for this basin, many of the agricultural land are devoid of crops and are classified as current fallow and harvested land. When it is about harvested lands nearly 1100 Sq Km is under this category and the rest of 450 Sq Km land is covered by vegetation. Among the wet crops, paddy is mainly cultivated in the basin in 2015. In 1998, about 36% of the basin area was irrigated but it has reduced to 33 % in 2015.

Dry crop: Planted in the area are Cholam, Kambu, Ragi, Onion and Groundnut. These crops have been scarcely cultivated in the area in 1998 compared to the recent time. In 1998 the dry crops were observed in over 9 % of the basin and in 2015 it is 31%.

The decrease in wet cropping and increase in dry cropping in the basin over time may be due to the change in the rainfall in the area, consequent adoption of cultivation pattern in the cropping lands and other socio economic problems.

Cashew plantation: It is majorly found near the Kaluveli swamp where the area has thick sedimentary deposits. About 1.4 % of the area has increased in cashew cultivation in the present.

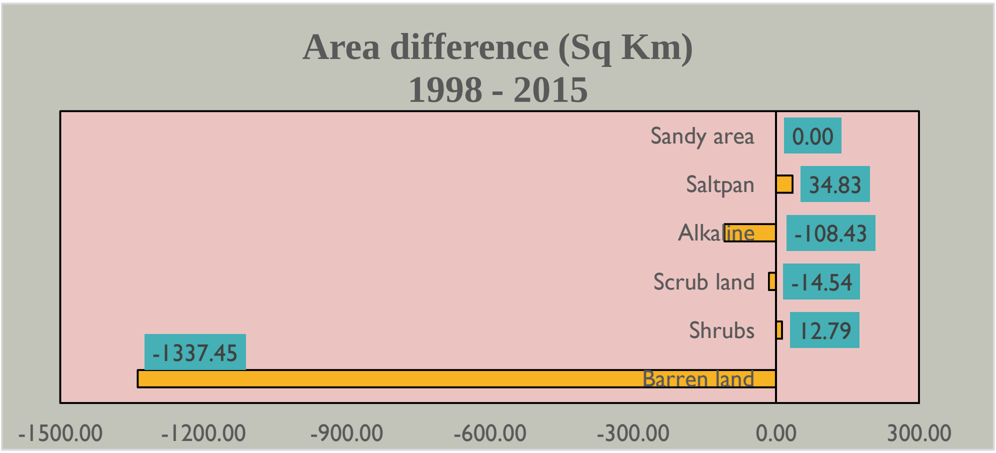
Groves: like Coconut, Mango and Casuarina are grown along the Varahanadhi river and area at west of Kaluveli. Over the 17 years span (1998 – 2015) barren land at west of Kaluveli and alkaline lands around banks of Varahanadhi river are enhanced for grove cultivation so that the 76 Sq Km grove land in 1998 is increased to 257 Sq Km, which is 3.8% high.



2.8.4 Forest

In the Varahanadhi basin, reserved forests and hills cover an area up to 189.5 Sq Km. Major reserved forests include, Alliyalamangalam, Paakkamalai, Paadipallam, Muttakaadu, Evuur, Kurumpuram, Agaram located from west to east. Hills in the basin ranges from 250 m to 350 m elevation and are sparsely covered by shrubs and scrubs. Some of the hills in the area are Jambodimalai, Paalapattumalai, Periyamalai, Muttatur and Matturmalai.

2.8.5 Barren/Uncultivable/Waste Land



Some of the land parts are not suitable for either cultivation or any other practice. Such lands are unproductive because of the nature of the soil ie alkaline, natural plantations like shrubs and scrubs occupies the land and may be barren with thin soil cover. The above said landforms are sparsely spread all over the basin. Even the beach with sand and sand dune which is located at the east cost of the basin cannot be used for advantageous purpose.

Uncultivable barren land and alkaline area are decreased since 1998. As mentioned before, the barren and alkaline lands are encroached by settlements as well as improved to agricultural lands and are utilized for cultivating wet crops, dry crops and also groves. Hence the barren land area has been reduced to 137.53 Sq Km from 1474.98 Sq Km and so the difference is 1337.45 Sq Km. In the case of alkaline land 108 Sq Km has been reclaimed and is reduced to 27 Sq Km from 135.51 Sq Km. Saltpan activities in the river basin covers 34.83 Sq Km near the swamps.

The other categories of wasteland viz. shrubs and scrubs occupy 76.89 Sq Km in 2015. However the shrubs are increased to 24.16 Sq Km from 11.37Sq Km and the scrubs are decreased from 67.27 Sq Km to 52.73Sq Km, the change doesn’t involve directly to any landform development. Sandy area viz beach and stable sand dunes which is developed along the east cost of the basin is of the areal extent 23.24 Sq Km.

2.8.6 Water body/wetlands

Water bodies viz. tanks, reservoirs and rivers and water logged wetlands/swamps in the river basin covers up to 516.2 Sq Km. This comprises of 610 WRD tanks and nearly 1200 panchayat union tanks, Vidur reservoir. The total water spread area of the tanks in 2015 is 412.09 Sq Km and the same was 378.28 Sq Km in 1998. The difference may be due to the area of water spread available at the time of the satellite passing over that water body. However the water spread area as per the data available in the field office for all the 610 WRD tanks works out to 532.80 Sq km. The Kaluveli swamp spreads over 82.84 Sq Km at present. However the area of Kaluveli swamp is reduced from 118.04 Sq Km (1998) which may be attributed to the development of saltpan.

2.9 Geophysics

Determination of Subsurface Geometry of Varahanadhi river basin based on Litholog data and Vertical Electrical Sounding

2.9.1 Introduction

Geophysics is a subject of natural science concerned with the physical properties of sub surface materials. Though different geophysical methods or techniques are used in many fields of investigations, 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 by keeping centre of spread in a fixed position is called Vertical Electrical Sounding (VES).

While interpreting and analyzing data, knowledge of subsurface lithology, hydrogeology and its relation to resistivity is very much essential. The resistivity of geological formations are dependent upon the mineral content, porosity, density and quality of water if it is an aquifer. Hence data have been correlated with existing lithological data of boreholes and inferred lithology is arrived. In view of this an integrated approach of geophysical survey (VES) data and actual lithological data collected from different investigation borewells are used appropriately to obtain the different depth of subsurface layers of the basin. The VES together with borehole lithology forms the data base in determination of depth, thickness and spatial distribution of Top Soil, Weathered Rock, Fractured and Jointed rocks.

2.9.2 Methodolgy

Geologically the Varahanadhi Basin is made up of hard rock such as Charnockite, Granitoid and Biotite Gneiss in the central and western part; while the eastern part comprises sedimentary rocks represented by alluvium, sand stone, lime stone, sand and clay. According to these geological information, the available data of bore hole lithology and 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. These details of 66 numbers of Vertical Electrical soundings are appropriately used with 121 numbers of bore well lithological data and a total number of 187 data are simulated using GIS software for sub surface geometry of the basin. The location details of boreholes and Vertical Electrical soundings are shown in map **Plate VAR -18.**

However the information about subsurface lithology is restricted to depth of borewells and depth of penetration of electrical resistivity measurements. The presence of inhomogeneity in the formation and poor quality of ground water are considered with the existing data for creation of data base for simulation. The information thus obtained are used in the GIS environment for creation of thematic maps showing spatial and vertical distribution pattern of top soil/unconsolidated formation, weathered rock and fractured / jointed rock layers of the basin. **(Map Plate VAR -19, Map Plates VAR- 20& Map Plates VAR- 21).**

2.9.3 Topsoil/ Unconsolidated formations.

The topsoil is the upper litho unit identified through this analysis, depicted as surface plot in Plate VAR19 showing spatial distribution pattern and depth of occurrence of topsoil in meters below ground level. The resistivity signature denotes the predominance of sand and sandy clay in eastern part of the basin where in sedimentary formations are observed. In hard rock area the top formations are classified as top soils and in sedimentary area these are unconsolidated top layers. Based on the depth of occurrence, these formations are classified further into four sub divisions namely 1. Layers from 1 -3 meters below ground level 2. Layers from 3-6 meters bgl 3.Layers from 6 -10 meters bgl and 4.Layers from 10-20 meters bgl.

The shallow layer of 1-3 meter bgl covers 50 % of the basin area especially in central and western parts of the basin. This layer is observed in Chetpet, Turinjapuram, Kilpennathur, Gingee, Mailam, Olakkur, Marakkanam, Mugaiyur, Kanai, Vikravandi, Acharapakkam, Maduranthagam, north of Lattur and south side of Thellar Blocks.These shallow top layers are observed above weathered and fissured hard rock formations such as Charnockite, Biotite gneiss and Migmatites.

The moderately deeper layer of 3-6 meters bgl are observed in almost all parts except the central part of the basin covering 35% to 40% of the area.This layer is observed in Pernamallur, Melmalaiyanur, Gingee, South and middle parts of Kanai, Western side of Vikravandi, Chittamur, Lattur, Southern side of Acharapakkam, Eastern side of Marakkanam, South side of

Vanur and parts Kandamangalam and Koliyanur Blocks. This layer over lies mainly hard rocks except in eastern and south eastern side where in sedimentary formations such as Alluvium, Clay, Sand and Sand stones are observed.

The deep layer of topsoil / unconsolidated formations (6- 10 meters bgl) are mainly observed in the area of sedimentary formations in eastern and south eastern side of the basin. This layer is mainly observed in parts of Koliyanur, Cuddalore, Vanur, Eastern side of Marakkanam and southern side of Chitamur blocks.

The deepest layers of unconsolidated formations (10- 20 meters bgl) are mainly observed in very limited area of sedimentary formations in eastern and south eastern side of the basin. This layer is observed in Kandamangalam, Marakkanam Cuddalore and Vanur blocks.

The area of deeper zones of top soils and unconsolidated formations are most suited for artificial recharge structures.

2.9.4 Weathered Formation

Map Plate VAR 20 represents spatial distribution, depth of occurrence and thickness of weathered rock below ground level. In general this layer in combination with jointed or fractured formation forms the primary or shallow aquifer in hard rock area. This layer is further subdivided into 5 sub layers based on depth of occurrence and thickness of layer in the basin.

The shallow depth of weathered rock (5 -10 meters bgl) exists in very limited places of the basin- in the central part of Marakkanam, South-east of Olakkur, northern part of Vallam and Melmalaiyanur blocks and as small patches in Mailam, Vanur, Gingee and Kanai blocks.

The weathered formations having depth of 10-15 meter bgl is observed in almost all blocks covering 45- 50% of the basin except Kanai,Kolianur and Gingee blocks where in only small patches of area are observed.

The formations having moderately appreciable depth and thickness of weathering ie.15- 25 meter bgl is observed mainly in western and northern side of the basin. Almost in major areas of Acharapakkam, Gingee, Kanai, Kolianur, Mugaiyur, Vikravandi and Turinjapuram blocks it is observed. It is also observed in western and southern side of Melmalayanur, Kilpennathur, and southern side of Thellar, Chitamur and in small parts of Vallam, Mailam, Vandavasi, Marakkanam and Vanur blocks.

It is noticed that the weathered thickness occurring at depth from 5 meter below ground level to 25 meter is observed in hard rock area consisting of charnockite, biotite gneiss and migmatite.

The sub layer at depth of 25-35 meters depth below ground level exists mainly in south eastern side of the basin as narrow patches surrounding the deep fractured formations in sedimentary areas. Small areas are observed mainly in Marakkanam, Chitamur, Vanur, Kandamangalam, Melmalaiyanur, South-West portion of Gingee and Kanai blocks.

The sub layer of weathered formations occurring at depths of 35- 75 meter below ground level is mainly observed in south eastern side of the basin and as small patches near the foot hills in western side of the basin. This layer which occurs in sedimentary formations are observed in eastern side of Marakkanam, Vanur and parts of Cuddalore blocks.

2.9.5 Fractured / Jointed Formations.

Map Plate VAR 21 represents spatial distribution, depth of occurrence and thickness of fractured/jointed formations below ground level. In general this zone underlies the weathered formations and overlies the basement or massive rocks forming the part of aquifer system. Based on depth of occurrence below ground level, this formation is further sub divided in to 5 sub layers.

The shallow sub surface layer from 5 – 30 meter below ground level exists in Marakkanam, Vanur blocks, small areas of Melmalaiyanur, eastern side of Pernamallur, and North western part of Thellar blocks. It is also observed in central part of Vallam, and as small patches of areas of Kanai and Vikravandi blocks.

The layer of fractured or jointed formations extending from 30 meter to 50 meter below ground level covers almost 50 to 60% of the basin especially in hard rock area. It is observed in almost all blocks except in south eastern side of the basin.

The sub surface layer occurring at a depth of 50 to 75 meters below ground level is observed in eastern, central and western side of the basin. This zone is observed in parts of Gingee, Mugaiyur,Melmalaiyanur, Vallam, Mailam, Olakkur, Vikravandi, Koliyanur, Vanur, Marakkanam and Chitamur blocks.

The sub surface layers extending from 75 -100 meters below ground level occurs mainly in south eastern side of the basin especially in sedimentary areas. In western side of Gingee, South side of Vanur, Marakkanam, as patches in Kandamangalam, Cuddalore, Kanai, Melmalaiyanur, Olakkur, Mailam and Vikravandi Blocks this subsurface layer is observed.

The deep fractured and jointed formations occurring at depth of 100 to 400 meter below ground level is observed in south eastern side of the basin covering sedimentary areas of Kandamangalam and Cuddalore blocks.

2.9.6 Depth to Bed Rock

Generally bed rocks are observed below weathered, fractured or fissured formations in hard rock area. Hence bottom of these formations are considered as depth of occurrence of bed rock. As per the classification of sub surface layers based on lithological data of bore well and Vertical Electrical Sounding, it is observed that the bottom layer of fissured rock is 30 meter to

45 meter below ground level which is considered as depth to bed rock in major part of hard rock area of the basin.

2.9.7 Conclusions

The Vertical Electrical Sounding data together with borehole lithology forms the data base in determination of depth of occurrence, thickness and spatial distribution of Top Soil, Weathered rock, Fractured and Jointed formation of the Varahanadhi Basin. Using these data of 187 locations maps such as thickness and depth of occurrence of Top Soil/ Unconsolidation, Weathered and Fractured formations are prepared using GIS software.(Restricted to depth of Bore well and depth of penetration of VES). In each category sub surface layers are distinguished and discussed according to depth of occurrence below ground level.

The shallow layer of top soil at 1-3 m bgl covers 50% of the basin area. Similarly moderately deeper layer of 3-6 m bgl is observed in 35 to 40% of the basin area. In remaining 10 to 15 % of the area of basin, deeper layers of unconsolidation is observed.

The weathered formations having 10-15 m bgl and 15-25 m bgl are observed in almost all blocks covering more than 80% area of the basin which comprises hard rock such as charnockite, biotite gneiss and migmatite.

The sub surface layer of fractured or jointed formation extending from 30 m to 50 meter bgl covers almost 50-60% of the basin in hard rock area.

It is observed that deeper layers of Top Soil, Weathered and Fractured formations occur mainly in sedimentary area and thus establishing crystalline – sedimentary rock contact.

In general, layers having more thickness of unconsolidated and weathered formation are most suitable for ground water recharge structures as chances of vertical seepage is more in such area. Such areas are demarcated in thematic maps and can be used effectively in water resources planning and management with proper field verification.

2.10 Soils

Soil is one of the natural resources, which has the most direct impact on agricultural development. In an agrarian State like TamilNadu, it becomes necessary to take steps for its proper conservation and management. Soil surveys provide nature of soils, their extent physico chemical characteristics etc.

Type of Soil Areas in Tamil Nadu	
Soil Type	***District Name***
Red Loam:	Krishnagiri, Thoothukudi, Virudhunagar, The Nilgirs,
	Dindigul, parts of Kancheepuram, Cuddalore, Salem,
	Dharmapuri, Coimbatore, Trichy, Thanjavur, Ramnad,
	Thirunelveli and Sivagangai.

Type of Soil Areas in Tamil Nadu	
Soil Type	***District Name***
Red Sandy Loam :	Namakkal, Erode, Thiruppur and Karur.
Red Sandy Clay Loam :	Theni
Laterite Soil:	Parts of The Nilgirs
Black Soil :	Parts of Kancheepuram, Cuddalore, Vellore, Thiruvarur
	Tiruvannamalai, Salem, Dharmapuri, Madurai, Ramnad,
	Thirunelveli, Sivagangai, Thoothukkudi, The Nilgiris,
	Virudhunagar ,Dindigul, Perambalur and Ariyalur
Black Sandy Clay Loam:	Pudukkottai
Sandy Coastal Alluviam :	On the coasts in the districts of Ramnad, Thanjavur,
	Nagapattinam, Cuddalore, Kancheepuram, Kanyakumari.
Red Sandy Soil :	Small patches in the districts of Coimbatore and The Nilgiris.
Source: Commissioner of Agriculture, Department of Agriculture, Chennai-600 005	

The soils of the Varahanadhi basin have been shown in **Plate-VAR-22 to 24**. The major soils types found this river basin are Inceptisols, Alfisol, Entisol and Vertisol. Due to different stage of weathering of parent material, the above soil types are met with in combination in some areas. The types of soils along with their sub groups are described as below.

2.10.1 Entisols

These soils show little or no evidence of development of pedogenic (diagnostic) horizons. Horizons have not been formed in these soils due to shortness of time for pedogenesis. Surface material is removed from the site as fast as or faster than most diagnostic horizons can form. They are found distributed on steep, actively eroding slopes and on flood plains which receive new deposits of alluvium. Erosion is active in these soils. Parts of Kancheepuram and Villupuram districts are covered by Entisols. The following are the 4 sub groups identified under Entisols.

1) Typic Ustorthentic:

a) Typic Ustorthents:

These are reddish brown to red, light to medium textured and mostly non calcarious 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.

b) Lithic Ustorthents:

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

c) Typic Ustifluvents:

These soils are dark brown to dark grey soils of fluvial(alluvial) origin with rapid permeability and are well drained. Stratification of layers on account of fluvials 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 an rainfed.

d) Typic Ustipsamments:

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

2.10.2 Inceptisols

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

2.10.3 Vertisols

This order includes dark brownish grey, very deep, calcareous, heavy clayey and self-churning soils that have deep wide cracks. The surface shows a complex microtopography of mounds and depressions. Slickenside feature is common in the sub surface and the mineralogy is dominantly montmorillonitic which is an expanding clay. They are moderately well drained with slow permeability except in the cracks. The vertisols are predominant in Nallavur subbasin and western part of Varahanadhi subbasin.

The following two sub groups are identified under Vertisols.

a) Typic Chromusterts:

These have a Chroma, moist of 1.50 or more and colour value, moist less than 3.50 and a value dry less than 5.50 throughout the 30 cm of the pedon i.e surface soils are gray in colour. The cracks remain open more than 150 cumulative days in most years.

b) Udorthentic Chromusterts:

The cracks of these soils remain open from 90 to 150 cumulative days in most years with higher colour values.

2.10.4 Alfisols

This consists of deep to very deep, matured soils with alluvial concentration of clay in the sub horizon. The surface horizon is massive and hard. Cultivation is extensive on these soils. This soil type is spread all over the basin. They have moderate to high base saturation. 9 sub groups belonging to this category is described below.

a) 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.

b) Udic Haplustalfs:

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

c) Ultic Haplustalfs:

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

d) Vertic Haplustalfs:

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

e) Typic Rhodustalfs:

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

f) Udic Rhodustalfs:

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

g) Udic Paleustalfs:

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

h) Vertic Natrudalfs:

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

i) Plinthustalfs:

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

j) Ultisols:

These soils are very deep to reddish and are distributed mostly in higher elevation and are humus rich but extensively leached soils resulting in low base status(less than 35 %). They are thoroughly weathered, well drained and occur in humid moist areas. The following 3 sub groups of this order are described as under.

i) Typic Haplohumults:

They have 0.90 % more organic carbon in the upper portion of the diagnostic horizon or 12 kg or more organic carbon in the soil per square metre in the sub surface. The moisture control section of these soils are dry for less than 90 days cumulatively.

ii) Typic Palehumults:

These are freely drained soils, very deep and reddish. The diagnostic horizon have few weatherable minerals.

iii) Humic Palcudults:

These soils have a colour value, moist less than 4 in the diagnostic horizon. Weatherable minerals are usually absent in these soils.

Soil Classification maps have been prepared in 1996 by National Bureau of Soil Survey and Land use Planning, Bangalore (NBSS) in co-operation with the Department of Agriculture, Tamil Nadu. The list of mapping units falling in the Varahanadhi river basin is shown in the following **Table 2.8.**

Table 2.8 Tamil Nadu Soils - Varahanadhi River Basin

Mapping Unit No	Description	Classification
169	Moderately deep, well drained, clayey soils on undulating lands, moderately eroded; associated with; rock outcrops.	Fine, mixed, Rhodic Paleustalfs. Rock outcrops.
178	Shallow, somewhat excessively drained, gravelly clay soils on moderately steeply sloping; isolated hills, severely eroded; associated with; rock outcrops.	Clayey skeletal, mixed, Lithic Rhodustalfs Rocky outcrops.
186	Deep well drained, clayey soils on gently sloping lands; moderately eroded; associated with rock outcrops.	Fine loamy, mixed typic Haplustalfs. Rock outcrops.
193	Very deep, somewhat excessively drained sandy soils on very gently sloping plains, slightly eroded.	Mixed, Typic Ustipsamments.
220	Deep, imperfectly drained, calcarious, clayey soils on nearly level lowlands, slightly eroded.	Fine, mixed, Typic Ustropepts.
259	Very deep, moderately well drained, calcarious, cracking clay soils nearly level lowlands, slightly eroded; associated with; very deep, moderately well drained, carcarious clay soils.	Fine, montmorillonitic, Vertic Ustropepts. Fine, mixed, Typic Ustropepts.
275	Moderately deep, moderately well drained, calcarious, cracking clay soils on gently sloping lowlands, slightly eroded; associated with; moderately shallow, moderately well drained, calcarious, cracking clay soils.	Very –fine, montmorillonitic, Typic pellusterts. Fine, montmorillonitic, Vertic Ustropepts.
277	Periodically flooded lands.	Marsh
285	Bare rocks	Rock land

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 Varahanadhi River Basin were identified. The irrigable soils main properties are summarized in **Table 2.9** and their interpretative classifications for land capability for crop production, irrigability and suitability for rice, sugarcane, groundnuts and cotton are given in Table **2.10.**

Table 2.9 Soil Major Properties

Type	Unit(*)	Drainage	Surface texture	Depth (cm)	Slope (%)
I	193	S.W.Exces	Sl	50-150	1-3
II	169 178 186	Well Well Well	C C C	100-150 100-150 100-150	1-3
III	220 259 275	Well Mod.Well Mod.well	C C C	100->150 >150 >150	1-3
IV	277 281 285				

Drainage

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

Texture

s = sandy
scl = sandy-clay-loam
ls = loamy-sand
sl = sandy-loam
c = clay, cl = clay loam

Erosion

Mod. = Moderate problem
Sev. = Severe problem
Non. = None (problem)

Table 2.10 Land Classification

Type	Unit (*)	Capability	Irrigability	Rice	Ground nuts	Cotton	Sugarcane
I	193	II s	3s	NR	S2	S3	NR
II	169 178 186	II s II s II s- II w	3s 3d 3d	S2 S1- S2 S1-S2	S2-S3 S2-S3 S1-S2	S1 S2 S3	S2 S2 S2
III	220 259 275	IIIs-Iis IIIw IIIw	3s-2d 2d 2d	S1 S1 S2	NR NR NR	NR NR NR	S1-S2 S1-S2 S2-S3
IV	277 285			NR NR	NR NR	NR NR	NR NR

(*) Soil association according to NBSS Publication No.46 1997

(**) Per 1 m of soil depth or the entire solum if the soil is shallower.

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

- ❖ Type-I soils. They are mostly with medium texture, well and moderately well drained, mostly moderately deep to deep, mostly with 1-3 % slope and with none to various degrees of erosion problems. Those soils are classified for irrigation mainly as 3s, for land capability as II to IV, and for crop suitability: rice – NR, sugarcane NR, groundnuts – S2 and S3 and cotton – S1 to S3. The soils are irrigable and suitable for crops like groundnuts, cotton, pulses, millets, maize, sorghum, vegetables and tree crops.
- ❖ Type-II soils. They are of fine texture, imperfectly drained, moderately deep to deep, with 1-3% slope, with none to moderate erosion problems. Those soils are classified for irrigation as 2d and 3d, for land capability as II, and for crop suitability: rice – NR, sugarcane NR, groundnuts – S3 and cotton – mainly S1 and some S3. The soils are irrigable and suitable for field crops relatively tolerant to imperfect drainage such as cotton, sorghum and some fodder crops. In spite of the above mentioned NR classification for sugarcane it can be concluded that in the future with improved irrigation methods and systems, Type-II soils with lower slopes, could also be cultivated by sugarcane.
- ❖ Type-III soil. They are mostly of fine texture, mostly imperfectly drained, moderately deep to deep, mostly with 1-3 % slope, with none to moderate erosion problems. Those soils are classified for irrigation mainly as 2d and 2s, for land capability as II, and for crop suitability: rice – mainly S2, sugarcane – mainly S2, groundnuts – mainly S3 and cotton – mainly S2. Type-III soils are irrigable and suitable to rice and sugarcane and also to relatively tolerant to imperfect drainage other crops such as cotton, sorghum and some fodder crops.
- ❖ Type-IV soils. They are similar to Type-III soils, however due to salinity and sodicity problems those soils could be sustainably irrigated if corrective measures to those problems would be taken.
- ❖ Type-V soils. Those soils include non-irrigable soils, such as rock outcrops, dunes, flooded areas, steep slopes, etc.

Based on this study and the corresponding soil map, the irrigable soils of the Varahanadhi basin were identified. The soils were classified for crop suitability purposes into four types:

Type 1 : Irrigable, fruits, vegetables and field crop soils

Type 2 : Irrigable crop soils

Type 3 : Irrigable rice soils

Type 4 : Non-Irrigable soils

Based on the soil properties and their classification the Basin irrigable soils could be grouped for planning purposes into major soil-crop suitability groups denoted Type-1, Type-2 and Type-3. Type-1 soils are coarse and medium texture, well drained, medium depth and 1-3 % slope and are suitable for crops like groundnuts, cotton, pulses, millets, maize, sorghum, and vegetables. Type-2 soils are mostly of medium texture, well to moderately well drained, deep and flat and are suitable to various degree to all kind of crops. Type-3 soils are mostly of fine texture, some of them are imperfectly drained, deep and flat and are suitable mainly for crops such as rice, sugarcane and some fodder crops. The rest non-irrigable soils were defined as Type-4. The different mapping unit numbers related with different type of soils are given in the following table.

Sl. No.	**Type of Soil**	**Mapping Unit Numbers**
1.	Inceptisol	220, 259, 277 & 285
2.	Alfisol	169, 178 & 186
3.	Entisol	193
4.	Vertisol	275

2.10.5 Soil Fertility

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

Intervention strategies for efficient use of land and water resources for effective adoption of technology and institutions are suggested for decision at different planning. The strategies are presented with field examples in different region with the set of development related issues and problems for detailed comprehensive consideration and decision. More specifically land use problems are related to flood incidence, drainage, water logging and acid soil. A review of change over the period of 7 years and across the region is done to discern the factors behind such changes particularly level of fertilizer using the irrigation.

Soil Fertility

It is viewed that nutrients are necessary for basic plant nourishment. This includes Nitrogen, Phosphorous and Potash and micro nutrients such as Boron, Chlorine, Cobalt, Copper, Iron, Magnesium, Molybdenum, Sulphur and zinc. These minerals promote plant nutrition. It contains soil organic matter that improves the structure of soil. This enables the soil to retain more moisture. The soil pH in the range of 6.0 to 6.8 has a good soil structure which results in well drained soil. It consists of variety of micro organism that supports the plant growth. The soil fertility based on Sodium, Phosphorus and Potash (NPK) is listed **(Table 2.11)** for selected villages in the Varahanadhi basin(Source: Soil ATLAS by Soil Survey and landuse organization, Department of Agriculture, Tamil Nadu - Tiruvannamalai, Villupuram and Kancheepuram districts). These values are used by the extension officers in the districts to guide the farmers in applying the fertilizer doses. Soil samples analysed in the soil testing labs of Tiruvannamalai, Villupuram and Kancheepuram districts (Figure 2.7, 2.8 and 2.9 respectively) are also attached.

Figure 2.7 Tiruvannamalai District

Figure 2.7

Figure 2.8 Villupuram District

Figure 2.8

Figure 2.9 Kancheepuram District

Figure 2.9

Table 2.11 Varahanadhi Basin - Soil fertility for selected villages

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
1	Agaram	Kancheepuram	Cheyyur	Ongur subbasin	71	28	46
2	Akkinambattu	Kancheepuram	Cheyyur	Ongur subbasin	96	3	55
3	Ammanampakkam	Kancheepuram	Cheyyur	Ongur subbasin	105	28	40
4	Ammanur	Kancheepuram	Cheyyur	Ongur subbasin	94	2	80
5	Andarakuppam	Kancheepuram	Cheyyur	Ongur subbasin	56	8	71
6	Arappedu	Kancheepuram	Cheyyur	Ongur subbasin	69	35	298
7	Cheyyur	Kancheepuram	Cheyyur	Ongur subbasin	68	5	25
8	Gengadevankuppam	Kancheepuram	Cheyyur	Ongur subbasin	95	25	220
9	Illedu	Kancheepuram	Cheyyur	Ongur subbasin	118	12	140
10	Indalur	Kancheepuram	Cheyyur	Ongur subbasin	54	13	40
11	Iraniyasithi	Kancheepuram	Cheyyur	Ongur subbasin	161	17	101
12	Irumbili	Kancheepuram	Cheyyur	Ongur subbasin	76	10	168
13	Kadapperi	Kancheepuram	Cheyyur	Ongur subbasin	75	29	93
14	Kadugupattu	Kancheepuram	Cheyyur	Ongur subbasin	58	2	63
15	Kadukkalur	Kancheepuram	Cheyyur	Ongur subbasin	63	6	442
16	Kanathur	Kancheepuram	Cheyyur	Ongur subbasin	54	3	43
17	Kayapakkam	Kancheepuram	Cheyyur	Ongur subbasin	60	22	119
18	Kesavarayanpettai	Kancheepuram	Cheyyur	Ongur subbasin	118	99	322
19	Kilmaruvathur	Kancheepuram	Cheyyur	Ongur subbasin	96	91	334
20	Kodur	Kancheepuram	Cheyyur	Ongur subbasin	36	7	98
21	Kokkaranthangal	Kancheepuram	Cheyyur	Ongur subbasin	60	15	264
22	Kolathur	Kancheepuram	Cheyyur	Ongur subbasin	54	3	43
23	Kottaikadu	Kancheepuram	Cheyyur	Ongur subbasin	46	43	237
24	Madayambakkam	Kancheepuram	Cheyyur	Ongur subbasin	52	9	140
25	Malrajakuppam	Kancheepuram	Cheyyur	Ongur subbasin	10	6	135
26	Maluvankaranai	Kancheepuram	Cheyyur	Ongur subbasin	78	8	39
27	Maruderi	Kancheepuram	Cheyyur	Ongur subbasin	59	10	240
28	Melmaruvathur	Kancheepuram	Cheyyur	Ongur subbasin	58	9	72
29	Mogaiyur	Kancheepuram	Cheyyur	Ongur subbasin	65	9	47
30	Mudaliarkuppam	Kancheepuram	Cheyyur	Ongur subbasin	110	60	290

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
31	Murunkkanthangal	Kancheepuram	Cheyyur	Ongur subbasin	80	12	175
32	Nedumaram	Kancheepuram	Cheyyur	Ongur subbasin	59	10	54
33	Nelvoypalayam	Kancheepuram	Cheyyur	Ongur subbasin	59	2	63
34	Nemandam	Kancheepuram	Cheyyur	Ongur subbasin	54	8	54
35	Nerkunam	Kancheepuram	Cheyyur	Ongur subbasin	59	18	248
36	Nerkunapattu	Kancheepuram	Cheyyur	Ongur subbasin	80	12	120
37	Othivilagam	Kancheepuram	Cheyyur	Ongur subbasin	90	30	195
38	Pakkur	Kancheepuram	Cheyyur	Ongur subbasin	63	10	119
39	Pakkuvancheri	Kancheepuram	Cheyyur	Ongur subbasin	71	24	315
40	Palur	Kancheepuram	Cheyyur	Ongur subbasin	71	24	315
41	Panaiyadivakkam	Kancheepuram	Cheyyur	Ongur subbasin	65	15	146
42	Panaiyur	Kancheepuram	Cheyyur	Ongur subbasin	110	60	230
43	Parukkal	Kancheepuram	Cheyyur	Ongur subbasin	101	4	119
44	Pavunjur	Kancheepuram	Cheyyur	Ongur subbasin	70	5	147
45	Perambakkam	Kancheepuram	Cheyyur	Ongur subbasin	112	11	66
46	Periyakilakkadi	Kancheepuram	Cheyyur	Ongur subbasin	64	8	244
47	Periyavellikadu	Kancheepuram	Cheyyur	Ongur subbasin	75	6	69
48	Perukkaranai	Kancheepuram	Cheyyur	Ongur subbasin	130	3	101
49	Perumalcheri	Kancheepuram	Cheyyur	Ongur subbasin	71	24	315
50	Perumbakkam	Kancheepuram	Cheyyur	Ongur subbasin	73	14	75
51	Polambakkam	Kancheepuram	Cheyyur	Ongur subbasin	120	15	195
52	Porur	Kancheepuram	Cheyyur	Ongur subbasin	120	12	210
53	Pudupattu	Kancheepuram	Cheyyur	Ongur subbasin	80	12	150
54	Pudupattu	Kancheepuram	Cheyyur	Ongur subbasin	162	6	175
55	Puliyani	Kancheepuram	Cheyyur	Ongur subbasin	95	12	190
56	Puraiyur	Kancheepuram	Cheyyur	Ongur subbasin	110	16	175
57	Puriyambakkam	Kancheepuram	Cheyyur	Ongur subbasin	63	8	56
58	Puthirankottai	Kancheepuram	Cheyyur	Ongur subbasin	150	7	192
59	Sengattur	Kancheepuram	Cheyyur	Ongur subbasin	80	6	135
60	Sirunagar	Kancheepuram	Cheyyur	Ongur subbasin	60	9	123
61	Siruvalambakkam	Kancheepuram	Cheyyur	Ongur subbasin	50	11	110
62	Sottupakkam	Kancheepuram	Cheyyur	Ongur subbasin	56	6	40

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
63	Tandalam	Kancheepuram	Cheyyur	Ongur subbasin	43	10	57
64	Tenpakkam	Kancheepuram	Cheyyur	Ongur subbasin	65	7	83
65	Thiruppurakkovil	Kancheepuram	Cheyyur	Ongur subbasin	63	19	57
66	Thuduvilampattu	Kancheepuram	Cheyyur	Ongur subbasin	130	4	190
67	Vadapatnam	Kancheepuram	Cheyyur	Ongur subbasin	10	2	114
68	Vanniyanallur	Kancheepuram	Cheyyur	Ongur subbasin	54	12	71
69	Vayalur	Kancheepuram	Cheyyur	Ongur subbasin	162	3	74
70	Vedal	Kancheepuram	Cheyyur	Ongur subbasin	44	4	31
71	Vellankondagaram	Kancheepuram	Cheyyur	Ongur subbasin	93	5	307
72	Vembanur	Kancheepuram	Cheyyur	Ongur subbasin	62	5	357
73	Venmalaharam	Kancheepuram	Cheyyur	Ongur subbasin	170	7	90
74	Vettam-perumpakkam	Kancheepuram	Cheyyur	Ongur subbasin	131	7	113
75	Vilambattu	Kancheepuram	Cheyyur	Ongur subbasin	130	4	190
76	Acharapakkam	Kancheepuram	Maduran takam	Ongur subbasin	104	1	20
77	Allanur	Kancheepuram	Maduran takam	Ongur subbasin	75	9	95
78	Allur	Kancheepuram	Maduran takam	Ongur subbasin	49	2	91
79	Anaikunnam	Kancheepuram	Maduran takam	Ongur subbasin	49	6	73
80	Anangal	Kancheepuram	Maduran takam	Ongur subbasin	35	80	65
81	Annandamangalam	Kancheepuram	Maduran takam	Ongur subbasin	40	9	79
82	Ariyanur	Kancheepuram	Maduran takam	Ongur subbasin	61	10	77
83	Athivakkam	Kancheepuram	Maduran takam	Ongur subbasin	56	5	64
84	Athur	Kancheepuram	Maduran takam	Ongur subbasin	61	10	77
85	Baburayampettai	Kancheepuram	Maduran takam	Ongur subbasin	35	7	34
86	Budur	Kancheepuram	Maduran takam	Ongur subbasin	58	8	90
87	Chinnavenmani	Kancheepuram	Maduran takam	Ongur subbasin	70	6	70
88	Chithamur	Kancheepuram	Maduran takam	Ongur subbasin	67	11	190
89	Chithamur	Kancheepuram	Maduran takam	Ongur subbasin	63	2	45

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
90	Devanur	Kancheepuram	Maduran takam	Ongur subbasin	68	4	108
91	Edayalam	Kancheepuram	Maduran takam	Ongur subbasin	61	5	53
92	Elapakkam	Kancheepuram	Maduran takam	Ongur subbasin	65	6	65
93	Endathur	Kancheepuram	Maduran takam	Ongur subbasin	75	10	90
94	Irumbedu	Kancheepuram	Maduran takam	Ongur subbasin	55	7	44
95	Kadamalaipthur	Kancheepuram	Maduran takam	Ongur subbasin	67	20	100
96	Kalathur	Kancheepuram	Maduran takam	Ongur subbasin	65	5	11
97	Karasangal	Kancheepuram	Maduran takam	Ongur subbasin	62	11	81
98	Kattudevanur	Kancheepuram	Maduran takam	Ongur subbasin	55	6	65
99	Kattugudalore	Kancheepuram	Maduran takam	Ongur subbasin	63	9	51
100	Kilathivakkam	Kancheepuram	Maduran takam	Ongur subbasin	146	12	118
101	Kilvasalai	Kancheepuram	Maduran takam	Ongur subbasin	53	10	63
102	Kongarimambattu	Kancheepuram	Maduran takam	Ongur subbasin	55	5	92
103	Kottakayapakkam	Kancheepuram	Maduran takam	Ongur subbasin	67	17	53
104	Madur	Kancheepuram	Maduran takam	Ongur subbasin	84	8	60
105	Minnalkilmunai	Kancheepuram	Maduran takam	Ongur subbasin	62	15	70
106	Mogalvadi	Kancheepuram	Maduran takam	Ongur subbasin	58	6	234
107	Munnakulam	Kancheepuram	Maduran takam	Ongur subbasin	61	16	64
108	Murukkambakkam	Kancheepuram	Maduran takam	Ongur subbasin	66	3	52
109	Murungai	Kancheepuram	Maduran takam	Ongur subbasin	58	6	234
110	Nallamur	Kancheepuram	Maduran takam	Ongur subbasin	58	12	60
111	Nallur	Kancheepuram	Maduran takam	Ongur subbasin	80	12	120
112	Nedungal	Kancheepuram	Maduran takam	Ongur subbasin	52	5	60
113	Neerpair	Kancheepuram	Maduran takam	Ongur subbasin	30	29	85

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
114	Nesapakkam	Kancheepuram	Maduranta kam	Ongur subbasin	192	2	58
115	Nettarambakkam	Kancheepuram	Maduranta kam	Ongur subbasin	64	17	180
116	Orathi	Kancheepuram	Maduranta kam	Ongur subbasin	53	8	50
117	Pallipettai	Kancheepuram	Maduranta kam	Ongur subbasin	63	12	51
118	Perumbairkandigal	Kancheepuram	Maduranta kam	Ongur subbasin	68	4	66
119	Pinnampoondi	Kancheepuram	Maduranta kam	Ongur subbasin	63	7	111
120	Pundi	Kancheepuram	Maduranta kam	Ongur subbasin	63	7	111
121	Puragal	Kancheepuram	Maduranta kam	Ongur subbasin	72	26	231
122	Rajapalayam	Kancheepuram	Maduranta kam	Ongur subbasin	53	2	41
123	Ravuthanallur	Kancheepuram	Maduranta kam	Ongur subbasin	59	6	62
124	Senaiyaneri	Kancheepuram	Maduranta kam	Ongur subbasin	34	7	31
125	Sirudamur	Kancheepuram	Maduranta kam	Ongur subbasin	64	3	85
126	Sirupairpandi	Kancheepuram	Maduranta kam	Ongur subbasin	56	6	51
127	Siruvangunnam	Kancheepuram	Maduranta kam	Ongur subbasin	90	12	175
128	Sitapuram	Kancheepuram	Maduranta kam	Ongur subbasin	55	5	61
129	Thimmapuram	Kancheepuram	Maduranta kam	Ongur subbasin	68	7	50
130	Thinnalur	Kancheepuram	Maduranta kam	Ongur subbasin	46	10	81
131	Thirumukkadu	Kancheepuram	Maduranta kam	Ongur subbasin	58	13	173
132	Thozuppedu	Kancheepuram	Maduranta kam	Ongur subbasin	67	4	51
133	Ulavetti	Kancheepuram	Maduranta kam	Ongur subbasin	54	8	50
134	Uttamanallur	Kancheepuram	Maduranta kam	Ongur subbasin	65	7	56
135	Vadakkupputhur	Kancheepuram	Maduranta kam	Ongur subbasin	70	6	110
136	Vadamanipakkam	Kancheepuram	Maduranta kam	Ongur subbasin	58	5	47
137	Veepankaranai	Kancheepuram	Maduranta kam	Ongur subbasin	69	17	112

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
138	Veliambakkam	Kancheepuram	Maduranta kam	Ongur subbasin	55	10	54
139	Vellari	Kancheepuram	Maduranta kam	Ongur subbasin	176	13	105
140	Venmani	Kancheepuram	Maduranta kam	Ongur subbasin	66	6	33
141	Vilangadu	Kancheepuram	Maduranta kam	Ongur subbasin	120	6	120
142	Vinnapoondi	Kancheepuram	Maduranta kam	Ongur subbasin	38	10	91
143	Alliyalamangalam RF	Tiruvannamalai	Polur	Varahanadhi subbasin	79	6	113
144	Chetpet	Tiruvannamalai	Polur	Varahanadhi subbasin	91	7	128
145	Mansurabad	Tiruvannamalai	Polur	Varahanadhi subbasin	77	9	112
146	Peranambakkam	Tiruvannamalai	Polur	Varahanadhi subbasin	44	8	121
147	Arappakkam	Tiruvannamalai	Tiruvanna malai	Varahanadhi subbasin	59	5	114
148	Budamangalam	Tiruvannamalai	Tiruvanna malai	Varahanadhi subbasin	84	8	72
149	Erumpudi	Tiruvannamalai	Tiruvanna malai	Varahanadhi subbasin	98	10	118
150	Ganalapadi	Tiruvannamalai	Tiruvanna malai	Varahanadhi subbasin	86	9	132
151	Ganapapuram	Tiruvannamalai	Tiruvanna malai	Varahanadhi subbasin	78	8	120
152	Kallikulam	Tiruvannamalai	Tiruvanna malai	Varahanadhi subbasin	84	9	119
153	Karanampundi	Tiruvannamalai	Tiruvanna malai	Varahanadhi subbasin	84	8	74
154	Karkonam	Tiruvannamalai	Tiruvanna malai	Varahanadhi subbasin	94	16	62
155	Katialampattu	Tiruvannamalai	Tiruvanna malai	Varahanadhi subbasin	81	13	74
156	Keekaloor	Tiruvannamalai	Tiruvanna malai	Varahanadhi subbasin	86	10	93
157	Kovur	Tiruvannamalai	Tiruvanna malai	Varahanadhi subbasin	98	12	61
158	Kunnankuppam	Tiruvannamalai	Tiruvanna malai	Varahanadhi subbasin	82	5	65
159	Mangalam	Tiruvannamalai	Tiruvanna malai	Varahanadhi subbasin	72	8	142
160	Nukkambadi	Tiruvannamalai	Tiruvanna malai	Varahanadhi subbasin	89	6	88
161	Pennathur(Kil)	Tiruvannamalai	Tiruvanna malai	Varahanadhi subbasin	8	8	98

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
162	Randam	Tiruvannamalai	Tiruvanna malai	Varahanadhi subbasin	95	9	63
163	Sevarapundi	Tiruvannamalai	Tiruvanna malai	Varahanadhi subbasin	85	14	113
164	Sorakolathur1	Tiruvannamalai	Tiruvanna malai	Varahanadhi subbasin	80	6	59
165	Velunganandal	Tiruvannamalai	Tiruvanna malai	Varahanadhi subbasin	61	4	61
166	Vettavalam	Tiruvannamalai	Tiruvanna malai	Varahanadhi subbasin	91	7	191
167	Aciamangalam	Tiruvannamalai	Vandavasi	Varahanadhi subbasin	95	15	194
168	Agilarakorakkottai	Tiruvannamalai	Vandavasi	Ongur subbasin	88	8	109
169	Agilarakorakkottai	Tiruvannamalai	Vandavasi	Varahanadhi subbasin	88	8	109
170	Aliyur	Tiruvannamalai	Vandavasi	Varahanadhi subbasin	86	8	90
171	Amundur	Tiruvannamalai	Vandavasi	Ongur subbasin	88	10	115
172	Ariyampundi	Tiruvannamalai	Vandavasi	Varahanadhi subbasin	89	7	116
173	Desur	Tiruvannamalai	Vandavasi	Ongur subbasin	94	6	59
174	Endal	Tiruvannamalai	Vandavasi	Varahanadhi subbasin	84	8	183
175	Gengampundi	Tiruvannamalai	Vandavasi	Varahanadhi subbasin	58	20	125
176	Kadiyanellur	Tiruvannamalai	Vandavasi	Ongur subbasin	72	11	277
177	Katteri(Shro)	Tiruvannamalai	Vandavasi	Ongur subbasin	60	6	210
178	Kilnamandu	Tiruvannamalai	Vandavasi	Varahanadhi subbasin	82	17	108
179	Kolippuliyur	Tiruvannamalai	Vandavasi	Varahanadhi subbasin	91	9	81
180	Korakkottai	Tiruvannamalai	Vandavasi	Ongur subbasin	92	10	99
181	Korakkottai	Tiruvannamalai	Vandavasi	Varahanadhi subbasin	92	10	99
182	Kunnagampundi	Tiruvannamalai	Vandavasi	Varahanadhi subbasin	84	16	132
183	Kutilavedu	Tiruvannamalai	Vandavasi	Ongur subbasin	70	10	120
184	Kutilavedu	Tiruvannamalai	Vandavasi	Varahanadhi subbasin	70	10	120
185	Matam	Tiruvannamalai	Vandavasi	Varahanadhi subbasin	102	9	107
186	Melacheri	Tiruvannamalai	Vandavasi	Varahanadhi subbasin	90	10	160

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
187	NAvalpakkam	Tiruvannamalai	Vandavasi	Ongur subbasin	87	10	118
188	Nedunkunam	Tiruvannamalai	Vandavasi	Varahanadhi subbasin	64	9	116
189	Palaveri	Tiruvannamalai	Vandavasi	Ongur subbasin	60	8	61
190	Panjarai	Tiruvannamalai	Vandavasi	Ongur subbasin	102	7	92
191	Perunkadaputtur	Tiruvannamalai	Vandavasi	Varahanadhi subbasin	100	8	121
192	Ramasamudram	Tiruvannamalai	Vandavasi	Ongur subbasin	63	10	202
193	Sathappundi	Tiruvannamalai	Vandavasi	Varahanadhi subbasin	110	7	93
194	Sathiyapadi	Tiruvannamalai	Vandavasi	Ongur subbasin	78	8	100
195	Seeyamangalam	Tiruvannamalai	Vandavasi	Varahanadhi subbasin	90	10	98
196	Senal	Tiruvannamalai	Vandavasi	Ongur subbasin	101	8	144
197	Teyyar	Tiruvannamalai	Vandavasi	Ongur subbasin	85	16	126
198	Tinnalur(Ten)	Tiruvannamalai	Vandavasi	Ongur subbasin	102	6	121
199	Vedal	Tiruvannamalai	Vandavasi	Varahanadhi subbasin	46	7	185
200	Venmandai	Tiruvannamalai	Vandavasi	Ongur subbasin	51	8	72
201	Veppampatti	Tiruvannamalai	Vandavasi	Varahanadhi subbasin	94	11	58
202	Anaiyeri	Viluppuram	Gingee	Varahanadhi subbasin	63	12	142
203	Anantapuram	Viluppuram	Gingee	Varahanadhi subbasin	80	-	202
204	Anjancheri	Viluppuram	Gingee	Varahanadhi subbasin	64	11	146
205	Annamangalam	Viluppuram	Gingee	Varahanadhi subbasin	73	-	70
206	Appambattu	Viluppuram	Gingee	Varahanadhi subbasin	79	-	122
207	Arkkampundi	Viluppuram	Gingee	Varahanadhi subbasin	72	-	201
208	Attippattu	Viluppuram	Gingee	Varahanadhi subbasin	54	-	231
209	Attiyur	Viluppuram	Gingee	Varahanadhi subbasin	80	19	85
210	Bharatantangal	Viluppuram	Gingee	Varahanadhi subbasin	73	18	104
211	Chinnanolambai	Viluppuram	Gingee	Varahanadhi subbasin	60	-	98
212	Chinnaponnanpundi	Viluppuram	Gingee	Varahanadhi subbasin	66	-	142
213	Chitteri	Viluppuram	Gingee	Varahanadhi subbasin	58	-	141

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
214	Chokkanandal	Viluppuram	Gingee	Varahanadhi subbasin	68	-	140
215	Chokkapalam	Viluppuram	Gingee	Varahanadhi subbasin	70	-	142
216	Devadanampettai	Viluppuram	Gingee	Varahanadhi subbasin	70	-	98
217	Devandavadi	Viluppuram	Gingee	Varahanadhi subbasin	60	-	203
218	Devanur	Viluppuram	Gingee	Varahanadhi subbasin	60	-	220
219	Embalam	Viluppuram	Gingee	Varahanadhi subbasin	68	-	142
220	Eyyal	Viluppuram	Gingee	Varahanadhi subbasin	79	-	88
221	Gangapuram	Viluppuram	Gingee	Varahanadhi subbasin	69	-	144
222	Gangavaram	Viluppuram	Gingee	Varahanadhi subbasin	66	-	70
223	Gingee	Viluppuram	Gingee	Varahanadhi subbasin	58	-	102
224	Jambodi	Viluppuram	Gingee	Varahanadhi subbasin	64	-	136
225	Jayankondan	Viluppuram	Gingee	Varahanadhi subbasin	83	15	76
226	Kadali	Viluppuram	Gingee	Varahanadhi subbasin	63	-	140
227	Kadappanandal	Viluppuram	Gingee	Varahanadhi subbasin	83	-	151
228	Kaividantangal	Viluppuram	Gingee	Varahanadhi subbasin	66	-	142
229	Kamagaram	Viluppuram	Gingee	Varahanadhi subbasin	55	12	136
230	Kanakkankuppam	Viluppuram	Gingee	Varahanadhi subbasin	78	-	92
231	Kappalambadi	Viluppuram	Gingee	Varahanadhi subbasin	67	-	142
232	Karai	Viluppuram	Gingee	Varahanadhi subbasin	56	14	76
233	Kattu Chittamur	Viluppuram	Gingee	Varahanadhi subbasin	66	-	150
234	Kavarai	Viluppuram	Gingee	Varahanadhi subbasin	57	-	68
235	Kilavanpundi	Viluppuram	Gingee	Varahanadhi subbasin	66	-	87
236	Kilmalai	Viluppuram	Gingee	Varahanadhi subbasin	68	12	132
237	Kodambadi	Viluppuram	Gingee	Varahanadhi subbasin	67	13	142

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
238	Kodukkankuppam	Viluppuram	Gingee	Varahanadhi subbasin	61	-	52
239	Kommedu	Viluppuram	Gingee	Varahanadhi subbasin	67	11	140
240	Konai	Viluppuram	Gingee	Varahanadhi subbasin	88	-	70
241	Konalur	Viluppuram	Gingee	Varahanadhi subbasin	66	-	141
242	Kottaippundi	Viluppuram	Gingee	Varahanadhi subbasin	71	-	140
243	Kovilpuraiyur	Viluppuram	Gingee	Varahanadhi subbasin	76	-	81
244	Kundalambattu	Viluppuram	Gingee	Varahanadhi subbasin	70	-	212
245	Maliyanur(Mel)	Viluppuram	Gingee	Varahanadhi subbasin	93	18	60
246	Malliresankuppam	Viluppuram	Gingee	Varahanadhi subbasin	64	10	142
247	Manalpadi	Viluppuram	Gingee	Varahanadhi subbasin	48	-	176
248	Manandal	Viluppuram	Gingee	Varahanadhi subbasin	99	-	98
249	Mannur(Mel)	Viluppuram	Gingee	Varahanadhi subbasin	54	-	166
250	Marakkonam	Viluppuram	Gingee	Varahanadhi subbasin	68	-	149
251	Mavanandal	Viluppuram	Gingee	Varahanadhi subbasin	63	-	121
252	Mel Arungunam	Viluppuram	Gingee	Varahanadhi subbasin	65	-	145
253	Mel Mambattu	Viluppuram	Gingee	Varahanadhi subbasin	66	-	145
254	Mel Puduppattu	Viluppuram	Gingee	Varahanadhi subbasin	-	-	-
255	Minamur	Viluppuram	Gingee	Varahanadhi subbasin	71	12	95
256	Nagalambattu	Viluppuram	Gingee	Varahanadhi subbasin	87	-	149
257	Nandipuram	Viluppuram	Gingee	Varahanadhi subbasin	66	12	144
258	Narasingarayanpettai	Viluppuram	Gingee	Varahanadhi subbasin	85	-	157
259	Nayampadi	Viluppuram	Gingee	Varahanadhi subbasin	67	-	141
260	Nemali(Mel)	Viluppuram	Gingee	Varahanadhi subbasin	66	13	144
261	Nochchilur	Viluppuram	Gingee	Varahanadhi subbasin	68	-	146

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
262	Oddambattu	Viluppuram	Gingee	Varahanadhi subbasin	56	-	72
263	Odiyattur	Viluppuram	Gingee	Varahanadhi subbasin	70	-	137
264	Padippallam	Viluppuram	Gingee	Varahanadhi subbasin	72	-	137
265	Pakkam	Viluppuram	Gingee	Varahanadhi subbasin	85	-	170
266	Palampundi	Viluppuram	Gingee	Varahanadhi subbasin	68	-	153
267	Palappattu	Viluppuram	Gingee	Varahanadhi subbasin	80	11	110
268	Pappantangal	Viluppuram	Gingee	Varahanadhi subbasin	62	-	136
269	Paraiyanpattu	Viluppuram	Gingee	Varahanadhi subbasin	64	-	138
270	Paraiyantangal	Viluppuram	Gingee	Varahanadhi subbasin	64	-	62
271	Paruttipuram	Viluppuram	Gingee	Varahanadhi subbasin	64	-	139
272	Pasumalaitangal	Viluppuram	Gingee	Varahanadhi subbasin	70	-	98
273	Periyamur	Viluppuram	Gingee	Varahanadhi subbasin	64	-	126
274	Periyanolambai	Viluppuram	Gingee	Varahanadhi subbasin	62	-	140
275	Perungappur	Viluppuram	Gingee	Varahanadhi subbasin	120	-	154
276	Peruvalur	Viluppuram	Gingee	Varahanadhi subbasin	65	-	143
277	Pinnanur	Viluppuram	Gingee	Varahanadhi subbasin	67	13	135
278	Ponnankuppam	Viluppuram	Gingee	Varahanadhi subbasin	83	-	52
279	Ponpatti	Viluppuram	Gingee	Varahanadhi subbasin	66	11	82
280	Porkunram	Viluppuram	Gingee	Varahanadhi subbasin	67	11	133
281	Pottuvay	Viluppuram	Gingee	Varahanadhi subbasin	67	13	125
282	Puduppalaiyam	Viluppuram	Gingee	Varahanadhi subbasin	70	13	132
283	Pulippattu	Viluppuram	Gingee	Varahanadhi subbasin	80	-	110
284	Pulivandi	Viluppuram	Gingee	Varahanadhi subbasin	107	-	90
285	Puttagaram	Viluppuram	Gingee	Varahanadhi subbasin	66	-	134

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
286	Sakkirapuram	Viluppuram	Gingee	Varahanadhi subbasin	74	6	137
287	Samattankuppam	Viluppuram	Gingee	Varahanadhi subbasin	61	12	145
288	Sangilikkuppam	Viluppuram	Gingee	Varahanadhi subbasin	67	-	141
289	Sattambadi	Viluppuram	Gingee	Varahanadhi subbasin	69	-	115
290	Sattanandal	Viluppuram	Gingee	Varahanadhi subbasin	67	-	145
291	Sattapputtur	Viluppuram	Gingee	Varahanadhi subbasin	68	13	149
292	Satyamangalam	Viluppuram	Gingee	Varahanadhi subbasin	14	-	138
293	Semmedu	Viluppuram	Gingee	Varahanadhi subbasin	69	-	150
294	Sennalur	Viluppuram	Gingee	Varahanadhi subbasin	84	14	86
295	Settavarai	Viluppuram	Gingee	Varahanadhi subbasin	62	-	130
296	Sevalapurai	Viluppuram	Gingee	Varahanadhi subbasin	70	-	126
297	Sindagampundi	Viluppuram	Gingee	Varahanadhi subbasin	85	35	134
298	Sindippattu	Viluppuram	Gingee	Varahanadhi subbasin	67	-	151
299	Sirudalaipundi	Viluppuram	Gingee	Varahanadhi subbasin	65	-	50
300	Sirukadambur	Viluppuram	Gingee	Varahanadhi subbasin	65	13	136
301	Sirunampundi	Viluppuram	Gingee	Varahanadhi subbasin	63	14	145
302	Sittampundi	Viluppuram	Gingee	Varahanadhi subbasin	85	-	134
303	Siyappundi	Viluppuram	Gingee	Varahanadhi subbasin	67	-	52
304	Tachchambattu	Viluppuram	Gingee	Varahanadhi subbasin	67	-	80
305	Tadagam	Viluppuram	Gingee	Varahanadhi subbasin	72	-	140
306	Tadanguppam	Viluppuram	Gingee	Varahanadhi subbasin	87	21	144
307	Tandavasamudram	Viluppuram	Gingee	Varahanadhi subbasin	77	12	88
308	Tayanur	Viluppuram	Gingee	Varahanadhi subbasin	63	-	79
309	Tenpalai	Viluppuram	Gingee	Varahanadhi subbasin	67	-	142

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
310	Torappadi	Viluppuram	Gingee	Varahanadhi subbasin	66	-	144
311	Tuttippattu	Viluppuram	Gingee	Varahanadhi subbasin	75	-	207
312	Unnamandal	Viluppuram	Gingee	Varahanadhi subbasin	87	-	134
313	Uranittangal	Viluppuram	Gingee	Varahanadhi subbasin	80	-	162
314	Vadapalai	Viluppuram	Gingee	Varahanadhi subbasin	104	14	156
315	Vadavetti	Viluppuram	Gingee	Varahanadhi subbasin	67	12	142
316	Vaduganpundi	Viluppuram	Gingee	Varahanadhi subbasin	71	-	87
317	Valatti	Viluppuram	Gingee	Varahanadhi subbasin	78	7	138
318	Vanakkambadi	Viluppuram	Gingee	Varahanadhi subbasin	68	12	148
319	Varikkal	Viluppuram	Gingee	Varahanadhi subbasin	62	-	66
320	Viramanallur	Viluppuram	Gingee	Varahanadhi subbasin	65	-	151
321	Adanur(Kil)	Viluppuram	Tindivanam	Ongur subbasin	118	40	71
322	Adanur(Mel)	Viluppuram	Tindivanam	Ongur subbasin	115	39	72
323	Adavallikuttan	Viluppuram	Tindivanam	Nallavur subbasin	71	16	82
324	Agaram (Vada)	Viluppuram	Tindivanam	Ongur subbasin	67	18	66
325	Akkur	Viluppuram	Tindivanam	Nallavur subbasin	109	32	156
326	Akshikkadu	Viluppuram	Tindivanam	Nallavur subbasin	71	40	89
327	Alagippakkam	Viluppuram	Tindivanam	Nallavur subbasin	126	32	135
328	Alagramam	Viluppuram	Tindivanam	Varahanadhi subbasin	120	29	223
329	Alappakkam	Viluppuram	Tindivanam	Nallavur subbasin	68	13	86
330	Alappakkam(Vada)	Viluppuram	Tindivanam	Nallavur subbasin	64	16	85
331	Alattur	Viluppuram	Tindivanam	Ongur subbasin	123	37	221
332	Ammanambakkam	Viluppuram	Tindivanam	Ongur subbasin	95	18	186
333	Andappattu	Viluppuram	Tindivanam	Ongur subbasin	131	35	171
334	Anganikuppam	Viluppuram	Tindivanam	Varahanadhi subbasin	-	-	-

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
335	Anumandai	Viluppuram	Tindivanam	Nallavur subbasin	97	31	222
336	Ariyankuppam	Viluppuram	Tindivanam	Nallavur subbasin	-	-	-
337	Athikuppam	Viluppuram	Tindivanam	Varahanadhi subbasin	118	18	216
338	Attipakkam	Viluppuram	Tindivanam	Ongur subbasin	118	18	216
339	Attur	Viluppuram	Tindivanam	Nallavur subbasin	116	44	131
340	Avanampattu	Viluppuram	Tindivanam	Nallavur subbasin	80	35	150
341	Avanippur	Viluppuram	Tindivanam	Ongur subbasin	124	16	123
342	Aviyakuppam	Viluppuram	Tindivanam	Nallavur subbasin	132	28	229
343	Chendur	Viluppuram	Tindivanam	Varahanadhi subbasin	152	32	208
344	Chettikuppam	Viluppuram	Tindivanam	Nallavur subbasin	76	27	108
345	Chinnanerkunam	Viluppuram	Tindivanam	Nallavur subbasin	76	15	70
346	Chiterippattu	Viluppuram	Tindivanam	Ongur subbasin	68	16	129
347	Chittamur(Kil)	Viluppuram	Tindivanam	Nallavur subbasin	89	11	54
348	Chittani	Viluppuram	Tindivanam	Varahanadhi subbasin	68	15	65
349	Elay	Viluppuram	Tindivanam	Varahanadhi subbasin	36	11	146
350	Eppakkam	Viluppuram	Tindivanam	Ongur subbasin	58	14	120
351	Evallur	Viluppuram	Tindivanam	Ongur subbasin	117	19	210
352	Ganapathipattu	Viluppuram	Tindivanam	Varahanadhi subbasin	158	34	300
353	Girandipuram	Viluppuram	Tindivanam	Ongur subbasin	40	44	86
354	Gudalur(Kil)	Viluppuram	Tindivanam	Ongur subbasin	63	31	76
355	Guruvammapettai	Viluppuram	Tindivanam	Nallavur subbasin	129	11	156
356	Iraiyanur	Viluppuram	Tindivanam	Nallavur subbasin	113	28	306
357	Kadayambakkam	Viluppuram	Tindivanam	Ongur subbasin	60	16	82
358	Kallakulattur	Viluppuram	Tindivanam	Nallavur subbasin	68	19	80
359	Kalpakkam	Viluppuram	Tindivanam	Ongur subbasin	80	27	94
360	Kambur	Viluppuram	Tindivanam	Ongur subbasin	128	29	224
361	Kandadu	Viluppuram	Tindivanam	Ongur subbasin	140	29	240

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
362	Kanniyam	Viluppuram	Tindivanam	Nallavur subbasin	70	-	128
363	Karanai (Kil)	Viluppuram	Tindivanam	Ongur subbasin	71	18	82
364	Karanavur	Viluppuram	Tindivanam	Nallavur subbasin	58	9	174
365	Karikkambattu	Viluppuram	Tindivanam	Ongur subbasin	106	19	80
366	Karuppur	Viluppuram	Tindivanam	Ongur subbasin	69	11	106
367	Karuvapakkam	Viluppuram	Tindivanam	Ongur subbasin	71	15	80
368	Kattalal	Viluppuram	Tindivanam	Ongur subbasin	138	-	246
369	Kattusiviri	Viluppuram	Tindivanam	Nallavur subbasin	130	29	229
370	Kenippatti	Viluppuram	Tindivanam	Nallavur subbasin	17	-	128
371	Kesavanayakkenpalaiyam	Viluppuram	Tindivanam	Ongur subbasin	71	8	104
372	Kodiam	Viluppuram	Tindivanam	Ongur subbasin	40	48	80
373	Kodima	Viluppuram	Tindivanam	Nallavur subbasin	93	36	92
374	Kodippakkam (Vada)	Viluppuram	Tindivanam	Ongur subbasin	64	32	98
375	Koliyankunam	Viluppuram	Tindivanam	Nallavur subbasin	148	33	207
376	Kollar	Viluppuram	Tindivanam	Nallavur subbasin	124	29	202
377	Konalur	Viluppuram	Tindivanam	Varahanadhi subbasin	52	20	121
378	Konamangalam	Viluppuram	Tindivanam	Varahanadhi subbasin	56	11	119
379	Kovadi	Viluppuram	Tindivanam	Nallavur subbasin	132	18	352
380	Kulappakkam (Ten)	Viluppuram	Tindivanam	Nallavur subbasin	80	18	114
381	Kulattur	Viluppuram	Tindivanam	Nallavur subbasin	56	7	120
382	Kunimedu	Viluppuram	Tindivanam	Nallavur subbasin	123	227	200
383	Kunnappakkam	Viluppuram	Tindivanam	Ongur subbasin	127	12	167
384	Kutterippattu	Viluppuram	Tindivanam	Nallavur subbasin	122	15	124
385	Mailam	Viluppuram	Tindivanam	Nallavur subbasin	120	-	140
386	Malaiyanur(Kil)	Viluppuram	Tindivanam	Ongur subbasin	104	29	150
387	Manbakkam	Viluppuram	Tindivanam	Ongur subbasin	84	-	112
388	Mangalam	Viluppuram	Tindivanam	Ongur subbasin	115	24	117

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
389	Mannampundi	Viluppuram	Tindivanam	Varahanadhi subbasin	-	-	-
390	Mannur(Kil)	Viluppuram	Tindivanam	Ongur subbasin	110	22	136
391	Manur	Viluppuram	Tindivanam	Nallavur subbasin	120	13	167
392	Marakkanam	Viluppuram	Tindivanam	Ongur subbasin	97	26	127
393	Mavilangal(Kil)	Viluppuram	Tindivanam	Ongur subbasin	85	31	100
394	Mavilangal(Mel)	Viluppuram	Tindivanam	Ongur subbasin	115	15	35
395	Melpakkam	Viluppuram	Tindivanam	Ongur subbasin	124	20	154
396	Molasur	Viluppuram	Tindivanam	Nallavur subbasin	115	39	250
397	Munnur	Viluppuram	Tindivanam	Nallavur subbasin	125	29	270
398	Muppuri	Viluppuram	Tindivanam	Nallavur subbasin	124	34	192
399	Murukkeri	Viluppuram	Tindivanam	Nallavur subbasin	124	26	136
400	Mutttiyur	Viluppuram	Tindivanam	Nallavur subbasin	87	29	110
401	Naduvanandal	Viluppuram	Tindivanam	Ongur subbasin	75	-	127
402	Nagalpakkam	Viluppuram	Tindivanam	Ongur subbasin	126	32	225
403	Nagar	Viluppuram	Tindivanam	Ongur subbasin	57	30	115
404	Nagavaram	Viluppuram	Tindivanam	Ongur subbasin	82	18	141
405	Nallalam(v)	Viluppuram	Tindivanam	Varahanadhi subbasin	122	37	211
406	Nallamur	Viluppuram	Tindivanam	Nallavur subbasin	60	27	106
407	Nallattur	Viluppuram	Tindivanam	Ongur subbasin	123	27	206
408	Nallur	Viluppuram	Tindivanam	Ongur subbasin	157	32	192
409	Nangunam	Viluppuram	Tindivanam	Ongur subbasin	136	20	150
410	Naramagani	Viluppuram	Tindivanam	Ongur subbasin	81	14	126
411	Nedumalaiyanur	Viluppuram	Tindivanam	Varahanadhi subbasin	74	12	108
412	Neduntondi	Viluppuram	Tindivanam	Ongur subbasin	76	10	88
413	Nemeli(Kil)	Viluppuram	Tindivanam	Ongur subbasin	120	24	155
414	Nerkunam (Vada)	Viluppuram	Tindivanam	Ongur subbasin	65	15	80
415	Nolambur	Viluppuram	Tindivanam	Ongur subbasin	123	32	210
416	Olakkur (Kilpadi)	Viluppuram	Tindivanam	Ongur subbasin	123	27	204
417	Omandur	Viluppuram	Tindivanam	Nallavur subbasin	149	36	288

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
418	Omipper	Viluppuram	Tindivanam	Nallavur subbasin	122	-	204
419	Ongur	Viluppuram	Tindivanam	Ongur subbasin	-	-	-
420	Padirippuliyur	Viluppuram	Tindivanam	Varahanadhi subbasin	79	98	70
421	Palapattu	Viluppuram	Tindivanam	Varahanadhi subbasin	84	24	135
422	Pampundi	Viluppuram	Tindivanam	Nallavur subbasin	80	24	124
423	Panchalam (v)	Viluppuram	Tindivanam	Ongur subbasin	106	13	120
424	Pangalathur	Viluppuram	Tindivanam	Ongur subbasin	84	-	124
425	Panichchamedu	Viluppuram	Tindivanam	Nallavur subbasin	85	23	178
426	Pattanam	Viluppuram	Tindivanam	Ongur subbasin	123	32	208
427	Peradikkuppam	Viluppuram	Tindivanam	Nallavur subbasin	59	25	148
428	Peradikkuppam (Mel)	Viluppuram	Tindivanam	Nallavur subbasin	117	-	98
429	Peramandur	Viluppuram	Tindivanam	Nallavur subbasin	191	59	252
430	Peramandur	Viluppuram	Tindivanam	Varahanadhi subbasin	135	30	260
431	Perani	Viluppuram	Tindivanam	Varahanadhi subbasin	80	35	85
432	Perapperi	Viluppuram	Tindivanam	Ongur subbasin	120	19	130
433	Periathachur	Viluppuram	Tindivanam	Varahanadhi subbasin	123	30	223
434	Pettal(Mel)	Viluppuram	Tindivanam	Ongur subbasin	77	-	182
435	Puduppattu(Kil)	Viluppuram	Tindivanam	Nallavur subbasin	106	19	135
436	Pulaiyur	Viluppuram	Tindivanam	Ongur subbasin	125	25	194
437	Pulliyanur	Viluppuram	Tindivanam	Ongur subbasin	73	4	90
438	Purangarai	Viluppuram	Tindivanam	Ongur subbasin	121	26	76
439	Rattanai	Viluppuram	Tindivanam	Nallavur subbasin	69	24	85
440	Rayanallur	Viluppuram	Tindivanam	Ongur subbasin	78	28	68
441	Salai	Viluppuram	Tindivanam	Nallavur subbasin	122	13	179
442	Salavadi	Viluppuram	Tindivanam	Nallavur subbasin	68	16	108
443	Saram	Viluppuram	Tindivanam	Ongur subbasin	120	-	175
444	Sattamangalam	Viluppuram	Tindivanam	Nallavur subbasin	-	-	-
445	Sattanur	Viluppuram	Tindivanam	Ongur subbasin	123	24	222

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
446	Sembakkam	Viluppuram	Tindivanam	Ongur subbasin	67	-	98
447	Sendamangalam	Viluppuram	Tindivanam	Ongur subbasin	130	26	241
448	Sendiyambakkam	Viluppuram	Tindivanam	Varahanadhi subbasin	116	-	197
449	Sevur(Kil)	Viluppuram	Tindivanam	Ongur subbasin	71	18	125
450	Seyyankuppam	Viluppuram	Tindivanam	Nallavur subbasin	111	31	142
451	Singanandal	Viluppuram	Tindivanam	Nallavur subbasin	80	26	114
452	Singanikuppam	Viluppuram	Tindivanam	Ongur subbasin	84	-	102
453	Singanur	Viluppuram	Tindivanam	Nallavur subbasin	80	7	103
454	Siruvadi	Viluppuram	Tindivanam	Ongur subbasin	135	32	292
455	Siviri(mel)	Viluppuram	Tindivanam	Ongur subbasin	77	-	71
456	Taludali	Viluppuram	Tindivanam	Nallavur subbasin	85	-	102
457	Taniyal	Viluppuram	Tindivanam	Ongur subbasin	69	13	104
458	Tengapakkam	Viluppuram	Tindivanam	Ongur subbasin	84	24	146
459	Tennampundi	Viluppuram	Tindivanam	Ongur subbasin	118	40	109
460	Tirukkanur	Viluppuram	Tindivanam	Nallavur subbasin	89	31	120
461	Ural	Viluppuram	Tindivanam	Ongur subbasin	85	40	98
462	Vadampundi	Viluppuram	Tindivanam	Ongur subbasin	148	32	194
463	Vaidapakkam	Viluppuram	Tindivanam	Ongur subbasin	75	23	78
464	Varaguppattu	Viluppuram	Tindivanam	Nallavur subbasin	86	15	81
465	Velangampadi	Viluppuram	Tindivanam	Nallavur subbasin	57	6	104
466	Veliyanur	Viluppuram	Tindivanam	Nallavur subbasin	188	-	318
467	Vempundi	Viluppuram	Tindivanam	Nallavur subbasin	57	6	87
468	Vengai	Viluppuram	Tindivanam	Nallavur subbasin	80	20	80
469	Venmaniyattur	Viluppuram	Tindivanam	Nallavur subbasin	59	6	79
470	Vepperi	Viluppuram	Tindivanam	Nallavur subbasin	82	15	126
471	Vidur	Viluppuram	Tindivanam	Varahanadhi subbasin	126	26	226
472	Vilukkam	Viluppuram	Tindivanam	Varahanadhi subbasin	145	19	117
473	Vithalapuram	Viluppuram	Tindivanam	Ongur subbasin	90	19	100

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
474	Adukkam	Viluppuram	Tirukkovilur	Varahanadhi subbasin	62	-	148
475	Alambadi	Viluppuram	Tirukkovilur	Varahanadhi subbasin	62	-	206
476	Kandachchipuram	Viluppuram	Tirukkovilur	Varahanadhi subbasin	69	-	88
477	Odaiyanattam RF	Viluppuram	Tirukkovilur	Varahanadhi subbasin	63	-	230
478	Oddambattu	Viluppuram	Tirukkovilur	Varahanadhi subbasin	67	-	112
479	Oduvankuppam	Viluppuram	Tirukkovilur	Varahanadhi subbasin	61	-	169
480	Satyakandanur	Viluppuram	Tirukkovilur	Varahanadhi subbasin	78	-	199
481	V.Puduppalaiyam	Viluppuram	Tirukkovilur	Varahanadhi subbasin	-	-	-
482	Virangipuram	Viluppuram	Tirukkovilur	Varahanadhi subbasin	68	-	148
483	Acharampattu	Viluppuram	Vanur	Nallavur subbasin	66	17	86
484	Adanappattu	Viluppuram	Vanur	Nallavur subbasin	65	17	97
485	Aiveli	Viluppuram	Vanur	Varahanadhi subbasin	81	16	88
486	Akasampattu	Viluppuram	Vanur	Nallavur subbasin	89	16	99
487	Ambulukkai	Viluppuram	Vanur	Varahanadhi subbasin	85	17	110
488	Anpakkam	Viluppuram	Vanur	Nallavur subbasin	83	-	77
489	Appirambattu	Viluppuram	Vanur	Nallavur subbasin	64	15	131
490	Aruvadai	Viluppuram	Vanur	Nallavur subbasin	62	14	90
491	Aruvapakkam	Viluppuram	Vanur	Nallavur subbasin	66	18	83
492	Bommayapalayam	Viluppuram	Vanur	Nallavur subbasin	71	13	72
493	Edaiyandapattu	Viluppuram	Vanur	Varahanadhi subbasin	68	20	121
494	Idaichcheri	Viluppuram	Vanur	Nallavur subbasin	68	17	116
495	Ilavampattu	Viluppuram	Vanur	Nallavur subbasin	70	19	106
496	Iraiyur	Viluppuram	Vanur	Nallavur subbasin	48	11	84
497	Irumbai	Viluppuram	Vanur	Nallavur subbasin	60	12	109

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
498	Kadagampattu	Viluppuram	Vanur	Varahanadhi subbasin	64	12	86
499	Kadapperikuppam	Viluppuram	Vanur	Varahanadhi subbasin	72	19	120
500	Kaluperumbakkam	Viluppuram	Vanur	Nallavur subbasin	92	13	100
501	Karasanur	Viluppuram	Vanur	Nallavur subbasin	75	11	102
502	Karattai	Viluppuram	Vanur	Nallavur subbasin	63	11	105
503	Kayilamedu	Viluppuram	Vanur	Nallavur subbasin	78	19	80
504	Kilappakkam	Viluppuram	Vanur	Nallavur subbasin	74	15	72
505	Kodur	Viluppuram	Vanur	Nallavur subbasin	80	16	85
506	Koluvari	Viluppuram	Vanur	Nallavur subbasin	64	-	146
507	Komadippattu	Viluppuram	Vanur	Nallavur subbasin	64	-	165
508	Kondalankuppam	Viluppuram	Vanur	Varahanadhi subbasin	56	12	80
509	Kondamur	Viluppuram	Vanur	Nallavur subbasin	52	14	83
510	Kottaikuppam	Viluppuram	Vanur	Nallavur subbasin	68	13	74
511	Kumalambattu RF	Viluppuram	Vanur	Nallavur subbasin	65	12	80
512	Kunjimangalam	Viluppuram	Vanur	Nallavur subbasin	65	10	80
513	Kunnam	Viluppuram	Vanur	Nallavur subbasin	71	11	110
514	Kurakkeni	Viluppuram	Vanur	Varahanadhi subbasin	62	14	82
515	Mattur	Viluppuram	Vanur	Nallavur subbasin	75	15	86
516	Murukkam	Viluppuram	Vanur	Nallavur subbasin	65	14	80
517	Nallavur	Viluppuram	Vanur	Nallavur subbasin	50	11	85
518	Nemali(Kil)	Viluppuram	Vanur	Varahanadhi subbasin	57	15	94
519	Nesal	Viluppuram	Vanur	Nallavur subbasin	60	-	60
520	Olundiyappattu	Viluppuram	Vanur	Nallavur subbasin	73	9	60
521	Ottai	Viluppuram	Vanur	Varahanadhi subbasin	84	14	144

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
522	Parangani	Viluppuram	Vanur	Nallavur subbasin	80	12	134
523	Parangani	Viluppuram	Vanur	Nallavur subbasin	80	12	134
524	Parikkalpattu	Viluppuram	Vanur	Nallavur subbasin	66	18	106
525	Perambai	Viluppuram	Vanur	Varahanadhi subbasin	72	22	108
526	Peravur	Viluppuram	Vanur	Nallavur subbasin	20	5	36
527	Perumbakkam	Viluppuram	Vanur	Nallavur subbasin	64	12	82
528	Pombur	Viluppuram	Vanur	Varahanadhi subbasin	63	18	139
529	Puduppakkam	Viluppuram	Vanur	Nallavur subbasin	84	-	77
530	Pulichapallam	Viluppuram	Vanur	Nallavur subbasin	61	13	116
531	Putturai	Viluppuram	Vanur	Varahanadhi subbasin	49	12	66
532	Rayaottai	Viluppuram	Vanur	Nallavur subbasin	51	19	86
533	Rayapuduppakkam	Viluppuram	Vanur	Nallavur subbasin	58	18	81
534	Semangalam	Viluppuram	Vanur	Nallavur subbasin	72	15	58
535	Sengamedu	Viluppuram	Vanur	Varahanadhi subbasin	75	15	58
536	Sirunavur	Viluppuram	Vanur	Nallavur subbasin	93	10	91
537	Siruvai	Viluppuram	Vanur	Varahanadhi subbasin	49	8	86
538	Tailapuram	Viluppuram	Vanur	Nallavur subbasin	55	16	85
539	Terkunam	Viluppuram	Vanur	Nallavur subbasin	52	29	60
540	Tiruchitambalam	Viluppuram	Vanur	Nallavur subbasin	40	28	56
541	Tiruvaikkarai	Viluppuram	Vanur	Varahanadhi subbasin	46	24	54
542	Tollamur	Viluppuram	Vanur	Nallavur subbasin	64	22	86
543	Toruvai	Viluppuram	Vanur	Nallavur subbasin	60	24	82
544	Ulagapuram	Viluppuram	Vanur	Nallavur subbasin	80	-	105
545	Vilvanattam	Viluppuram	Vanur	Nallavur subbasin	66	15	86

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
546	Asur	Viluppuram	Vikravandi	Varahanadhi subbasin	110	12	90
547	Avadaiyarpattu	Viluppuram	Vikravandi	Varahanadhi subbasin	95	-	100
548	Ayyuragaram	Viluppuram	Vikravandi	Varahanadhi subbasin	86	9	105
549	Brammadesam	Viluppuram	Vikravandi	Varahanadhi subbasin	94	-	108
550	Chinna Thachhur	Viluppuram	Vikravandi	Varahanadhi subbasin	86	-	120
551	Enaviram	Viluppuram	Vikravandi	Varahanadhi subbasin	77	-	85
552	Esalam	Viluppuram	Vikravandi	Varahanadhi subbasin	80	-	80
553	Ichchanguppam	Viluppuram	Vikravandi	Varahanadhi subbasin	91	7	87
554	Kapiyampuliyur	Viluppuram	Vikravandi	Varahanadhi subbasin	84	8	84
555	Kasbakaranai	Viluppuram	Vikravandi	Varahanadhi subbasin	91	-	97
556	Konkarambundi	Viluppuram	Vikravandi	Varahanadhi subbasin	96	7	120
557	Kottiyampundi	Viluppuram	Vikravandi	Varahanadhi subbasin	82	-	110
558	Kundalappuliyur	Viluppuram	Vikravandi	Varahanadhi subbasin	82	-	108
559	Kuthampondi	Viluppuram	Vikravandi	Varahanadhi subbasin	88	-	115
560	Mandagapattu (E)	Viluppuram	Vikravandi	Varahanadhi subbasin	106	-	112
561	Melkondai	Viluppuram	Vikravandi	Varahanadhi subbasin	100	-	108
562	Mundiyambakkam	Viluppuram	Vikravandi	Varahanadhi subbasin	76	-	101
563	Mungilpattu	Viluppuram	Vikravandi	Varahanadhi subbasin	82	10	97
564	Muttattur	Viluppuram	Vikravandi	Varahanadhi subbasin	87	-	98
565	Nagar	Viluppuram	Vikravandi	Varahanadhi subbasin	98	-	76
566	Nandivadi	Viluppuram	Vikravandi	Varahanadhi subbasin	106	15	80
567	Narasinganur	Viluppuram	Vikravandi	Varahanadhi subbasin	88	-	90
568	Nemur	Viluppuram	Vikravandi	Varahanadhi subbasin	94	14	102
569	Orattur	Viluppuram	Vikravandi	Varahanadhi subbasin	114	-	78

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
570	Pagandai	Viluppuram	Vikravandi	Varahanadhi subbasin	108	17	76
571	Panapakkam	Viluppuram	Vikravandi	Varahanadhi subbasin	110	-	91
572	Panayapuram	Viluppuram	Vikravandi	Varahanadhi subbasin	90	-	67
573	Pappanpattu	Viluppuram	Vikravandi	Varahanadhi subbasin	99	-	90
574	Pidarippattu	Viluppuram	Vikravandi	Varahanadhi subbasin	98	14	94
575	Radhapuram	Viluppuram	Vikravandi	Varahanadhi subbasin	80	-	92
576	Sattanur(V)	Viluppuram	Vikravandi	Varahanadhi subbasin	55	-	82
577	Suravalikuppam	Viluppuram	Vikravandi	Varahanadhi subbasin	82	-	92
578	Tennavarayanpattu	Viluppuram	Vikravandi	Varahanadhi subbasin	91	5	90
579	Tenper	Viluppuram	Vikravandi	Varahanadhi subbasin	108	-	82
580	Tirunandipuram	Viluppuram	Vikravandi	Varahanadhi subbasin	90	-	87
581	Toravi	Viluppuram	Vikravandi	Varahanadhi subbasin	76	-	90
582	Tumbur	Viluppuram	Vikravandi	Varahanadhi subbasin	81	5	92
583	Vadakuchchipalayam	Viluppuram	Vikravandi	Varahanadhi subbasin	86	11	86
584	Vakkur	Viluppuram	Vikravandi	Varahanadhi subbasin	80	-	92
585	Veliyandal	Viluppuram	Vikravandi	Varahanadhi subbasin	77	11	96
586	Vembi	Viluppuram	Vikravandi	Varahanadhi subbasin	78	-	109
587	Vettukkadu	Viluppuram	Vikravandi	Varahanadhi subbasin	82	10	106
588	Alattur	Viluppuram	Viluppuram	Varahanadhi subbasin	75	7	80
589	Aliyur	Viluppuram	Viluppuram	Varahanadhi subbasin	72	6	90
590	Arasankuppam	Viluppuram	Viluppuram	Varahanadhi subbasin	90	-	100
591	Aripisampalayam	Viluppuram	Viluppuram	Varahanadhi subbasin	92	-	100
592	Cholampundi	Viluppuram	Viluppuram	Varahanadhi subbasin	80	-	80
593	Ilangadu	Viluppuram	Viluppuram	Varahanadhi subbasin	-	-	-

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
594	KA.Kuppam	Viluppuram	Viluppuram	Varahanadhi subbasin	115	-	86
595	Kallappattu	Viluppuram	Viluppuram	Varahanadhi subbasin	100	-	106
596	Kandamangalam	Viluppuram	Viluppuram	Varahanadhi subbasin	105	7	85
597	Kilperumbakkam	Viluppuram	Viluppuram	Varahanadhi subbasin	-	-	-
598	Kolippttu	Viluppuram	Viluppuram	Varahanadhi subbasin	104	-	85
599	Koliyanur	Viluppuram	Viluppuram	Varahanadhi subbasin	100	8	85
600	Kondangi	Viluppuram	Viluppuram	Varahanadhi subbasin	110	-	106
601	Kondur	Viluppuram	Viluppuram	Varahanadhi subbasin	95	-	100
602	Kottambakkam	Viluppuram	Viluppuram	Varahanadhi subbasin	96	9	106
603	Kumidiyankuppam	Viluppuram	Viluppuram	Varahanadhi subbasin	-	-	-
604	Maharajapuram 2	Viluppuram	Viluppuram	Varahanadhi subbasin	-	-	-
605	Mandagappattu	Viluppuram	Viluppuram	Varahanadhi subbasin	110	10	102
606	Mangkuppam	Viluppuram	Viluppuram	Varahanadhi subbasin	-	-	-
607	Melpadi	Viluppuram	Viluppuram	Varahanadhi subbasin	115	-	89
608	Nannadu	Viluppuram	Viluppuram	Varahanadhi subbasin	90	-	90
609	Naraiyur	Viluppuram	Viluppuram	Varahanadhi subbasin	100	4	95
610	Pallichcheri	Viluppuram	Viluppuram	Varahanadhi subbasin	-	-	-
611	Pallippuduppattu	Viluppuram	Viluppuram	Varahanadhi subbasin	76	-	92
612	Pallittendal	Viluppuram	Viluppuram	Varahanadhi subbasin	86	10	92
613	Panampattu	Viluppuram	Viluppuram	Varahanadhi subbasin	95	-	100
614	Poyyapakkam	Viluppuram	Viluppuram	Varahanadhi subbasin	85	-	90
615	Pudur	Viluppuram	Viluppuram	Varahanadhi subbasin	98	-	82
616	Salaiagram	Viluppuram	Viluppuram	Varahanadhi subbasin	75	7	73
617	Salaiyampalaiyam	Viluppuram	Viluppuram	Varahanadhi subbasin	90	6	70

Sl. No.	Village Name	District Name	Taluk Name	Subbasin Name	N	P	K
618	Sattipattu	Viluppuram	Viluppuram	Varahanadhi subbasin	75	-	70
619	Sengadu 1	Viluppuram	Viluppuram	Varahanadhi subbasin	80	-	92
620	Siruvandadu	Viluppuram	Viluppuram	Varahanadhi subbasin	108	6	90
621	Todandanur	Viluppuram	Viluppuram	Varahanadhi subbasin	70	10	85
622	Tugavadi	Viluppuram	Viluppuram	Varahanadhi subbasin	80	-	80
623	Vaduganatham Kuppam	Viluppuram	Viluppuram	Varahanadhi subbasin	-	-	-
624	Vailamur	Viluppuram	Viluppuram	Varahanadhi subbasin	-	-	-
625	Viramur	Viluppuram	Viluppuram	Varahanadhi subbasin	80	8	92
626	Virattikuppam	Viluppuram	Viluppuram	Varahanadhi subbasin	100	6	70

Nutrient Management

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

Resource Management

When crops are harvested, a considerable amount of nutrients are removed from the soil system. Only a part of nutrients are available. It is replaced in the form of manure from crop residue. Leaching, erosion, Volatilization etc., removes some nutrients from the soil. Soil fertility may be retained by soil testing and adding required organic matter so that the soil will be ready for the next yield.

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, are having indirect bearing on water planning. The nature of employment viz., agricultural, industrial etc., in the Basin also would reflect on the water requirement.

The Varahanadhi River Basin falls 95.4% in TamilNadu in the districts of Villupuram, Kancheepuram, Tiruvannamalai & Cuddalore and 4.6 % in Puduchery Union Territory. An analysis of social and demographic characteristics in Villupuram, Kancheepuram, Tiruvannamalai & Cuddalore districts gives an idea of such characteristics in the Varahanadhi River Basin.

2.11.1 Population in Varahanadhi River Basin

45.76% of total area of Villupuram District (3287.206 sq.km out of 7182.86 sq.km), 17% of total area of Kancheepuram District (753.81 sq.km out of 4428.49 sq.km), 7.78% of total area of Tiruvannamali District (481.402 sq.km out of 6186.82 sq.km) and 0.38% of total area of Cuddalore District (14.092 sq.km out of 3699.61 sq.km) covers the Varahanadhi River Basin and population of districts covered in Varahanadhi River Basin within the Basin as per census 2011 is given below in **Table 2.12.1**.

Table 2.12.1 District wise Population details of Varahanadhi River Basin

Sl. No	Name of the District	Population as per census 2011			Population as projected to 2017		
		Rural (in Million)	Urban (in Million)	Total (in Million)	Rural (in Millions)	Urban (in Millions)	Total (in Million)
1	Villupuram	1.353	0.285	1.638	1.436	0.321	1.757
2	Kancheepuram	0.371	0.038	0.409	0.393	0.043	0.436
3	Tiruvannamalai	0.153	0.022	0.175	0.163	0.024	0.187
4	Cuddalore	0.011	0.000	0.010	0.011	0.000	0.011
	Total	**1.888**	**0.345**	**2.233**	**2.003**	**0.389**	**2.392**

There are 3 (three) sub Basins in Varahanadhi 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 Varahanadhi River Basin are given in **Appendix 2.10.1 to 2.10.3.** The Sub Basin wise Population of Varahanadhi River Basin is given in the **Table 2.12.2**. The population of Varahanadhi River Basin is projected for the targeted years 2017, 2020, 2030, 2040 & 2050 which is detailed in Chapter 7.

Table 2.12.2 Sub Basin wise Population in Varahanadhi River Basin

S. No	NAME OF SUB BASIN	As per census 2011 (in million)			As projected to 2017 (in million)		
		Rural	Urban	Total	Rural	Urban	Total
1.	Nallavur	0.279	0.094	0.373	0.296	0.106	0.402
2.	Ongur	0.520	0.055	0.575	0.552	0.062	0.614
3.	Varahanadhi	1.089	0.196	1.285	1.155	0.221	1.376
	Total	**1.888**	**0.345**	**2.233**	**2.003**	**0.389**	**2.392**

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, transportation infrastructure, natural amenities, and land use and development across space and time.

In the micro level reappraisal study of the Varahanadhi River Basin, water demand from 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 Varahanadhi River Basin based on census 2011 is projected to the present year 2017. The average annual exponential growth rate is used to find the growth of urban and rural population and projecting the population.

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

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

Where Pt = Population after'‘t’ years

Po = Population in the beginning years

X = Average Annual exponential growth rate and is calculated by

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

Where, X = Annual growth rate

Yo = Population in base year

Yt = Population in t^{th} year

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

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

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

S.No	Census Period	Average Annual Exponential growth rate	
		Rural	Urban
1	1991-2001	-052%	3.7%
2	2001-2011	0.06%	2.4%

Projections may be made with reference to the recent observed trend in growth. Hence, for this present forecast the growth rate may be adopted as 1% for Rural population and 2% for Urban Population.The projected population in Varahanadhi River Basin for 2017 is given below in **Table 2.12.3,**

Table 2.12.3 Projected population in Varahanadhi River Basin for 2017

S. No	NAME OF SUB BASIN	Area in Sq.km	Total Rural Population in million		Total Urban Population in million		Total	
			2011	2017	2011	2017	2011	2017
1	Nallavur	788.777	0.279	0.296	0.094	0.106	0.373	0.402
2	Ongur	1274.731	0.520	0.552	0.055	0.062	0.575	0.614
3	Varahanadhi	2473.003	1.089	1.155	0.196	0.221	1.285	1.376
	Total	**4536.510**	**1.888**	**2.003**	**0.345**	**0.389**	**2.233**	**2.392**

Source: Census 2011

From the above table it is inferred that about 85% of people live in Rural area in this Varahanadhi River Basin.

2.11.3 Population Density

Population density is a measurement of population per unit area. The Sub Basin wise population density of Varahanadhi River Basin is given in **Table 2.12.4.** The population density is higher in Varahanadhi sub Basin (519 persons per sq.km) and lower in Ongur sub Basin (451 Persons per sq.km).

Table 2.12.4 Sub Basin wise population density in the Varahanadhi River Basin

Sl. No	Name of the sub Basin	Area (Sq.km)	Total population 2011	Density (Person/Sq.km)
1.	Nallavur	788.777	373265	473
2.	Ongur	1274.731	575117	451
3.	Varahanadhi	2473.003	1284704	519
Total		**4536.51**	**2233086**	**492**
Average population Density				**492**

2.11.4 Population by Sex

The sex wise distribution of population in Varahanadhi River Basin as per census 2011 is given in **Table 2.12.5,**

Table 2.12.5 District wise population by Sex in Varahanadhi River Basin

Sl. No	Name of the District	Area of the district in the Basin in Sq.km	Total Population (million) As per Census 2011	Population of Male (million)	% Male	Population of Female (million)	% Female
1	Villupuram	3287.206	1.638	0.822	50%	0.816	50%
2	Kanchee puram	753.810	0.409	0.205	50%	0.204	50%
3	Tiruvanna malai	481.402	0.176	0.088	50%	0.088	50%
4	Cuddalore	14.092	0.010	0.005	50%	0.005	50%
	Total	**4536.51**	**2.233**	**1.120**	**50%**	**1.113**	**50%**

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 Ongur Sub Basin & Varahanadhi Sub Basin has a equal sex ratio of 1000 females to every 1000 males. The sex wise distribution of population in all the sub basins of Varahanadhi River Basin is given below in **Table 2.12.6,**

Table 2.12.6 Sex wise population distribution in the Varahanadhi River Basin

Sl. No	Name of the Sub Basin	Population			Male %	Female %	Total %	Sex Ratio
		Male	Female	Total				
1	Nallavur	0.188	0.186	0.374	50%	50%	100%	989 females for 1000 males
2	Ongur	0.288	0.287	0.575	50%	50%	100%	1000 females for 1000 males
3	Varahanadhi	0.644	0.640	1.284	50%	50%	100%	1000 females for 1000 males
	Total	**1.120**	**1.113**	**2.233**	50%	50%	100%	998 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 Varahanadhi River Basin is worked out sub basin wise and is given in **Table 2.12.7.** The overall literacy rate of Varahanadhi River Basin is found to be 66.25 %.

Table 2.12.7 Details of Literacy level in Varahanadhi River Basin

(Population in Million)

Sl. No.	Name of the Sub Basin	Literacy Population			Total Population			% Literacy of Population		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
1	Nallavur	0.140	0.112	0.252	0.188	0.186	0.374	74.46%	60.28%	67.41%
2	Ongur	0.208	0.165	0.373	0.288	0.287	0.575	72.16%	57.45%	64.82%
3	Varahanadhi	0.476	0.379	0.855	0.644	0.640	1.284	73.84%	59.20%	48.64%
	Total	**0.824**	**0.656**	**1.480**	**1.120**	**1.113**	**2.233**	**73.45%**	**58.93%**	**66.25%**

Source: Census 2011

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 Varahanadhi River Basin as per the Statistical Handbook of Tamil Nadu 2016 for the period 2012 is given in **Table 2.12.8,**

Table 2.12.8

Details of Births and Deaths Registered in Districts covered in Varahanadhi River Basin

Sl. No.	Name of the District	Mid – Year Estimated Population for 2017	As on Year 2015				
			Births	Deaths	Infant Deaths	Still Births	Maternal Deaths
1	Villupuram	1959494	45618	20133	356	295	14
2	Kancheepuram	1767591	44566	23724	233	97	22
3	Thiruvannamalai	1655002	32545	17906	220	74	8
4	Cuddalore	2829790	37047	14697	273	127	5

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 aim of the programme at the early stage was to reduce births by fixing contraceptive targets only. But, now it has been changed to bring down fertility through improving maternal and child health care. The "Target oriented approach" has been shifted to "Community Needs Assessment Approach" in which the needs of the community have to be assessed based on the requirements of the people in the implementation of family welfare and maternity child health programmes.

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. The adoption of family planning practices reveal that sterilization has been the most favorable method, followed by the use of IUD (Intra – Uterine Device).

Family welfare Programme details for the districts covered by the Varahanadhi Basin for the period of 2014-15 is given in **Table 2.12.9**

Table 2.12.9

Details of Family Welfare Programme in Districts of Varahanadhi River Basin

Name of the District	2015-16				2016-17			
	Sterilization	IUCD	Oral Pill Users	Users of Conventional Contraceptives	Sterilization	IUCD	Oral Pill Users	Users of Conventional Contraceptives
Villupuram	11025	17754	3413	4071	10901	14264	3580	5129
Kancheepuram	14576	12813	2274	2310	14065	13368	2085	2441
Tiruvannamalai	9405	12097	1476	2826	9170	11308	1558	2238
Cuddalore	8358	17174	3390	5409	8197	15363	3215	6549

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 Varahanadhi River Basin is given in **Table 2.12.10,**

Table No 2.12.10 Number of Households in Varahanadhi River Basin (2011)

Sl.No	Name of the Sub Basin	Total Population (in million)	Number of House Holds
1	Nallavur	0.374	87148
2	Ongur	0.575	140829
3	Varahanadhi	1.284	302638
	Total	**2.233**	**530614**

Source: Census of India 2011

2.11.10 Economic Profile of the Districts covered in Varahanadhi River Basin

There are 852 small scale industries, 54 large & medium scale industries in Varahanadhi River Basin. The water requirement for the industrial purpose for large & medium and small scale industries are estimated as 7.942 Mcum and 3.838 Mcum respectively. The projected future water demand for large & medium scale industries for the targeted year 2020, 2030, 2040 & 2050 are estimated as 10.483 Mcum, 18.869 Mcum, 33.965 Mcum & 61.137 Mcum respectively. The projected future water demand for small scale industries for the targeted year 2020, 2030, 2040 & 2050 are estimated as 5.066 Mcum, 9.119 Mcum, 16.413 Mcum & 29.544 Mcum respectively.

Villupuram District

The district is an agrarian district and the main activity for livelihood of the people in the district is paddy cultivation. There is a good scope for the industry that is willing to manufacture energy food all the age groups. Traditional industries like weaving of lunghi spread over at Gingee, Kandamangalam, Kanai and Mugaiyur blocks of the district. Blue metal industries are coming up now-days at Mailam and Marakkanam blocks of the district. Wheat products and food processing units are coming up at Vanur block of this district. Export of fish, frozen fruits and vegetables having good scope in the coastal area of Marakkanam Block of the district.

Kancheepuram District

Kancheepuram district is one of the industrially fastest growing districts in Tamil Nadu. The electronic and software industry is one of the fastest growing sectors in the district. Special industrial parks for software industries assisted the growth of this sector. Auto components and automobile industry,garment industry , agro based industry, dairy and dairy products, textile and leather industry are some of industries present in this district.

Tiruvannamalai District

Agriculture is the main stay of the Economy. The main agriculture produce are paddy, groundnut, banana and sugarcane. Dairy farming is an important source of subsidiary income to small and marginal farmers. Poultry is also an important occupation. There are only small and tiny industries found in this District.

2.11.11 Employment Opportunities

The resources available in the basin also have a direct link with the water planning for the basin .The various resources available in the districts falling in the Varahanadhi River Basin are discussed hereunder. The various industries discussed above in the districts covering Varahanadhi River Basin provide employment to the people in the Basin.

The District Industries Centre and the Single Window Committee headed by the Collector help industrialists in getting the needed clearances from various Government Organizations. The committee co-operates all district level officers necessary to handle the requests seeking by the entrepreneurs for minor and medium industries. Other institutions like SIPCOT, TIDCO, TIIC and Directorate of Industries and Commerce provide valuable support for major industries.

The District Industries Centre was started on the objective to find out the Micro Small Medium Enterprises (MSME) in the District. Also it helps those Enterprises to tackle their hurdles faced by the MSME's under one roof. The District Industries Centre functioning at the district level, provides all the services and support facilities to the entrepreneurs for setting up Small and medium Industries.

The District Industrial Centre is offering assistances in form of various subsidies to the Entrepreneurs. Through motivation campaigns, Entrepreneur Development programme for Women, Small scale industries registration, concession & subsides subsidy for asset creation for intellectual property etc, the DICs motivate the entrepreneurs.

In Varahanadhi River Basin, the District Industrial Centers are functioning at Villupuram, Kancheepuram & Tiruvannamalai District.

The various schemes of District Industrial Centre are,

i. MSME – Micro Small and Medium Enterprises
ii. PMEGP – Prime Ministers Employment Generation Programme
iii. UYEGP – Unemployed Youth Employment Generation Programme
iv. NEEDS - New Enterprise Cum Enterprise Development scheme

Through the above schemes loans has been offered for the entrepreneurs for commencing manufacturing and servicing unit. Subsidies in various forms have also been offered particularly for the backward blocks in the district.

The details of backward blocks in Varahanadhi River Basin is given in **Table 2.12.11** as below,

Table No 2.12.11 District wise list of Backward Blocks

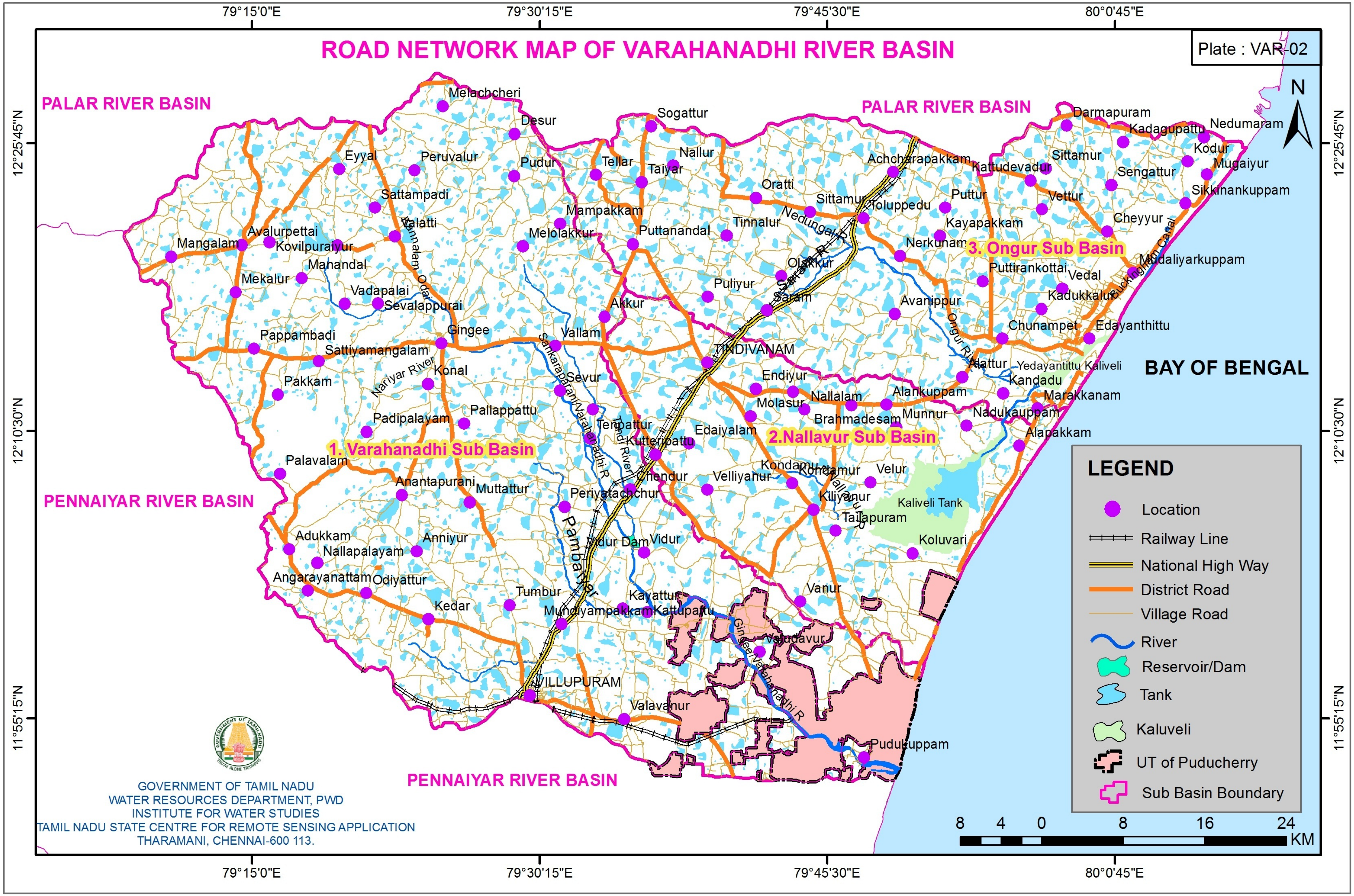
Sl. No.	Name of District	Backward Blocks in the District	Backward Blocks in the Varahanadhi River Basin
1	Villupuram	Chinnaselam Gingee Kallakurichi Kalvarayan Hill Kanani Kandamangalam Marakannam Mel Malaiyanur Milam Mugaiyur Olakkur Rishivandhiyam Sankarapuram Thiagadurgam	Gingee Kanani Kandamangalam Milam Marakannam Mel Malaiyanur Olakkur Vallam Vanur Vikkiravandi

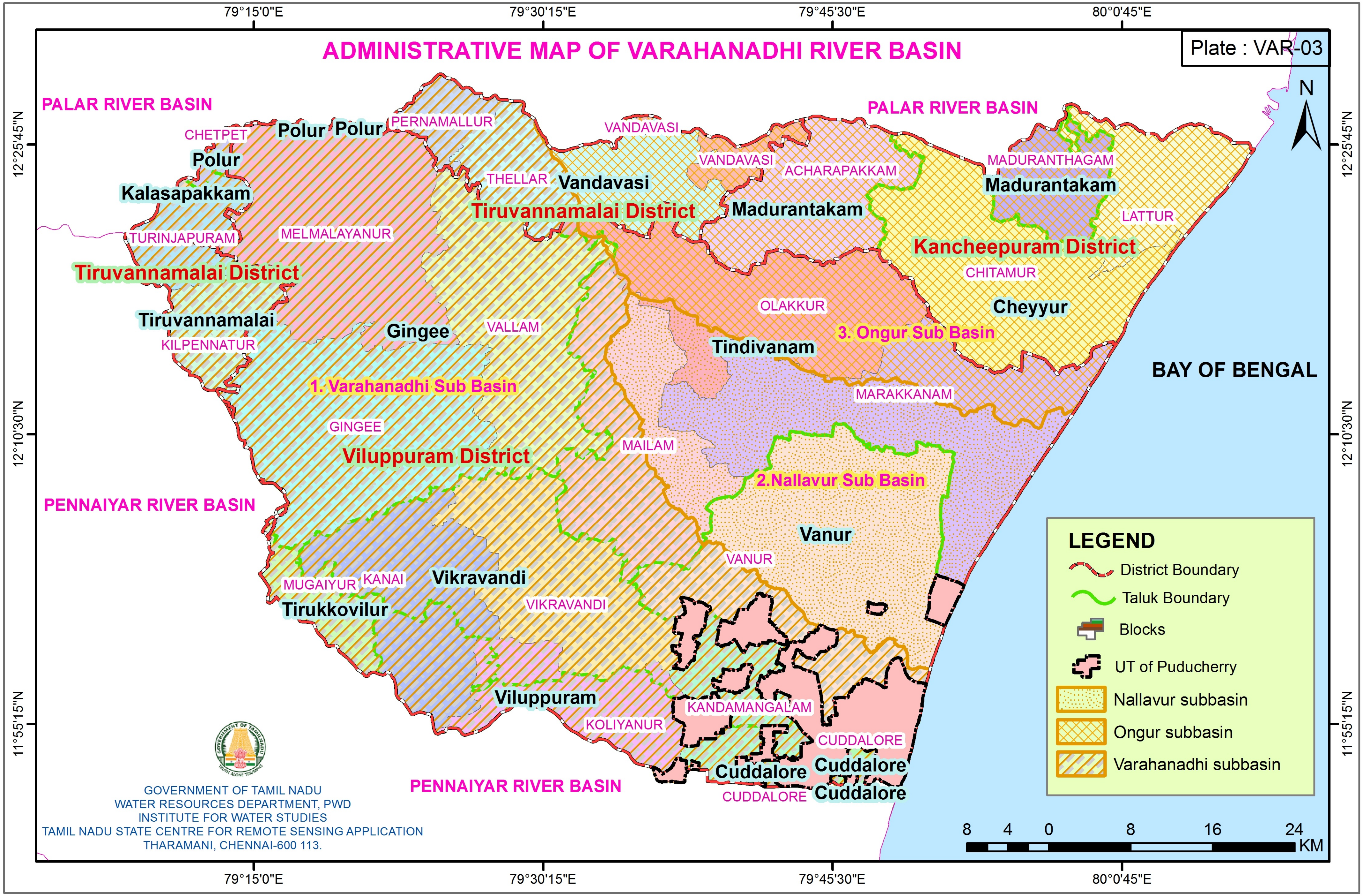
		Thirukoilur Thirunavalur T.V.Nallur Ulundurpet Vallam Vanur Vikkiravandi	
2	Kancheepuram	Archarapakkam Chittamur Kannathur Lathur Maduranthagam Tirukalukundram Uthiramerur Walajabad	Archarapakkam Chittamur Lathur Maduranthagam
3	Tiruvannamalai	Anakavur Arani Chengam Chetpet Cheyyar Jawathu Hills Kalasapakkam Keelpennathur Peramanallur Polur Pudhupalayam Thandarampet Thellar Thurinjapuram Vandavasi Vembakkam West- Arani	Chetpet Kalasapakkam Keelpennathur Peramanallur Thurinjapuram Thellar Vandavasi
4	Cuddalore	Annagramam Kammapuram Kattumannarkoil Kumaratchi Kurinjipadi Mangalur Mel-Bhuvanagiri Nallur Parangipettai	Nil

(Source: Directorate of Industries & Commerce, Government of Tamil Nadu)

Industrial Policy has been pursued by the Tamil Nadu Government with a main objective to achieve massive increase in employment by promoting Small Industries and Rural Industries. In accordance with this policy, promotion of large and medium scale industries as well as small-scale industries have been aimed at the districts of the Tamil Nadu, in collaboration with Tamil Nadu Industrial Investment Corporation (TIIC), Tamil Nadu Industrial Development Corporation (TIDCO) and Tamil Nadu Corporation for Industrial Infrastructure Development (TACID).

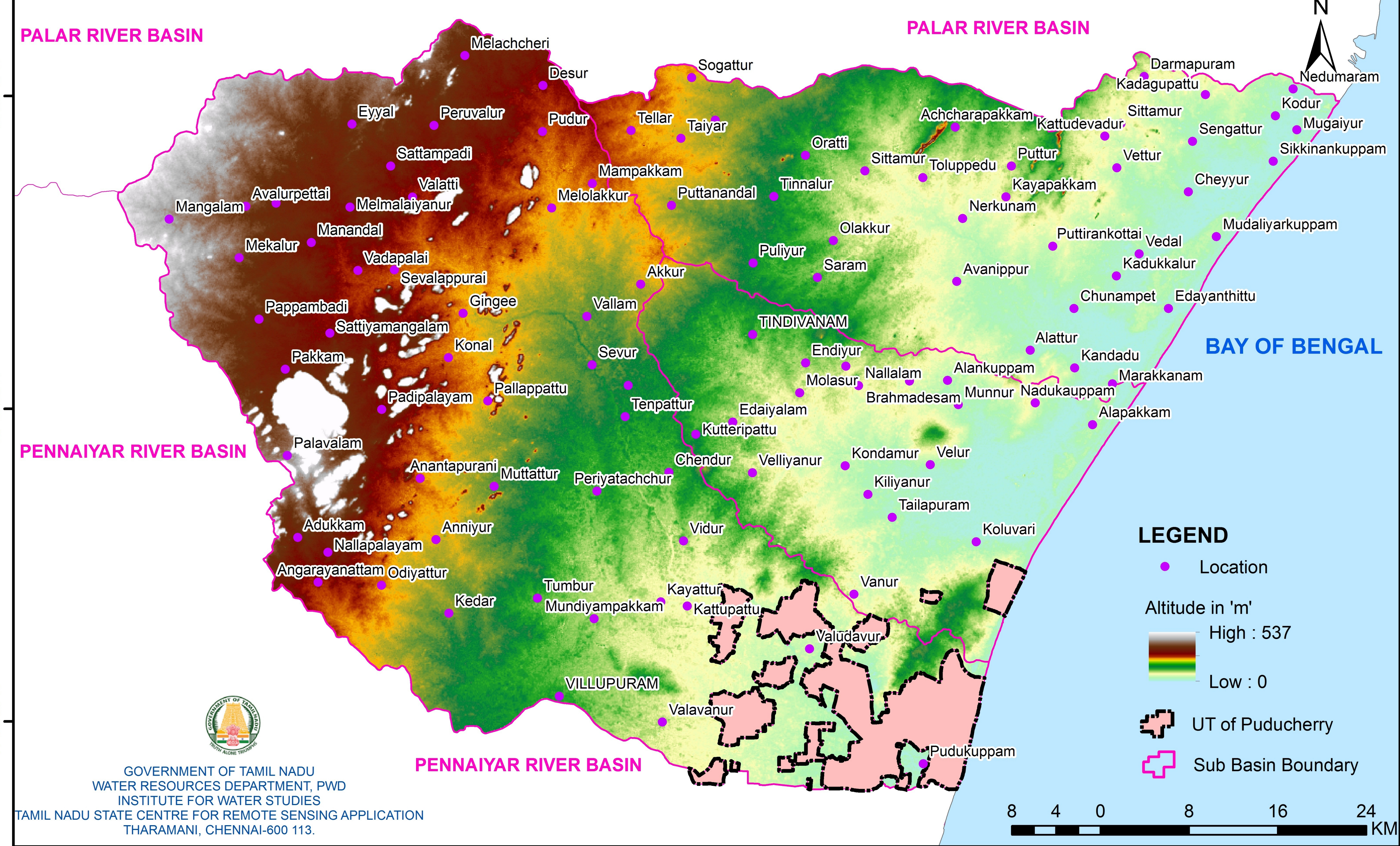
For this purpose, a thrust has been given to establish, promote and develop the rural industries and the Government also in active move in promoting Self-Employment opportunity in Urban and Rural areas by extending financial assistance through banking sector for the establishment and development of small industries.


ROAD NETWORK MAP OF VARAHANADHI RIVER BASIN
Plate : VAR-02
79°15'0"E
79°30'15"E
79°45'30"E
80°0'45"E
12°25'45"N
12°10'30"N
11°55'15"N
N
PALAR RIVER BASIN
PALAR RIVER BASIN
PENNAIYAR RIVER BASIN
PENNAIYAR RIVER BASIN
BAY OF BENGAL
1. Varahanadhi Sub Basin
2.Nallavur Sub Basin
3. Ongur Sub Basin
Melachcheri
Desur
Sogattur
Darmapuram
Kadagupattu
Nedumaram
Kodur
Mugaiyur
Eyyal
Peruvalur
Pudur
Tellar
Nallur
Taiyar
Achcharapakkam
Kattudevadur
Sittamur
Sengattur
Sikkinankuppam
Sattampadi
Oratti
Sittamur
Toluppedu
Puttur
Vettur
Mampakkam
Valatti
Melolakkur
Puttanandal
Tinnalur
Kayapakkam
Cheyyur
Mangalam
Avalurpettai
Kovilpuraiyur
Nerkunam
Mudaliyarkuppam
Mahandal
Olakkur
Puttirankottai
Vedal
Mekalur
Vadapalai
Sevalappurai
Puliyur
Saram
Avanippur
Kadukkalur
Akkur
Gingee
Vallam
Chunampet
Edayanthittu
Pappambadi
Sattiyamangalam
TINDIVANAM
Alattur
Yedayantittu Kaliveli
Kandadu
Konal
Sevur
Endiyur
Pakkam
Nallalam
Alankuppam
Marakkanam
Molasur
Nadukauppam
Padipalayam
Pallappattu
Tenpattur
Brahmadesam
Munnur
Alapakkam
Edaiyalam
Kutteripattu
Palavalam
Kondamur
Kondamur
Velur
Anantapurani
Chendur
Velliyanur
Muttattur
Periyatachchur
Kiliyanur
Kaliveli Tank
Tailapuram
Adukkam
Anniyur
Vidur Dam
Vidur
Koluvari
Nallapalayam
Angarayanattam
Odiyattur
Vanur
Tumbur
Kayattur
Kedar
Mundiyampakkam
Kattupattu
Valudavur
VILLUPURAM
Valavanur
Pudukuppam
Nariyar River
Sankaraparani/Varahanadhi R
Tindi River
Pambaiyar
Ongur R
Nallavur
Gingee/Varahanadhi R
Nedungal R
Buckingham Canal
Vannalam Odai
LEGEND
Location
Railway Line
National High Way
District Road
Village Road
River
Reservoir/Dam
Tank
Kaluveli
UT of Puducherry
Sub Basin Boundary
8 4 0 8 16 24
KM
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI-600 113.

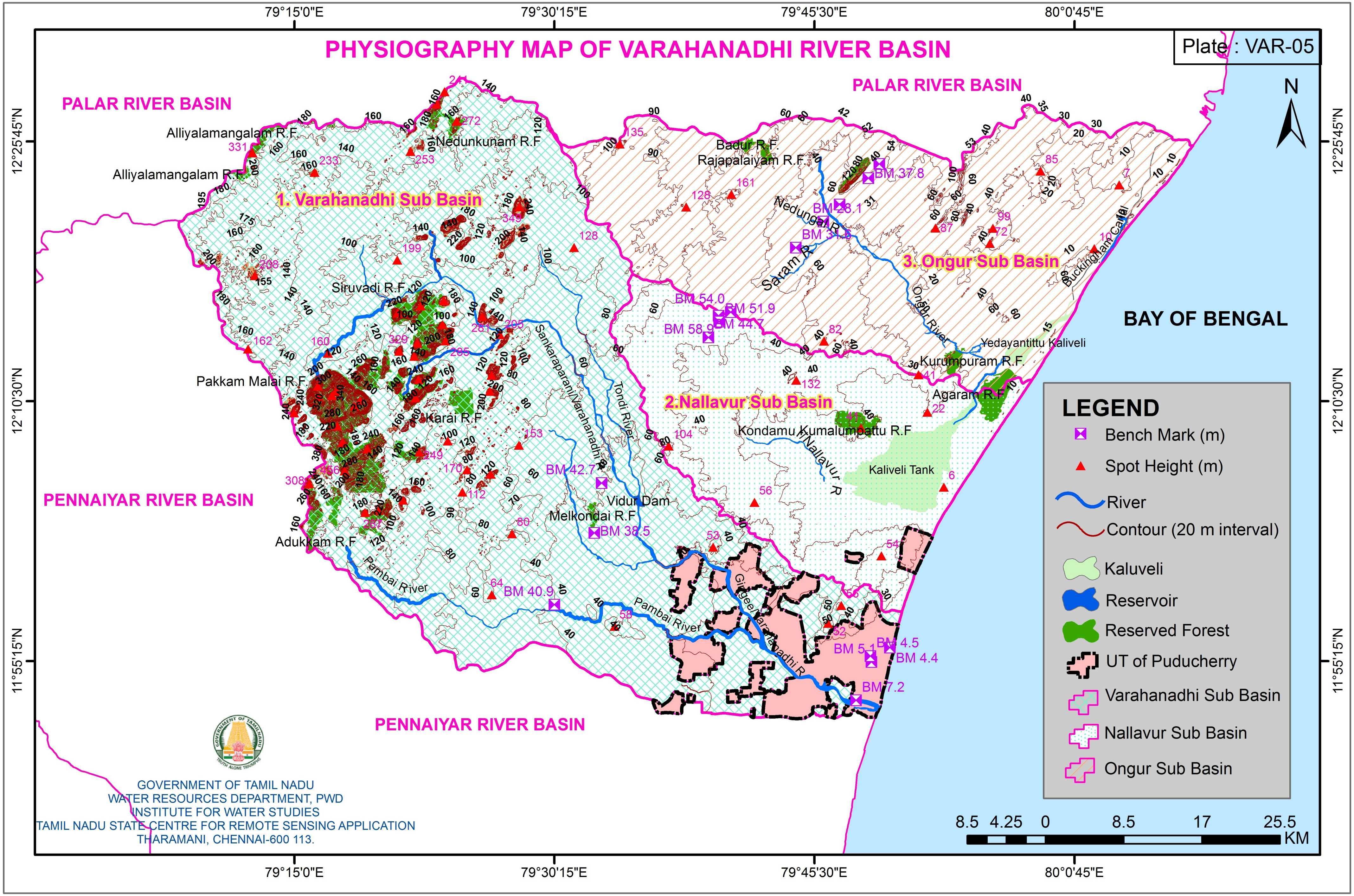

ADMINISTRATIVE MAP OF VARAHANADHI RIVER BASIN
Plate : VAR-03
79°15'0"E
79°30'15"E
79°45'30"E
80°0'45"E
12°25'45"N
12°10'30"N
11°55'15"N
N
PALAR RIVER BASIN
PALAR RIVER BASIN
PENNAIYAR RIVER BASIN
PENNAIYAR RIVER BASIN
BAY OF BENGAL
CHETPET
Polur
Polur
Polur
PERNAMALLUR
VANDAVASI
VANDAVASI
ACHARAPAKKAM
MADURANTHAGAM
Madurantakam
Madurantakam
LATTUR
THELLAR
Vandavasi
Kalasapakkam
Tiruvannamalai District
Tiruvannamalai District
Kancheepuram District
TURINJAPURAM
MELMALAYANUR
CHITAMUR
Cheyyur
OLAKKUR
3. Ongur Sub Basin
Tiruvannamalai
KILPENNATUR
Gingee
VALLAM
Tindivanam
1. Varahanadhi Sub Basin
MARAKKANAM
GINGEE
MAILAM
Viluppuram District
2.Nallavur Sub Basin
Vanur
VANUR
MUGAIYUR
KANAI
Vikravandi
Tirukkovilur
VIKRAVANDI
Viluppuram
KANDAMANGALAM
KOLIYANUR
CUDDALORE
Cuddalore
Cuddalore
CUDDALORE
Cuddalore
LEGEND
District Boundary
Taluk Boundary
Blocks
UT of Puducherry
Nallavur subbasin
Ongur subbasin
Varahanadhi subbasin
8 4 0 8 16 24
KM
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI-600 113.

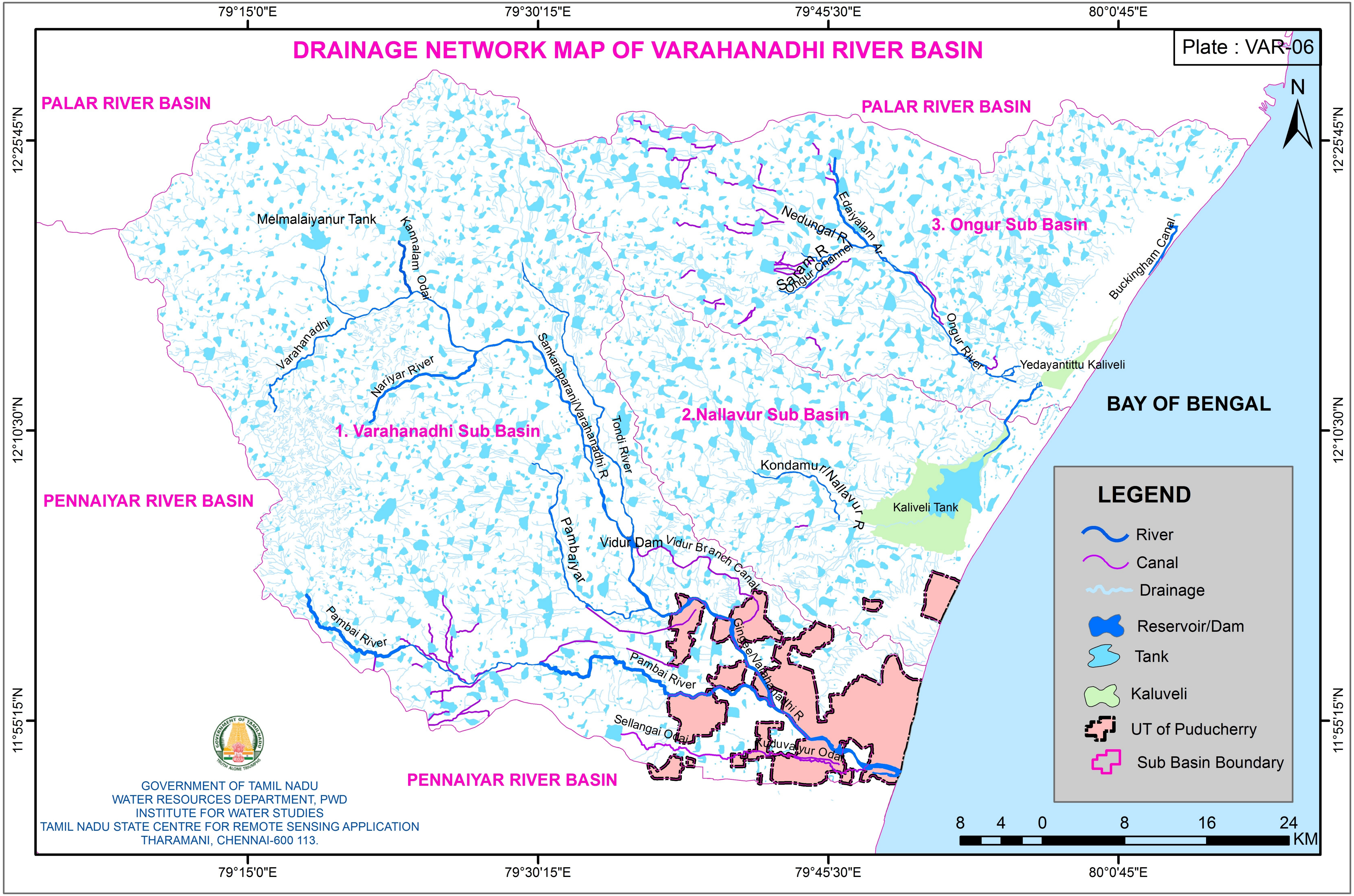
DIGITAL ELEVATION MODEL OF VARAHANADHI RIVER BASIN

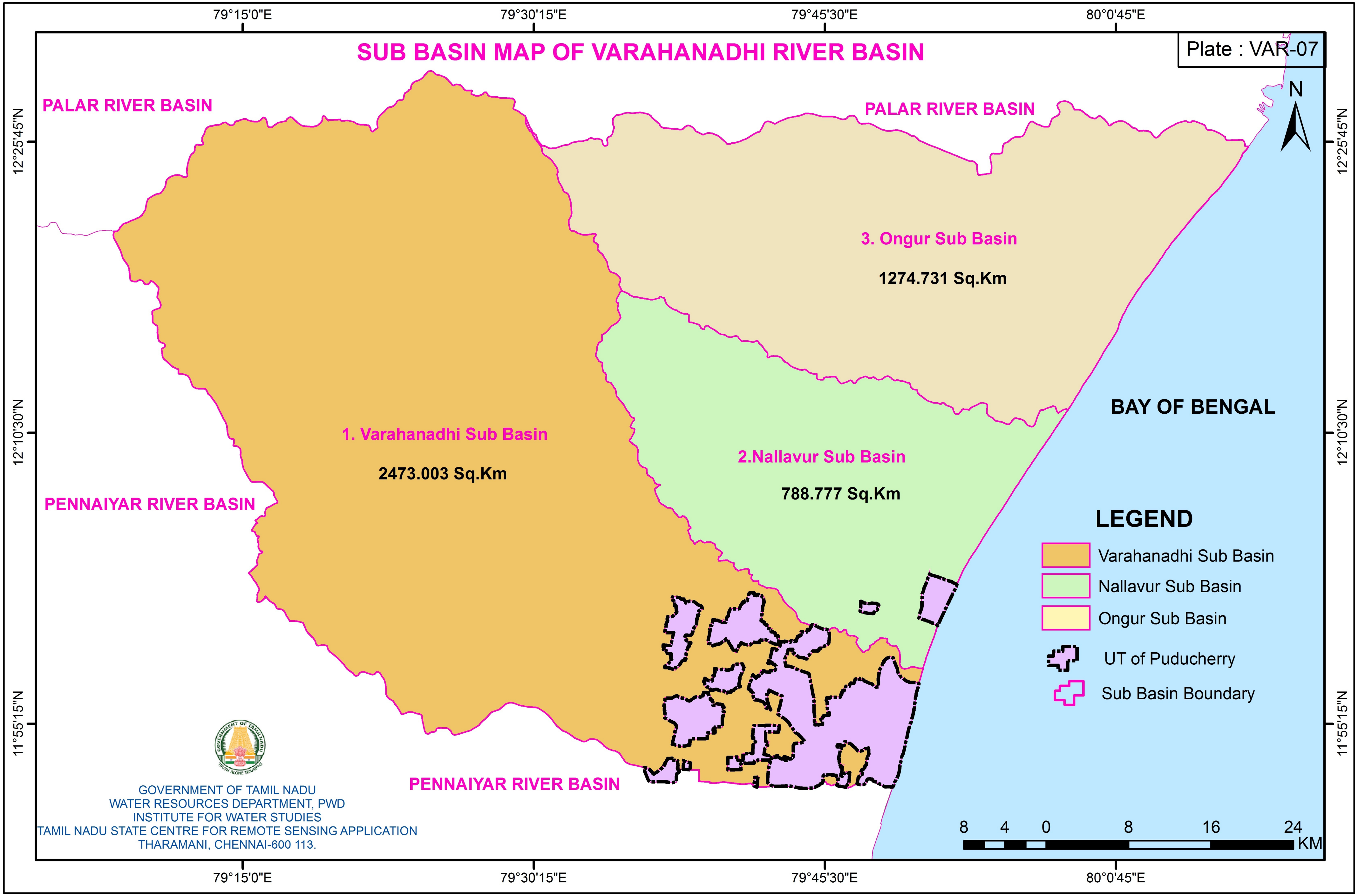
Plate : VAR-04



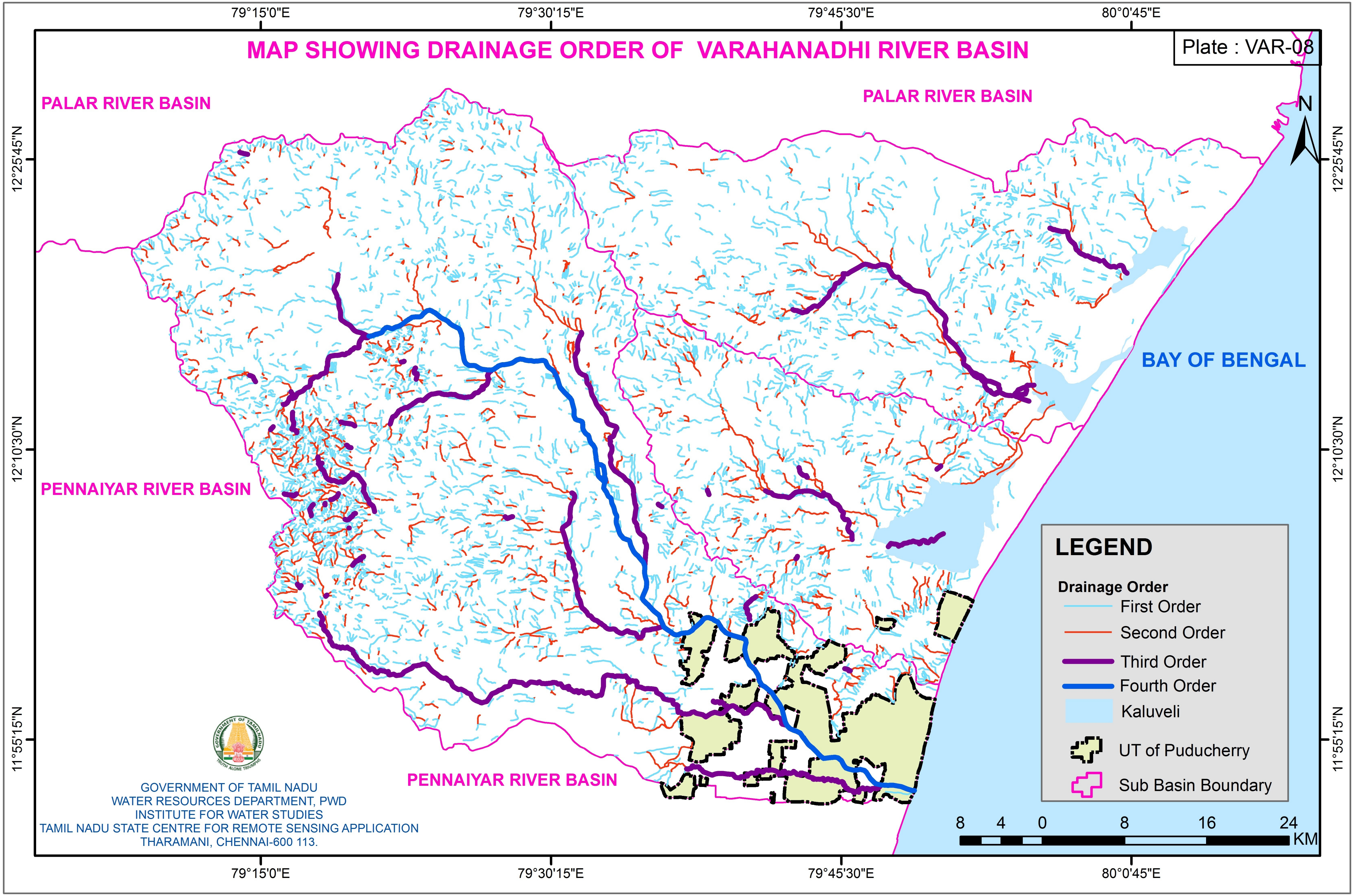
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI-600 113.

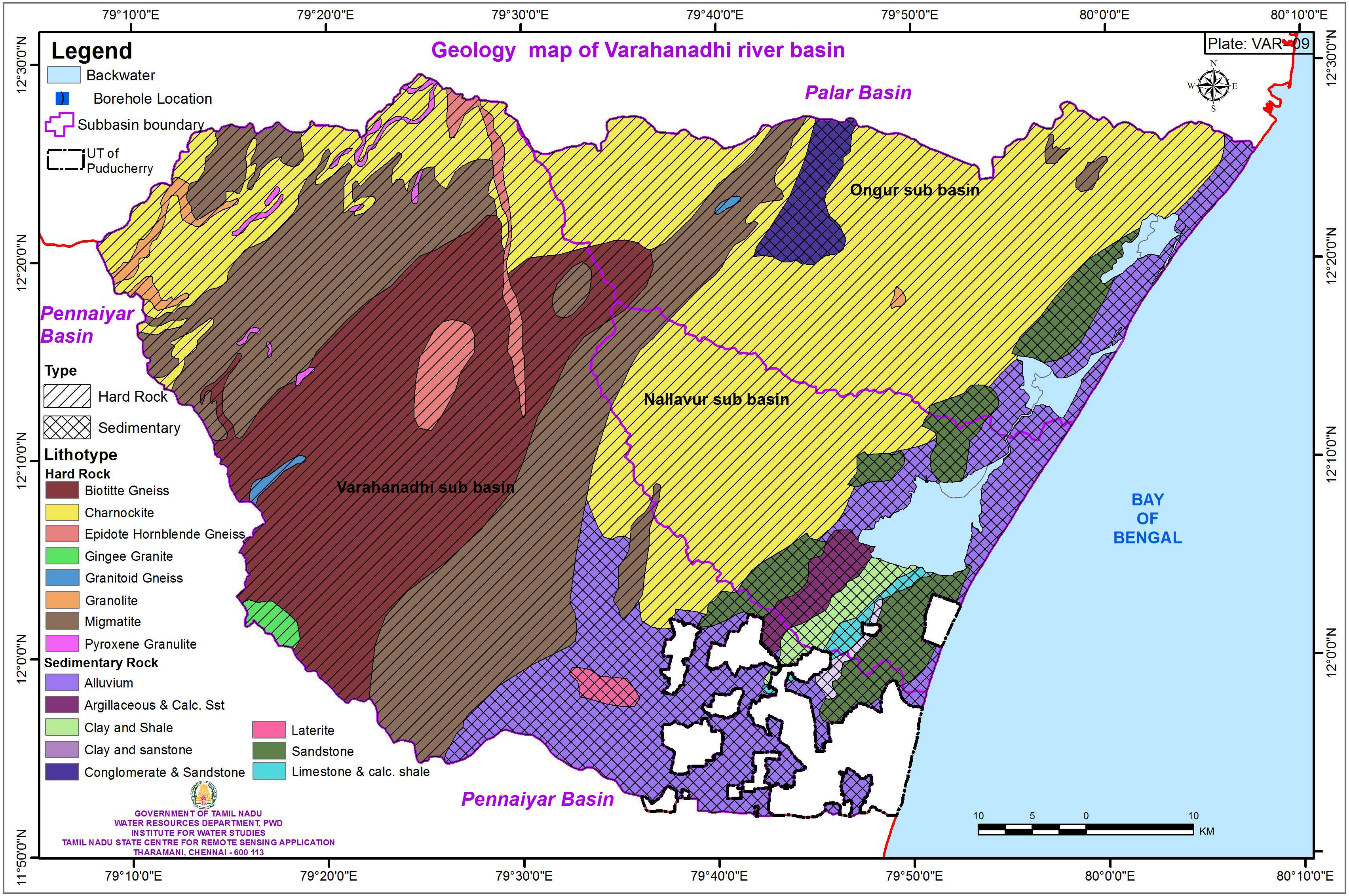

PHYSIOGRAPHY MAP OF VARAHANADHI RIVER BASIN
Plate : VAR-05
79°15'0"E
79°30'15"E
79°45'30"E
80°0'45"E
12°25'45"N
12°10'30"N
11°55'15"N
PALAR RIVER BASIN
PENNAIYAR RIVER BASIN
BAY OF BENGAL
1. Varahanadhi Sub Basin
2.Nallavur Sub Basin
3. Ongur Sub Basin
Alliyalamangalam R.F.
Nedunkunam R.F
Siruvadi R.F
Pakkam Malai R.F.
Karai R.F
Adukkam R.F
Melkondai R.F
Vidur Dam
Badur R.F.
Rajapalaiyam R.F.
Kondamu Kumalumpattu R.F
Kaliveli Tank
Yedayantittu Kaliveli
Kurumpuram R.F.
Agaram R.F
Sankaraparani/Varahanadhi R
Tondi River
Pambai River
Gingee/Varahanadhi R
Nedungal R
Saram R
Ongur River
Nallavur R
Buckingham Canal
BM 54.0
BM 51.9
BM 58.9
BM 44.7
BM 37.8
BM 28.1
BM 31.8
BM 42.7
BM 38.5
BM 40.9
BM 5.1
BM 4.5
BM 4.4
BM 7.2
N
LEGEND
Bench Mark (m)
Spot Height (m)
River
Contour (20 m interval)
Kaluveli
Reservoir
Reserved Forest
UT of Puducherry
Varahanadhi Sub Basin
Nallavur Sub Basin
Ongur Sub Basin
8.5 4.25 0 8.5 17 25.5
KM
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI-600 113.

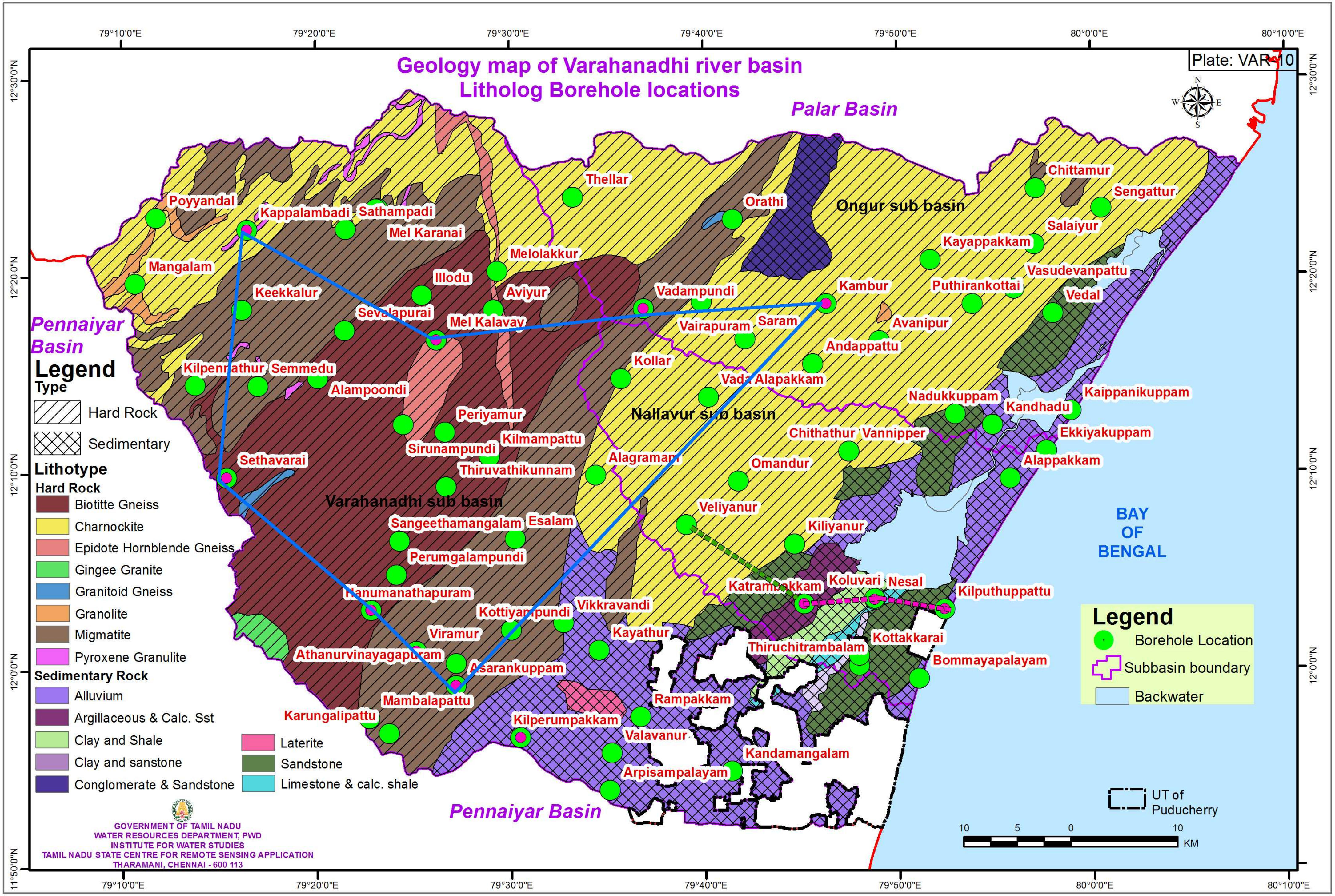

DRAINAGE NETWORK MAP OF VARAHANADHI RIVER BASIN
Plate : VAR-06
79°15'0"E
79°30'15"E
79°45'30"E
80°0'45"E
12°25'45"N
12°10'30"N
11°55'15"N
N
PALAR RIVER BASIN
PALAR RIVER BASIN
PENNAIYAR RIVER BASIN
PENNAIYAR RIVER BASIN
BAY OF BENGAL
1. Varahanadhi Sub Basin
2.Nallavur Sub Basin
3. Ongur Sub Basin
Melmalaiyanur Tank
Kannalam Odai
Varahanadhi
Nariyar River
Sankaraparani/Varahanadhi R
Tondi River
Pambaiyar
Vidur Dam
Vidur Branch Canal
Pambai River
Pambai River
Gingee/Varahanadhi R
Sellangai Odai
Kuduvaiyur Odai
Kondamur/Nallavur R
Kaliveli Tank
Nedungal R
Edaiyalam Ar
Salam R
Ongur Channel
Ongur River
Yedayantittu Kaliveli
Buckingham Canal
LEGEND
River
Canal
Drainage
Reservoir/Dam
Tank
Kaluveli
UT of Puducherry
Sub Basin Boundary
8 4 0 8 16 24
KM
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI-600 113.



SUB BASIN MAP OF VARAHANADHI RIVER BASIN
Plate : VAR-07
79°15'0"E
79°30'15"E
79°45'30"E
80°0'45"E
12°25'45"N
12°10'30"N
11°55'15"N
N
PALAR RIVER BASIN
PALAR RIVER BASIN
PENNAIYAR RIVER BASIN
PENNAIYAR RIVER BASIN
BAY OF BENGAL
1. Varahanadhi Sub Basin
2473.003 Sq.Km
2.Nallavur Sub Basin
788.777 Sq.Km
3. Ongur Sub Basin
1274.731 Sq.Km
LEGEND
Varahanadhi Sub Basin
Nallavur Sub Basin
Ongur Sub Basin
UT of Puducherry
Sub Basin Boundary
8 4 0 8 16 24
KM
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI-600 113.


MAP SHOWING DRAINAGE ORDER OF VARAHANADHI RIVER BASIN
Plate : VAR-08
79°15'0"E
79°30'15"E
79°45'30"E
80°0'45"E
12°25'45"N
12°10'30"N
11°55'15"N
N
PALAR RIVER BASIN
PALAR RIVER BASIN
PENNAIYAR RIVER BASIN
PENNAIYAR RIVER BASIN
BAY OF BENGAL
LEGEND
Drainage Order
First Order
Second Order
Third Order
Fourth Order
Kaluveli
UT of Puducherry
Sub Basin Boundary
8 4 0 8 16 24
KM
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI-600 113.

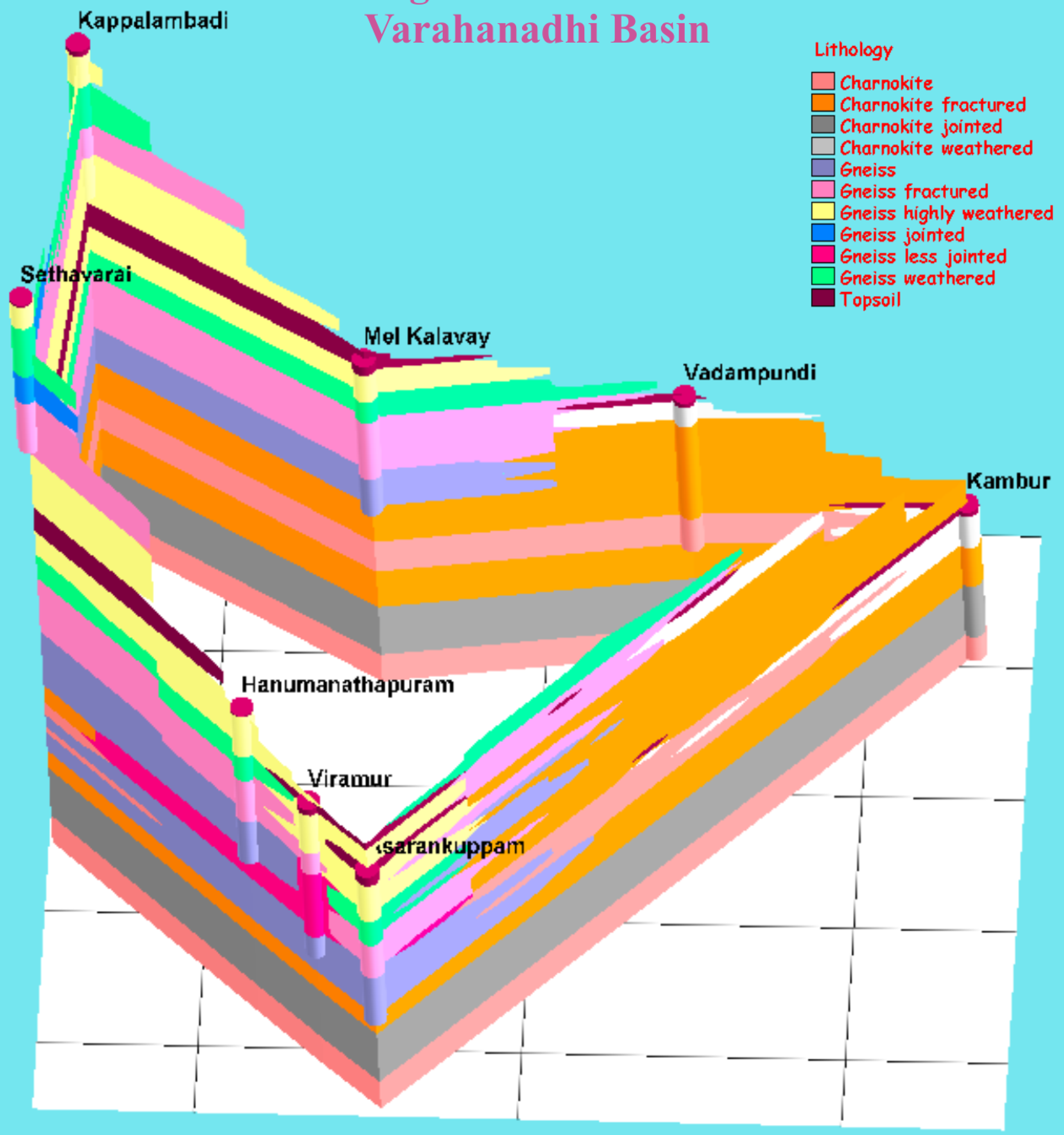

Geology map of Varahanadhi river basin
Plate: VAR-09
Legend
Backwater
Borehole Location
Subbasin boundary
UT of Puducherry
Type
Hard Rock
Sedimentary
Lithotype
Hard Rock
Biotitte Gneiss
Charnockite
Epidote Hornblende Gneiss
Gingee Granite
Granitoid Gneiss
Granolite
Migmatite
Pyroxene Granulite
Sedimentary Rock
Alluvium
Argillaceous & Calc. Sst
Clay and Shale
Clay and sanstone
Conglomerate & Sandstone
Laterite
Sandstone
Limestone & calc. shale
Palar Basin
Pennaiyar Basin
Pennaiyar Basin
Ongur sub basin
Nallavur sub basin
Varahanadhi sub basin
BAY OF BENGAL
N
S
E
W
79°10'0"E
79°20'0"E
79°30'0"E
79°40'0"E
79°50'0"E
80°0'0"E
80°10'0"E
12°30'0"N
12°20'0"N
12°10'0"N
12°0'0"N
11°50'0"N
10 5 0 10
KM
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI - 600 113



Geology map of Varahanadhi river basin
Litholog Borehole locations
Plate: VAR-10
Palar Basin
Pennaiyar Basin
Pennaiyar Basin
Ongur sub basin
Nallavur sub basin
Varahanadhi sub basin
BAY OF BENGAL
Poyyandal
Kappalambadi
Sathampadi
Mel Karanai
Mangalam
Thellar
Orathi
Chittamur
Sengattur
Salaiyur
Kayappakkam
Melolakkur
Illodu
Aviyur
Keekkalur
Sevalapurai
Mel Kalavay
Vadampundi
Kambur
Puthirankottai
Vasudevanpattu
Vedal
Vairapuram
Saram
Avanipur
Andappattu
Kollar
Kilpennathur
Semmedu
Alampoondi
Vada Alapakkam
Periyamur
Nadukkuppam
Kandhadu
Kaippanikuppam
Sirunampundi
Kilmampattu
Chithathur
Vannipper
Ekkiyakuppam
Sethavarai
Thiruvathikunnam
Alagramam
Omandur
Alappakkam
Veliyanur
Sangeethamangalam
Esalam
Kiliyanur
Perumgalampundi
Hanumanathapuram
Katrambakkam
Koluvari
Nesal
Kilputhuppattu
Kottiyampundi
Vikkravandi
Viramur
Kayathur
Thiruchitrambalam
Kottakkarai
Athanurvinayagapuram
Asarankuppam
Bommayapalayam
Mambalapattu
Rampakkam
Karungalipattu
Kilperumpakkam
Valavanur
Kandamangalam
Arpisampalayam
Legend
Type
Hard Rock
Sedimentary
Lithotype
Hard Rock
Biotitte Gneiss
Charnockite
Epidote Hornblende Gneiss
Gingee Granite
Granitoid Gneiss
Granolite
Migmatite
Pyroxene Granulite
Sedimentary Rock
Alluvium
Argillaceous & Calc. Sst
Clay and Shale
Clay and sanstone
Conglomerate & Sandstone
Laterite
Sandstone
Limestone & calc. shale
Legend
Borehole Location
Subbasin boundary
Backwater
UT of Puducherry
10 5 0 10
KM
79°10'0"E
79°20'0"E
79°30'0"E
79°40'0"E
79°50'0"E
80°0'0"E
80°10'0"E
12°30'0"N
12°20'0"N
12°10'0"N
12°0'0"N
11°50'0"N
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI - 600 113

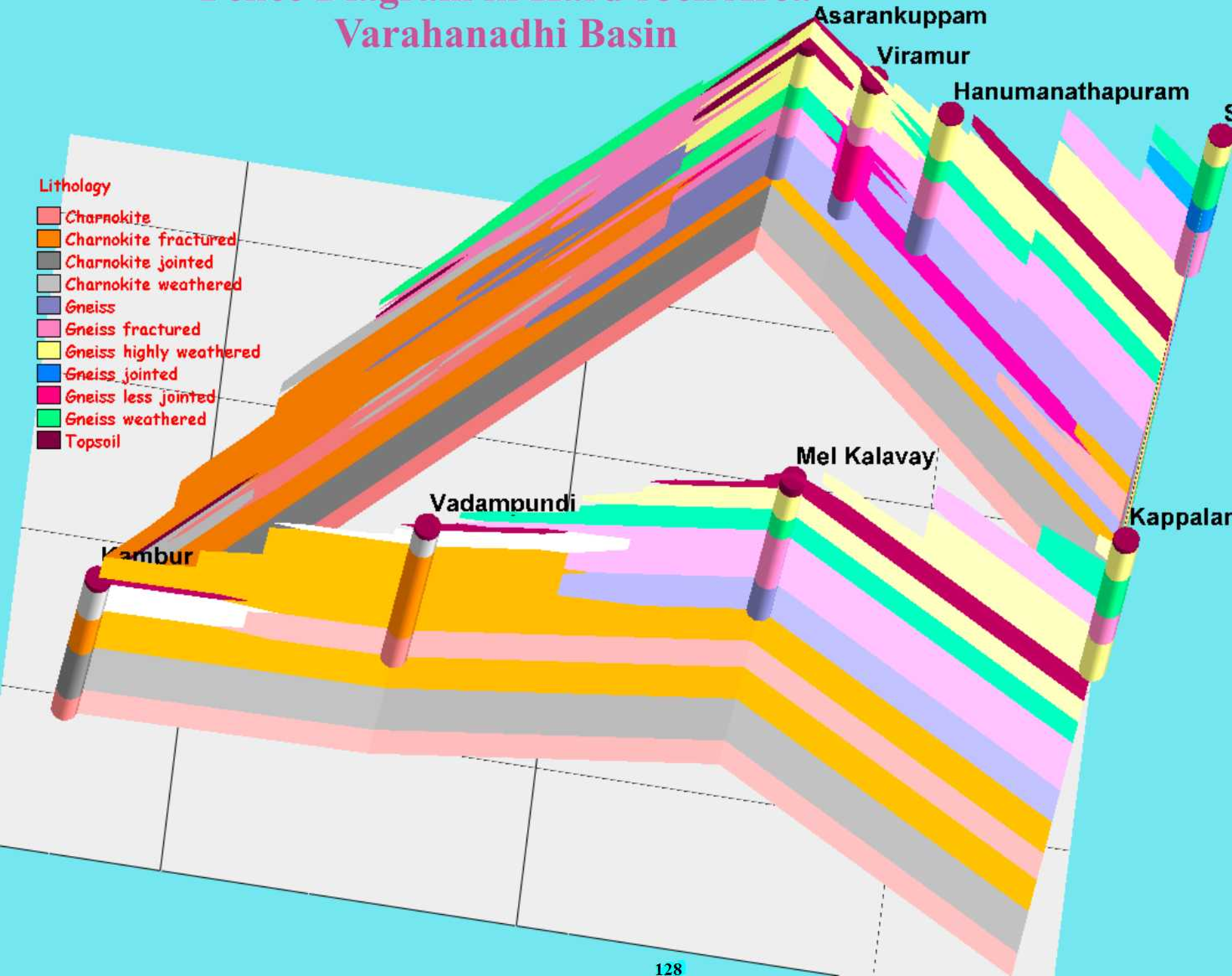
Fence Diagram in Hard rock Area
Varahanadhi Basin

Plate: VAR-11A

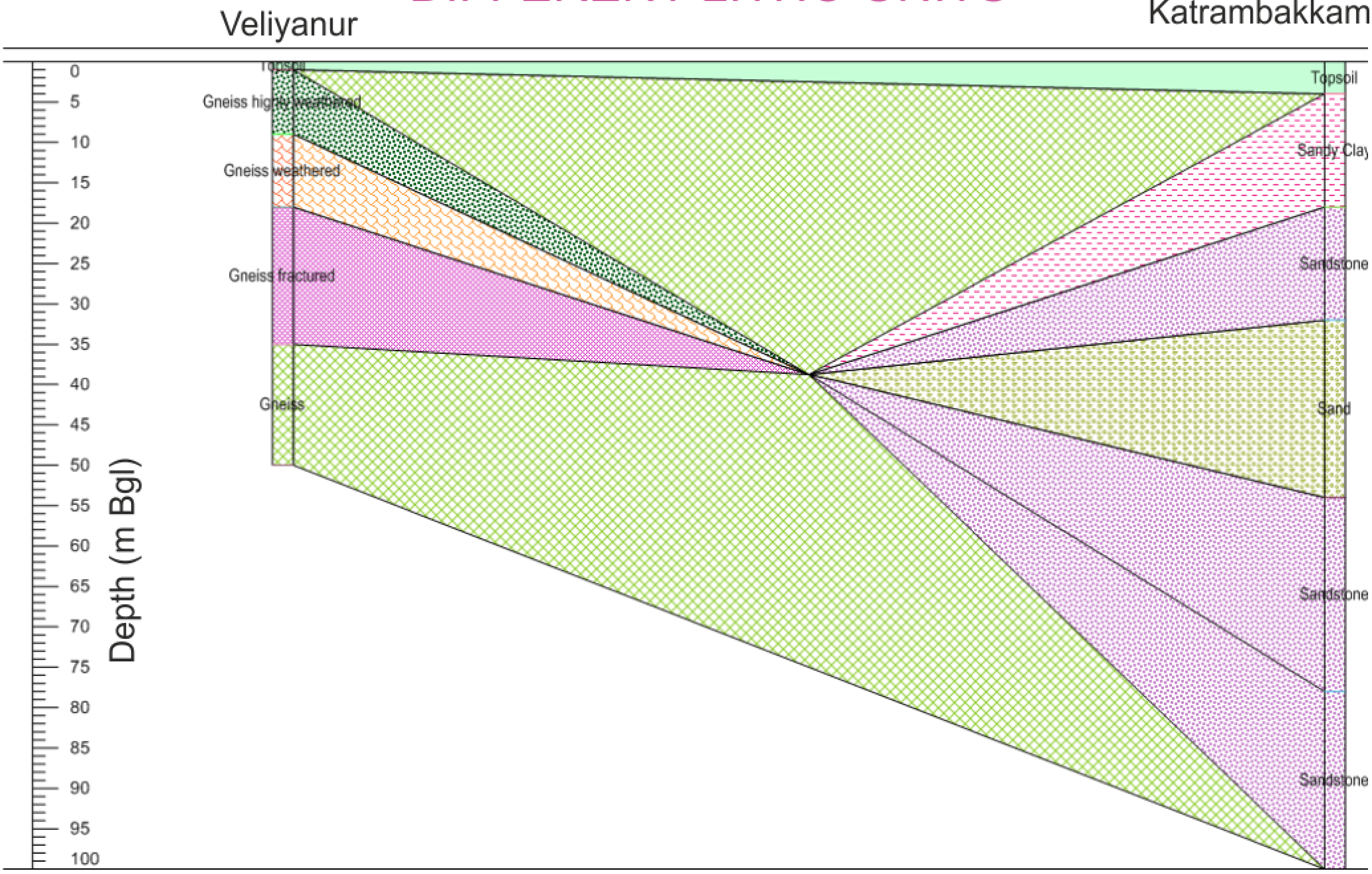


Fence Diagram in Hard rock Area
Varahanadhi Basin

Plate: VAR-11B



CROSS SECTION CONNECTING BOREHOLES OF DIFFERENT LITHO UNITS



CROSS SECTION CONNECTING LITHOLOGS OF SEDIMENTARY ROCK REGION

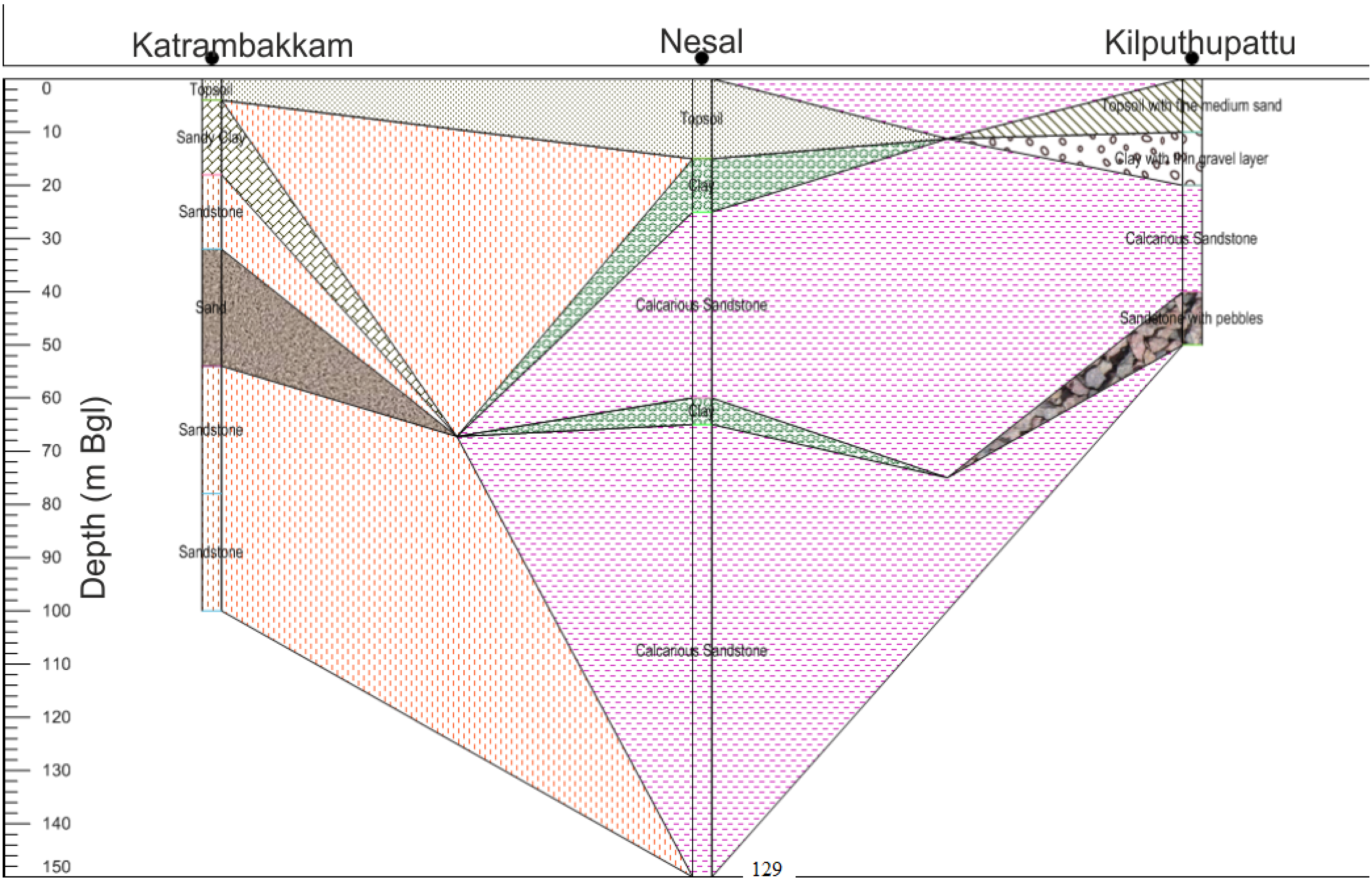
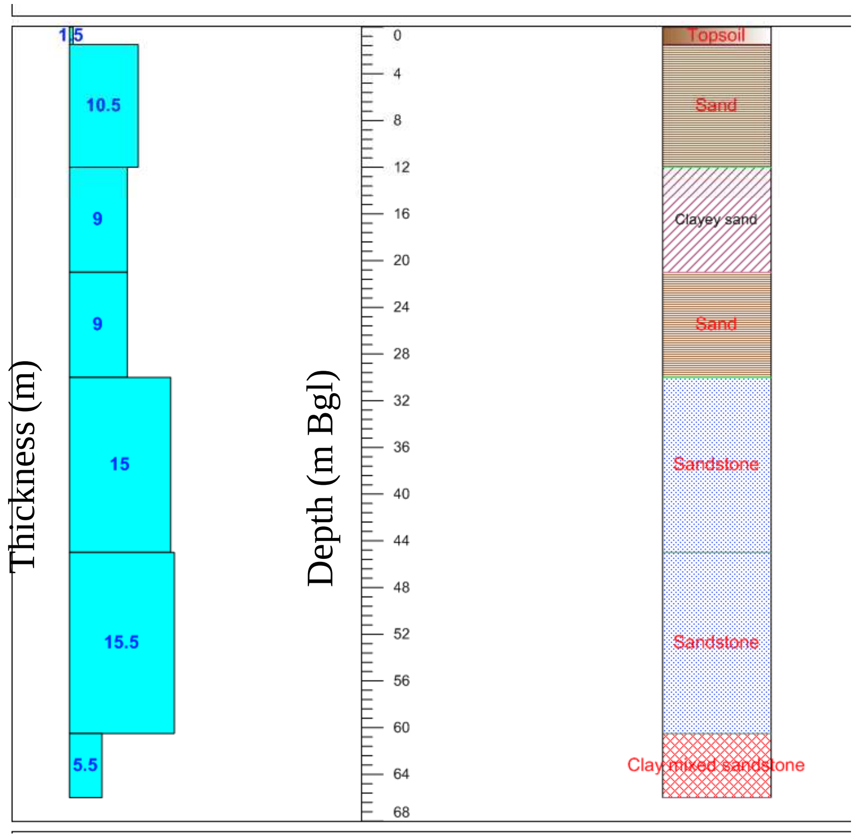


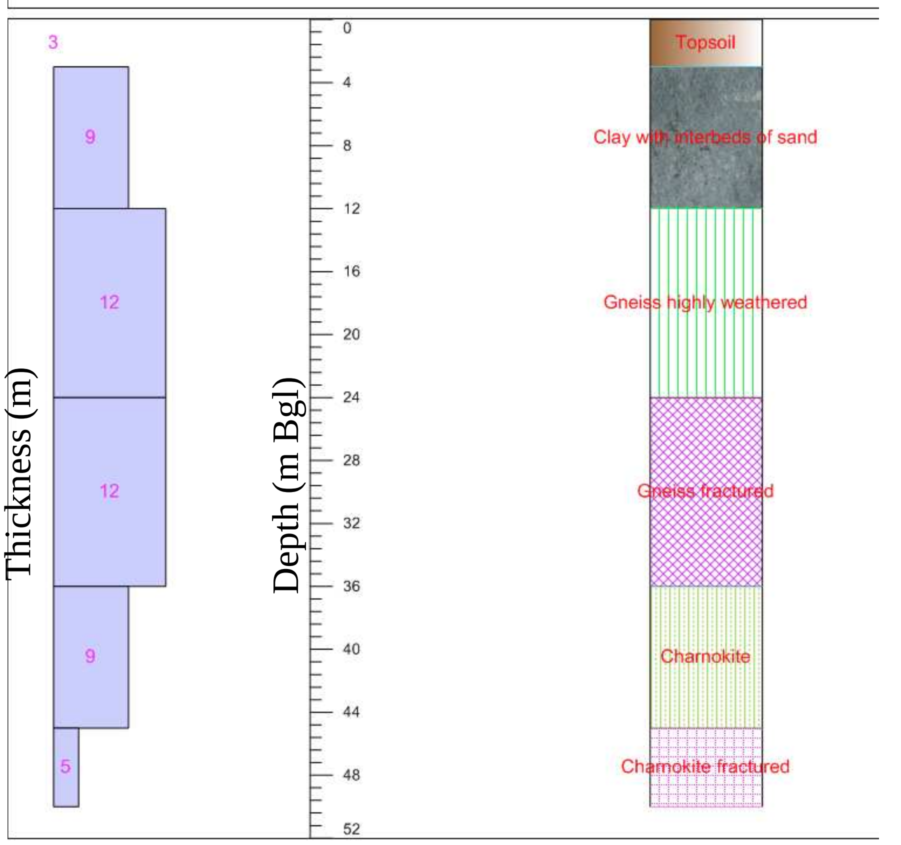
Plate: VAR-13

Lithology log for selected borehole data

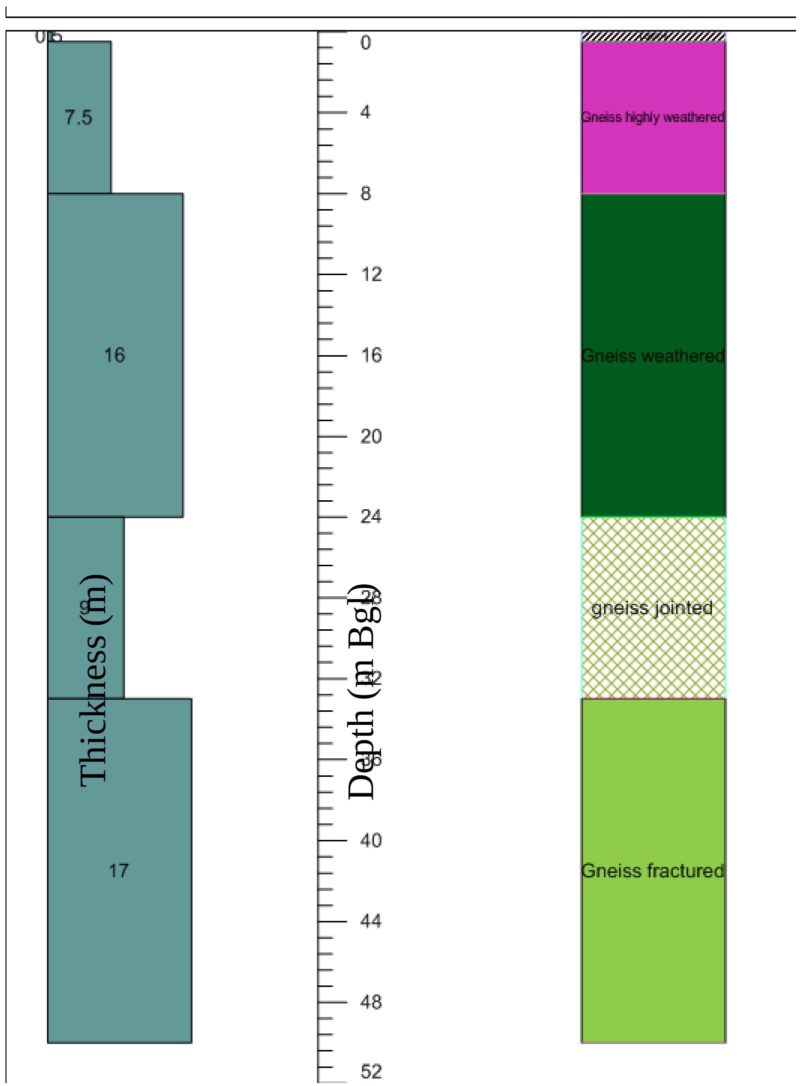
Rampakkam



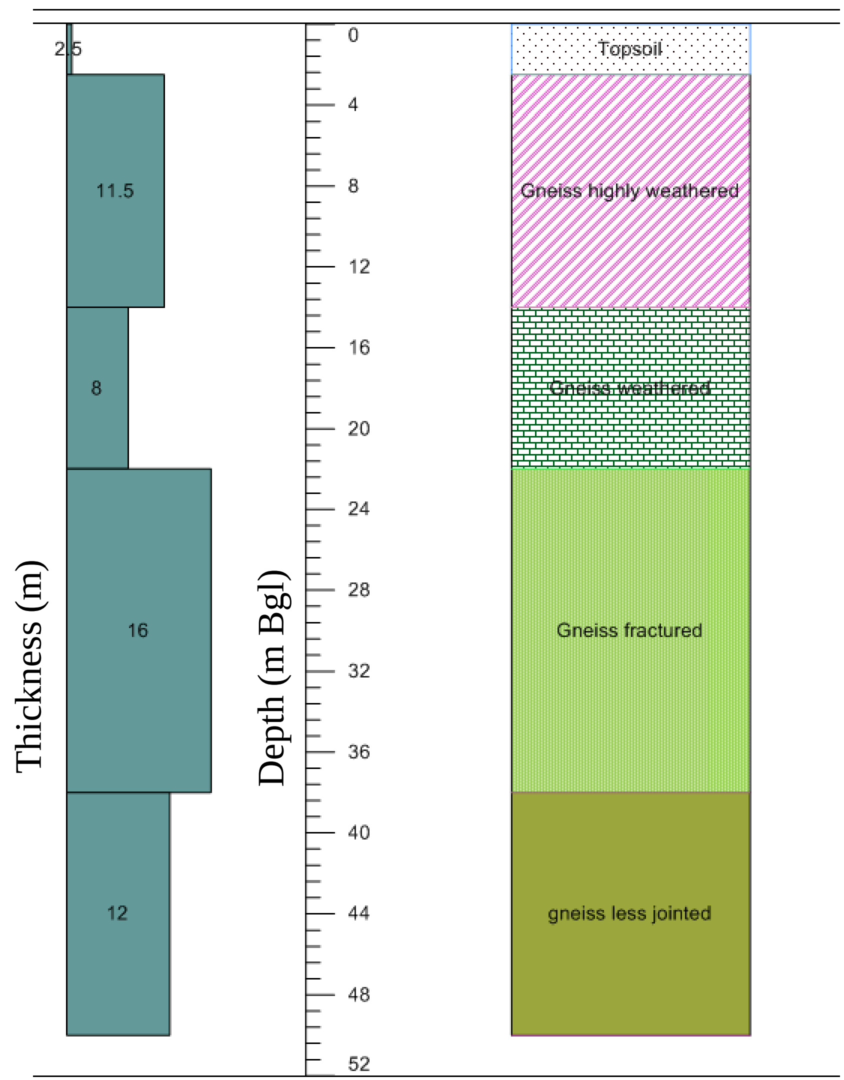
Kayathur



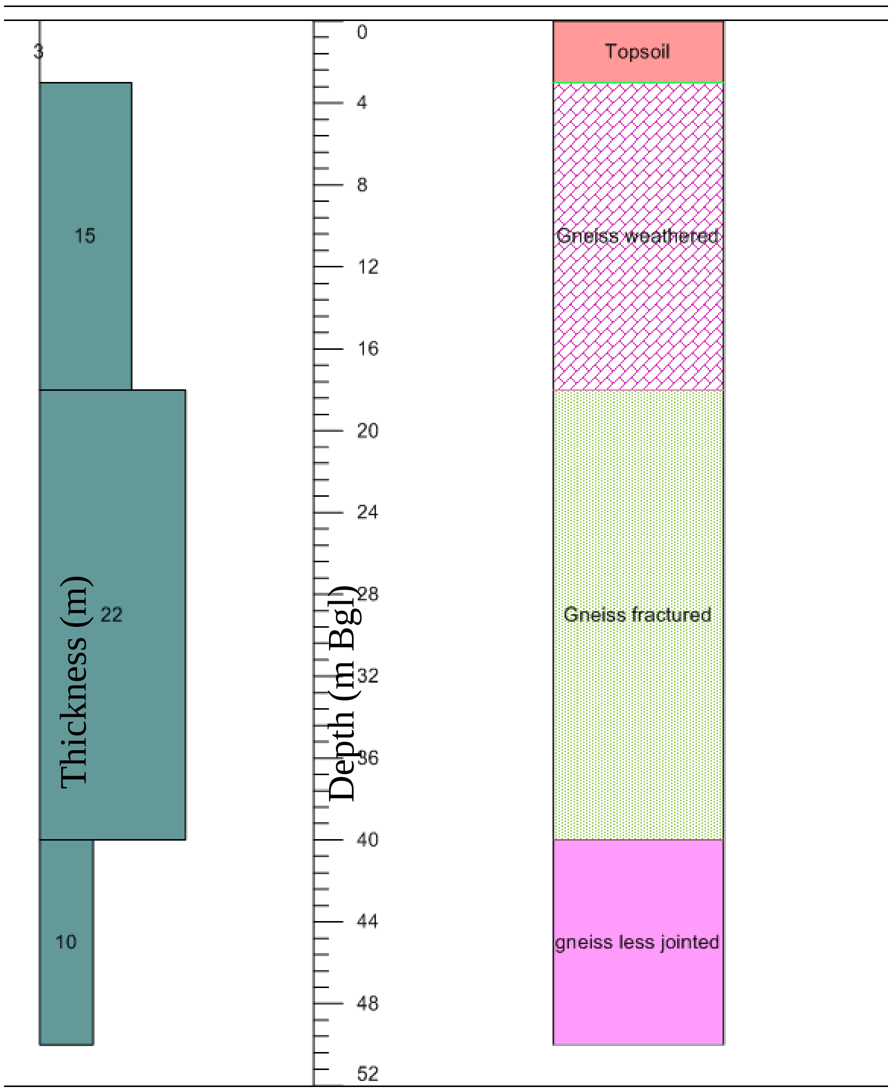
Sethavarai



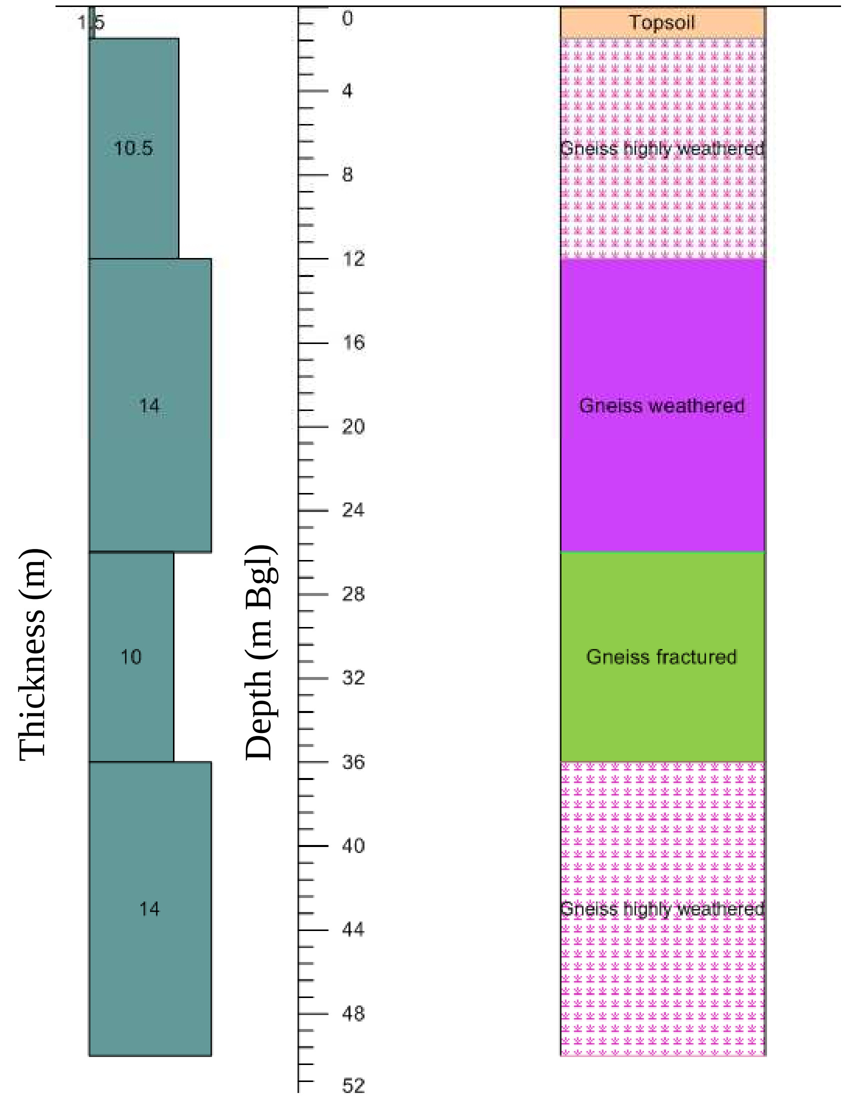
Periyamur



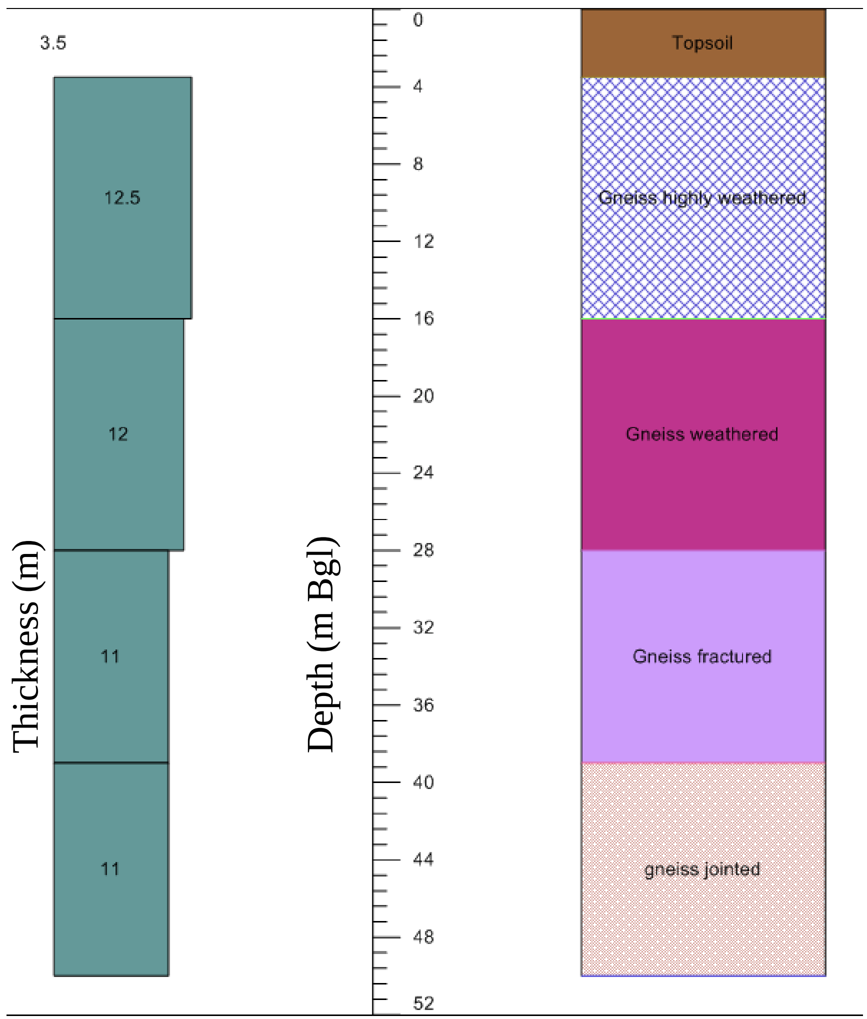
Karungalipattu



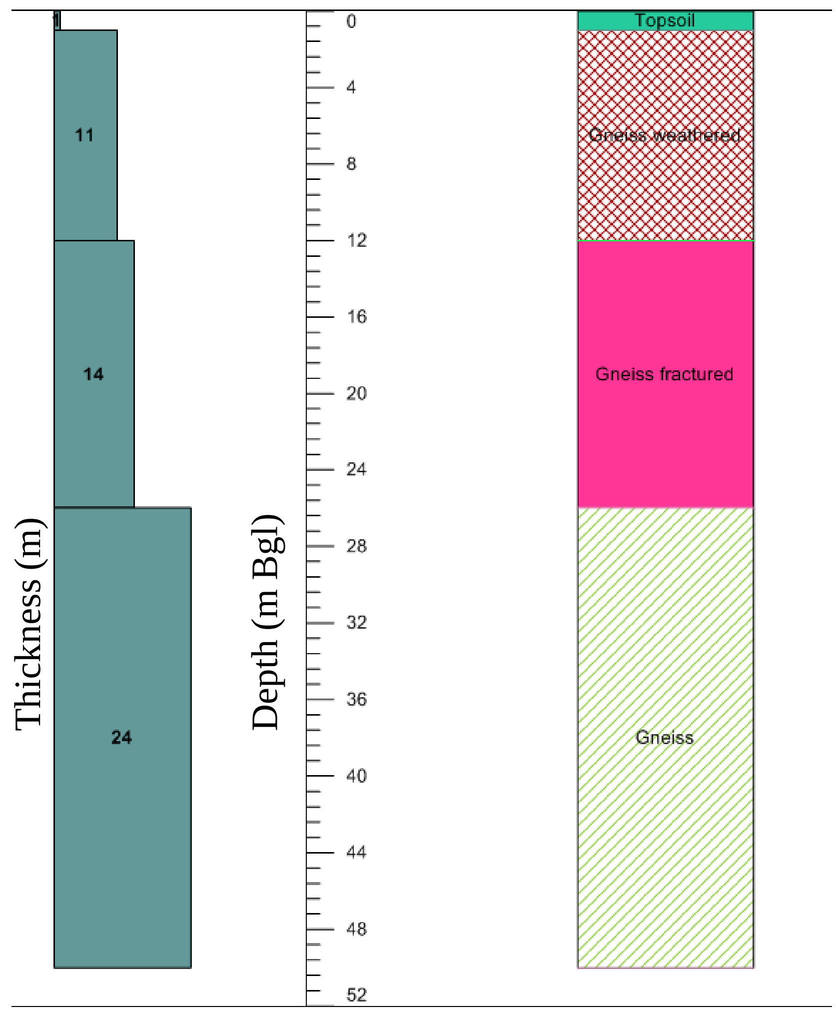
Kappalambadi



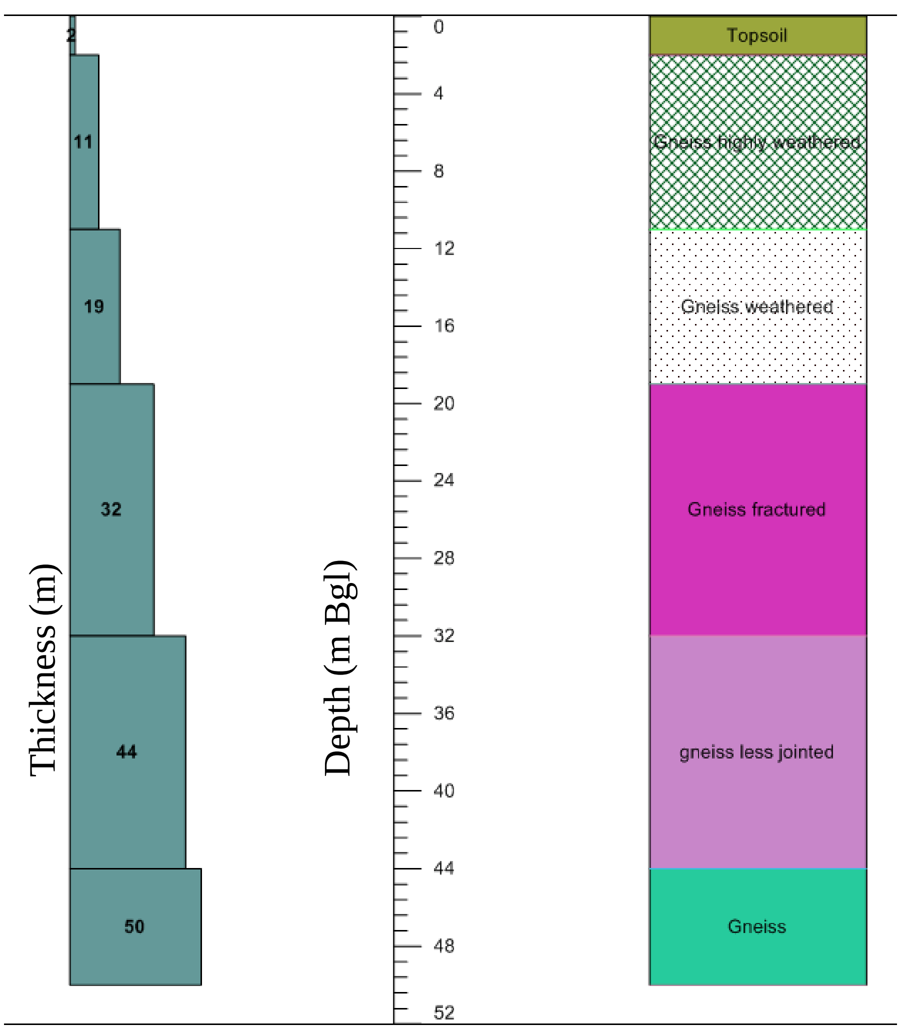
Sevalaporai



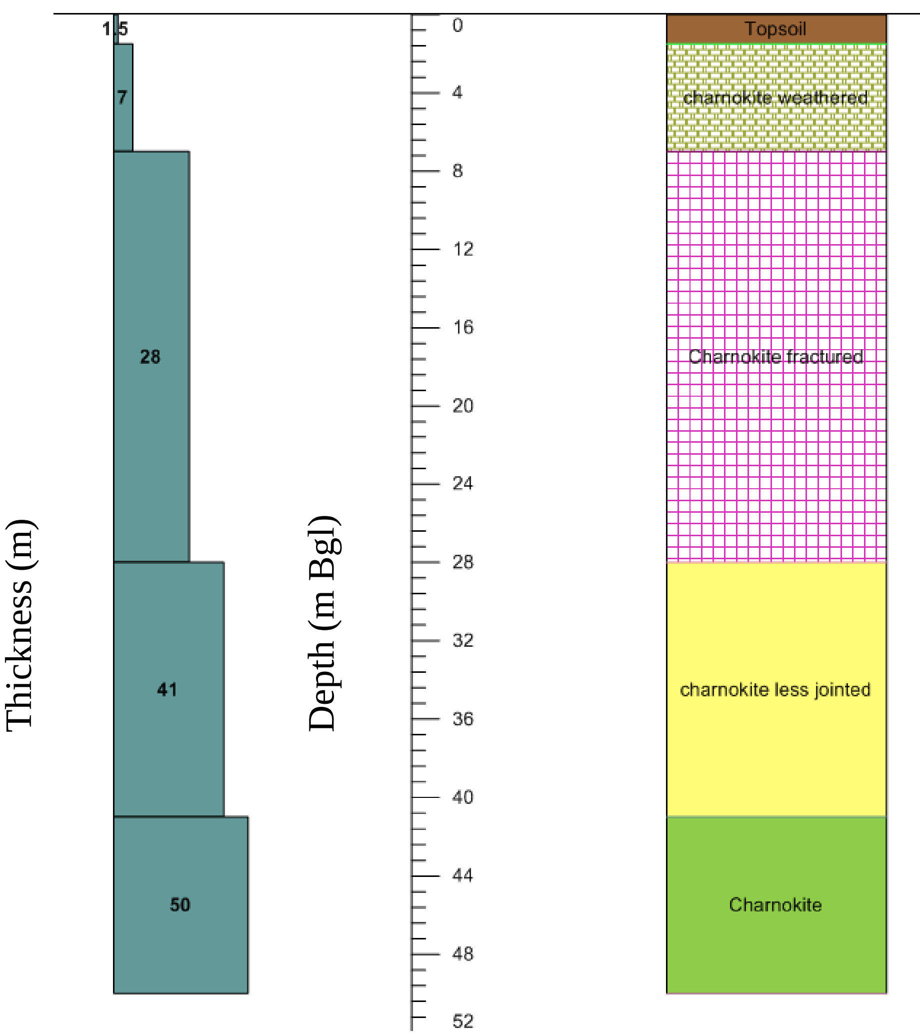
Illodu



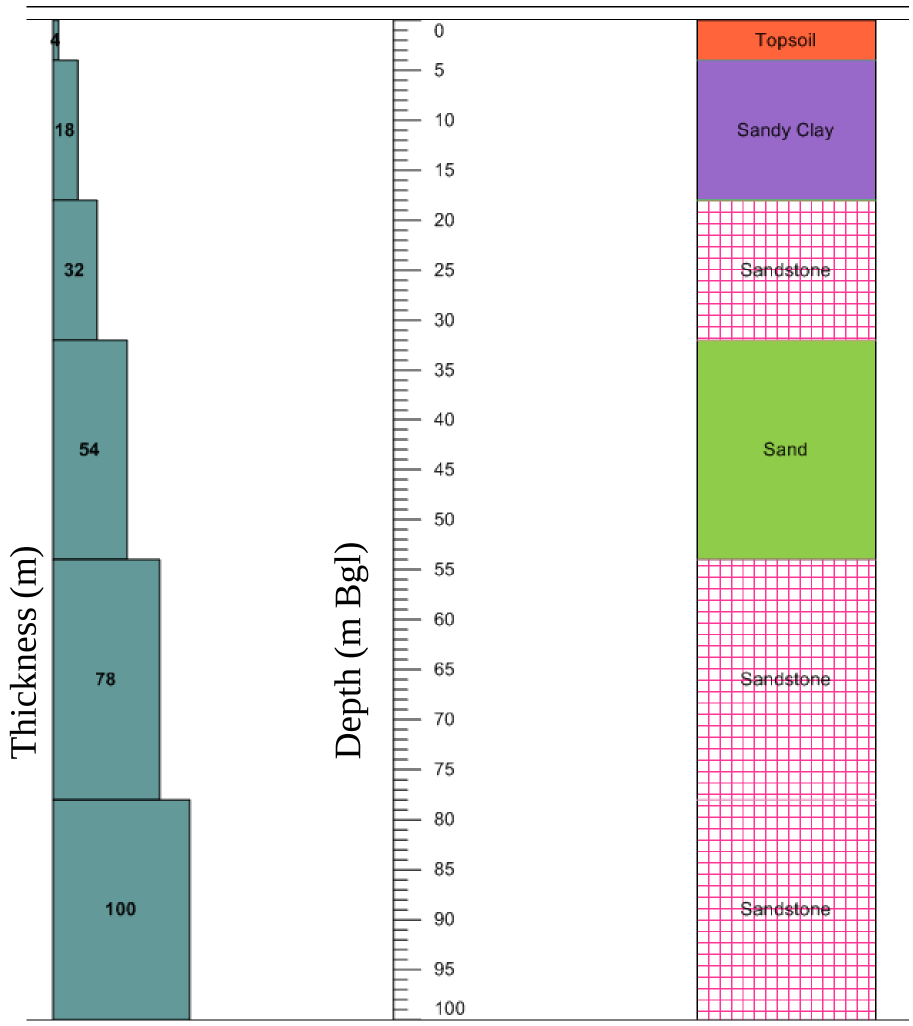
Kollar



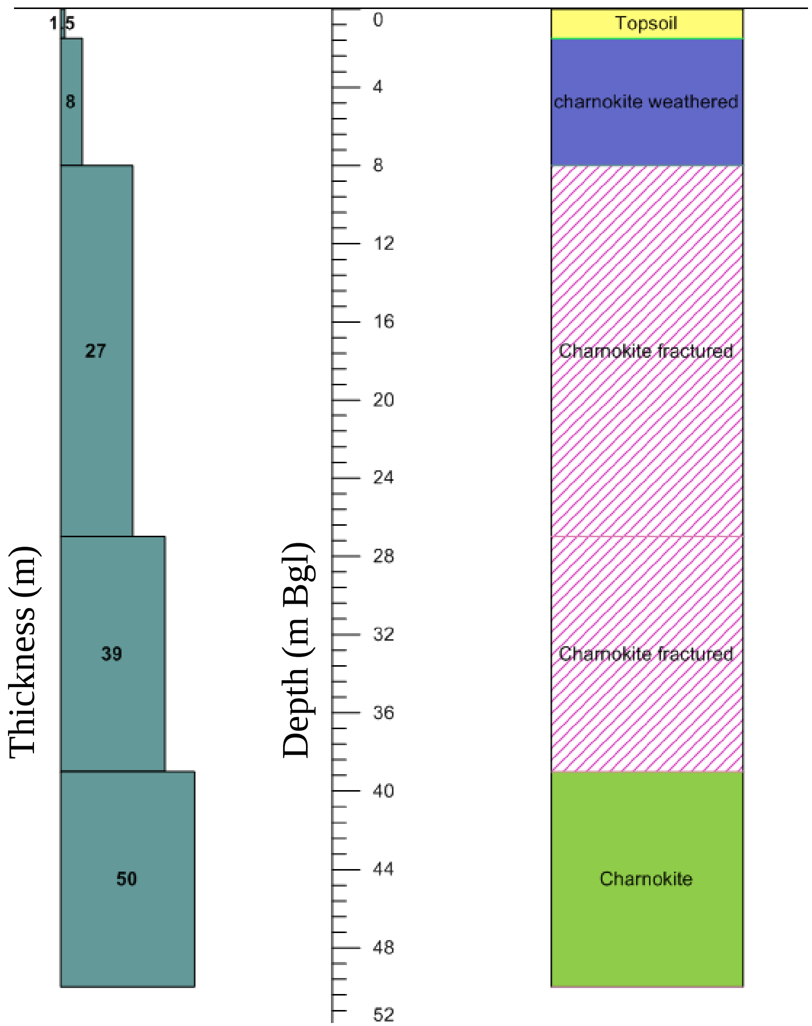
Vanniper



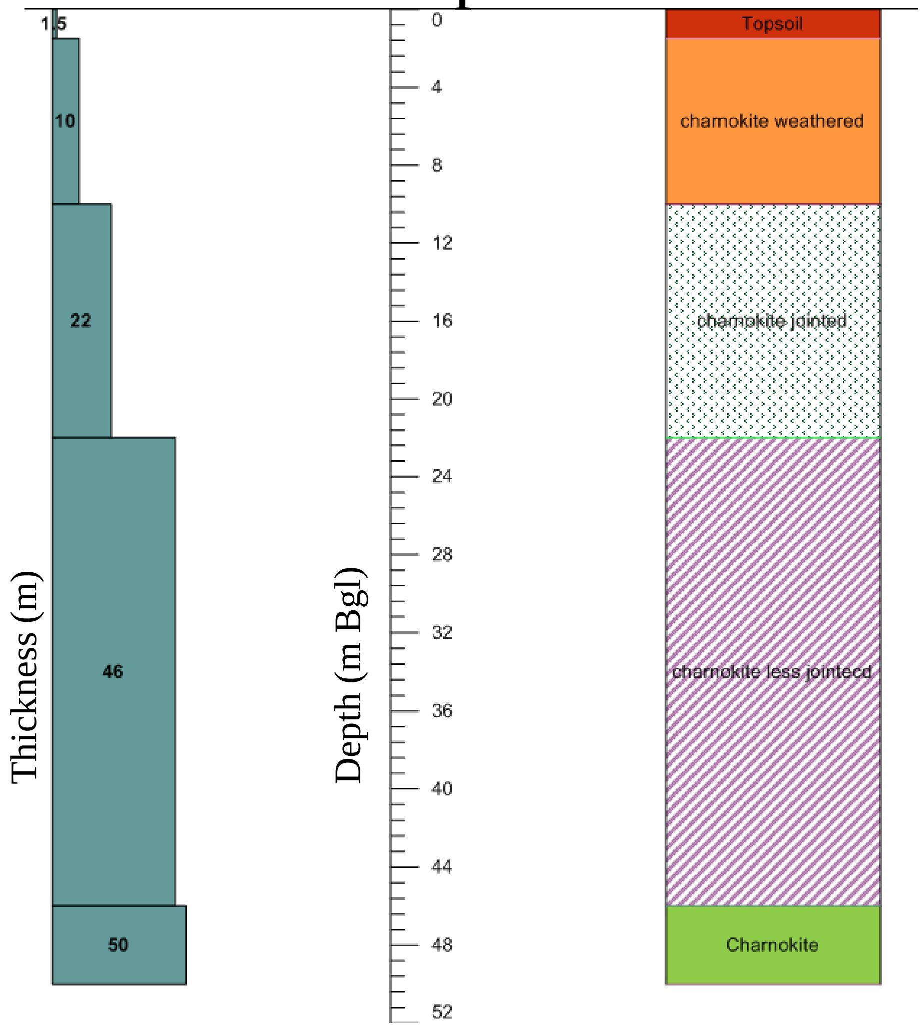
Katrambakkam



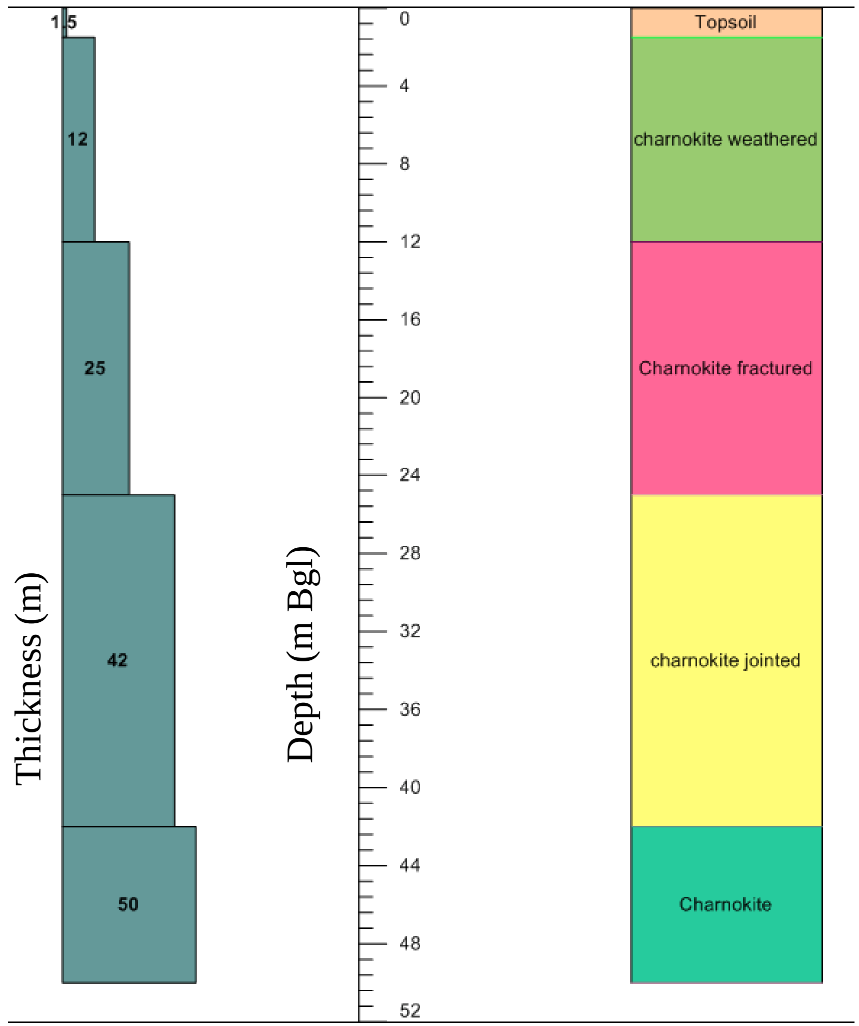
Vadampoondi



Andapattu



Kambur



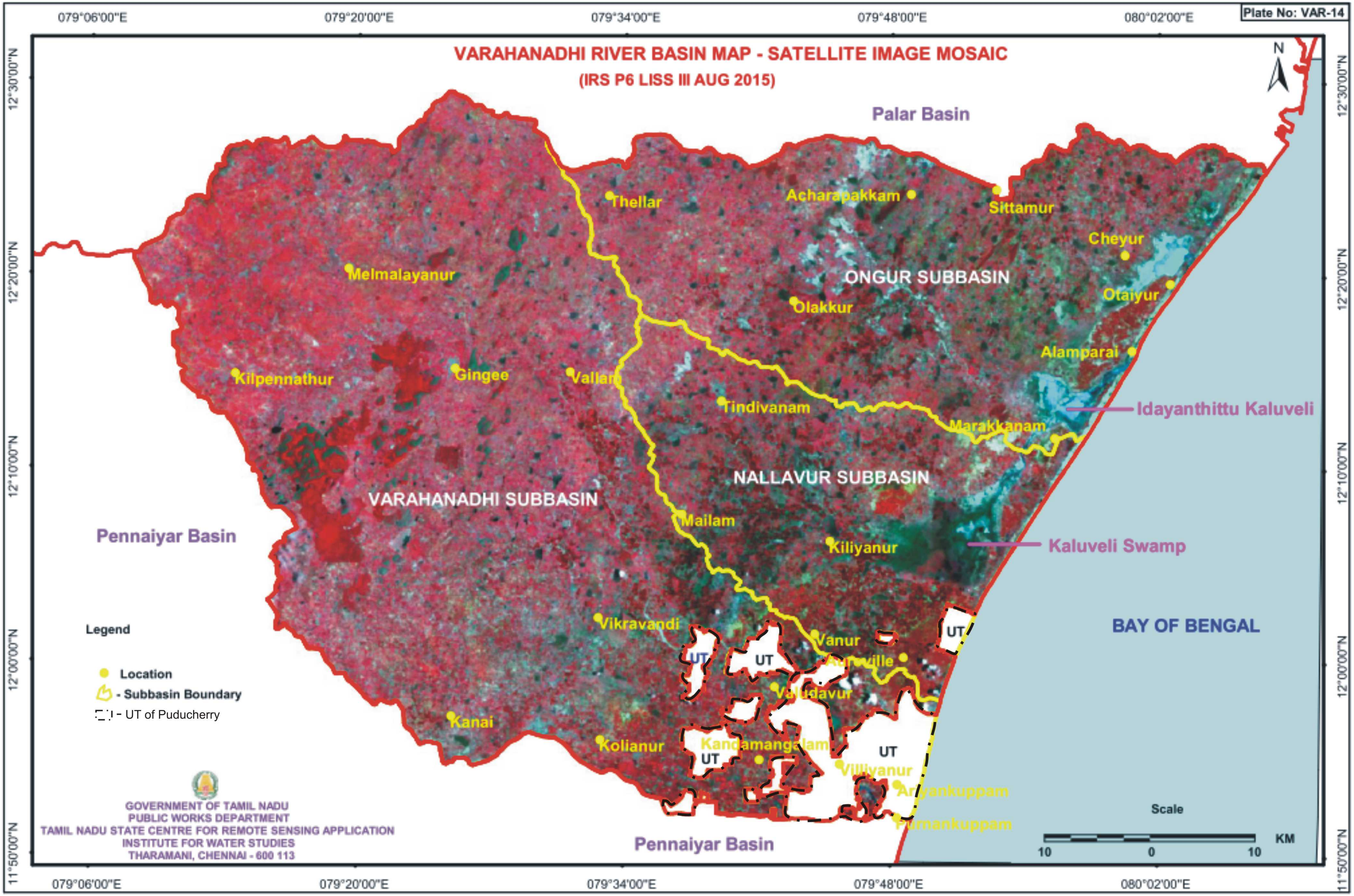
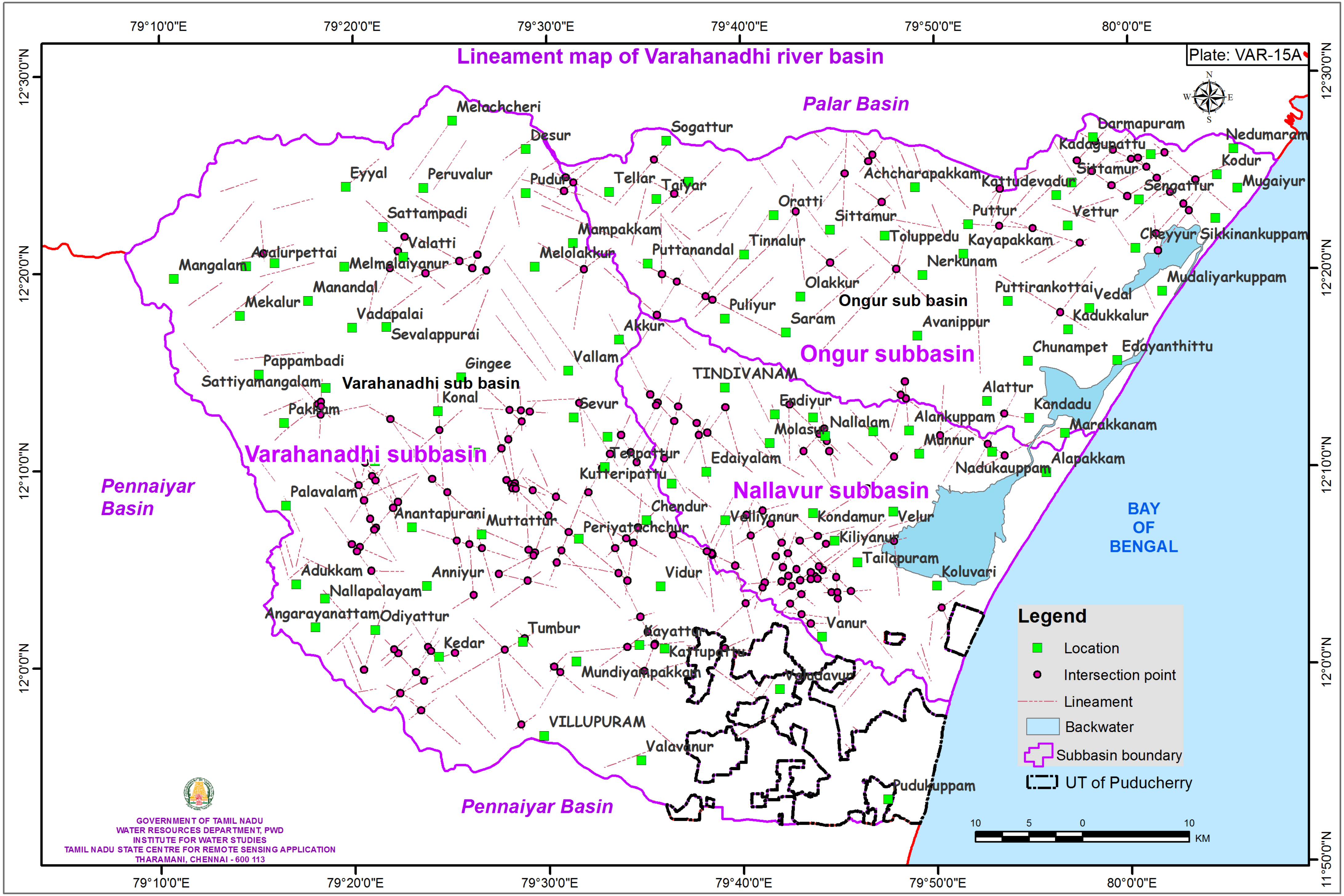
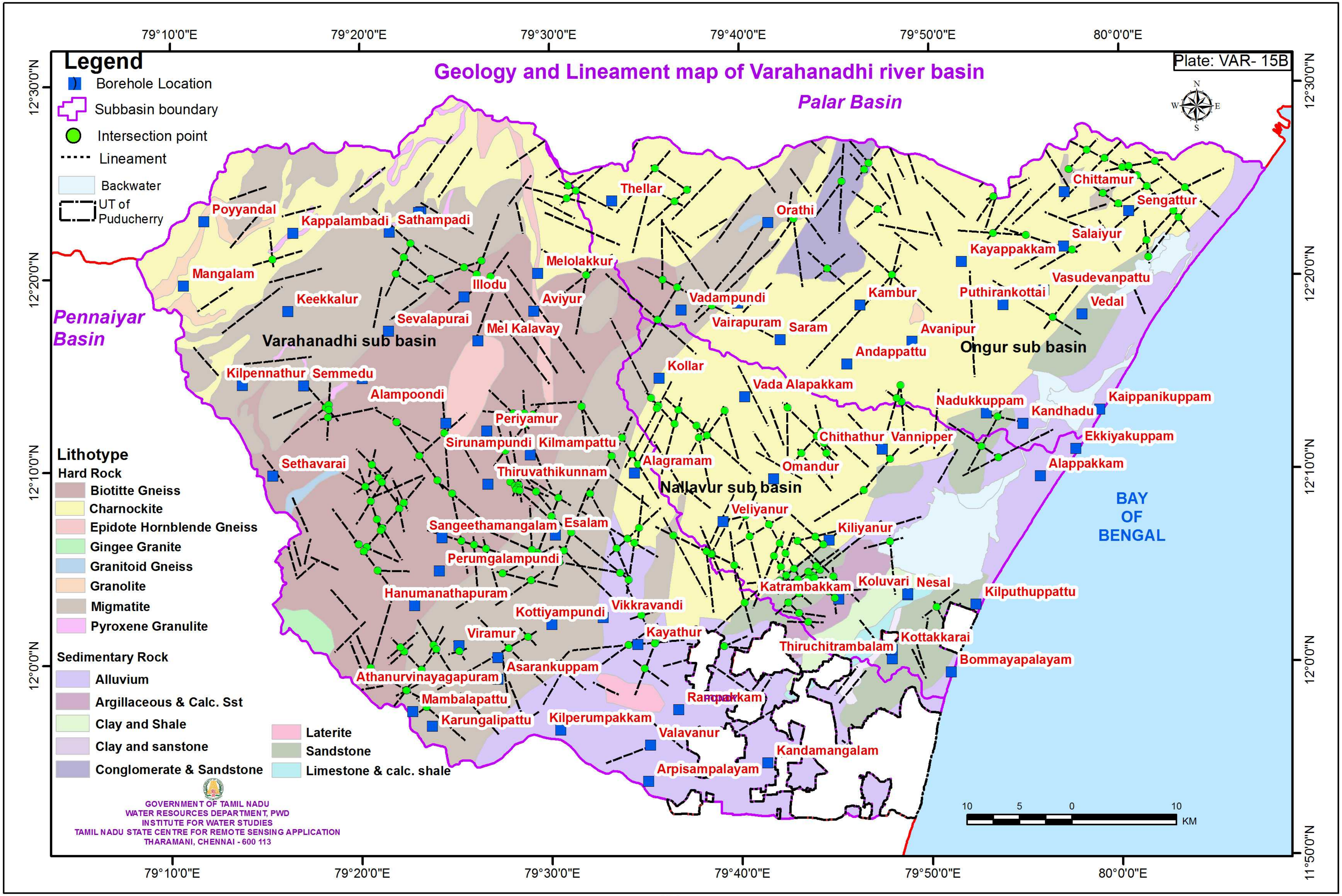
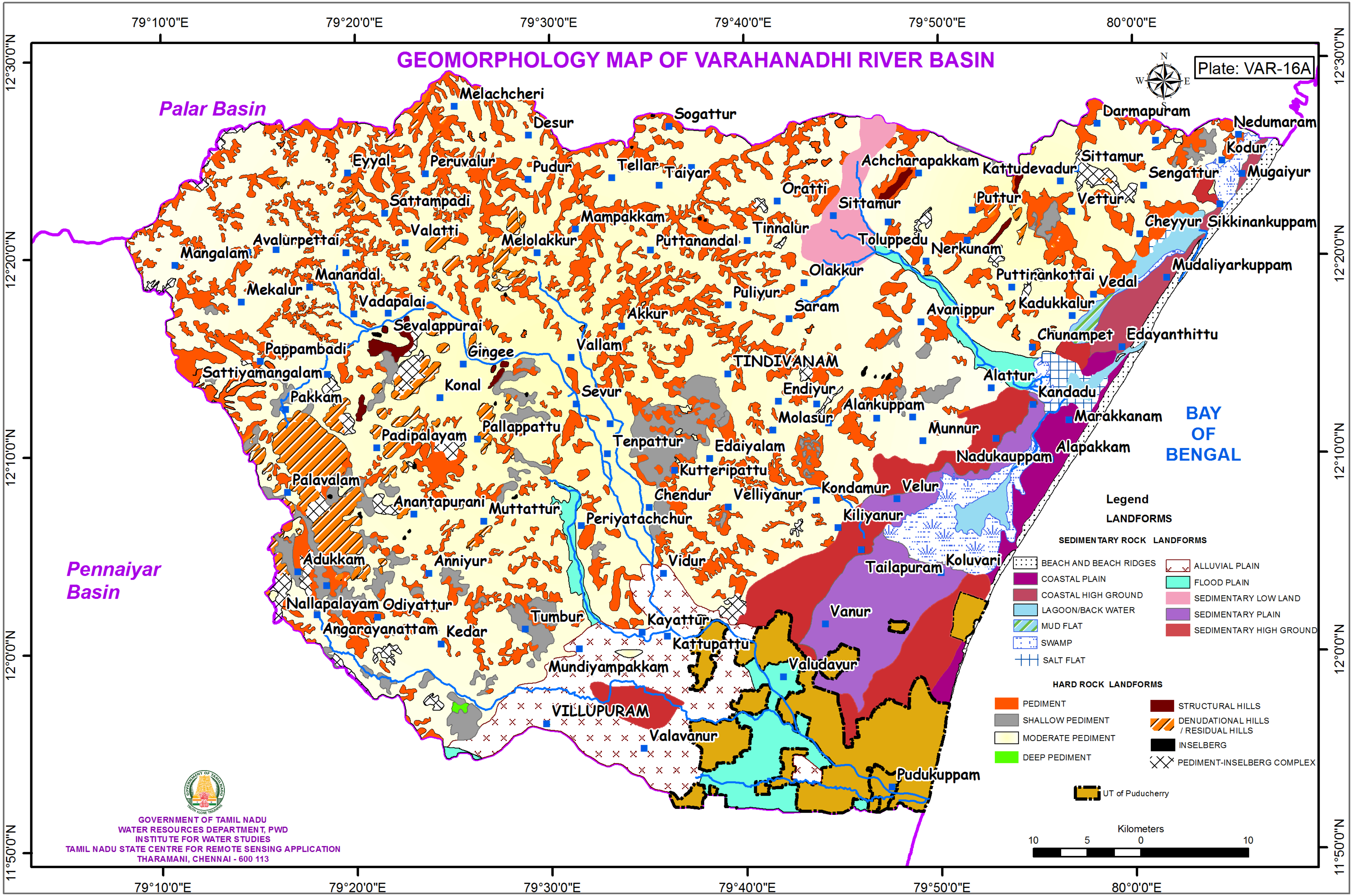
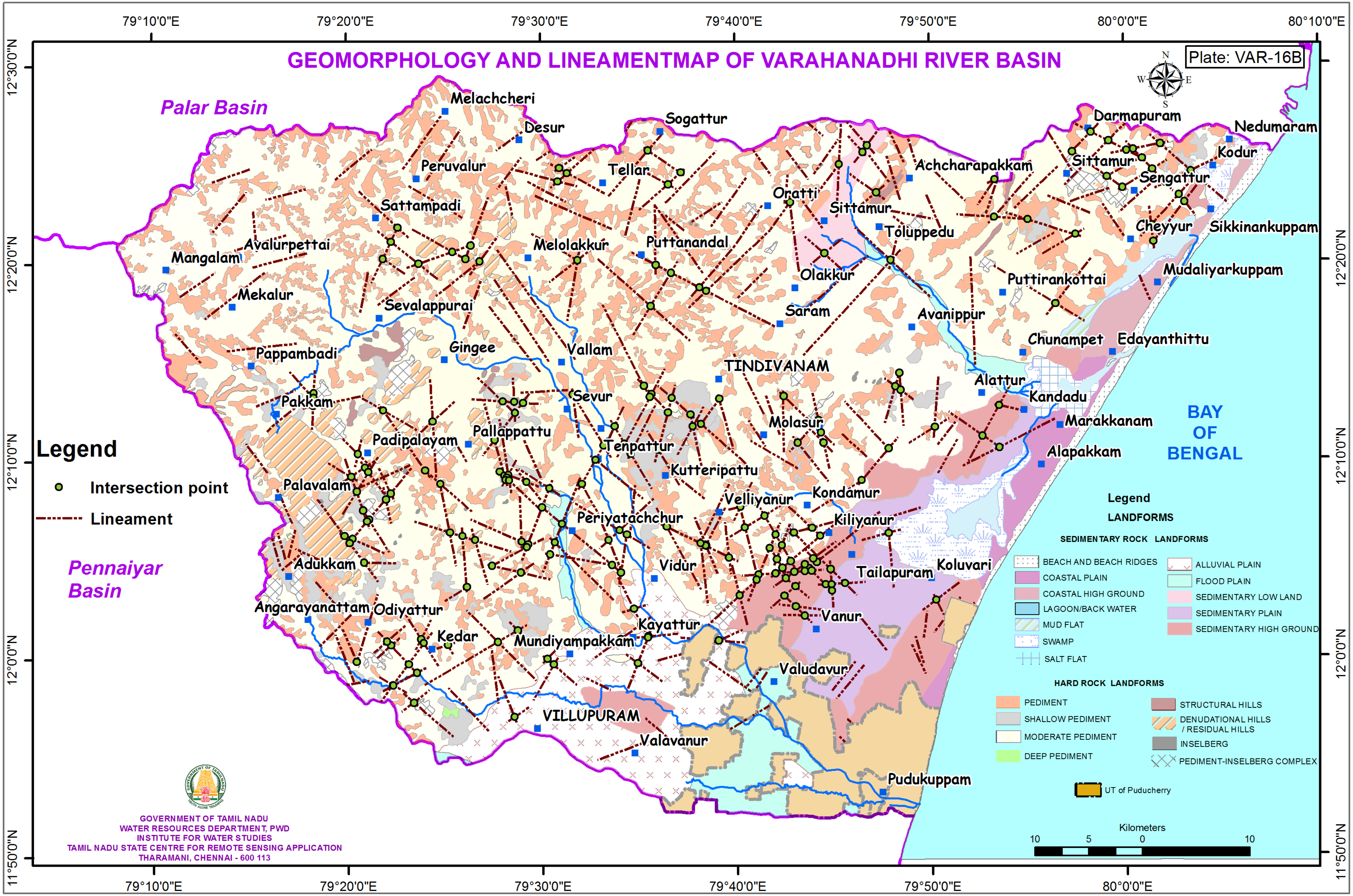


Plate No: VAR-14
VARAHANADHI RIVER BASIN MAP - SATELLITE IMAGE MOSAIC
(IRS P6 LISS III AUG 2015)
079°06'00"E
079°20'00"E
079°34'00"E
079°48'00"E
080°02'00"E
12°30'00"N
12°20'00"N
12°10'00"N
12°00'00"N
11°50'00"N
N
Palar Basin
Thellar
Acharapakkam
Sittamur
Cheyur
Melmalayanur
ONGUR SUBBASIN
Olakkur
Otaiyur
Alamparai
Kilpennathur
Gingee
Vallam
Tindivanam
Idayanthittu Kaluveli
Marakkanam
NALLAVUR SUBBASIN
VARAHANADHI SUBBASIN
Mailam
Pennaiyar Basin
Kiliyanur
Kaluveli Swamp
Legend
Vikravandi
Vanur
UT
BAY OF BENGAL
Auroville
Location
- Subbasin Boundary
- UT of Puducherry
Valudavur
Kanai
Kolianur
Kandamangalam
Villiyanur
Ariyankuppam
Pumankuppam
Scale
10 0 10 KM
GOVERNMENT OF TAMIL NADU
PUBLIC WORKS DEPARTMENT
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
INSTITUTE FOR WATER STUDIES
THARAMANI, CHENNAI - 600 113
Pennaiyar Basin


Lineament map of Varahanadhi river basin
Plate: VAR-15A
Palar Basin
Ongur subbasin
Ongur sub basin
Varahanadhi subbasin
Varahanadhi sub basin
Nallavur subbasin
Pennaiyar Basin
Pennaiyar Basin
BAY OF BENGAL
TINDIVANAM
VILLUPURAM
Legend
Location
Intersection point
Lineament
Backwater
Subbasin boundary
UT of Puducherry
KM
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI - 600 113


Geology and Lineament map of Varahanadhi river basin
Plate: VAR- 15B
Palar Basin
Pennaiyar Basin
Varahanadhi sub basin
Ongur sub basin
Nallavur sub basin
BAY OF BENGAL
Legend
Borehole Location
Subbasin boundary
Intersection point
Lineament
Backwater
UT of Puducherry
Lithotype
Hard Rock
Biotitte Gneiss
Charnockite
Epidote Hornblende Gneiss
Gingee Granite
Granitoid Gneiss
Granolite
Migmatite
Pyroxene Granulite
Sedimentary Rock
Alluvium
Argillaceous & Calc. Sst
Clay and Shale
Clay and sanstone
Conglomerate & Sandstone
Laterite
Sandstone
Limestone & calc. shale
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI - 600 113
79°10'0"E
79°20'0"E
79°30'0"E
79°40'0"E
79°50'0"E
80°0'0"E
12°30'0"N
12°20'0"N
12°10'0"N
12°0'0"N
11°50'0"N
10 5 0 10 KM
Poyyandal
Kappalambadi
Sathampadi
Mangalam
Keekkalur
Sevalapurai
Illodu
Melolakkur
Aviyur
Mel Kalavay
Thellar
Orathi
Vadampundi
Vairapuram
Saram
Kambur
Avanipur
Andappattu
Kayappakkam
Chittamur
Sengattur
Salaiyur
Vasudevanpattu
Puthirankottai
Vedal
Kilpennathur
Semmedu
Alampoondi
Periyamur
Sirunampundi
Kilmampattu
Thiruvathikunnam
Sethavarai
Kollar
Vada Alapakkam
Nadukkuppam
Kandhadu
Kaippanikuppam
Ekkiyakuppam
Alappakkam
Chithathur
Vannipper
Alagramam
Omandur
Veliyanur
Kiliyanur
Sangeethamangalam
Esalam
Perumgalampundi
Hanumanathapuram
Kottiyampundi
Vikkravandi
Katrambakkam
Koluvari
Nesal
Kilputhuppattu
Viramur
Kayathur
Thiruchitrambalam
Kottakkarai
Bommayapalayam
Asarankuppam
Athanurvinayagapuram
Mambalapattu
Karungalipattu
Kilperumpakkam
Rampakkam
Valavanur
Kandamangalam
Arpisampalayam


GEOMORPHOLOGY MAP OF VARAHANADHI RIVER BASIN
Plate: VAR-16A
Palar Basin
Pennaiyar Basin
BAY OF BENGAL
79°10'0"E
79°20'0"E
79°30'0"E
79°40'0"E
79°50'0"E
80°0'0"E
12°30'0"N
12°20'0"N
12°10'0"N
12°0'0"N
11°50'0"N
Melachcheri
Desur
Sogattur
Darmapuram
Nedumaram
Kodur
Mugaiyur
Sittamur
Sengattur
Eyyal
Peruvalur
Pudur
Tellar
Taiyar
Oratti
Achcharapakkam
Kattudevadur
Vettur
Puttur
Sittamur
Sattampadi
Valatti
Mampakkam
Tinnalur
Toluppedu
Nerkunam
Cheyyur
Sikkinankuppam
Avalurpettai
Mangalam
Melolakkur
Puttanandal
Olakkur
Puttirankottai
Vedal
Mudaliyarkuppam
Manandal
Mekalur
Vadapalai
Sevalappurai
Puliyur
Saram
Avanippur
Kadukkalur
Akkur
Gingee
Vallam
Chunampet
Edayanthittu
Pappambadi
Sattiyamangalam
TINDIVANAM
Alattur
Kandadu
Konal
Pakkam
Sevur
Endiyur
Alankuppam
Molasur
Marakkanam
Munnur
Padipalayam
Pallappattu
Tenpattur
Edaiyalam
Alapakkam
Nadukauppam
Kutteripattu
Palavalam
Chendur
Velliyanur
Kondamur
Velur
Anantapurani
Muttattur
Periyatachchur
Kiliyanur
Adukkam
Anniyur
Vidur
Tailapuram
Koluvari
Nallapalayam
Odiyattur
Vanur
Tumbur
Kayattur
Angarayanattam
Kedar
Kattupattu
Valudavur
Mundiyampakkam
VILLUPURAM
Valavanur
Pudukuppam
Legend
LANDFORMS
SEDIMENTARY ROCK LANDFORMS
BEACH AND BEACH RIDGES
COASTAL PLAIN
COASTAL HIGH GROUND
LAGOON/BACK WATER
MUD FLAT
SWAMP
SALT FLAT
ALLUVIAL PLAIN
FLOOD PLAIN
SEDIMENTARY LOW LAND
SEDIMENTARY PLAIN
SEDIMENTARY HIGH GROUND
HARD ROCK LANDFORMS
PEDIMENT
SHALLOW PEDIMENT
MODERATE PEDIMENT
DEEP PEDIMENT
STRUCTURAL HILLS
DENUDATIONAL HILLS / RESIDUAL HILLS
INSELBERG
PEDIMENT-INSELBERG COMPLEX
UT of Puducherry
Kilometers
10 5 0 10
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI - 600 113



GEOMORPHOLOGY AND LINEAMENTMAP OF VARAHANADHI RIVER BASIN
Plate: VAR-16B
Palar Basin
Pennaiyar Basin
BAY OF BENGAL
Legend
Intersection point
Lineament
Legend
LANDFORMS
SEDIMENTARY ROCK LANDFORMS
BEACH AND BEACH RIDGES
COASTAL PLAIN
COASTAL HIGH GROUND
LAGOON/BACK WATER
MUD FLAT
SWAMP
SALT FLAT
ALLUVIAL PLAIN
FLOOD PLAIN
SEDIMENTARY LOW LAND
SEDIMENTARY PLAIN
SEDIMENTARY HIGH GROUND
HARD ROCK LANDFORMS
PEDIMENT
SHALLOW PEDIMENT
MODERATE PEDIMENT
DEEP PEDIMENT
STRUCTURAL HILLS
DENUDATIONAL HILLS / RESIDUAL HILLS
INSELBERG
PEDIMENT-INSELBERG COMPLEX
UT of Puducherry
Kilometers
10 5 0 10
Melachcheri
Desur
Sogattur
Darmapuram
Nedumaram
Kodur
Peruvalur
Tellar
Achcharapakkam
Sittamur
Sengattur
Sattampadi
Oratti
Sittamur
Toluppedu
Cheyyur
Sikkinankuppam
Avalurpettai
Mangalam
Melolakkur
Puttanandal
Olakkur
Mudaliyarkuppam
Mekalur
Sevalappurai
Saram
Puttirankottai
Avanippur
Pappambadi
Gingee
Vallam
Chunampet
Edayanthittu
TINDIVANAM
Alattur
Kandadu
Pakkam
Sevur
Molasur
Marakkanam
Padipalayam
Pallappattu
Tenpattur
Alapakkam
Kutteripattu
Palavalam
Velliyanur
Kondamur
Periyatachchur
Kiliyanur
Adukkam
Vidur
Tailapuram
Koluvari
Angarayanattam
Odiyattur
Vanur
Kayattur
Kedar
Mundiyampakkam
Valudavur
VILLUPURAM
Valavanur
Pudukuppam
79°10'0"E
79°20'0"E
79°30'0"E
79°40'0"E
79°50'0"E
80°0'0"E
80°10'0"E
12°30'0"N
12°20'0"N
12°10'0"N
12°0'0"N
11°50'0"N
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
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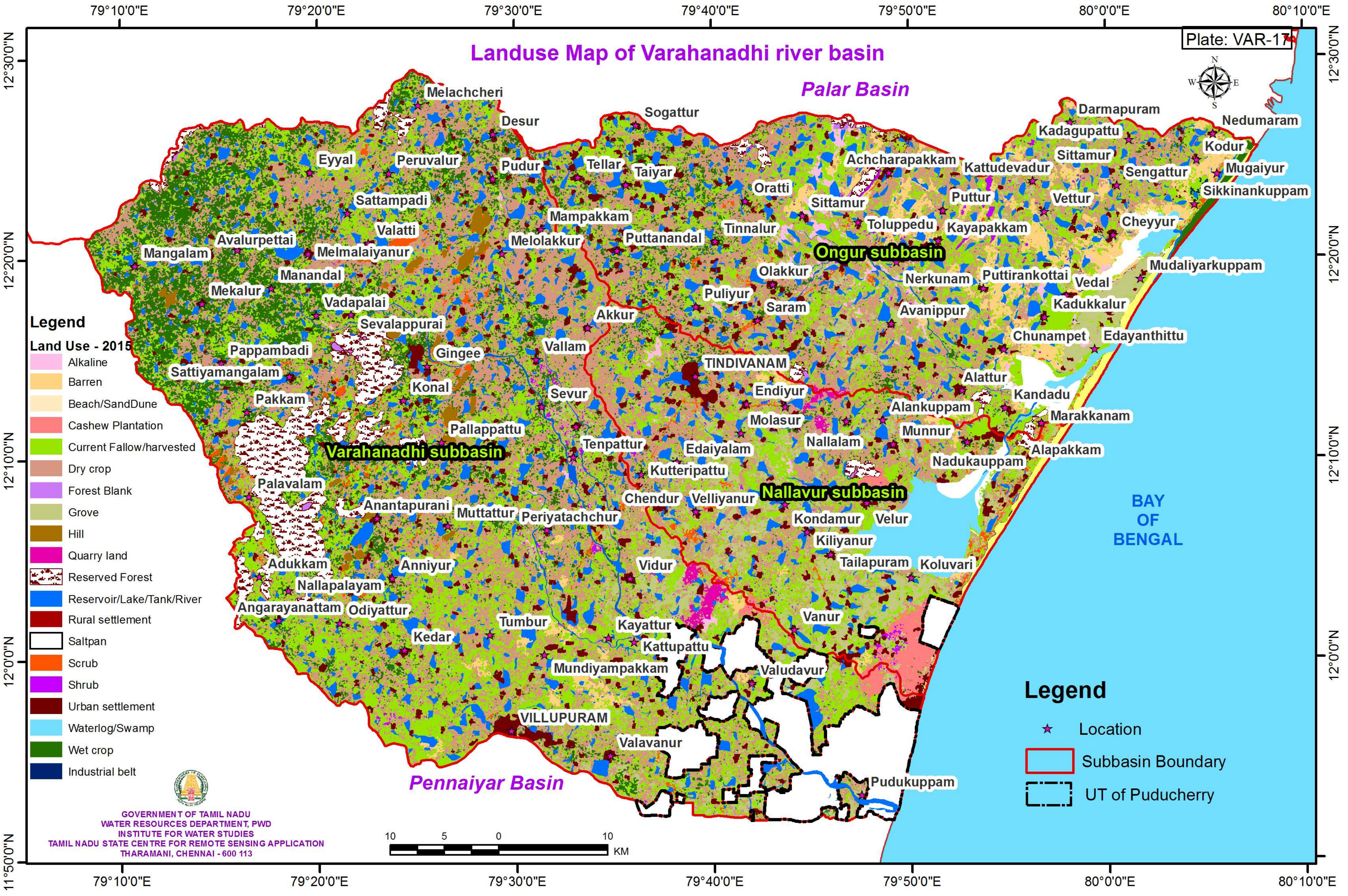
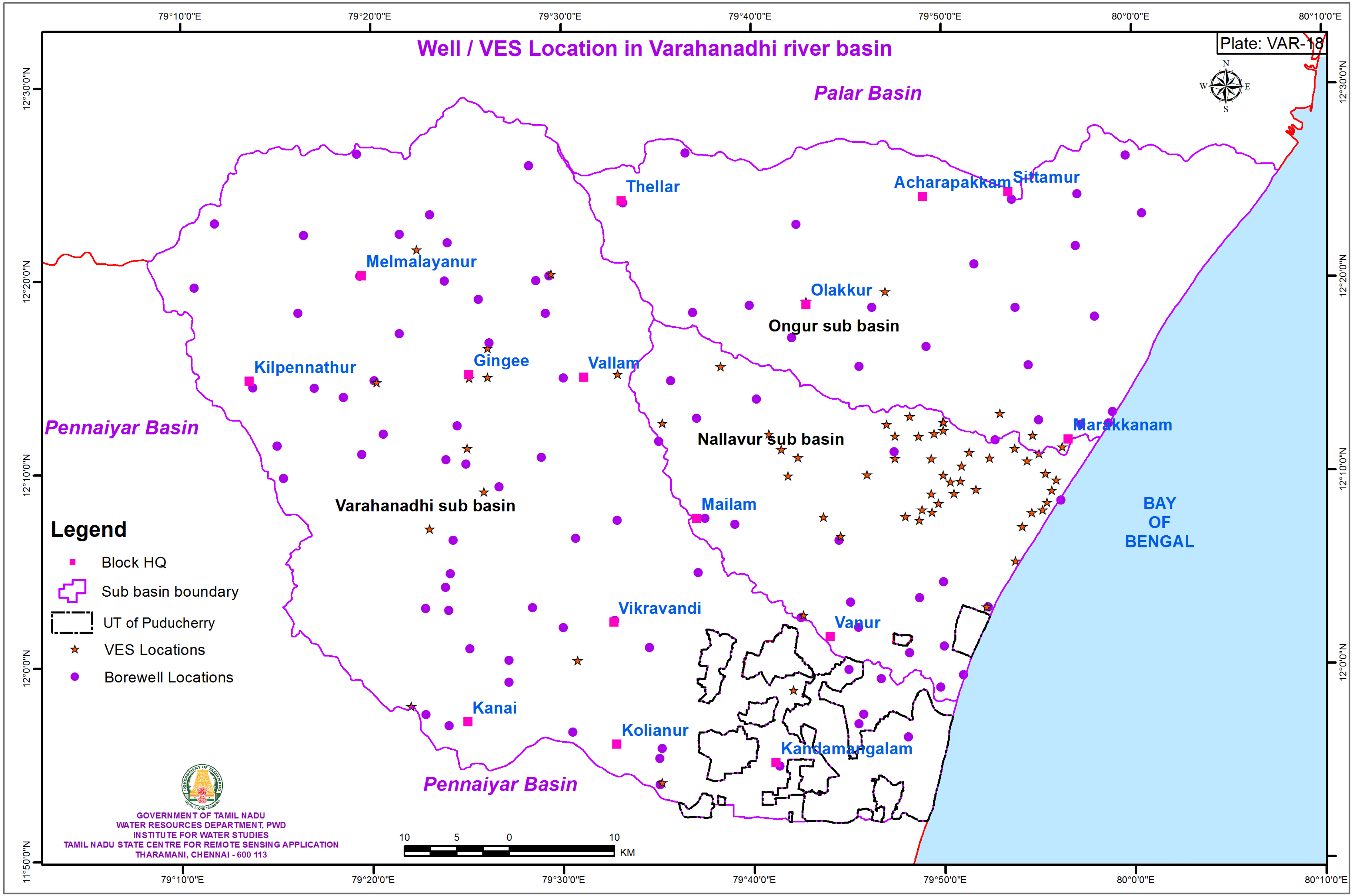
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI - 600 113



Landuse Map of Varahanadhi river basin
Plate: VAR-17
Palar Basin
Pennaiyar Basin
BAY OF BENGAL
Varahanadhi subbasin
Ongur subbasin
Nallavur subbasin
Legend
Land Use - 2015
Alkaline
Barren
Beach/SandDune
Cashew Plantation
Current Fallow/harvested
Dry crop
Forest Blank
Grove
Hill
Quarry land
Reserved Forest
Reservoir/Lake/Tank/River
Rural settlement
Saltpan
Scrub
Shrub
Urban settlement
Waterlog/Swamp
Wet crop
Industrial belt
Legend
Location
Subbasin Boundary
UT of Puducherry
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI - 600 113
10 5 0 10 KM
79°10'0"E
79°20'0"E
79°30'0"E
79°40'0"E
79°50'0"E
80°0'0"E
80°10'0"E
12°30'0"N
12°20'0"N
12°10'0"N
12°0'0"N
11°50'0"N



Well / VES Location in Varahanadhi river basin
Plate: VAR-18
Palar Basin
Pennaiyar Basin
Pennaiyar Basin
BAY OF BENGAL
Varahanadhi sub basin
Ongur sub basin
Nallavur sub basin
Thellar
Acharapakkam
Sittamur
Melmalayanur
Olakkur
Kilpennathur
Gingee
Vallam
Marakkanam
Mailam
Vikravandi
Vanur
Kanai
Kolianur
Kandamangalam
Legend
Block HQ
Sub basin boundary
UT of Puducherry
VES Locations
Borewell Locations
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
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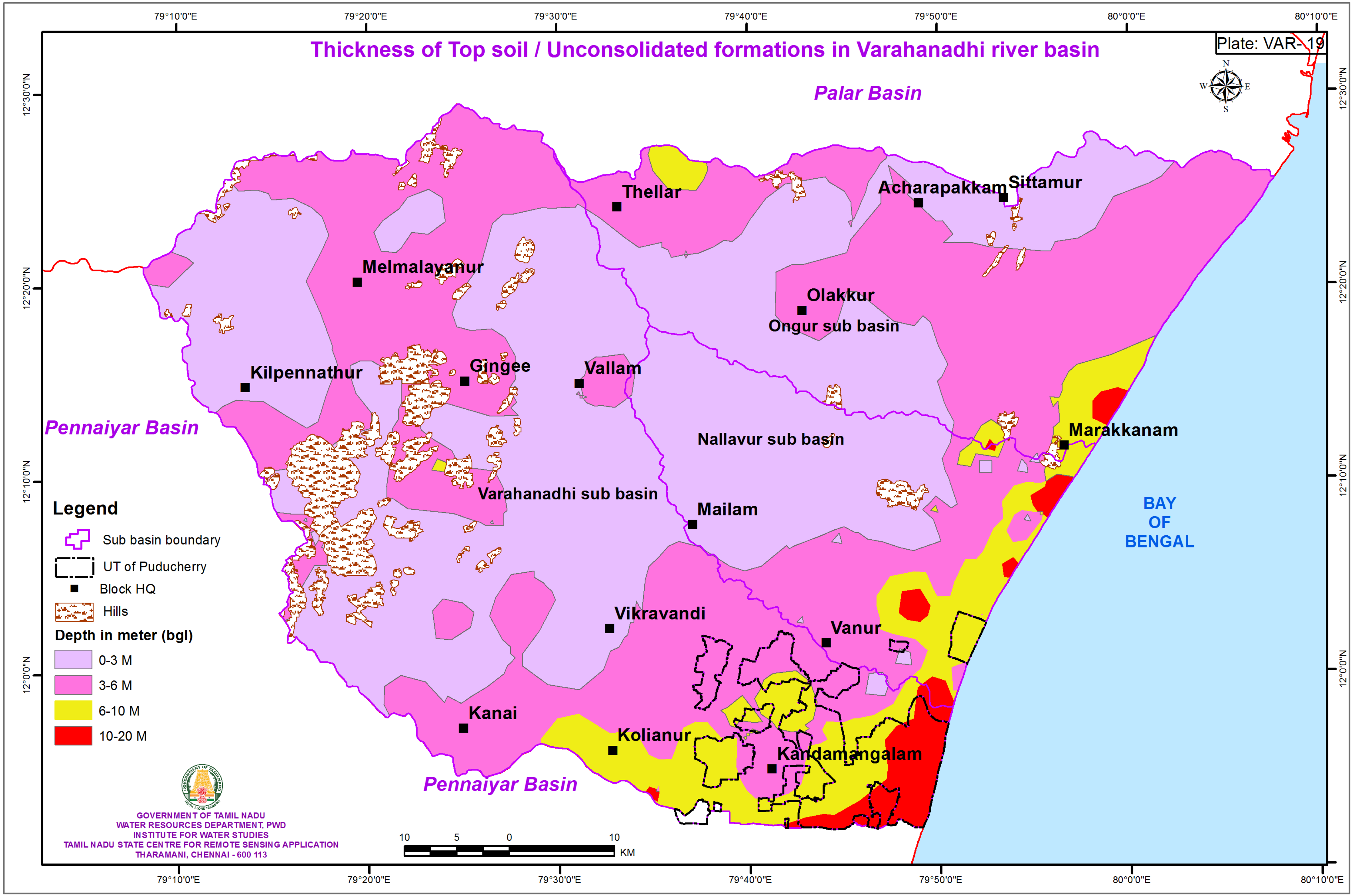
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI - 600 113
KM



Thickness of Top soil / Unconsolidated formations in Varahanadhi river basin
Plate: VAR- 19
Palar Basin
Pennaiyar Basin
Pennaiyar Basin
BAY OF BENGAL
Thellar
Acharapakkam
Sittamur
Melmalayanur
Olakkur
Ongur sub basin
Kilpennathur
Gingee
Vallam
Marakkanam
Nallavur sub basin
Varahanadhi sub basin
Mailam
Vikravandi
Vanur
Kanai
Kolianur
Kandamangalam
Legend
Sub basin boundary
UT of Puducherry
Block HQ
Hills
Depth in meter (bgl)
0-3 M
3-6 M
6-10 M
10-20 M
GOVERNMENT OF TAMIL NADU
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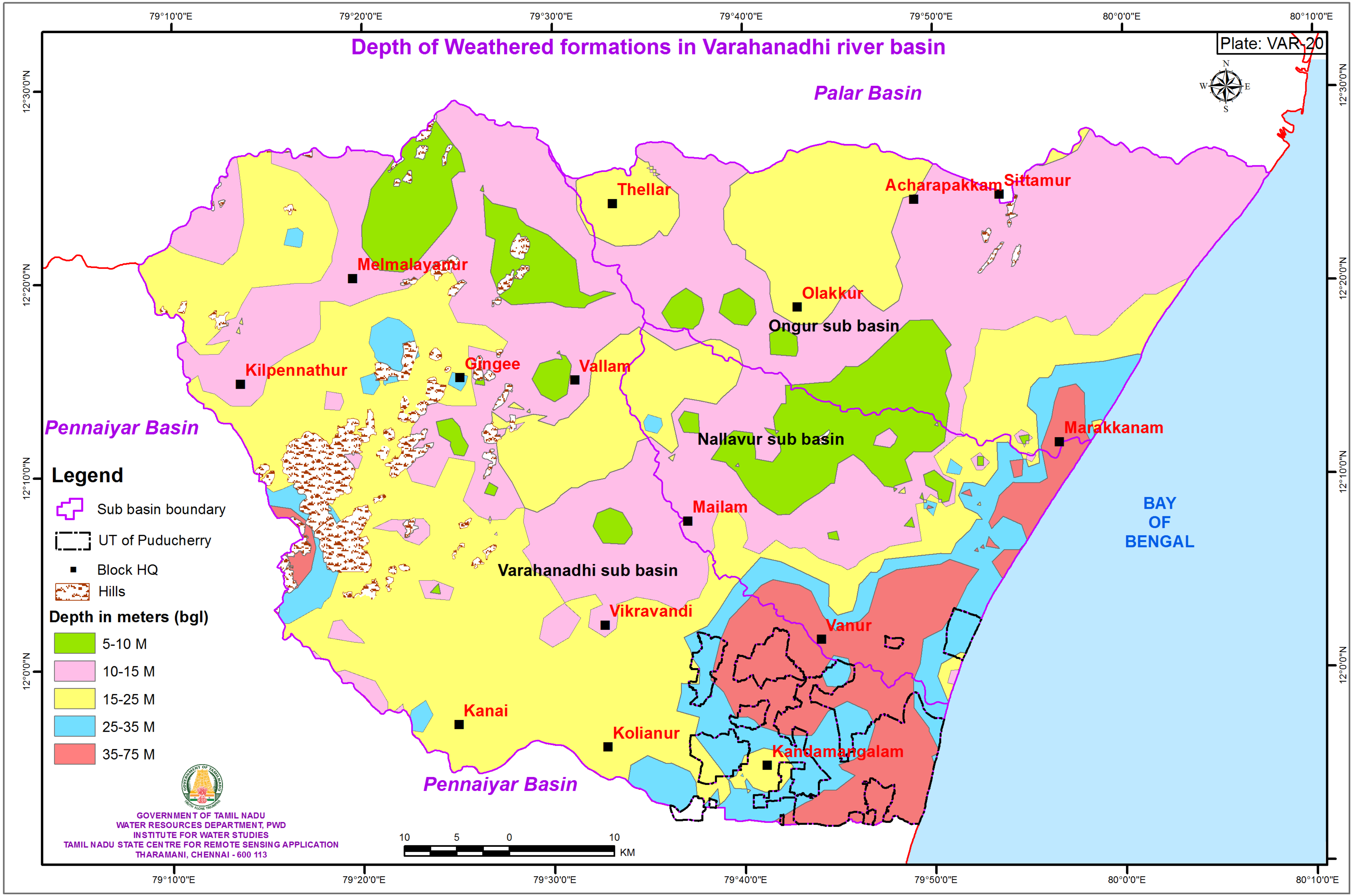
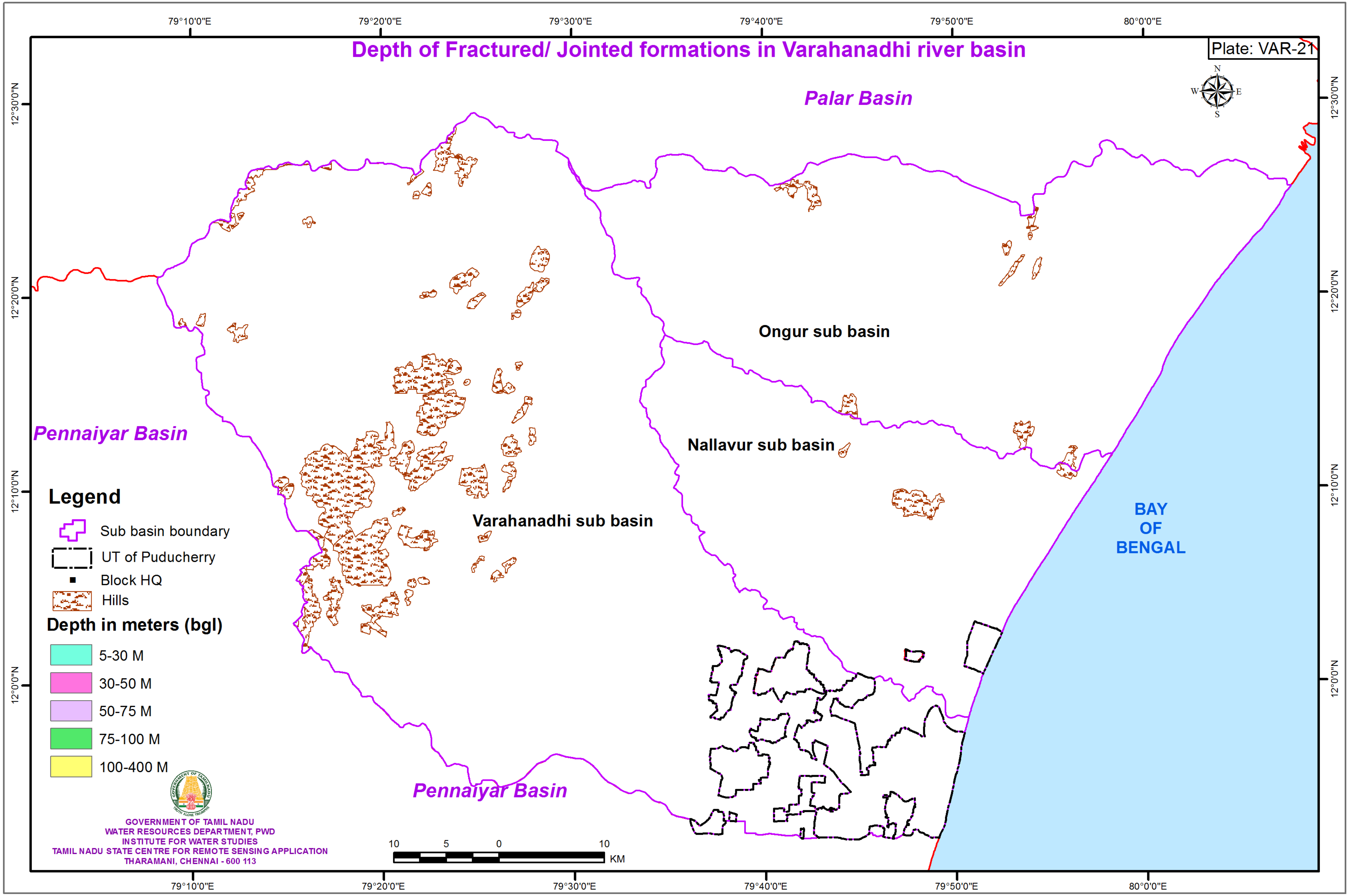
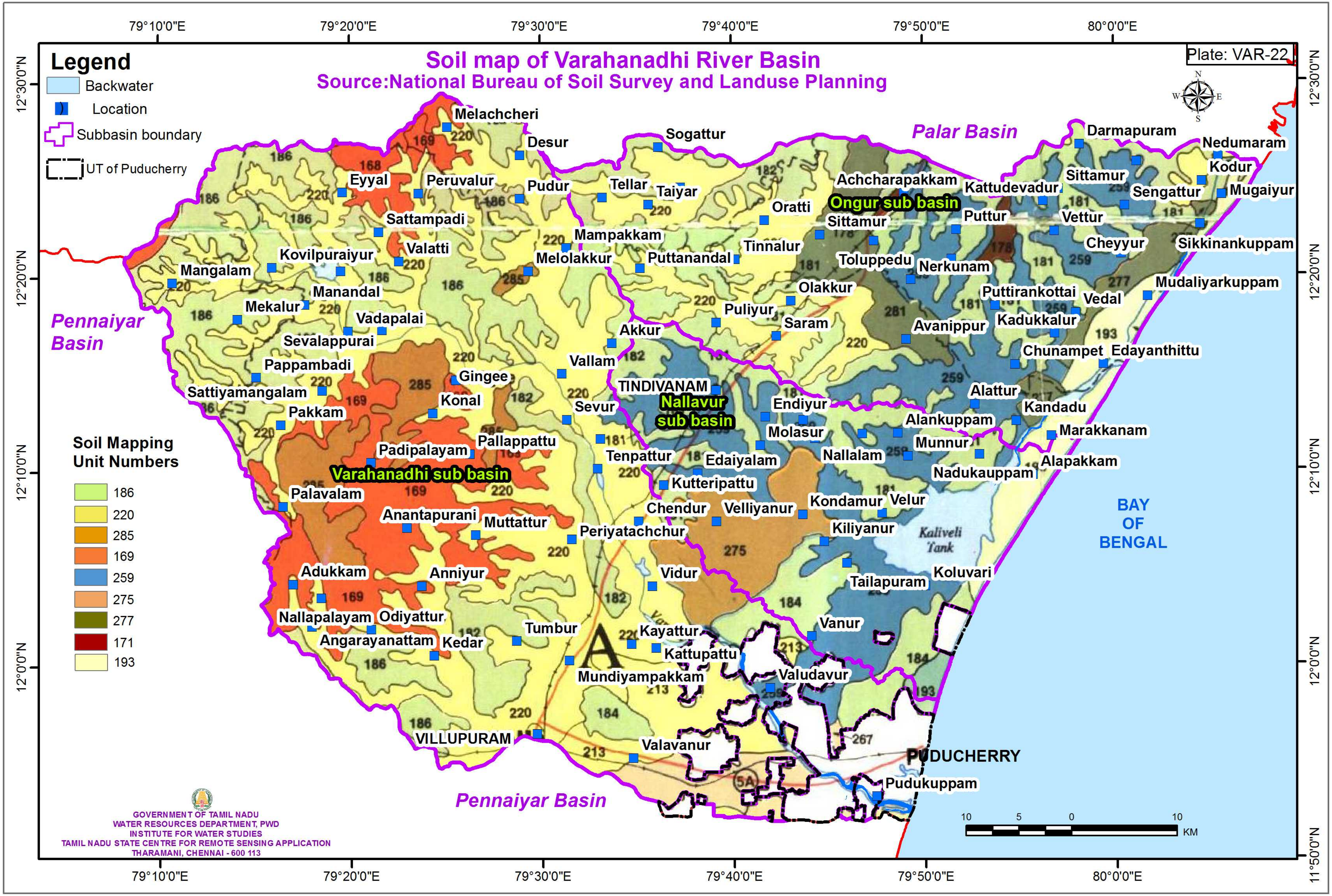
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI - 600 113
10 5 0 10
KM
79°10'0"E
79°20'0"E
79°30'0"E
79°40'0"E
79°50'0"E
80°0'0"E
80°10'0"E
12°30'0"N
12°20'0"N
12°10'0"N
12°0'0"N



Depth of Weathered formations in Varahanadhi river basin
Plate: VAR-20
Palar Basin
Pennaiyar Basin
Pennaiyar Basin
BAY OF BENGAL
Ongur sub basin
Nallavur sub basin
Varahanadhi sub basin
Thellar
Acharapakkam
Sittamur
Melmalayanur
Olakkur
Kilpennathur
Gingee
Vallam
Marakkanam
Mailam
Vikravandi
Vanur
Kanai
Kolianur
Kandamangalam
Legend
Sub basin boundary
UT of Puducherry
Block HQ
Hills
Depth in meters (bgl)
5-10 M
10-15 M
15-25 M
25-35 M
35-75 M
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI - 600 113
10 5 0 10 KM
79°10'0"E 79°20'0"E 79°30'0"E 79°40'0"E 79°50'0"E 80°0'0"E 80°10'0"E
12°30'0"N 12°20'0"N 12°10'0"N 12°0'0"N


Depth of Fractured/ Jointed formations in Varahanadhi river basin
Plate: VAR-21
Palar Basin
Ongur sub basin
Nallavur sub basin
Varahanadhi sub basin
Pennaiyar Basin
Pennaiyar Basin
BAY OF BENGAL
Legend
Sub basin boundary
UT of Puducherry
Block HQ
Hills
Depth in meters (bgl)
5-30 M
30-50 M
50-75 M
75-100 M
100-400 M
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI - 600 113
10 5 0 10
KM
79°10'0"E
79°20'0"E
79°30'0"E
79°40'0"E
79°50'0"E
80°0'0"E
12°30'0"N
12°20'0"N
12°10'0"N
12°0'0"N


Soil map of Varahanadhi River Basin
Source:National Bureau of Soil Survey and Landuse Planning
Plate: VAR-22
Legend
Backwater
Location
Subbasin boundary
UT of Puducherry
Soil Mapping Unit Numbers
186
220
285
169
259
275
277
171
193
Pennaiyar Basin
Palar Basin
Pennaiyar Basin
BAY OF BENGAL
Varahanadhi sub basin
Nallavur sub basin
Ongur sub basin
TINDIVANAM
VILLUPURAM
PUDUCHERRY
Melachcheri
Desur
Sogattur
Darmapuram
Nedumaram
Kodur
Mugaiyur
Eyyal
Peruvalur
Pudur
Tellar
Taiyar
Oratti
Achcharapakkam
Kattudevadur
Sittamur
Sengattur
Sattampadi
Mampakkam
Sittamur
Puttur
Vettur
Cheyyur
Sikkinankuppam
Valatti
Kovilpuraiyur
Melolakkur
Puttanandal
Tinnalur
Toluppedu
Nerkunam
Mangalam
Manandal
Olakkur
Puttirankottai
Vedal
Mudaliyarkuppam
Mekalur
Vadapalai
Puliyur
Saram
Avanippur
Kadukkalur
Sevalappurai
Akkur
Chunampet
Edayanthittu
Pappambadi
Vallam
Gingee
Sattiyamangalam
Konal
Sevur
Endiyur
Alattur
Pakkam
Kandadu
Molasur
Alankuppam
Marakkanam
Padipalayam
Pallappattu
Tenpattur
Edaiyalam
Nallalam
Munnur
Alapakkam
Nadukauppam
Palavalam
Kutteripattu
Chendur
Velliyanur
Kondamur
Velur
Anantapurani
Muttattur
Periyatachchur
Kiliyanur
Kaliveli Tank
Adukkam
Anniyur
Vidur
Koluvari
Tailapuram
Nallapalayam
Odiyattur
Tumbur
Kayattur
Vanur
Angarayanattam
Kedar
Kattupattu
Mundiyampakkam
Valudavur
Valavanur
Pudukuppam
10 5 0 10 KM
79°10'0"E
79°20'0"E
79°30'0"E
79°40'0"E
79°50'0"E
80°0'0"E
12°30'0"N
12°20'0"N
12°10'0"N
12°0'0"N
11°50'0"N
GOVERNMENT OF TAMIL NADU
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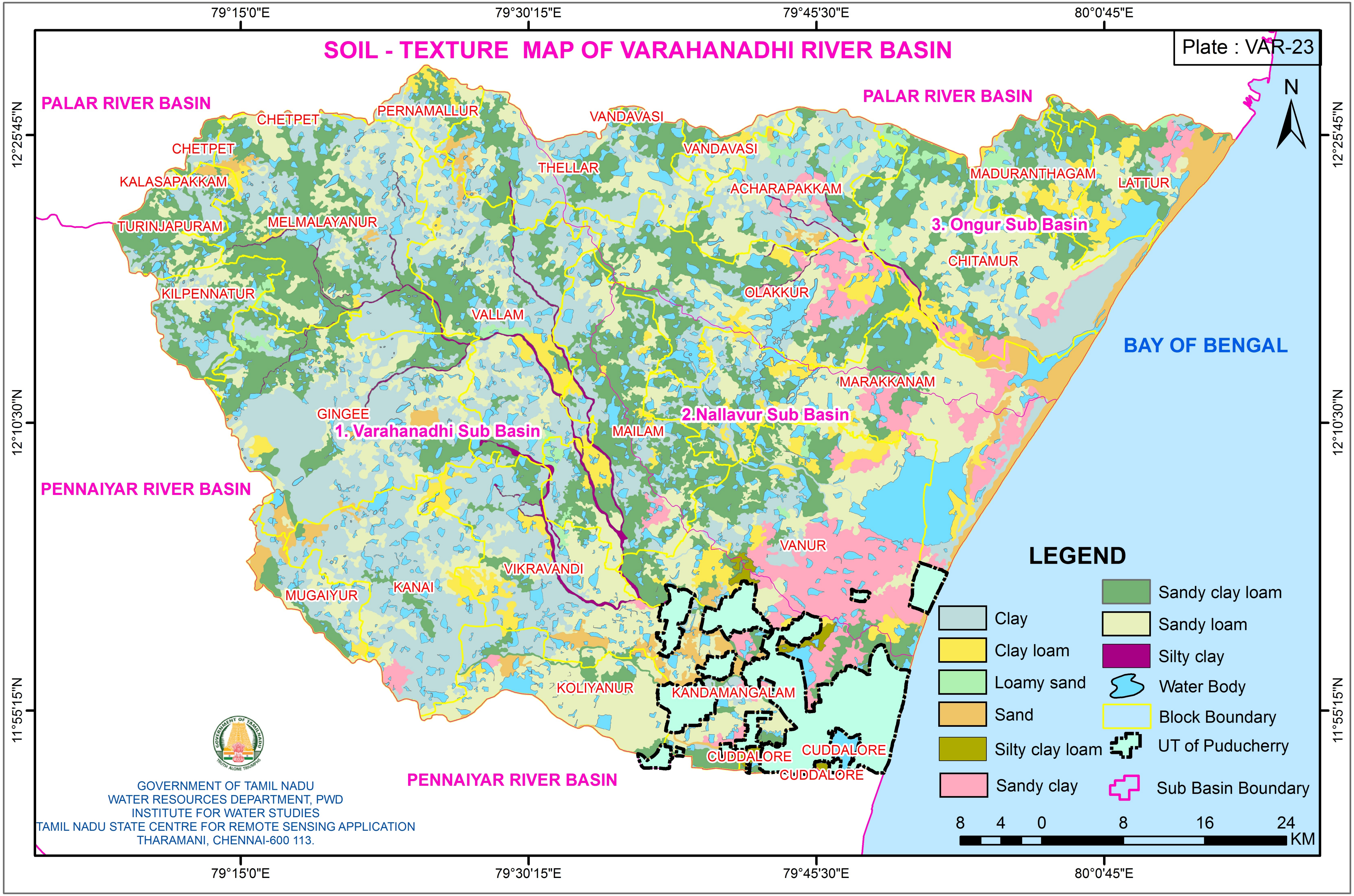
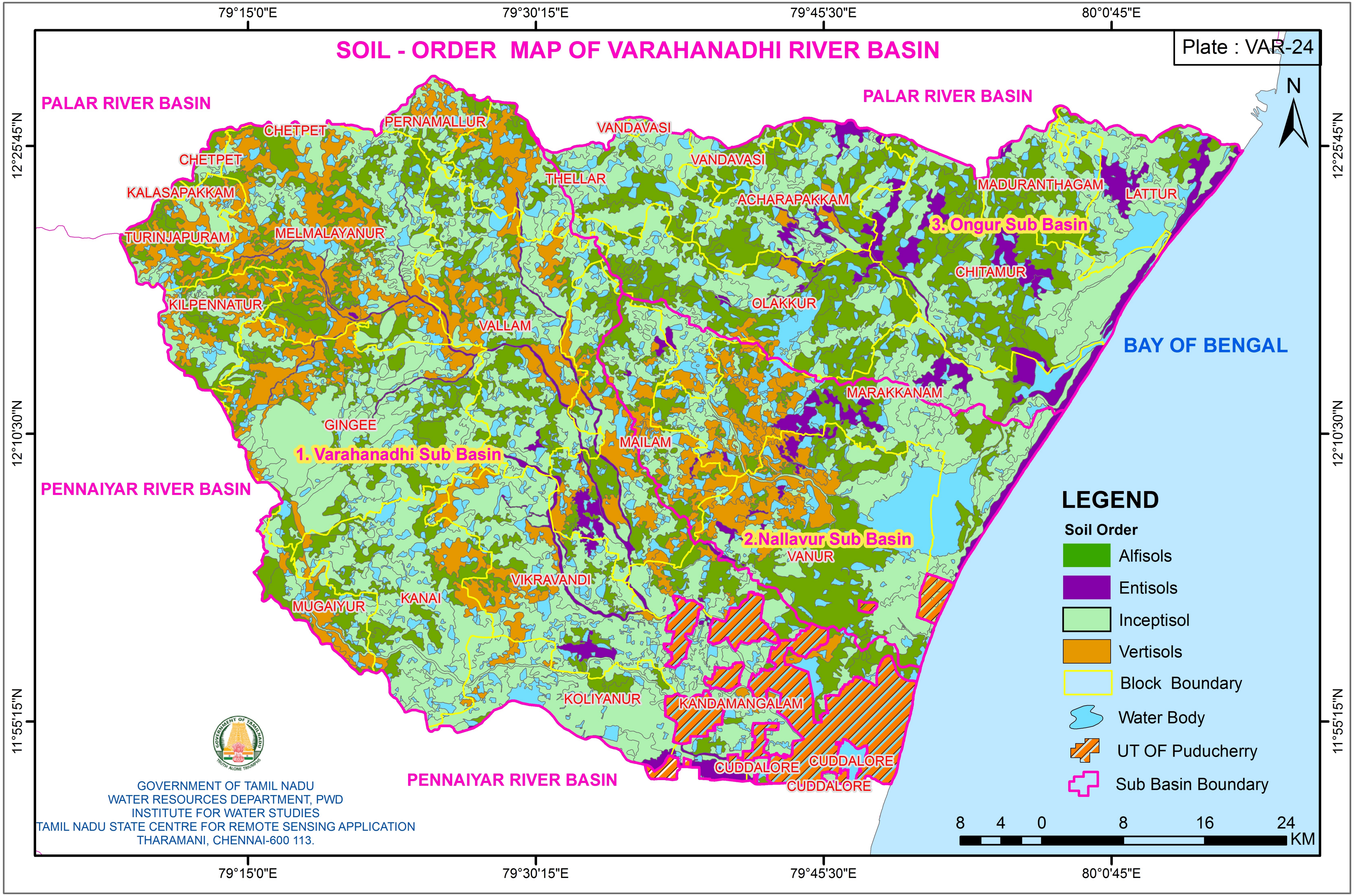

SOIL - TEXTURE MAP OF VARAHANADHI RIVER BASIN
Plate : VAR-23
79°15'0"E
79°30'15"E
79°45'30"E
80°0'45"E
12°25'45"N
12°10'30"N
11°55'15"N
N
PALAR RIVER BASIN
PALAR RIVER BASIN
PENNAIYAR RIVER BASIN
PENNAIYAR RIVER BASIN
BAY OF BENGAL
1. Varahanadhi Sub Basin
2.Nallavur Sub Basin
3. Ongur Sub Basin
CHETPET
CHETPET
PERNAMALLUR
VANDAVASI
VANDAVASI
THELLAR
ACHARAPAKKAM
MADURANTHAGAM
LATTUR
KALASAPAKKAM
TURINJAPURAM
MELMALAYANUR
CHITAMUR
KILPENNATUR
VALLAM
OLAKKUR
MARAKKANAM
GINGEE
MAILAM
VANUR
VIKRAVANDI
MUGAIYUR
KANAI
KOLIYANUR
KANDAMANGALAM
CUDDALORE
CUDDALORE
CUDDALORE
LEGEND
Clay
Clay loam
Loamy sand
Sand
Silty clay loam
Sandy clay
Sandy clay loam
Sandy loam
Silty clay
Water Body
Block Boundary
UT of Puducherry
Sub Basin Boundary
8 4 0 8 16 24
KM
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI-600 113.


SOIL - ORDER MAP OF VARAHANADHI RIVER BASIN
Plate : VAR-24
79°15'0"E
79°30'15"E
79°45'30"E
80°0'45"E
12°25'45"N
12°10'30"N
11°55'15"N
PALAR RIVER BASIN
PALAR RIVER BASIN
PENNAIYAR RIVER BASIN
PENNAIYAR RIVER BASIN
BAY OF BENGAL
CHETPET
CHETPET
PERNAMALLUR
VANDAVASI
VANDAVASI
KALASAPAKKAM
THELLAR
ACHARAPAKKAM
MADURANTHAGAM
LATTUR
TURINJAPURAM
MELMALAYANUR
3. Ongur Sub Basin
CHITAMUR
KILPENNATUR
OLAKKUR
VALLAM
MARAKKANAM
GINGEE
MAILAM
1. Varahanadhi Sub Basin
2.Nallavur Sub Basin
VANUR
VIKRAVANDI
KANAI
MUGAIYUR
KOLIYANUR
KANDAMANGALAM
CUDDALORE
CUDDALORE
CUDDALORE
N
LEGEND
Soil Order
Alfisols
Entisols
Inceptisol
Vertisols
Block Boundary
Water Body
UT OF Puducherry
Sub Basin Boundary
8 4 0 8 16 24
KM
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI-600 113.

CHAPTER - 3

HYDROMETEOROLOGICAL CHARACTERISTICS

CHAPTER - 3

HYDROMETEOROLOGICAL CHARACTERISTICS

3.1 General

Rainfall is the key climatic inconsistent that governs the regional hydrologic cycle and main source of water resources. It is also one of the most composite and difficult elements of the hydrological cycle to understand due to the great range of variation over a wide range of scales both in space and time.

To determine the rainfall pattern in certain area, it needs the rainfall data from rain gauge stations which spread in the study area. The rainfall data which measured by rain gauge indicate only the quantity of water (i.e.,) depth of rainfall, but not the source of rainfall. These data help us to predict the quantity of rainfall, but could not help us to uncover the hidden factor beside the rainfall. By identifying the dominant factors which causes the rainfall, one can interpret the rainfall data better and can help us to make the better prediction in the future.

In this section Varahanadhi River Basin climate parameters are studied. The study made on the hydro-meteorological characteristics, includes analysis of rainfall, temperature, humidity, wind speed, sunshine and evaporation. Study also made on rainfall Pattern of Varahanadhi Basin, which includes the spatial distribution and variability through different seasons, precipitation ratio and its dependability. Geographical Information System (GIS) plays a vital role in interpolating and displaying various attributes of rainfall.

The Varahanadhi River Basin lies in the districts of Villupuram, Thiruvannamalai and Cuddalore of Tamil Nadu state. A detailed study report on the hydro meteorological parameters for Varahanadhi River Basin is furnished below.

3.2 Rainfall

3.2.1 Rain gauge Stations

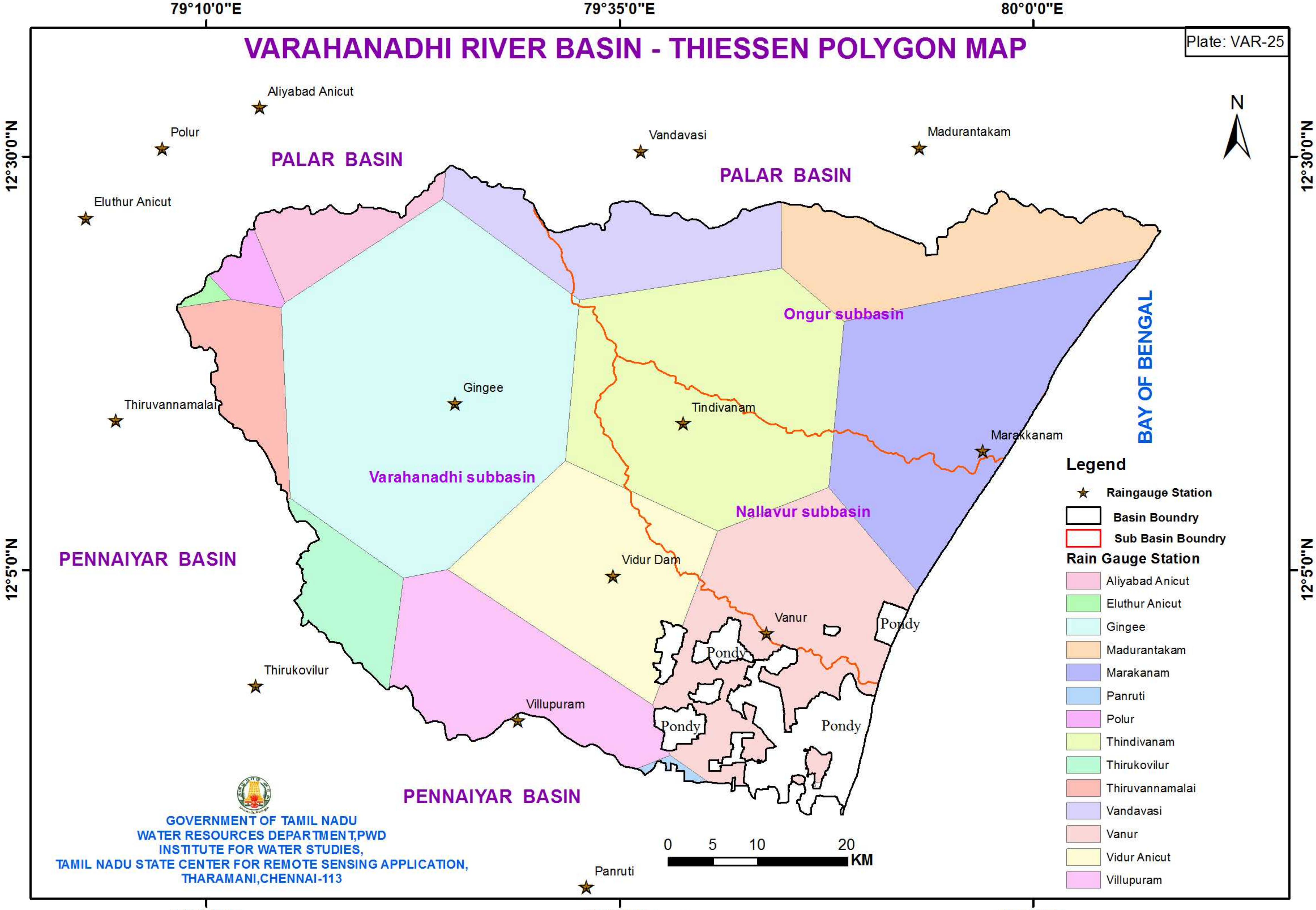
Monthly rainfall data for the period of 39 years from 1977 to 2016 has been collected from State Ground & Surface Water Resources Data Centre, Tharamani, Chennai. There are 14 rainfall stations in and around the Basin which have been taken into consideration for analyzing long term mean monthly, seasonal and annual rainfall pattern.

Out of twenty Raingauge Stations found in and around the vicinity of Varahanadhi River Basin, only five Raingauge stations lies inside the basin. But fourteen rain gauge stations have been selected, considering their location, geographical coordinates and continuous data available for the study period of detailed analysis. The details of influencing and non-influencing rain gauge stations in Varahanadhi River basin are given in the **Table 3.1 (a) and (b)**. 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 Tamilnadu 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 spanning from October to December with dominant northeast winds. Finally, dry season starts from January and ends at May. The monsoon period is hydrological a significant for water resource analysis.

Geographical Information System (GIS) plays a vital role in interpolating and displaying various attributes of rainfall. The monthly and season-wise rainfalls for 14 rain gauge stations are given in the **Appendix 3.1**. The Thiessen Polygon Map is given in **Plate No: VAR – 25.** Probable Mean Area rainfall analysis for 25%, 50%, 75%, 90% and the average for southwest, northeast, winter, summer and annual rainfall for all the sub basins have been analysed and tabulated in **Table 3.2 to 3.4**. The season wise Isohyets maps (**Plate No: VAR –26 to 30)** are also presented.


VARAHANADHI RIVER BASIN - THIESSEN POLYGON MAP
Plate: VAR-25
79°10'0"E
79°35'0"E
80°0'0"E
12°30'0"N
12°5'0"N
N
PALAR BASIN
PALAR BASIN
PENNAIYAR BASIN
PENNAIYAR BASIN
BAY OF BENGAL
Ongur subbasin
Varahanadhi subbasin
Nallavur subbasin
Aliyabad Anicut
Polur
Eluthur Anicut
Vandavasi
Madurantakam
Gingee
Thiruvannamalai
Tindivanam
Marakkanam
Vidur Dam
Vanur
Thirukovilur
Villupuram
Panruti
Pondy
Pondy
Pondy
Pondy
Legend
Raingauge Station
Basin Boundry
Sub Basin Boundry
Rain Gauge Station
Aliyabad Anicut
Eluthur Anicut
Gingee
Madurantakam
Marakanam
Panruti
Polur
Thindivanam
Thirukovilur
Thiruvannamalai
Vandavasi
Vanur
Vidur Anicut
Villupuram
0 5 10 20
KM
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT,PWD
INSTITUTE FOR WATER STUDIES,
TAMIL NADU STATE CENTER FOR REMOTE SENSING APPLICATION,
THARAMANI,CHENNAI-113

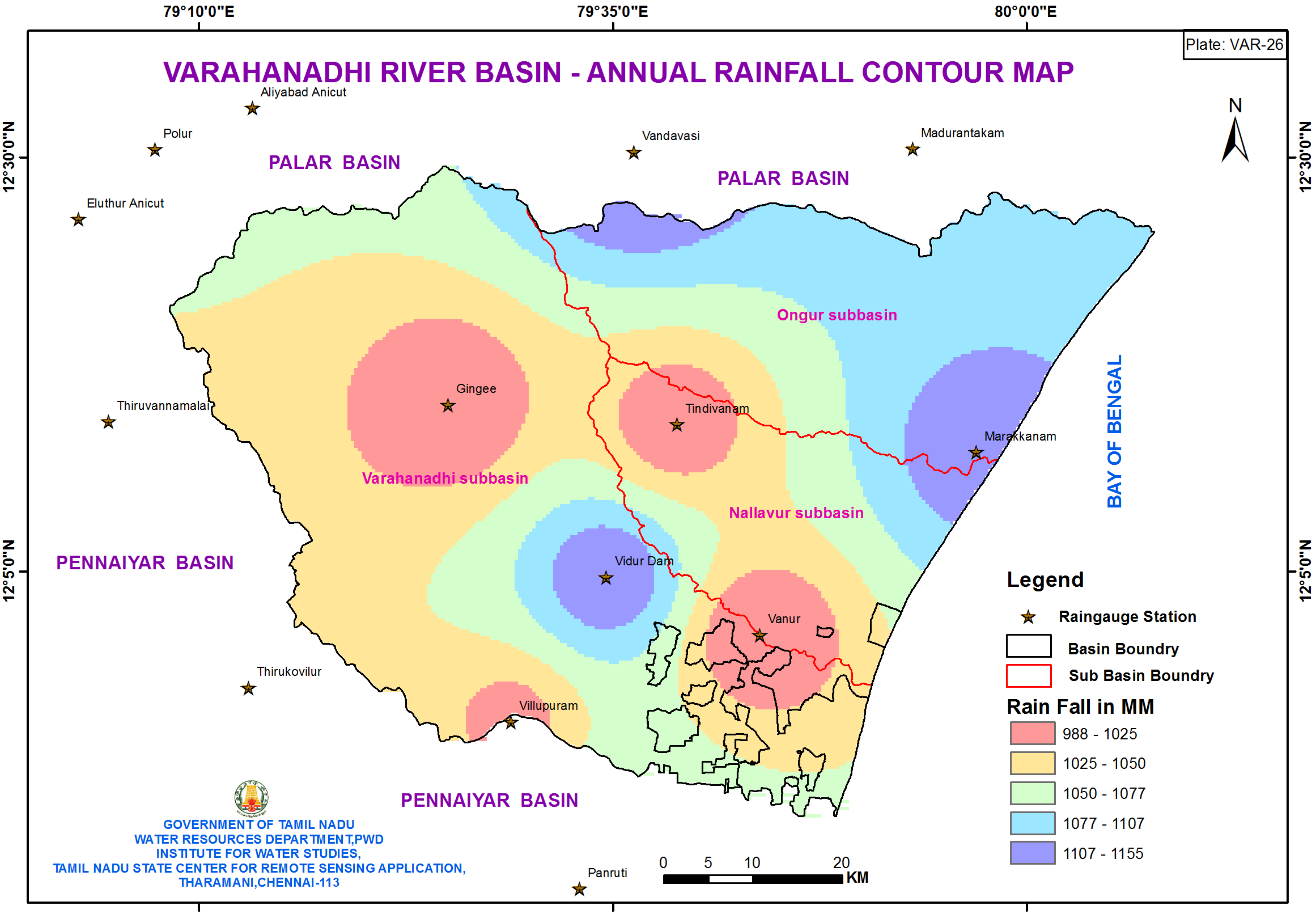


Plate: VAR-26
VARAHANADHI RIVER BASIN - ANNUAL RAINFALL CONTOUR MAP
79°10'0"E
79°35'0"E
80°0'0"E
12°30'0"N
12°5'0"N
N
PALAR BASIN
PALAR BASIN
PENNAIYAR BASIN
PENNAIYAR BASIN
BAY OF BENGAL
Ongur subbasin
Varahanadhi subbasin
Nallavur subbasin
Aliyabad Anicut
Polur
Eluthur Anicut
Vandavasi
Madurantakam
Thiruvannamalai
Gingee
Tindivanam
Marakkanam
Vidur Dam
Vanur
Thirukovilur
Villupuram
Panruti
Legend
Raingauge Station
Basin Boundry
Sub Basin Boundry
Rain Fall in MM
988 - 1025
1025 - 1050
1050 - 1077
1077 - 1107
1107 - 1155
0 5 10 20 KM
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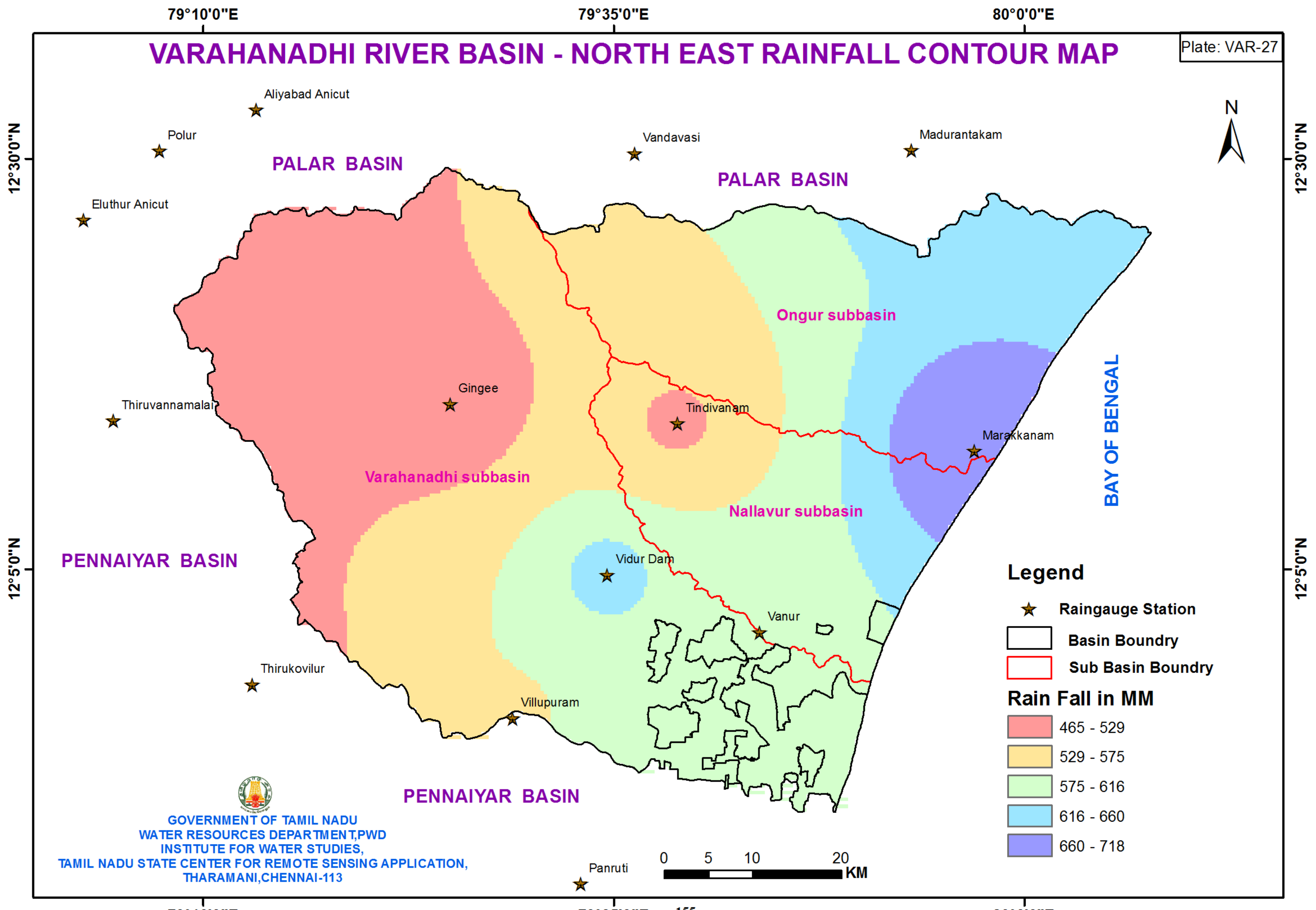
VARAHANADHI RIVER BASIN - NORTH EAST RAINFALL CONTOUR MAP
Plate: VAR-27
79°10'0"E
79°35'0"E
80°0'0"E
12°30'0"N
12°5'0"N
N
Aliyabad Anicut
Polur
Vandavasi
Madurantakam
PALAR BASIN
PALAR BASIN
Eluthur Anicut
Ongur subbasin
Gingee
Thiruvannamalai
Tindivanam
Marakkanam
BAY OF BENGAL
Varahanadhi subbasin
Nallavur subbasin
PENNAIYAR BASIN
Vidur Dam
Vanur
Thirukovilur
Villupuram
PENNAIYAR BASIN
Legend
Raingauge Station
Basin Boundry
Sub Basin Boundry
Rain Fall in MM
465 - 529
529 - 575
575 - 616
616 - 660
660 - 718
Panruti
0 5 10 20
KM
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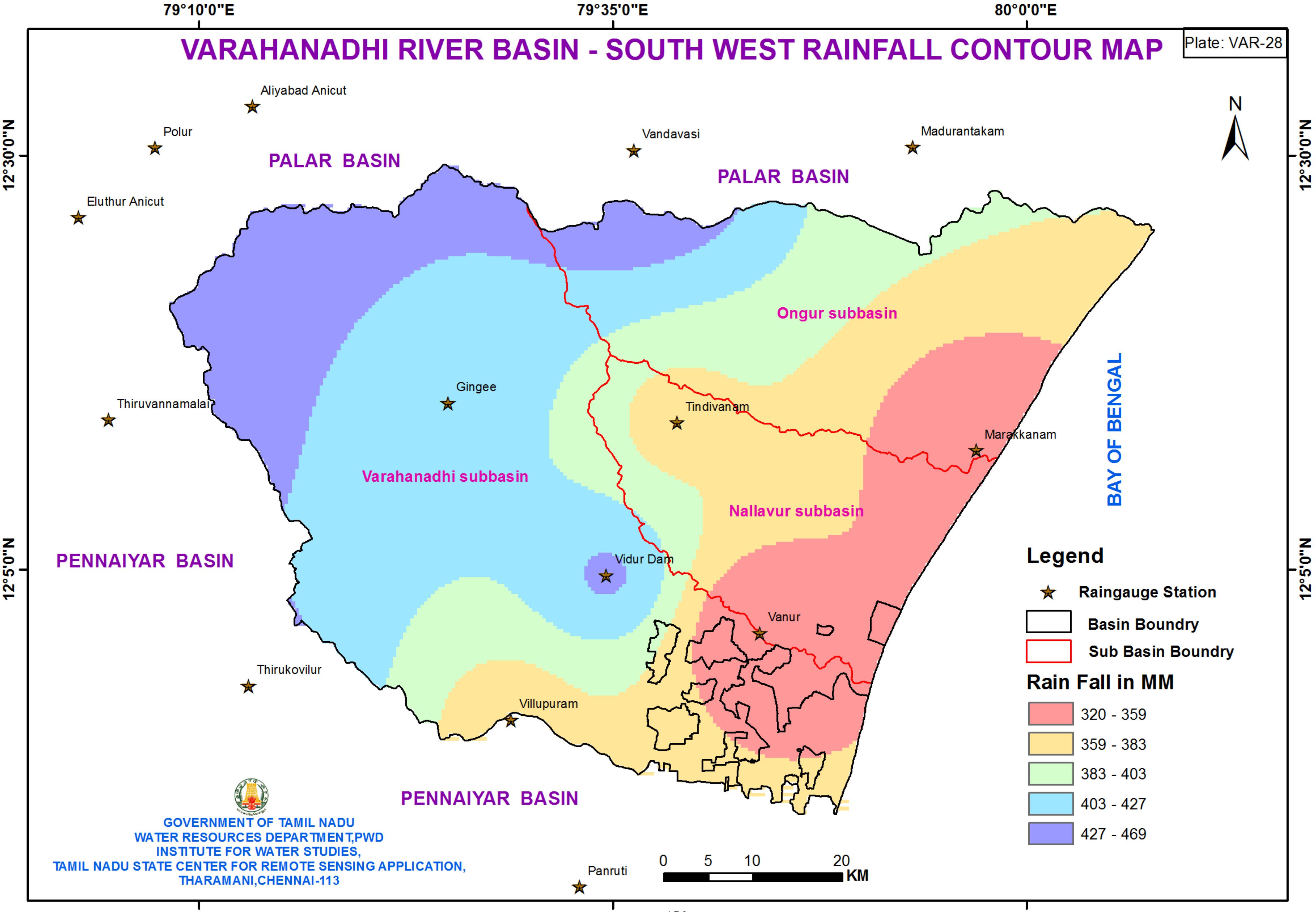
VARAHANADHI RIVER BASIN - SOUTH WEST RAINFALL CONTOUR MAP
Plate: VAR-28
79°10'0"E
79°35'0"E
80°0'0"E
12°30'0"N
12°5'0"N
N
Aliyabad Anicut
Polur
Eluthur Anicut
Vandavasi
Madurantakam
PALAR BASIN
PALAR BASIN
Ongur subbasin
Gingee
Thiruvannamalai
Tindivanam
Marakkanam
BAY OF BENGAL
Varahanadhi subbasin
Nallavur subbasin
PENNAIYAR BASIN
Vidur Dam
Vanur
Thirukovilur
Villupuram
PENNAIYAR BASIN
Legend
Raingauge Station
Basin Boundry
Sub Basin Boundry
Rain Fall in MM
320 - 359
359 - 383
383 - 403
403 - 427
427 - 469
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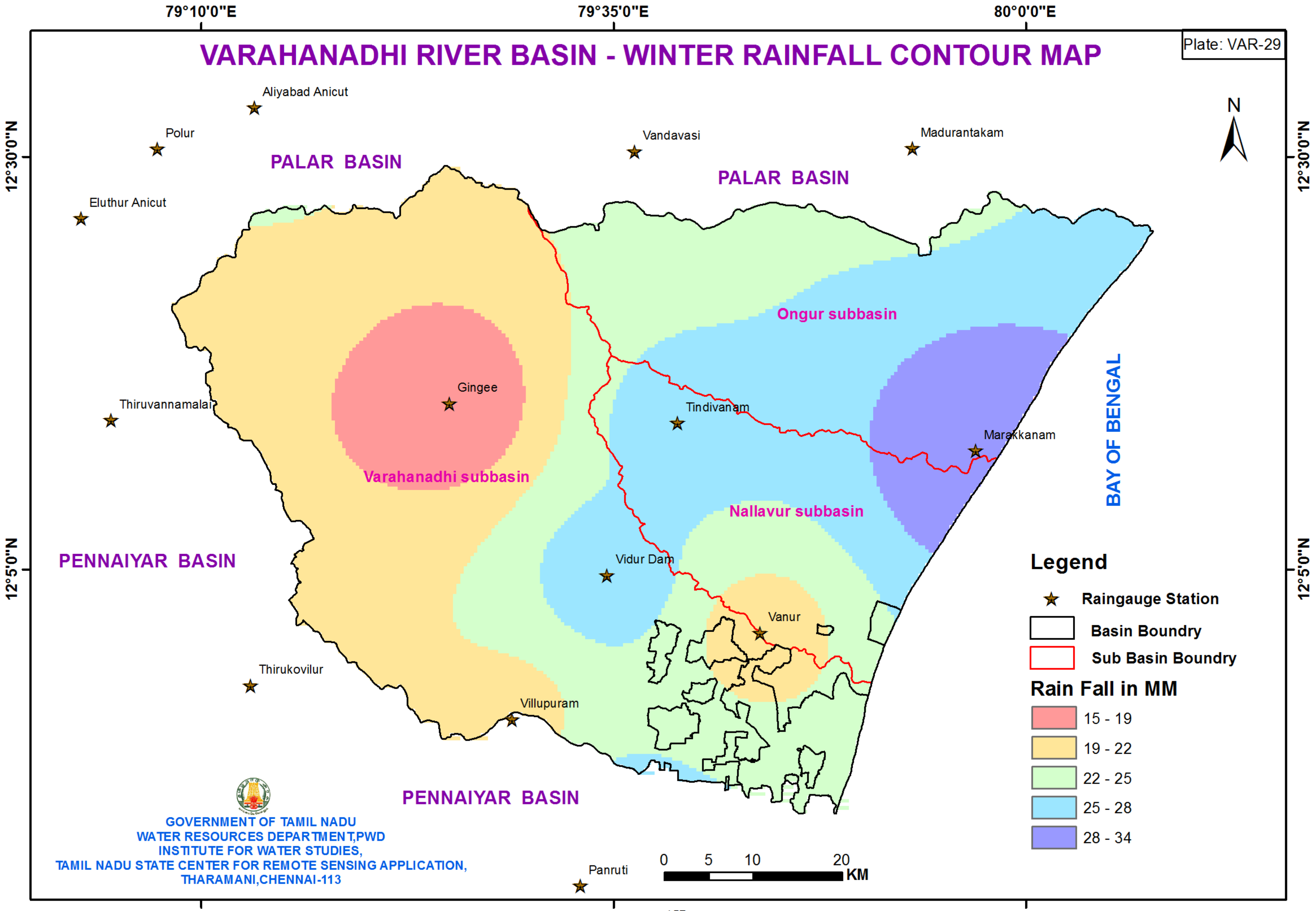
Panruti
0 5 10 20
KM



VARAHANADHI RIVER BASIN - WINTER RAINFALL CONTOUR MAP
Plate: VAR-29
79°10'0"E
79°35'0"E
80°0'0"E
12°30'0"N
12°5'0"N
N
PALAR BASIN
PALAR BASIN
PENNAIYAR BASIN
PENNAIYAR BASIN
BAY OF BENGAL
Ongur subbasin
Varahanadhi subbasin
Nallavur subbasin
Aliyabad Anicut
Polur
Eluthur Anicut
Thiruvannamalai
Thirukovilur
Villupuram
Gingee
Vandavasi
Madurantakam
Tindivanam
Marakkanam
Vidur Dam
Vanur
Panruti
Legend
Raingauge Station
Basin Boundry
Sub Basin Boundry
Rain Fall in MM
15 - 19
19 - 22
22 - 25
25 - 28
28 - 34
0 5 10 20
KM
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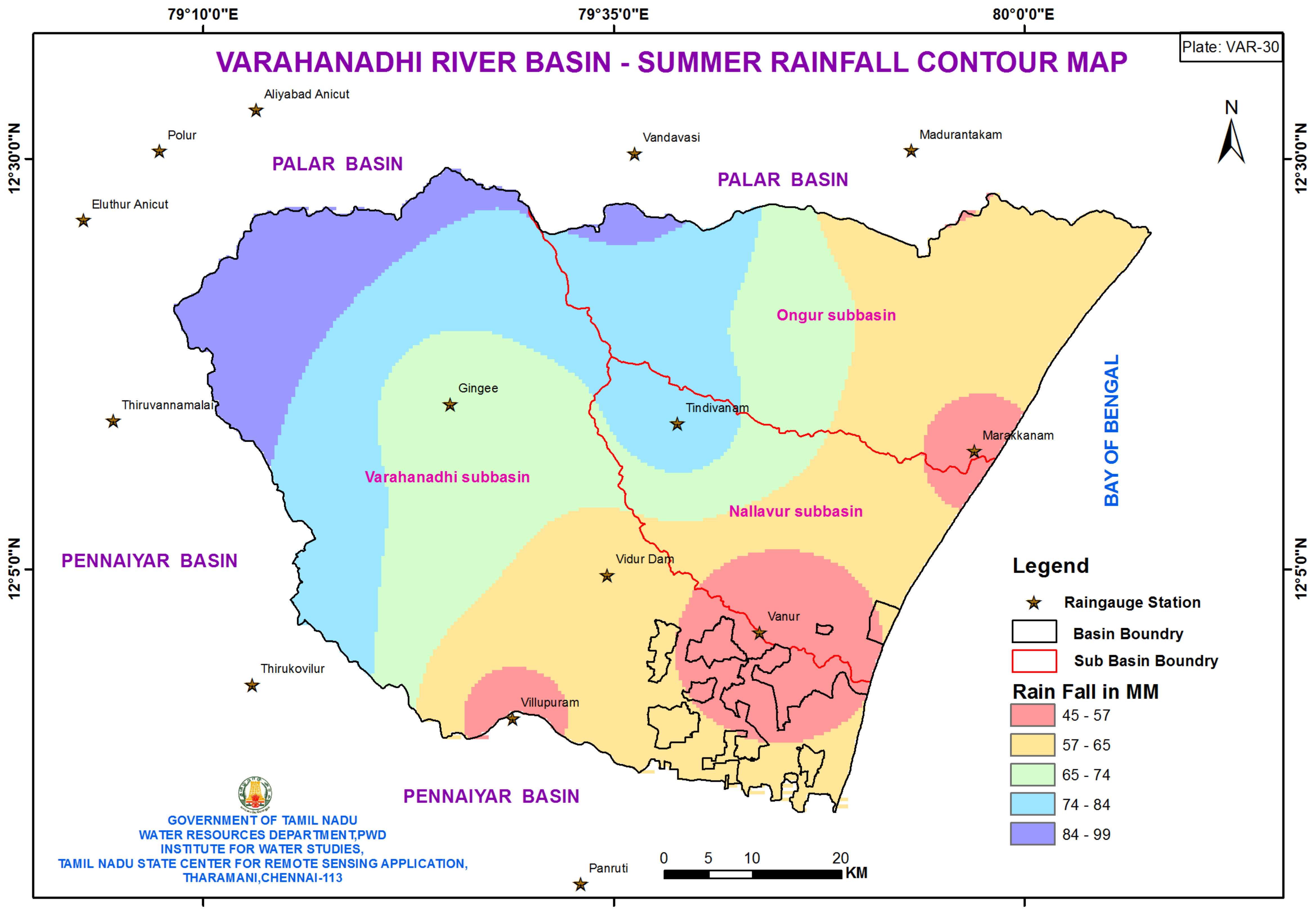

VARAHANADHI RIVER BASIN - SUMMER RAINFALL CONTOUR MAP
Plate: VAR-30
79°10'0"E
79°35'0"E
80°0'0"E
12°30'0"N
12°5'0"N
N
Aliyabad Anicut
Polur
Vandavasi
Madurantakam
Eluthur Anicut
PALAR BASIN
PALAR BASIN
Ongur subbasin
Gingee
Thiruvannamalai
Tindivanam
Marakkanam
BAY OF BENGAL
Varahanadhi subbasin
Nallavur subbasin
PENNAIYAR BASIN
Vidur Dam
Vanur
Thirukovilur
Villupuram
PENNAIYAR BASIN
Panruti
Legend
Raingauge Station
Basin Boundry
Sub Basin Boundry
Rain Fall in MM
45 - 57
57 - 65
65 - 74
74 - 84
84 - 99
0 5 10 20
KM
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Table 3.1 (a)
Influencing Raingauge Stations of Varahanadhi River Basin

Sl.no	Station Code	Taluk	District	Source	Lat	Long	Data Availability Period
1	Aliyabad Anicut	Polur	Thiruvannamalai	PWD	12°33'00"	79°13'15"	1977-2016
2	Eluthur Anicut	Polur	Villupuram	PWD	12°26'18"	79°02'45"	1977-2016
3	Gingee	Gingee	Villupuram	PWD	12°15'05"	79°25'04"	1977-2016
4	Madurantakam	Madurantakam	Kancheepuram	PWD	12°30'33"	79°53'08"	1977-2016
5	Marakkanam	Tindivanam	Villupuram	PWD	12°12'13"	79°56'58"	1977-2016
6	Panruti	Cuddalore	Cuddalore	PWD	11°45'51"	79°33'01"	1977-2016
7	Polur	Thiruvannamalai	Thiruvannamalai	PWD	12°30'31"	79°07'21"	1977-2016
8	Tindivanam	Tindivanam	Villupuram	PWD	12°13'54"	79°38'53"	1977-2016
9	Thirukovilur	Thirukovilur	Villupuram	PWD	11°56'30"	79°11'32"	1977-2016
10	Thiruvannamalai	Thiruvannamalai	Thiruvannamalai	PWD	12°14'04"	79°04'34"	1977-2016
11	Vandavasi	Vandavasi	Thiruvannamalai	PWD	12°30'21"	79°36'17"	1977-2016
12	Vanur	Vanur	Villupuram	PWD	12°01'11"	79°43'55"	1977-2016
13	Vidur Dam	Tindivanam	Villupuram	PWD	12°04'40"	79°34'38"	1977-2016
14	Villupuram	Villupuram	Villupuram	PWD	11°55'56"	79°28'52"	1977-2016

Table 3.1 (b) Non-Influencing Raingauge Stations of Varahanadhi River Basin

S.No	Name of Raingauge Station	Taluk	District	Source	Latitutde	Longitude	Data avilability Period
1	Vanamadevi.	Kattumannarkoil	Cuddalore	PWD	11°44'31"	79°38'35"	1984-2008
2	Kilnatchupattu	Panruti	Cuddalore	PWD	11°44'49"	79°38'10"	1997-2015
3	Kovilur anicut	Cheyyar	Thiruvannamalai	PWD	12°34'13"	79°31'18"	1977-2015
4	Vanapuram	Thiruvannamalai	Thiruvannamalai	PWD	12°06'16"	79°01'05"	1963-2016
5	Cuddalore	Cuddalore	Cuddalore	PWD	11°45'23"	79°45'57"	1977-2016
6	Cheyyar anicut	Cheyyar	Thiruvannamalai	PWD	12°35'37"	79°23'16"	1980-2016

Table 3.2 - Varahandhi Sub Basin - Season wise - Dependable Rainfall (in mm)

Name of the Sub basin		Varahanadhi			
Season	25%	50%	75%	90%	Average
SW	483.76	393.99	316.22	275.42	405.79
NE	663.86	503.46	374.04	336.75	530.69
Winter	19.39	7.01	0.66	0.00	19.45
Summer	92.34	49.83	26.34	10.86	69.23
Annual	1145.67	1008.35	816.92	713.18	1025.16

Table 3.3 - Nallavur Sub Basin - Season wise - Dependable Rainfall (in mm)

Name of the Sub basin		Nallavur			
Season	25%	50%	75%	90%	Average
SW	432.50	317.73	249.16	208.41	346.82
NE	742.79	570.60	488.46	398.45	600.40
Winter	12.80	5.13	0.00	0.00	25.95
Summer	82.55	52.13	13.61	1.05	60.26
Annual	1162.88	1009.92	905.50	691.97	1033.43

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

Name of the Sub basin		Ongur			
Season	25%	50%	75%	90%	Average
SW	466.44	361.15	285.02	217.14	376.10
NE	765.57	609.57	453.05	340.33	630.52
Winter	23.76	7.02	1.14	0.00	27.64
Summer	88.59	43.97	22.31	10.45	66.09
Annual	1293.03	1063.30	879.87	746.75	1100.35

3.2.3 Dependable Rainfall

The 25%, 50%, 75% and 90% dependable rainfall for Varahanadhi River Basin are tabulated below in **Table 3.5**

Table 3.5 - Dependable Rainfall in mm – Varahanadhi River Basin

Name of the basin	**Varahanadhi Basin**			
Season	**Dependability**			
	25%	**50%**	**75%**	**90%**
SW	460.90	357.60	283.50	233.70
NE	724.10	561.20	438.5	358.50
Annual	1200.50	1027.20	867.40	717.50

3.2.4 Frequency Analysis

The range of annual precipitation and their frequency have been analysed and furnished in **Table 3.6**. From the table it is noticed that rainfall exceeding 1000mm occurred maximum of 67% of the study period (1977-2016) in Eluthur anicut, Marakanam, Panruti, Vandavasi, Vidur dam and minimum of 46% of study period in Gingee, Thirukovilur, Thiruvannamalai, Vanur. Rainfall in the range of 900-1000mm occurred nearly 28% of the study period in Vanur. Rainfall in the range of 800-900mm occurred in nearly 18% of the study period in Vidur dam, Villupuram. Rainfall in the range 600 to 800mm rainfall occurred nearly 26% of the study period in Polur. 400 to 600mm rainfall occurred nearly 18% of the study period in Gingee. 200 to 400mm rainfall occurred nearly 8% of the study period in Panruti. Less than 200 mm rainfall is not occurred in any of the stations considered for analysis.

Table 3.6 - 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	Aliyabad Anicut	39	21	5	6	3	4	0	0
2	Eluthur Anicut	39	26	6	0	5	2	0	0
3	Gingee	39	18	3	5	4	7	2	0
4	Madurantakam	39	22	5	2	7	1	2	0
5	Marakkanam	39	26	3	3	5	2	0	0
6	Panruti	39	25	3	3	4	1	3	0
7	Polur	39	20	4	4	10	1	0	0
8	Tindivanam	39	19	5	5	5	5	0	0
9	Thirukovilur	39	18	10	5	4	2	0	0
10	Thiruvannamalai	39	18	7	5	7	2	0	0
11	Vandavasi	39	25	5	6	3	0	0	0
12	Vanur	39	18	11	3	5	2	0	0
13	Vidur Dam	39	26	3	7	3	0	0	0
14	Villupuram	39	20	5	7	3	4	0	0

3.2.5 Maximum, minimum and average rainfall

The maximum, minimum and average annual rainfall for all 14 rain gauge stations in the three sub basins have been tabulated in **Appendix-3.1.1 to 3.1.14**

- Maximum annual average Rainfall of this basin is 1100.38 mm i.e. in Ongur Sub basin.
- Minimum annual average Rainfall of this basin is 1028.94 mm in Varahanadhi Sub basin
- Annual average rainfall of the Varahanadhi River Basin is 1054.19 mm.

Sub basin wise rainfall details are tabulated below **in Table 3.7**

Table 3.7 - Rainfall Details of the Varahanadhi Basin

Sl. No.	Name of the Sub-basin	No. of influencing Raingauage Staions	Rainfall range in mm(1977 - 2016)					Annual Average Rainfall in mm
			Annual	NE	SW	Winter	Summer	
1	Varahanadhi	10	1583.15 To 604.73	963.10 To 186.60	757.06 To 225.12	126.70 To 0.0	271.65 To 3.90	1028.94
2	Nallavur	4	1663.35 To 631.63	994.80 To 286.10	700.13 To 181.12	293.62 To 0.0	241.10 To 0.0	1033.25
3	Ongur	4	1863.83 To 567.60	1159.70 To 220.33	676.30 To 196.30	272.53 To 0.0	350.94 To 1.33	1100.38

3.2.6 Moving Average

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 **Appendix 3.2** and **Appendix 3.3.1 to 3.3.3** respectively.

- **The Varahanadhi sub basin is showing the increasing trend line.**
- **The Ongur sub basin is showing the slightly increasing trend line.**
- **The Nallavur sub basin is showing the decreasing trend line.**

3.2.7 Statistical Analysis

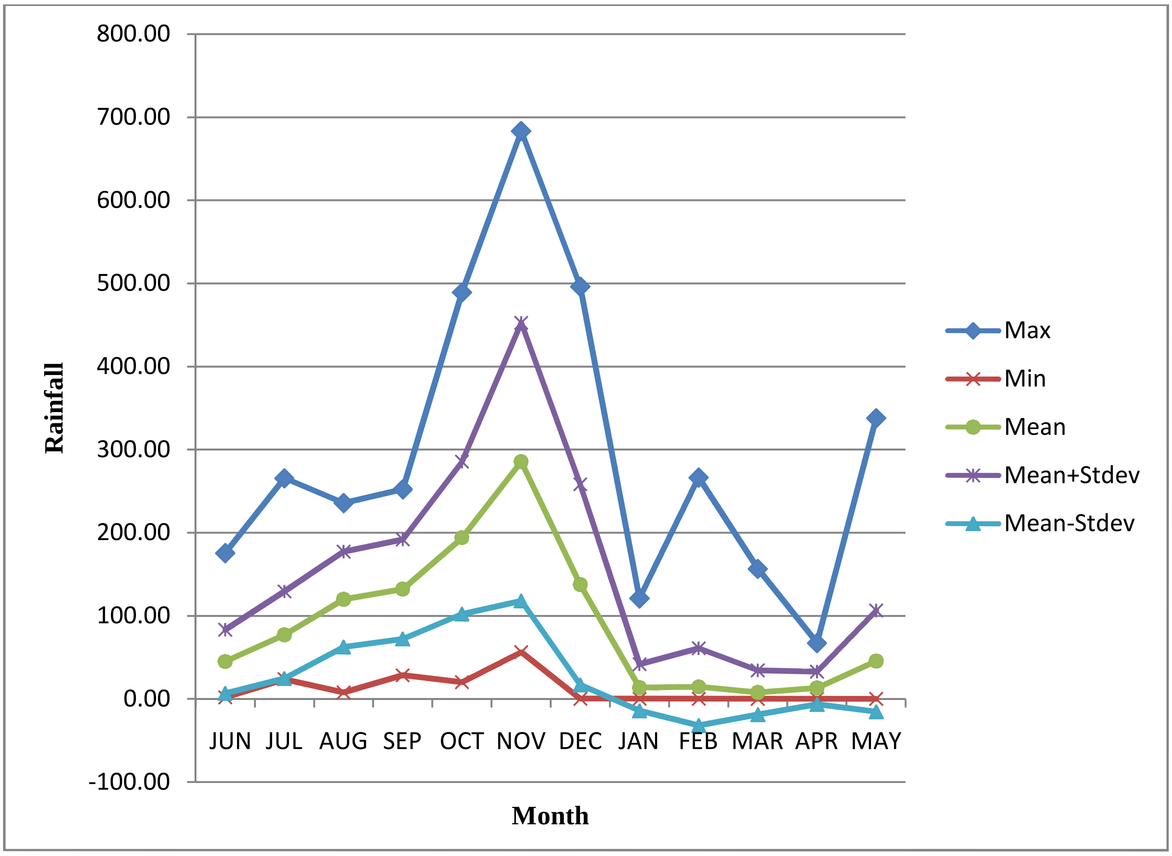
The statistical analysis for the rainfall data has been done for all the sub basins for the various seasons namely southwest, northeast, winter, summer and annual. The statistical results namely, Standard Deviation, Coefficient of variation, Skewness and Kurtosis have been analysed and tabulated in **Appendix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

The average value of the Ongur Sub Basin statistical Parameters are

- Standard Deviation - 292.95
- Coefficient of variation - 0.27
- Skewness - 0.61
- Kurtosis - 0.81

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 Ongur Sub-basin is given below in **Fig 3.1**

Fig.3.1 Statistical Parameters of Ongur Sub-basin (1977-78 to 2015-16)



3.2.8 Moisture Index for Climatic Classification

A 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. 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 Penman Monteith method through CROPWAT model. (PET is annual evapotranspiration value).

Climatic classification is based on Moisture Index. Moisture Index varies from -100% to +100%.

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

The different Climatic zones for different Moisture Index ranges are given in **Table 3.8**

Table 3.8 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 evapo transpiration (i.e. PET) of Kilnachipattu (1717.69 mm/year) weather Station is adopted for calculating moisture Index. The Moisture index (Im) for all the 14 rain gauge stations and for all the sub basins has been worked out in **Table 3.9 and 3.10**

.

Table 3.9 - Moisture Index (Im) for Climatic Classification

Sl. No	Station Name	Annual Ave. Precipitation "P" in mm	PET in mm	Difference between P & PET in mm	Humidity Index (Ih in %)	Aridity Index (Ia in %)	Moisture Index (Im=Ih-Ia) (%)	Classification
1	Aliyabad Anicut	1056.1	1718	661.6	0	38.5	-38.5	Semi-arid
2	Eluthur Anicut	1133.8	1718	583.9	0	34.0	-34.0	Semi-arid
3	Gingee	988.6	1718	729.1	0	42.4	-42.4	Semi-arid
4	Madurantakam	1108.1	1718	609.6	0	35.5	-35.5	Semi-arid
5	Marakkanam	1132.4	1718	585.3	0	34.1	-34.1	Semi-arid
6	Panruti	1143.6	1718	574.1	0	33.4	-33.4	Semi-arid
7	Polur	1025.6	1718	692.1	0	40.3	-40.3	Semi-arid
8	Tindivanam	1000.7	1718	717.0	0	41.7	-41.7	Semi-arid
9	Thirukovilur	1043.1	1718	674.6	0	39.3	-39.3	Semi-arid
10	Thiruvannamalai	989.6	1718	728.1	0	42.4	-42.4	Semi-arid
11	Vandavasi	1181.1	1718	536.6	0	31.2	-31.2	Dry Sub-humid
12	Vanur	993.2	1718	724.5	0	42.2	-42.2	Semi-arid
13	Vidur Dam	1146.7	1718	571.0	0	33.2	-33.2	Semi-arid
14	Villupuram	1012.4	1718	705.3	0	41.1	-41.1	Semi-arid

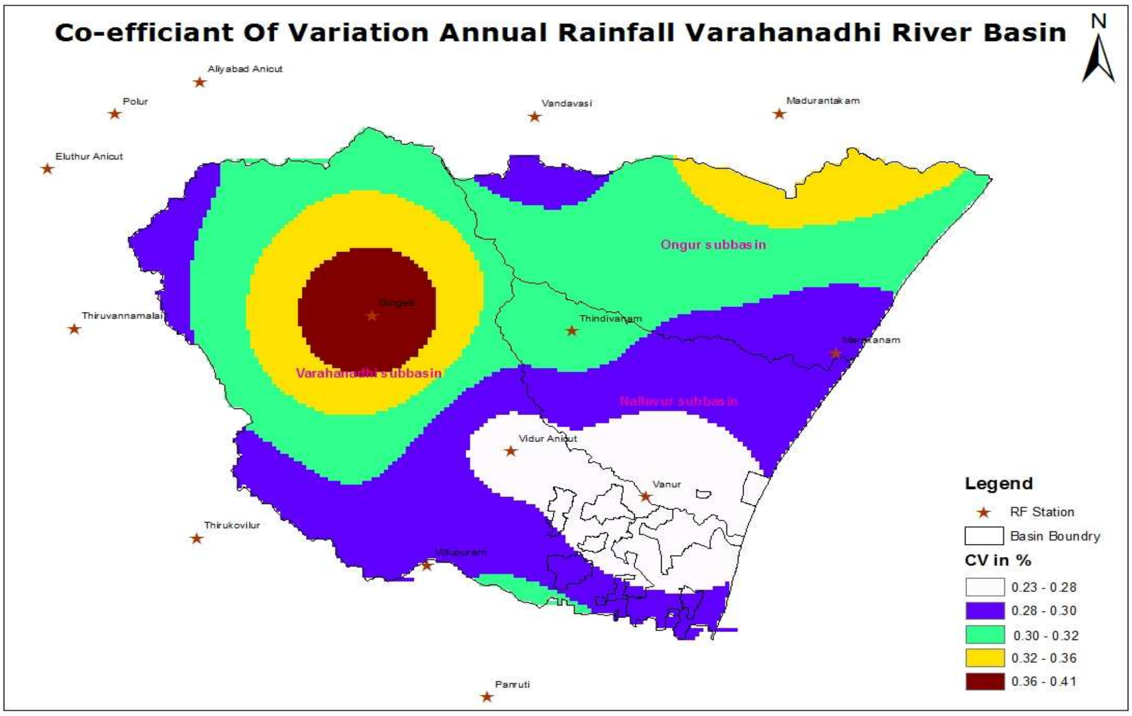
Table 3.10 - Moisture Index (Im) for Sub Basin wise Climatic Classification

Sl.No	Basin Name	Annual Ave. Rainfall "P" in mm	PET in mm	Difference between P&PET in mm	Humidity Index (Ih in %)	Aridity Index (Ia in %)	Moisture Index (Im=Ih-Ia) (%)	Classification
1	Varahanadhi	1028.94	1718	688.8	0	40.1	-40.1	Semi-arid
2	Nallavur	1033.25	1718	684.4	0	39.8	-39.8	Semi-arid
3	Ongur	1100.38	1718	617.3	0	35.9	-35.9	Semi-arid

3.2.9 Spatial Variability of Rainfall as Deduced from Coefficient of Variation

The coefficient of variation (cv) defined as the standard deviation divided by the mean value of rainfall. The spatial distribution of rainfall can be analysed by the construction of isohyetal maps, illustrating the variation of average rainfall depth with topography, which includes both position and elevation. The main hydrological objective of the isohyetal map, which can be derived subjectively by someone familiar with the effect of topography, or objectively by computer-based techniques, is to deduce the rainfall over a basin to compare with runoff depth. It can be particularly helpful where rainfall records are distributed unevenly throughout the basin and the influence of elevation could be underestimated. The distribution characteristics of the rainfall of Varahanadhi River basin data show certain pattern, which says precisely the spatial variability of rainfall in the study area. Based on the Spatial variability data from RF Station location points using an inverse distance weighted (IDW) technique, CV of Varahanadhi basin for annual rainfall arrived which ranges between 23% and 41% (988 mm to 1155 mm) where as the annual average Rainfall of the basin is 1054.19 mm.

Fig.3.2 Coefficient of variation for mean annual Rainfall



The annual spatial variation in the northeast part of the basin ranges from (30%-36%) and annual average rainfall of this portion is in the range of 1155-1077 mm. This range shows positive deviation. The Central part of the basin shows the CV in the range of 0.3 to 0.32. This region also shows negative deviation as the annual average rainfall ranges from 988 mm to 1025 mm. Southern part of the basin shows the CV in the range of 0.23 to 0.30. This region indicates negative deviation as the annual average rainfall in the range of 988 mm to 1050 mm.

3.2.10 Deviation in Rainfall from Mean

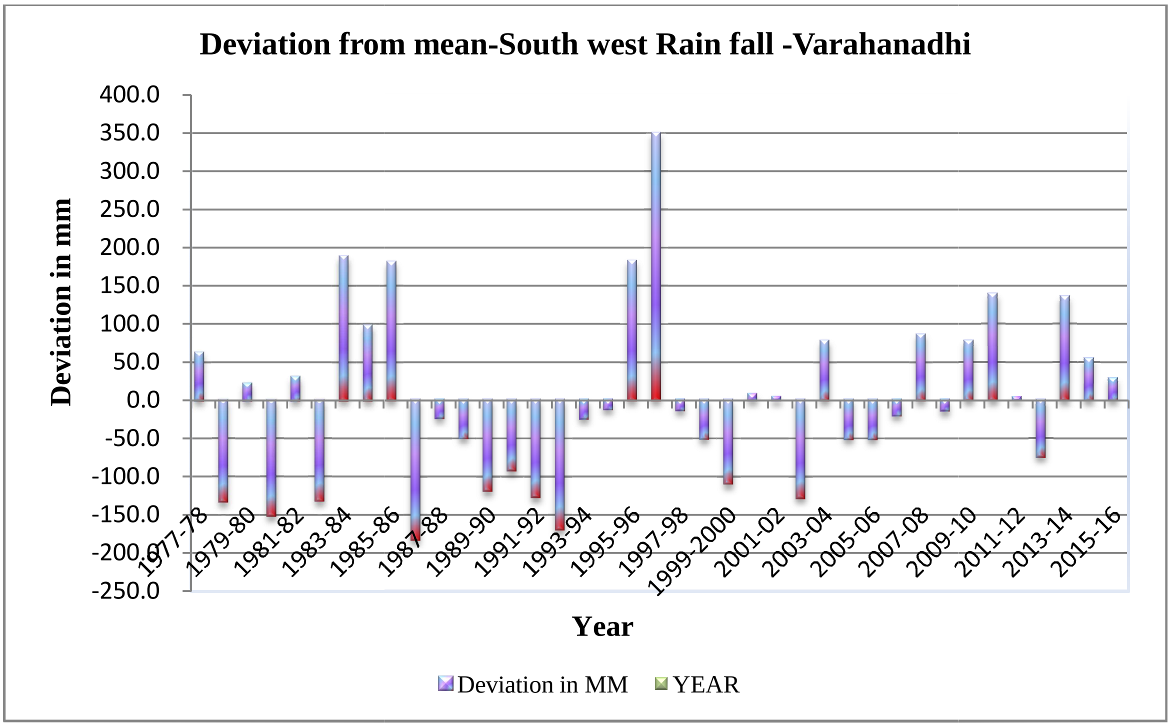


Fig.3.3 Deviation from mean South West monsoon Rainfall

The variability of rainfall may be defined as the deviation from the mean. The deficient or excess rainfall years are defined when rainfall of that year departs from the mean rainfall. The rainfall pattern over the basin for 39 years is found to be of alternating sequences of wet (+ve- Deviation) and dry (-ve - Deviation) periods are given in **Table 3.11**. as depicted from the **fig.3.3**.

Table 3.11 – Details of deviation in South West monsoon Rainfall

Monsoon	Period of Years	No. of years	Deviation in MM	Deviation
South West Monsoon	1977-1995	12	11 to 185	Negative (-)
		7	21 to 182	Positive (+)
	1996-2016	9	11 to 128	Negative (-)
		11	28 to 350	Positive (+)

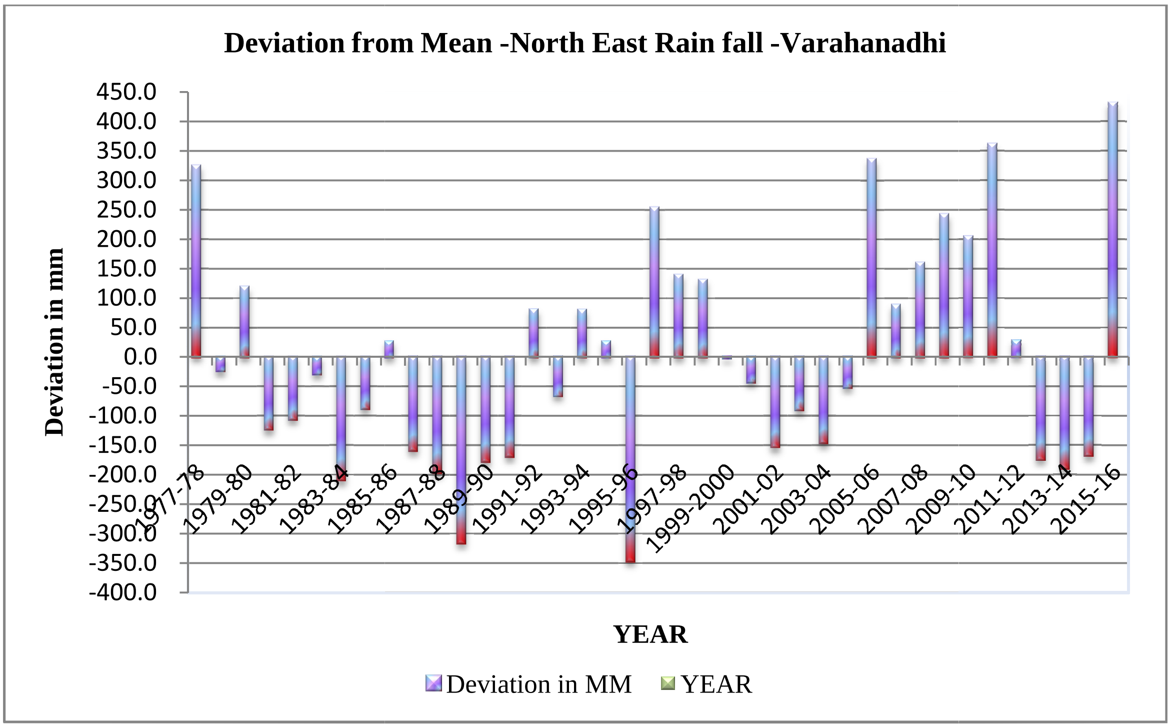


Fig.3.4 Deviation from mean North East monsoon Rainfall

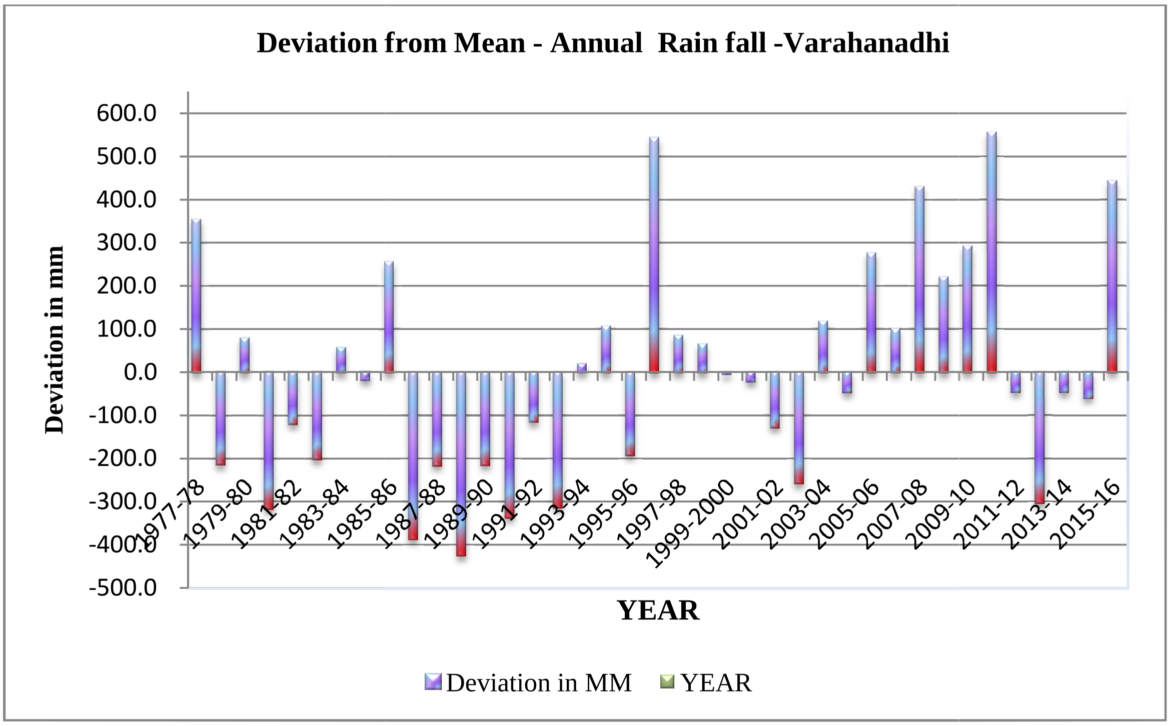


Fig.3.5 Deviation from mean annual rainfall

Table 3.12 – Details of deviation in North east monsoon Rainfall

Monsoon	Period of Years	No. of years	Deviation in MM	Deviation
North East Monsoon	1977-1995	13	24 to 346	Negative (-)
		6	25 to 325	Positive (+)
	1996-2016	9	42 to 189	Negative (-)
		11	27 to 431	Positive (+)

The North East monsoon and Annual Rainfall deviation from mean details are given in **Table 3.12 & 3.13** as depicted from the **fig.3.4 & 3.5** respectively**.**

Table 3.13 – Details of deviation in Annual Rainfall

Monsoon	Period of Years	No. of years	Deviation in MM	Deviation
Annual Rainfall	1977-1995	13	17 to 424	Negative (-)
		6	18 to 352	Positive (+)
	1996-2016	9	21 to 303	Negative (-)
		11	64 to 554	Positive (+)

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

3.3 Climate

Factors like climate change and urbanization have also had an impact on the variation in rainfall. This study assessed the implications of baseline climate conditions on the sensitivity of PET to a large range of plausible changes in temperature (T), relative humidity (RH), solar radiation (Rs) and wind speed (uz). Seven climatic variables (monthly mean air temperature, monthly mean daily minimum and maximum air temperature, monthly mean relative humidity, monthly precipitation, monthly mean solar radiation and monthly potential evapotranspiration) were built using neural networks. Climate is different than weather, in that weather only describes the short-term conditions of these variables in a given region. Climate is the average weather in a place over many years. While the weather can change in just a few hours, climate takes hundreds, thousands, even millions of years to change.

Kiladayalam weather station is situated inside Varahanadhi River Basin and Kilnachipattu weather station lies adjacent to the Basin. Considering the station having long term records, Kilnachipattu weather station data is taken for analysis. The Location details of weather station considered for analysis are furnished in **Table 3.14** and its climatological values are listed in **Table 3.15.**

Table-3.14-Weather Stations

Sl.No	Name of the weather station	Block	Sub-basin	Maintained by
1	Kilnatchupattu	Thiruvannamalai	Thurinjalar	PWD

Table-3.15-Climatological Parameters (1991-2016)

Sl. No	Climatological Parameter (Annual Average)	Kilnachipattu
1	Average monthly temperature Maximum in ^{0} Celsius (1991-2016)	36.24
2	Average monthly temperature Minimum in ^{0} Celsius (1991-2016)	21.10
3	Average mean temperature in ^{0} Celsius (1991-2016)	28.65
4	Average relative humidity in % (1991-2016)	64.96
5	Average wind velocity in km/hour (1991-2016)	5.44
6	Average Sunshine hours / day (2005-2016)	5.21
7	Average Pan Evaporation in mm/month (1991-2016)	170.48

3.3.1 Temperature

The meteorological 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 climatological station. The monthly average Maximum and Minimum Temperature of the Kilnachipattu station is 43.00^0 Celsius (May-2001), 29.00^0 Celsius (Dec-1992). The monthly average Minimum temperature varies from 28.62^0 Celsius (July-2015), 15.00^0 Celsius (Jan-2012).

The average mean, average minimum and average maximum temperature for the Kilnachipattu stations have been computed and tabulated in **Appendix 3.4.4 & 3.4.5.**

3.3.2 Relative Humidity

Relative humidity is the ratio of the partial pressure of water vapor in an air-water mixture to the saturated vapor pressure of water at a prescribed temperature. The relative humidity of air depends on temperature and the pressure of the system. The monthly average relative humidity of the Kilnachipattu station varies from 89.55% (Nov1993) to 46.40% (May 1996) **Appendix-3.4.3**

3.3.3 Wind speed

Wind velocity is an important meteorological parameter which has considerable influence on evaporation and evapotranspiration phenomena. Wind has direct impact on climate & vegetation and is linked with the circulation pattern of the monsoon. The monthly average wind velocity of the Kilnachipattu station varies from 14.59 Kmph (Dec 1995) to 0.89 Kmph (Mar 1995) **Appendix 3.4.6**

3.3.4. Sunshine

The monthly average sunshine hours of the Kilnachipattu station varies from 8.37 hrs/day (Mar 2005) to 1.40 hrs/day (July 2013) Appendix **3.4.7.**

3.3.5 Evaporation

Evaporation is an essential part of the water cycle. The sun (solar energy) drives evaporation of water from oceans, lakes, moisture in the soil, and other sources of water. Evaporation is one of the main factors causing hydrologic cycle. The loss of water is caused due to evaporation. Hence, 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 **3.4.12.**

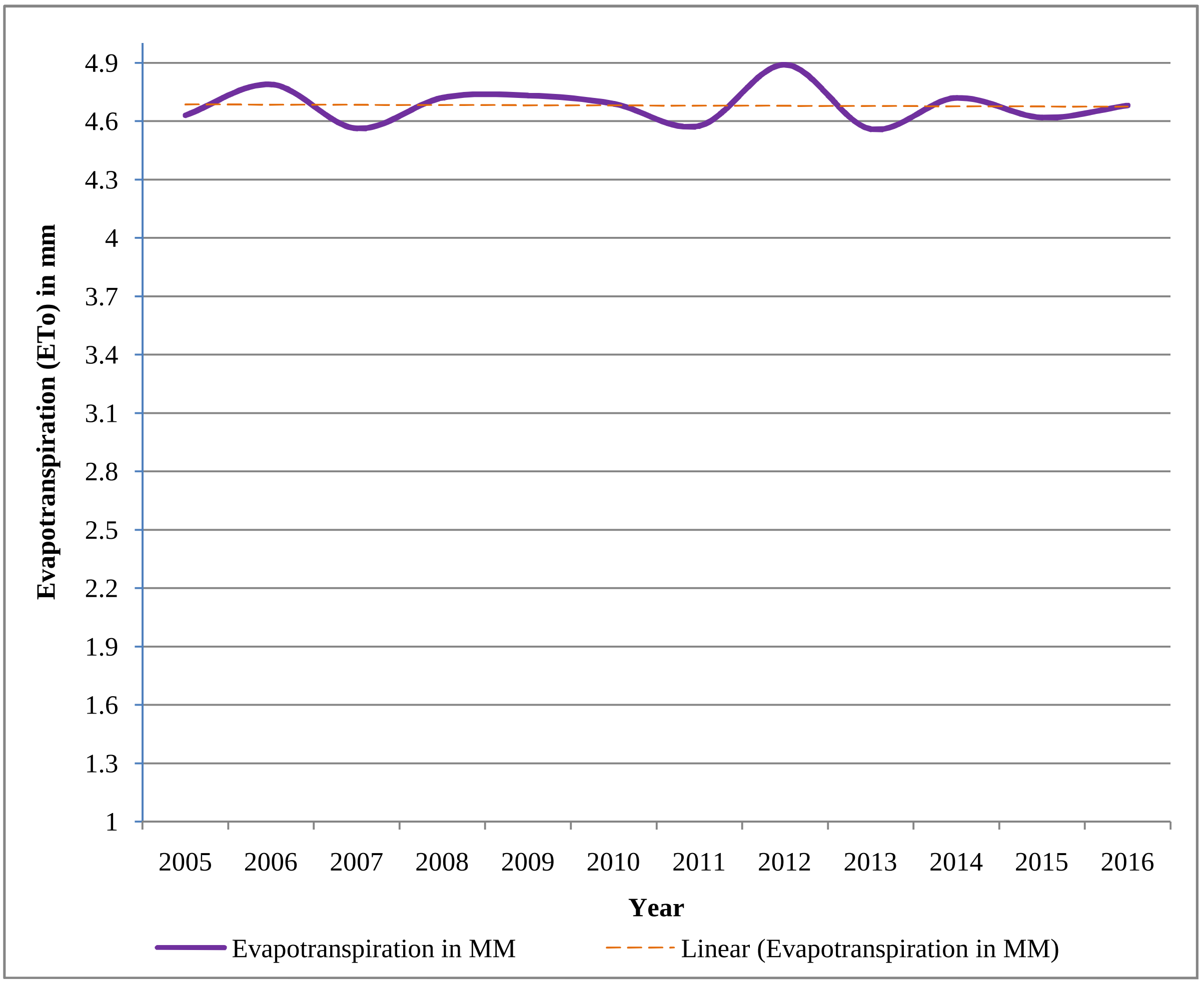
Evapotranspiration

In hydrology, evaporation and transpiration (which involves evaporation within plant stomata) are collectively termed as evapotranspiration. The monthly average ETo in mm for the Weather station (Kilnachipattu) is estimated using Modified Penman Montieth Method. The estimated ETo values for the station is given in **Appendix 3.4.1.**

Potential Evapotranspiration (PET)

Potential Evapotranspiration (PET) arrived for Kilnachipattu station is 1717.69 mm (Annual). The potential Evapotranspiration (PET) for each month has been calculated and tabulated in **Appendix 3.4.**There is not much variation in the trend of Potential Evapotranspiration for Kilnachipattu (1991-2016) and is shown in **Fig 3.6.**

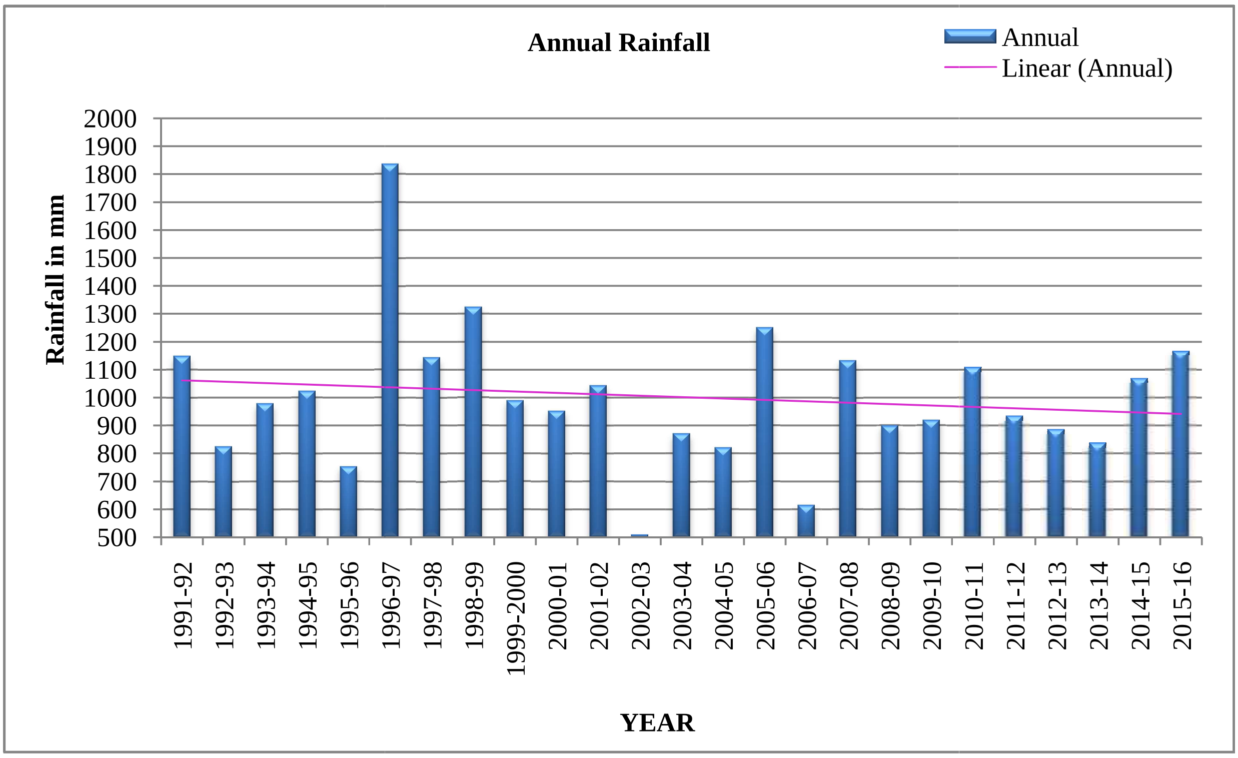
Fig.3.6 Evapotranspiration of weather Station in Kilnachipattu

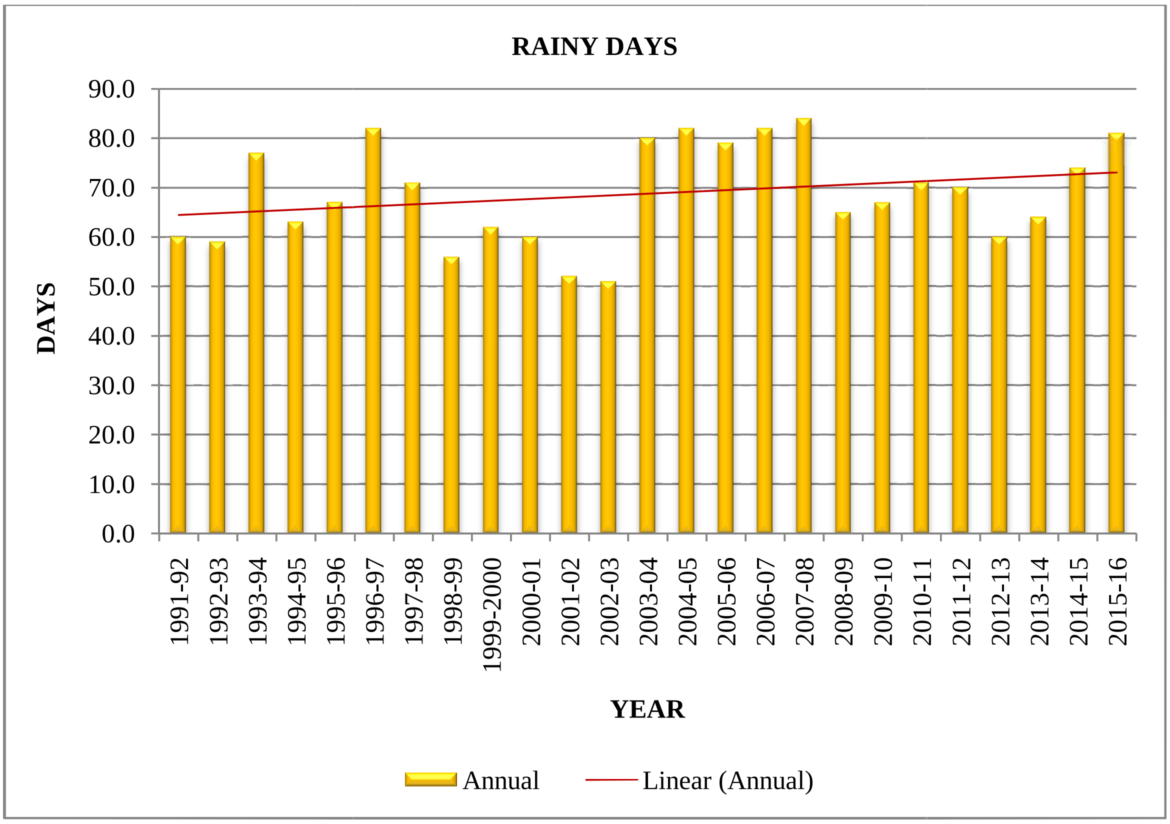


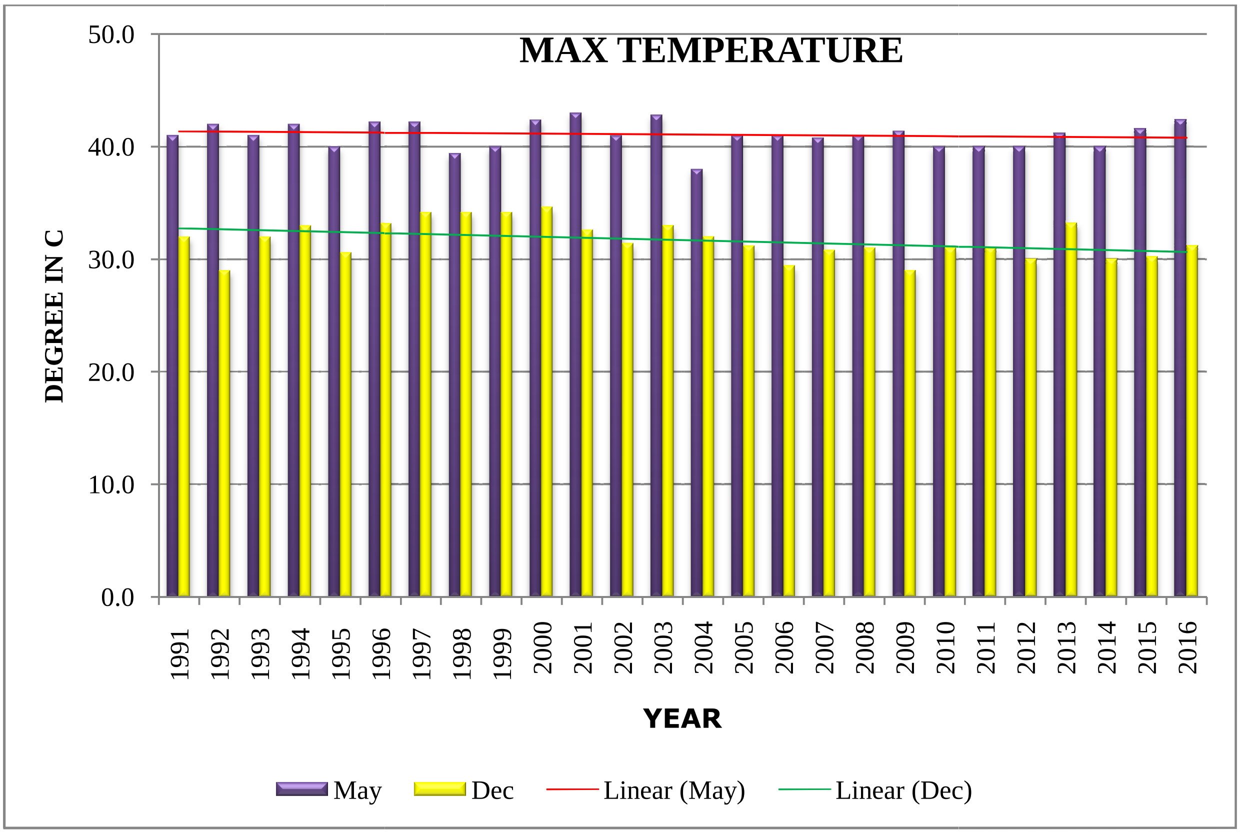
To study the climatic pattern of Varahanadhi river Basin, climatic data (1991-2016) of the weather station in Kilnachipattu is taken for analysis and its results are given below:

- The trend of annual rainfall is slightly decreasing.
- The trend of number of rainy days shows increasing.
- There is not much variation seen in summer & winter maximum temperature trend.
- Summer and winter minimum temperature trend shows increase in pattern.

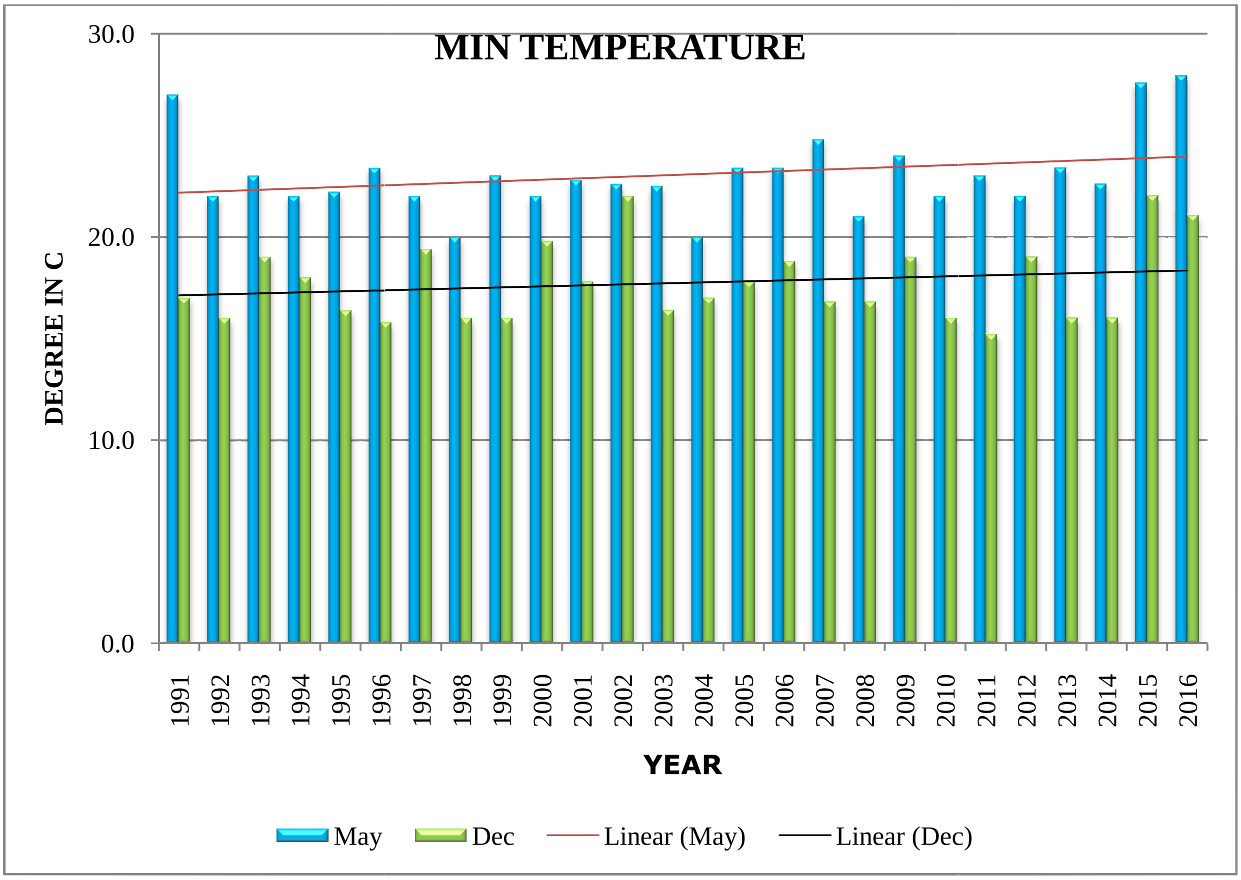
Fig 3.7 Results of climatic data – Kilnachipattu (1991-2016)







MAX TEMPERATURE
50.0
40.0
30.0
20.0
10.0
0.0
DEGREE IN C
1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
YEAR
May
Dec
Linear (May)
Linear (Dec)



MIN TEMPERATURE
30.0
20.0
10.0
0.0
DEGREE IN C
1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
YEAR
May
Dec
Linear (May)
Linear (Dec)

3.3.6 Meteorological Drought Assessment

Drought is a normal, recurrent feature of climate, although it is erroneously considered as a rare and random event. It differs from aridity, which is restricted to low rainfall regions and is a permanent feature of climate. Drought should be considered relative to some long-term average conditions of the balance between precipitation and evapotranspiration in a particular area. It is also related to the timing (principal season of occurrence, delays in the start of the rainy season, occurrence of rains in relation to principal crop growth stages) and the effectiveness (i.e., rainfall intensity, number of rainfall events) of the rains. However, these are only conceptual definitions, which are unable to give an operational definition of drought.

Meteorological drought is usually defined on the basis of the degree of dryness (in comparison to some "normal" or average amount) and the duration of the dry period. Definitions of meteorological drought must be considered as specific to a region since the atmospheric conditions that result in deficiencies of precipitation are highly variable from region to region. Study of droughts is important for planning short-term operations, especially in connection with Irrigation scheduling.

India 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

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

Where Pi is the annual rainfall in the year i and $\overline{P}$ is the long-term annual mean rainfall. The percentage deviation of rainfall Di and the category of drought assessment as per IMD are given below in **Table 3.16.**

Table-3.16 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 the last fifteen years for all the fourteen rain gauge stations. The drought severity such as no, mild, moderate and severe drought for fourteen stations from the available data were found out and presented in **Table 3.17** and an abstract is also given in **Table 3.18**. It is observed from the **Table 3.17 & 3.18** that Mo (No

Drought) is more than the M1, M2 & M3 (Mild, Moderate and Severe Drought). This basin is not drought prone. Some of the stations have been moderately drought years. Severe drought conditions was felt in two Stations Panruti – (2011-12, 2012-13, 2013-14, 2014-15), which is located outside of this basin in southern part of boundary.

Drought frequency analysis for 15-year period (2001-02 to 2014-15) indicates that

- Mild drought occurred for 9 years in Vanur, 8years in Aliyabad Anicut & Vandavasi, 5 years in Marakanam, Tindivanam, Vidur dam and Villupuram Raingauge stations.
- Moderate drought occurred for 4 years in Marakkanam, Tindivanam Raingauge stations.
- **Severe drought occurred for** 4 years in Panruti, 1 year in Villupuram out of 15 years.
- In general all rainfall stations in this basin toggle from no drought to mild drought in most of the years.

3.4 Summary

The main use of rainfall measurements are used as the major input in water balance studies, such as assessment of water potential. However, they are also valuable for the extension of short-term flow records and identifying the critical periods for water resources purposes. In the case of regional water resources investigations & Management, rainfall studies provide the simplest guide to variations in water supply over an area. However, the records need careful analysis, linked with an understanding of the effect of topography and aspect on rainfall distribution.

Varahanadhi River Basin consists of three Sub Basins. The sub basin wise influencing rain gauge stations, area of influence of each rain gauge station, area of the sub basin and 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 3.19.** The 39 years annual average rainfall of the basin is 1054.19 mm.

The previous water plan study of Varahanadhi River Basin was carried out in the year 2004 by IWS. The data for the period from 1935-2003 was considered and the Station wise average annual rainfall of the basin was reported as 1076.47 mm.

In general, Varahanadhi basin receives more rainfall in North East monsoon than South West monsoon.

The rainfall in the basin increases from west to east, and the higher rainfall experienced near the sea coast. All the three sub basins are having average annual rainfall of above 1000 mm. The highest rainfall of 1100.38mm was received in Ongur sub basin. Similarly lowest rainfall of 1028.94mm was received in Varahanadhi sub basin. On viewing the climatic pattern, it is observed that there is increase in number of rainy days, but rainfall trend line shows decrease in manner. In summer & winter, maximum and minimum temperature trend is marginally increasing in order.

Table - 3.17 Meteorological Drought in Varahanadhi River Basin using IMD Method Drought

(MO - No Drought-M1 - Mild Drought, M2 - Moderate Drought, M3 - Severe Drought) (2001-02 to 2015-16)

Sl. No	Station Code	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
1	Aliyabad Anicut	M1	M1	M1	M1	M0	M1	M0	M1	M1	M0	M0	M0	M1	M0	M0
2	Eluthur Anicut	M0	M2	M0	M0	M0	M0	M0	M1	M1	M0	M0	M1	M0	M0	M0
3	Gingee	M1	M1	M0	M0	M0	M0	M0	M0	M0	M0	M1	M2	M0	M0	M0
4	Madurantakam	M0	M2	M0	M1	M1	M0	M0	M0	M0	M0	M1	M2	M1	M2	M0
5	Marakkanam	M0	M2	M1	M1	M0	M2	M0	M1	M1	M0	M0	M2	M2	M1	M0
6	Panruti	M1	M1	M0	M0	M0	M0	M0	M0	M1	M0	M3	M3	M3	M3	M0
7	Polur	M2	M2	M0	M0	M0	M1	M0	M0	M1	M0	M0	M0	M2	M0	M0
8	Tindivanam	M1	M2	M0	M1	M0	M2	M0	M1	M2	M0	M2	M1	M0	M1	M0
9	Thirukovilur	M1	M2	M0	M0	M0	M0	M0	M1	M1	M1	M2	M0	M2	M0	M0
10	Thiruvannamalai	M0	M2	M0	M0	M0	M2	M0	M0	M1	M0	M1	M0	M0	M1	M1
11	Vandavasi	M0	M2	M0	M1	M0	M1	M0	M1	M1	M1	M0	M1	M1	M1	M0
12	Vanur	M1	M1	M1	M1	M1	M2	M1	M0	M0	M0	M1	M2	M1	M1	M0
13	Vidur Dam	M1	M1	M0	M1	M0	M2	M0	M0	M0	M0	M1	M2	M0	M1	M0
14	Villupuram	M2	M3	M0	M1	M0	M0	M0	M1	M0	M0	M0	M1	M1	M1	M0

Table 3.18 - Abstract of Drought Assessment (From 2001-02 to 2015-16)

Sl.No.	Station Code	M0	M1	M2	M3
1	Aliyabad Anicut	7	8	0	0
2	Eluthur Anicut	11	3	1	0
3	Gingee	11	3	1	0
4	Madurantakam	8	4	3	0
5	Marakkanam	6	5	4	0
6	Panruti	8	3	0	4
7	Polur	10	2	3	0
8	Tindivanam	6	5	4	0
9	Thirukovilur	8	4	3	0
10	Thiruvannamalai	9	4	2	0
11	Vandavasi	6	8	1	0
12	Vanur	4	9	2	0
13	Vidur Dam	8	5	2	0
14	Villupuram	8	5	1	1

Table 3.19 - Influencing Raingauge Stations of Each sub-basin

Sl.No	Sub Basin		Rain gauge Station	RG Station Influencing Area in Sq.km	Sub basin Area in Sq.km	Weight in %	Annual average weighted rainfall for the Stations in mm	Annual average weighted rainfall for the sub-basin in mm
1	**Varahanadhi**	1	Thirukovilur	133.68	**2473.00**	0.054	1043.14	**1028.94**
		2	Vanur	183.01		0.074	993.16	
		3	Aliyabad Anicut	108.83		0.044	1056.10	
		4	Villupuram	351.30		0.142	1012.43	
		5	Thiruvannamalai	144.72		0.059	989.64	
		6	Vidur Anicut	373.93		0.151	1146.71	
		7	Thindivanam	75.58		0.031	1000.70	
		8	Vandavasi	74.74		0.030	1181.08	
		9	Polur	37.06		0.015	1025.62	
		10	Gingee	990.16		0.400	988.58	
2	**Nallavur**	1	Vanur	288.38	**788.78**	0.366	993.16	**1033.25**
		2	Vidur Anicut	40.99		0.052	1146.71	
		3	Thindivanam	293.34		0.372	1000.70	
		4	Marakanam	166.07		0.211	1132.39	
3	**Ongur**	1	Madurantakam	329.70	**1274.73**	0.259	1108.07	**1100.38**
		2	Thindivanam	328.96		0.258	1000.70	
		3	Marakanam	431.51		0.339	1132.39	
		4	Vandavasi	184.56		0.145	1181.08	
			Basin Total Area	**4536.51**	**4536.51**			**1054.19**

CHAPTER 4

IRRIGATION AND AGRICULTURE

CHAPTER – 4

IRRIGATION AND AGRICULTURE

4.1 Introduction

Agriculture is the fulcrum of rural economy and remains as the main occupation and source of livelihood for the rural people. It is the single largest consumer of water in the State, consuming 75 percent of the State's water resources. Tamilnadu State has an area of 130 lakh hectares with a gross cropped area of 59.94 lakh hectares. (Source: Statistical Hand Book of Tamilnadu 2016). The State's irrigation potential in per capita terms is 0.08 ha when compared to the all-India average of 0.15 ha. (Source: 3.9 Irrigation, Agriculture and allied sectors). According to 2001/2002 Agriculture census, only 58.1 million hectares of land was actually irrigated in India. The total arable land in India is 160 million hectares (395 million acres). As per World Bank data, only about 35% of total agricultural land in India was reliably irrigated in 2010. (Source: Net irrigated area, FAO). The three main sources of irrigation in the State are rivers, tanks and wells.

The Gross State Domestic Product (GSDP) of 2014-15 at constant price stood as Rs.942735.89 crores with a growth rate of 8.65% where as the GSVA (Gene Set Variation Analysis) on Agriculture, constant prices showed a positive growth rate of 4.51%. (Source: Season and Crop Report Tamil Nadu 2014-15). This shows increasing share of Agriculture in the Gross State Domestic product of the State.

The principle purpose of irrigation is augmenting the agriculture production. Intensive and extensive practices for cultivation of land depend mainly on the irrigation water. Medium & minor irrigation schemes are being implemented in the state for augmenting the irrigation for agriculture.

In the year 2015-16, gross area irrigated is 1.98 lakh Ha and gross area sown is estimated as 2,60,583 Ha. The main crops cultivated are Paddy, Blackgram, Sugarcane, Ground nut, Coconut, Fruits and Vegetables. Major source of irrigation in this basin are wells.

Soil is a natural body developed by natural forces acting on natural materials. It is usually differentiated into horizons of mineral and organic constituents of variable depth which differ from the parent material below in morphology, physical properties & constituents, chemical properties & its composition and biological characteristics. The soil is a natural medium which supplies nutrients for plant growth. Some soils are naturally productive and support luxuriant crops of great value. The soils mainly found in Kancheepuram Districts are Red soil, brown soil, Mixed soil, Black soil and Alluvial soil. Red sand was predominant in

Chengam, Tiruvannamalai and Vandavasi Taluks. Different types of soils like ferruginous loamy and sandy loamy were seen extensively throughout the Tiruvannamalai District.

4.2 Land Holdings

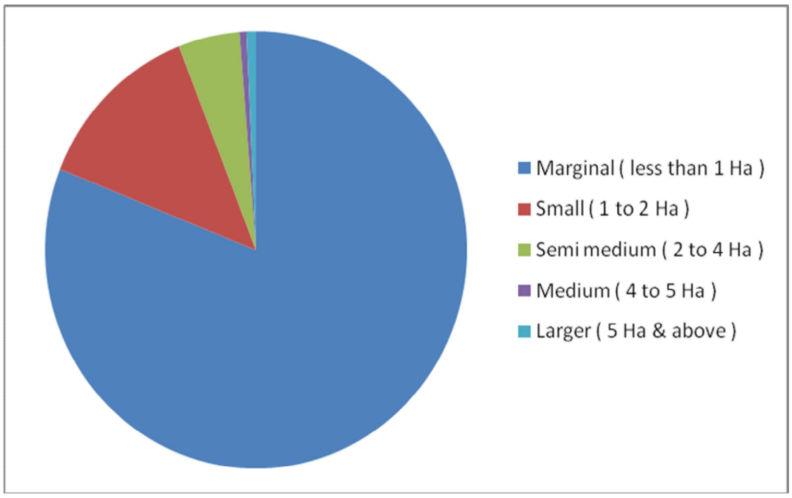
A combination of factors such as increasing industrialization, urbanization, housing activities and infrastructure development triggered the conversion of agricultural land into non agricultural uses. This has resulted into a declination of area under cultivation. The scope for the expansion of area available for cultivation is also very limited. Average size of holding in the state was 0.80 ha, which is 44% lesser than the average size of land holding of the country (1.15 ha). In Tamil Nadu, the per capita availability of land is only 0.19 ha and the per capita net sown area is only 0.10 ha.

As per the latest Agricultural Census 2010-11, marginal and small holdings of less than 2 hectares accounted for 92.0 percent of the total holdings and 61.0 percent of the total operated area. The total number of operational land holdings in the State declined from 81.93 lakh in 2005 – 06 to 81.18 lakh in 2010 – 11 (0.9%). This implies that the farmers may have given up their cultivation because of the lucrative price offered for land on account of fast urbanization. This was more prevalent in the vicinity of urban areas. With continuous fragmentation of small (1 to 2 hectares), medium (2 to 10 hectares) and large (10 hectares and above) holdings, the number of marginal holdings increased in the State from 62.28 lakh to 62.66 lakh (0.6%) between the two Censuses. The category of agriculturists/farmers in Varahanadhi Basin on the land holding size is given in **Table 4.1,** marginal farmers accounts for 81.01% in Varahanadhi Basin. (Source: Agriculture census 2010-11, Blockwise Number of Operational Holding and Area in Hectares).

Table -4.1 Sub Basinwise Number Of Operational Holding

Social Group	Varahanadhi	Nallavur	Ongur	Total	% of Total
Marginal (less than 1 Ha)	199004	49149	77374	325528	81.01
Small (1 to 2 Ha)	30579	9153	12668	52399	13.04
Semi medium (2 to 4 Ha)	10118	3787	4963	18869	4.70
Medium (4 to 5 Ha)	1036	494	646	2176	0.54
Larger (5 Ha & above)	1137	678	1060	2875	0.72
Total	**241874**	**63262**	**96711**	**401847**	**100.00**

Fig 4.1 Land Holdings in Varahanadhi Basin



4.3 Crop Water Requirement

4.3.1 Crop Water Requirement Calculation

Crop water Requirement (ET crop) is defined as the depth (or amount) of water needed to meet the water loss through evapotranspiration. The crop water requirement always refers to a crop grown under optimal conditions, i.e. a uniform crop, actively growing, completely shading the ground, free of diseases, and favourable soil conditions (including fertility and water). The crop thus reaches its full production potential under the given environment.

The crop water need mainly depends on:

- **climate**: in a sunny and hot climate, crops need more water per day than in a cloudy and cool climate
- **crop type**: crops like maize or sugarcane need more water than crops like millet or sorghum
- **growth stage of the crop:** fully grown crops need more water than crops that have just been planted.

Water is needed mainly to meet the demands of evaporation (E), transpiration (T) and metabolic needs of the plants, all together is known as consumptive use (CU). Since water used in the metabolic activities of plant is negligible, being only less than one percent of quantity of water passing through the plant, evaporation (E) and transpiration (T), i.e. ET is directly considered as equal to consumptive use (CU). In addition to ET, water requirement (WR) includes losses during the application of irrigation water to field (percolation, seepage, and run off) and water required for special operation such as land preparation, transplanting, leaching etc.

WR = CU + application losses + water needed for special operations.

Water requirement (WR) is therefore, demand and the supply would consist of contribution from irrigation, Effective Rainfall (ER) and soil profile contribution including that from shallow water tables (S)

WR = IR + ER + S

Under field conditions, it is difficult to determine evaporation and transpiration separately. They are estimated together as evaportranspiration (ET). IR is the Irrigation Requirement. The evapo-transpiration of a crop (Etc in mm) under irrigation is obtained by the following equation:

ETc = Kc x ETo, Where ETo is the reference evapo-transpiration and Kc is the crop coefficient. The ET_0 is estimated by using Penmann Monteith method. The normal Reference Crop Evapo-transpiration values are tabulated in Chapter-3, **Appendix 3.4.**

4.3.2 Crop Parameters

The Kc stages and coefficients are taken from Food and Agriculture Organization (FAO) irrigation Paper No. 56 (Ref: Evapotranspiration - Guidelines for computing crop water requirements). The growth stage of a crop as in **Fig. 4.2** profoundly influences Kc values. The crop growing period can be divided into four distinct growth stages:

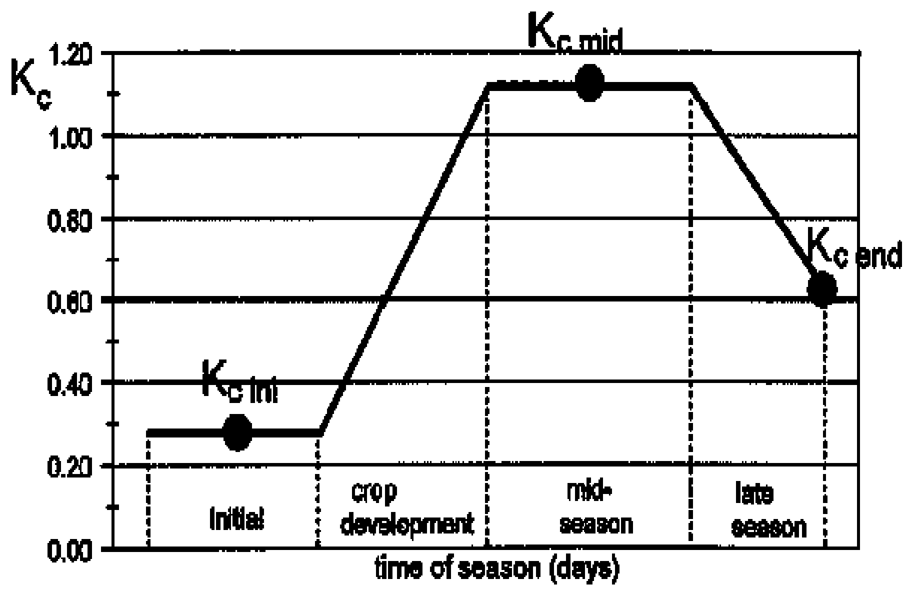
(i) the initial stage (from sowing to about 10% ground cover),

(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 4.2 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. Important physiological and critical growth stages of crops for irrigation are tabulated in **Table 4.2.**

Table 4.2 Important physiological and critical growth stages of crops for irrigation

Sl.No.	Crop	Physiological stage	Critical Stage
1	Paddy	Early tillering, panicle initiation, flowering, milking and dough	Early tillering and flowering and milky
2	Sugarcane	Sprouting, tiller initiation, tillering and grand growth	Sprouting and grand growth
3	Groundnut	Emergence, flowering, pod formation and pod development	Flowering and pod development
4	Cotton	Branching, pre-flowering and boll formation	Flowering and boll formation
5.	Banana	Emergence, Flowering and Fruit Development	All Stages

4.3.3 Factors influencing crop water requirements for irrigation

The following are the factors which affect the water requirements of the crops.

1. **Influence of climate**:

   In hot climate the evaporation loss is more and the water requirement will be more and vice versa. Apart from sunshine, humidity and wind speed also influence crop water need. Hence it is to say that crops grown in different climatic zones will have different water needs.

2. **Influence of crop type on crop water needs**:

   The crop type has an influence on the daily water needs of a fully grown crop. i.e. the peak daily water needs of a fully developed maize crop will need more water per day than a fully developed crop of onion. The crop type has an influence on the duration of the total growing season of the crop. There are short duration crops, long duration crops and also perennial crops that are in the field for many years.

3. **Water table**:

   If the water table is nearer to the ground surface, the water requirement will be less & vice versa

4. **Ground Slope**:

   If the slope of the ground is steep the water requirement will be more due to less absorption time for the soil.

5. **Intensity of Irrigation**:

   It is directly related to water requirements, the more the intensity greater will be the water required for a particular crop.

6. **Conveyance Losses**:

   It is the loss of water in an irrigation channel due to absorption, seepage or percolation and evaporation. The absorption losses depends on type of soil, sub soil water, age of canal, amount of silt carried by canal and wetted perimeter.

7. **Method of Application of Water**:

   In Precision farming method, less water is required where as in flooding method, more water is required

8. **Crop period**:

   It is the time normally in days that a crop takes from the instance of its sowing to harvesting. More the crop period, water requirement will be more.

4.3.4 Methodology to calculate irrigation demand

The block wise data on irrigated area for various seasons are collected from the Economics and Statistics Department. Average block wise crop area irrigated was transformed to the sub basin area by its block area proportion. Sub-basin wise average irrigated area of crops in Varahanadhi basin is given in **Table 4.3**. **Fig 4.3** shows sub basin wise distribution of average irrigated area of crops in this basin and **Fig 4.4** shows average irrigated area of major crops in this basin. As the rainfed crops are purely dependent on rainfall only, rain fed crops are not considered for calculating crop water requirements. Only irrigated crops raised with surface water and ground water or both are considered for calculating the water requirement of crop. Crop parameters and Basic water need for crops considered for calculating crop water requirement of this basin are tabulated in **Table 4.4** and **Table 4.5** respectively.

Fig.4.5 explains about the methodology adopted in the calculation of Irrigation Demand. **Table 4.6** gives the Irrigation water requirement at 75% rainfall dependability in Paravanar sub basin and Irrigation Water Demand for 25%, 50%, 75%, 90%. Rainfall Dependability of entire basin is tabulated in **Tables 4.7, 4.8, 4.9, 4.10** respectively.

Figure 4.3 Sub basin wise irrigated area of crops (Ha) in Varahanadhi Basin

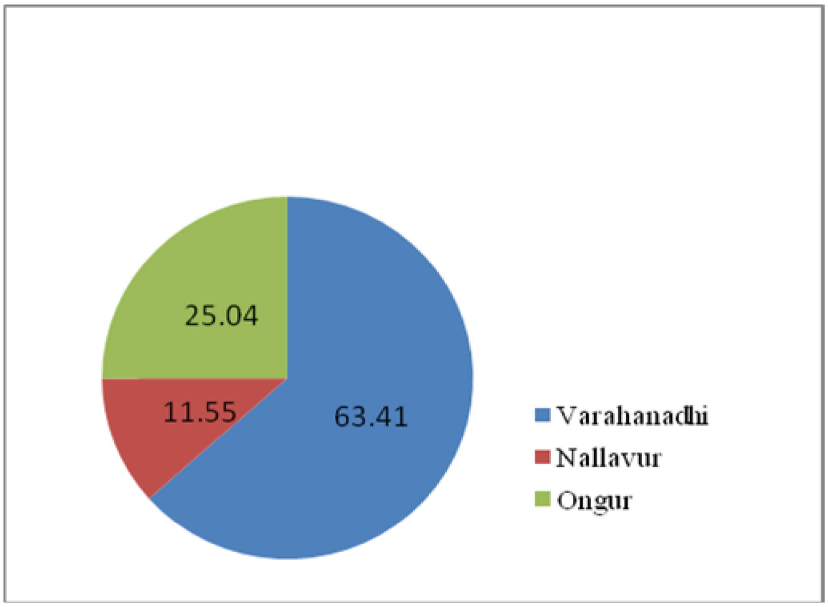


Figure 4.4 Irrigated area of Major crops (Ha) in Varahanadhi Basin

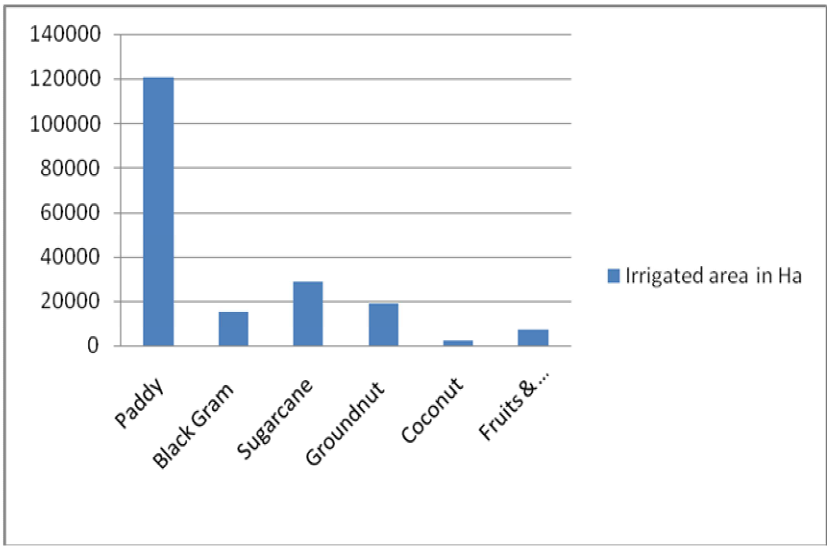


Figure 4.5 Methodology for calculating Irrigation Demand - Varahanadhi River Basin

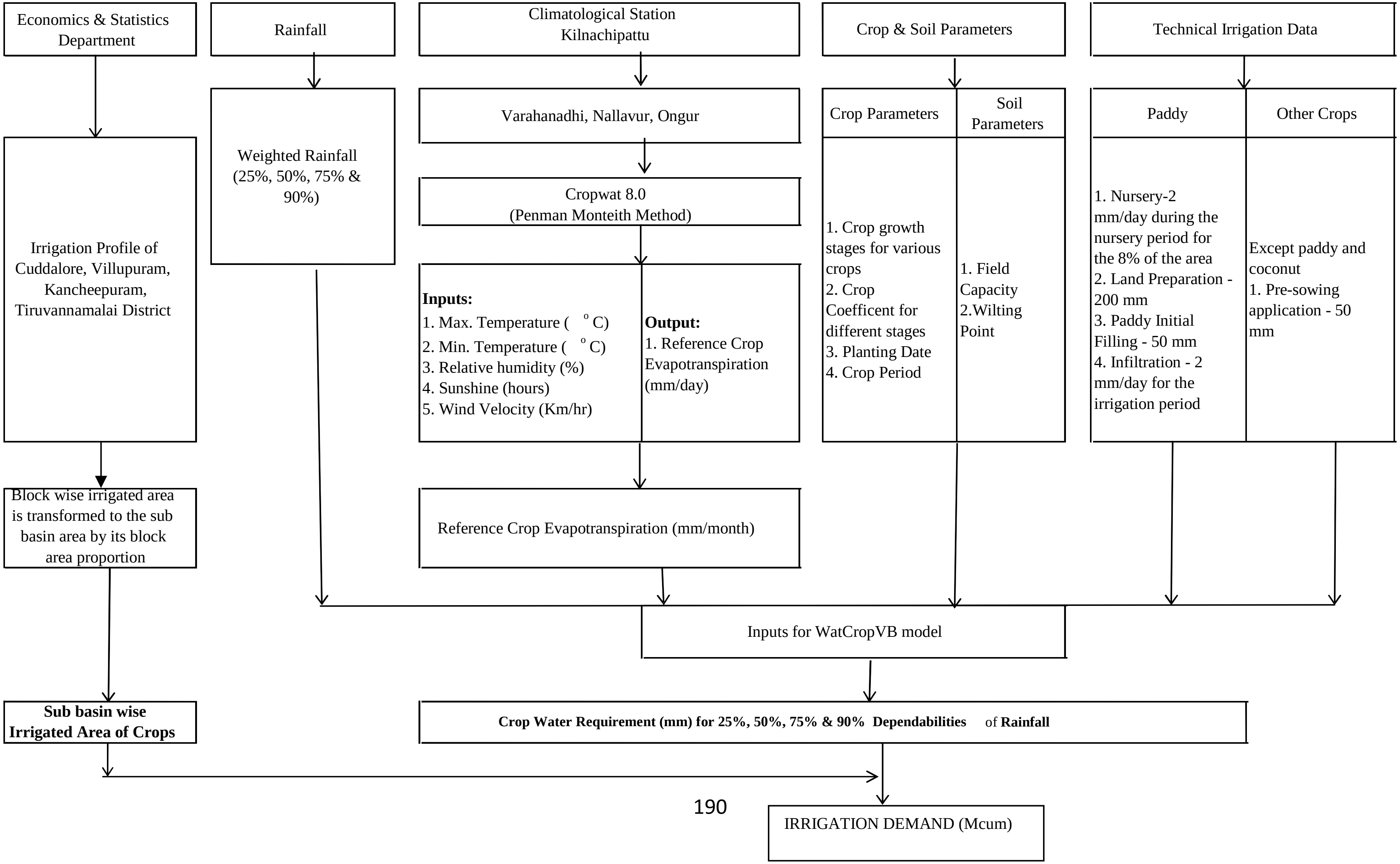


Table -4.3

Sub Basinwise Irrigated Area of Crops (Ha.) - Varahanadhi Basin

Crop	Varahanadhi	Nallavur	Ongur	Total
Coconut - Per - Jan	325	545	1307	**2177**
Paddy - First Crop - June	54212	9265	27024	**90501**
Paddy - Second Crop - Oct	18071	3088	9008	**30167**
Cholam - Feb	68	2	1	**71**
Cumbu - Mar	445	69	20	**534**
Ragi - Jan	1868	224	128	**2220**
Maize - Jul	248	1	0	**249**
Red Gram - June	176	3	47	**226**
Black Gram - Jan	10674	2562	1664	**14900**
Green Gram - Jan	685	138	85	**908**
Other Cereals - July	102	19	8	**129**
Chillies - Jan	147	38	40	**225**
Onion-June	0	0	0	**0**
Fodder - Mar	136	0	2	**138**
Condiments -Sep	0	0	0	**0**
Sugarcane - Dec	25011	1849	1499	**28359**
Banana - Dec	0	0	0	**0**
Groundnut - Dec	9204	3308	6442	**18954**
Cotton - Feb	348	96	3	**447**
Gingelly - Feb	626	169	104	**898**
Fruits & Vegetables - June	3383	1520	2327	**7230**
Flowers - Per - June	311	54	56	**421**
Turmeric - June	3	0	0	**3**
TOTAL	**126042**	**22952**	**49764**	**198758**

Table 4.4 Crop Parameters in Varahanadhi River Basin

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

Table 4.5 Basic Water Need For Crops in Varahanadhi River Basin

Crop No.	Crop Name	Field application efficiency	Technical Irrigation											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		(%)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
1	Coconut- Per-Jan	60												
2	Paddy-First crop-Jun	60						319.5	112	162	54			
3	Paddy-Second crop-Oct	60	34									288.8	110	162
4	Cholam-July	60							50					
5	Cumbu - April	60				50								
6	Ragi-July	60							50					
7	Maize-June	60						50						
8	Red gram - July	60							50					
9	Blackgram-Mar	60			50									
10	Other Cereals-July	60							50					
11	Chillies-Jan	60	50											
12	Onion-Jun	60						50						
13	Fodder-Apr	60				50								
14	Condiments-Sep	60									50			
15	Sugarcane-Dec	60												50
16	Greengram - Aug	60								50				
17	Banana- Dec	60												50
18	Groundnut-April	60				50								
19	Cotton - July	60							50					
20	Gingelly-Apr	60				50								
21	Fruits & Veg-Per June	60						50						
22	Flowers-Per-June	60						50						

Table 4.6 Net Irrigation Water Requirement at 75% Dependable Rainfall

Varahanadhi Sub Basin in Varahanadhi Basin

S.No.	Crop Name	Crop Area	Crop Water Requirement in MCM												Total	
		(Ha.)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mcm	Mcft
1	Coconut- Per-Jan	325.17	0.20	0.14	0.31	0.34	0.52	0.57	0.47	0.31	0.00	0.00	0.00	0.00	2.86	100.96
2	Paddy-First crop-Jun	54212.11	0.00	0.00	0.00	0.00	0.00	258.40	111.51	145.74	29.27	0.00	0.00	0.00	544.92	19244.01
3	Paddy-Second crop-Oct	18070.70	16.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	52.19	19.88	29.27	118.17	4173.25
4	Cholam-July	67.78	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.03	1.20
5	Cumbu - April	445.28	0.00	0.00	0.00	0.30	0.68	0.71	0.00	0.00	0.00	0.00	0.00	0.00	1.69	59.63
6	Ragi-July	1867.78	0.00	0.00	0.00	0.00	0.00	0.00	1.87	1.76	0.00	0.00	0.00	0.00	3.64	128.38
7	Maize-June	247.99	0.00	0.00	0.00	0.00	0.00	0.12	0.27	0.36	0.00	0.00	0.00	0.00	0.76	26.79
8	Red gram - July	175.58	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.15	0.00	0.00	0.00	0.00	0.24	8.34
9	Blackgram-Mar	10674.46	0.00	0.00	5.34	21.30	10.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.99	1306.36
10	Other Cereals-July	101.86	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.10	0.00	0.00	0.00	0.00	0.15	5.40
11	Chillies-Jan	146.98	0.11	0.14	0.25	0.25	0.27	0.24	0.00	0.00	0.00	0.00	0.00	0.00	1.27	44.97
12	Onion-Jun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	Fodder-Apr	136.24	0.00	0.00	0.00	0.07	0.29	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.64	22.62
14	Condiments-Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	Sugarcane-Dec	25010.77	14.71	0.00	49.98	45.67	55.49	55.10	47.48	34.40	0.00	0.00	0.00	12.51	315.33	11136.02
16	Greengram - Aug	684.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.34	12.09
17	Banana- Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	Groundnut-April	9203.57	0.00	0.00	0.00	6.35	15.82	19.05	4.92	0.00	0.00	0.00	0.00	0.00	46.14	1629.32
19	Cotton - July	347.81	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.69	0.00	0.00	0.00	0.00	0.86	30.49
20	Gingelly - April	626.08	0.00	0.00	0.00	0.31	1.11	1.30	0.00	0.00	0.00	0.00	0.00	0.00	2.72	96.07
21	Fruits & Veg-Per June	3382.96	3.83	3.56	5.18	5.57	5.93	2.57	2.46	1.97	0.00	0.00	0.00	0.00	31.06	1097.01
22	Flowers-Per-June	310.76	0.32	0.30	0.45	0.47	0.49	0.16	0.40	0.33	0.00	0.00	0.00	0.00	2.90	102.54
	Total	**126038.55**	**35.99**	**4.14**	**61.52**	**80.62**	**90.96**	**338.50**	**169.72**	**186.16**	**29.27**	**52.19**	**19.88**	**41.78**	**1110.73**	**39225.45**

Table 4.7

Net Irrigation Water Demand (Mcm) at 25 % Dependable Rainfall in Varahanadhi Basin

Sl.No	SUB BASIN	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	VARAHANADHI	43.85	28.83	43.64	77.80	0.00	315.06	62.06	88.17	108.47	52.19	19.88	43.23	**883.18**
2	NALLAVUR	5.74	4.17	6.40	14.02	16.97	48.34	22.01	15.08	5.14	8.92	3.40	8.59	**158.78**
3	ONGUR	12.23	2.89	8.71	7.87	20.93	124.55	69.25	43.82	14.60	26.02	9.91	15.34	**356.11**
TOTAL		61.82	35.88	58.76	99.69	37.90	487.94	153.32	147.07	128.20	87.13	33.18	67.16	**1398.07**

Table 4.8

Net Irrigation Water Demand (Mcm) at 50% Dependable Rainfall in Varahanadhi Basin

Sl.No	SUB BASIN	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	VARAHANADHI	37.68	27.86	42.68	61.26	65.89	306.91	165.20	88.57	29.27	52.19	19.88	41.78	**939.18**
2	NALLAVUR	6.61	4.03	6.63	14.23	0.00	57.53	29.13	15.08	14.93	8.92	3.40	6.50	**166.98**
3	ONGUR	5.19	5.42	7.66	12.59	17.85	122.61	46.04	65.09	14.59	26.02	9.91	15.34	**348.32**
TOTAL		49.49	37.31	56.97	88.08	83.74	487.04	240.37	168.74	58.79	87.13	33.18	63.62	**1454.48**

Table 4.9

Net Irrigation Water Demand (Mcm) at 75 % Dependable Rainfall in Varahanadhi Basin

Sl.No	**SUB BASIN**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
1	VARAHANADHI	35.99	4.14	61.52	80.62	90.96	338.50	169.72	186.16	29.27	52.19	19.88	41.78	**1110.73**
2	NALLAVUR	5.79	3.98	6.58	14.22	12.36	58.50	24.15	30.12	5.08	12.06	3.40	5.93	**182.17**
3	ONGUR	13.03	4.54	7.66	13.88	20.67	122.01	33.54	94.16	48.56	26.02	9.91	15.34	**409.32**
	TOTAL	54.80	12.66	75.76	108.72	124.00	519.01	227.40	310.44	82.92	90.27	33.18	63.05	**1702.22**

Table 4.10

Net Irrigation Water Demand (Mcm) at 90 % Dependable Rainfall in Varahanadhi Basin

Sl.No	**SUB BASIN**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
1	VARAHANADHI	36.02	29.17	43.10	80.48	77.80	343.38	146.08	113.63	113.15	52.19	19.88	51.09	**1105.99**
2	NALLAVUR	7.48	4.06	6.65	14.23	15.59	53.85	20.41	31.08	20.09	8.92	3.40	6.56	**192.32**
3	ONGUR	6.53	5.21	7.17	15.84	14.62	133.07	53.41	85.02	39.76	26.02	9.91	22.50	**419.06**
	TOTAL	50.04	38.43	56.92	110.55	108.01	530.31	219.91	229.73	173.01	87.13	33.18	80.15	**1717.37**

4.3.5 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.

Paddy, which is the staple food crop of Tamilnadu is extensively cultivated in all Districts in a normal area of 17.65 LHa. Paddy accounts for about 50% of the total irrigated area of the state. Nearly 94% of the Paddy area is raised only under irrigated condition. Considering this facts, the lower limit for the future irrigation demand is determined taking into consideration the cultivation of paddy using SRI (System of Rice Intensification) method than conventional method. The objective of better yield for a drop of water is achieved, then comparatively less water consuming practice of cultivation are considered for future planning purposes. Lower Limit Scenario of sub basin wise irrigated area of crops in Varahanadhi River Basin are tabulated in **Table 4.11** and net irrigation Water Demand at 25%, 50%, 75%, 90% Dependable Rainfall of Lower Limit Scenario are tabulated in **Tables 4.12 to 4.15**. Savings in demand in implementing lower limit scenario pattern of crops in Varahanadhi River Basin is listed in **Table 4.16.**

Table 4.11
Sub Basinwise Irrigated Area of Crops (Ha.) in Varahanadhi Basin
Lower Limit Scenario

Crop	Varahanadhi	Nallavur	Ongur	Total
Coconut - Per - Jan	325	545	1307	**2177**
Paddy - First Crop - June	16264	2779	8107	**27150**
SRI Paddy I - June	37948	6485	18917	**63350**
Paddy II - Oct	5421	926	2702	**9050**
SRI Paddy II - Oct	12649	2162	6306	**21117**
Cholam - Feb	68	2	1	**71**
Cumbu - Mar	445	69	20	**534**
Ragi - Jan	1868	224	128	**2220**
Maize - Jul	248	1	0	**249**
Red Gram - June	176	3	47	**226**
Black Gram - Jan	10674	2562	1664	**14900**
Green Gram - Jan	685	138	85	**908**
Other Cereals - July	102	19	8	**129**
Chillies - Jan	147	38	40	**225**
Onion-June	0	0	0	**0**
Fodder - Mar	136	0	2	**138**
Condiments -Sep	0	0	0	**0**
Sugarcane - Dec	25011	1849	1499	**28359**
Banana - Dec	0	0	0	**0**
Groundnut - Dec	9204	3308	6442	**18954**
Cotton - Feb	348	96	3	**447**
Gingelly - Feb	626	169	104	**898**
Fruits & Vegetables - June	3383	1520	2327	**7230**
Flowers - Per - June	311	54	56	**421**
Turmeric - June	3	0	0	**3**
TOTAL	**126042**	**22952**	**49764**	**198758**

Table 4.12
Lower Limit Scenerio

Net Irrigation Water Demand (Mcm) at 25 % Dependable Rainfall in Varahanadhi Basin

Sl.No	SUB BASIN	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	VARAHANADHI	37.18	28.83	43.64	77.80	0.00	246.37	45.06	63.58	88.86	37.58	14.31	35.03	718.24
2	NALLAVUR	5.00	4.17	6.40	14.02	16.97	37.51	17.20	10.88	3.73	6.42	2.45	6.70	131.45
3	ONGUR	9.98	2.89	8.71	7.87	20.93	93.53	52.99	31.57	10.51	18.73	7.13	11.26	276.09
TOTAL		52.16	35.88	58.76	99.69	37.90	377.41	115.25	106.02	103.10	62.73	23.89	52.99	1125.78

Table 4.13

Net Irrigation Water Demand (Mcm) at 50% Dependable Rainfall in Varahanadhi Basin

Sl.No	SUB BASIN	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	VARAHANADHI	32.68	27.86	42.68	61.26	65.89	239.66	134.69	63.98	21.08	37.58	14.31	33.58	**775.26**
2	NALLAVUR	5.58	4.03	6.63	14.23	0.00	45.15	23.40	10.88	11.75	6.42	2.45	5.10	**135.62**
3	ONGUR	4.34	5.42	7.66	12.59	17.85	92.05	34.13	47.21	10.51	18.73	7.13	11.26	**268.88**
TOTAL		42.60	37.31	56.97	88.08	83.74	376.87	192.23	122.07	43.34	62.73	23.89	49.94	**1179.76**

Table 4.14

Net Irrigation Water Demand (Mcm) at 75 % Dependable Rainfall in Varahanadhi Basin

Sl.No	SUB BASIN	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	VARAHANADHI	31.28	4.14	61.52	80.62	90.96	266.15	138.50	145.35	21.08	37.58	14.31	33.58	**925.06**
2	NALLAVUR	5.02	3.98	6.58	14.22	12.36	46.02	19.19	23.01	3.68	9.32	2.45	4.53	**150.36**
3	ONGUR	10.63	4.54	7.66	13.88	20.67	91.60	25.06	69.56	36.58	18.73	7.13	11.26	**317.31**
TOTAL		46.94	12.66	75.76	108.72	124.00	403.76	182.75	237.92	61.34	65.63	23.89	49.37	**1392.73**

Table 4.15

Net Irrigation Water Demand (Mcm) at 90 % Dependable Rainfall in Varahanadhi Basin

Sl.No	SUB BASIN	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	VARAHANADHI	31.43	29.17	43.10	80.48	77.80	270.24	118.10	82.13	94.85	37.58	14.31	40.74	**919.92**
2	NALLAVUR	6.33	4.06	6.65	14.23	15.59	42.08	15.92	23.78	15.89	6.42	2.45	5.16	**158.56**
3	ONGUR	5.68	5.21	7.17	15.84	14.62	100.36	39.91	62.95	29.42	18.73	7.13	16.83	**323.84**
TOTAL		43.44	38.43	56.92	110.55	108.01	412.68	173.93	168.86	140.16	62.73	23.89	62.73	**1402.33**

Table - 4.16

Irrigation Water Demand at 75 % Dependable Rainfall In Varahanadhi Basin

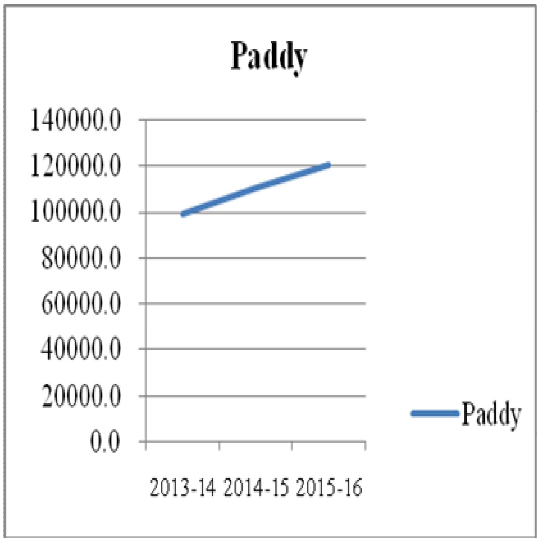
Sl. No.	Sub Basin	Present Irrigation Demand (Mcm)	Lower Limit Irrigation Demand (Mcm)	% of Savings in Demand
1	Varahanadhi	1110.73	925.06	16.72
2	Nallavur	182.17	150.36	17.46
3	Ongur	409.32	317.31	22.48
	Total	**1702.22**	**1392.73**	**18.18**

4.4 Cropping Pattern

From time immemorial due to the good soil health and plentiful water availability, farmers have a set cropping pattern in command areas, tank-fed areas and well irrigated areas, which predominantly paddy, banana, sugarcane, coconut 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 (in Ha) of various crops for past 3 years in this basin is given in graph and details are tabulated in Table 4.17.

Table 4.17 Irrigated area of Major crops (Ha) for the years 2013 to 2015

Major Crops	2013-14	2014-15	2015-16
Paddy	99224.0	110653.0	120668.0
Blackgram	7209.0	11768.0	14900.0
Sugarcane	30908.0	29845.0	28359.0
Groundnut	18186.0	19767.0	18954.0
Coconut	1576.0	2208.0	2177.0
F&V	5283.0	6452.0	7230.0
Total	**162386**	**180693**	**192288**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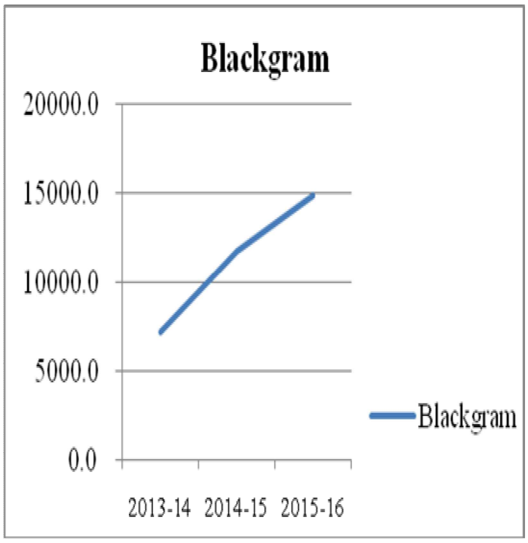
2013-14 2014-15 2015-16
Paddy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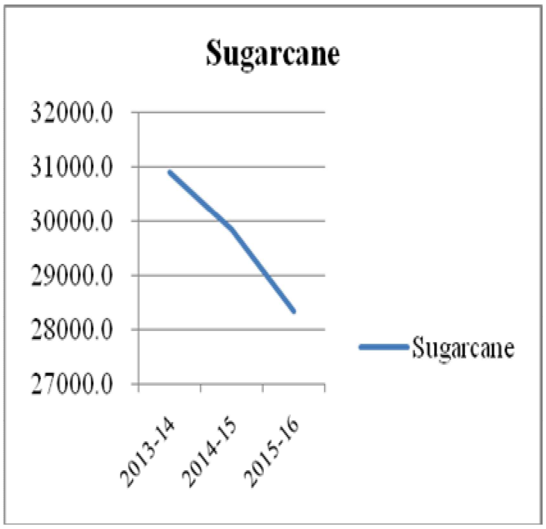
Blackgram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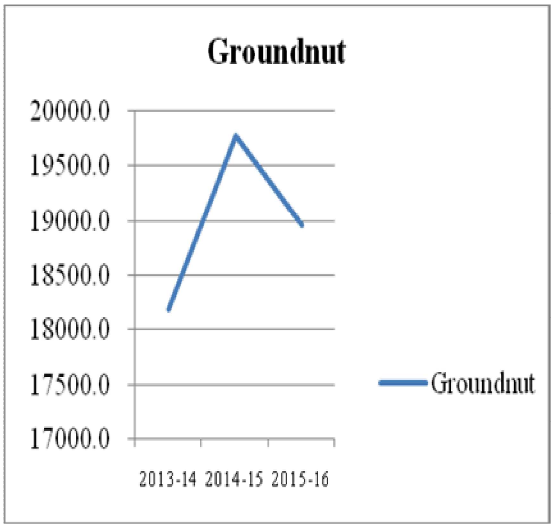
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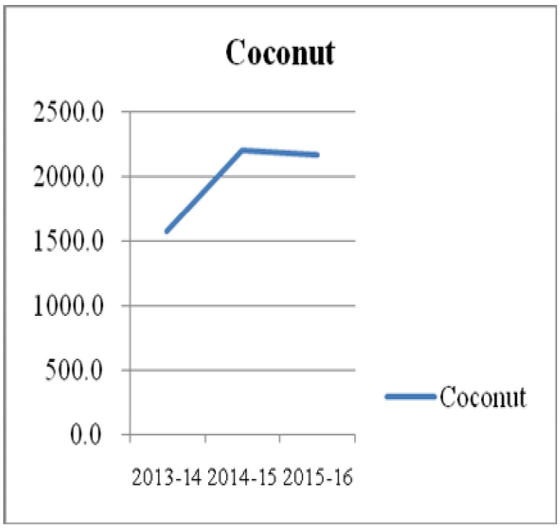
Groundnut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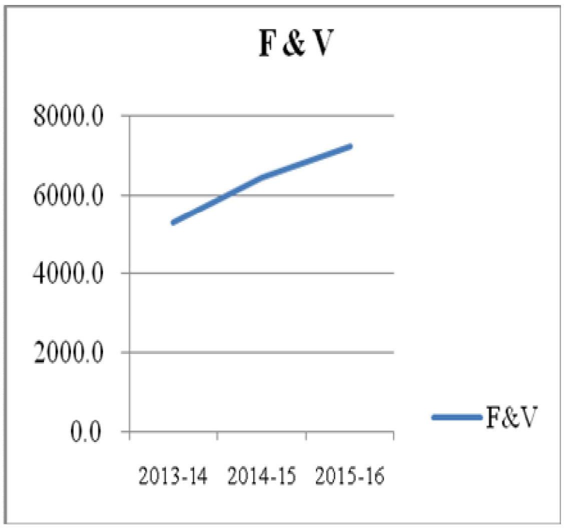
2013-14 2014-15 2015-16
Coconut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2013-14 2014-15 2015-16
F&V

4.4.1 Existing & Suggested Cropping Pattern in Varahanadhi Basin

The major crops cultivated in Varahanadhi Basin are Paddy, Blackgram, Sugarcane, Ground nut, Coconut and Fruits & Vegetables. The irrigated area for the year 2015-16 in Varahanadhi Basin under different crops is 1,98,758 ha. Paddy is cultivated in 1,20,667 ha. In the remaining area, other crops are cultivated. Sub basin vs Irrigated area of crops in Varahanadhi river basin in given in **Fig 4.6.**

The distribution of rain also plays a vital role in crop productivity. Existing cropping pattern during normal rain year (+19% to -19% of normal rainfall) and suggested cropping pattern for Poor rain year (-19% to -59% of normal rainfall) for the Districts covered in this basin are given in the **Table 4.18**.

Figure 4.6 Sub basin area vs Irrigated area of crops in Varahanadhi River Basin

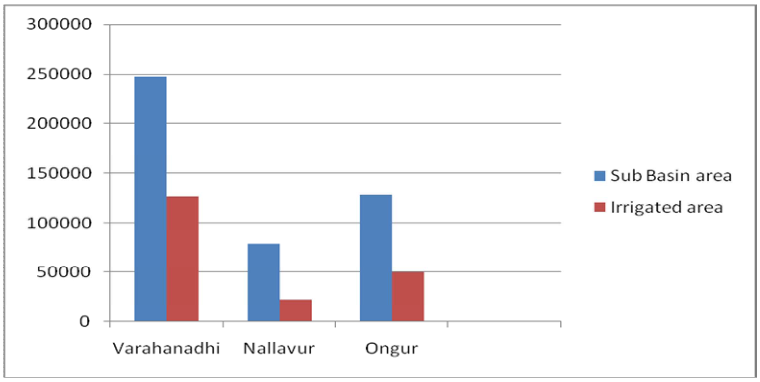


Table 4.18 Cropping Pattern in Varahanadhi River Basin

Areas	Existing cropping pattern	Normal year	Moderate drought year	Severe drought year
Tank fed areas	Rice (Aug-Jan) -Pulses (Jan-Apr)	Rice / Vegetables (Aug-Jan)-Gingelly/Pulses (Feb-May)	Pearl millet + clusterbean (Aug-Jan) - Pulses (Feb-Apr)	Fodder / Pulses (Nov-Feb)
Well irrigated areas	Rice (Aug – Jan)-Ground nut (Feb-Apr)-Gingelly (April –Jun)	• Rice (Aug-Jan) – Groundnut (Feb-Apr)-Gingelly (Apr-Jun) • Maize (June-Sep)-Marigold (Oct-Feb)-Pulses (Feb-May) • Vegetables (June-Oct)-Maize (Oct-Jan)-Pulses(Feb-May) • Sugarcane (Dec-Jan)-Ratoon sugarcane (Jan-Nov)-Rice (Dec-May)-Groudnut (June-Sep/Oct)	Vegetables (May-July)-Maize/Sunflower (Aug-Dec)-Groundnut, Gingelly (Jan-Apr)	Pearl millet / sorghum (July-Oct)-Maize,varagu, Gingelly, Groundnut (Nov-Feb) – Cluster bean/bhendi/lab lab/watermelon (Feb-May)

(Source: Data collected from Agriculture Department)

Comparison of cropping pattern between 2004 and 2018

Crops	2004	2017
Wet Crops	**Area in Ha**	**Area in Ha**
Paddy	104784	120668
Coconut	2099	2177
Sugarcane	14663	28359
Banana	430	0
Total	**121976**	**151204**
Dry Crops		
Groundnut	23676	18954
Gingelly	909	898
Pulses	694	16034
Millets	1765	3074
Total	**27044**	**38960**

4.5 Organic Farming

Organic farming is a system, which avoids or largely excludes the use of synthetic inputs (such as fertilizers, pesticides, hormones, feed additives etc) and to the maximum extent feasible relies upon crop rotations, crop residues, animal manures, off-farm organic waste, mineral grade rock additives and biological system of nutrient mobilization and plant protection.

Need to practice the organic farming

With the increase in population our compulsion would be not only to stabilize agricultural production but also to increase it further in sustainable manner. Excessive use over years of agro-chemicals like pesticides and fertilizers may affect the soil health and lead to declining of crop yields and quality of products. Hence, a natural balance needs to be maintained at all cost for existence of life and property. The obvious choice would be judicious use of agro-chemicals and more and more use of naturally occurring material in farming systems. Though the yield of crop is comparatively less in organic farming, because the produce fetches higher price in the international market, corporate companies are encouraging the farmers to go for organic farming on contract basis to facilitate export of the certified produce to other countries.

Benefits of organic farming

1. It helps in maintaining environment health by reducing the level of pollution
2. It reduces human and animal health hazards by reducing the level of residues in the product.
3. It helps in keeping agricultural production at a higher level and makes it sustainable.
4. It reduces the cost of agricultural production and also improves the soil health
5. It ensures optimum utilization of natural resources for short-term benefit and helps in conserving them for future generation.
6. It not only saves energy for both animal and machine, but also reduces risk of crop failure.
7. It improves the soil physical properties such as granulation, and good tilth, good aeration, easy root penetration and improves water-holding capacity.
8. It improves the soil's chemical properties such as supply and retention of soil nutrients, and promotes favorable chemical reactions.

4.5.1 Organic Farming in Tamilnadu

Various Training programmes under Organic Farming are being conducted by TNAU – Information and Training Centre, Chennai for the benefit of farmers/youth, urban men and women.

Paramparagat Krishi Vikas Yojana (PKVY) Organic farming, certification by Participatory Guarantee System (PGS) and marketing the produces in local markets are encouraged in this scheme by cluster approach. This is shared scheme between Government of India and the State Government of Tamilnadu with a sharing pattern of 60:40. This is a three year continuous programme. The scheme is implemented in 27 districts viz., Ariyalur, Coimbatore, Cuddalore, Dharmapuri, Dindigul (including Kodaikanal), Erode, Kancheepuram, Karur, Krishnagiri, Kanyakumari, Madurai, Namakkal, Pudukkottai, Salem, Sivagangai, Tiruvannamalai, Thanjavur, The Nilgiris, Theni, Tiruppur, Tirunelveli, Tiruvallur, Trichy, Tuiticorin, Vellore, Villupuram and Virudhunagar. This scheme was started in the year 2015-16 to bring 2,550 Acre of horticulture crops under organic cultivation and PGS certification. In the first year (2015-16), it was implemented in 51 clusters in 27 districts at an outlay of Rs.3.60 Crore. During the year 2016-17, the second year programme was being implemented at an outlay of Rs.1.19 Crore in the same clusters. During third year i.e., 2017-18, assistance for Residue analysis, crop cultivation, conversion of 164 land to organic, biological Nitrogen harvest planting, packaging, labeling and branding of organic produces, Custom hiring of agriculture implements etc. will be extended at an outlay of Rs.1.47 Crore and an additional area of 900 Acre of land will be brought under organic cultivation and PGS certification by forming 18 new clusters at an outlay of Rs.1.27 Crore. Area of crops under Organic Farming in Varahanadhi River Basin is given in Table 4.19 (Source: Data collected from Agriculture Department).

Table 4.19 - Area of crops under Organic Farming in Hectares for past five years in Varahanadhi Basin

Sub basin	2010-11	2011-12	2012-13	2013-14	2014-15
Varahanadhi	179	144	160	224	217
Nallavur	44	36	47	58	73
Ongur	0	0	0	41	51
Total	223	180	207	323	340

4.5.2 Bio Fertilizers

Bio fertilizer is a substance which contains living microorganisms which, when applied to seeds, plant surfaces, or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. Bio-fertilizers add nutrients through the natural processes of nitrogen fixation, solubilizing phosphorus, and stimulating plant growth through the synthesis of growth-promoting substances. Bio-fertilizers can be expected to reduce the use of chemical fertilizers and pesticides. The microorganisms in bio-fertilizers restore the soil's natural nutrient cycle and build soil organic matter. Through the use of bio-fertilizers, healthy plants can be grown, while enhancing the sustainability and the health of the soil. Since they play several roles, a preferred scientific term for such beneficial bacteria is "Plant-Growth Promoting Rhizobacteria" (PGPR). Therefore, they are extremely advantageous in enriching soil fertility and fulfilling plant nutrient requirements by supplying the organic nutrients through microorganism and their byproducts. Hence, bio-fertilizers do not contain any chemicals which are harmful to the living soil.

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 and cannot replace chemical fertilizers that are indispensable for getting maximum crop yields.
- It increases the crop yield by 20% to 30% and replaces chemical nitrogen and phosphorus by 25%.
- It stimulates plant growth
- It activate the soil biologically and restores natural soil fertility
- It provide protection against drought and some soil borne diseases

The quantity of biofertilizers distribution target, quantity distributed and area covered in Ha for the year 2013-14 & 2014-15 for Varahanadhi Basin have been tabulated in **Table 4.20.**

Table 4.20 Bio fertilizer Details in Varahanadhi River Basin

Sl. No	Sub Basin	Bio Fertilizers									
		No. of Production units		Quantity Produced in tonnes		Distribution target in Tonnes		Quantity distributed in tonnes		Area covered in Ha	
		2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
1	Varahanadhi	Nil		Nil		100	107	100	107	37996	39482
2	Nallavur					14	14	14	14	5424	5650
3	Ongur					25	25	27	29	2206	2199
	Total					**139**	**146**	**141**	**150**	**45626**	**47331**

(Source: Bio fertilizers details collected from Agriculture Department**)**

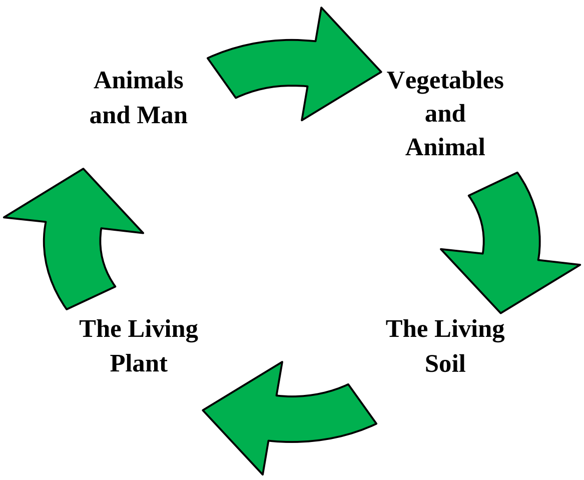
4.5.3 Vermicompost

Vermicomposting is the process of turning organic debris into worm castings. The worm castings are very important to the fertility of the soil. The castings contain high amounts of nitrogen, potassium, phosphorus, calcium, and magnesium. Any types of biodegradable wastes are used for the preparation of vermicompost.

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 bad odour.
- It improves soil structure, texture, aeration, and waterholding capacity and prevents soil erosion.
- Rich in beneficial micro flora such as a fixers, P- solubilizers, cellulose decomposing micro-flora etc in addition to improve soil environment.
- Contains earthworm cocoons and increases the population and activity of earthworm in the soil.
- It neutralizes the soil protection.
- It prevents nutrient losses and increases the use efficiency of chemical fertilizers.
- Free from pathogens, toxic elements, weed seeds etc.
- It minimizes the incidence of pest and diseases.
- It enhances the decomposition of organic matter in soil.
- It contains valuable vitamins, enzymes and hormones like auxins, gibberellins etc.

Nutrient Cycle through Compost



Encouraging the farmers to produce required organic manure in their own lands by extending subsidy for establishment of 1400 Vermicompost units at a cost Rs.2.17 crore under National Mission for Sustainable Agriculture (NMSA) – Rainfed Area Development is continuing for the year 2017-18 also.

The vermicompost details such as number of units under subsidy and area covered under Vermicompost for the year 2013-14 and 2014-15 for Varahanadhi Basin are tabulated in **Table 4.21**.

Table 4.21 - Details of Vermicompost in Varahanadhi River Basin

Sl.No	Sub Basin	No of units given under subsidy		Area covered under Vermicompost (Ha)	
		2013-14	2014-15	2013-14	2014-15
1.	Varahanadhi	13	13	1164	1202
2.	Nallavur	2	2	269	273
3.	Ongur	12	12	3	3
	Total	**27**	**27**	**1436**	**1478**

(Source: Data are collected from Agriculture Department)

4.5.4 Major Schemes covered in the Varahanadhi Basin by Agricultural Engineering Department

In order to improve the Irrigation Efficiency and crop production, certain schemes are implemented,

1. Soil and Water Conservation in the Catchments of River valley Projects under National Agricultural Development Programme.
2. Command area Development and Water Management Programme (PMKSY)
3. TN IAMWARM Project.

1. Soil and Water Conservation in the Catchments of River valley Projects under National Agricultural Development Programme.

This is a State Plan which gives 100% grant for all Soil Conservation measures which is aiming the following

- prevention and control of soil loss from the catchments to reduce sedimentation of multipurpose reservoirs
- Prevention of land degradation and watershed management in the catchment areas
- Improvement of land capability and moisture regime in the watersheds
- Promotion of land use to match land capability

Works such as Drainage line Treatment, Afforestation and Silt detention structure are being executed under this scheme.

2. Command area Development and Water Management Programme (PMKSY)

This is a centrally sponsored scheme. This scheme covers the Districts Villupuram, Cuddalore, Tiruvannamalai. The main objectives of the scheme is as follows

- To bridge the gap between the irrigation potential created and utilized
- To improve the water use efficiency in canal irrigated areas
- To ensure equity distribution of irrigation water from head reach to tail end
- To ensure Participatory Irrigation Management
- To reduce the wastage of Irrigation Water.
- To reach the above said objectives, works such as Construction of Field Channels, rotational water supply works, field drains, Infrastructure for Micro Irrigation are contemplated in the scheme.

Command Area Development and Management Programme

TN IAMWARM Project

This is a centrally sponsored scheme, focussing the following objectives.

- More income per drop of water.
- To reduce wastage of water and to increase the water use efficiency.
- To increase the yield and income of the farmer.

TN IAMWARM Project has been completed in 3 Phases in Varahandhi River Basin. In Phase I, Varahanadhi Sub basin and in Phase III, Nallavur and Ongur Sub basin has been completed. In Varahanadhi River Basin, Areas cultivated during IAMWARM Project in

Agriculture Department under various crops are 6259 Ha, Horticulture Department is 3900 Ha, TNAU is 5689 Ha. As a result of this, Fully irrigated area has been increased, Partially irrigated area is reduced and Gap has become reduced. This resulted in 71.23 % increase in irrigated area in Varahanadhi, 8.02 % in Nallavur and 57.52 % in Ongur Sub Basin. (Source: MDPU, Chennai).

4.6 Water Saving Techniques in Crop Production

For some of the major crops grown in Varahanadhi basin, the following specific strategies can be adopted.

Paddy:

The ***System of Rice Intensification***, known as SRI is a methodology for increasing the productivity of rice by changing the management of plants, 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), mat nursery method, young seedling transplantation (14 days old seedlings), single seedling in square planting method, water saving upto 40%, using conoweeder to plough back the weeds, getting higher tillering which enhances yield and hence high income. SRI, a bouquet of technological practices for the judicious use of water was promoted in 5.81 lakh Ha during 2016-17 in the State. It has been programmed to promote this initiative in an area of 9.91 lakh Ha during 2017-18.

To encourage the farmers to go for SRI cultivation, the Government is providing an incentive of Rs.7500 per hectare under NFSM (Rice) which includes Cono weeder and other inputs. Farmers are also provided training on this method by the Agriculture Department as well as by Krishi Vigyan Kendra., Vridhachalam.

System of Rice Intensification (SRI) Method of Paddy Cultivation

Sugarcane:

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

- Raising nursery using single budded chips, transplanting young seedlings (25-35 days old)
- Maintaining wide spacing (5 x 2 feet) in the main field
- Providing sufficient moisture through water saving efficient irrigation technologies viz., skip furrow, alternate furrow and sub surface drip irrigation
- Practicing intercropping with effective utilization of land,
- Promotes mechanization in cultivation
- To promote drip irrigation, government provides 100 percent subsidy for small & medium farmers and 75 percent for large farmers

Sustainable Sugarcane Initiative (SSI)

When compared to the conventional furrows, irrigation water saving of 50% and 34.2% is achieved using Skip furrow method and Alternate furrow method respectively. State promoted SSI in 275 Ha during 2016-17. During 2017-18, an area of 16,000 Ha planned to brought under SSI, besides an additional area of 14,000 Ha planned to bought under Micro Irrigation.

Coconut:

In the first year, irrigate on alternate days and from the second year till the time of maturity, irrigation shall be given twice a week and afterwards once in 10 days. The coconut husks at about 30 cm depth around the coconut trees at a radius of one meter and covering it up with earth will conserve soil moisture.

Use of coir waste as soil mulch around the tree to a thickness of about 3 cm is advantageous to conserve soil moisture especially under scarcity condition. By this water saving by 63 percent, yield increase by 7 percent and labour saving by 40 percent could be achieved.

Vegetables:

Drip irrigation at 75 percent of cumulative pan evaporation has registered increased yield up to 59 percent along with water saving up to 29 percent as compared to furrow irrigation at 0.8 irrigation water / cumulative pan evaporation.

Groundnut:

The infiltration rate of water is considerably improved by the application of coir waster which also gives highest yield of ground nut. More number of irrigation in pre flowering and maturing phase has no substantial increase in the Pod yield.

With the existing area of cultivation in Varahanadhi Basin for some of the crops, by adopting Water saving techniques on cultivation, savings in water is given below.

Sl. No.	Crop	Cultivated area in Ha	Water requirement- conventional method (MCM)	% of saving by adopting saving technique	Saving (MCM)
1	SRI-Paddy	120668	1105.32	40	442
2	SSI-Sugarcane	28539	356.975	40	143
3	Coconut	2177	19	63	12
4	Groundnut	18954	83	49.4	41
5	Vegetables	7230	67	29	20
				Total	**658**

4.7 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 Varahanadhi Basin. The cost of cultivation of crops in Tamilnadu is also appended in **Appendix 4.1 to 4.12 of Volume-II.**

4.8 Summary

4.8.1 Conclusion

- The Gross irrigated area of crops in Varahanadhi Basin is reported to be 198758 Ha and Gross area estimated as 2,60,583 Ha.
- Irrigated area in Varahanadhi sub basin is 126042 Ha and in Nallavur sub basin is 22952 Ha and Ongur sub basin is 49764 Ha.
- Out of the total area irrigated, about 60% is under paddy cultivation and 14% is under Sugarcane cultivation, 10% under Groundnut, remaining Pulses, Coconut and millets.
- Net Irrigation demand of this basin at 75% dependable rainfall is 1702.22 MCM.
- Net Irrigation demand of this basin at 50% dependable rainfall is 1454.48 MCM.
- Varahanadhi sub basin has the maximum irrigated area of 126042 Ha which accounts for about 63% of the total irrigated area.
- Nallavur sub basin has the minimum irrigated area of 22952 Ha which accounts for about 12% of the total irrigated area.
- Varahanadhi sub basin has the maximum irrigation demand of about 1111 MCM (about 65%) and Nallavur sub basin has the minimum irrigation demand of about 182 MCM (about 11%).
- 20% of surface water and 80% of Ground water is being used for irrigation. (Source: Irrigation profile of Villupuram, Kancheepuram and Tiruvannamalai Districts).
- Organic farming practice is to be extended in larger manner in this Basin.
- Irrigation intensity of the Districts covered under this Basin is showing increasing trend.

Sl.No.	Districts	2011-12	2012-13	2013-14	2014-15
1.	Villupuram	1.08	1.07	1.50	1.44
2.	Tiruvannamalai	1.32	1.33	1.34	1.46
3.	Kancheepuram	1.14	1.08	1.19	1.14

- As per 2004 Varahanadhi Microlevel Reappraisal Study Report, Irrigation demand was calculated as 1250.75 MCM at 75% dependable rainfall with the irrigated crop area of 1,52,522 Ha. Irrigated area of wet crops is calculated as 1, 21,976 Ha. In that Paddy is found to be 86%, Coconut as 1.7% and sugarcane as 12%. Irrigated area of dry crops is calculated as 27,044 Ha. In that, irrigated area of Groundnut is found to be 87.5%, Pulses as 2.56%, Gingelly as 3.36% and Millets as 6.52%.
- As per 2017 Varahanadhi Microlevel Reappraisal Study Report, Irrigation demand was calculated as 1702.22 MCM at 75% dependable rainfall with the irrigated crop area of 1,98,758 Ha. Irrigated area of wet crops is calculated as 1, 51,204 Ha. In that, irrigated area of Paddy is found to be 79.8%, Coconut as 1.44% and sugarcane as 18.75%. Irrigated area of dry crops is calculated as 38,960 Ha. In that, irrigated area of Groundnut is found to be 48.65%, Pulses as 41.15%, Gingelly as 2.30% and Millets as 7.9%.
- On comparing the cultivation area of Varahanadhi River Basin Microlevel Reappraisal Reports for the years 2014 & 2018, it is found that the total irrigated area is increased with increase in Groundwater Irrigation. Increase in wet crop cultivation such as Paddy & Sugarcane and dry crops such as Pulses & Millets is noticed. Coconut cultivation area remains the same and Groundnut cultivation area is reduced.

4.8.2 Recommendation

- Savings in Irrigation demand of about 658 MCM can be achieved if 70% area Paddy cultivation practice is changed to SRI method.
- Using drip irrigation, for the cultivation, sugarcane, water savings to the tune of 40% (143 MCM) could be achieved.
- Using coir pith as soil mulch for coconut trees, 63% of irrigation water could be saved (About 12 MCM of water can be saved).
- In ground nut crop, among 4,5 and 6 width plots, plot of 5 m width, four irrigations with eight splashes per irrigation was found to be the best proposition for higher yield of ground nut pods, which consumed 202 mm of water against flood irrigation (500 mm). It resulted in a saving of 247 mm of water (49.4 % saving of water).
- By adopting water saving techniques in Irrigation, approximately 3.8 % of irrigation water can be saved and the same thing can be utilized for improving cultivation area.

References:

1. Statistical Hand Book 2016.
2. Season crop Report for the Fasali 1420, 1421, 1422, 1423, 1424.
3. Irrigation profile 2013-14, 2014-15 & 2015-16 for the Districts of Villupuram, Kancheepuram, Tiruvannamalai and Cuddalore.
4. Impacts of watershed Development Programmes : Experiences and Evidences from Tamilnadu by K.Palanisami and D. Sureshkumar, Agricultural Economics Research Review, Vol.22 (Conference Number) 2009, pp 387-396.
5. "Advanced technologies in Sugarcane Cultivation during DRIP Irrigation in Tamilnadu" by Sivanappan – Concept paper by Ramanandha Adigalar Foundation, Coimbatore, Tamilnadu.
6. Agriculture Department Policy Note 2017-18.
7. Vision 2023, Government of Tamilnadu.
8. Agrometeorological Data Collection, Analysis and Management by ICAR - Central Research Institute for Dryland Agriculture.
9. Recent Advances in Irrigation Management for Field crops by Dr. C. R. Chinnamuthu, Dr. A. Velayutham, Dr. S. Ramasamy, Dr. N. Sankaran, Dr. S.D. Sundarsingh.
10. Performance of Agriculture in River Basins of Tamil Nadu In the last three Decades – A Total Factor Productivity Approach, A Project Sponsored by Planning Commission, Government of India by K.Palanisami, C.R.Ranganathan, A.Vidhyavathi, Rajkumar.M and N.Ajjan, Centre for Agricultural and Rural Development Studies, Tamil Nadu Agricultural University, Coimbatore.
11. State of Indian Agriculture 2015-16, Government of India, Ministry of Agriculture & Farmers Welfare Department of Agriculture, Cooperation & Farmers Welfare, Directorate of Economics & Statistics.

CHAPTER – 5

SURFACE WATER RESOURCES AND IRRIGATION SYSTEM

CHAPTER – 5

SURFACE WATER RESOURCES AND IRRIGATION SYSTEM

5.1 Location

The Varahanadhi basin is one of the 17 major river basin and is spread out in four districts of Tamil Nadu viz. Villupuram, Thiruvannamalai, Kancheepuram Cuddalore and Union Territory of Pondicherry. The basin lies between North latitude 11° 50’ 00” to 12° 28’ 00” and East longitude 79° 08’ 00” to 80° 10’ 00”. The Varahanadhi basin is surrounded by Bay of Bengal in the East, Palar basin in the North and Pennaiyar basin in the South and West. The area of the basin in Tamilnadu is 4536.51sq.km and in Union Territory of Pondicherry is 220.119 sq.km. Maximum area of the basin lies in Villupuram district.

Three individual rivers viz. Varahanadhi, Ongur and Nallavur forms the basin. They had separate catchment area and flows and confluence separately ie. the Varahanadhi river confluence with Bay of Bengal, the Ongur river flows into Yedayantittu Kaluveli tank and the Nallavur river joins the Kaluveli swamp.

The Varahanadhi river basin consists of three sub basins namely Varahanadhi, Ongur and Nallavur. The tributaries of this basin include Annamangalam (Kannalam Odai), Nariyar, Tondiar, Varahanadhi, Pambai Ar and Sellangi odai. Water Potential assessment, Water Balance and Water Planning are done by integrating all the three sub basins under Varahanadhi river basin.

5.1.1 Varahanadhi River

The Varahanadhi River has two arms. The right arm originates from Pakkammalai hills lies in Kilpennathur taluk of Thiruvannamalai district and left arm originates from Melmalayanur tank, which is located in Gingee taluk of Villupuram district. They join together near Thenpalai village and forms the main river Varahanadhi or Sankaraparani and flows in an easterly direction. The first tributary called Annamangalam surplus course (Kannalam Odai) joins the main river near Melacheri. Then the river takes a turn towards south in the eastern part of Singavaram village near Gingee and then flows again towards east. The second tributary called “Nariyar odai” joins Varahanadhi river near Uranithangal Village.

Near Vallam village the main Varahanadhi river takes a turn towards the south. The third tributary called Tondiar joins near Vidur. The Vidur reservoir across Varahanadhi is situated just below the confluence of this tributary in Tindivanam taluk.

Below Vidur reservoir, the river turns towards South East and flows into Villupuram Taluk. In this reach the fourth tributary called Varahanadhi joins the main river near Radhapuram village in Villupuram taluk. From there, the river runs East upto Kodukkur and South East in Tamil Nadu and Pondichery states alternately. In this reach, the fifth tributary called Pambai Ar joins Varahanadhi river near Rajaputrapalayam in Villupuram Taluk and lastly the sixth tributary Chellangi Odai joins Varahanadhi river near Sankarakkudi in Villupuram taluk just 3 kms. above its confluence with Bay of Bengal, a little South of Pondichery State. The total length of the Varahanadhi river is 78.50 kms.

5.1.2 Ongur River

Ongur river originates in Tinidivanam taluk of Villupuram district. In the initial reach it has two arms. The right arm originates from the surplus course of Vairapuram tank which is fed by number of upper tanks and empties into Saram Eri (tank). In addition to that, the drainage course to Saram Eri is also receiving water from number of tanks on either side. The surplus course of Saram Eri called Saram river or Saram Odai flows towards the North Eastern direction.

Similarly the left arm called Nariyar Odai or Murungai Odai originates from surplus course of Olakkur Melpadi Eri which is fed by surplus water of number of tanks. It joins the Saram Odai about 3 Kms West of Ongur village. From this point the river is called as Ongur river.

After this, a local stream Nedungal Ar joins Ongur river on its left side. Nedungal stream originates from the surplus course of Kalathur and Kilthivakkam tank which receives surplus water from number of tanks in Maduranthagam Taluk of Kancheepuram District. It joins Ongur river near Veliyambakkam village of Maduranthagam Taluk. The total length of this stream is about 6 kms. Then the river flows towards the South East until it falls into the Yedayantittu Kaluveli tank and the surplus of which joins the Bay of Bengal. The length of Ongur river from its origin till its confluence with the sea is about 43 kms.

5.1.3 Nallavur River

Nallavur Ar is another river that flows in between Varahanadhi and Ongur river. At the starting point it has two arms. The right arm originates from the surplus course of Singanur tank which receives the surplus water from upper tanks. Similarly the left arm originates from the surplus water of Tindivanam tank which also received the surplus water from upper tanks.

The two arms join together and form a river near Karanavur village at about 4 kms. South of Tindivanam town and turns towards South.

Another drainage course, called Kondamur i.e., surplus from more than 10 tanks East of Mailam town join on the right hand side of the river at about 4 kms South East of Sithamur village. After this, the river traverses in the Eeastern direction in between Aruvapakkam and Kondamur.

At North of Kondamur, another drainage course, receiving water from a number of tanks in the upper reaches, joins the main river. This main river is called Nallavur Ar or Kondamur Ar. Below this point, number of drainage courses join at the right side of this river before it empties into Kaluveli swamp. The surplus water of Kaluveli swamp finds its way to feed Yedayantittu Kaluveli tank (where Ongur river also joins) near Marakkanam before confluencing with the Bay of Bengal. The length of this river is about 25 kms.

5.2 Kazhuveli Swamp

The Kazhuveli swamp is a large lagoon with triangular shape. It is near the seashore along the Eastern boarder of the Tindivanam taluk of Villupuram district. On the eastern side the swamp area is bounded by Marakkanam to Pondicherry road and on the Western side by Brahmadesam Kiliyanur and in the southern side by Olinthiyapattu to Pudupattu road. It is spread over an area of about 71.48 sq.km and links with Yedayanthittu swamp or Kodhadu swamp on the North by a tidal creak of about 8 kms in length which in turn opens into the sea at about 9.7 km north of Marakkanam. This large swamp is full of water during rainy season and remains dry for the greater part of the year and is partly covered by the nooks or car grass and partly by ordinary grass. When it is dry, it presents an appearance of arid waste with patches of salt efflorescence. Because of high tides seawater enter into this swampy area, reclamation efforts taken earlier have proved futile and costly. Although for several years the problem of reclaiming the waste area has been under consideration, there is a need of economically viable proposal to reclaim this swamp by arresting the seawater intrusion into the swamp, so that it can help in producing drainage relief to the adjoining lands by storing their surplus flow during normal years. This swampy area may be suitable for fish culture or prawn culture, which is to be explored. If, in future a suitable pumping scheme can be formulated from the swamp, (it can store 28 Mcum of water) then adjoining dry land can be brought under irrigation. A portion of land inside the swamp can also be reclaimed.

5.3 Details of Tributaries

Table 5.1 Details of Tributaries

Sl.No.	Name of the Tributaries	Description
VARAHANADHI RIVER		
1.	Annamangalam Surplus Course (Kannalam Odai)	It joins with the main river Varahanadhi near Melacheri village about 6 Km downstream from the origin of Varahanadhi at its left side and it is the first tributary. Total length is approximately 10.4 km
2.	Nariyar	It is second tributary of 13 km length and joins the main river near Uranithangal village about 15 km downstream from origin.
3.	Tondiar	It joins the main river from left side near Vidur reservoir at 41 km from the origin and after traversing a distance of 31.78 km.
4.	Varahanadhi	It joins the main river near Chinnabara Samuthavam from right in Villupuram taluk about 63 km from origin and is about 87 km long.
5.	Pambai Ar	It joins the main river at its right side, after traversing a length of 23.81 km, near Radhapuram village in Villupuram Taluk about 47 km from origin.
6.	Chellangi Odai	It is sixth and the last tributary that joins the main river at its right side near Sankarakudi in Villupuram taluk just 3 km above its confluence with the sea. It joins at about 75.5 km from origin. The total length of the stream is about 16 km.
ONGUR RIVER		
7.	Nariyar Odai (or) Murungal Odai	It joins with the Ongur river at its left side near Ongur.
8.	Nedungal Aru	It joins with the main river at its left side near Veliyambakkam village.
NALLAVUR RIVER		
No tributaries for this river course		

5.4 Gauging Sites in the Basin

Presently there is only one Gauge & Discharge site in the Varahanadhi basin, at Vidur Reservoir across Varahanadhi river, which is maintained by the Public Works Department. The Inflow and outflow of Vidur reservoir is taken for flow analysis and it is given in Appendix 5.1 of Volume II.

5.5 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 precipitation, intensity, duration, the direction of storm, slope, soil, land use, etc.

The upper reaches are influenced by southwest monsoon and lower reaches are influenced by northeast monsoon. The following influential rainfall stations having long term records are considered for analysis.

As the basin falls in both the Tamil Nadu and Pondicherry States, area falls in the Tamil Nadu state alone is considered for rainfall analysis.

Table 5.2 Details of the influencing Raingauge stations

S. No.	Name of subbasins	Sub basin area (sq.km.)	Raingauge stations	No. of Raingauge Stations
1	Varahanadhi	2473.003	Thirukovilur, Vanur, Aliyabad Anicut, Villupuram, Thiruvannamalai, Vidur dam, Tindivanam, Polur, Vandavasi & Gingee	10
2	Ongur	1274.731	Vanur, Vidur dam, Tindivanam & Marakkanam	4
3	Nallavur	]788.777	Madhuranthagam, Tindivanam, Marakkanam & Vandavasi	4
	Total	**4536.510**		

Sub basin wise average annual rainfall is given vide Appendix 5.5 of Vol II Surface Water Potential is assessed by the following three methods:

- Rainfall –Runoff Co-efficient Method
- Monthly Runoff Simulation Model (MRS Model)
- National Water Development Agency Approach (NWDA Approach)

5.5.1 Rainfall – Runoff Co-efficient Method

Varahanadhi River Basin has a drainage area of **4536.510** Sq.Km. A rational approach to obtain the Run-off of a catchment, is by assuming a suitable Run-off Co-efficient.

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

Y- Yield in Mcum

A - area of catchment in Sq.Km

P - weighted rainfall arrived from Theisson Polygon

C - Run-off Co-efficient

Deciding the rainfall runoff factor is a cumbersome one. As adopted in the earlier reports prepared by IWS, it has been decided that a runoff coefficient of 0.15 for the plains, 0.20 for hilly region and 0.12 for forest area would be more appropriate in general. The runoff from each sub basin is cumulatively added to arrive at the basin yield. Surface water potential thus calculated using this method at 75% dependability is **575.59 MCM** and is given below.

Table 5.3 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 Mcum			Total Potential in Mcum
							in hilly Area	in Forest area	in Plain Area	
1	Varahanadhi	2473.00	41.78	151.64	2279.58	816.22	6.82	14.85	279.10	300.77
2	Nallavur	788.78	0.72	10.43	777.62	905.79	0.13	1.13	105.65	106.92
3	Ongur	1274.73	4.35	17.82	1252.55	879.56	0.77	1.88	165.25	167.90
Total		**4536.51**	**46.86**	**179.91**	**4309.74**	**2601.57**	**7.72**	**17.87**	**550.00**	**575.59**

Table 5.4 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	75% dependable Rainfall in mm	Surface Water Potential in Mcum			Total Potential in Mcum
							in hilly Area	in Forest area	in Plain Area	
1	Varahanadhi	2473.00	41.784	151.643	2279.58	1008.17	8.43	18.35	344.73	371.50
2	Nallavur	788.78	0.724	10.437	777.62	1009.33	0.15	1.26	117.73	119.14
3	Ongur	1274.73	4.356	17.827	1252.55	1063.24	0.93	2.27	199.76	202.96
Total		**4536.51**	**46.86**	**179.91**	**4309.74**	**3080.74**	**9.50**	**21.88**	**662.23**	**693.61**

5.5.2 Surface Water Potential by MRS Model:

(i) History of MRS Model

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 a class of 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 their various components, and their computational time-steps. Generally speaking, the shorter the time-step, the larger are the number of watershed parameters operated on 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 MRS model 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 observations led to the development of the present monthly model, requiring easily accessible monthly rainfall as input. 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 5.2 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.

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

Having calibrated the model, it is then applied to long-term rainfall data, maintaining the same in Thiessen network and potential evapotranspiration.

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

V	(evapotranspiration 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

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:

Now, the following model parameters are adopted based on the calibration made in the inflow of Vidur reservoir in the Varahanadhi sub basin.

V	(evapo transpiration adjustment factor)	0.7
Z	(coefficient of runoff)	0.08
P	(fraction of impervious area)	0.09
M	SMAX (upper limit of SM)	50
C	(base flow recession rate)	0
G	GWMAX (upper limit of GW)	300
B	(fraction of recharge becoming base flow)	0.05

Table 5.5 75% Dependable Surface Water Potential – MRS Model

in Mcum

Sl.No.	Name of the Sub Basin	SW	NE	NM	Annual
1.	Varahanadhi	98.69	195.13	19.74	313.56
2.	Ongur	63.80	93.13	7.59	164.52
3.	Nallavur	33.31	70.73	1.87	105.91
Total		195.80	358.99	29.20	583.99
South West Monsoon Potential		**195.80**			
North East Monsoon Potential		**358.99**			
Non Monsoon Potential		**29.20**			
Annual Potential		**583.99**			

Table 5.6 50% Dependable Surface Water Potential – MRS Model

in Mcum

Sl.No.	Name of the Sub Basin	SW	NE	NM	Annual
1.	Varahanadhi	152.09	259.29	5.18	416.55
2.	Ongur	46.53	148.30	8.87	203.70
3.	Nallavur	48.05	83.45	3.20	134.70
Total		246.67	491.04	17.25	754.95
South West Monsoon Potential **North East Monsoon Potential** **Non Monsoon Potential** **Annual Potential**		**246.67** **491.04** **17.25** **754.95**			

In Varahanadhi basin, Ongur, Nallavur and Varahanadhi rivers are considered as influent river, since the base flow is considered for arriving at the Surface Water Potential of the basin.

Surface Water Potential of Varahanadhi Basin at 75% dependability is 583.99 Mcum.

The Sub basin wise runoff assessed by MRS model is given in Appendix 5.3 of Volume II.

5.5.3 Surface Water Potential by NWDA Approach

Methodology adopted for working out Surface water potential:

(i) Varahanadhi sub basin lies in the lower side of Varahanadhi Basin. There are 10 rain gauge stations in and around Varahandhi sub basin. Monsoon rainfall data is available for the period from 1977-78 to 2016-17. Weighted rainfall for the sub basin is computed by Thiessen polygon method using Arc GIS software.

(ii) Utilisations in the upstream reach of Varahanadhi sub basin during monsoon period has been estimated adopting the data on yearly irrigated area (Collected from the Department of Economics and Statistics).

(iii) Available observed flow data in Vidur reservoir for the period from 1977-1978 to 2016-17 is tabulated. By adding this value with the upstream utilization for irrigation, Gross monsoon yield in Mcum is obtained. This yield, divided by the Sub Basin area gives the Runoff in mm.

(iv) Using the Runoff during monsoon and the corresponding figures of weighted average monsoon rainfall for each year for the period from 1977-78 to 2016-17, rainfall-runoff relationships are worked out based on regression analysis for the sub basin. The equation is $y = 0.105x+187.427$mm.

(v) The gross monsoon yield series of the sub basin for the period from 1977-78 to 2016-17 has been generated using the above equation and considering the corresponding weighted monsoon rainfall. From the yield series, the 75% dependable gross monsoon yield value of 344.27 Mcum for Varahanadhi sub basin is obtained.

(vi) For the remaining sub basins namely, Ongur and Nallavur, where the flow data are not available, only the upstream utilization quantity is considered and the gross monsoon yields are evaluated. **The details are given in Appendix 5.4.1 to 5.4.12 of Vol II**. **75% dependable Monsoon yield (June to December)**

For the whole Varahanadhi river basin using NWDA approach works out to 681.42 Mcum

Table 5.7 75% Surface Water Potential

S. No.	Name of Sub basins	Surface Water Potential in Mcum
1	Varahanadhi	344.27
2	Ongur	233.31
3	Nallavur	103.84
	Total	**681.42**

Table 5.8 50% Surface Water Potential

S. No.	Name of Sub basins	Surface Water Potential in Mcum
1	Varahanadhi	364.66
2	Ongur	233.31
3	Nallavur	103.84
	Total	**701.81**

Table 5.9 75 % dependable Surface Water Potential by three methods

S. No.	Name of Sub basin	Rainfall Runoff Co efficient method	MRS Model	NWDA Approach
1	Varahanadhi	300.77	313.56	344.27
2	Ongur	167.90	164.52	233.31
3	Nallavur	106.92	105.91	103.84
Total		**575.59**	**583.99**	**681.42**

Table 5.10 50 % dependable Surface Water Potential by three methods

S. No.	Name of Sub basin	Rainfall Runoff Co efficient method	MRS Model	NWDA Approach
1	Varahanadhi	371.50	416.55	364.66
2	Ongur	202.96	203.70	233.31
3	Nallavur	119.14	134.70	103.84
Total		**693.61**	**754.95**	**701.81**

5.6 The Existing Surface Water Supply Systems

Vidur dam is the only major reservoir in the Varahanadhi basin. Surface water is stored in the tanks and then water is drawn for usage from the tanks. The tanks are classified as System tanks and Non system tanks.

The non-system tanks use the surface runoff from their own catchment, whereas the system tanks are filled by the canal flow diverted by the anicuts across the river apart from the direct runoff from their own catchment.

5.6.1 Vidur Reservoir

Vidur reservoir is the only reservoir in the Varahanadhi basin. It is situated near Vidur village in Tindivanam taluk of Villupuram District lies in Latitude 12^{o}5’N and Longitude 79^{o}35’E and 800m below the confluence Point of Sanakarabarani river and Thondiar. The reservoir was constructed during the year 1958-59. Below the reservoir, the river is called as Varahanadhi. Nearly 69% of the command area under this reservoir, lies within the boundary of Tamil Nadu state and remaining 31% lies in the Union Territory of Pondicherry. The total Command area of the reservoir is 1295.02 ha. Out of which, in Tamil Nadu, it is about 890.33 ha and in Pondicherry about 404.69 ha. The total catchment area is 1298 sq.km. The water spread area at FRL is 7.98 sq.km and capacity at FRL is 17.13 Mcum. There are two numbers of river sluices of size 1.52 x 1.83m each. The hydraulic particulars of the Vidur reservoir are given in Table 5.13. The encroachments in the catchment of Veedur Dam, around 500 acres has been evicted.

Additional Spillway and Fuse Plug :

A peak inflow of 3231 Cumecs was observed at the reservoir due to the heavy flood occurred in November 1985, against the designed discharge of 1907 Cumecs (Old Spillway). At that time, the water level at the reservoir was observed at an EL of + 40.09 m (Just 0.14 m below the top of the dam) with reference to the designed FRL/MWL at an EL of +37.800m despite opening all the existing spillway gates fully.

Studies were done on the basis of hydrological review and finally it was decided to provide an additional spillway & fuse plug and the work was completed in 2002. Additional Spillway having 3 vents of size 12.20m x 6.10 m with crest level +31.720m. The length of fuse plug compartment I is 105 m and its sill level is +37.80m. The fuse plug compartment II is 210 m long and its sill level is +37.80m.

Now, as per the SPF observed in 2009, CWC has vetted the peak inflow of 7228 m^3/sec, for this peak inflow, an additional Fuse plug of length 200 m is proposed under DRIP, left to the existing fuse plug compartment and provisions has been made for extension of the fuse section barriers at both end of the fuse plugs.

5.6.2 Anicuts

There are totally 60 anicuts in the basin. The hydraulic particulars of these are furnished in the annexure 5.6 of Volume II.

Varahanadhi Sub basin	
1	Unnamandal Anicut
2	Sangilikuppam Anicut
3	Sekkadikuppam Anicut
Varahanadhi Sub basin	
4	Kodambadi Anicut
5	Kunthalampattu Anicut
6	Avalurpet Anicut
7	Koilpuraiyur Anicut
8	Siyampoondi Anicut
9	Melpudupet Anicut
10	Nallanpillaipetral Anicut
11	Sathiyamangalam Anicut
12	Thenpalai Anicut
13	Gudapattu Anicut
14	Varahanadhi Anicut/ Sevalapuri Anicut
15	Chokkapalam Anicut
16	Kannalam Anicut
17	Kadali Anicut
18	Konai Anicut
19	Ponpathy Anicut
20	Jayankondan Anicut

21	Jambothy Anicut
22	Rajampuliyur / Modaiyur Anicut
23	Nedimozhiyanur No I
24	Nedimozhiyanur No II
25	Perani Anicut
26	Damanur Odai Anicut
27	Thondur Anicut
28	Mel-Olakkur Anicut
29	Sengamedu Anicut
30	Aviyur/ Agalur Anicut
Varahanadhi Sub basin	
31	Nangiyanandal Anicut
32	Melathur / Vallam anicut
33	Rettanai Anicut
34	Chendur Anicut
35	Pathirapuliyur Anicut
36	Vilvamadevi
37	Aniladi
38	Panchalam
39	Periya Thantchanur
40	Melkondai
41	Thoravi
42	Vadanur Regulator
43	Kothampakkam Anicut
44	Rangarayanallur
45	Thiruvadur
46	Kattarampakkam
47	Mittamandagapattu

Nallavur Sub Basin	
1	Eraiyuanur Dividing Wall
2	Annamaputhur Dividing Wall
3	Ommandur anicut
4	Kondamur anicut
5	Kazhuveli Regulator
Ongur Sub Basin	
1	Konerikuppam Anicut
2	Karasangal anicut
3	Minnal Chithamur anicut
4	Arasur Anicut
Ongur Sub Basin	
5	Kollimedu Anicut
6	Veliyambakkam anicut
7	Venmelagaram anicut (Abandonded)
8	Parameswaramangalam Anicut (Abandonded)

Anicut details are subject to validation with the field Engineers

5.6.3 Tanks

There are about 614 tanks in the basin. Out of the above, 22 are system tanks with a registered ayacut of 1853.35 ha and 592 are non-system tanks with a registered ayacut of 49679.75 ha. The total ayacut benefited by the tanks in the basin comes out to 51533.10 ha. The total capacity of all tanks is 2128.34 Mcum.

Tanks are mainly used to irrigate paddy. Water scarcity exists at field level, due to problems of tank siltation, poor water scheduling and water losses. Conjunctive use of tank and well water can improve the overall performance of irrigation systems. Detailed tank particulars such as name of the tank, village and registered ayacut are given in Appendix 5.5 of Volume II.

Table 5.11 Details of Tanks

Sl.No.	Name of the Sub Basin	System Tanks			Non System tanks		
		Number	Capacity in Mcum	Ayacut in Ha	Number	Capacity in Mcum	Ayacut in Ha
1	Varahanadhi	22	328.50	1853.35	259	1630.18	22472.30
2	Ongur	-	-	-	235	119.26	18649.04
3	Nallavur	-	-	-	98	50.40	8558.41
Total		**22**	**328.50**	**1853.35**	**592**	**1799.84**	**49679.75**

Sl.No.	Name of the Sub Basin	Total Number of Tanks	Total Capacity in Mcum	Total Ayacut in Ha
1	Varahanadhi	281	1958.68	24325.65
2	Ongur	235	119.26	18649.04
3	Nallavur	98	50.4	8558.41
Total		**614**	**2128.34**	**51533.10**

Tank details are subject to validation with the field Engineers

5.7 Surface Water Quality

Surface water is water on the surface of the planet such as in a stream, river, lake, wetland or ocean. It can be contrasted with groundwater and atmospheric water. It is mainly accumulated due to rainfall and runoff.

Non-saline surface water is replenished by precipitation and by recruitment from ground-water. It is lost through evaporation, seepage into the ground where it becomes ground-water, used by plants for transpiration, extracted by mankind for agriculture, livelyhood, industry etc. or discharged to the sea where it becomes saline.

The Nation’s surface-water resources—the water in the nation's rivers, streams, creeks, lakes, and reservoirs are vitally important to our everyday life. The main uses of surface water include drinking-water and other public uses, irrigation uses, and for use by the thermoelectric-power industry to cool electricity-generating equipment. The majority of water used for thermoelectric power, public supply, irrigation, mining, and industrial purposes came from surface-water sources.

Surface Water Resources of Tamilnadu

The total surface water potential of the state is 24864 Mcum. There are 17 major river basins in the State with 89 (85+4) reservoirs and about 41948 tanks of the annual water potential of 46540 Million Cubic Meters (MCM), (Source: ENVIS Centre). Most of the surface water has already been tapped primarily for irrigation. 24 lakh hectares are irrigated by surface water through major, medium and minor schemes. The utilization of surface water for irrigation is about 90 percent.

In Varahanadhi River Basin, surface water samples were collected by traversing across the basin from the following sources.

1. Mel Malayanoor
2. Sevalapurai Anaicut
3. Vidur Reservoir
4. Konerikuppam

5. Tank near Tholuppedu

The water samples were analyzed in the Geochemical Laboratory, under State Ground & Surface Water Resources Data Center (SG&SWRDC), Tharamani, Chennai.

Based on the results of water samples analyzed, it is observed that all the parameters are well within the limits and the water can be used for both domestic and agriculture purposes.

5.7.1 Daily threats to surface water health

- When toxic substances enter lakes, streams, rivers, oceans and other water bodies, get dissolved or lie suspended in water. This results in the pollution of water. Due to pollution, the quality of water deteriorates, affecting aquatic ecosystems. These pollutants can also seep down and affect the groundwater deposits. The most polluting source of water is sewage and industrial waste. Agricultural run- off or the water from the fields that drain into rivers is another major water pollutant as it contains excess fertilizers and pesticides.
- Deforestation and poor land use practices in the catchment area which disturb topsoil and vegetative cover resulting in decreased infiltration rates, increased runoff, sediment transport and deposition in rivers and storage reservoirs.
- Over abstraction of surface water sources at the upstream reduces the minimum flow required in the downstream sections for the sustenance of ecosystems and mangroves.Use of lawn fertilizers and pesticides.
- High water consumption (i.e., long showers, leaky taps and damaged pipe lines).
- Old or Abandoned wells.
- Leaky septic tanks.
- Improper disposal of household hazardous wastes (Medicines, cleaning products and electronics).
- Storm sewer contamination (soap from car washing, animal wastes).

5.7.2 Protection measures to Surface water health

Monitoring the health of our lakes and rivers is an important part of the drinking water source, since our health and our way of living rely on clean water resources.

- The seepage and percolation wastages in surface flow i.e., canals and channels have to be arrested by way of lining the canals wherever necessary
- Treating of industrial wastes before letting to drain into the river.

- Minimize the use of chemical fertilizers and increase the use of bio organic fertilizers.
- Proper disposal of domestic and agricultural wastes.
- Proper lining of septic tanks
- Cleaning the storm water drainage before monsoon.
- Following simple Rain water harvesting techniques.

By following the above measures we can enjoy our largest natural resource, at its best.

5.8 Irrigation system

Vidur reservoir is the only reservoir in the Varahanadhi basin. The command area in Tamil Nadu is about 890.33 ha and about 404.69 ha in Pondicherry. Total ayacut of 1295 ha. is benefited by this reservoir. The Irrigation system map is furnished vide **Plate No:31**

Based on the availability of water in the Vidur Reservoir, the Vidur main canal is supposed to be kept open for 135 days to irrigate short term crops to an extent of 3200 acres (2200 acres TN and 1000 acres Pondicherry).

5.9 Issues in the Management of Surface Water Resources

Problems in Tanks 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. Tank irrigation system, account for over 30 percent of total irrigated area of Tamil Nadu, Karnataka and Andhra Pradesh States. These tanks are mainly used to irrigate paddy fields during the late monsoon to early dry season from September to December.

At present the overall efficiency of tank irrigation system is very low. In a modernised agrarian context, as witnessed in several parts of Tamil Nadu irrigation by tans are becoming scarce year by year. Choosing crops, date of sowing / harvesting under tank / canal irrigation, ultimately depends upon the availability and the timing of the release of water from reservoir / tanks.

There has been some reduction in storage capacity of tanks due to ***siltation, foreshore encroachment and damaged tank components***. Available water is further reduced due to poor water scheduling and losses in the distribution system. Inadequate supplies over the command produces water stress condition and reduce the yield, which inturn forced the farmers to dig wells for supplemental irrigation to minimize the yield reductions. Need for supplemental irrigation is high when water level in the tank is depleted. Wells in the tank command recharge mainly from tanks and irrigated fields. Recharging of wells located nearby tanks, therefore depends upon the hydraulic interaction between tanks and aquifer tapped by the wells. Conjunctive use of tank and well water help in increasing the crop production and also improve performance of the tanks system.

Canal Lining

Water losses in the unlined canals are 30 percent. The canals of some tanks are lined to reduce the losses leading to saving in water losses by 15 percent. However, reduction in groundwater recharge may be 10 percent due to lining. Thus reduction in seepage due to lining may not justify lining. Moreover it will reduce recharge to groundwater and conjunctive use. However, lining of canal may be restricted to those reaches where the seepage loss is appreciable.

Abandoned Anicut

Venmelagaram Anicut

Venmelagaram anicut was constructed across Ongur river at Venmelagaram village in Cheyyur taluk for a length of 105 m. The crest level of the anicut is 32 m and the depth of flow is 0.75 m.

Ayacut of Arasur tank 63.97 ha have been benefitted by this anicut. At present, the anicut was totally washed out on southern side and about 20 m only left in northern side leads off take for Arasur Supply channel. The Plan Formulation wing of WRD has inspected the site and follow up action is being taken for reconstruction.

Parameswaramangalam Anicut

Parameswaramangalam Anicut was constructed across Poigai Maduvu in Cheyyar Taluk of Kancheepuram, district.

During 1985 flood, the anicut was completely damaged. Originally the anicut was constructed with Random Rubble stone to irrigate 113.19 Hectares of land in Puran Cheri, Solaikadu, Natham, Parameswaramangalam, Vepanchery and Cuddalore villages.

The flood protection wall was constructed for a length of 3000 m. Surplus water of 415.30 cusecs have been released to this anicut through the Pallavan Kulam tank weir. Capacity of the anicut is 50 Mcft.

The following repairs are to be carried out:

- Wall of anicut for a length of 27.10 m.
- Side walls and Aprons on both the sides.

- Head Sluice.
- Flood protection wall for a length of 6000 m.

The approximate cost of the work is Rs.500 lakhs.

Gauging Sites

The basin comprises three individual rivers such as Varahanadhi, Ongur and Nallavur had separate catchment areas and flows and confluence separately into Bay of Bengal. But there is only one gauging site at Vidur reservoir, which is constructed across Varahanadhi course. No gauging sites were established across Ongur and Nallavur reach. Hence necessary action may be taken to establish necessary number of gauging sites across three river course. It is essential to establish a Gauging site especially at the tail end, so as to assess the surplus flow to sea.

5.10 Suggestions for meeting future needs

The Surface Water Potential of this basin has been almost utilized in full. The maximum quantity of Surface Water, i.e. 85 to 90% is consumed by agriculture. If about 10% of this consumption could be reduced, it would result in considerable savings and the quantum of water could be spared for other purposes. The following short term measures are suggested for reducing the consumption of water for irrigation.

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

It is possible to increase the recharge to ground water, by enhancing the storage capacity of the nearby tanks. Also due to increased irrigation, recharge to groundwater from the conveyance system and irrigated fields would increase. Irrigation intensity can be increased substantially.

5.11 Inter Basin Transfer of Water

The adjacent river basins to Varahanadhi river basin are Palar and Penniyar. Palar river basin is deficit as per the micro level reappraisal study of Palar basin (2014) and hence there is no possibility of interbasin transfer from Palar river basin.

There is an off-take point at Thirukoilur anicut from Pennaiyar river called Pambai vaikkal which confluences with Pambai Aru at Malliyapattu village which in turn confluences with Varahanadhi river at Amanakuppam village.

For domestic purpose, there was an inter basin transfer of sub surface water for a quantum of 4 Mcum per annum from the adjoining Pennaiyar basin to this basin. At present the system is not functioning.

5.12 Out Flow to Sea

Pillaiyarkuppam anicut is the last anicut constructed across Varahanadhi course before it confluences with the Bay of Bengal, but located in Pondicherry Union Territorry. There is no Gauging and Discharge site in Ongur and Nallavur course. Hence, the flow data of the Vidur reservoir for the period from 1962-63 to 2015-16 (54 years) is taken for assessing the quantity of surplus flow to sea.

The analysis reveals that there was no surplus flow in 17 years, the quantity exceeding 2000 Mcum and 1000 Mcum are for 1 year. The quantity of flow between 400 – 1000 Mcum occurs in 13 years and less than 100 Mcum in 22 years. The analysis of the surplus flow details reveals that the flow to sea at 75% dependability is Nil.

In Ongur and Nallavur course no Gauging sites are installed to quantify the flow to sea.

Outflow to Sea

Table 5.12 Vidur Reservoir Outflow (1962-63 to 2015-16)

Sl. No.	Year	Discharge in Mcum	Descending order of Discharge in Mcum Rank M	Relative Frequency (M/N+1)
1	1962-63	51.28	2446.64	0.02
2	1963-64	103.52	1667.60	0.04
3	1964-65	80.82	410.08	0.05
4	1965-66	74.73	391.31	0.07
5	1966-67	95.64	384.31	0.09
6	1967-68	43.57	305.39	0.11
7	1968-69	3.75	254.88	0.13
8	1969-70	177.87	211.63	0.15
9	1970-71	10.94	186.39	0.16
10	1971-72	7.88	185.76	0.18
11	1972-73	74.55	180.73	0.20
12	1973-74	9.27	177.87	0.22
13	1974-75	0.00	146.72	0.24
14	1975-76	0.00	143.53	0.25
15	1976-77	42.24	103.52	0.27

Sl. No.	Year	Discharge in Mcum		Descending order of Discharge in Mcum Rank M	Relative Frequency (M/N+1)
16	1977-78	211.63		99.54	0.29
17	1978-79	90.06		95.64	0.31
18	1979-80	146.72		90.06	0.33
19	1980-81	0.00		80.82	0.35
20	1981-82	0.39		74.73	0.36
21	1982-83	0.00		74.55	0.38
22	1983-84	143.53		66.01	0.40
23	1984-85	0.30		51.28	0.42
24	1985-86	410.08		45.84	0.44
25	1986-87	0.00		43.57	0.45
26	1987-88	0.00		42.24	0.47
27	1988-89	0.00		30.49	0.49
28	1989-90	0.00		15.03	0.51
29	1990-91	0.00		10.94	0.53
30	1991-92	185.76		10.34	0.55
31	1992-93	10.34		9.27	0.56
32	1993-94	3.15		7.88	0.58
33	1994-95	45.84		3.75	0.60
34	1995-96	15.03		3.15	0.62
35	1996-97	384.31		0.39	0.64
36	1997-98	66.01		0.38	0.65
37	1998-99	305.39		0.30	0.67
38	1999-00	0.00		0.00	0.69
39	2000-01	0.38		0.00	0.71
40	2001-02	0.00		0.00	0.73
41	2002-03	0.00		0.00	0.75
42	2003-04	0.00		0.00	0.76
43	2004-05	180.73		0.00	0.78
44	2005-06	391.31		0.00	0.80
45	2006-07	0.00		0.00	0.82
46	2007-08	99.54		0.00	0.84
47	2008-09	186.39		0.00	0.85
48	2009-10	30.49		0.00	0.87
49	2010-11	1667.60		0.00	0.89
50	2011-12	254.88		0.00	0.91
51	2012-13	0.00		0.00	0.93
52	2013-14	0.00		0.00	0.95
53	2014-15	2446.64		0.00	0.96
54	2015-16	0.00		0.00	0.98

N = 54

5.13 Conclusion

Varahanadhi river is not a perennial river and it has flows only during the monsoon season alone. The Water Potential of a basin comprises of both Surface Water Potential and Ground Water Potential. For Varahanadhi basin the total potential works out to **1573.32 Mcum.**

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

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

The annual Surface Water Potential of Varahanadhi River Basin calculated using Rainfall – Run-off Co-efficient Method is **575.59 Mcum** at 75% dependability and that by using MRS Model is **583.99 Mcum**. Also the 75% dependable Monsoon yield (June to December) for the whole Varahanadhi river basin using NWDA approach works out to **681.42 Mcum**.

The 75% dependable annual Surface Water Potential value of **583.99 Mcum**, calculated using MRS model is taken for Water Balance calculations, given in Chapter 8, since the monthly rainfall values are adopted in MRS model.

The surplus flow from the Vidur reservoir to sea is **22.76 Mcum** and **Nil** for **50%** and **75%** dependability respectively.

Suitable proposal may be evolved, (both economically and technically viable) for reclaiming the Kazhuveli Swamp area, so as to store the considerable quantum of water during flood, which can be used during lean period.

As there is no Gauging site is installed across Ongur and Nallavur course, surplus flow to sea is measured in Vidur Reservoir only in the Varahanadhi course. Hence automatic flow measuring devices may be installed in other anicuts of the sub basin, so as to quantify the Surplus flow to sea.

Comparison of Surface Water Potential between 2005 and 2017

S.No.	Name of the Sub basin	75% dependable Surface Water Potential in Mcum			
		MRS		Rainfall runoff coefficient method	
		2005	2017	2005 *	2017
1	Ongur	117.32	164.52		167.90
2	Varahanadhi	221.75	313.56		300.77
3	Nallavur	89.38	105.91		106.92
	Total	428.45	583.99		575.59

* In the Microlevel study report of Varahanadhi river basin (2005), the Surface water potential is not assessed by Rainfall runoff coefficient method. There is an increase in Surface Water Potential from 2009 to 2017 i.e.,428.45 Mcum (2009) to 583.99 Mcum (2017).

HYDRAULIC PARTICULARS OF VIDUR RESERVOIR

Table 5.13

1.	Location	:	Lat : $12^{0}5'$N	21.	Type	:	Lift gates
		:	Long: $79^{0}35'$E	**River Sluice**			
General				22.	Vent	:	2 Nos 1.52 x 1.83 m
2.	River	:	Varahanadhi	23.	Sill	:	+28.04 m
3.	Basin	:	Varahanadhi	24.	Discharge	:	55.05cumecs
4.	Sub basin		Varahanadhi				
5.	Nearest Town	:	Tindivanam	**Canal Sluice**			
6.	District	:	Villupuram	25.	Left Side Vent	:	2 Nos 1.22 X 1.83 m
7.	Construction Period	:	1958 - 59	26.	Sill	:	+32.04 m
8.	Cost	:	Rs.89 lakh	27.	Discharge	:	3.54 cumecs
Reservoir				**Canal (left)**		:	
9.	Catchment Area	:	1298 Sq.km	28.	Length	:	+17.7 km
10.	Design Flood	:	Original 1907 cumecs Revised as per Drip 7228 Cumecs cumecs	39.	Discharge	:	3.5 cumecs

11.	F. R.L/M.W.L	:	+37.80 m				
12.	Area at F.R.L	:	7.98 Sq.km				
13.	Capacity at F.R.L Gross/Net	:	17.13 Mcum / 17.13 Mcum				
Dam				34.	**Canal (left) Ayacut**	:	1295.02 ha
14.	Type	:	Earth Dam	35.	Tamil Nadu	:	890.33 ha
15.	Top of Road Way	:	+40.023 m	36.	Pondicherry	:	404.69 ha
16.	Maximum Height	:	22.55 m				
17.	Length of Earth Dam	:	4379.98 m				
Spill Way							
18.	Vents	:	9 Nos 10.97 mx4.57 m				
19.	Crest	:	+33.22 m				
20.	Discharge	:	1907 Cumecs				

Hydraulic Particulars of Vidur dam Additional Spillway:

Sl.No.	Hydraulic Particulars		
1.	Size of Vents	:	3 Nos. 12.20 x 6.10 m
2.	Crest Level	:	31.72 m
3.	Shutter type	:	Radial Shutters
4.	Discharge Capacity	:	1665 m^3/s
5.	Height of Dam	:	13.26 m
6.	Top of Roadway	:	+ 40.23 m
7.	Maximum Water Level	:	+39.23 m
8.	Full Reservoir Level	:	+37.80 m
9.	Size of Stilling basin		42.10 m x 31.00 m
10.	Stilling Basin Level		+23.00 m
11.	U/s side Bed level		+23.00 m
12.	Bed level of Surplus Channel		+27.00 m
13.	Rear Water level (under SPF)		+34.50 m
14.	Crest of Spill way		+33.22 m
15.	Crest of Additional spillway		+31.72 m
16.	Head sluice		2 x 1.20m x 1.80m
17.	Ayacut (TN)		2200 Acres
18.	Ayacut (Pondicherry)		1000 Acres
19.	**Length of Main canal**		
20.	Tamil Nadu		LS 0 km – LS 16.305 km
21.	Pondicherry		LS 16.305 km – LS 17.640 km
22	Discharge of Head Sluice		125 c/s
23.	MFD (observed)		3231 cumecs
23.	Date of completion		25.07.2002

Fig 5.1 Varahanadhi River Basin
Flow diagram of Varahanadhi River

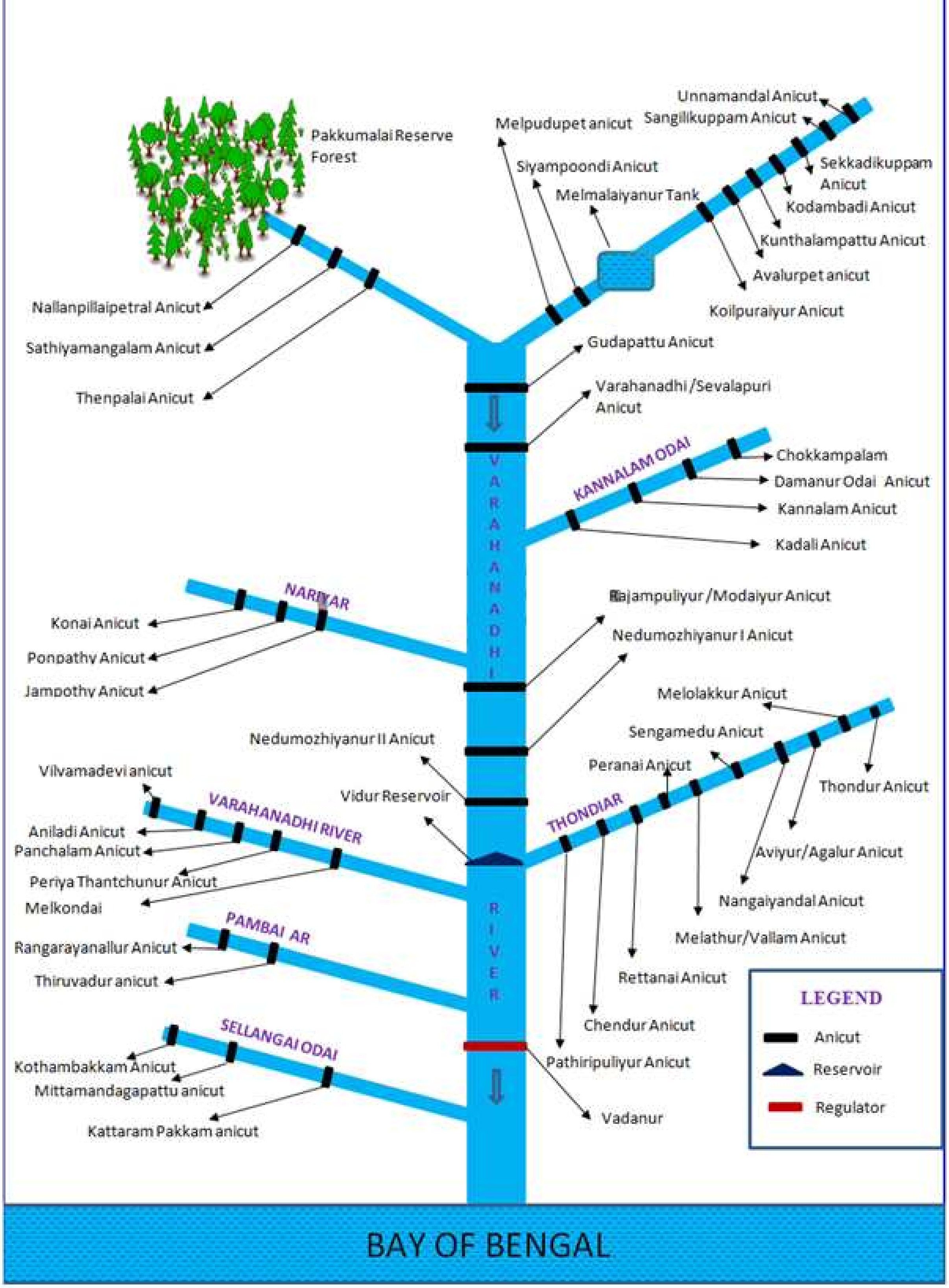
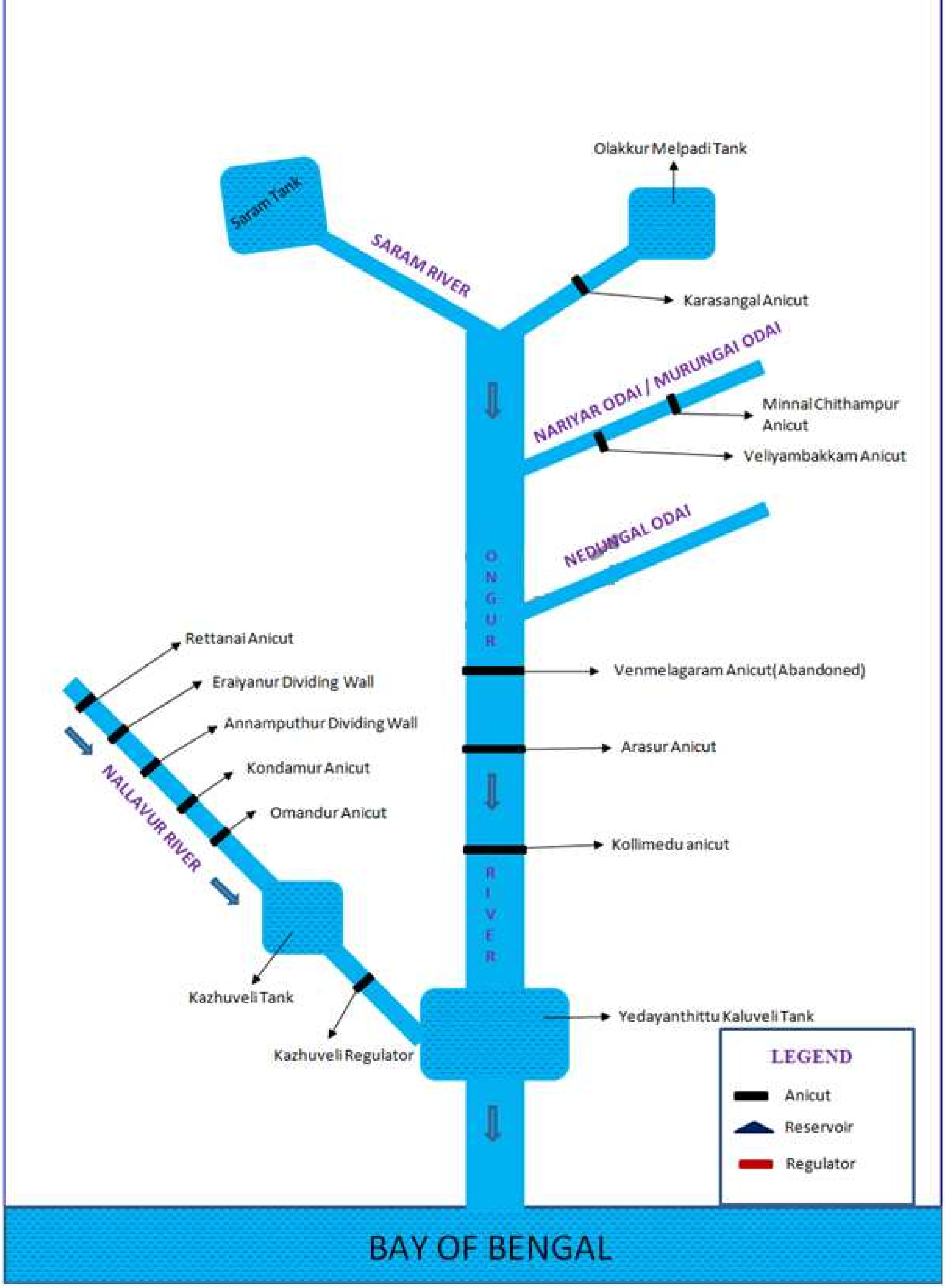
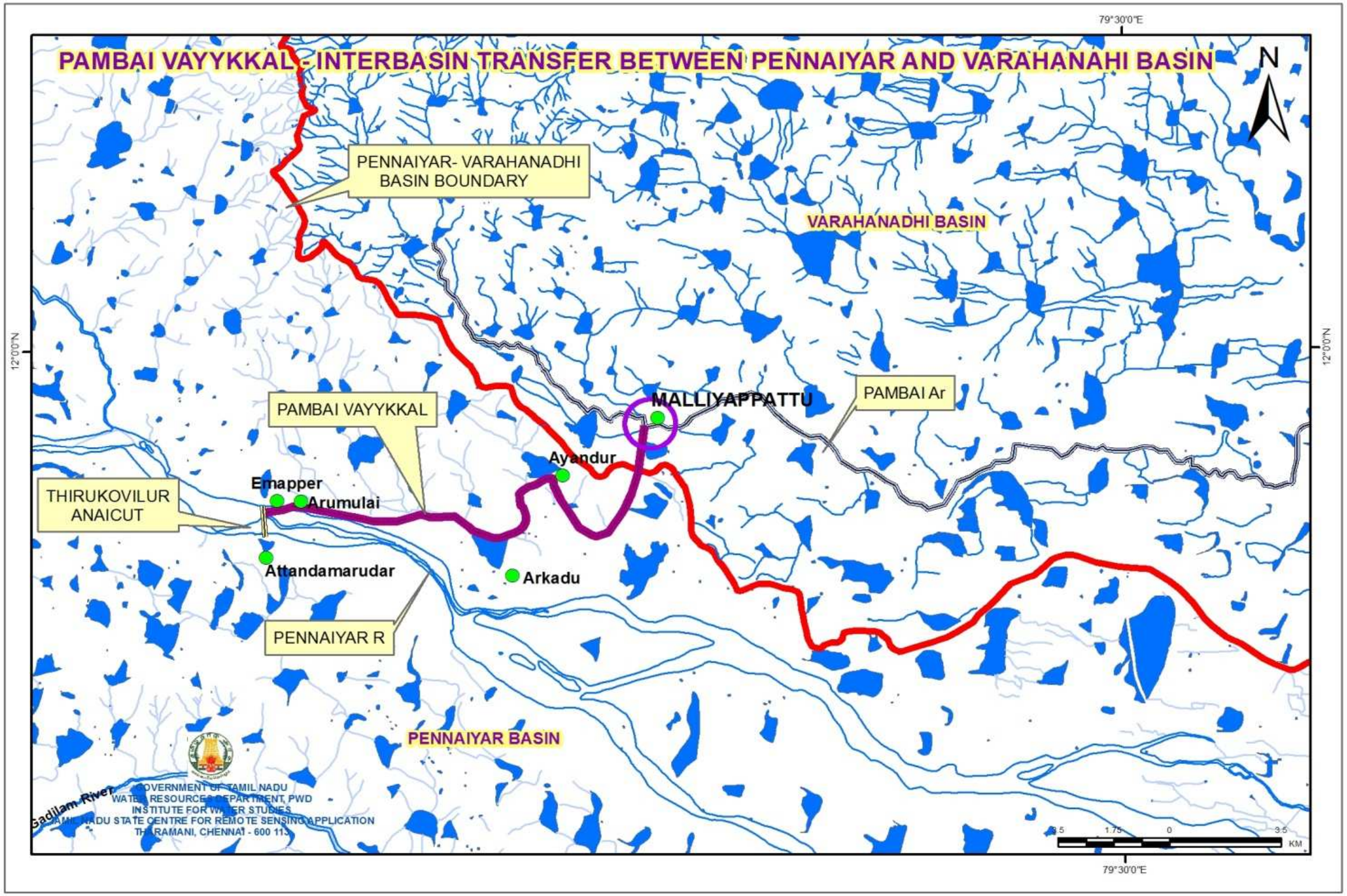
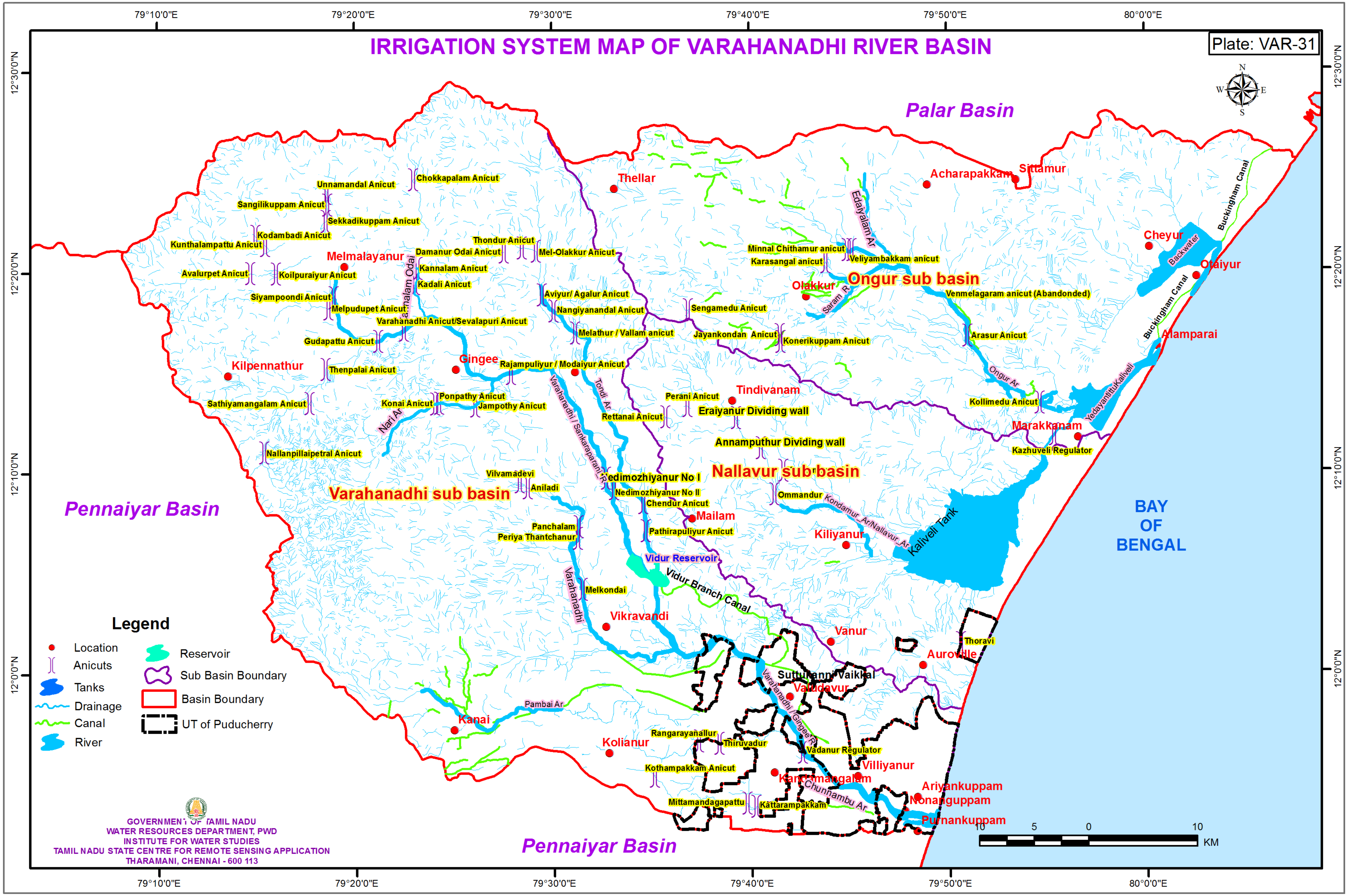


Fig 5.2 Varahanadhi River Basin
Flow Diagram of Ongur and Nallavur River



A MAP SHOWING INTERBASIN TRANSFER FROM PENNAIYAR RIVER TO VARAHANADHI RIVER





IRRIGATION SYSTEM MAP OF VARAHANADHI RIVER BASIN
Plate: VAR-31
Palar Basin
Pennaiyar Basin
BAY OF BENGAL
Varahanadhi sub basin
Nallavur sub basin
Ongur sub basin
Legend
Location
Aniccuts
Tanks
Drainage
Canal
River
Reservoir
Sub Basin Boundary
Basin Boundary
UT of Puducherry
Vidur Reservoir
Vidur Branch Canal
Kaliveli Tank
Buckingham Canal
Backwater
Melmalayanur
Gingee
Kilpennathur
Thellar
Tindivanam
Mailam
Kiliyanur
Vikravandi
Vanur
Auroville
Valudavur
Kanai
Kolianur
Villiyanur
Ariyankuppam
Nonanguppam
Purnankuppam
Olakkur
Acharapakkam
Sittamur
Cheyur
Otaiyur
Alamparai
Marakkanam
Unnamandal Anicut
Chokkapalam Anicut
Sangilikuppam Anicut
Sekkadikuppam Anicut
Kodambadi Anicut
Kunthalampattu Anicut
Avalurpet Anicut
Koilpuraiyur Anicut
Siyampoondi Anicut
Melpudupet Anicut
Gudapattu Anicut
Thenpalai Anicut
Sathiyamangalam Anicut
Nallanpillaipetral Anicut
Damanur Odai Anicut
Thondur Anicut
Mel-Olakkur Anicut
Kannalam Anicut
Kadali Anicut
Varahanadhi Anicut/Sevalapuri Anicut
Aviyur/ Agalur Anicut
Nangiyanandal Anicut
Melathur / Vallam anicut
Rajampuliyur / Modaiyur Anicut
Ponpathy Anicut
Konai Anicut
Jampothy Anicut
Rettanai Anicut
Perani Anicut
Eraiyanur Dividing wall
Annamputhur Dividing wall
Nedimozhiyanur No I
Nedimozhiyanur No II
Chendur Anicut
Pathirapuliyur Anicut
Ommandur
Vilvamadevi
Aniladi
Panchalam
Periya Thantchanur
Melkondai
Minnal Chithamur anicut
Karasangal anicut
Veliyambakkam anicut
Venmelagaram anicut (Abandonded)
Sengamedu Anicut
Jayankondan Anicut
Konerikuppam Anicut
Arasur Anicut
Kollimedu Anicut
Kazhuveli Regulator
Thoravi
Suttukanni Vaikkal
Rangarayanallur
Thiruvadur
Vadanur Regulator
Kothampakkam Anicut
Mittamandagapattu
Kattarampakkam
Edaiyalam Ar
Saram R
Ongur Ar
Yedayantittu Kaliveli
Tondi Ar
Nari Ar
Varahanadhi / Sankaraparani R
Varahanadhi
Varahanadhi / Gingee R
Chunnambu Ar
Pambai Ar
Kondamur_Ar/Nallavur_Ar
79°10'0"E
79°20'0"E
79°30'0"E
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79°50'0"E
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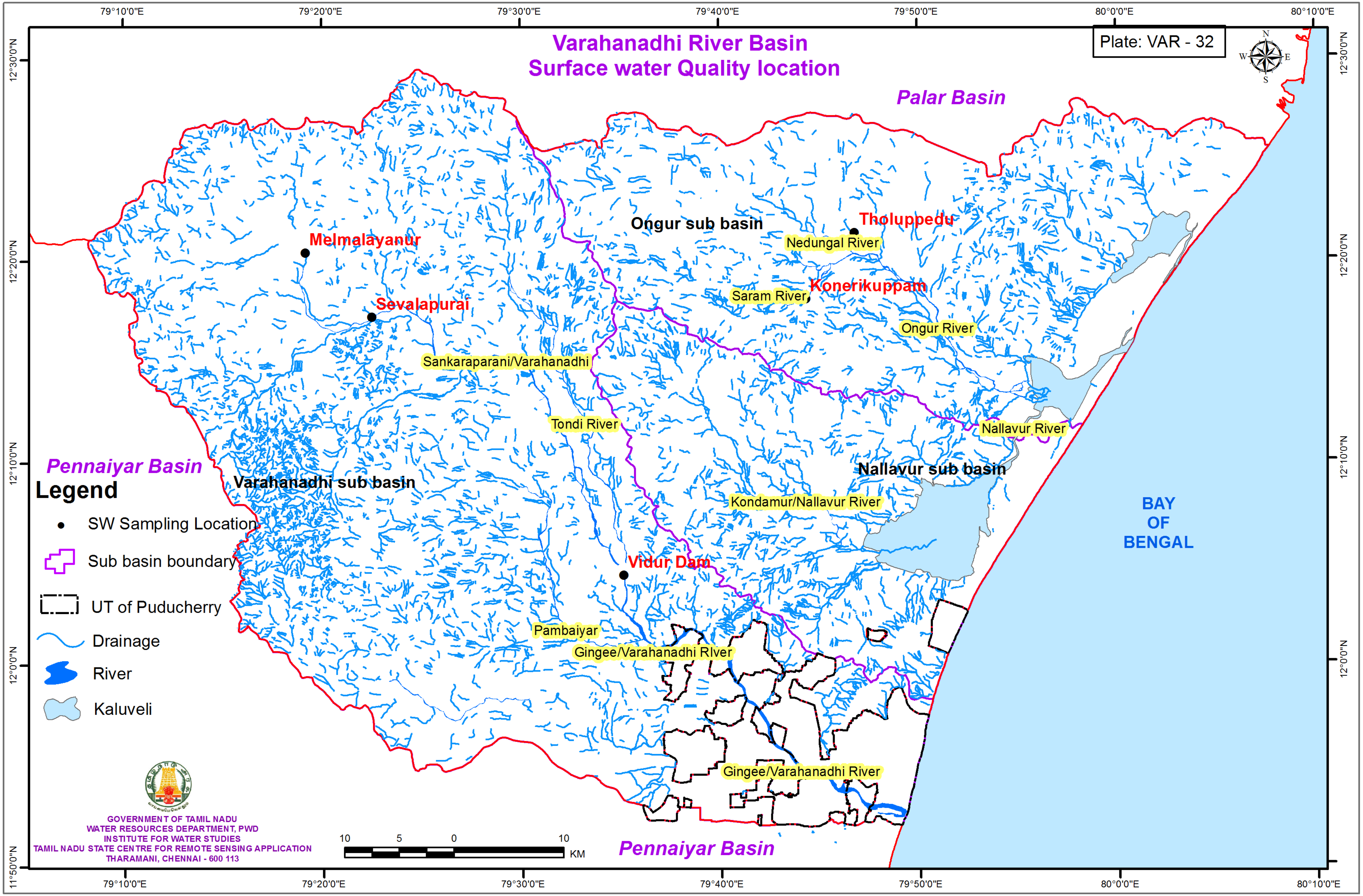
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI - 600 113


Varahanadhi River Basin
Surface water Quality location
Plate: VAR - 32
Palar Basin
Ongur sub basin
Tholuppedu
Nedungal River
Melmalayanur
Konerikuppam
Saram River
Sevalapurai
Ongur River
Sankaraparani/Varahanadhi
Tondi River
Nallavur River
Pennaiyar Basin
Varahanadhi sub basin
Nallavur sub basin
Kondamur/Nallavur River
BAY OF BENGAL
Vidur Dam
Pambaiyar
Gingee/Varahanadhi RIver
Gingee/Varahanadhi River
Pennaiyar Basin
Legend
SW Sampling Location
Sub basin boundary
UT of Puducherry
Drainage
River
Kaluveli
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI - 600 113
10 5 0 10
KM
79°10'0"E
79°20'0"E
79°30'0"E
79°40'0"E
79°50'0"E
80°0'0"E
80°10'0"E
12°30'0"N
12°20'0"N
12°10'0"N
12°0'0"N
11°50'0"N

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 depend on rainfall. Minor quantity of rainfall only percolates into ground depending on soil condition whereas major quantity of rainfall is stored in water bodies like reservoirs, tanks, lakes and ponds. Due to lack of statutory control over groundwater, extraction is rampant in Tamilnadu for various demands resulting fast depletion of groundwater. In order to improve the groundwater level effective methods are to be adopted.

Groundwater is a more reliable, easily available natural resource, serves as dependable water resource during drought and in achieving food security. As per the latest assessment, ie as on **31st March 2013,** the **Dynamic Ground Water Resources of India** is as stated below:

- **Total annual replenishable Groundwater Resources: 447 BCM**
- **Net annual Ground Water availability: 411 BCM.**
- **Annual Groundwater draft (extraction) for all uses: 253 BCM.**
- **The stage of Groundwater Development: 62 %.**

Groundwater has steadily emerged as the backbone of India's agriculture and drinking water security. Groundwater contributes nearly 62% in irrigation, 85% in rural water supply and 45% in urban water supply (MoWR, RD& GR).

The dynamic groundwater resource of Tamilnadu was assessed at macro size unit of Block level upto 2009 and from **2011 onwards** the assessment is being done at **micro size unit of Firka** level**.** As per the latest assessment, ie as on **31st March 2013,** the **Dynamic Ground Water Resources of Tamilnadu** is as stated below:

- **Total annual replenishable Groundwater Resources: 20.65 BCM**
- **Net annual Ground Water availability: 18.59 BCM.**
- **Annual Groundwater draft (extraction) for all uses: 14.36 BCM.**
- **The stage of Groundwater Development: 77 %.**

For long term planning, development and management, a systematic and scientific assessment of groundwater resources is quite indispensable. The following sections explain the groundwater availability and status prevailing in Varahanadhi River Basin.

6.2 Groundwater Estimation Methodology

Groundwater resources of India have been estimated based on the guidelines and recommendations of the Groundwater Estimation Committee 1997(GEC-97). Groundwater resources was assessed at macro size administrative unit of Block level upto 2009 and from 2011 onwards it is being assessed at micro size administrative unit of Firka level for more accuracy.

Groundwater recharge is estimated season-wise both for 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.

6.2.1 Total annual replenishable Groundwater Resources

The Total Annual Replenishable Ground Water Resources of the area is the sum of recharge during monsoon and non monsoon seasons.

6.2.2 Net annual Ground Water availability

The Net annual ground water availability is the available groundwater resource after deducting the natural discharges (10%) from the Annual Replenishable Groundwater Resource.

6.3 Aquifers

6.3.1 General

Groundwater is extracted from shallow aquifer and Geologists or Engineers are encountered with finding reliable and representative values of the hydraulic characteristics of aquifers. Pump test in dug wells or bore wells plays a prominent role in evaluating hydraulic properties of aquifers in different geological formations. The groundwater availability in aquifer is 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 which are evaluated through pump test. Based on the pump test results, yield and recharging rate of aquifers are being predicted.

6.3.2 Aquifer Parameters

Geologically, Varahanadhi basin is underlain with crystalline formation and sedimentary formation. Crystalline formation comprises of granite gneisses, charnockites & hybrid gneisses. Sedimentary formation comprises of cretaccous & tertiary sandstones and quaternary alluvial formation.

The aquifer parameters of the geological formations in Varahanadhi River Basin are given in the following tables.

Table: 6.1 Aquifer parameter in Hard Rock

S. No	Parameters	Range
1.	Specific capacity	1.20 to 118 lpm/m draw down
2.	Transmissivity (T) in m^2/day	0.45 to 338 m^2/day
3.	Storativity (S) value	2.6/1,00,000 to 3.6/1,00,000
4	Well Yield	60 to 180 lpm

Table: 6.2 Aquifer parameter Sedimentary area

S. No	Parameters	Range
1.	Specific capacity	159 to 11892 lpm/m draw down
2.	Transmissivity (T) in m^2/day	323 to 1937 m^2/day
3.	Storativity (S) value	1.13/1,00,000 to 2.975/1,00,000
4	Well Yield	61 to 11273 lpm

Note:

lpm/m = litre per minute per metre of draw down
m^2/day = metre square per day
lpm = litre per minute

6.3.3 Groundwater Occurrence

There are 206 wells are lying in Varahanadhi Basin. In this report an inventory of about 83 observation wells spread over the entire Varahanadhi Basin has been analyzed based on the availability of data, period ranging from four (4) years to forty four (44) years. All the observation wells analyzed are falling in Thiruvannamalai, Villupuram and Kanchepuram districts. The periodical water level fluctuations were examined sub-basin wise and geological formation wise, to understand the hydrogeological nature and groundwater occurrence. Location details, i.e, district, sub-basin, latitude, longitude, elevation, etc. of these observation wells are presented in **Appendix 6.1.** Details of Observation Wells in Varahanadhi River Basin are shown in **Plate: VAR-33**

6.3.4 Occurrence of Groundwater in 3 Sub-basins of Varahanadhi River Basin.

Table 6.3 Number of observation wells in different Geological Formations and Extent of hilly area

SI. No	Type of Geological formations	No of observation wells		
		Ongur Sub-basin	Nallaur Sub-Basin	Varahanadhi Sub-basin
1	Charnokite (CNK)	16	7	6
2	Granite (GRT)	-	1	2
3	Granite Gneiss (GGN)	1	2	31
4	Sandstone (SST)	-	3	0
5	Sandstone (Tertiary) (TSS)	1	2	0
6	Sedimentary Sandstone (SDM)	-	1	1
7	Gneiss (GNS)	-	-	1
8	Alluvium (ALV)	2	-	6
11	Hilly Area in Sq.Km	4.36	0.72	41.78
12	Percentage of Hilly Area	0.34	0.09	1.69

Table 6.4 Groundwater occurrence in the three sub basins are given below:

Sl. No	Sub-basin	No of Wells	Pre-monsoon		Post-monsoon	
			Minimum Water level	Maximum Water Level	Minimum Water level	Maximum Water Level
1	Ongur	20	**0.55m** (Well No: 3301 in Mar 2012)	**45.50m** (Well No: HP31566 in May 2012)	**0.29m** (Well No: 23012 in Jan 2012)	**38.95m** (Well no: HP31529 in Feb 2014)
2	Nallaur	16	**0.13m** (Well No:33026 in Mar 2012)	**88.50m** (Well No: HP31571 in May 2015)	**0.03m** (Well No: 33026 in Jan 2002)	**73.72m** (Well No: HP31571 in Feb 2007)
3	Varahanadhi	47	**0.35m** (Well No: 33004 in Mar 2012)	**30.50m** (Well No: HP31556 in Mar 2004)	**0.10m** (Well No: MWS31600 in Jan 2011)	**30.05m** (Well No: HP31556 in Feb 2004)

6.4 Groundwater Flow Regime and Water Level Fluctuations

Monitoring of groundwater flow regime is an effort to obtain information on water levels. The groundwater regime responds to 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 systems are dynamic and adjust continually to short-term and long-term changes in 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 over one or more decades in order to compile a hydrology record that represents the availability range of natural water-level fluctuations and tracks the trend over time. But four years period is relatively short period for water level data analysis, but it is at least sufficient to provide a record of ground water level fluctuation for few seasons

Contour maps showing the depths of groundwater table for pre monsoon and post monsoon for July 1985, January 1986, July 1995, January 1996, July 2005, January 2006, July 2015 and January 2016 have been prepared and are shown in **Plate: VAR-34 to VAR-41** respectively. Groundwater levels of the 83 observation wells are displayed in the form of hydrographs in **Appendix 6.8** for analysis of the long-term trends.

6.4.1 Water Level Fluctuations

Hydrographs (depending on availability of well data from 1972 to 2016) of groundwater level for the 83 observation wells have been prepared. Though 10 observation wells are having data for only 4 years period, they were also considered to understand the recent trend in groundwater level. The observation wells those are considered for the analysis are based on well location; period of data availability and their present condition are presented in **Appendix 6.1.**

The linear trend lines shown in the Hydrograph of observation 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). If long term water level depletion or rise is in the range of 2-3 metre, it is classified as moderate depletion or rise. But, if long term water level depletion or rise as ascertained from the trend line, is greater than 3 metre, it is classified as high depletion or rise.

Eighty three observation wells were analysed and based on that the long term linear trend lines show rise in the 12 observation wells and 8 wells show depletion in water level.

i) Long-term Rise in Water Level:

- High rise in water level (more than 3.00m) in the following twelve Observation Wells

Table 6.5 High rise Observation Wells

Sl.No	Well No	Sub-Basin	District
1	OW122005794447	Ongur	Kanchipuram
2	OW122158800040		
3	HP31569	Nallavur	Villupuram
4	HP31573		
5	33004	Varahanadhi	Villupuram
6	33005		
7	33016		
8	33018		
9	33042		
10	HP31526		
11	HP31556		
12	HP31568		

ii) Long-term Depletion in Water Level

- High depletion in water level (more than 3.00m) in the following eight Observation Wells

Table 6.6 High Depletion Observation Wells

Sl.No	Well No	Sub-Basin	District
1	23063	Ongur	Tiruvannamalai
2	HP31566		Villupuram
3	MCR02010	Varahanadhi	Tiruvannamalai
4	MWS31602		Villupuram
5	MWS31610		
6	OW11104		
7	OW11105		
8	U33005A		

iii) Annual Groundwater Level Fluctuations

Annual groundwater level fluctuations are significant in the sense that it indicates the level/degree of groundwater recharge. Annual water level fluctuation varies from 1.30m to 32.17m in Ongur sub-basin, 0.50m to 119.80m in Nallaur sub-basin and 0.80m to 19.20m in Varahanadhi sub-basin.

iv) Monsoon Groundwater Level Variation

- In Ongur sub-basin, pre-monsoon groundwater level varies from 0.55m to 45.50m and post monsoon groundwater level varies from 0.29m to 38.95m
- In Nallavur sub-basin, pre-monsoon groundwater level varies from 0.13m to 88.50m and post monsoon groundwater level varies from 0.03m to 73.72m
- In Varahanadhi sub-basin, pre-monsoon groundwater level varies from 0.35m to 30.50m and post monsoon groundwater level varies from 0.10m to 30.05m.

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. The water table contour map indicates that groundwater flows generally from west to east of the Varahanadhi basin.

Comparison of pre-monsoon and post-monsoon contour maps (depth to water table) for four different years (one year for a decade: Jul-85 & Jan-86, Jul-95 & Jan-96 and Jul-2005 & Jan-2006, Jul-2015& Jan-2016) have been prepared. The details of contour data are tabulated in **Appendix 6.2 of Vol-II**.

6.4.3 Groundwater Level Scenario

i) Pre-Monsoon

During July 1985 July 1995, July 2005 and July 2015: Groundwater level is deeper (63.20m to 164.90m) in upper region, moderate depth (33.90m to 92.20m) in middle region and shallow (0.10m to 38.40m) in tail end region.

ii) Post-Monsoon:

During January 1986, January 1996January, January 2006 and January 2016: : Groundwater level is deeper (76.10m to 1172.65m) in upper region, moderate depth (50.90m to 93.80m) in middle region and shallow (0.03m to 64.40m) in tail end region.

6.5 Categorization of Firkas

As per latest Groundwater assessment done during 2013, all the 1,139 revenue Firkas in Tamil Nadu were categorized into Safe, Semi Critical, Critical and Over-Exploited categories depending upon the stage of groundwater development. The criteria for categorization of assessment of Firkas are as follows:

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 is the rising demand for groundwater for agriculture. Cropping pattern and cropping intensity will alter the stress on groundwater. This problem is compounded by the free electricity/power to farmers since power is a main component in the cost of groundwater extraction. Thus power subsidy undoubtedly encouraging farmers to use groundwater (Planning Commission 2007).

Varahanadhi basin encompasses 76 Firkas either fully or partially and all firkas are falling in Tiruvannamalai, Villupuram and Kanchepuram districts. A map **(Plate: VAR-42)** showing the categorization of firkas falling in Paravanar Basin is also prepared.

The list of categorization of 76 firkas in Varahanadhi Basin based on the level of Ground Water Development assessment as on March 2013 is given in **Table 6.7**.

Table 6.7 Categorization of Firkas

Sl. No.	Firka	Sub-Basin	District	Categorisation of Firkas
1	Cheyyur	Ongur	Kancheepuram	Semi CritIcal
2	Chithamur			Semi CritIcal
3	Kadapakkam			Safe
4	Kayapakkam			Safe
5	Kodur			Safe

Sl. No.	Firka	Sub-Basin	District	Categorisation of Firkas
6	Lathur			Safe
7	Sunampedu			Safe
8	Acchirupakkam			Semi CritIcal
9	Jameenendathur			Semi CritIcal
10	Onampakkam			Semi CritIcal
11	Orathi			Critical
12	Perumpakkam			Semi CritIcal
13	Chennavaram		Tiruvannamalai	Critical
14	Desur			Critical
15	Malaiyur			Over exploited
16	Osur			Over exploited
17	Thellar			Semi CritIcal
18	Vandavasi			Over exploited
19	Melolakkur		Viluppuram	Over exploited
20	Brammadesam		Viluppuram	Over exploited
21	Deevanur			Safe
22	Marakkanam			Over exploited
23	Olakkur			Over exploited
24	Siruvadi			Over exploited
25	Tindivanam			Over exploited
26	Vadasiruvalur			Over exploited
27	Brammadesam	Nallaur	Viluppuram	Over exploited
28	Deevanur	Nallaur	Viluppuram	Safe
29	Mailam			Semi CritIcal
30	Marakkanam			Over exploited
31	Olakkur			Over exploited
32	Rettanai			Safe
33	Siruvadi			Over exploited
34	Tindivanam			Over exploited
35	Vadasiruvalur			Over exploited
36	Kiliyanur			Over exploited

Sl. No.	Firka	Sub-Basin	District	Categorisation of Firkas
37	Nemili			Over exploited
38	Uppuvelur			Over exploited
39	Vanur			Critical
40	Retty chavadi	Varahanadhi	Cuddalore	Over exploited
41	Kalasapakkam		Tiruvannamalai	Semi CritIcal
42	Modayur			Semi CritIcal
43	Thachambadi			Critical
44	Kilpennathur			Over Exploited
45	Mangalam			Semi CritIcal
46	Nayadumangalam			Critical
47	Somaspadi			Over Exploited
48	Thurinjapuram			Over Exploited
49	Vettavlam			Semi CritIcal
50	Desur			Critical
51	Malaiyur			Over Exploited
52	Nedungunam		Tiruvannamalai	Critical
53	Thellar			Semi CritIcal
54	Kanjanur		Villupuram	Critical
55	Sithalampattu			Over Exploited
56	Vikkiravandi			Over Exploited
57	Arakandanallur			Semi CritIcal
58	Avalurpettai	Varahanadhi	Villupuram	Over Exploited
59	Gingee			Over Exploited
60	Melmalaiyanur			Over Exploited
61	Melolakkur			Over Exploited
62	Sathampati			Over Exploited
63	Sathiyamangalam			Over Exploited
64	Vallam			Over Exploited
65	Deevanur			Safe
66	Mailam			Semi Critical
67	Rettanai			Safe

Sl. No.	Firka	Sub-Basin	District	Categorisation of Firkas
68	Vadasiruvalur			Over Exploited
69	Anniyur			Over Exploited
70	Mugaiyur			Semi Critical
71	Nemili			Over Exploited
72	Vanur			Critical
73	Kanai			Semi Critical
74	Kandamangalam			Semi Critical
75	Valavanur			Safe
76	Villupuram			Critical

Summary of Categorization of Firkas

Sl.No	Category	2013 Assessment
1	Safe	11
2	Semi Critical	18
3	Critical	11
4	Over Exploited	36

6.6 Groundwater Availability

6.6.1 Groundwater Availability in the Study Area

The sub-basin wise groundwater availability and draft (extraction) are calculated from the Firkas' availability and draft (extraction) on proportionate basis i.e based on the percentage of firka area falling in the sub-basin. The balance of groundwater availability in each firka for further development is arrived by deducting the gross groundwater extraction from the net groundwater availability. If the balance groundwater availability is found to be negative, that negative value is ignored and the balance is taken as zero for that sub-basin. The sub-basin's groundwater availability, draft (extraction) and the balance is calculated by adding the proportionate quantity of all the firkas falling in 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 **6.8.**

Table 6.8 Groundwater Availability, Extraction and balance Availability

(Based on March 2013 Assessment)

Sl. No.	Sub-Basin	Net Annual Groundwater Availability in sub basin (MCM)	Gross Annual Groundwater Extraction in sub basin (MCM)	Balance Annual Groundwater Availability in sub basin (MCM)	Stage of Development (%)
1	Ongur	289.22	228.11	70.43	78.87
2	Nallaur	130.73	156.56	7.75	109.73
3	Varahanadhi	569.38	624.78	38.73	109.73
	TOTAL	**989.33**	**1009.45**	**116.91**	**102.03**

The firka-wise groundwater availability, extraction and balance available for future development are presented in Appendix 6.5, 6.6 and 6.7. The three sub-basins' contribution in groundwater availability and extraction is represented in the doughnut graph in Fig.6.1. The inner doughnut represents the **Area of each sub basin**, the middle doughnut represents the **Net Availability of groundwater** of each sub basin and the outer doughnut represents the **Gross Extraction of groundwater** of each sub basin.

Fig: 6.1 Contribution of Each Sub Basin in Groundwater Availability and Extraction

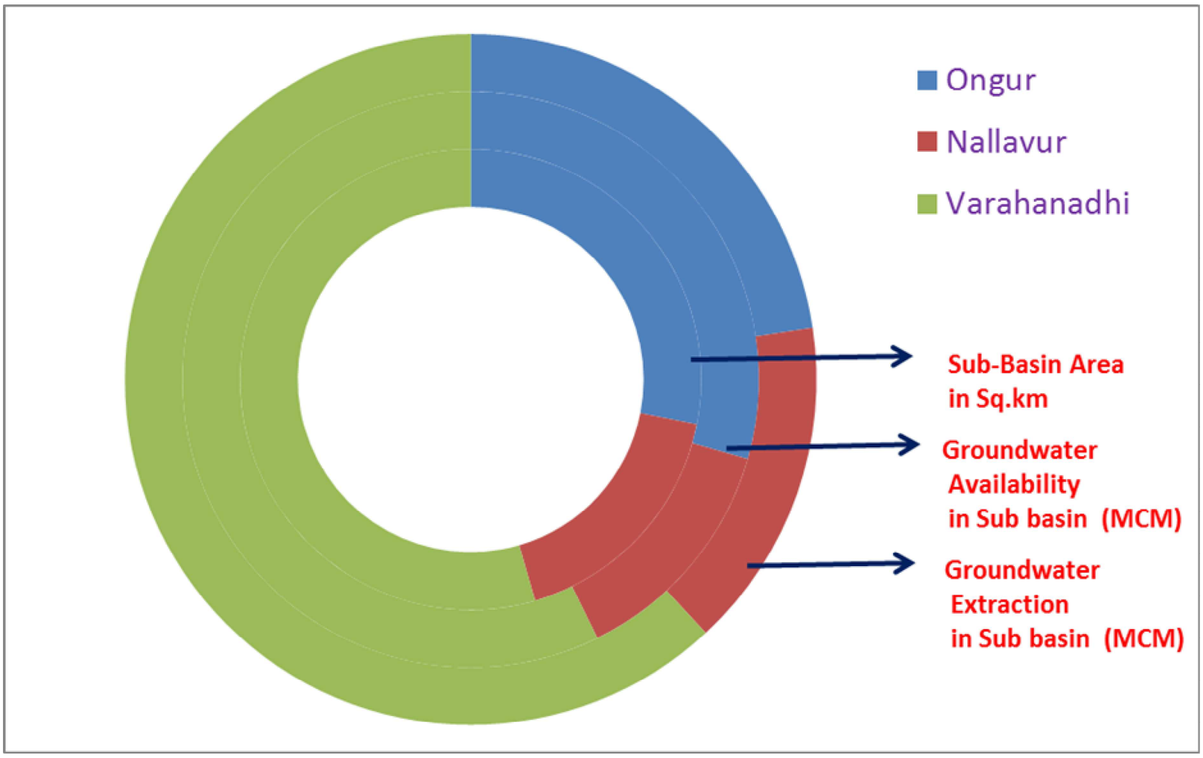
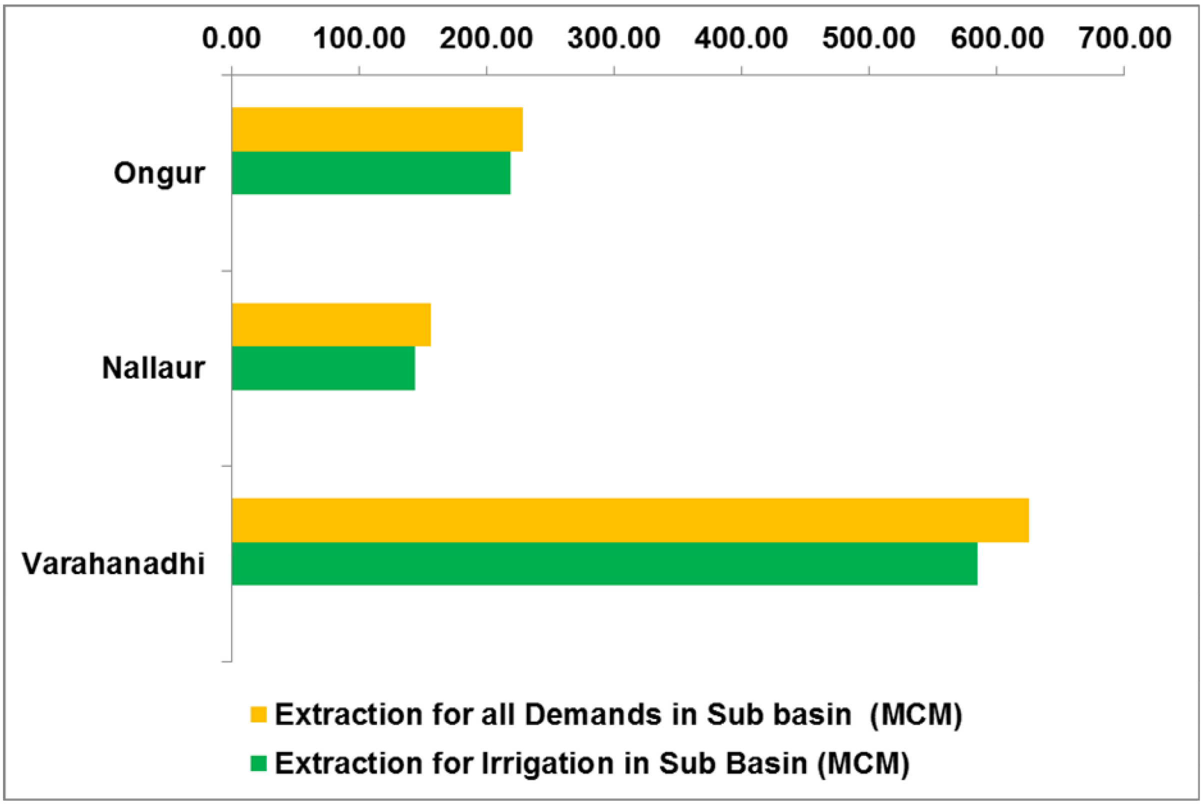


Table 6.9 shows the comparison of groundwater extraction for all demands and extraction for irrigation demand based on 2013 assessment.

Table: 6.9 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	Ongur	218.62	228.11	95.84
2	Nallaur	143.89	156.56	91.91
3	Varahanadhi	585.04	624.78	93.64
	TOTAL	**947.55**	**1009.45**	**93.87**

Fig: 6.2 Groundwater extraction for all demands and extraction for irrigation demand



6.6.2 Comparison of Groundwater Resources

Groundwater resources calculated in Varahanadhi Appraisal study repot prepared in 2005 based on assessment done during 2003 at Block level unit with latest assessment done in March 2013 at Firka level unit adopted in this report.

Table: 6.10 Comparison of groundwater resources: 2003 and 2013

Sl. No	Sub-Basin	Net Annual Groundwater Availability (MCM)		Gross Annual Groundwater Extraction (MCM)		Balance Annual Groundwater Availability (MCM		Stage of Development (%)	
		2003	2013	2003	2013	2003	2013	2003	2013
1	Ongur	292.56	289.22	293.93	228.11	28.59	70.43	100.47	78.87
2	Nallaur	181.17	130.73	193.17	156.56	3.71	7.75	106.62	119.76
3	Varahanadhi	781.99	569.38	858.77	624.78	54.09	38.73	109.82	109.73
	TOTAL	**1255.72**	**989.33**	**1345.87**	**1009.45**	**86.39**	**116.91**	**107.18**	**102.03**
	Change	**Decreased: 21.21%**		**Decreased: 25.00%**		**Increased: 35.33%**			

6.7 Groundwater Quality

6.7.1 Introduction

Generally Water Quality is the physical, chemical and biological characteristics of water. It may vary from one place to another depending upon the source of origin. The primary parameter which decides the quality of water is the presence of dissolved solids. When the solid contents are minimum, the quality is good and when it is more, the quality becomes poor.

Water is used for all types of domestic and industrial purposes. Urbanization and industrialization consumes large amount of surface and groundwater. Parallely these activities spoil the good quality of water to some extent. Hence the attention on water quality is a necessary and indispensable one in the present scenario.

For the present study in Varahanadhi river basin, water quality data from 86 wells are taken to assess the Groundwater quality.

The State Ground and Surface Water Resources Data Center, PWD, Tharamani, Chennai- 113 is monitoring Groundwater quality by collecting ground water samples from the observation wells located in all the river basins in Tamilnadu twice a year, i.e during the pre monsoon period (July) and the post monsoon period (January) since 1972 onwards. Major cations and anions are analyzed for the water samples collected from observation wells twice in a year. These samples are analyzed in the Geochemical Laboratory (Level 11+) located at Tharamani, Chennai – 113. For this basin, water quality data of Kancheepuram, Thiruvannamalai and Villupuram district were collected and the water quality assessment has been made for the pre-monsoon period of the year 2015. Water quality data of 84 wells were taken to assess the water quality of Varahanadhi river basin (**Refer Table 6.14 for Water quality results**). Total Dissolved Solids, Chloride, Total Hardness, Alkalinity, Sulphate and Nitrate are considered as the deciding parameters for discussion.

6.7.2 Objectives:

The main objectives of the ground water quality assessment are as follows:

1. To analyze the presence of various physico – chemical parameters of groundwater in the basin and to find its suitability for drinking, agriculture, irrigation and industrial purposes.
2. To understand the Ground water quality of the basin as an aid for optimal management of ground water resources.
3. To determine long-term trends in ground water quality and to relate observed human activities as a basis for decision-making.
4. To identify and monitor the locations of major pollutant sources.
5. To determine the quality in the vicinity of public supply sources, threatened by point source pollution or saline intrusion, to protect the integrity of the water supply and maintain its use.

Need for Water Quality Analysis

Water quality analysis is to quantify the presence of different types of parameters to find out the suitability of water for a particular purpose / usage adopting standard methods. Water quality analysis is required mainly to monitor the quality changed over a period of time. This quality monitoring is necessary to find out the suitability of water. Some importance of such assessment includes:

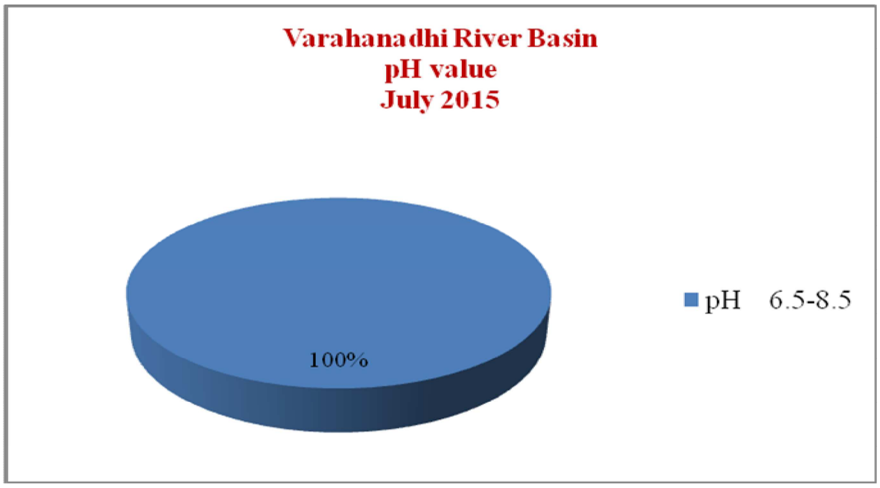
1. To check whether the water quality is in compliance with the standards and hence suitable or not for the designated use.
2. To monitor the efficiency of a system, working for water quality maintenance.
3. To check whether up gradation / change of an existing system is required and to decide what changes should take place.

6.7.3. Groundwater quality scenario of Varahanadhi River Basin

pH

pH value determines whether the water is acidic, neutral or alkaline in nature. pH is measured on a logarithmic scale between 1 and 14, with 1 being extremely acidic, 7 neutral and 14 extremely basic. The permissible value of pH in water is 6.5 – 8.5.

In this basin, the pH value varies in the range of 7.4 – 8.3 and the value of all the samples in Varahanadhi, Nallavur and Ongur sub basins lie within the desirable range



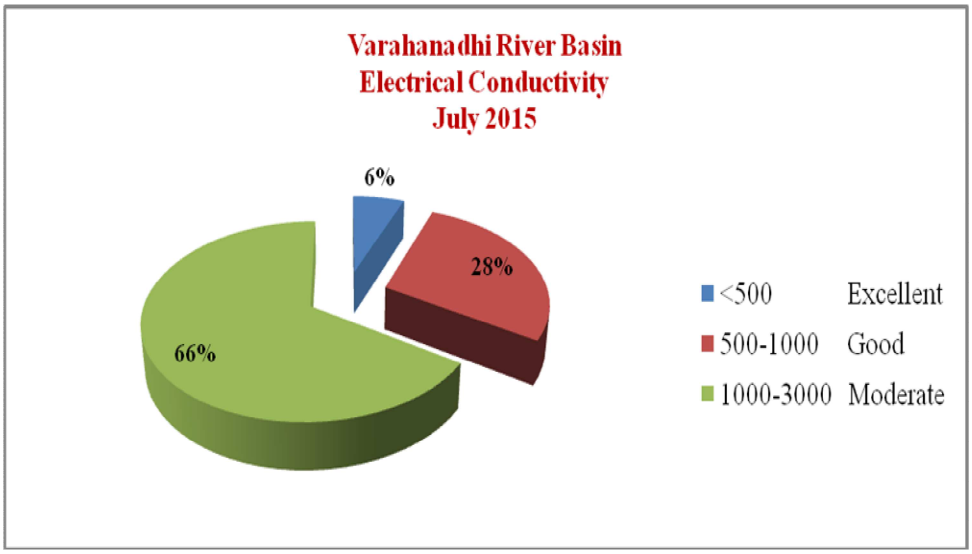
Electrical Conductivity

The concentration of total dissolved solids (TDS) is related to electrical conductivity (EC, umhos/cm) or specific conductance. The conductivity measures the capacity of water to transmit electrical current. The **Conductivity increases as the concentration of TDS increases**.

Table: 6.11 Classification of groundwater based on Electrical Conductivity

Electrical Conductivity uS/cm	**No. of samples**	**Percentage (%)**	**Description**
<500	5	6	Excellent
500 – 1000	24	28	Good
1000 – 3000	57	66	Moderate
>3000	Nil	-	Unsuitable

Regarding Varahanadhi basin, the number of samples with EC value less than 500 is 5 and the number of samples with EC values 500- 1000 is 24 and the number of samples with EC values 1000 – 3000 is 57. The EC value ranges from 250 to 2920 umhos/cm.



Total Hardness (TH)

Hardness of water is determined by the concentration of multivalent cations in the water. Multivalent cations are positively charged metal complexes with a charge greater than 1+. Usually the cations have the charge of 2+. Common cations found in hard water include Ca^{2+} and Mg^{2+}. These ions enter a water supply by leaching from minerals within an aquifer. Common calcium containing minerals are calcite and gypsum. A common magnesium mineral is dolomite (which also contains calcium).

The following equilibrium reaction describes the dissolving and formation of calcium carbonate.

$CaCO_3$ (s) + CO_2 (aq) + H_2O (l) $\leftrightharpoons$ Ca^{2+} (aq) + $2HCO_3^-$ (aq)

Table: 6.12 Classification of groundwater based on Hardness range

Total Hardness	No. of samples	Percentage (%)	Description
<300	41	48	Good
300 – 600	34	39	Moderate
>600	11	13	Poor

TH in Varahanadhi Sub Basin

Total Hardness value within desirable limit of 300 mg/L is observed in parts of Kalasapakkam, Turinjapuram, Kilpennathur, Thellar, Vikravandi and Kiliyanur blocks of Varahanadhi sub basin. Moderate quality is found in most of the blocks of the sub basin. Poor quality is observed in parts of Kanai and Gingee blocks of the sub basin.

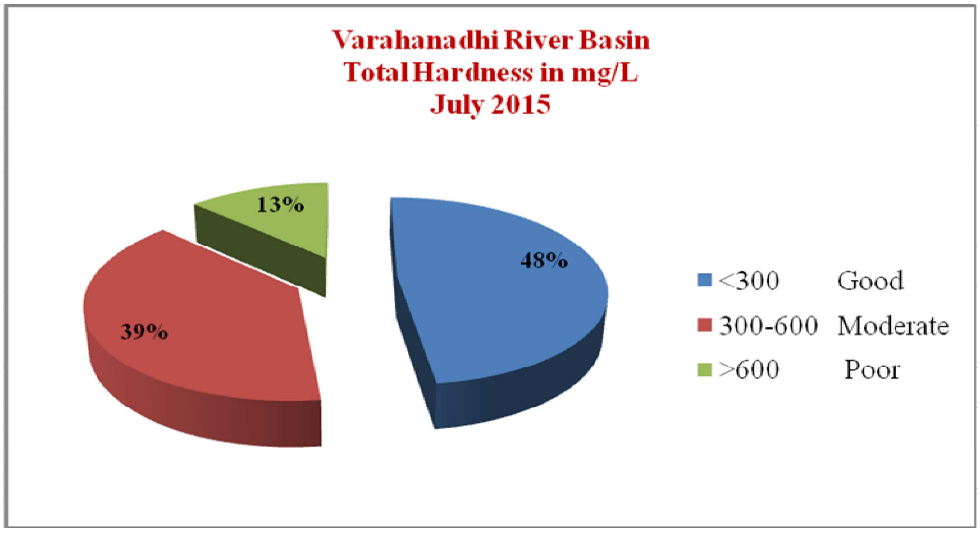
TH in Nallavur Sub Basin

Moderate quality of water is observed in almost all the blocks of the Nallavur subbasin with respect to TH.

TH in Ongur Sub Basin

North Eastern blocks like Maduranthagam, Lattur, Chittamur and Marakkanam are characterized by desirable limit of TH while the other blocks are characterized by moderate quality of water.

In Varahanadhi river basin the value of TH varies from 80 mg/L to 1020 mg/L. **The spatial distributions of the quality of samples are shown in map, Plate No.VAR-46.**



Total Dissoved Solids (TDS)

This is an indicator of the concentration of dissolved electrolyte ions in the water.Significant increase in conductivity is an indicator that polluting discharges have entered the water. Elevated dissolved solids can cause different types of mineral taste such as bitter, sour, salty etc., in drinking water.

Table: 6.13 Classification of groundwater based on TDS

TDS mg/L	No. of samples	Percentage (%)	Description
<500	26	30	Good
500 – 2000	60	70	Moderate
>2000	Nil	-	Poor

TDS in Varahanadhi Sub Basin

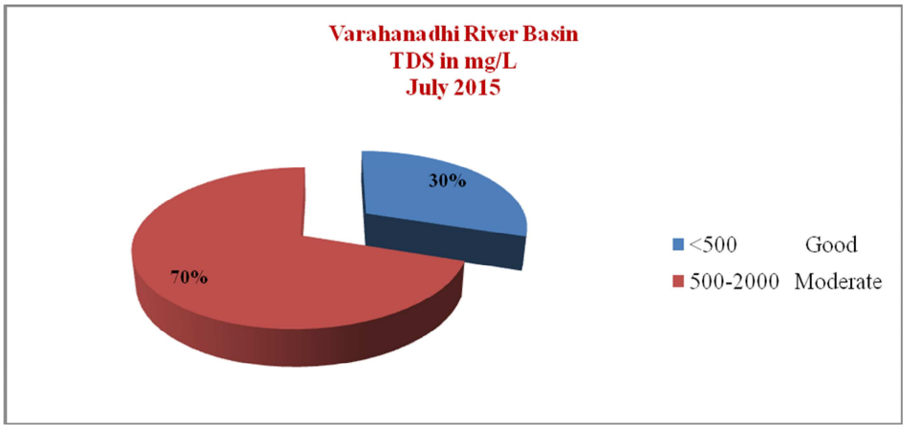
Good quality of Water within desirable limit of TDS is scattered in Kilpennathur, Mugaiyur and Vikravandi blocks of the sub basin. Moderate quality is prominent in Vrahanadhi sub basin.

TDS in Nallavur Sub Basin

Moderate quality of water with TDS less than 2000 mg/L is observed in most of the blocks of the basin.

TDS in Ongur Sub Basin

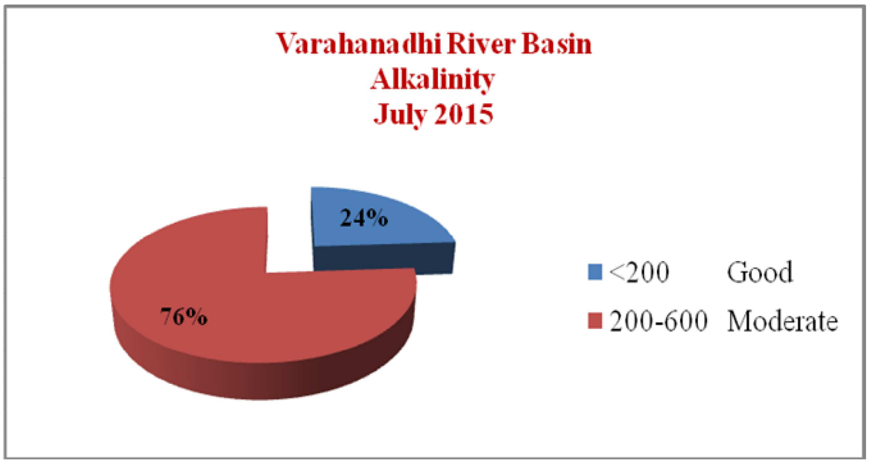
North Eastern parts of the sub basin are characterized by good quality of water within desirable limit of BIS. Moderate quality is observed in most of the blocks of the sub basin. The value of TDS ranges from 202 mg/L to 1988 mg/L in the basin. **The spatial distribution of quality of water samples with respect to TDS is shown in map Plate No.VAR-45.**



Alkalinity

Alkalinity is defined as the capacity of natural water to neutralize acid added to it. In other words, its ability to maintain a relatively constant pH. The possibility to maintain constant pH is due to the hydroxyl, carbonate and bicarbonate ions present in water.

The value of bicarbonate is moderate in most of the wells while it is good in some of the wells in the basin.



Chloride

Chloride is the most common anion in groundwater. It generally combines with calcium, magnesium or sodium to form various salts. Small amounts of chloride are required for normal cell functions in plant and animal life.

Chloride in Varahanadhi Sub Basin

Chloride values within desirable limit is observed in parts of Chetpet, Kalasapakkam, Thurinjapuram, Kilpennathur, Mugaiyur, Pernamallur, Thellar, Vikravandi, Koliyanur and Vanur blocks while the other blocks in the sub basin are characterized by moderate quality.

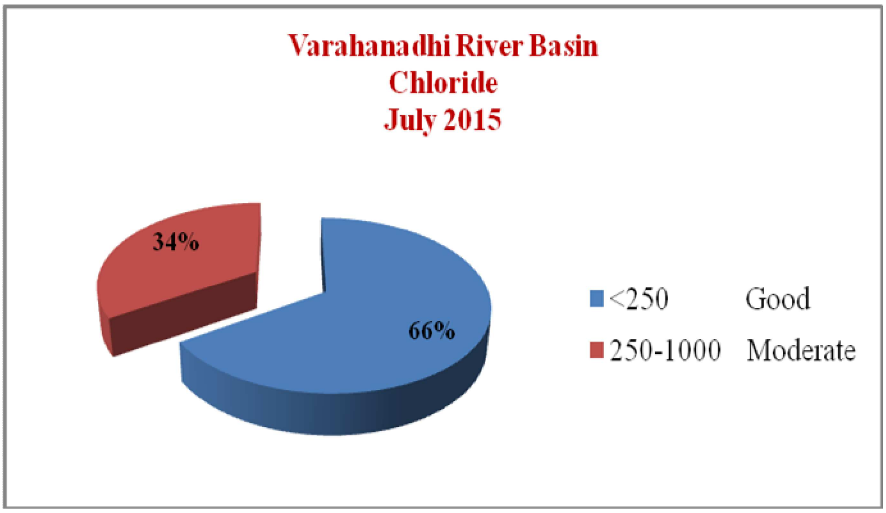
Chloride in Nallavur Sub Basin

Chloride values range from good to moderate quality in the sub basin

Chloride in Ongur Sub Basin

Chloride values within desirable limit are observed in most of the blocks of the sub basin while a few blocks are characterized by moderate quality of water with respect to chloride.

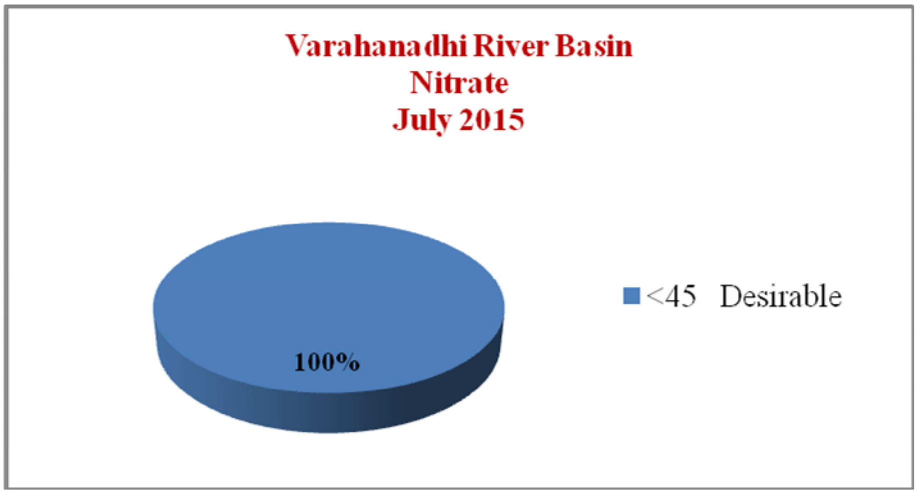
In varahanadhi basin, the value of chloride ranges from 25 mg/L to 886 mg/L. **The spatial distribution of quality with respect to chloride is shown in map Plate No.VAR-47.**



Nitrate

Nitrogen is a major constituent of the earth's atmosphere and occurs in many different forms such as elemental nitrogen, nitrate and ammonia. While nitrate is a common nitrogenous compound due to natural process of the nitrogen cycle, anthropogenic sources have greatly increased the nitrate concentration particularly in groundwater. Incidence of methemoglobinemia appears to be the result of high nitrate levels.

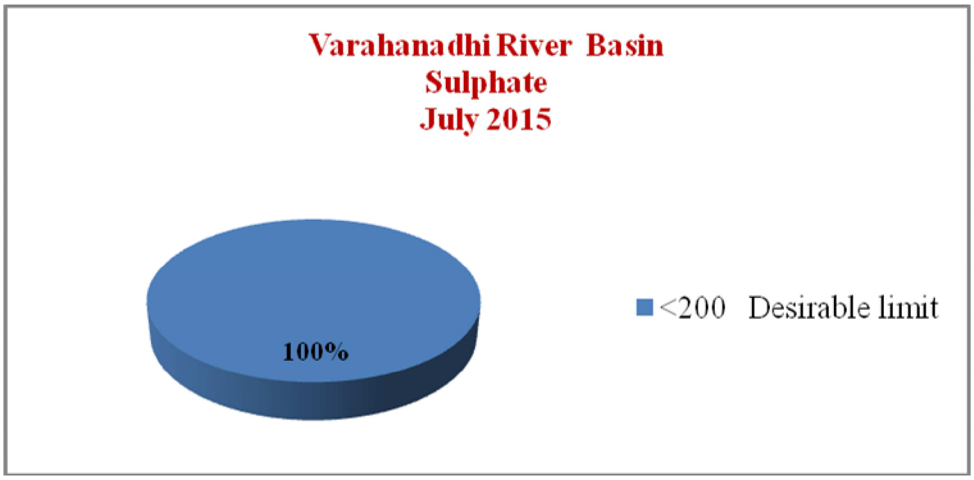
All the wells in the basin have nitrate values within the desirable limit of 45 mg/L.



Sulphate

It is one of the major anion next to bicarbonate. Sulphates occur naturally in numerous minerals including barite ($BaSO_4$), epsomite ($MgSO_4.7H_2O$) and gypsum ($CaSO_4.2H_2O$). These dissolved minerals contribute to the mineral content of the water.

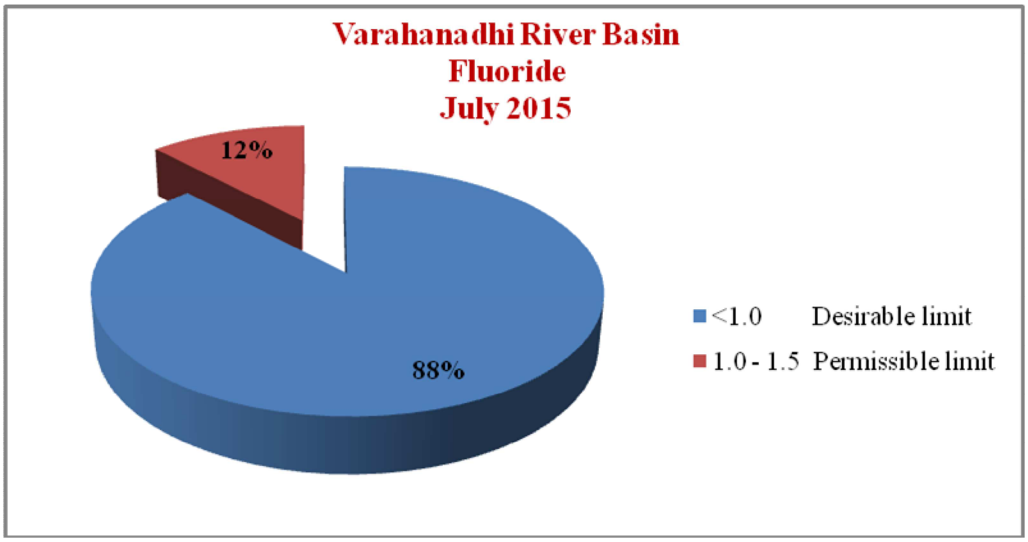
The value of sulphate is within the desirable limit (<200mg/L) in all the wells in the basin. The value of sulphate ranges from 11 mg/L to 102 mg/L.



Fluoride

Fluorides are compounds containing the element fluorine. Most common fluorides are sodium and calcium fluoride. Excess fluoride in drinking water can cause dental fluorosis and skeletal fluorosis. The desirable limit of fluoride in drinking water is 1 mg/L and the permissible limit of fluoride is 1.5 mg/L.

This basin is safe as all the values lie within the permissible limit of BIS standards.

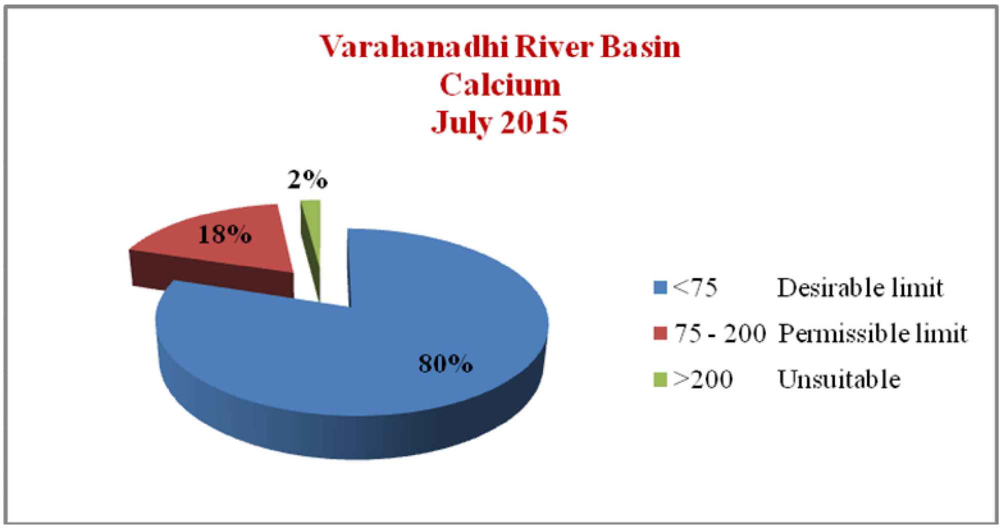


Calcium

Calcium is naturally present in water. It may dissolve from rocks such as limestone, marble, calcite, dolomite and gypsum. Calcium is a determinant of water hardness, because it is found in wter as Ca^{2+} ions.

The desirable value of calcium in drinking water is 75 mg/L and the permissible value (in the absence of alternate source) is 200 mg/L.

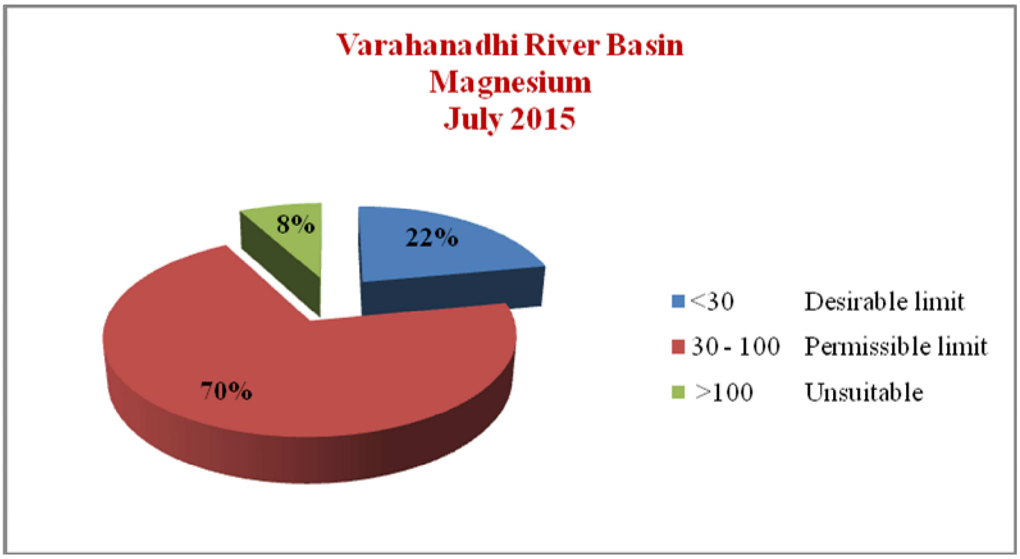
Almost all the wells in the basin falls in permissible range while the value of two wells is greater than 200 mg/L.



Magnesium

Magnesium ions together with calcium contribute to water hardness. The desirable value of magnesium is 30 mg/L and the permissible value (in the absence of alternate source) is 100 mg/L in water.

The value of magnesium is within the permissible limit in most of the wells while the value exceeds the permissible limit in a few wells in the basin.



6.7.4 Water Quality and Irrigation

Electrical Conductivity (EC), Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC) are the deciding parameters for irrigation water quality.

TABLE: 6.14 Water Quality Parameters for Irrigation

Sl. No	Well No.	Village	Block	EC µmho s/cm	SAR meq/L	RSC meq/ L	Water class
1	33002	Chinnanolambai	Melmalayanur	2110	4.5	0.0	Moderate
2	33007	Melolakkur	Vallam	1130	2.3	0.0	Moderate
3	33015	Nattarmangalam	Gingee	1700	5.3	0.0	Moderate
4	33018	Melpappampadi	Gingee	2180	4.6	0.0	Moderate
5	MWS31610	Kappalambadi	Melmalayanur	870	1.8	0.0	Moderate
6	HP31527	Thiruvathikunnam	Gingee	1630	3.2	0.0	Moderate
7	MWS31606	Periyamur	Gingee	2170	3.6	0.0	Moderate
8	MWS31611	Sevalapurai	Melmalayanur	2770	11.3	1.4	Bad
9	33005	Melmalayanur	Melmalayanur	2450	5.3	0.0	Bad
10	33006	Annamangalam	Gingee	2510	9.4	1.9	Bad
11	MWS31627	Mel Karanai	Gingee	1110	2.9	0.0	Moderate
12	33040	Karanai	Gingee	620	2.5	0.0	Good
13	OW11106	Kappiyampuliyur	Vikravandi	250	0.5	0.0	Good
14	OW11107	Pagandi	Annagramam	1040	3.6	0.0	Moderate
15	HP31517	Mambalapattu	Kanai	2920	2.6	0.0	Bad
16	HP31568	Valavanur	Koliyanur	900	2.9	0.0	Moderate
17	MWS31602	Hanumandapuram	Kanai	2240	3.6	0.0	Moderate
18	U33006A	Pakkam	Gingee	1120	2.7	0.0	Moderate
19	33030	Perumpakkam	Kanai	1010	3.3	1.6	Moderate
20	33044A	Vanur	Vanur	660	0.2	0.0	Good
21	HP31569	Thiruchitrambalam	Vanur	1200	4.7	2.3	Moderate
22	33025	Peravur	Vanur	540	0.4	0.0	Good
23	33029	Kiliyanur	Vanur	1910	1.6	0.0	Moderate

Sl. No	Well No.	Village	Block	EC µmho s/cm	SAR meq/L	RSC meq/ L	Water class
24	HP31530	Kiliyanur	Vanur	1480	3.8	0.0	Moderate
26	33031	Padhirapuliyur	Mailam	2390	6.5	0.0	Bad
27	MWS31571	Nesal	Vanur	2650	5.4	0.0	Bad
28	MWS31614	Veliyanur	Mailam	2480	6.7	2.7	Bad
29	33033	Kalyanampundi	Kanai	1890	2.3	0.0	Moderate
30	HP31524	Sangeethamangalam	Kanai	2620	5.3	0.0	Bad
31	OW11100	Panampattu	Koliyanur	1910	8.9	1.2	Moderate
32	OW11105	Melakondai	Vikravandi	1150	3.0	0.0	Moderate
33	INV31458	Kayathur	Vikravandi	3460	8.0	0.0	Bad
34	33008	Vadasiruvalur	Sankarapuram	2720	4.2	0.0	Bad
35	33010A	Padhiri	Olakkur	910	2.6	0.0	Moderate
36	33011	Nagar	Vikravandi	1880	3.8	0.0	Moderate
37	MWS31519 A	Vairapuram	Olakkur	1220	2.3	0.0	Moderate
38	MWS31624	Kambur	Olakkur	1740	2.7	0.0	Moderate
39	HP31532	Kilperumpakkam	Koliyanur	2580	6.1	0.0	Bad
40	33012	Kilsevur	Tindivanam	970	3.1	2.0	Moderate
41	33014	Salai	Mailam	730	1.3	0.0	Good
42	33024	Omandur	Tindivanam	2320	8.7	3.8	Bad
43	MWS31613	Kollar	Mailam	1890	1.7	0.0	Moderate
44	MWS31615	Vada Alapakkam	Marakkanam	830	2.9	0.5	Moderate
45	HP31566	Nadukkuppam	Thellar	790	1.1	0.0	Moderate
46	HP11915	Chittamur	Chithamur	1280	3.7	0.0	Moderate
47	MWW14	Kattudevadur	Maduranthakam	690	1.8	0.0	Good
48	HP11916	Kayappakkam	Chithamur	980	2.2	0.0	Moderate
49	HP11956	Puthirankottai	Chithamur	400	0.4	0.0	Good
50	MWW1	Chennakayapakkam	Chithamur	610	0.6	0.0	Good
51	MWW11	Vedal	Chithamur	520	0.9	0.0	Good

Sl. No	Well No.	Village	Block	EC µmho s/cm	SAR meq/L	RSC meq/ L	Water class
52	MWW3	Chunambedu	Chithamur	1410	6.0	4.7	Moderate
53	11733	Nedumaram	Lathur	490	1.7	0.0	Good
54	13251	Mugaiyur	Lathur	540	1.8	0.0	Good
55	HP11917	Sengattur . 171	Lathur	850	1.3	0.0	Moderate
56	MWW15	Pavunjur Bdo	Lathur	540	0.7	0.0	Good
57	A13023	Acharpakkam Mosque	Acharapakkam	1760	4.9	0.0	Moderate
58	13242	Ammanur	Lathur	690	1.9	0.0	Good
59	13003	Karasangal	Acharapakkam	1600	2.5	0.0	Moderate
60	HP11936	Orathi	Acharapakkam	520	1.0	0.0	Good
61	13238	Kannivakkam	Kattankolathur	1160	4.6	2.1	Moderate
62	11425	Endiyur	Marakkanam	1470	2.6	0.0	Moderate
63	11426	Alathur	Marakkanam	670	0.5	0.0	Good
64	11427	Kurumbaram	Marakkanam	380	0.1	0.0	Good
65	11429	Karasanur	Vanur	1200	2.8	0.0	Moderate
66	11428	Kodi Ma	Mailam	2190	5.8	0.5	Moderate
67	HP31575A	Pugaipatti	Ulundurpettai	2030	7.5	2.0	Moderate
68	Lab Kpm02	Anakaputhur	Thirukalukundra m	1470	2.1	0.0	Moderate
69	Lab Kpm03	Ottiambakkam	St.Thomas mount	1190	3.6	0.0	Moderate
70	LabKpm01	Rajakeelpakkam	Chithamur	1500	2.9	0.0	Moderate
71	Hp11916A	Salaiyur	Chithamur	1880	8.9	1.2	Moderate
72	23008	Naidumangalam	Thurinjapuram	1430	4.6	0.0	Moderate
73	23102	Vadamathimangalam	Chetpet	440	1.8	0.0	Good
74	HP21565	Mangalam	Thurinjapuram	1460	3.9	0.0	Moderate
75	HP21566	Poyanabdel	Thirukovilur	1080	3.3	0.0	Moderate
76	HP21568	Keekalur	Kilpennathur	740	1.2	0.0	Good
77	23063	Amudur	Vandavasi	1390	2.4	0.0	Moderate

Sl. No	Well No.	Village	Block	EC µmhos/cm	SAR meq/L	RSC meq/L	Water class
78	HP21576	Osur	Vandavasi	1340	3.0	2.3	Moderate
79	A23011A	Thellar	Thellar	1470	5.6	0.0	Moderate
80	HP21575	Thellar	Thellar	2260	2.7	0.0	Moderate
81	23064	Nedungunam	Peranamallur	1060	4.1	0.0	Moderate
82	MCR02017	Azhiyur	Peranamallur	820	1.7	0.0	Moderate
83	MCR02011	Nedugunam	Peranamallur	560	0.9	0.0	Good
84	23013	Desur	Thellar	1740	4.6	0.0	Moderate

Water Quality & Irrigation

Electrical Conductivity

The conductivity increases as the concentration of TDS increases. A lesser EC value is most suitable for irrigation (<2250 umhos/cm). As far as Varahanadhi basin is concerned, the EC value is well permissible within the limit and the water is used for irrigation throughout the year.

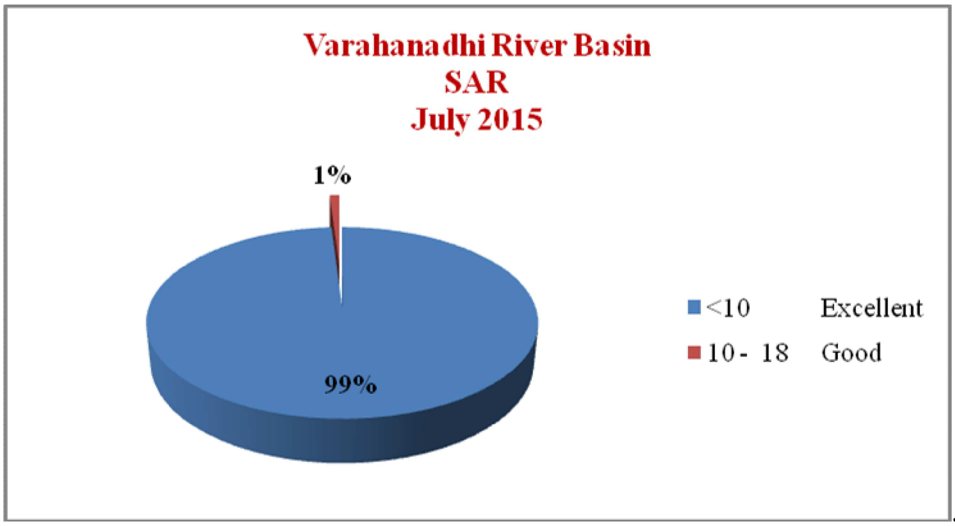
Sodium Adsorption Ration (SAR)

Sodium adsorption ratio is a measure of the suitability of water for use in agricultural irrigation, as determined by the concentration of solids dissolved in the water. The formula for calculating sodium adsorption ratio is:

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

The higher, the sodium adsorption ratio, the less suitable, the water for irrigation. If irrigation water with a high SAR is applied to a soil for years, the sodium in the water can displace the calcium and magnesium in the soil. This will cause a decrease in the ability of the soil to form stable aggregates and a loss of soil structure and tilth. This will lead to a decrease in infiltration and permeability of the soil to water leading to problems with crop production.

The SAR value is within the range in all the wells in the basin.



Residual Sodium Carbonate (RSC)

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

RSC is expressed in meq/L.

The formula for calculating RSC index is:

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

The RSC value in this basin is very less and hence there are no particular issues regarding RSC. The water quality in the basin is of good to moderate quality and is suitable for agriculture.

Water quality related problems in irrigated agriculture

Salinity

Salts in soil or the salinity reduce water availability to the crop to such an extent that yield is affected. The salinity in the basin is less and it has no impact in the yield.

Water Infiltration rate

Relatively high sodium or low calcium content of soil or water reduces the rate at which irrigation water enters soil to such an extent that sufficient water cannot be infiltered to supply the crop adequately from one irrigation to the next.

Since the SAR value is less, the infiltration rate and permeability of the soil is higher in the basin.

Specific ion toxicity

Certain ions (Sodium, Chloride or Boron) from soil or water accumulate in a sensitive crop to concentrations high enough to cause crop damage and reduce yields.

No such specific ion toxicity is found in the basin.

Miscellaneous

Excessive nutrients reduce yield or quality, unsightly deposits on fruit or foliage reduces marketability, excessive corrosion of equipment increases maintenance and repairs.

There are no excessive nutrients in the water sample and the problems due to it is nil in this basin.

Approach to Evaluating Water Quality

The four problems viz., Salinity, Infiltration, Toxicity and Miscellaneous are used for evaluation. Water quality problems are often complex and a combination of problems may affect crop production more severely than a single problem in isolation. The more complex the problem, the more difficult it is, to formulate an economical management programme for solution.

If problems do occur in combination, they are more easily understood and solved if each factor is considered individually. A number of factors are evaluated for each of the problem areas such as,

- The type and concentration of salts causing the problem
- The soil - water plant interactions that may cause the loss in crop yield
- The expected severity of the problem following long term use of the water
- The management options that are available to prevent, correct or delay the onset of the problem.

As far as Varahanadhi river basin is concerned the water quality data available in the study reveals that the basin is well within the safe limits.

6.7.5 Measures to prevent the groundwater pollution:

- Maintain the well and test the water quality annually.
- Keep household chemicals, paint and motor oil away from the water source such as well and dispose of them properly by taking them to a recycling center or household hazardous waste collection site.
- Judicious use of pesticides and fertilizers.
- Install a well cap and keep it clear of leaves, dirt, and other materials.
- Practicing water conservation measures in the home and install low water use appliances.
- Industrial and sewage effluents should be treated properly and then only led into main streams of water to avoid heavy metals seepage into the water. As the basin has considerable amount of run off during the rainy days artificial recharge of groundwater

by constructing structures such as check dams, percolation pond, recharge shafts etc., wherever possible to be adopted.

6.7.6 Conclusion:

- Percentage of Electrical Conductivity values in the basin is as follows: 6% of the basin falls under excellent category, 28% falls under good and 66 % falls under moderate range.
- pH value lies within the permissible limit of 6.5 to 8.5 in all the wells in this basin.
  The value of TDS ranges from good to moderate in Varahanadhi river basin.. (30% good and 70% moderate) **Refer table 6.15, 6.16(a) to 6.16(f) & 6.17(a) to 6.17(b) for BIS standards.**
- 48% of samples have hardness value less than 300mg/L; 39% of samples have hardness value in the range of 300 – 600 mg/L and 13% of samples fall under poor category.
- The nitrate value is within the permissible limit of 45 mg / L in all the wells in this basin.
- Fluoride value is within the permissible limit of 1.5 mg / L in all the wells in this basin.
- In general, the quality of groundwater is “good to moderate” in Varahanadhi river basin.
- The reason for higher values of physico – chemical parameters at certain wells may be due to the unscientific disposal of solid wastes, the depth of wells and the composition of rocks and soils which has direct influence on water quality.
- Organic manures can be substituted for chemical fertilizers in order to increase the liveliness of the soil and to increase its fertility.
- Recharging rain water into the aquifers helps in utilizing the primary source of water and thereby improving the quality and quantity of existing groundwater through dilution.
- Water Quality parameters are included in **Appendix 6.9 in Volume II** for Reference.

Table 6.15 Indian Standards For Drinking Water (BIS 10500 : 1991)

Sl.No	Substance or Characteristic	Requirement Desirable Limit	Permissible limit in the absence of Alternate source
Essential Characteristics			
1	Colour, (Hazen units), Max	5	25
2	Odour	Unobjectionable	--
3	Taste	Agreeable	--
4	Turbidity (NTU), Max	5	10
5	pH Value	6.5 to 8.5	No Relaxation
6	Total Hardness (as $CaCo_3$) mg/L, Max	300	600

Table 6.15 Indian Standards For Drinking Water (BIS 10500 : 1991)			
Sl.No	**Substance or Characteristic**	**Requirement**	**Permissible limit in the absence of Alternate source**
7	Iron (as Fe) mg/L, Max	0.3	1
8	Chlorides (as Cl) mg/L, Max.	250	1000
9	Residual, free chlorine, mg/L, Min	0.2	--
10	Fluoride (as F) mg/L, Max	1	1.5
Desirable Characteristics			
11	Total Dissolved solids mg/L, Max	500	2000
12	Calcium (as Ca) mg/L, Max	75	200
13	Magnesium (as mg) mg/L, Max	30	100
14	Copper (as Cu) mg/L, Max	0.05	1.5
15	Manganese (as Mn)mg/L, Max	0.1	0.3
16	Sulfate (as SO_4) mg/L, Max	200	400
17	Nitrate (as NO_3) mg/L, Max	45	No Relaxation
18	Phenolic Compounds (as C_6H_5OH) mg/L, Max	0.001	0.002
19	Mercury (as Hg) mg/L, Max	0.001	No relaxation
20	Cadmium (as Cd) mg/L, Max	0.01	No relaxation
21	Selenium (as Se) mg/L,Max	0.01	No relaxation
22	Arsenic (as As) mg/L, Max	0.01	No relaxation
23	Cyanide (as CN) mg/L, Max	0.05	No relaxation
24	Lead (as Pb) mg/L, Max	0.05	No relaxation
25	Zinc (as Zn) mg/L, Max	5	15
26	Anionic detergents (as MBAS) mg/L, Max	0.2	1
27	Chromium (as Cr^{6+}) mg/L, Max	0.05	No relaxation
28	Poly nuclear aromatic hydrocarbons (as PAH) mg/L, Max	--	--
29	Mineral Oil mg/L, Max	0.01	0.03
30	Pesticides mg/L, Max	Absent	0.001
31	Radioactive Materials		
	i. Alpha emitters Bq/L, Max	--	0.1
	ii. Beta emitters pci/L, Max	--	1
32	Alkalinity mg/L, Max	200	600
33	Aluminium (as Al) mg/L, Max	0.03	0.2
34	Boron mg/L, Max	1	5

Table 6.16 (a)
Safe limits for Electrical Conductivity for Irrigation Water

Sl .No	Nature of soil	Crop growth	Upper permissible limit of EC in water µmhos/cm at 25˚C
1	Deep black soil and alluvial soils having clay content more than 30% soils that are fairly to moderately well drained.	Semi-tolerant	1500
		Tolerant	2000
2	Heavy textured soils having clay contents of 20-30% soils that are well drained internally and have good surface drainage system.	Semi-tolerant	2000
		Tolerant	4000
3	Medium textured soils having clay 10-20% internally very well drained and having good surface drainage system.	Semi-tolerant	4000
		Tolerant	6000
4	Light textured soils having clay less than 10% soil that have excellent internally and surface drainage system.	Semi-tolerant	6000
		Tolerant	8000

Table 6.16 (b)
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 6.16 (c)
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 6.16 (d)
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 6.16 (e)
Tolerance Limits for Industrial Effluence (IS: 2490, Part-I-1981)

Sl.No	Characteristic	Maximum tolerance limits for industrial effluents discharged (mg/l)			
		Into inland surface water	**Into public sewers**	**On land for irrigation**	**Marine/ Coastal Area**
1	Colour and Odour	Absent	-	Absent	Absent
2	Suspended solids	100	600	200	a) For Process waste water 100 b)For cooling water effluent 10 percent above total suspended matter of effluent
3	Particle size of suspended solids	Shall pass 850 micron IS Sieve	-	-	a)Floatable solids, max. 3 mm b)Settleable solids max 856 microns
4	Dissolved solids (inorganic)	2100	2100	2100	-
5	pH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
6	Temperature ˚C	Shall not exceed 40 in any section of the stream within 15 meters downstream from the effluent outlet	45 at the point of discharge	-	-

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
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 d)	2	1.0	-	2.0
18	Hexavalant Chromium (as Cr+6)	0.1	2.0	-	1.0
19	Total Chromium (as Cr)	2.0	2.0	-	2.0
20	Copper (as Cu)	3.0	3.0	-	30
21	Zinc (as Zn)	5.0	15	-	15
22	Selenium (as Se)	0.05	0.05	-	0.05
23	Nickel (as Ni)	3.0	3.0	-	-
24	Boron (as B)	2.0	2.0	2.0	-
25	Percent sodium	-	60	60	-

Table 6.16 (f)

Effects of water quality parameters of water being used in industries

Sl.No.	Parameters	Prescribed limits IS:10500, 1991		Probable effects
		Desirable limit	**Permissible limit**	
1	pH value	**6.5**	**8.2**	Low pH increases corrosion of concrete, pH 7.0 is required for most industry, pH 2.7- 7.2 advised for carbonated beverage industry.
2	Total dissolved solids, mg/l	**50**	**3000**	Causes foaming in boilers and solids interfere with clearness, colour or taste of finished products. Low TDS value are required in most industries. High TDS leads to corrosion.
3	Iron mg/l	**0.1**	**2.0**	Recommended value for food processing units is 0.2, for paper and photographic industry iron of 0.1 mg/l is recommended iron less than 0.1 mg/l is recommended in cooling waters.
4	Chloride mg/l	**25**	**200**	Significantly affect the rate of corrosion of steel and Aluminium.
5	Fluoride mg/l	**0.2**	**1.0**	Harmful in industries involved in production of food beverages, pharmaceuticals and medical items.
6	Calcium 20 mg/l	**20**	**500**	High calcium leads to spots on films. Have undesirable effects like forming scale, precipitates and curds in industry. It may interferes in formation of emulsions and processing of colloids upsetting fermentation process, and electroplating rinsing operation.

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

Table 6.17 (a) Standards of Water Quality for Construction

Sl.No	Parameter	Limit
1	Sodium & Potassium Carbonate & Bicarbonate	Upto 1000 ppm
2	Calcium Bicarboante and Magnesium Bicarbonate	400 ppm
3	Silt and Sediments	2000ppm

Table 6.17 (b) Tolerance Limit of Sulphate Used For Reinforced Concrete		
Sl.No.	**Sulphate Concentration (mg/l)**	**Effect on RCC**
1	0 - 150	Negligible
2	150 - 1000	Positive
3	1000 - 2000	Considerable
4	Above 2000	Severe

6.8 Management of Groundwater Resources

Studies show that groundwater recharge and discharge conditions are reflection of the precipitation regime, climatic variables, landscape characteristics and human impacts. Hence, predicting the behavior of recharge and discharge conditions under changing climate is of great importance for groundwater conservation & management.

The groundwater crisis prevailing in the State is not the result of natural factors; it has been caused by anthropogenic actions. 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. The water requirement for the industry also shows an overall increase. Hence, management of groundwater is extremely complex and it requires a combination of supply side and demand side management as described in the following sections.

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. On the other hand, roof-top rainwater harvesting, either for storage and direct use or for recharge into the aquifers is suited for urban habitations with its characteristic space constraints.

Structural measures have been taken by the Government to increase the groundwater availability. Various State Government agencies such as Water Resources Department, Agricultural Department, Agricultural Engineering Department, TWAD Board and Forest

Department with and without Central Government assistance have taken up augmentation of ground water resources through artificial recharge structures.

Success of Artificial Recharge Structures (ARS) depends largely on geological and hydrological features of an area, site selection and design of ARS. While 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 tracts, tidal regulators which impound the fresh water upstream and enhance the natural recharge, help control salinity ingress effectively. In case of urban areas and hilly terrains with high rainfall, roof top rain water structures are most useful.

Data on Artificial Recharge Structures (ARS) constructed in the recent years were obtained from the office of Chief Engineer, Chennai Region, WRD, PWD. The list of ARS constructed in Varahanadhi basin is listed in Table 6.18.

Table 6.18 List of ARS constructed by WRD in Varahanadhi Basin

Sl. No	Name of Work	G.O.No. Ms No:51/PW (R2) D/ dt:23.2.2011 Project Cost Rs. In lakh	Name of the Sub Basin	Latitude	Longitude
1	Construction of recharge structure across Kattrampakkam river in Kodur village of Vanur Taluk of Villupuram District	24.00	Nallaur	12°04'0"	79°47'0"
2	Construction of recharge structure across Varahanadhi in Vanakampadi village in Gingee Taluk of Villupuram District	64.00	Varahanadhi	12°18'0"	79°24'0"
3	Construction of recharge structure across Varahanadhi near Modaiyur-Vallam village in Gingee Taluk of Villupuram District	99.00	Varahanadhi	12°14'25"	79°29'30"
4	Construction of recharge structure across Varahanadhi in Thenpalai village in Gingee Taluk of Villupuram District	42.00	Varahanadhi	12°16'0"	79°20'0"

6.8.1.2 Artificial Recharge Measures

It is need of the time to artificially recharge the groundwater by constructing various types of Artificial Recharge Structures. 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.

Table 6.19 ARS Recommended by IWS and their Details

Sl. No	Details of proposed ARS	Location	Latitude	Longitude	Sub basin	Firka
ARS Recommended in Over Exploited Firkas						
1	Recharge Shaft	Valathy Tank	12° 21' 8"	79° 22' 10"	Varahanadhi	Sathampatti
2	Recharge Shaft	Thailapuram Periya eri	12° 5' 20"	79° 45' 13"	Nallavur	Kiliyanur
3	Recharge Shaft	Annpakkam Tank	12° 4' 45"	79° 46' 38"	Nallavur	Kiliyanur
4	Recharge Shaft	Radhapuram Iyyanar eri	12° 0' 44"	79° 35' 15"	Varahanadhi	Sithalampattu
5	Recharge Shaft	Thenpair Tank	12° 5' 47"	79° 29' 22"	Varahanadhi	Vikiravandi
6	Check Dam	Varahanadhi below Vidur Dam	12° 2' 5	79° 35' 35"	Varahanadhi	Nemili
7	Check Dam	Varahanadhi left arm	12° 1' 1	79° 35' 24"	Varahanadhi	Vikiravandi
8	Check Dam	Varahanadhi - west of Valudavur	11° 58' 41"	79° 41' 8	Varahanadhi	Sithalampattu
9	Check Dam	Thondi Ar	12° 11' 22"	79° 33' 27"	Varahanadhi	Vallam
10	Check Dam	Kondamur_Ar/Nallavur_Ar	12° 6' 14"	79° 45' 52"	Nallavur	Kiliyanur
ARS Recommended in Critical Firkas						
11	Recharge Shaft	Kilathivakkam Tank	12° 23' 2"	79° 42' 50"	Ongur	Orathi
12	Recharge Shaft	Irumbai Tank	12° 0' 21" N	79° 47' 29"	Nallavur	Vanur
13	Recharge Shaft	Rayaputhupakkam Tank	12° 1' 47"	79° 47' 50"	Nallavur	Vanur
	ARS Recommended in Safe Firkas					
14	Recharge Shaft	Valavanur Tank	11° 54' 30"	79° 34' 28"	Varahanadhi	Valavanur
15	Check Dam	Ongur Ar	12° 20' 5"	79° 48' 0"	Ongur	Kayapakkam

A detailed investigation has to be done on the hydrological aspects of rainfall and maximum surface runoff, geological and geomorphological characteristics and yield test on any site prior to constructing any ARS in the above recommended locations listed in table 6.11.

6.8.2 Demand-side Management of Groundwater

Groundwater extraction for irrigation sector is 62% in India. In Varahanadhi basin, groundwater extraction for irrigation sector is 947.55MCM within the total extraction of 1009.45MCM.

Table: 6.20 Groundwater Availability and Extraction as per 2013 Assessment

Sl. No	Sub Basin	Net Annual Groundwater Availability in (MCM)	Gross Annual Extraction for irrigation in (MCM)	Gross Annual Extraction for other purposes in (MCM)	Gross Annual Extraction for all Sectors (MCM)	Irrigation Extraction in Total Extraction (%)
1	Ongur	289.22	218.62	9.49	228.11	95.84
2	Nallaur	130.73	143.89	12.67	156.56	91.91
3	Varahanadhi	569.38	585.04	39.74	624.78	93.64
	Total	**989.33**	**947.55**	**61.90**	**1009.45**	**93.87**

The groundwater extraction for irrigation is above 90% in all three sub-basins of Varahanadhi Basin (Groundwater extraction for irrigation sector is 93.87%) which is an alarming condition whilst comparing Tamilnadu state’s total groundwater extraction for all sectoral demand of 77%. 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 modern irrigation practices like drip irrigation and sprinkler irrigation to reduce the groundwater extraction for irrigation. The predominant crops in this basin are paddy and sugarcane which are water intensive crops and in order to reduce the water at field level a greater thrust has to be insisted on farmers to adopt the latest less water consumption agriculture technique like System of Rice Intensifications (SRI) and Sustainable Sugarcane Initiative (SSI).

6.9 Summary

A total of 206 wells lying in Varahanadhi Basin and an inventory of 83 observation wells spread over the entire Varahanadhi Basin has been scrutinized for study purpose based on the availability of data period, ranging from four (4) years to forty four (44) years. 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 shallow aquifers are drawn.

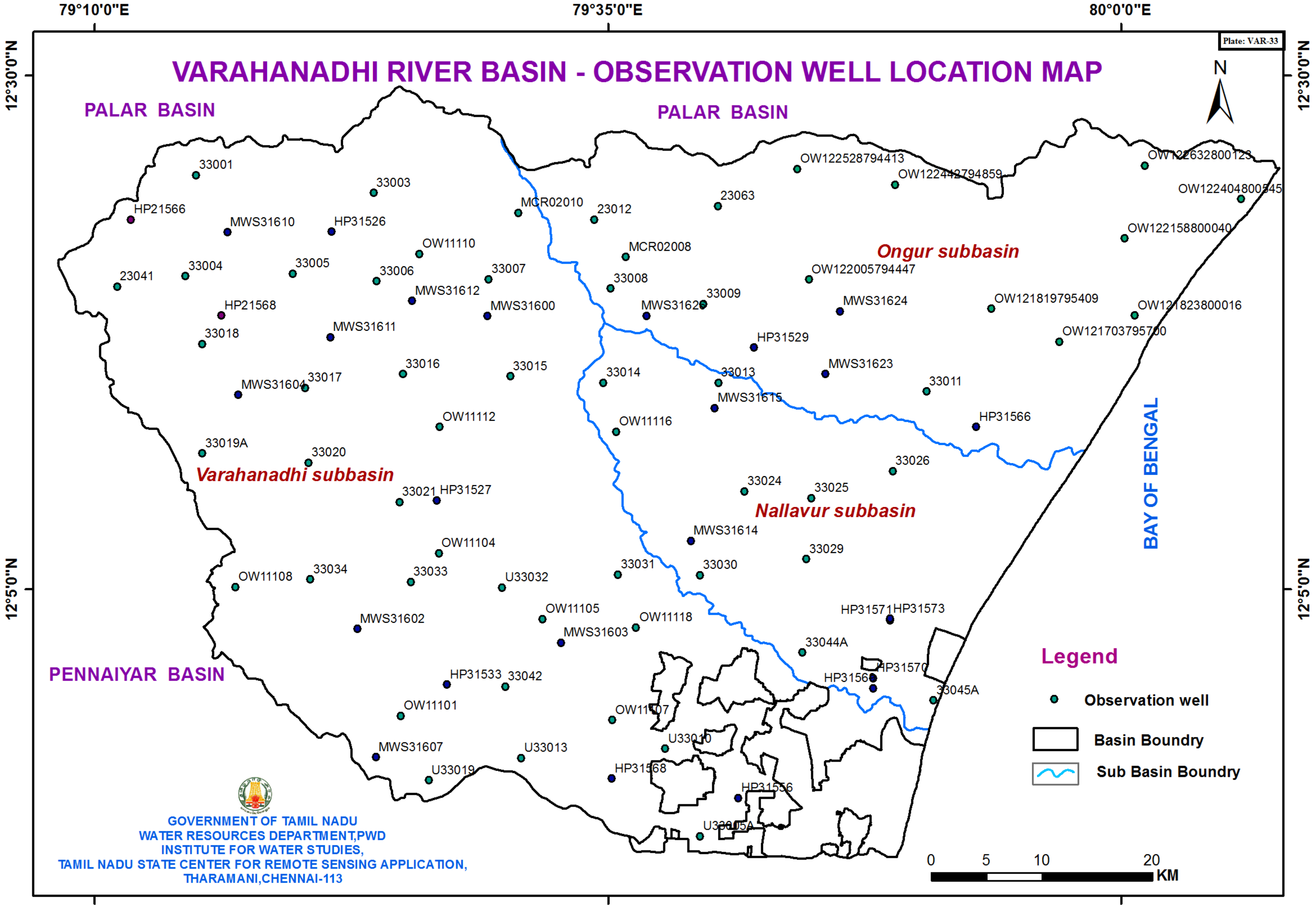
Findings:

- ❖ Hydrographs (depending on available of well data from 1972 to 2016) of the groundwater depths for the 83 observation wells have been prepared.
- ❖ Long-term water level rise found in 43 observation wells and high rise in water level (more than 3.00m) found in 12 wells.
- ❖ Long-term water level depletion found in 40 observation wells and high depletion in water level (more than 3.00m) found in 8 wells.
- ❖ In Ongur sub-basin, pre-monsoon groundwater depth varies from 0.55m to 45.50m and post monsoon groundwater depth varies from 0.29m to 38.95m
- ❖ In Nallavur sub-basin, pre-monsoon groundwater depth varies from 0.13m to 88.50m and post monsoon groundwater depth varies from 0.03m to 73.72m
- ❖ In Varahanadhi sub-basin, pre-monsoon groundwater depth varies from 0.35m to 30.50m and post monsoon groundwater depth varies from 0.10m to 30.05m.
- ❖ Total annual groundwater availability in Varahanadhi Basin is 989.33 MCM and total annual groundwater extraction in the basin is 1009.45MCM. The balance groundwater available for further development is 116.91MCM.
- ❖ Whilst comparing groundwater resources calculated in Varahanadhi Basin Appraisal report prepared in 2005 with the groundwater resources calculated in this Reappraisal study, it is observed that the total annual groundwater availability of Varahanadhi Basin has decreased by 21.21% (from 1255.72MCM to 989.33MCM) and total annual groundwater extraction in Varahanadhi basin has also decreased by 25.00% (from 1345.87MCM to 1009.45MCM in 2011).
- ❖ The quality of groundwater in Varahanadhi Basin is generally good to moderate.
- ❖ One artificial recharge structure in Nallavur sub-basin and three artificial recharge structures in Varahanadhi sub-basin were constructed.

- ❖ Annually groundwater extracted for irrigation in Varahanadhi basin is 947.55MCM which is 93.87% in total annual groundwater extraction of 1009.45MCM for all sectoral demands.

Recommendations:

- Groundwater recharge is utmost important in Nemili, Sithalampattu, Kiliyanur firkas in Varahanadhi sub-basin.
- Judicious control over groundwater extraction has to be ensured in Siruvadi firka in Nallaur sub-basin and in Rettychavadi & Sathiyamangalam firkas in Varahanadhi sub-basin to avoid further depletion of groundwater.
- Groundwater extraction for irrigation sector in Varahanadhi basin is alarmingly high at 93.87% in total extraction. In order to reduce the groundwater extraction for irrigation, modern irrigation method like drip irrigation and latest cultivation practices like System of Rice Intensification (SRI) and Sustainable Sugarcane Initiative (SSI) have to be implemented in large scale.
- It is suggested to construct Artificial Recharge Structures (ARS), like Check Dams and Recharge Shafts as follows:
    - ❖ 10 ARS in Over Exploited firkas
    - ❖ 3 ARS in in Critical firkas
    - ❖ 2 ARS in Safe firkas



VARAHANADHI RIVER BASIN - OBSERVATION WELL LOCATION MAP
Plate: VAR-33
79°10'0"E
79°35'0"E
80°0'0"E
12°30'0"N
12°5'0"N
N
PALAR BASIN
PALAR BASIN
PENNAIYAR BASIN
BAY OF BENGAL
Varahanadhi subbasin
Ongur subbasin
Nallavur subbasin
33001
33003
HP21566
MWS31610
HP31526
MCR02010
23012
23063
OW122528794413
OW122442794859
OW122632800123
OW122404800545
OW11110
MCR02008
OW122158800040
23041
33004
33005
33006
33007
33008
OW122005794447
MWS31612
MWS31600
33009
MWS31626
MWS31624
OW121819795409
OW121823800016
HP21568
33018
MWS31611
HP31529
OW121703795700
33016
33015
33014
33013
MWS31623
33011
MWS31604
33017
MWS31615
HP31566
OW11112
OW11116
33019A
33020
33026
33024
33025
33021
HP31527
MWS31614
OW11104
33029
33031
33030
OW11108
33034
33033
U33032
HP31571
HP31573
OW11105
OW11118
MWS31602
MWS31603
33044A
HP31570
HP31533
33042
33045A
OW11101
MWS31607
U33013
U33019
U33010
HP31568
HP31556
Legend
Observation well
Basin Boundry
Sub Basin Boundry
0
5
10
20
KM
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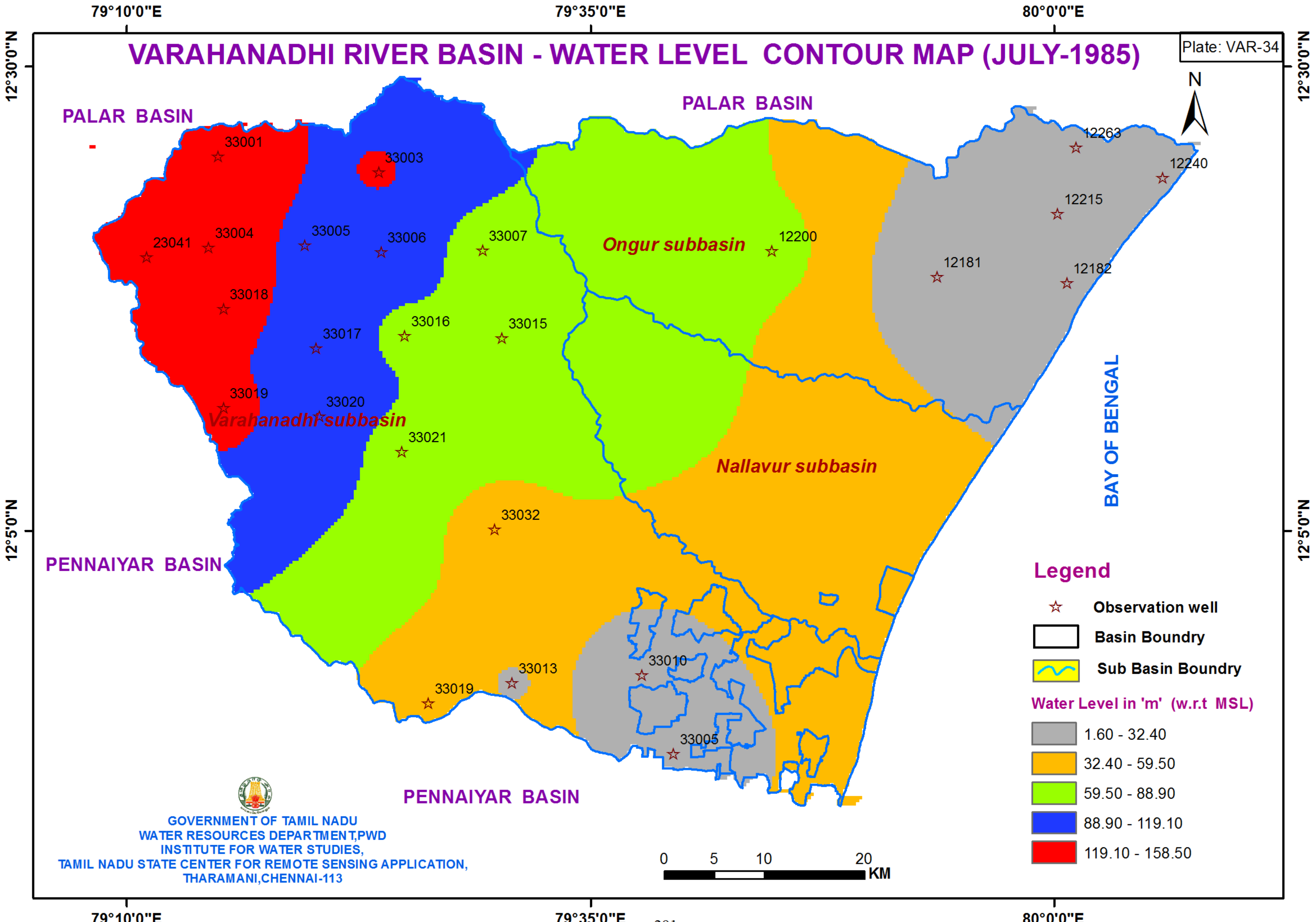

79°10'0"E
79°35'0"E
80°0'0"E
12°30'0"N
12°5'0"N
VARAHANADHI RIVER BASIN - WATER LEVEL CONTOUR MAP (JULY-1985)
Plate: VAR-34
N
PALAR BASIN
PALAR BASIN
PENNAIYAR BASIN
PENNAIYAR BASIN
BAY OF BENGAL
Ongur subbasin
Varahanadhi subbasin
Nallavur subbasin
33001
33003
23041
33004
33005
33006
33007
12200
12263
12240
12215
12181
12182
33018
33016
33015
33017
33019
33020
33021
33032
33013
33019
33010
33005
Legend
Observation well
Basin Boundry
Sub Basin Boundry
Water Level in 'm' (w.r.t MSL)
1.60 - 32.40
32.40 - 59.50
59.50 - 88.90
88.90 - 119.10
119.10 - 158.50
0 5 10 20
KM
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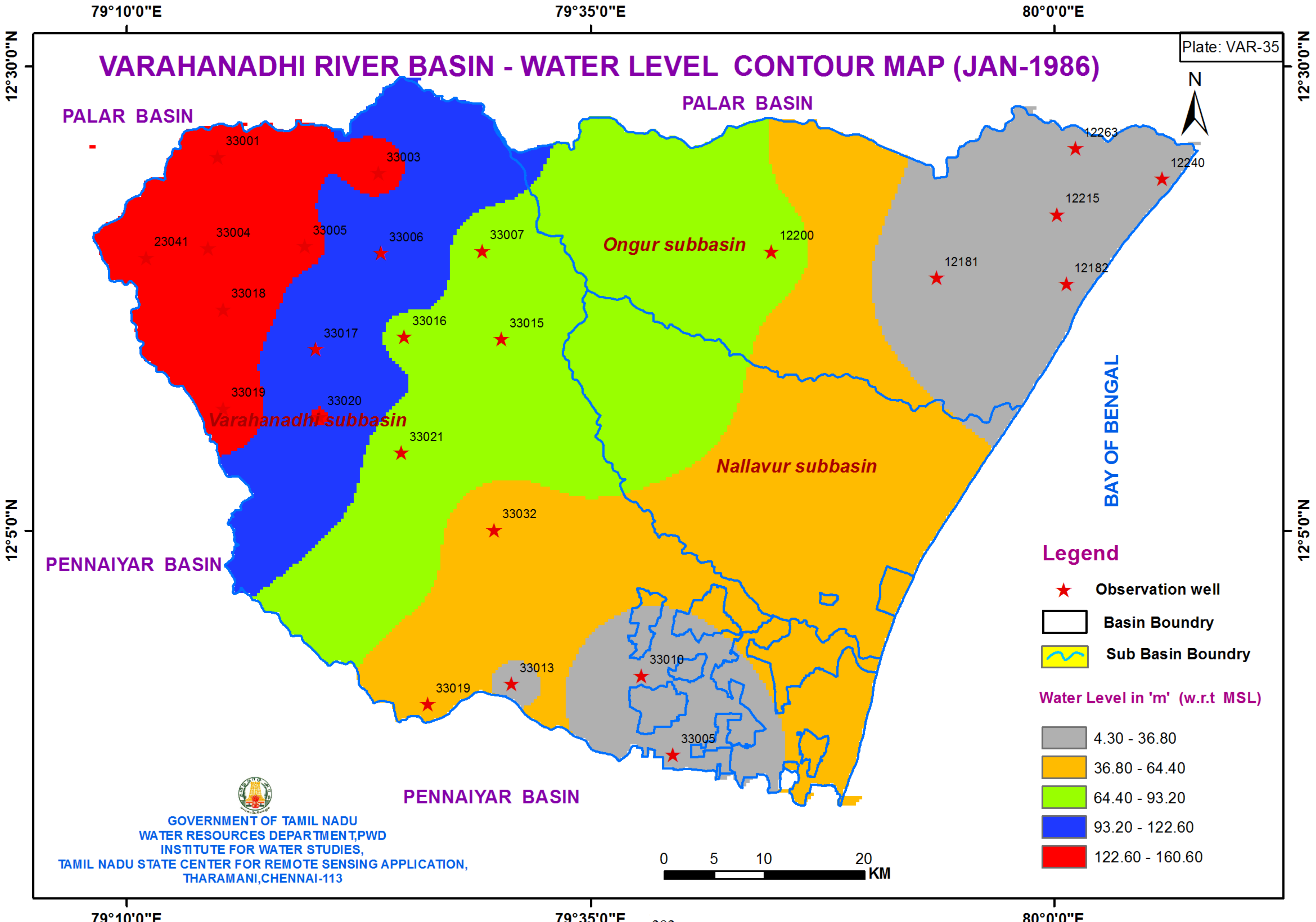

VARAHANADHI RIVER BASIN - WATER LEVEL CONTOUR MAP (JAN-1986)
Plate: VAR-35
79°10'0"E
79°35'0"E
80°0'0"E
12°30'0"N
12°5'0"N
N
PALAR BASIN
PALAR BASIN
PENNAIYAR BASIN
PENNAIYAR BASIN
BAY OF BENGAL
Ongur subbasin
Varahanadhi subbasin
Nallavur subbasin
33001
33003
23041
33004
33005
33006
33007
12200
12263
12240
12215
12181
12182
33018
33017
33016
33015
33019
33020
33021
33032
33013
33019
33010
33005
Legend
Observation well
Basin Boundry
Sub Basin Boundry
Water Level in 'm' (w.r.t MSL)
4.30 - 36.80
36.80 - 64.40
64.40 - 93.20
93.20 - 122.60
122.60 - 160.60
0 5 10 20
KM
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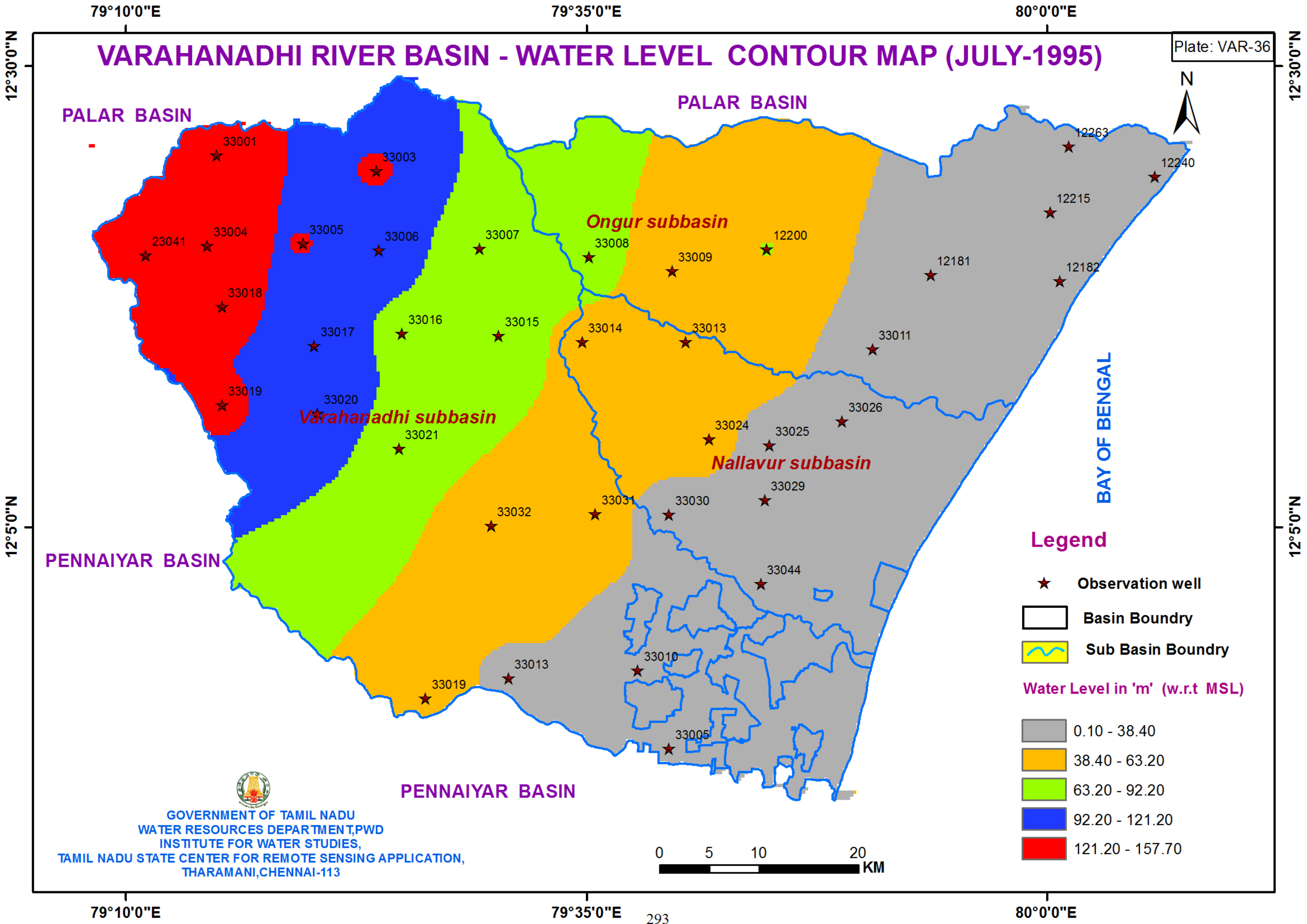
VARAHANADHI RIVER BASIN - WATER LEVEL CONTOUR MAP (JULY-1995)

Plate: VAR-36



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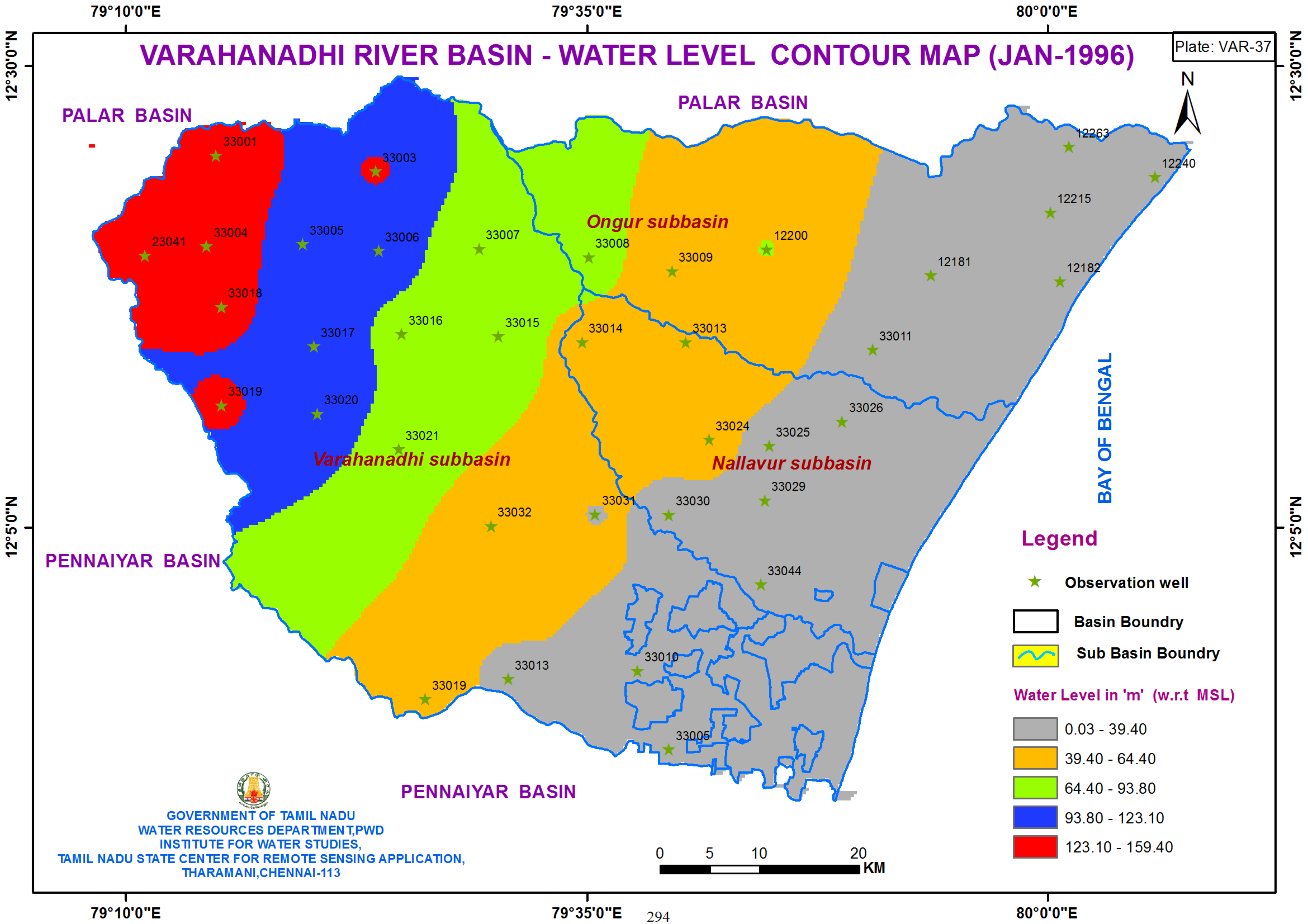

79°10'0"E
79°35'0"E
80°0'0"E
12°30'0"N
12°5'0"N
VARAHANADHI RIVER BASIN - WATER LEVEL CONTOUR MAP (JAN-1996)
Plate: VAR-37
N
PALAR BASIN
PALAR BASIN
PENNAIYAR BASIN
PENNAIYAR BASIN
BAY OF BENGAL
Ongur subbasin
Varahanadhi subbasin
Nallavur subbasin
33001
33003
23041
33004
33005
33006
33007
33008
12200
33009
12263
12240
12215
12181
12182
33018
33016
33015
33014
33013
33017
33011
33019
33020
33026
33024
33025
33021
33029
33031
33030
33032
33044
33013
33010
33019
33005
Legend
Observation well
Basin Boundry
Sub Basin Boundry
Water Level in 'm' (w.r.t MSL)
0.03 - 39.40
39.40 - 64.40
64.40 - 93.80
93.80 - 123.10
123.10 - 159.40
0 5 10 20
KM
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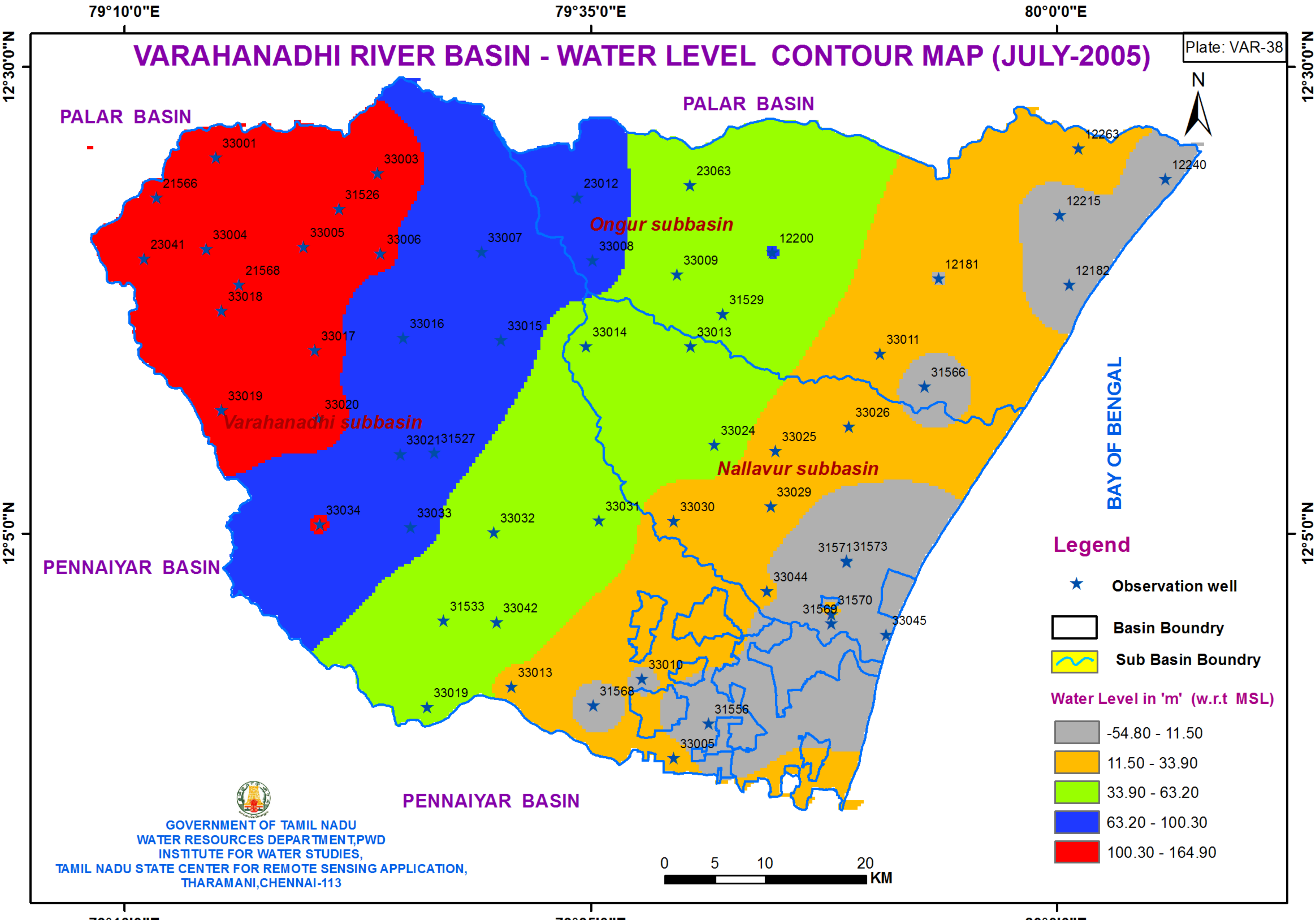
VARAHANADHI RIVER BASIN - WATER LEVEL CONTOUR MAP (JULY-2005)
Plate: VAR-38
79°10'0"E
79°35'0"E
80°0'0"E
12°30'0"N
12°5'0"N
N
PALAR BASIN
PALAR BASIN
PENNAIYAR BASIN
PENNAIYAR BASIN
BAY OF BENGAL
Ongur subbasin
Varahanadhi subbasin
Nallavur subbasin
33001
33003
21566
31526
23041
33004
33005
33006
21568
33018
33017
33019
33020
33016
33015
33007
23012
33008
23063
12200
33009
31529
33014
33013
33021
31527
33034
33033
33032
33031
33030
33024
33025
33026
33029
33011
31566
12181
12263
12240
12215
12182
31571
31573
33044
31569
31570
33045
31533
33042
33013
33019
33010
31568
31556
33005
Legend
Observation well
Basin Boundry
Sub Basin Boundry
Water Level in 'm' (w.r.t MSL)
-54.80 - 11.50
11.50 - 33.90
33.90 - 63.20
63.20 - 100.30
100.30 - 164.90
0 5 10 20
KM
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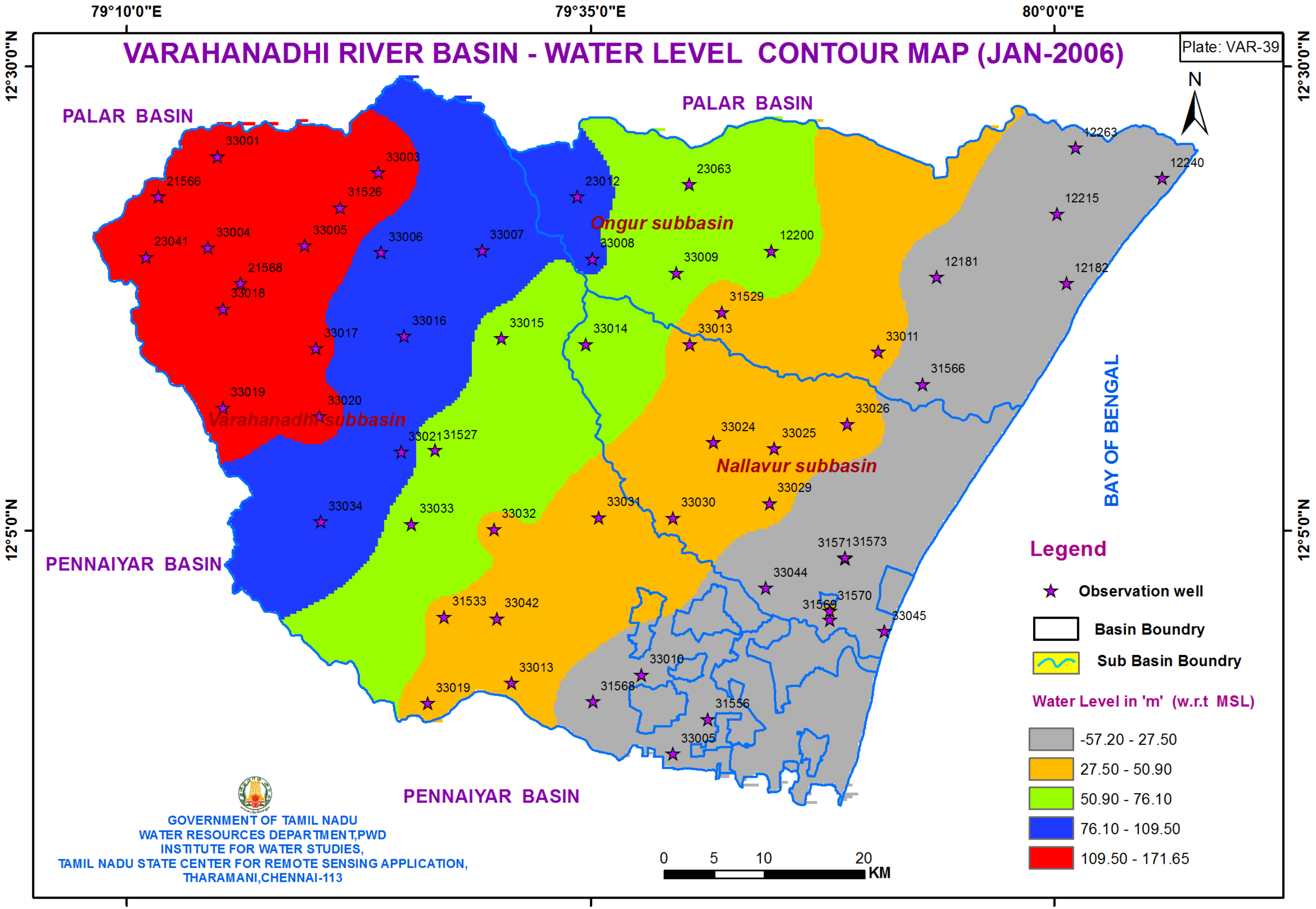
VARAHANADHI RIVER BASIN - WATER LEVEL CONTOUR MAP (JAN-2006)
Plate: VAR-39
79°10'0"E
79°35'0"E
80°0'0"E
12°30'0"N
12°5'0"N
N
PALAR BASIN
PALAR BASIN
PENNAIYAR BASIN
PENNAIYAR BASIN
BAY OF BENGAL
Ongur subbasin
Varahanadhi subbasin
Nallavur subbasin
33001
33003
21566
31526
33004
33005
23041
33006
33007
21568
33018
33017
33016
33015
33019
33020
33021
31527
33034
33033
33032
23012
23063
33008
12200
33009
31529
33013
33014
33011
12263
12240
12215
12181
12182
31566
33026
33024
33025
33029
33031
33030
31571
31573
33044
31570
31569
33045
31533
33042
33013
33019
33010
31568
31556
33005
Legend
Observation well
Basin Boundry
Sub Basin Boundry
Water Level in 'm' (w.r.t MSL)
-57.20 - 27.50
27.50 - 50.90
50.90 - 76.10
76.10 - 109.50
109.50 - 171.65
0 5 10 20
KM
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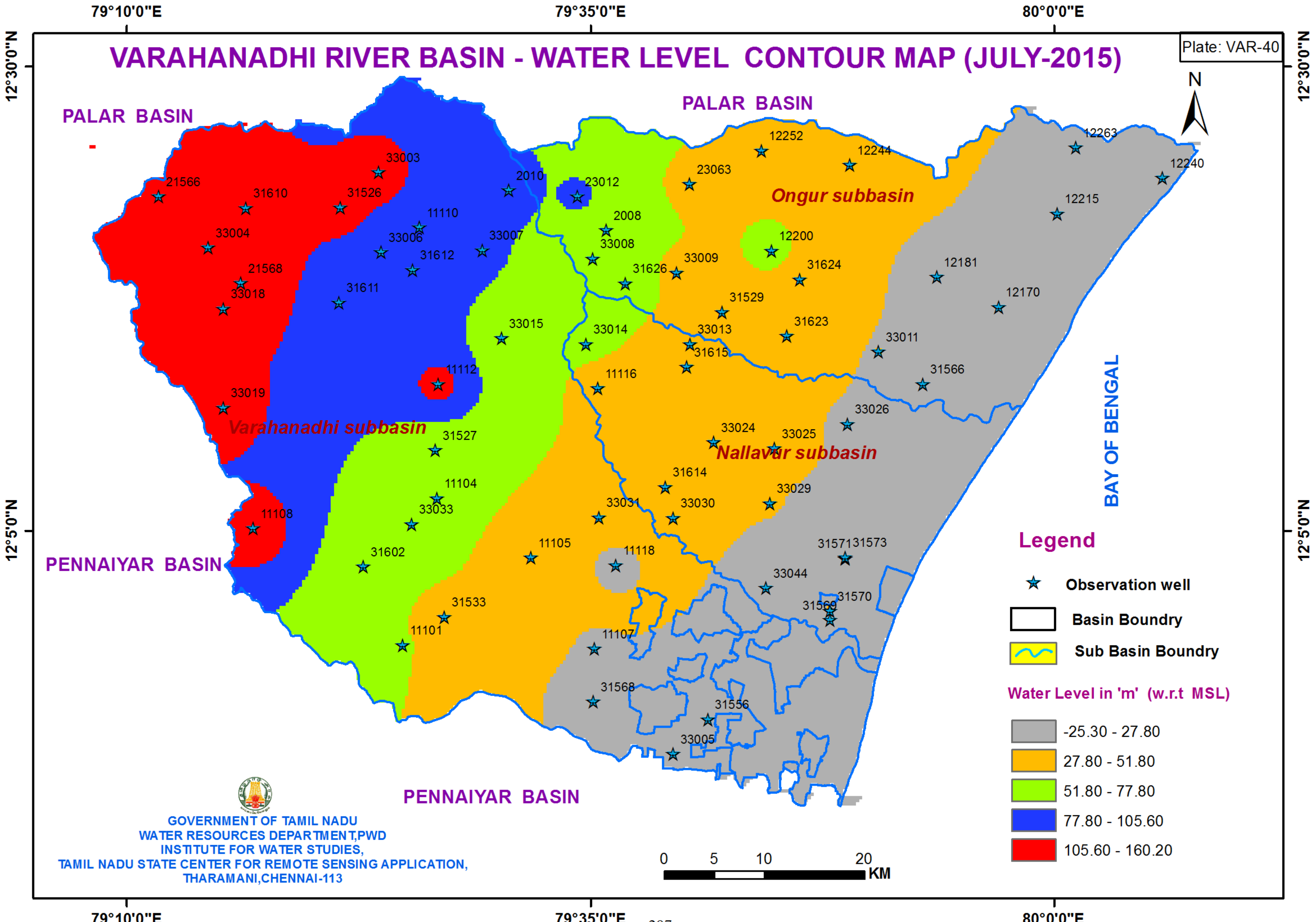
VARAHANADHI RIVER BASIN - WATER LEVEL CONTOUR MAP (JULY-2015)
Plate: VAR-40
79°10'0"E
79°35'0"E
80°0'0"E
12°30'0"N
12°5'0"N
N
PALAR BASIN
PALAR BASIN
PENNAIYAR BASIN
PENNAIYAR BASIN
BAY OF BENGAL
Ongur subbasin
Varahanadhi subbasin
Nallavur subbasin
Legend
Observation well
Basin Boundry
Sub Basin Boundry
Water Level in 'm' (w.r.t MSL)
-25.30 - 27.80
27.80 - 51.80
51.80 - 77.80
77.80 - 105.60
105.60 - 160.20
0 5 10 20
KM
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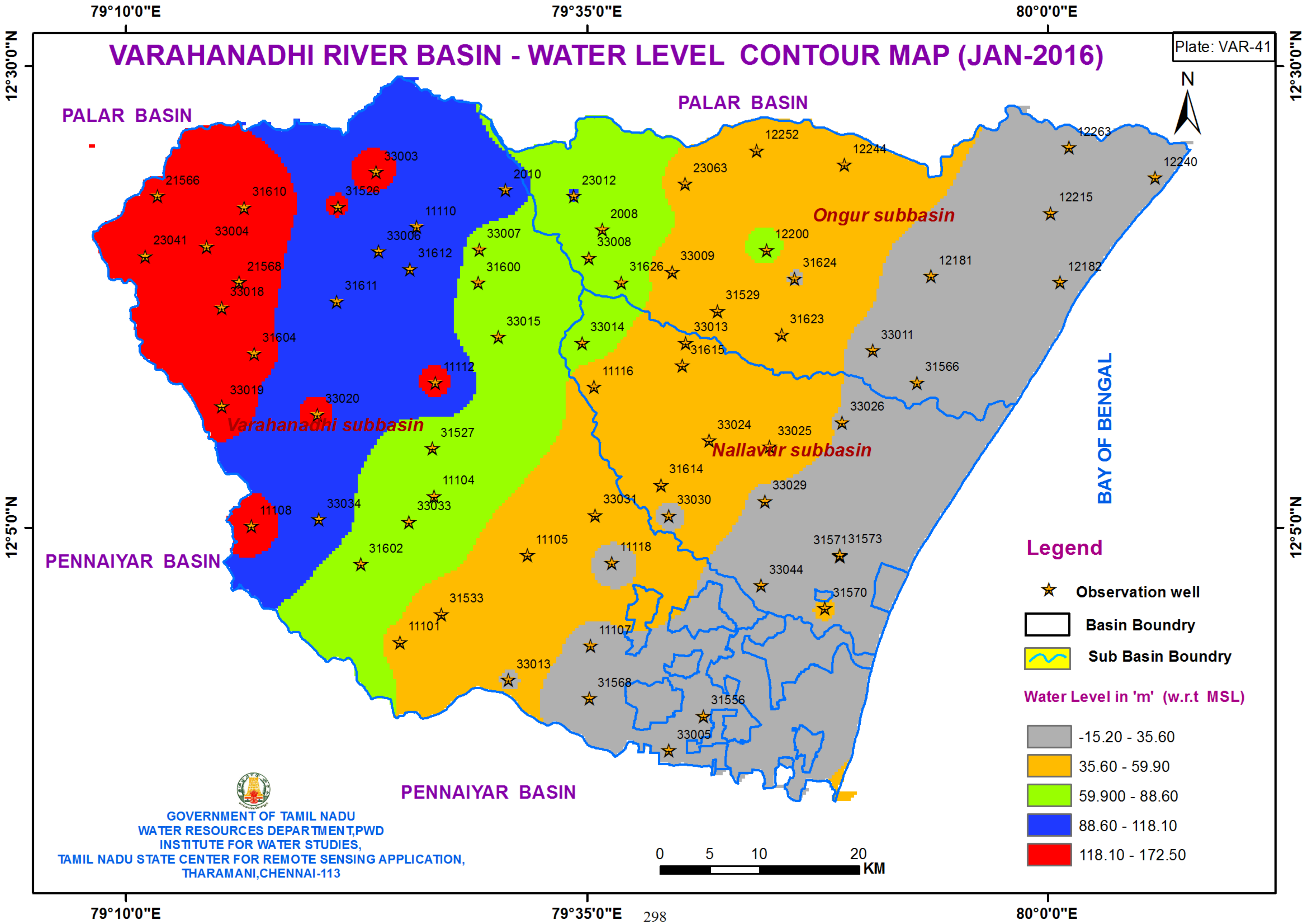
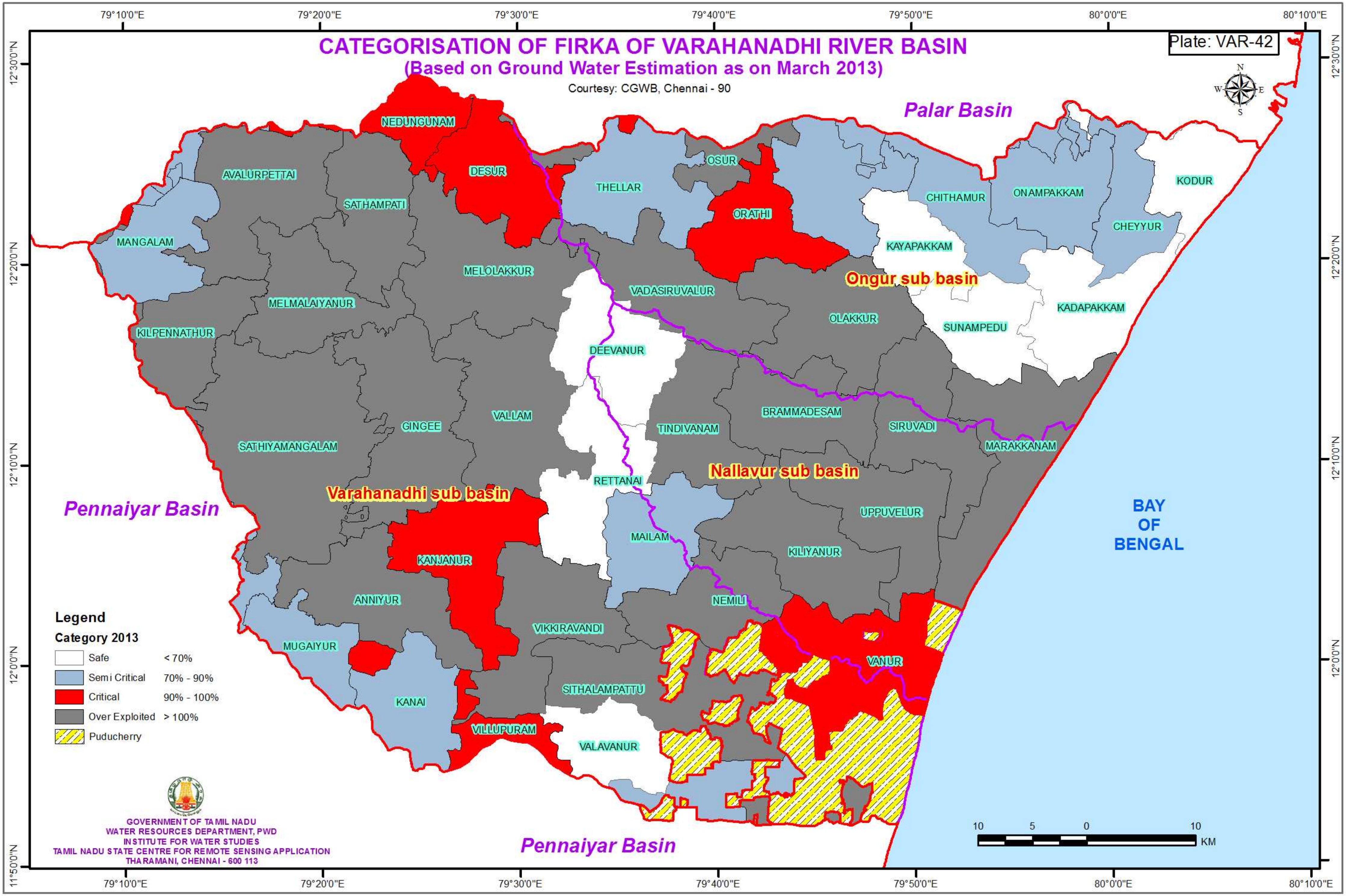
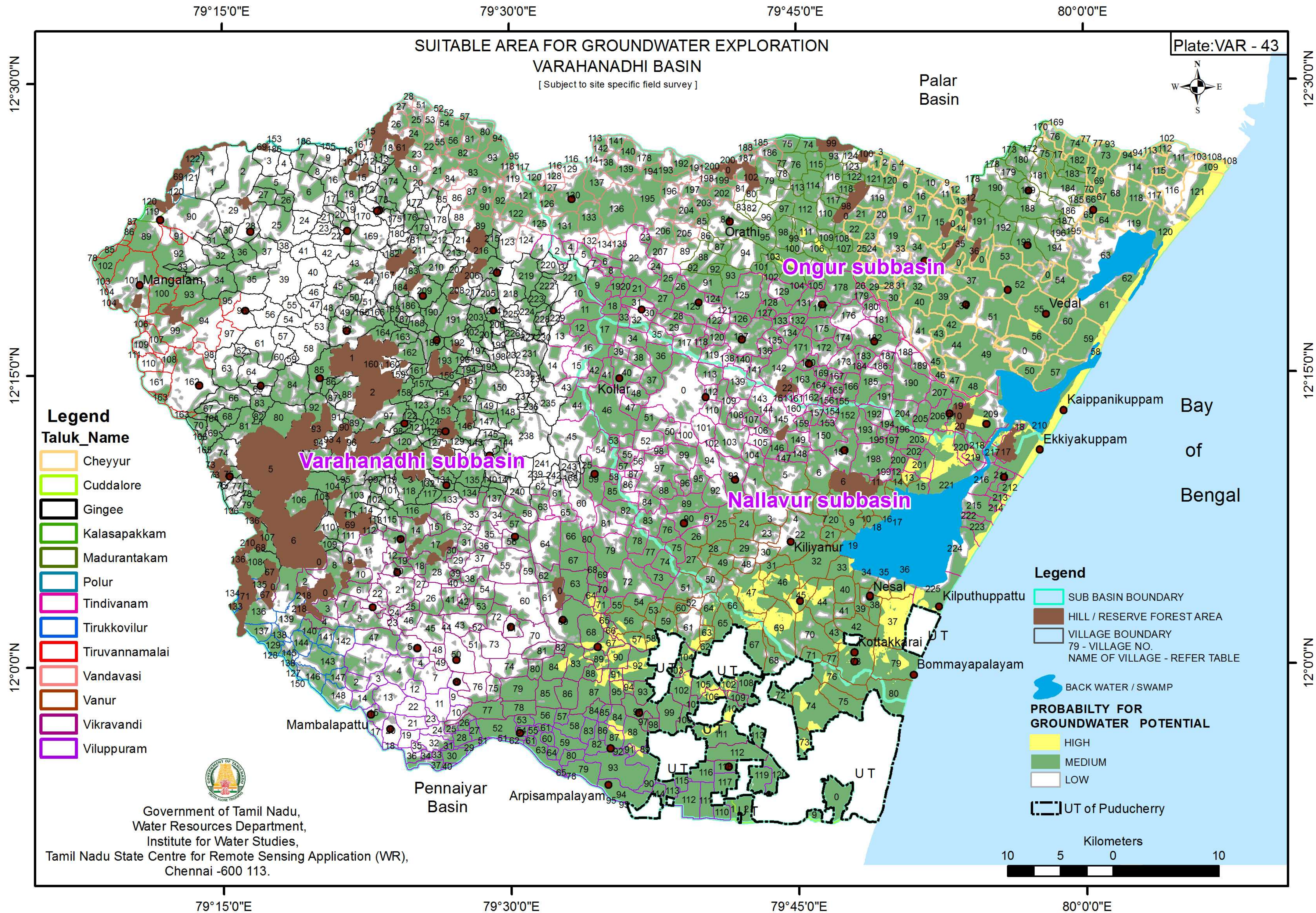
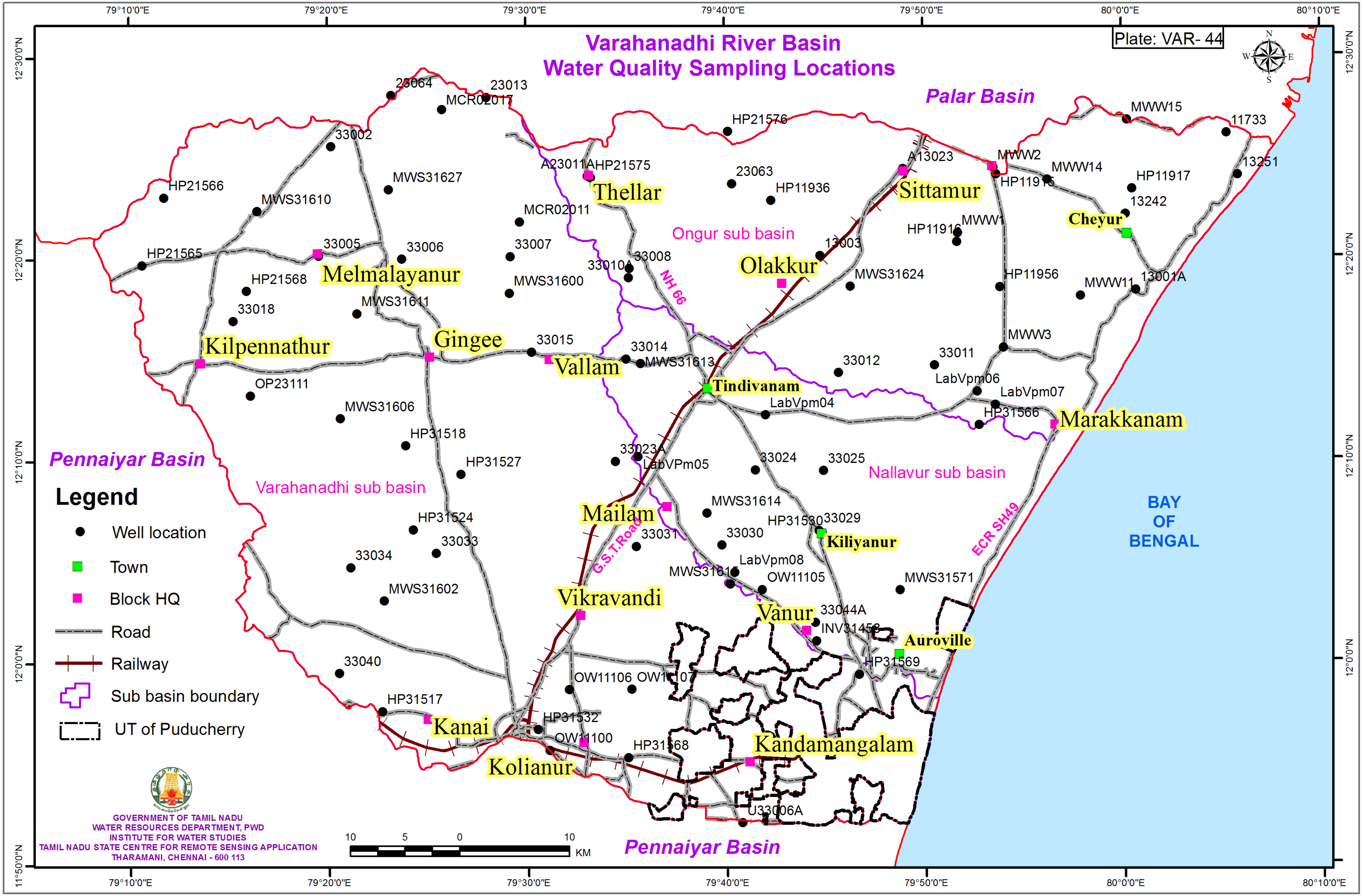

VARAHANADHI RIVER BASIN - WATER LEVEL CONTOUR MAP (JAN-2016)
Plate: VAR-41
79°10'0"E
79°35'0"E
80°0'0"E
12°30'0"N
12°5'0"N
N
PALAR BASIN
PALAR BASIN
PENNAIYAR BASIN
PENNAIYAR BASIN
BAY OF BENGAL
Ongur subbasin
Varahanadhi subbasin
Nallavur subbasin
Legend
Observation well
Basin Boundry
Sub Basin Boundry
Water Level in 'm' (w.r.t MSL)
-15.20 - 35.60
35.60 - 59.90
59.900 - 88.60
88.60 - 118.10
118.10 - 172.50
0 5 10 20
KM
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT,PWD
INSTITUTE FOR WATER STUDIES,
TAMIL NADU STATE CENTER FOR REMOTE SENSING APPLICATION,
THARAMANI,CHENNAI-113



CATEGORISATION OF FIRKA OF VARAHANADHI RIVER BASIN
(Based on Ground Water Estimation as on March 2013)
Courtesy: CGWB, Chennai - 90
Plate: VAR-42
Palar Basin
Pennaiyar Basin
Pennaiyar Basin
BAY OF BENGAL
Ongur sub basin
Nallavur sub basin
Varahanadhi sub basin
NEDUNGUNAM
DESUR
AVALURPETTAI
SATHAMPATI
THELLAR
OSUR
ORATHI
CHITHAMUR
ONAMPAKKAM
KODUR
CHEYYUR
KAYAPAKKAM
MANGALAM
MELOLAKKUR
VADASIRUVALUR
MELMALAIYANUR
OLAKKUR
SUNAMPEDU
KADAPAKKAM
KILPENNATHUR
DEEVANUR
BRAMMADESAM
VALLAM
GINGEE
SIRUVADI
TINDIVANAM
MARAKKANAM
SATHIYAMANGALAM
RETTANAI
UPPUVELUR
MAILAM
KILIYANUR
KANJANUR
ANNIYUR
NEMILI
VIKKIRAVANDI
MUGAIYUR
VANUR
SITHALAMPATTU
KANAI
VILLUPURAM
VALAVANUR
Legend
Category 2013
Safe < 70%
Semi Critical 70% - 90%
Critical 90% - 100%
Over Exploited > 100%
Puducherry
10 5 0 10 KM
N S E W
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI - 600 113
79°10'0"E
79°20'0"E
79°30'0"E
79°40'0"E
79°50'0"E
80°0'0"E
80°10'0"E
12°30'0"N
12°20'0"N
12°10'0"N
12°0'0"N
11°50'0"N


SUITABLE AREA FOR GROUNDWATER EXPLORATION
VARAHANADHI BASIN
[Subject to site specific field survey]
Plate:VAR - 43
Palar Basin
Ongur subbasin
Varahanadhi subbasin
Nallavur subbasin
Bay of Bengal
Pennaiyar Basin
Mangalam
Orathi
Kollar
Vedal
Kaippanikuppam
Ekkiyakuppam
Kiliyanur
Nesal
Kilputhuppattu
Kottakkarai
Bommayapalayam
Mambalapattu
Arpisampalayam
UT
Legend
Taluk_Name
Cheyyur
Cuddalore
Gingee
Kalasapakkam
Madurantakam
Polur
Tindivanam
Tirukkovilur
Tiruvannamalai
Vandavasi
Vanur
Vikravandi
Viluppuram
Legend
SUB BASIN BOUNDARY
HILL / RESERVE FOREST AREA
VILLAGE BOUNDARY
79 - VILLAGE NO.
NAME OF VILLAGE - REFER TABLE
BACK WATER / SWAMP
PROBABILTY FOR GROUNDWATER POTENTIAL
HIGH
MEDIUM
LOW
UT of Puducherry
Kilometers
10 5 0 10
Government of Tamil Nadu,
Water Resources Department,
Institute for Water Studies,
Tamil Nadu State Centre for Remote Sensing Application (WR),
Chennai -600 113.
79°15'0"E
79°30'0"E
79°45'0"E
80°0'0"E
12°30'0"N
12°15'0"N
12°0'0"N



Varahanadhi River Basin
Water Quality Sampling Locations
Plate: VAR- 44
Palar Basin
Pennaiyar Basin
Ongur sub basin
Varahanadhi sub basin
Nallavur sub basin
BAY OF BENGAL
Melmalayanur
Kilpennathur
Gingee
Vallam
Thellar
Olakkur
Sittamur
Cheyur
Tindivanam
Marakkanam
Mailam
Kiliyanur
Vikravandi
Vanur
Auroville
Kanai
Kolianur
Kandamangalam
NH 66
G.S.T.Road
ECR SH49
Legend
Well location
Town
Block HQ
Road
Railway
Sub basin boundary
UT of Puducherry
GOVERNMENT OF TAMIL NADU
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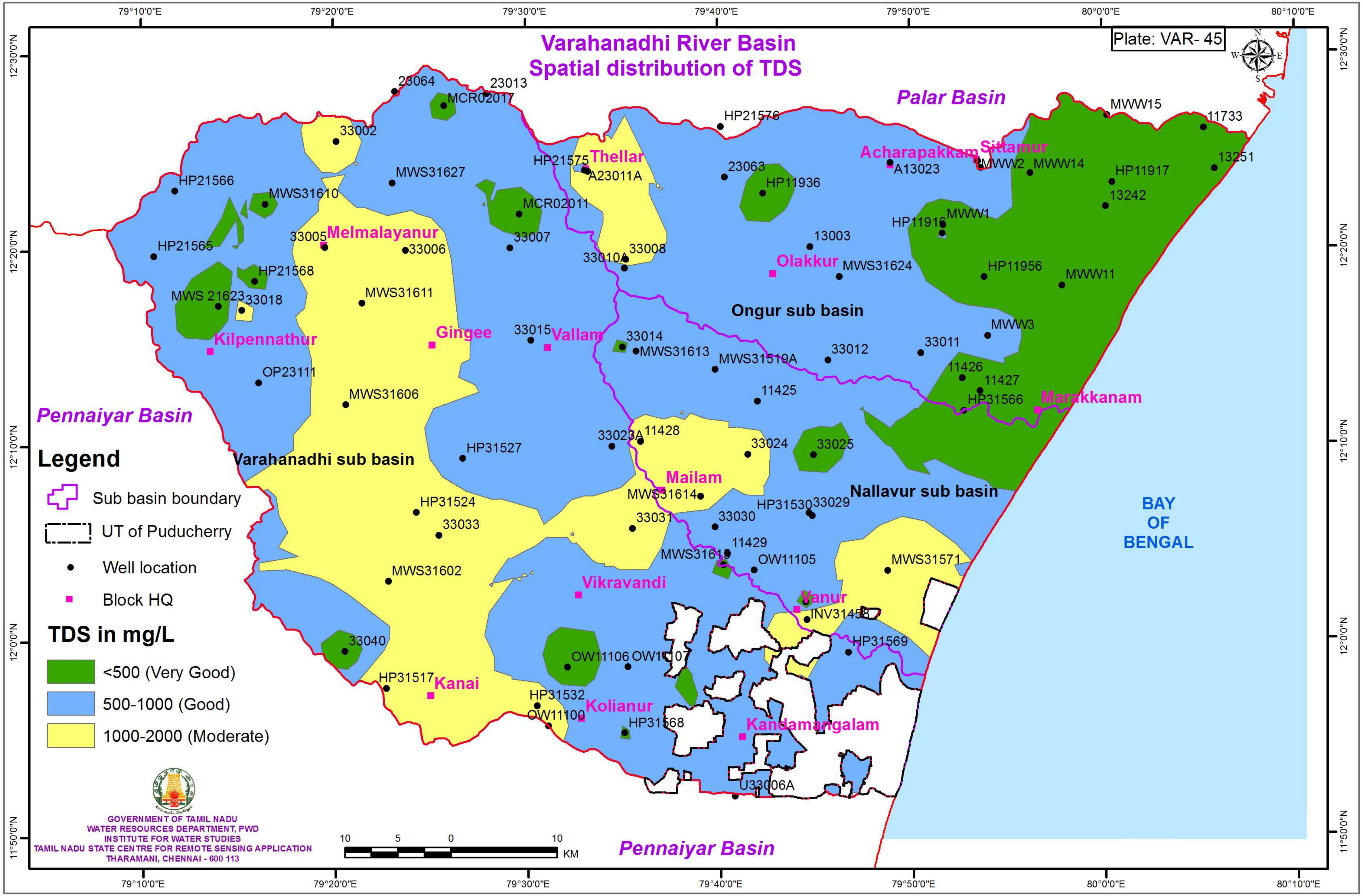
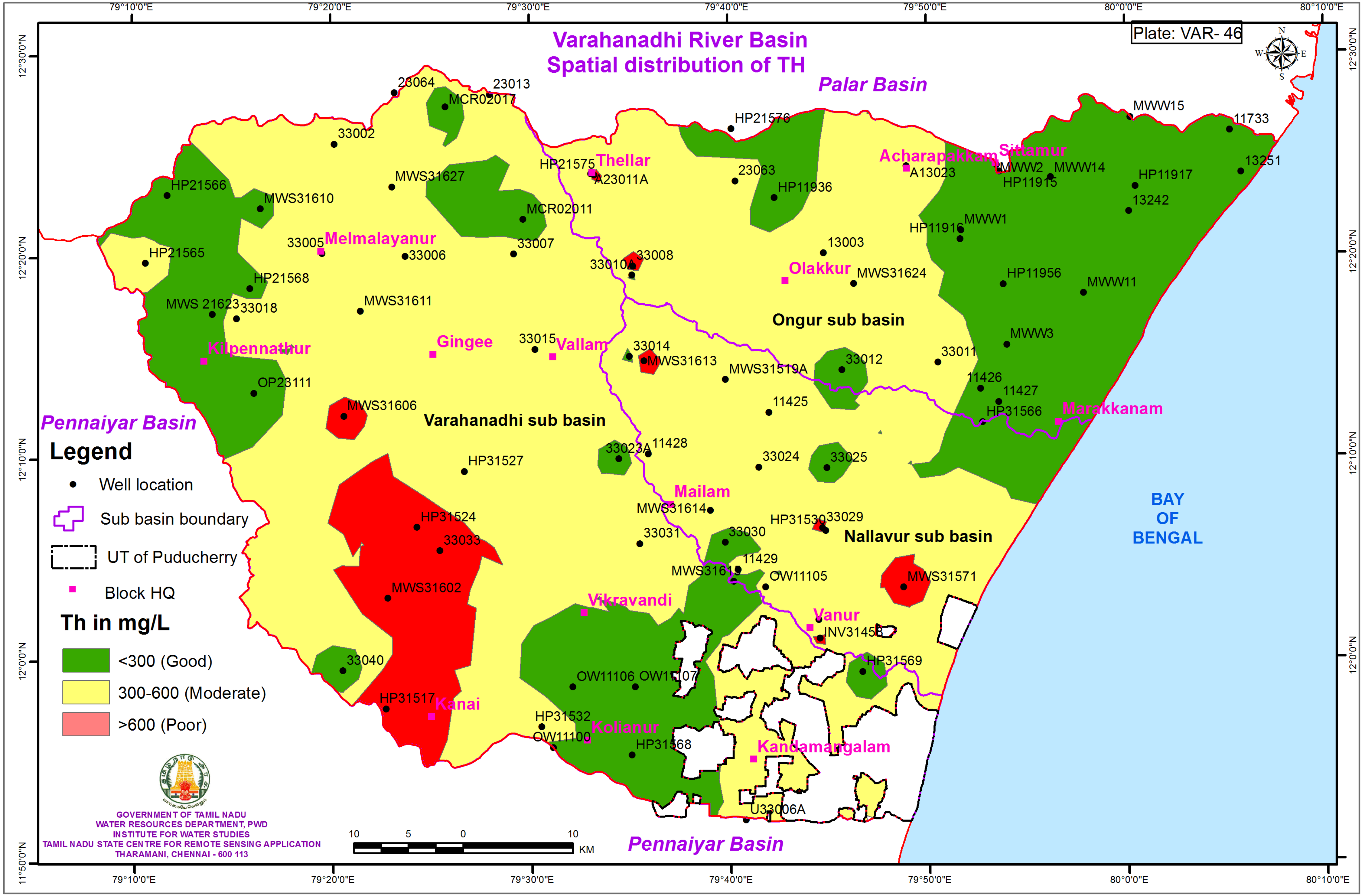
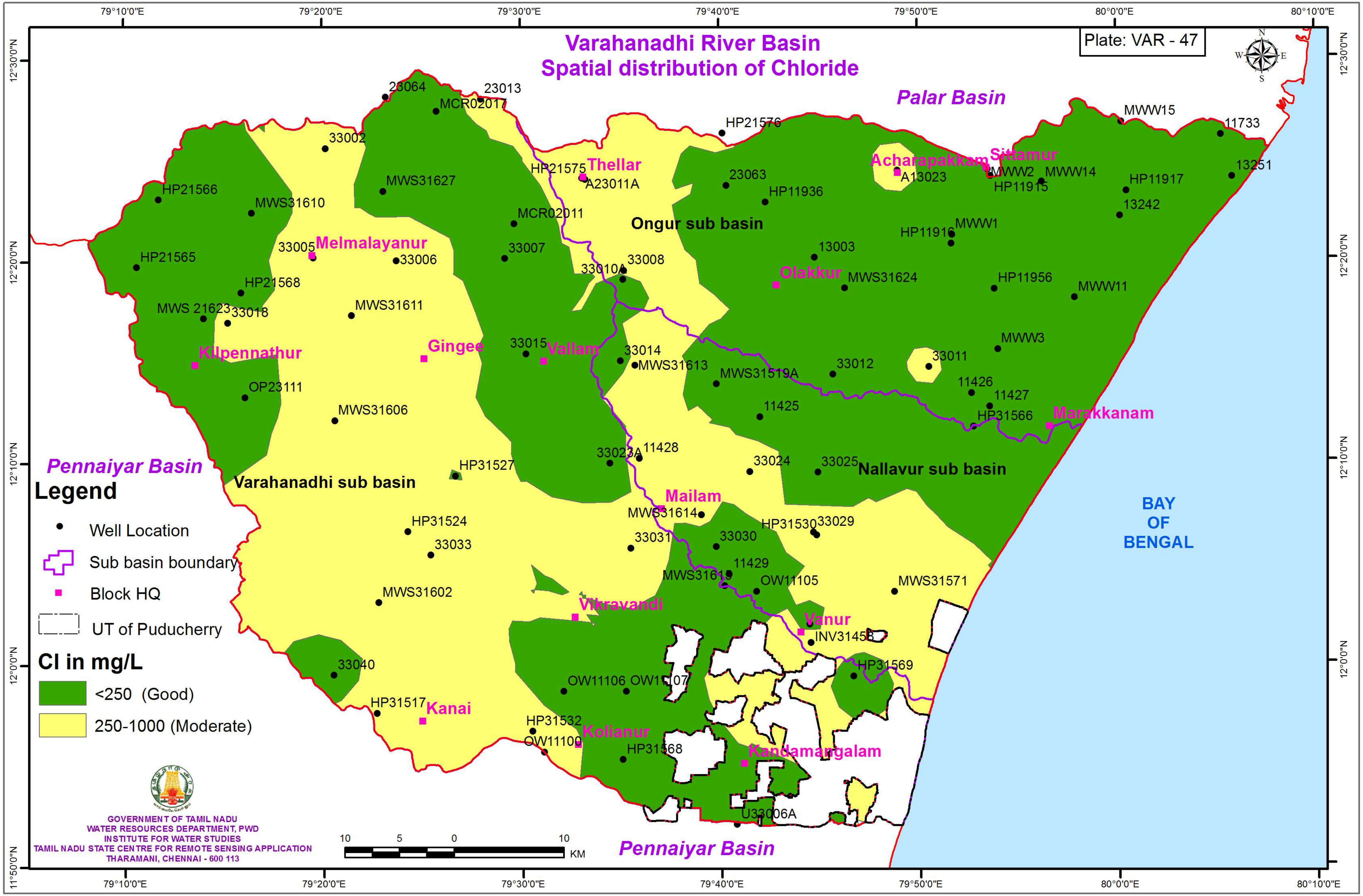
THARAMANI, CHENNAI - 600 113
10 5 0 10 KM



Varahanadhi River Basin
Spatial distribution of TDS
Plate: VAR- 45
N
S
E
W
Palar Basin
Pennaiyar Basin
Pennaiyar Basin
BAY OF BENGAL
Varahanadhi sub basin
Ongur sub basin
Nallavur sub basin
Thellar
Melmalayanur
Kilpennathur
Gingee
Vallam
Olakkur
Acharapakkam
Sittamur
Marakkanam
Mailam
Vikravandi
Vanur
Kanai
Kolianur
Kandamangalam
23064
23013
MCR02017
33002
HP21566
MWS31610
MWS31627
HP21575
A23011A
MCR02011
33005
33006
33007
HP21565
HP21568
MWS 21623
33018
MWS31611
33010A
33008
HP21576
23063
HP11936
A13023
MWW2
MWW14
MWW15
11733
13251
HP11917
13242
HP11916
MWW1
13003
MWS31624
HP11956
MWW11
33015
33014
MWS31613
MWS31519A
33012
33011
MWW3
OP23111
MWS31606
11426
11427
11425
HP31566
33023A
11428
33024
33025
HP31527
MWS31614
HP31524
33033
33031
33030
HP31530
33029
11429
OW11105
MWS31571
MWS31602
INV31458
33040
HP31569
OW11106
HP31517
HP31532
OW11100
HP31568
U33006A
Legend
Sub basin boundary
UT of Puducherry
Well location
Block HQ
TDS in mg/L
<500 (Very Good)
500-1000 (Good)
1000-2000 (Moderate)
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI - 600 113
10 5 0 10
KM
79°10'0"E
79°20'0"E
79°30'0"E
79°40'0"E
79°50'0"E
80°0'0"E
80°10'0"E
12°30'0"N
12°20'0"N
12°10'0"N
12°0'0"N
11°50'0"N



Varahanadhi River Basin
Spatial distribution of TH
Plate: VAR- 46
Palar Basin
Pennaiyar Basin
BAY OF BENGAL
Varahanadhi sub basin
Ongur sub basin
Nallavur sub basin
Legend
Well location
Sub basin boundary
UT of Puducherry
Block HQ
Th in mg/L
<300 (Good)
300-600 (Moderate)
>600 (Poor)
Melmalayanur
Gingee
Vallam
Kilpennathur
Thellar
Olakkur
Acharapakkam
Sitamur
Marakkanam
Mailam
Vikravandi
Vanur
Kanai
Kolianur
Kandamangalam
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI - 600 113
10 5 0 10 KM


Varahanadhi River Basin
Spatial distribution of Chloride
Plate: VAR - 47
Palar Basin
Pennaiyar Basin
Ongur sub basin
Nallavur sub basin
Varahanadhi sub basin
BAY OF BENGAL
Legend
Well Location
Sub basin boundary
Block HQ
UT of Puducherry
Cl in mg/L
<250 (Good)
250-1000 (Moderate)
GOVERNMENT OF TAMIL NADU
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TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI - 600 113
KM

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.

The following are the three types of water use,

- **Withdrawals or abstractions**, where water is taken from a surface or ground water source, and after use returned to a natural water body, e.g., water used for cooling in industrial processes that is returned to a river. Such return flows are particularly important for downstream users provided they are properly treated for pollution.
- **Consumptive water use or water consumption** that starts with a withdrawal or an abstraction, but in this case without any return flow. Water consumption is the water abstracted that is no longer available for use because it has been evaporated, transpired, used for products and crops, consumed by man or livestock or otherwise removed from freshwater resources. Water losses during the transport of water between the points of abstractions and the point of use, (e.g., resulting from leakage from distribution pipes), are excluded from the consumptive water use figure.
- **Non-Consumptive water use** i.e., the in situ use of a water body for navigation, in-stream flow requirements (to meet environmental demands), recreation, effluent disposal and hydroelectric power generation.

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 Varahanadhi 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 Varahanadhi River Basin is projected to the future years 2020, 2030, 2040 & 2050 in this Chapter.

7.1.3 Gap in Supply and Demand

With the change in water use pattern there is a gap between supply and demand. Also the actual demand is found to be more or less than the estimated theoretical demand due to this gap.

On the supply side the generation of water in a catchment area naturally fluctuates, both within years and between years. Water also occurs in different forms that often have different uses. Special reference is made to rainfall and its use in agriculture which cannot be allocated in the same way as water occurring in rivers and aquifers. Dry land agriculture and other land uses too, however, influence the partitioning of rainfall into groundwater recharge, surface runoff and soil moisture storages and can, therefore, significantly influence water availability. Leakage in water supply pipes and the water wasted unaccounted are also the important factor.

On the demand side the following are the various parameters affect demand at a catchment level,

(1) Variability of water demands: Fluctuations in demand are normally much less than those on the supply side. However, for many types of water use, demand increases as water availability decreases (during the dry season).

(2) Degree of water consumption: Much of the water abstracted is typically converted into water vapour, which, in this form cannot be allocated to other users. Water uses that are non-consumptive allow others to use the water afterwards (eg. recreational water uses). However, some non-consumptive uses alter when this water becomes available for other users. A typical example is water used for the generation of hydropower: electricity is needed also during the wet season, and thus water has to be released from dams for power generation when demands from other water use sectors may be low. This results in water that is used for electricity generation being unavailable to other potential users when they need it.

(3) Return flows: Many uses of water generate return flows that in principle are available for other uses. However, return flows are often of lower quality than the water originally abstracted. This may severely limit their re-use. The quality of return flows may pose risks to public health and the environment.

7.1.4 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,

- Leakage in water supply system can be maintained periodically and rectified.
- Improve the supply system and storage structures by properly removing the accumulated silt, weeds and plastic wastes.
- Constructing diversion structures across rivers / streams for diverting and storing flood water.
- Artificial recharge through construction of check dams, anicuts and erection of recharge shafts.
- Construction of rain water harvesting structures for storing the run off both at domestic level (houses) as well as in public sectors (offices, farms etc.)
- Improving the irrigation efficiency by rehabilitation of irrigation structures and adoption of new irrigation techniques.
- The industries need to be monitored for the quantity of ground and surface water used with respect to the sanctioned drawal limit by fixing metering devices.
- The quality of the water let out after use should be monitored and treated accordingly and recycled if possible.
- Recycling and reuse of water to the maximum possible extent for domestic and industrial purposes.

7.2 Domestic Water Supply

The Tamil Nadu Water Supply and Drainage Board (TWAD) is implementing Water Supply Schemes in the Varahanadhi River Basin. The combined water supply schemes (CWSS) provided by the TWAD Board for the varahanadhi River Basin is given below in **table 7.1**. The TWAD Board is supplying 26.71MLD of water and it is benefited by 673092 populations in the Varahanadhi River basin.

Table 7.1 Water Supply Schemes by TWAD

Sl. No	District	Name of CWSS	Location	Type of Source	Designed Quantity in MLD	Population Benefited
1	Vilupuram	Alappakkam CWSS	Ala pakkam	BW	0.50	13200.00
2	Vilupuram	Gingee RTP-Anantha-puram RTP and 10habs	Nerku nam and Emaper	IW & BW	3.14	60700
3	Thiruvanna malai	CWSS to Devikapuram and 11 other habitations	Pallacherry	I.W & B.W.	0.598	10873
4	Thiruvanna malai	CWSS to Menallur H and 10 other habitations in Vembakkam Union	Vayalathur	IW BW OW	0.32	8025
5	Thiruvanna malai	CWSS to Vadailuppai and 25 othrer habitations in Vembakkam Union	Bramma-desam	IW BW	0.71	10060
6	Thiruvanna malai	CWSS to Sodiambakkam and 10 other habitations in Vembakkam Union	Pudu-palayam	IW BW OW	0.53	9650
7	Thiruvanna malai	CWSS to Parasur and 13 other habitations in Cheyyar Union	Keezhathur	IW	0.38	7333
8	Thiruvanna malai	CWSS to Eraiyur and 10 other habitations in Cheyyar Union	Eraiyur	IW	0.46	8318
9	Thiruvanna malai	CWSS to Kilkodungalore and 76 other habitations in Vandavasi Union	Hanumanth an dalam	IW	0.94	32227
10	Thiruvanna malai	CWSS to Thenpoondipattu and 9 other habitations in Cheyyar Union.	Near Arugavur	IW	0.182	4624
11	Cuddalore	Kazhuthur & 7 other habs	Keel siruvai	BW	0.210	6186
12	Cuddalore	Veppur & 11 other habs	Eraiyur	BW	0.320	8138
13	Kancheepuram	Tambaram - Pallavaram CWSS	Palayaseeva ram, Vengudi, Pullambakk am and Melacheri	IW, BW, IG	14.42	455602
14	Kancheepuram	Sembur, Thandarai	Thandarai	BW	0.12	2850
15	Kancheepuram	Budur-Thatchur CWSS	Budur	BW, IW	0.06	1506
16	Kancheepuram	CWSS to Padur & 13 other habs.	Thiru mukkudal	BW, IW	0.1	7800
17	Kancheepuram	Maraimalai Nagar	Nerumbur, Ayapakkam	IW, BW	3.72	26000
	Total				**26.71**	**673092.00**

IW –Infiltration Well, BW-Bore Well, OW-Open Well, IG- Infiltration Gallery

7.3 Domestic Water Demand

Domestic consumption of water per capita is the amount of water consumed per person for the purposes of ingestion, hygiene, cooking, washing of utensils and other household purposes including garden uses. This is an indicator of the quantity of water needed and/or available to individuals in particular communities for their basic needs. It helps to identify communities where these basic requirements are not being met enabling actions to be planned and priorities for water supply development to be set. With the increase in economic and social development of the people the per capita requirement of domestic water may also increase. Domestic water requirement is closely linked with several socio-economic and environmental indicators, such as population, growth rate, population density, growth rate of urban population, land use change, annual withdrawals of ground and surface water, and irrigation percentage of cultivable land etc,.

The Central Public Health and Environmental Engineering Organization (CPHEEO) recommended the norms for per capita water demand is given in **Table 7.2** as follows:-

Table 7.2: Recommended Norms for Per Capita Water Supply by CPHEEO

Sl. No	Classification of towns/cities	Recommended maximum water supply levels (lpcd)
1	Towns provided with piped water supply but without sewerage system	70
2	Cities provided with piped water supply where sewerage system is existing/contemplated	135
3	Metropolitan and Mega cities provided with piped water supply where sewerage system is existing/contemplated	150

In the above norms, **an additional 15%** should be included 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 Varahanadhi River Basin as per census 2011 given in Chapter 2 of this report is used for calculating the domestic water requirement.

7.3.1 Future Domestic Water Demand

The domestic water requirement may increase in future with the increase in population, development in living standards of the people, etc. The annual growth rate to be used for estimation of population in the river basin is given below:-

Population Sector	Annual Growth Rates
Urban	2 % per year
Rural	1 % per year

The accepted average growth rate as described above is applied in the population projection calculation. Exponential growth formula is adopted for the population growth in the present study.

Exponential Growth Formula Method

The exponential growth formula is

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

Where P_t = Population after'ť' years

P_o = Population in the beginning years

X = Annual growth rate

t = Period in years

Exponential interpolations of, possible changes in trends of growth rates resulting from economic or cultural development, or differences in observed growth rates between various sub-basins or inter basin migrations are taken into account in this method of population projection.

The population of Varahanadhi River Basin arrived in Chapter 2 sub basin wise is projected for the present year 2017 and the target years 2020, 2030, 2040 & 2050. The sub-basin wise population projection for the Varahanadhi river basin for the present year 2017 and the target years 2020, 2030, 2040 & 2050 are arrived as **2.393 million, 2.477 million, 2.784 million, 3.132 million & 3.53 million** respectively and is given in **Table No. 7.3.**

Accordingly, the domestic water demand for the present year 2017 and the target years 2020, 2030, 2040 & 2050 are obtained as **80.502Mcum, 83.621Mcum, 95.038Mucm, 108.232Mcum & 123.520Mcum** respectively and are given in **Table No. 7.4.**

Table 7.3 Sub basin wise Projected Population for Varahanadhi River Basin

Population in Million

Sl. No.	Name of the Sub Basin	Actual			Projected Population														
		Population in 2011			Population during 2017			Population during 2020			Population during 2030			Population during 2040			Population during 2050		
		Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
1	Nallavur	0.279	0.094	0.373	0.296	0.106	0.402	0.305	0.112	0.417	0.337	0.137	0.474	0.372	0.167	0.539	0.411	0.203	0.615
2	Ongur	0.52	0.055	0.575	0.552	0.062	0.614	0.569	0.066	0.634	0.628	0.080	0.708	0.694	0.098	0.792	0.767	0.119	0.886
2	Varahanadhi	1.089	0.196	1.285	1.156	0.221	1.377	1.191	0.234	1.425	1.316	0.286	1.601	1.453	0.348	1.801	1.605	0.424	2.030
Total		**1.888**	**0.345**	**2.233**	**2.004**	**0.389**	**2.393**	**2.065**	**0.412**	**2.477**	**2.281**	**0.503**	**2.784**	**2.52**	**0.613**	**3.132**	**2.783**	**0.747**	**3.53**

Table 7.4 Sub basin wise Projected Domestic Water Demand for Varahanadhi River Basin

Water Demand in Mcum

Sl.No	Name of the Sub Basin	Water Demand 2017			Water Demand 2020			Water Demand 2030			Water Demand 2040			Water Demand 2050		
		Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
1	Nallavur	8.648	5.989	**14.637**	8.910	6.356	**15.266**	9.842	7.747	**17.590**	10.872	9.444	**20.316**	12.009	11.512	**23.522**
2	Ongur	16.118	3.504	**19.622**	16.607	3.719	**20.325**	18.344	4.533	**22.877**	20.263	5.526	**25.789**	22.383	6.736	**29.119**
3	Varahanadhi	33.755	12.488	**46.243**	34.778	13.252	**48.030**	38.416	16.154	**54.571**	42.436	19.692	**62.127**	46.875	24.004	**70.880**
Total		**58.521**	**21.981**	**80.502**	**60.294**	**23.326**	**83.621**	**66.603**	**28.435**	**95.037**	**73.571**	**34.662**	**108.232**	**81.268**	**42.252**	**123.520**

7.4 Irrigation Demand

Agriculture is the prime driving force for food security, rural economy and sustainable socio economic development of farmers. A fast growing agriculture sector alone can increase the agricultural production, raise the per capita income of the rural community and create avenues for localized Employment, slowing down migration towards urban areas.

The technological breakthrough in increasing the productivity and cultivable area has removed the impasse in Agriculture production and paved way for the state to surpass 100 Lakh MT of food grain production in 2011-12,2012-13, 2013-14, 2014-15 and 2015-16. As per the final estimate of 2015-16, the food grain production of the State is 113.69 Lakh MT.

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 Irrigation for agriculture.

The requirement of irrigation water is arising out of the necessity to supplement water to the crops either due to aridity and drought or for ensuring the best possible crop returns. The Cropping pattern mainly depends on change in market and climatic conditions and also as per the farmer's choice. Irrigation water demand for 75% rainfall dependability of Varahanadhi River Basin is tabulated in **Table 7.5** and the season wise Irrigation water demand (mcm) at 75 % rainfall dependability in Varahanadhi basin is tabulated in **Table 7.6**

The major crops cultivated in Varahanadhi Basin are Paddy, Sugarcane, Ground nut, Blackgram and Fruits & Vegetables. The irrigated area for the year 2015-16 in Varahanadhi Basin under different crops is 1,98,758 ha with paddy as the main crop of the basin cultivated in 1,20,667 ha. In the remaining area, other crops are cultivated.

Table 7.5 Irrigation Water Demand (Mcm) At 75 % Rainfall Dependability

Sl.No	Sub Basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	Varahanadhi	35.99	4.14	61.52	80.62	90.96	338.50	169.72	186.16	29.27	52.19	19.88	41.78	**1110.73**
2	Nallavur	5.79	3.98	6.58	14.22	12.36	58.50	24.15	30.12	5.08	12.06	3.40	5.93	**182.17**
3	Ongur	13.03	4.54	7.66	13.88	20.67	122.01	33.54	94.16	48.56	26.02	9.91	15.34	**409.32**
TOTAL		54.80	12.66	75.76	108.72	124.00	519.01	227.40	310.44	82.92	90.27	33.18	63.05	**1702.22**

Table 7.6 Irrigation Water Demand (Mcm) At 75 % Rainfall Dependability in Varahanadhi Basin (Season Wise)

Sub Basin	Winter	Summer	Southwest	Northeast	Total
Varahanadhi	40.12	233.10	723.66	113.85	1110.73
Nallavur	9.77	33.16	117.85	21.38	182.17
Ongur	17.57	42.22	298.27	51.27	409.32
Total	67.46	308.48	1139.77	186.50	1702.22

7.5 Industrial Water Demand

The department of Industries and Commerce has classified the industries as large, medium and small scale industries. The list of small, medium and large scale industries in Cuddalore, Kancheepuram, Thiruvannamali and Villupuram 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 Varahanadhi River Basin are listed out. At present in the Varahanadhi River Basin there are 54 numbers of large and medium industries and 852 numbers of small scale industries. Accordingly, the yearly requirement of water for Large & Medium and small scale industries at present is estimated as **11.779 Mcum.** The Sub Basin wise water requirement of Industries is given in **Table 7.8.**

7.5.1 Industrial water Demand Projection

For forecasting the water demand of Industries for future years, a simple arithmetic increase of 8% per annum (as per the Annual Survey of Industries) over the present requirement has been adopted.

The demand for small scale Industries during 2017 is estimated as 3.838 Mcum. The demand for the small scale Industries is projected for the target years 2020, 2030, 2040 & 2050 are estimated as 4.758 Mcum, 8.566 Mcum, 15.419 Mcum & 27.753 Mcum respectively and is given in Table 7.7(a).

The Sub Basin wise details of small scale Industries in Varahanadhi River Basin is given in Appendix 7.1 to 7.3.

The demand for large & medium scale Industries during 2017 is estimated as 7.941Mcum.The demand for large & medium scale industries projected for the target years 2020, 2030, 2040 & 2050 are estimated as 9.849 Mcum, 17.726 Mcum, 31.906 Mcum & 57.432 Mcum and is given in Table 7.7(b). The Subbasin wise details of large & medium scale Industries in Varahanadhi River Basin is given in Appendix 7.4 to 7.6.

The total Industrial water demand of Varahanadhi River Basin for the year 2017, 2020, 2030, 2040 & 2050 are estimated as 11.770 Mcum, 14.607 Mcum, 26.292 Mcum, 47.325 Mcum & 85.185 Mcum respectively and is given in table 7.8.

Table 7.7 (a) Water Demand of Small Scale Industries in Varahanadhi River Basin

Sl.No.	Name of the Sub Basin	2017		2020		2030		2040		2050	
		Number of Industries	Water Demand in Mcum	Number of Industries	Water Demand in Mcum	Number of Industries	Water Demand in Mcum	Number of Industries	Water Demand in Mcum	Number of Industries	Water Demand in Mcum
1	Nallavur	270	1.622	335	2.011	603	3.620	1085	6.516	1953	11.728
2	Ongur	124	1.505	154	1.866	277	3.360	498	6.047	897	10.885
3	Varahanadhi	458	0.711	568	0.881	1022	1.586	1840	2.856	3312	5.140
Total		**852**	**3.838**	**1057**	**4.758**	**1902**	**8.566**	**3423**	**15.419**	**6162**	**27.753**

Table 7.7 (b) Water Demand of Large & Medium Scale Industries in Varahanadhi River Basin

Sl.No.	Name of the Sub Basin	2017		2020		2030		2040		2050	
		Number of Industries	Water Demand in Mcum	Number of Industries	Water Demand in Mcum	Number of Industries	Water Demand in Mcum	Number of Industries	Water Demand in Mcum	Number of Industries	Water Demand in Mcum
1	Nallavur	12	0.816	15	1.012	27	1.821	48	3.278	87	5.900
2	Ongur	6	3.050	7	3.783	13	6.809	24	12.255	43	22.060
3	Varahanadhi	36	4.075	45	5.054	80	9.096	145	16.373	260	29.472
Total		**54**	**7.941**	**67**	**9.849**	**120**	**17.726**	**217**	**31.906**	**390**	**57.432**

Table 7.8 Total Industrial Water Demand in Varahanadhi River Basin

Water Demand in Mcum

Sl. No	Name of the Sub Basin	2017			2020			2030			2040			2050		
		L&MI	SSI	Total	L&MI	SSI	Total	L&MI	SSI	Total	L&MI	SSI	Total	L&MI	SSI	Total
1	Nallavur	0.816	1.622	**2.438**	1.012	2.011	**3.023**	1.821	3.620	**5.441**	3.278	6.516	**9.794**	5.900	11.728	**17.628**
2	Ongur	3.050	1.505	**4.555**	3.783	1.866	**5.649**	6.809	3.360	**10.169**	12.255	6.047	**18.302**	22.060	10.885	**32.945**
3	Varahanadhi	4.075	0.711	**4.786**	5.054	0.881	**5.935**	9.096	1.586	**10.682**	16.373	2.856	**19.229**	29.472	5.140	**34.612**
Total		**7.941**	**3.838**	**11.779**	**9.849**	**4.758**	**14.607**	**17.726**	**8.566**	**26.292**	**31.906**	**15.419**	**47.325**	**57.432**	**27.753**	**85.185**

7.6 Live stock Water Demand

Tamil Nadu has vast resource of livestock and poultry, 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, changing taste and preference and increased awareness about food nutrition. Also with the rapid increase in human population the demand for livestock based products also increases and there is a significant growth of certain species of livestock.

The 19th livestock census 2012, 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 Varahanadhi River Basin. The livestock population details of each sub basins are given in **Appendix 7.7 to 7.9.**

The norms of the Indian Council of Agriculture and Research for the live stock per capita water requirement have been adopted in the estimation of livestock water demand and are given in **Table 7.9**

Table 7.9 Per Capita Water Requirement for Live Stock

Sl. No.	Name	Standard Norms in lpcd
1	Cattle	110
2	Buffalo	150
3	Sheep	20
4	Goats	20
5	Horses & Ponies	150
6	Donkeys	40
7	Pigs	40
8	Dogs	15
9	Rabbits	0.35
10	Poultry	0.25

To predict the future livestock water demand in the basin, the present livestock population needs to be projected.

The census on livestock, poultry is conducted once in 5 years since 1951. To calculate the growth rate of different species of livestock, the 18th and 19th census of livestock conducted by the Department of Animal Husbandry, Tamil Nadu during 2007and 2012 is taken to calculate growth rate of different species of livestock in Tamil Nadu and is given in **Appendix 7.10.** The growth rate of livestock population is calculated using the formula,

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

Where, G = Annual growth rate
Yo = Population of livestock species in base year
Yt = Population in t^{th} year
t = Number of years (Current year – Base year)

It shows that among the various species of livestock the growth rate of donkeys, rabbit and farm poultry shows increasing trend because of the increasing need of the products from them. Hence for estimating the future livestock water demand, the present live stock demand arrived for various species of livestock can be projected with respect to the growth rate.

Table 7.10 Growth rate of various species of Livestock in Tamil Nadu

Sl.No.	Name of the Livestock	Annual growth rate in %
1	Cattle	-4.66%
2	Buffalo	-17.23%
3	Sheep	-9.74%
4	Goat	-2.57%
5	Horses & Ponies	-4.29%
6	Donkeys	13.97%
7	Pig	-8.34%
8	Dog	-3.40%
9	Rabbit	31.05%
10	Backyard Poultry	-13.94%
11	Farm Poultry	0.32%

From the 19th livestock census data the sub basin wise livestock population is arrived and projected for the present year 2017 and for the target years 2020, 2030, 2040 & 2050 and is presented in **Table No. 7.11.** The livestock water demand during 2017, 2020, 2030, 2040 & 2050 is worked out as 17.266 Mcum, 14.938 Mcum, 9.407 Mcum, 6.426 Mcum & 10.088 Mcum respectively and presented in **Table 7.12.** There is no elephants and camel in Varahanadhi River Basin.

Table 7.11 Sub Basin wise Projected Livestock Population in Varahanadhi River Basin

Sl. No	Year	Livestock	Livestock Population			Total
			Nallavur	Ongur	Varahanadhi	
1	2012	Cattle	63177	95266	299163	457606
		Buffallo	1902	2046	2926	6874
		Sheep	20329	41930	102369	164628
		Goat	36082	47903	163635	247620
		Horses & Ponies	0	3	13	16
		Donkeys	0	0	15	15
		Pigs	40	362	4956	5358
		Dog	2779	3187	18052	24018
		Rabbit	180	159	1318	1657
		Backyard Poultry	51189	48004	169986	269179
		Farm Poultry	235293	506150	1035935	1777378
		Total	**410971**	**745010**	**1798368**	**2954349**
2	2017	Cattle	49766	75044	235659	360469
		Buffallo	739	795	1137	2670
		Sheep	12178	25119	61326	98623
		Goat	31678	42056	143661	217395
		Horses & Ponies	0	2	10	13
		Donkeys	0	0	29	29
		Pigs	26	234	3206	3467
		Dog	2338	2681	15185	20203
		Rabbit	696	615	5094	6405
		Backyard Poultry	24165	22661	80245	127071
		Farm Poultry	239082	514300	1052616	1805999
		Total	**360667**	**683507**	**1598170**	**2642344**
3	2020	Cattle	43128	65034	204225	312387
		Buffallo	419	451	645	1514
		Sheep	8955	18471	45095	72521
		Goat	29298	38896	132867	201061
		Horses & Ponies	0	2	9	11
		Donkeys	0	0	43	43
		Pigs	20	180	2469	2670
		Dog	2107	2417	13688	18212
		Rabbit	1566	1383	11466	14415
		Backyard Poultry	15402	14444	51147	80994
		Farm Poultry	241384	519253	1062754	1823392
		Total	**342280**	**660531**	**1524409**	**2527219**

Sl. No	Year	Livestock	Livestock Population			Total
			Nallavur	Ongur	Varahanadhi	
4	2030	Cattle	26762	40354	126724	193840
		Buffallo	63	68	97	229
		Sheep	3214	6629	16184	26027
		Goat	22582	29980	102411	154972
		Horses & Ponies	0	1	6	7
		Donkeys	0	0	158	158
		Pigs	8	75	1034	1117
		Dog	1491	1710	9685	12886
		Rabbit	23396	20666	171310	215372
		Backyard Poultry	3432	3219	11398	18050
		Farm Poultry	249221	536111	1097256	1882588
		Total	**330169**	**638814**	**1536263**	**2505246**
5	2040	Cattle	16606	25040	78634	120281
		Buffallo	10	10	15	34
		Sheep	1153	2379	5808	9341
		Goat	17405	23108	78935	119449
		Horses & Ponies	0	1	4	5
		Donkeys	0	0	584	584
		Pigs	3	32	433	468
		Dog	1055	1210	6853	9118
		Rabbit	349550	308769	2559482	3217801
		Backyard Poultry	765	717	2540	4022
		Farm Poultry	257312	553516	1132878	1943705
		Total	**643859**	**914782**	**3866166**	**5424808**
5	2050	Cattle	10304	15538	48794	74636
		Buffallo	1	2	2	5
		Sheep	414	854	2084	3352
		Goat	13416	17811	60841	92068
		Horses & Ponies	0	1	2	3
		Donkeys	0	0	2158	2158
		Pigs	1	13	181	196
		Dog	746	856	4849	6452
		Rabbit	5222512	4613219	38240395	48076126
		Backyard Poultry	170	160	566	896
		Farm Poultry	265665	571485	1169657	2006807
		Total	**5513231**	**5219938**	**39529531**	**50262700**

Table 7.12 Sub Basin wise Livestock Water Demand in Varahanadhi River Basin

Sl. No	Year	Livestock	Standard Norms in lpcd	Live Stock Water Demand in Mcum			
				Nallavur	Ongur	Varahanadhi	Total
1	2017	Cattle	**110**	1.998	3.013	9.462	14.473
		Buffallo	**150**	0.040	0.044	0.062	0.146
		Sheep	**20**	0.089	0.183	0.448	0.720
		Goat	**20**	0.231	0.307	1.049	1.587
		Horses & Ponies	**150**	0.000	0.000	0.001	0.001
		Donkeys	**40**	0.000	0.000	0.000	0.000
		Pigs	**40**	0.000	0.003	0.047	0.051
		Dog	**15**	0.013	0.015	0.083	0.111
		Rabbit	**0.35**	0.000	0.000	0.001	0.001
		Backyard Poultry	**0.25**	0.002	0.002	0.007	0.012
		Farm Poultry	**0.25**	0.022	0.047	0.096	0.165
Total				**2.396**	**3.614**	**11.255**	**17.266**
2	2020	Cattle	**110**	1.732	2.611	8.200	12.542
		Buffallo	**150**	0.023	0.025	0.035	0.083
		Sheep	**20**	0.065	0.135	0.329	0.529
		Goat	**20**	0.214	0.284	0.970	1.468
		Horses & Ponies	**150**	0.000	0.000	0.001	0.001
		Donkeys	**40**	0.000	0.000	0.001	0.001
		Pigs	**40**	0.000	0.003	0.036	0.039
		Dog	**15**	0.012	0.013	0.075	0.100
		Rabbit	**0.35**	0.000	0.000	0.001	0.002
		Backyard Poultry	**0.25**	0.001	0.001	0.005	0.007
		Farm Poultry	**0.25**	0.022	0.047	0.097	0.166
Total				**2.069**	**3.119**	**9.749**	**14.938**
3	2030	Cattle	**110**	1.074	1.620	5.088	7.783
		Buffallo	**150**	0.003	0.004	0.005	0.013
		Sheep	**20**	0.023	0.048	0.118	0.190
		Goat	**20**	0.165	0.219	0.748	1.131
		Horses & Ponies	**150**	0.000	0.000	0.000	0.000
		Donkeys	**40**	0.000	0.000	0.002	0.002
		Pigs	**40**	0.000	0.001	0.015	0.016
		Dog	**15**	0.008	0.009	0.053	0.071
		Rabbit	**0.35**	0.003	0.003	0.022	0.027
		Backyard Poultry	**0.25**	0.000	0.000	0.001	0.002
		Farm Poultry	**0.25**	0.023	0.049	0.100	0.172
Total				**1.301**	**1.954**	**6.153**	**9.407**

Sl. No	Year	Livestock	Standard Norms in lpcd	Live Stock Water Demand in Mcum			Total
				Nallavur	Ongur	Varahanadhi	
4	2040	Cattle	**110**	0.667	1.005	3.157	4.829
		Buffalo	**150**	0.001	0.001	0.001	0.002
		Sheep	**20**	0.008	0.017	0.042	0.068
		Goat	**20**	0.127	0.169	0.576	0.872
		Horses & Ponies	**150**	0.000	0.000	0.000	0.000
		Donkeys	**40**	0.000	0.000	0.009	0.009
		Pigs	**40**	0.000	0.000	0.006	0.007
		Dog	**15**	0.006	0.007	0.038	0.050
		Rabbit	**0.35**	0.045	0.039	0.327	0.411
		Backyard Poultry	**0.25**	0.000	0.000	0.000	0.000
		Farm Poultry	**0.25**	0.023	0.051	0.103	0.177
Total				**0.877**	**1.289**	**4.260**	**6.426**
5	2050	Cattle	**110**	0.414	0.624	1.959	2.997
		Buffalo	**150**	0.000	0.000	0.000	0.000
		Sheep	**20**	0.003	0.006	0.015	0.024
		Goat	**20**	0.098	0.130	0.444	0.672
		Horses & Ponies	**150**	0.000	0.000	0.000	0.000
		Donkeys	**40**	0.000	0.000	0.032	0.032
		Pigs	**40**	0.000	0.000	0.003	0.003
		Dog	**15**	0.004	0.005	0.027	0.035
		Rabbit	**0.35**	0.667	0.586	4.885	6.138
		Backyard Poultry	**0.25**	0.000	0.000	0.000	0.000
		Farm Poultry	**0.25**	0.024	0.052	0.107	0.183
Total				**1.210**	**1.403**	**7.471**	**10.088**

7.7 Aquaculture Water Demand

Tamil Nadu is blessed with rich and diverse aquatic resources and is one of the leading States in India with respect to Fisheries Development. The Fisheries resources in the State provide livelihood to more than ten lakh fishermen including those who involve in inland and brackish water fishing.

Aquaculture is emerging as a prominent income generating activity in rural areas. On integration with Agriculture, it will augment the unit productivity. The different types of aquatic resources in Tamilnadu like marine, freshwater, brackish water, riverine stretches, cold water streams in upland area are bestowed with rich biodiversity of aqauatic fauna and flora. The fisheries in the state are one of the vital sources for food security.

In addition to extensive fish culture system on reservoirs and ponds, there are greater possibilities to introduce and expand rural and commercial aquaculture within controlled environment. The present and future socio-economic conditions in the country equally support fish development. Aquaculture requires sufficient water supply of the required quality. Recreational fishing is an additional opportunity that water resources can provide and to be integrated with tourism.

The District wise water requirement details for aquaculture was obtained from the Assistant Director of Fisheries and are distributed to the sub basins of Varahanadhi River Basin. The sub basin wise aquaculture demand is arrived and is presented in **Table No. 7.13.**

Table 7.13 Sub Basin wise Aquaculture Water Demand in Varahanadhi River Basin

Name of Sub basin	Water demand 2017 in Mcum
Nallavur	0.000
Ongur	0.059
Varahanadhi	0.240
Total	**0.299**

For forecasting the future aquaculture water demand, it is assumed that there is no increase in fish farms as the fishes are seeded in the same water bodies.

7.8 Power Generation (Hydro-Electric)

There was no Hydro-electric power station functioning within the Varahanadhi River Basin. Hence there was no water demand for Power generation.

7.9 Total Water Demand

The sub basin wise total water demand of five sectors, i.e., Domestic, Irrigation, Livestock, Industries and Aquaculture of Varahanadhi River Basin for the present year 2017 and the projected target years 2020, 2030, 2040 & 2050 are worked out as **1812.065 Mcum, 1815.684 Mcum, 1833.257 Mucm, 1864.502 Mcum & 1921.313 Mcum** respectively and are given in **Table No.7.14.**

Table 7.14 Sub Basin Wise Projected total Water Demand in Varahanadhi River Basin

Water Demand in Mcum

Sl. No	Name of the Sub Basin	2017						2020						2030					
		Domestic	**Irrigation**	**livestock**	**Industries**	**Aquaculture**	**Total**	**Domestic**	**Irrigation**	**livestock**	**Industries**	**Aquaculture**	**Total**	**Domestic**	**Irrigation**	**livestock**	**Industries**	**Aquaculture**	**Total**
1	Nallavur	14.637	182.170	2.396	2.438	0.000	**201.641**	15.266	182.170	2.069	3.023	0.000	**202.528**	17.590	182.170	1.301	5.441	0.000	**206.502**
2	Ongur	19.622	409.320	3.614	4.555	0.059	**437.170**	20.325	409.320	3.119	5.649	0.059	**438.472**	22.877	409.320	1.954	10.169	0.059	**444.379**
3	Varahan adhi	46.243	1110.730	11.255	4.786	0.240	**1173.254**	48.030	1110.730	9.749	5.935	0.240	**1174.684**	54.571	1110.730	6.153	10.682	0.240	**1182.376**
Total		**80.502**	**1702.220**	**17.266**	**11.779**	**0.299**	**1812.065**	**83.621**	**1702.220**	**14.937**	**14.607**	**0.299**	**1815.684**	**95.038**	**1702.220**	**9.408**	**26.292**	**0.299**	**1833.257**

Sl. No	Name of the Sub Basin	2040						2050					
		Domestic	**Irrigation**	**livestock**	**industries**	**Aquaculture**	**Total**	**Domestic**	**Irrigation**	**livestock**	**Industries**	**Aquaculture**	**Total**
1	Nallavur	20.316	182.170	0.877	9.794	0.000	**213.157**	23.522	182.170	1.210	17.628	0.000	**224.53**
2	Ongur	25.789	409.320	1.289	18.302	0.059	**454.759**	29.119	409.320	1.407	32.945	0.059	**472.85**
3	Varahanadhi	62.127	1110.730	4.260	19.229	0.240	**1196.586**	70.880	1110.730	7.471	34.612	0.240	**1223.933**
Total		**108.232**	**1702.220**	**6.426**	**47.325**	**0.299**	**1864.502**	**123.521**	**1702.220**	**10.088**	**85.185**	**0.299**	**1921.313**

7.10 Summary

While comparing the previous reappraisal study of Varahanadhi River Basin carried out during 2005, it is learnt that

1. The population has been increased from 1.913 million to 2.393 million for the present year (2017). Therefore the domestic water demand has been increased from 59.475Mcum to 80.502 Mcum during 2017.
2. The livestock population have been decreased at present (2017) and hence the livestock demands has been decreased from 73.479 Mcum to 17.266Mcum
3. The number of large scale industries in the Varahanadhi River Basin found to be increased at present, but the number of small scale industries is found to be decreased. Hence the estimated value of Industrial Water Demand in Varahanadhi River Basin for the present year 2017 has been decreased from 39.91 Mcum to 11.779 Mcum.
4. As per 2005 Varahanadhi study report, irrigation demand was given as 1139.40 Mcum at 75% rainfall dependability with then crop area of 152522 Ha. The net irrigation demand of this basin for the year 2017 at 75% dependable rainfall is 1702.220 Mcum with crop area of 198758 Ha.

The Comparision between the reappraisal study of Varahanadhi River Basin carried out during 2005and 2017 is presented in the **Table 7.15**

Table 7.15 Comparison between the reappraisal studies of Varahanadhi River Basin carried out during 2005 and 2017

Water Demand in Mcum

SI.No	Water Demand	Year	
		2005	**2017**
1.	Domestic Demand	59.475	80.502
2.	Irrigation Demand	1139.40	1702.220
3.	Industrial Demand	39.91	11.779
4.	Livestock Demand	73.479	17.266
5.	Aquaculture Demand	-----	0.299
Total demand		**1312.264**	**1812.066**

The total water demand of five sectors, i.e., Domestic, Irrigation, Livestock, Industries and aquaculture of Varahanadhi River Basin for the present year 2017 was worked out as 1812.065 Mcum**.** But the water demand in 2005 was 1312.264. This shows that that there is 27.58% increase in water demand within 12 years for the present year, when compared to the water demand during 2005.

CHAPTER – 8

WATER BALANCE STUDY

CHAPTER – 8

WATER BALANCE STUDY

Water, once an abundant natural resource, is becoming a more valuable commodity due to drought and overuse. In view of the vital importance of water for human and animal life, for maintaining ecological balance and for economic and development activities of all kinds and considering its increasing scarcity, the planning and management of this resource and its optimal, economical and equitable use has become a matter of the utmost urgency. 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 its demand. If the availability of water is more than its demand, which is not the case in many basins, then ways and means have to be found out to use it effectively within the basin or by transferring the excess water to nearby deficit basins. If it is the other way, that is, if the availability of water is less than its requirements, then also we have to find ways and means to meet out its full demand. Hence, it is imperative that effective water management is the only option in such cases in addition to other approaches. **Water balance study** is necessary to understand the availability and the overall 'state' of water resources in a hydrological system, considering all of inflows and outflows into and from the basin.

8.1 Water Potential of Varahanadhi River Basin

Total water potential of a basin is the sum of Surface Water Potential and Ground Water Potential. The Surface Water Potential of Varahanadhi basin is estimated sub basin wise using Monthly Runoff Simulation Model and is furnished in Chapter 5. The Ground Water Potential of the basin is estimated based on **Firka Wise classification 2013** and is furnished in Chapter 6**.** The 75% dependable total water potential of Varahanadhi River Basin is 1573.32 Mcum as given below:

Surface water potential (Vide Chapter - 5)	= 583.99 MCM
Ground water potential (Vide Chapter - 6)	= 989.33 MCM

Total Water Potential of the basin	= **1573.32** MCM

8.2 Water Demand of Varahanadhi River Basin

Total water demand is the sum of the sectoral demands such as Domestic, Irrigation, Livestock, Industrial, Ecological and Aquaculture sector. Domestic demand is calculated based on the population of Varahanadhi River Basin. Exponential growth formula is adopted for estimating the population growth. Irrigation demand is estimated using CROPWAT model. Industrial water demand is calculated based on the requirement of Small, Medium and Large scale industries in the basin. The actual consumption of water for the Industries have been considered for assessing the Industrial Water demand. The norms of the Indian Council of Agriculture and Research has been adopted for calculating the Livestock per capita water requirement in the estimation of livestock water demand. In order to maintain the health and biodiversity of rivers Environmental Flow Requirement (EFR) is necessary. Hence in this assessment provisions are given for ecological requirements at a rate of 0.5% of surface Water Potential at 75% dependability for the current year (i.e) 2017 and at 1% for 2020, 2030, 2040 and 2050.The above demand calculations are detailed in **Chapter – 7**. The total water demand in Varahanadhi River Basin for different planning stages is tabulated below:

Table 8.1
Total Sectoral Water Demand in Varahanadhi River Basin (75% dependability)

Sl. No.	Type of Demand	Total Demand in Mcum				
		2017	2020	2030	2040	2050
1	Domestic	80.50	83.62	95.04	108.23	123.52
2	Irrigation (including losses @ the rate of 33% = 1702.22*1.33)	2263.95	2263.95	2263.95	2263.95	2263.95
3	Live Stock	17.27	14.94	9.41	6.43	10.08
4	Industries	11.78	14.61	26.29	47.33	85.19
5	Ecological	2.92	5.84	5.84	5.84	5.84
6	Aquaculture	0.30	0.30	0.30	0.30	0.30
	Total	**2376.72**	**2383.26**	**2400.83**	**2432.07**	**2488.88**

Water Balance

Water Potential for the year 2017 = **1573.32** MCM

Water demand for the year 2017 = **2376.72**Mcum

Deficit = 803.40 **Mcum**

% of Deficit with respect to potential = (-) 51.10%

Varahanadhi River Basin is deficit by 803.40 Mcum (51.10 %) at present, i.e., for the year 2017 for 75% dependable values.

8.3 Water Balance at 75% Dependability

Water balance is also projected for the future, i.e., for the years 2020, 2030, 2040 and 2050. The present and the future demands are given in **Table 8.1**. While assuming that there will not be much variation in the availability of Surface as well as Ground water in future, the present potential of 1573.32 Mcum, is not sufficient for future planning periods. Based on the above calculated values, water balance for the present and the future is given in **Table 8.2.**

The yearly requirement of water for large and small scale industries in Varahanadhi basin works out to 11.78 Mcum (From Chapter 7). Total quantity of waste water available for treatment is 9.424 Mcum (assuming that 80% of water is available after being used in the industries). Assuming that 80% of water after being used in the industries is 7.54 Mcum (i.e) 9.424*0.8 = 7.54 Mcum. The industries can also be advised to reuse the treated waste water so as to maintain zero discharge in future.

Table 8.2

Water Balancing for Varahanadhi River Basin at 75% dependability
Water Potential, Demand and Deficit (Both long & short term)

Sector	2017	2020	2030	2040	2050
Total Water Potential (Surface Water + Ground Water Potential) in Mcum	**1573.32**	**1573.32**	**1573.32**	**1573.32**	**1573.32**
Total Water Demand (Domestic + Livestock+ Industrial+ Agricultural+ Ecological+ Aquaculture Demand) in Mcum	**2376.72**	**2383.26**	**2400.83**	**2432.07**	**2488.89**
Total water deficit in Mcum	**-803.40**	**-809.94**	**-827.51**	**-858.75**	**-915.56**
% of deficit with respect to potential	**-51.1%**	**-51.5%**	**-52.6%**	**-54.6%**	**-58.2%**
Quantity of waste water from Large , Medium & Small scale industries used for irrigation, if treated in Mcum	**7.54**	**7.54**	**7.54**	**7.54**	**7.54**
Quantity of deficit in Varahanadhi basin after considering waste water reuse in Mcum	**-795.86**	**-802.40**	**-819.97**	**-851.22**	**-908.03**

From the table, it seen that the basin is deficit by 51.1% at present. For future years, the trend in the deficit seems to be increasing towards the year 2050; this is because of increase in population, livestock and industrialization.

Sub basin wise water balance statements are given in **Table 8.4**, **Table 8.5**, **Table 8.6**, **Table 8.7** and **Table 8.8,** for existing scenario.

During 2017, Varahanadhi basin as a whole is deficit by 803.40 Mcum. Ongur, Nallavur and Varahanadhi sub basins are deficit by 26.3%, 10.8% and 74.6 % respectively. Necessary and Suitable proposals may be formulated from the adjacent surplus basin for meeting out this deficit.

Water balance statements are also given for future projected years. During the years of 2020, 2030, 2040 and 2050 also the whole Varahanadhi basin is a deficit 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 of 745.95 MCM, taken from the output of MRS model and the irrigation demand values at 50% dependable rainfall taken from the output of CROPWAT model is taken for calculation. Water balancing for Varahanadhi River Basin at 50% dependability is given in the following table. While the water deficit at 75% dependability for the year 2017 is on the average of 51.1% and the water deficit at 50% dependability is on the average of 17.4%. Sub basin wise water balance statements at 50% dependability are given in **Table 8.9**, **Table 8.10**, **Table 8.11**, **Table 8.12** and **Table 8.13,** for existing scenario.

Table 8.3 Water Balancing for Varahanadhi River Basin at 50% dependability Water Potential, Demand and Deficit (Both long & short term)

Sector	2017	2020	2030	2040	2050
Total Water Potential (Surface Water + Ground Water Potential) in Mcum	1744.28	1744.28	1744.28	1744.28	1744.28
Total Water Demand (Domestic + Livestock+ Industrial+ Agricultural + Ecological + Aquaculture Demand) in Mcum	2048.08	2055.47	2073.04	2104.29	2161.10
Total water Deficit in Mcum	**-303.80**	**-311.19**	**-328.76**	**-360.01**	**-416.81**
% of Deficit with respect to potential	**-17.4%**	**-17.8%**	**-18.8%**	**-20.6%**	**-23.9%**
Quantity of Waste Water from Small, Medium & Large scale industries that can be reused, if treated	7.54	7.54	7.54	7.54	7.54
Quantity of deficit in Varahanadhi basin after considering waste water reuse in Mcum	**-292.26**	**-303.65**	**-321.22**	**-352.47**	**-409.28**

8.5 Water Balance calculation for various Scenarios

The following different planning scenarios for Varahanadhi River Basin are considered:

1) Existing scenario

Tables 8.2 and 8.3 given above shows the water balance of Varahanadhi River Basin in the Existing scenario.

2) Full Tank capacity scenario

In this scenario, the tanks in Varahanadhi River Basin is assumed to attain its full capacity. Hence, net capacity of the tanks is added to the Surface water potential.

3) No silt scenario

This scenario represents a condition, where the tanks are effectively desilted.

4) Lower Limit scenario

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

The lower limit for the future irrigation demand is determined taking into consideration of adaptation of latest Micro Irrigation techniques and planting System Rice Intensification (SRI) as recommended by Agricultural department. Since the twin objectives of changing over to economic value addition of agricultural produce and higher priority for drinking water in future have to be achieved, comparatively less water consuming paddy variety and latest irrigation techniques are considered for planning purposes.

5) Improve Efficiency

This scenario represents an irrigation system with loss taken as Nil.

The results of different scenarios are given in appendix vide Table No. 8.1 to 8.5 given in Volume II. The bar charts are given in **Figure 8.1 to Figure 8.5** for various scenarios.

For the year 2017, the basin is deficit in all the four scenarios at 75% dependable values except tank capacity scenario. When projected for the years 2020, 2030, 2040 and 2050, the deficit values are slightly increased due to increase in domestic, irrigation and livestock demands, as shown in Figures 8.2 and 8.3. **Thus Varahanadhi River Basin is found to be deficit when simulated for various scenarios such as Existing, No silt, Decrease Irrigation and Improving**

efficiency except Full Tank Capacity scenario. Hence suitable proposals may be initiated for meeting out this scarcity. Also necessary steps may be taken for safeguarding our ancient water bodies in the basin by proper and periodical maintenance and to limit the Ground water Extractions.

8.6 Summary

The Varahanadhi River Basin is found to be a deficit basin both at 75% and 50% dependable rainfall and surface water potential values for the existing scenario. In 75% dependable calculations, the deficit percentage is 51.1% during 2017 and it increases to 58.2 % during 2050 due to increase in domestic, irrigation and livestock demands.

Description	2017	2020	2030	2040	2050
Total water deficit in Mcum	**-803.40**	**-809.94**	**-827.51**	**-858.75**	**-915.56**
% of deficit with respect to potential	**51.1%**	**51.5%**	**52.6%**	**54.6%**	**58.2%**

From the total water demand, it is found that the irrigation demand accounts for about 90% of the total water demand. Hence steps may be taken to improve the percentage of water use efficiency by means of lining of canals, proper maintenance of irrigation structures, and adopting innovative micro irrigation techniques.

In addition, the new proposals for Check dams, Vertical shaft and Percolation Ponds identified using GIS has been listed out in the Conclusion and Action Plan (Chapter 11) of this report, to meet out the crisis of water shortage during lean periods.

Table 8.4

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

2017

Details of Water Potential and Demand		Ongur	Nallavur	Varahanadhi	Total
Water sources potential in Mcum	Surface water potential (a)	164.52	105.91	313.56	583.99
	Ground water potential (b)	289.22	130.73	569.38	989.33
	Total water potential (c = a+b)	453.74	236.64	882.94	1573.32
Water demand in Mcum	Domestic demand (d)	19.62	14.64	46.24	80.50
	Irrigation demand (e)	544.40	242.29	1477.27	2263.95
	Livestock demand (f)	3.61	2.40	11.26	17.27
	Industrial demand (g)	4.56	2.44	4.79	11.78
	Ecological demand (h)	0.82	0.53	1.57	2.92
	Aquaculture demand (i)	0.06	0.00	0.24	0.30
	Total water demand (h = d+e+f+g+h+i))	573.07	262.29	1541.36	2376.72
Surplus / Deficit in Mcum (c-h)		-119.33	-25.65	-658.42	-803.40
Percentage		-26.3%	-10.8%	-74.6%	-51.1%

Deficit in Varahanadhi basin	=	-803.40	Mcum	-51.1%
Yearly requirement of water for large and small scale industries	=	11.78	Mcum	
Quantity of waste water from Large & Small scale Industries that can be reused if treated	=	7.54	Mcum	
Deficit in Varahanadhi basin considering waste water reuse	=	-795.86	Mcum	

Table 8.5

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

2020

Details of Water Potential and Demand		Ongur	Nallavur	Varahanadhi	Total
Water sources potential in Mcum	Surface water potential (a)	164.52	105.91	313.56	583.99
	Ground water potential (b)	289.22	130.73	569.38	989.33
	Total water potential (c = a+b)	**453.74**	**236.64**	**882.94**	**1573.32**
Water demand in Mcum	Domestic demand (d)	20.33	15.27	48.03	83.62
	Irrigation demand (e)	544.40	242.29	1477.27	2263.95
	Livestock demand (f)	3.12	2.07	9.75	14.94
	Industrial demand (g)	5.65	3.02	5.93	14.61
	Ecological demand (h)	1.65	1.06	3.14	5.84
	Aquaculture demand (i)	0.06	0.00	0.24	0.30
	Total water demand (h = d+e+f+g)	**575.19**	**263.70**	**1544.36**	**2383.26**
Surplus / Deficit in Mcum (c-h)		**-121.45**	**-27.06**	**-661.42**	**-809.94**
Percentage		**-26.8%**	**-11.4%**	**-74.9%**	**-51.5%**

Deficit in Varahanadhi basin	=	**-809.94**	**Mcum -**	**-51.5%**
Yearly requirement of water for large and small scale industries	=	**11.78**	**Mcum**	
Quantity of waste water from Large & Small scale Industries that can be reused if treated	=	**7.54**	**Mcum**	
Deficit in Varahanadhi basin considering waste water reuse	=	**-802.40**	**Mcum**	

Table 8.6

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

2030

Details of Water Potential and Demand		**Ongur**	**Nallavur**	**Varahanadhi**	**Total**
Water sources potential in Mcum	Surface water potential (a)	164.52	105.91	313.56	583.99
	Ground water potential (b)	289.22	130.73	569.38	989.33
	Total water potential (c = a+b)	**453.74**	**236.64**	**882.94**	**1573.32**
Water demand in Mcum	Domestic demand (d)	22.88	17.59	54.57	95.04
	Irrigation demand (e)	544.40	242.29	1477.27	2263.95
	Livestock demand (f)	1.95	1.30	6.15	9.41
	Industrial demand (g)	10.17	5.44	10.68	26.29
	Ecological demand (h)	1.65	1.06	3.14	5.84
	Aquaculture demand (i)	0.06	0.00	0.24	0.30
	Total water demand (h = d+e+f+g)	**581.10**	**267.68**	**1552.05**	**2400.83**
Surplus / Deficit in Mcum (c-h)		**-127.36**	**-31.04**	**-669.11**	**-827.51**
Percentage		**-28.1%**	**-13.1%**	**-75.8%**	**-52.6%**

Deficit in Varahanadhi basin	=	**-827.51**	**Mcum -**	**-52.6%**
Yearly requirement of water for large and small scale industries	=	**11.78**	**Mcum**	
Quantity of waste water from Large & Small scale Industries that can be reused if treated	=	**7.54**	**Mcum**	
Deficit in Varahanadhi basin considering waste water reuse	=	**-819.97**	**Mcum**	

Table 8.7

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

2040

Details of Water Potential and Demand		Ongur	Nallavur	Varahanadhi	Total
Water sources potential in Mcum	Surface water potential (a)	164.52	105.91	313.56	583.99
	Ground water potential (b)	289.22	130.73	569.38	989.33
	Total water potential (c = a+b)	**453.74**	**236.64**	**882.94**	**1573.32**
Water demand in Mcum	Domestic demand (d)	25.79	20.32	62.13	108.23
	Irrigation demand (e)	544.40	242.29	1477.27	2263.95
	Livestock demand (f)	1.29	0.88	4.26	6.43
	Industrial demand (g)	18.30	9.79	19.23	47.33
	Ecological demand (h)	1.65	1.06	3.14	5.84
	Aquaculture demand (i)	0.06	0.00	0.24	0.30
	Total water demand (h = d+e+f+g)	**591.48**	**274.33**	**1566.26**	**2432.07**
Surplus / Deficit in Mcum (c-h)		**-137.74**	**-37.69**	**-683.32**	**-858.75**
Percentage		**-30.4%**	**-15.9%**	**-77.4%**	**-54.6%**

Deficit in Varahanadhi basin = **-858.75** **Mcum -** **-54.6%**

Yearly requirement of water for large and small scale industries = **11.78** **Mcum**

Quantity of waste water from Large & Small scale Industries that can be reused if treated = **7.54** **Mcum**

Deficit in Varahanadhi basin considering waste water reuse = **-851.22** **Mcum**

Table 8.8

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

2050

Details of Water Potential and Demand		Ongur	Nallavur	Varahanadhi	Total
Water sources potential in Mcum	Surface water potential (a)	164.52	105.91	313.56	583.99
	Ground water potential (b)	289.22	130.73	569.38	989.33
	Total water potential (c = a+b)	**453.74**	**236.64**	**882.94**	**1573.32**
Water demand in Mcum	Domestic demand (d)	29.12	23.52	70.88	123.52
	Irrigation demand (e)	544.40	242.29	1477.27	2263.95
	Livestock demand (f)	1.41	1.21	7.47	10.09
	Industrial demand (g)	32.94	17.63	34.61	85.19
	Ecological demand (h)	1.65	1.06	3.14	5.84
	Aquaculture demand (i)	0.06	0.00	0.24	0.30
	Total water demand (h = d+e+f+g)	**609.57**	**285.71**	**1593.61**	**2488.89**
Surplus / Deficit in Mcum (c-h)		**-155.83**	**-49.07**	**-710.67**	**-915.57**
Percentage		**-34.3%**	**-20.7%**	**-80.5%**	**-58.2%**

Deficit in Varahanadhi basin = **-915.57** **Mcum -** **-58.2%**

Yearly requirement of water for large and small scale industries = **11.78** **Mcum**

Quantity of waste water from Large & Small scale Industries that can be reused if treated = **7.54** **Mcum**

Deficit in Varahanadhi basin considering waste water reuse = **-908.03** **Mcum**

Table 8.9

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

2017

Details of Water Potential and Demand		**Ongur**	**Nallavur**	**Varahanadhi**	**Total**
Water sources potential in Mcum	Surface water potential (a)	203.70	134.70	416.55	754.95
	Ground water potential (b)	289.22	130.73	569.38	989.33
	Total water potential (c = a+b)	**492.92**	**265.43**	**985.93**	**1744.28**
Water demand in Mcum	Domestic demand (d)	19.62	14.64	46.24	80.50
	Irrigation demand (e)	463.27	222.08	1249.11	1934.46
	Livestock demand (f)	3.61	2.40	11.26	17.27
	Industrial demand (g)	4.56	2.44	4.79	11.78
	Ecological demand (h)	1.02	0.67	2.08	3.77
	Aquaculture demand (i)	0.06	0.00	0.24	0.30
	Total water demand (h = d+e+f+g+h+i))	**492.13**	**242.23**	**1313.72**	**2048.08**
Surplus / Deficit in Mcum (c-h)		**0.79**	**23.20**	**-327.79**	**-303.80**
Percentage		**0.2%**	**8.7%**	**-33.2%**	**-17.4%**

Deficit in Varahanadhi basin	=	**-303.80**	**Mcum**	**-17.4%**
Yearly requirement of water for large and small scale industries	=	**11.78**	**Mcum**	
Quantity of waste water from Large & Small scale Industries that can be reused if treated	=	**7.54**	**Mcum**	
Deficit in Varahanadhi basin considering waste water reuse	=	**-296.26**	**Mcum**	

Table 8.10

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

2020

Details of Water Potential and Demand		**Ongur**	**Nallavur**	**Varahanadhi**	**Total**
Water sources potential in Mcum	Surface water potential (a)	203.70	134.70	416.55	754.95
	Ground water potential (b)	289.22	130.73	569.38	989.33
	Total water potential (c = a+b)	**492.92**	**265.43**	**985.93**	**1744.28**
Water demand in Mcum	Domestic demand (d)	20.33	15.27	48.03	83.62
	Irrigation demand (e)	463.27	222.08	1249.11	1934.46
	Livestock demand (f)	3.12	2.07	9.75	14.94
	Industrial demand (g)	5.65	3.02	5.93	14.61
	Ecological demand (h)	2.04	1.35	4.17	7.55
	Aquaculture demand (i)	0.06	0.00	0.24	0.30
	Total water demand (h = d+e+f+g)	**494.46**	**243.79**	**1317.23**	**2055.47**
Surplus / Deficit in Mcum (c-h)		**-1.54**	**21.64**	**-331.30**	**-311.19**
Percentage		**-0.3%**	**8.2%**	**-33.6%**	**-17.8%**

Deficit in Varahanadhi basin	=	**-311.19**	**Mcum**	**-17.8%**
Yearly requirement of water for large and small scale industries	=	**11.78**	**Mcum**	
Quantity of waste water from Large & Small scale Industries that can be reused if treated	=	**7.54**	**Mcum**	
Deficit in Varahanadhi basin considering waste water reuse	=	**-303.65**	**Mcum**	

Table 8.11

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

2030

Details of Water Potential and Demand		Ongur	Nallavur	Varahanadhi	Total
Water sources potential in Mcum	Surface water potential (a)	203.70	134.70	416.55	754.95
	Ground water potential (b)	289.22	130.73	569.38	989.33
	Total water potential (c = a+b)	**492.92**	**265.43**	**985.93**	**1744.28**
Water demand in Mcum	Domestic demand (d)	22.88	17.59	54.57	95.04
	Irrigation demand (e)	463.27	222.08	1249.11	1934.46
	Livestock demand (f)	1.95	1.30	6.15	9.41
	Industrial demand (g)	10.17	5.44	10.68	26.29
	Ecological demand (h)	2.04	1.35	4.17	7.55
	Aquaculture demand (i)	0.06	0.00	0.24	0.30
	Total water demand (h = d+e+f+g)	**500.36**	**247.76**	**1324.92**	**2073.04**
Surplus / Deficit in Mcum (c-h)		**-7.44**	**17.67**	**-338.99**	**-328.76**
Percentage		**-1.5%**	**6.7%**	**-34.4%**	**-18.8%**

Deficit in Varahanadhi basin = **-328.76** **Mcum** **-18.8%**

Yearly requirement of water for large and small scale industries = **11.78** **Mcum**

Quantity of waste water from Large & Small scale Industries that can be reused if treated = **7.54** **Mcum**

Deficit in Varahanadhi basin considering waste water reuse = **-321.22** **Mcum**

Table 8.12

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

2040

Details of Water Potential and Demand		Ongur	Nallavur	Varahanadhi	Total
Water sources potential in Mcum	Surface water potential (a)	203.70	134.70	416.55	754.95
	Ground water potential (b)	289.22	130.73	569.38	989.33
	Total water potential (c = a+b)	**492.92**	**265.43**	**985.93**	**1744.28**
Water demand in Mcum	Domestic demand (d)	25.79	20.32	62.13	108.23
	Irrigation demand (e)	463.27	222.08	1249.11	1934.46
	Livestock demand (f)	1.29	0.88	4.26	6.43
	Industrial demand (g)	18.30	9.79	19.23	47.33
	Ecological demand (h)	2.04	1.35	4.17	7.55
	Aquaculture demand (i)	0.06	0.00	0.24	0.30
	Total water demand (h = d+e+f+g)	**510.74**	**254.42**	**1339.13**	**2104.29**
Surplus / Deficit in Mcum (c-h)		**-17.82**	**11.01**	**-353.20**	**-360.01**
Percentage		**-3.6%**	**4.1%**	**-35.8%**	**-20.6%**

Deficit in Varahanadhi basin = **-360.01** **Mcum** **-20.6%**

Yearly requirement of water for large and small scale industries = **11.78** **Mcum**

Quantity of waste water from Large & Small scale Industries that can be reused if treated = **7.54** **Mcum**

Deficit in Varahanadhi basin considering waste water reuse = **-352.47** **Mcum**

Table 8.13
VARAHANADHI BASIN - Sub Basin wise water balance at 50% dependability (Existing scenario) 2050

Details of Water Potential and Demand		Ongur	Nallavur	Varahanadhi	Total
Water sources potential in Mcum	Surface water potential (a)	203.70	134.70	416.55	754.95
	Ground water potential (b)	289.22	130.73	569.38	989.33
	Total water potential (c = a+b)	**492.92**	**265.43**	**985.93**	**1744.28**
Water demand in Mcum	Domestic demand (d)	29.12	23.52	70.88	123.52
	Irrigation demand (e)	463.27	222.08	1249.11	1934.46
	Livestock demand (f)	1.41	1.21	7.47	10.09
	Industrial demand (g)	32.94	17.63	34.61	85.19
	Ecological demand (h)	2.04	1.35	4.17	7.55
	Aquaculture demand (i)	0.06	0.00	0.24	0.30
	Total water demand (h = d+e+f+g)	**528.83**	**265.79**	**1366.48**	**2161.10**
Surplus / Deficit in Mcum (c-h)		**-35.91**	**-0.36**	**-380.55**	**-416.82**
Percentage		**-7.3%**	**-0.1%**	**-38.6%**	**-23.9%**

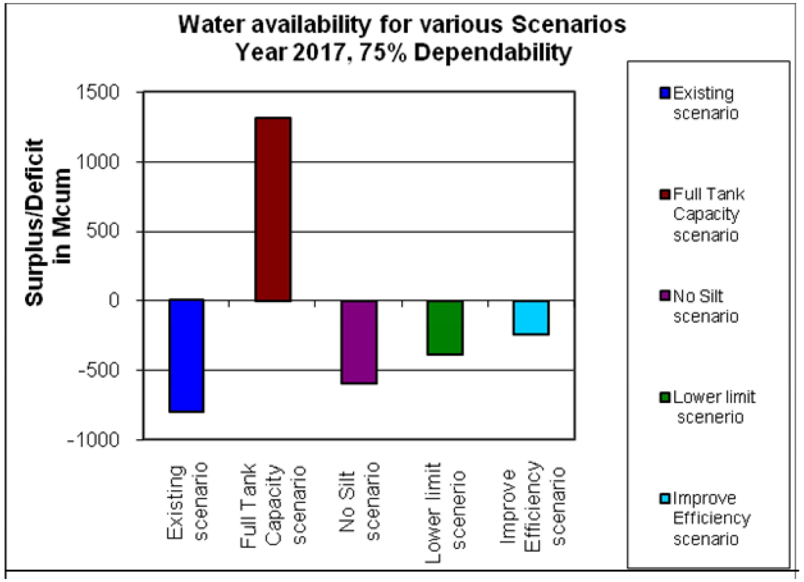
Deficit in Varahanadhi basin	=	**-416.82**	**Mcum -**	**-23.9%**
Yearly requirement of water for large and small scale industries	=	**11.78**	**Mcum**	
Quantity of waste water from Large & Small scale Industries that can be reused if treated	=	**7.54**	**Mcum**	
Deficit in Varahanadhi basin considering waste water reuse	=	**-409.28**	**Mcum**	

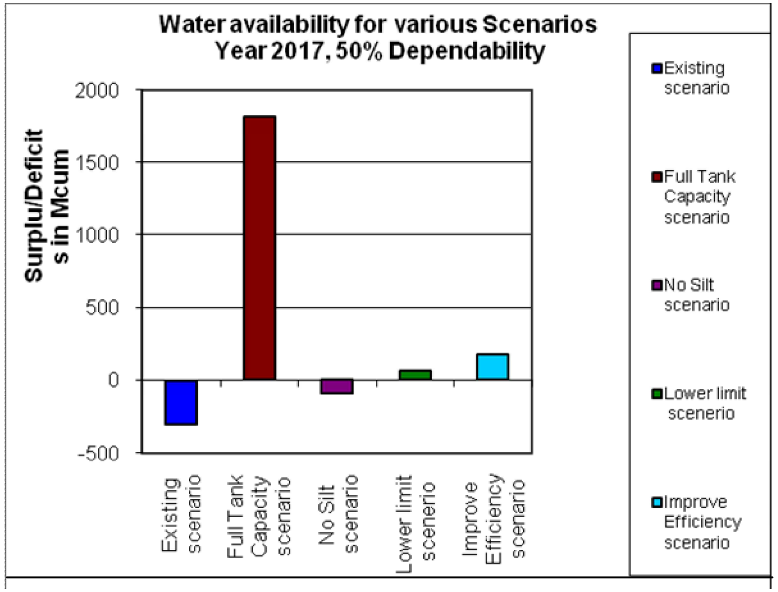
Figure - 8.1

Varahanadhi River Basin - Water availability at 75% & 50% dependabilities during 2017 for various Scenarios

Water avilability during 2017 at 75% dependability		
Sl.No.	**Scenario**	**Surplus/Deficit in Mcum**
1	Existing scenario	-803
2	Full Tank Capacity	1314
3	No Silt	-592
4	Lower limit scenario	-392
5	Improve Efficiency	-242

Water availability during 2017 at 50% dependability		
Sl.No.	**Scenario**	**Surplus/Deficit in Mcum**
1	Existing scenario	-304
2	Full Tank Capacity	1814
3	No Silt	-92
4	Lower limit scenario	62
5	Improve Efficiency	176





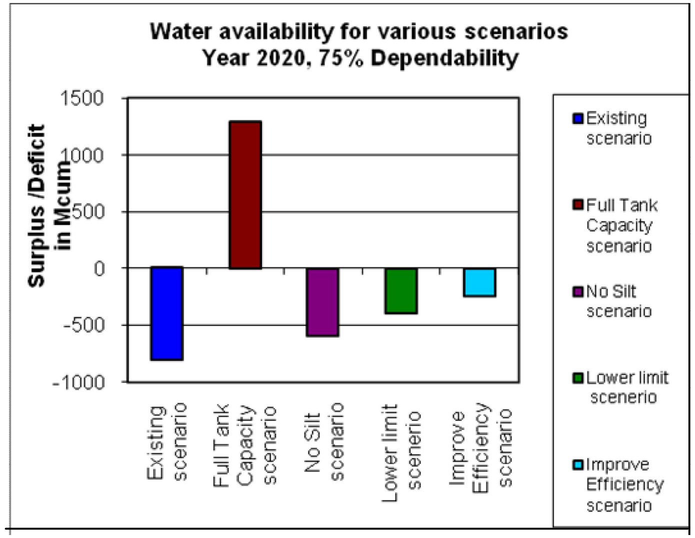
Description of Scenarios	
Existing Scenario	Present condition
Full Tank Capacity	Net capacity of the tanks is doubled, which means two fillings per year
No Silt	Condition when tanks are desilted
Lower limit scenario	1/3rd of the present Paddy and Sugarcane areas replaced by non-paddy crops like cholam, cumbu, ragi, Maize, redgram, black gram, green gram and fodder
Improve Efficiency	Condition where efficiency is increased to 75%

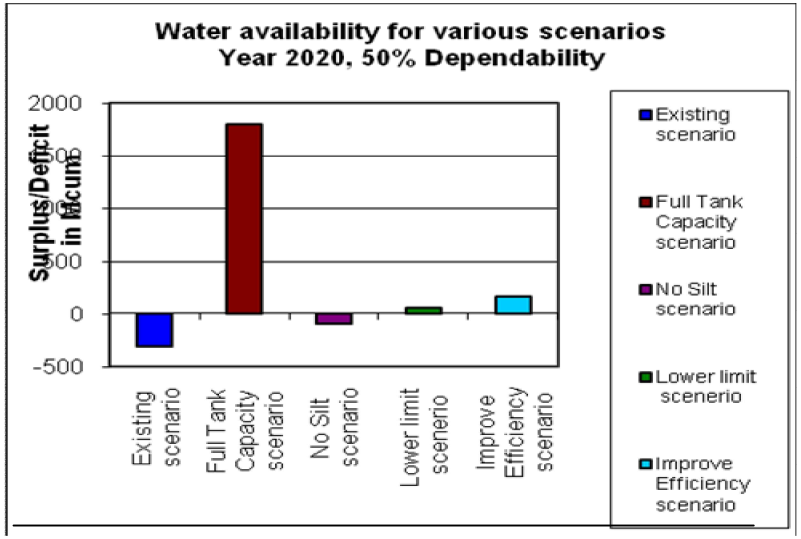
Figure - 8.2

Varahanadhi River Basin - Water availability at 75% & 50% dependabilities during 2020 for various Scenarios

Water Availability during 2020 at 75% dependability		
Sl.No.	**Scenario**	**Surplus/Deficit in Mcum**
1	Existing scenario	-810
2	Full Tank Capacity	1297
3	No Silt	-599
4	Lower limit scenario	-398
5	Improve Efficiency	-248

Water availability during 2020 at 50% dependability		
Sl.No.	**Scenario**	**Surplus/Deficit in Mcum**
1	Existing scenario	-311
2	Full Tank Capacity	1796
3	No Silt	-100
4	Lower limit scenario	54
5	Improve Efficiency	169





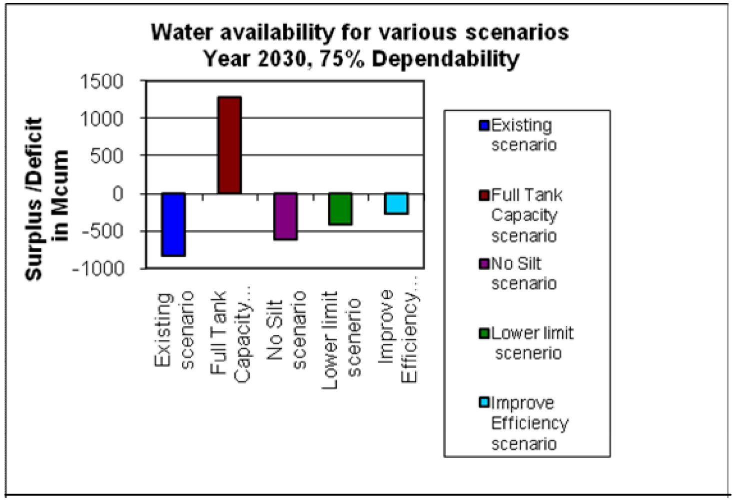
Description of Scenarios	
Existing Scenario	Present condition
Full Tank Capacity	Net capacity of the tanks is doubled, which means two fillings per year
No Silt	Condition when tanks are desilted
Lower limit scenario	1/3rd of the present Paddy and Sugarcane areas replaced by non-paddy crops like cholam, cumbu, ragi, Maize, redgram, black gram, green gram and fodder
Improve Efficiency	Condition where efficiency is increased to 75%

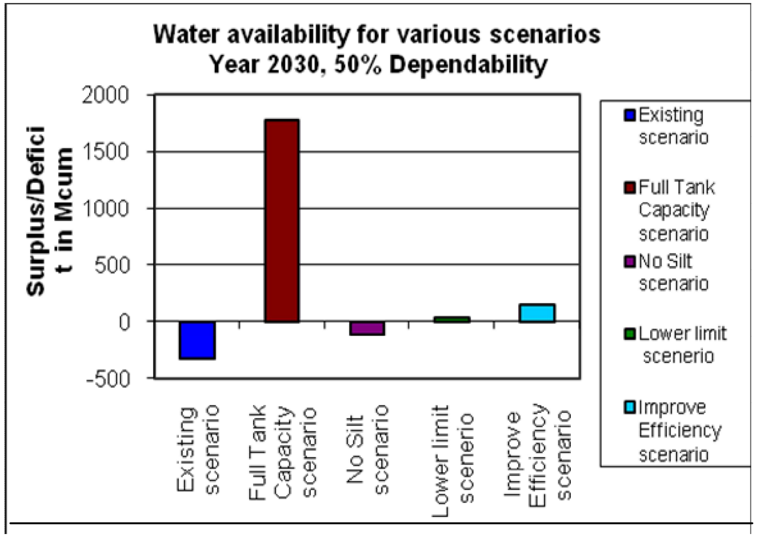
Figure - 8.3

Varahanadhi 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	-828
2	Full Tank Capacity	1280
3	No Silt	-617
4	Lower limit scenario	-416
5	Improve Efficiency	-266

Water availability during 2030 at 50% dependability		
Sl.No.	**Scenario**	**Surplus/Deficit in Mcum**
1	Existing scenario	-329
2	Full Tank Capacity	1778
3	No Silt	-118
4	Lower limit scenerio	37
5	Improve Efficiency	151



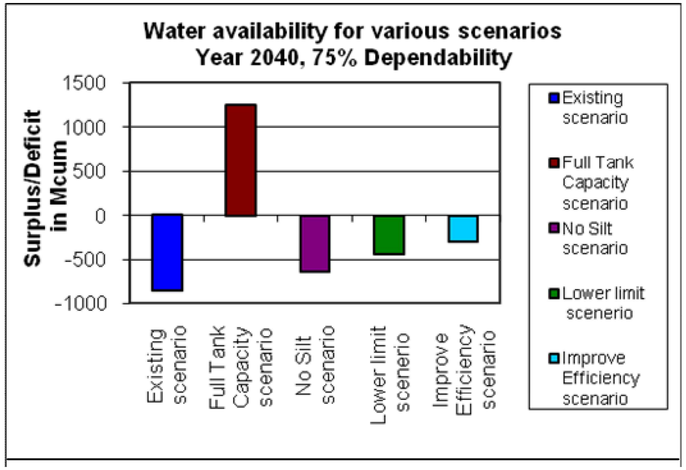


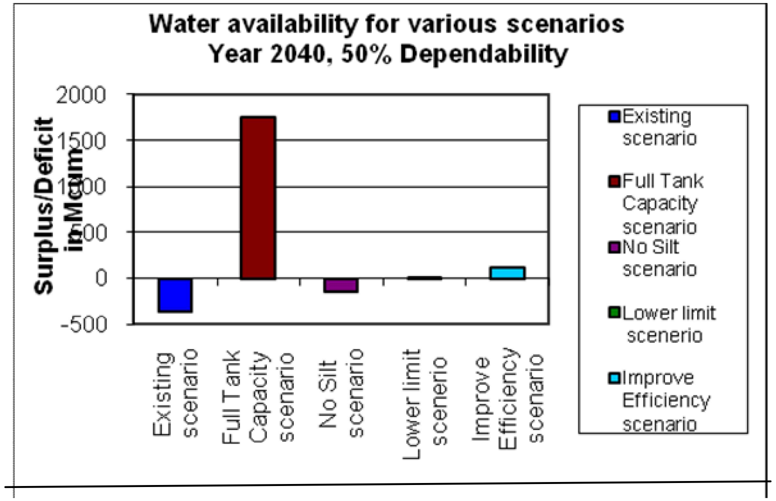
Description of Scenarios	
Existing Scenario	Present condition
Full Tank Capacity	Net capacity of the tanks is doubled, which means two fillings per year
No Silt	Condition when tanks are desilted
Lower limit scenario	1/3rd of the present Paddy and Sugarcane areas replaced by non-paddy crops like cholam, cumbu, ragi, Maize, redgram, black gram, green gram and fodder
Improve Efficiency	Condition where efficiency is increased to 75%

Figure - 8.4
Varahanadhi 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	-859
2	Full Tank Capacity	1248
3	No Silt	-648
4	Lower limit scenerio	-447
5	Improve Efficiency	-297

Water availability during 2040 at 50% dependability		
Sl.No.	**Scenario**	**Surplus/Deficit in Mcum**
1	Existing scenario	-360
2	Full Tank Capacity	1747
3	No Silt	-149
4	Lower limit scenario	5
5	Improve Efficiency	120



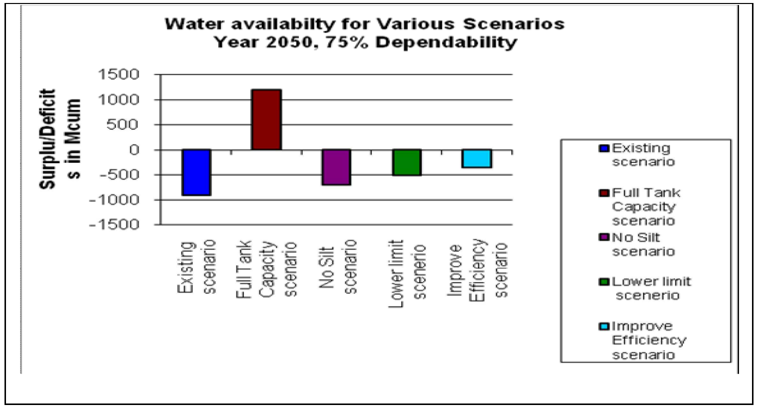


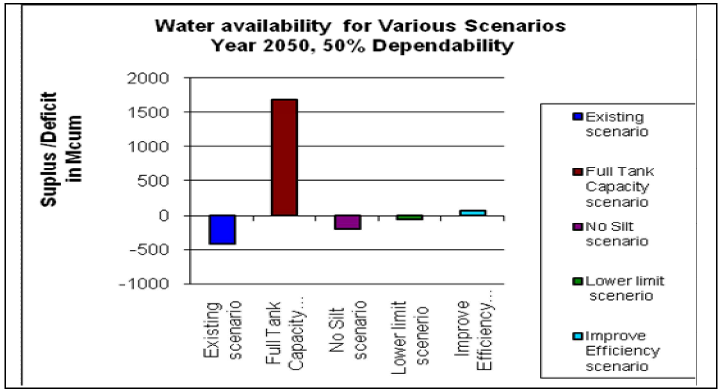
Description of Scenarios	
Existing Scenario	Present condition
Full Tank Capacity	Net capacity of the tanks is doubled, which means two fillings per year
No Silt	Condition when tanks are desilted
Lower limit scenario	1/3rd of the present Paddy and Sugarcane areas replaced by non-paddy crops like cholam, cumbu, ragi, Maize, redgram, black gram, green gram and fodder
Improve Efficiency	Condition where efficiency is increased to 75%

Figure - 8.5
Varahanadhi river basin - Water availability at 75% & 50% dependabilities during 2050 for various Scenarios

Water availability during 2050 at 75% dependability		
Sl.No.	**Scenario**	**Surplus/Deficit in Mcum**
1	Existing scenario	-916
2	Full Tank Capacity	1191
3	No Silt	-705
4	Lower limit scenario	-504
5	Improve Efficiency	-354

Water availability during 2050 at 50% dependability		
Sl.No.	**Scenario**	**Surplus/Deficit in Mcum**
1	Existing scenario	-417
2	Full Tank Capacity	1690
3	No Silt	-206
4	Lower limit scenario	51
5	Improve Efficiency	63





Description of Scenarios	
Existing Scenario	Present condition
Full Tank Capacity	Net capacity of the tanks is doubled, which means two fillings per year
No Silt	Condition when tanks are desilted
Lower limit scenario	1/3rd of the present Paddy and Sugarcane areas replaced by non-paddy crops like cholam, cumbu, ragi, Maize, redgram, black gram, green gram and fodder
Improve Efficiency	Condition where efficiency is increased to 75%

CHAPTER - 9

ENVIRONMENTAL ASPECTS

CHAPTER - 9
ENVIRONMENTAL ASPECTS

INTRODUCTION

Environment encompasses the interaction of all living species, climate, weather and natural resources that affect human survival and economic activity. The rapid growth in urbanization has had a tremendous effect on the environment and has increased the environmental issues manifold. Environmental issues are the harmful effects of human activity on the biophysical environment. Poor air and water quality, insufficient water availability, waste-disposal problems and high energy consumption are further aggravated by the increasing population density and demands of urban environments. This has necessitated the importance for protecting the natural environment at individual, organizational or governmental levels, for the benefit of both the environment and humans.

A few decades ago environmental issues were not a matter of concern. For a developing country like India, protection of environment is an essential part of development. Without environmental protection, development will be unsustainable and without development, resources would be inadequately or ineffectively harnessed.

Definition of Environment in ISO 14001:2004

The term environment is derived from the French word “environed” which means surroundings. It is the sum of all social, economical, biological, physical and chemical factors which constitute the surrounding of humans who are the both creator and moulder of the environment. According to ISO 14001:2004 environmental aspects is an element of an organization’s activities or products or services that can interact with the environment.

The urbanization and increase in population caused environmental degradation and in turn reduced the efficiency of the irrigation structures considerably. It has also led to the realization that the water resources development should be planned in such a manner that it leads to enhancement in the quality of environment.

More precisely, the environmental impacts on resources contribute to the human welfare but it should be noted that these resources are becoming more and more scarce that ultimately impairs the welfare of the human beings. All the development activity affecting the natural environment needs to be carefully planned and controlled. Development of water resources is a major challenge to be accomplished in an environmentally sound manner for achieving economic development.

In this context, it is more appropriate to discuss the environmental issues and remedial measures in the Varahanadhi basin.

The major environmental issues that are dealt in this chapter are deterioration of water quality – both ground and surface water due to the discharge of trade and domestic effluents into the water bodies and land, Solid waste Management, Sea water intrusion, Public Health etc. The other related issues which have an impact in the environment are Pollution sources, Sedimentation, Water weeds, Catchment Area Treatments, Salinity, Fisheries, Wild life, tourism, Socio-economic aspects & Legal Issues etc.

9.1 Pollution Sources

The major pollution sources are as follows.

- Agriculture
- Industries
- Domestic

9.1.1 Agricultural Pollution

Agricultural pollution predominantly arises from farming practices. Modern farming and agricultural operations contribute to the degradation and contamination of our environment as well as the ecosystem. Fertilizers, pesticides, herbicides, animal manure and other agro-chemicals are rich in chemical nutrients and toxic substances which are often the major sources of agricultural pollution.

9.1.1.1 Causes of Agricultural pollution:

Agricultural pollution comes from a variety of sources because of its complexity. However, the main sources include:

a) Leaching of Pesticides, Herbicides and other Agro-chemicals.

Herbicides and Pesticides among other agro-chemicals are the prevailing causes of agricultural pollution owing to the numbers of invasive pests, weeds, and diseases. They are highly toxic and have the potential of remaining in the environment for ages. When it rains, water interacts with these toxic chemicals which then leach into groundwater sources or washed into the nearby waterways. Consequently, the chemicals contaminate waters and the soils, and so soil microorganisms plus beneficial insects are killed.

b) Excess Nutrients

The excess chemical nutrients especially phosphorus and nitrogen make up the main causes of nutrient pollution from agricultural sources. Excess nutrients can have tragic consequences on water quality and the survival of aquatic life. When these nutrients are washed into the water systems e.g. rivers, lakes, streams or oceans during rainy periods, it alters the marine and freshwater nutrient cycles. The most common consequence is eutrophication which depletes the water dissolved oxygen, and in consequence can kill fish and other aquatic life.

c) Heavy Metals

The primary agricultural inputs including pesticides, industrial by-product wastes, some fertilizers, and specific agrochemical products contain traces of heavy metals such as arsenic, cadmium, mercury and lead. When these substances accumulate in the soil or waste dump, they can be washed into waterways or leach into ground water sources or get absorbed by plants and are eventually consumed by animals and humans affecting their health or even causing premature deaths.

d) Invasive Pests, Weeds, and Diseases

They do not directly cause agricultural pollution. However, because of the increase in number of pests, weeds, and diseases which can negatively impact crop yields, farmers resort to the use of pesticides, herbicides, and other agro-chemicals to combat this issue. The extensive use of these chemical products persists in destroying the soils, plants, water & animals and in consequence gradually alters the ecosystem.

9.1.1.2 Fertilizers and Pesticide Consumption in Varahanadhi basin:

In Varahanadhi basin, the main elements of agricultural pollution are phosphates, nitrates, potassium etc. The year wise consumption of fertilizers and Pesticides used in Villupuram, Kancheepuram, Thiruvannamalai and CuddaloreDistrictsis furnished in **Table 9.1 and 9.2**

Table 9.1 Consumption of fertilizers in Villupuram, Kancheepuram, Thiruvannamalai and Cuddalore Districts

Year	N	P	K	Total (NPK) In MT
2006-07	112115	60329	46163	218607
2007-08	106399	48744	57493	212636
2008-09	120621	37743	71324	229688
2009-10	121720	46505	55499	223724
2010-11	130496	55381	53659	239536
2011-12	152556	63591	47701	263848
2012-13	240989	51447	42534	334970
2013-14	236695	48552	53395	338642
2014-15	239708	49529	57190	346427
Total (MT)	**1461299**	**461821**	**484958**	**2408078**

Source: Department of Agriculture, Chennai

Table 9.2 Consumption of Pesticides in Villupuram,Kancheepuram, Thiruvannamalai, and Cuddalore Districts

Year	Liquid (litres)	Dust/Solid (kgs) in Metric Tonnes
2005-06	659000	148006
2006-07	215000	151639
2007-08	1787000	93776
2008-09	1761000	116338
2009-10	1513000	186500
2010-11	1309250	123591
2011-12	1232000	117200
2012-13	1293350	118567
2013-14	1217000	118430
2014-15	1194000	118382
Total (MT)	**12180600**	**1292429**

Source: Department of Agriculture, Chennai

The consumption of fertilizers 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 charts in **Fig: 9.2**

Fig 9.1 Consumption of Fertilizers in Villupuram,Kancheepuram, Thiruvannamalai, and Cuddalore Districts

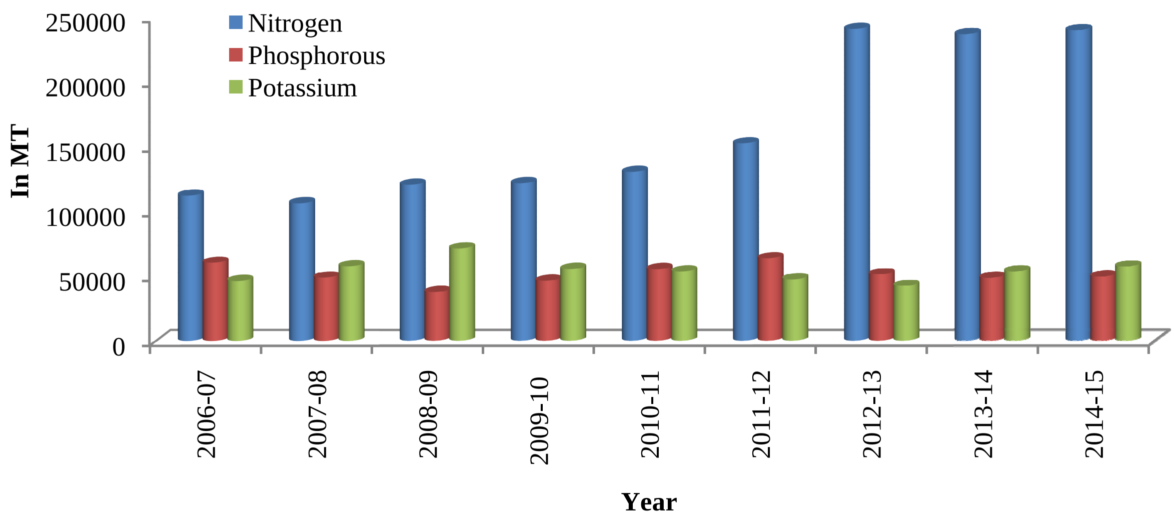
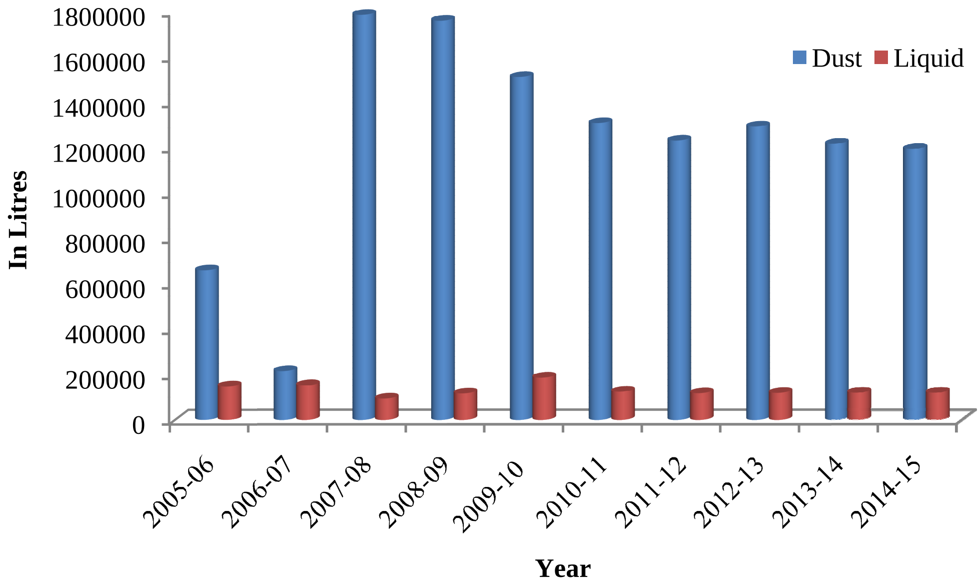


Fig 9.2 Consumption of Pesticides in Villupuram,Kancheepuram, Thiruvannamalai, and Cuddalore Districts



9.1.1.3 Effects of Agricultural pollution

- Chemicals from fertilizers and pesticides make their way into the groundwater that end up in drinking water. This may result in health related problems.
- The excess usage of potassium fertilizers has reduced the availability of micronutrients like calcium, zinc, manganese, and magnesium etc to the soil.
- High nitrate concentrations in drinking water causes blue baby syndrome which causes death in infants.
- Oil, degreasing agents, metals and toxins from farm equipment cause health problems when they get into drinking water.
- 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.
- The nutrients contained in fertilizers will not only promote the growth of crops but also of wild plants, weeds as well as algae and aquatic plants in rivers and lakes
- Excessive rates of fertilizer application adversely affect crop growth.

9.1.1.4 Mitigation measures

- Educating farmers and agro industries about reducing the nutrient loads entering the water bodies by ensuring better management of household and live stock waste in the villages, crop nutrient management, planting of buffer strips and conservation tillage.
- Promoting broad farmer awareness campaigns.
- Strengthening State policy, regulatory enforcement and institutional capacity against agricultural nutrient pollution and also encouraging organic farming.

9.1.1.5 Organic farming

Organic farming is gaining importance worldwide. India, as a result of "Green Revolution" has attained self sufficiency in food grain production. But this has definitely led to overexploitation of our natural resources and indiscriminate use of chemicals for cultivation. With food safety concerns looming large, we have to definitely take a stand on sustainable agriculture by adopting organic farming methods especially in food crops.

Advantages of Organic Farming

- Maintains the environmental health by reducing the level of pollution.
- Reduces human and animal health hazards by reducing the level of residues in the products.
- Reduces the cost of agricultural production and also improves the soil health.
- Ensures optimum utilization of natural resources for short-term benefit and helps in conserving them for future generation.
- Improves the soil physical properties such as granulation, aeration, easy root penetration and improves water-holding capacity.
- Improves the soil's chemical properties such as supply and retention of soil nutrients, and promotes favorable chemical reactions.
- Development of less intensive farming methods with reduced levels of fertilizer application.

9.1.2 Industrial Pollution

Industrial activities cause series of problems relating to environmental pollution.

The major pollutants from industries are

- Soluble organics or oxygen demanding wastes.
- Suspended solids.
- Priority pollutants such as phenol and other toxic organics.
- Oil and grease.
- Heavy metals and cyanides.
- Colour and turbidity.
- Nitrogen and phosphorus.
- Pesticides.etc.

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.

In G.O. Ms. No. 213 Environment and Forest (EC-I) deptdt. 30.03.1989 the Government has ordered that no new industry is to be sited within 1 km from water resources. The TNPCB will examine the case and obtain the approval of the Government for setting up highly polluting industries away from water sources as stipulated in the guidelines.

9.1.2.1 Industries in Varahanadhi basin:

Some of the major industries located in Varahanadhi basin are as follows

1. Rajshree Sugars and chemicals Ltd, Semmedu Village.**(RED)**

The company has interests across integrated fields such as Sugar, Distillery, Power and Biotechnology. The trade effluents from the industry are collected together and treated in the Automated Effluent treatment plant and the final treated water is used for farming in the company owned land, thus achieving Zero Liquid Discharge. The quality of the treated water is periodically checked by TNPCB.

2. Grace Infrastructure Pvt Ltd, Thiruchitrambalam**(RED)**

The company is involved in processing metal surface treatment such as pickling/ electroplating/ paint stripping/ heat treatment, finishing and anodizing .The trade effluents are treated in Automated Effluent treatment plant, where 75 % of the treated water is reused and the balance is put into Automated Evaporation system, thereby achieving Zero Liquid Discharge.

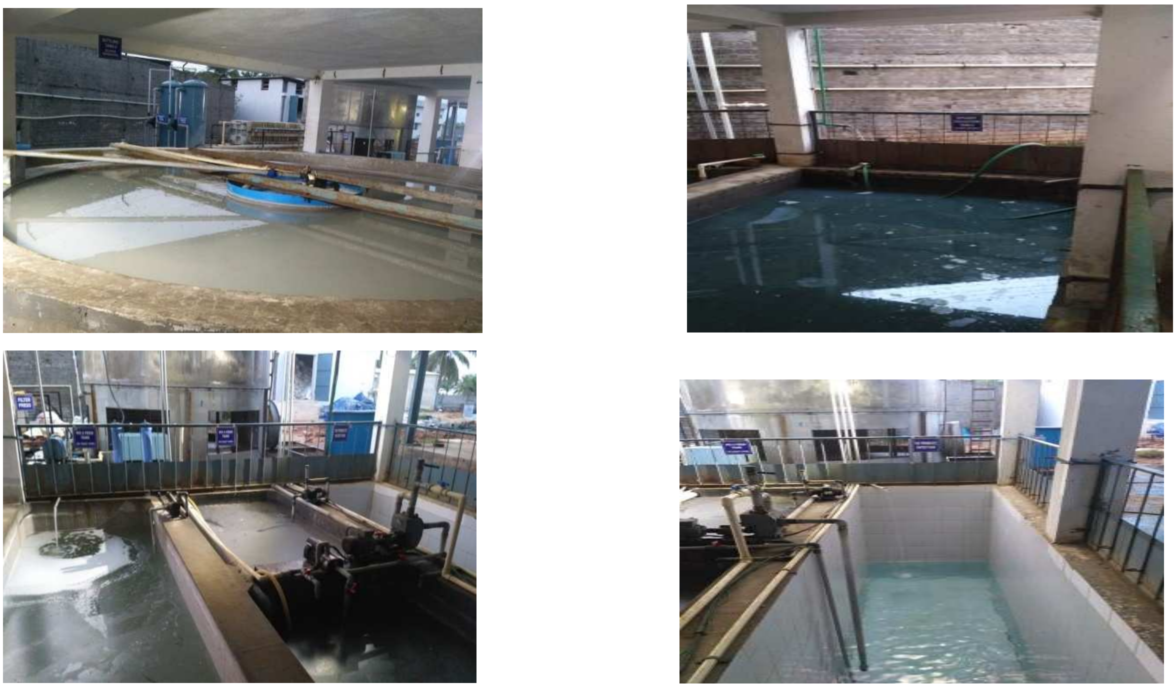


Fig 9.3 Effluent treatment plant at Grace Infrastructure Pvt Ltd, Thiruchitrambalam

The details of the large, medium & small industries in the basin along with the wastewater generated is given below in **Table 9.3 & Table 9.4**

Table 9.3 Waste Water generated in Large Industries in Mcum / year

Sl. No.	Name of sub basin	Number of large industries	Water demand in Mcum per year	Waste water generated in Mcum per year (80 % of water demand)
1.	Nallavur	12	0.816	0.653
2.	Ongur	6	3.050	2.440
3.	Varahanadhi	36	4.075	3.260
Total		**54**	**7.941**	**6.353**

Source: Analysis done in chapter 7

Table 9.4 Waste Water generated in Small &Medium industries in Mcum / year

Sl. No.	Name of sub basin	Number of small & medium industries	Water demand in Mcum per year	Waste water generated in Mcum per year (80 % of water demand)
1.	Nallavur	270	1.622	1.297
2.	Ongur	124	1.505	1.204
3.	Varahanadhi	458	0.711	0.569
Total		**852**	**3.838**	**3.070**

Source: Analysis done in chapter 7

Waste water from Large Industries = 6.353Mcum per year

Waste water from Small & Medium Industries = 3.070Mcum per year

Total = 9.423Mcum per year

9.1.2.2 Effluent Disposal

The problems relating to the disposal of industrial solid wastes are associated with lack of infrastructural facilities and negligence of industries to take proper safe guards. The effluent from sewage treatment plants may be discharged into waters bodies such as lakes, tanks, streams, or on land only after proper treatment. While discharging the effluents, the industries should follow the general standards of Environment Protection Rules. The nature and degree of treatment given to the sewage is dependent upon the requirement imposed by the regulatory authorities.

9.1.2.3 Suggestions

Most of the large scale industries in Varahanadhi basin are following Zero liquid discharge. Golden cashew products, Larsen & Toubro Ltd and United Spirits at Sedarapet, Puducherry seems to be polluting the Varahanadhi Basin. Hence the TNPCB should advise the Puducherry Pollution Committee to check the pollution levels of the industries and adhere to adopt National Norms in Environment protection.

9.1.2.4 General Mitigation measures

- Recycled treated Effluents should be used in Industries for cooling process
- Sewage treatment units must be installed, operated and maintained.
- Agglomeration of industries shall be encouraged so that the by-product or waste of one industry may be a raw material for some other industries, which will lead to reduction of natural water requirements.
- The treated waste water of one industry may be used as input for cooling tower of other industries like Thermal plant, Pharmaceutical, petro chemical, Refineries, Fertilizer industries, and so on, so that the fresh water requirement for those industries getting reduced.
- The residue from the treatment plant may be utilized for manufacture of fertilizers.
- The industries may be encouraged to use the treated waste water for flushing the cisterns in rest rooms, so that the fresh water requirements get reduced.

9.1.3 Domestic Sector

In Varahanadhi River Basin, domestic sewage in Villupuram Municipality is managed by two Sewage Treatment Plants (STP) which are set up at Ka. Kuppam and Erumanthangal in Villupuram as part of an underground drainage project being executed by the Tamil Nadu Water Supply and Drainage Board. Practically there is zero discharge of domestic sewage in the case of villages as they are independently let out in small trenches in minimal amount. The reuse of domestic sewage generated from the Municipalities and Town Panchayats is warranted. The details of STP in VillupuramDitrict is given below Table 9.5

Table 9.5 Sewage Treatment Plant in Villupuram District

Sl. No.	Name of the District	STP location	Technology	STP Capacity in MLD
1.	Villupuram	KaKuppam	Activated Sludge Process (ASP)	9.00
		Erumanthangal	Activated Sludge Process (ASP)	3.20
Total				**12.20**

The wastewater generated from domestic sector has been calculated based on the per capita water supply norms adopted by the TWAD Board for Municipality, Town panchayats, etc. The generation of sewage in Rural and Urban areas in Varahanadhi River Basin are shown in **Table 9.6** and **9.7** respectively**.**

Table 9.6 Generation of Sewage in Rural Areas

Collection of sewage is assumed as 80% of water demand

Sl. No.	Name of the Sub basin	Projected Population in 2017 in millions	Water Demand 2017 in Mcum	Volume of sewage generated in Mcum/ year
1.	Nallavur	0.296	8.648	6.918
2.	Ongur	0.552	16.118	12.894
3.	Varahanadhi	1.156	33.755	27.004
Total		**2.004**	**58.521**	**46.816**

Source: Analysis done in chapter 7

Table 9.7 Generation of Sewage in Urban Areas

Collection of sewage is assumed as 80% of water demand

Sl. No.	Name of the Sub basin	Projected Population in 2017 in millions	Water Demand 2017 in Mcum	Volume of sewage generated in Mcum/ year
1.	Nallavur	0.106	5.989	4.791
2.	Ongur	0.062	3.504	2.803
3.	Varahanadhi	0.221	12.488	9.990
TOTAL		**0.389**	**21.981**	**17.584**

Source: Analysis done in chapter 7

Sewage from Rural Areas = 46.816Mcum per year

Sewage from Urban Areas = 17.584Mcum per year

Total = 64.400Mcum per year

9.1.3.1 Waste Water Management

A) Sewerage Treatment Process:

The below diagram shows the typical process involved in the sewerage treatment,

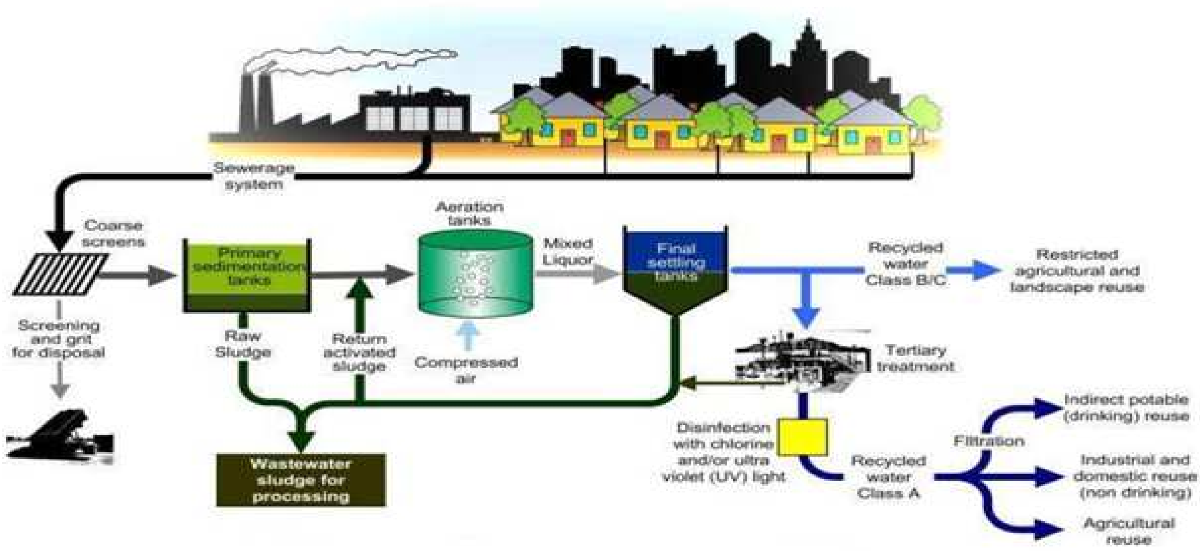


Fig 9.4 Sewerage Treatment Process

Here the recycled water from secondary treatment can be used for restricted agricultural and landscape reuse and the recycled water from the tertiary treatment after disinfection can be used for direct agricultural reuse, industrial and domestic reuse. This water is further treated with RO process using the dual membrane technology and after disinfection by Ultra Violet technology can be used for drinking purpose.

B) Constructed Wetlands:

Constructed wetlands are man-made wetlands built to remove various types of pollutants present in the waste water that flows through these systems. They are constructed to recreate the structure and function of natural wetlands. They possess a rich microbial community to effect the biochemical transformation of pollutants. They are biologically productive and most importantly they are self sustainable. They are simpler with regard to Operation & Maintenance and require energy only for pumping (lower than conventional STP). They can deliver consistent and high level of treatment for Organics, Pathogens and nutrients.

C) Sewage Farming

The nutrients in sewage like nitrogen, phosphorous and potassium along with the micronutrients and organic matter present in it can be advantageously employed for manufacture of fertilizer, enhancing sewage farming and improving the drainage characteristic of the soil. Even application of treated effluent to land has to be carried out with certain precautions as it is not completely free from risk.

A good sewage farm should be run on scientific lines with efficient supervision with the prime objective of not polluting the soil. Effluent from properly designed waste stabilization ponds is also suitable for application on land. Under no condition, application of raw sewage on sewage farms should be permitted.

D) CASE STUDY - Reuse of Municipal Effluent for Potable use:

The "neWater" is the brand name given to reclaimed water produced by Singapore's Public Utilities Board. More specifically, it is treated wastewater (sewage) that has been purified using dual-membrane (via microfiltration and reverse osmosis) and ultraviolet technologies, in addition to conventional water treatment processes. The water is potable and is consumed by humans, but is mostly consumed by industries requiring high purity water. The quality of neWater consistently exceeds the requirements set by WHO guidelines and is cleaner than Singapore's other water sources.

Fig 9.5: Bottles of neWater for drinking purpose

9.1.3.2 General Mitigation Measures

- 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.
- Open discharge of domestic effluents into the river must completely be stopped.
- Sanitary facilities have to be provided at public places.
- Awareness has to be created among the public to prevent pollution of water bodies.
- Public may be encouraged to reuse the treated water for different purposes like pisciculture, aquaculture, horticulture and irrigation.
- Subsidies may be provided by the Government to the communities for treating waste water.

9.2 Sedimentation

Sedimentation is a natural process of all water bodies like lakes, rivers, estuaries, coastal zones and even the deep ocean. Sedimentation in one area is linked to erosion or impoverishment in another area. The environmental impacts of sedimentation include loss of important or sensitive aquatic habitat, decrease in fishery resources, loss of coral reef communities, human health concerns, changes in fish migration, increase in erosion, loss of wetlands, changes in nutrient balance, circulation changes, increase in turbidity , loss of submerged vegetation, loss of recreation attributes and coastline alteration.

Under natural conditions, sediment is transported from land to water in runoff. The sediment flow varies widely both annually and seasonally over time. In case of reservoirs, the coarser & heavier sediments, gravel and sand tend to settle out at the upper end of reservoir, forming a backwater delta which gradually advances towards the dam. The lighter sediments, silt and clay tend to be deposited nearer the dam. The rate of reservoir sedimentation depends mainly on the size of reservoir relative to the amount of sediment flowing into it. The amount of sediment carried into a reservoir is at its highest during floods. While the rate of sedimentation varies for each reservoir and each river, eventually all reservoirs develop a reduced water-storage capacity due to the exchange of storage space for sediment.

Most modern dams are designed such that, the dams can afford to lose some storage capacity without their performance being impaired, by means of "dead storage" that lies beneath the lowest outlet of the dam. However sediments do not build up evenly along a horizontal plane, so that some "live storage" is usually lost long before the dead storage is filled.

Similarly, sedimentation in tanks has also become increasingly important since the sediments deposited inside the tank reduces its capacity thereby thwarting the very purpose for which it was constructed.

Considering the above facts, periodic capacity surveys and sedimentation studies are essential to assess the rate of siltation and the impact of sedimentation on the performance of the Reservoirs and tanks.

In Varahanadhi basin there are 614 tanks, out of which 21 tanks have a capacity of more than 30 Mcum. So far no sedimentation study has been conducted in any of these tanks in the basin. It is suggested to carry out sedimentation studies atleast in the major tanks so as to assess the present storage capacity of the tanks for its efficient utilization.

Vidur dam is the only dam located in Varahanadhi River Basin. The sedimentation study for Vidur dam was conducted by the Water Shed Management Division during 2009 and the details are shown in **Table 9.8**

Table 9.8 Details of sedimentation study conducted in Vidur Dam during 2009

Name of the Reservoir	Year of completion of the dam	Original capacity in Mcum.	Capacity Survey done during the Year	Present capacity in Mcum	Capacity loss in Mcum	Average Annual silting rate in M.Cum/ year	Average annual silting rate in %	Average annual silting load/sq.km	
								catchment Mm³/sq.km	water spread Mm³/sq.km
Vidur	1959	17.132	2009 (First)	14.40	2.732	0.0546	0.32	0.000042	0.0070

Source: Executive Engineer, Water Shed Management, Pollachi

From the above table it is inferred that the loss in capacity in Vidur dam during the last 58 years is around 16 %.

9.2.1 Mitigation measures

Abatement or control of sedimentation can be successful if implemented on a broad land area or watershed scale and is directly related to improvement in land-use practices. Agriculture and forestry (logging) improvements where soil loss is minimized are not only technically feasible, they can also be carried out at a moderate cost and with net benefits. The mitigation measures for sedimentation are as follows.

- Construction of terraces for agriculture and modifying the slope of the land, thereby intercepting the runoff and reducing soil loss. This also helps to improve soil fertility and increase the productivity of the agricultural areas establishedon these terraces
- Operation of reservoir may be arranged in such a way that more of suspended sediment water is withdrawn at appropriate time.
- Construction of dykes, check dams and formation of detention basins in the upstream stretch of main river and tributaries which will help in reducing the muddy flood peaks by detaining sediment
- Formation of Gullies control and stream bank protection measures may be adopted.
- Watershed management including afforestation and the promotion of farming practices which reduce soil erosion is frequently advocated as the best way of cutting sediment deposition in reservoirs.
- Ensuring environmentally acceptable methods for the disposal of dredged sediments and ensuring use of sediments for enhancement where appropriate.
- To manage sediments supply at source by putting in place agricultural best practice and techniques.
- To reinstate sediments to increase the quantity and / or quality of spawning habitat for targeted species and reducing fine sediment deposition in spawning and / or rearing habitats.

9.3 Water Weeds

Water weeds are unwanted and undesirable vegetation that reproduce, grow and complete their entire life cycle in water. If left unchecked it chokes the water body posing a serious menace to the aquatic environment and its relative eco-environment. The Aquatic weeds cause tremendous loss of water from water bodies through evapotranspiration, which results in reducing the capacity of the water storage and therefore affecting efficient irrigation. In flowing water system, aquatic weeds impede the flow of water in irrigation canals and drainage channels thereby increasing evaporation, damage structures in canals and dams, clog gates, siphons, valves, bridge piers, pump etc. Impediment in flow of water may also result in localised floods in neighboring areas.

Therefore, considering the losses caused, it is essential to keep aquatic weeds under control in water bodies, flow water systems, ponds and tanks so that these systems can be utilized to the best of their efficiency.

9.3.1 Types of Water weeds

Water weeds are broadly classified as Floating type, submerged type and Emergent type.

Water weeds

Floating type Roots of the floating plants hang in water and not attached to soil.	**Submerged type** Weeds growing below the water surface	**Emergent type** Rooted waterweeds extending above the water surface
Eichhorniacrassipes (Water hyacinth), *Pistiastratoites* (Water lettuce), *Salvia cuculata* and *Salvinianatans*, *Spirodelapolyrhiza*, *Lemna minor* and *Wolffiaarrhiza*(duck weed), *Azollapinnata* (water fern).	*Hydrillaverticillata(Hydrilla)*, *Vallisneria*, *Myriophyllumspicatum*(water milfoil).	*Typhaspp*(Cattails), *Cyperusspp*, *Scirpusspp* (bulrush), *Phragmitescommunis* (reed) etc.

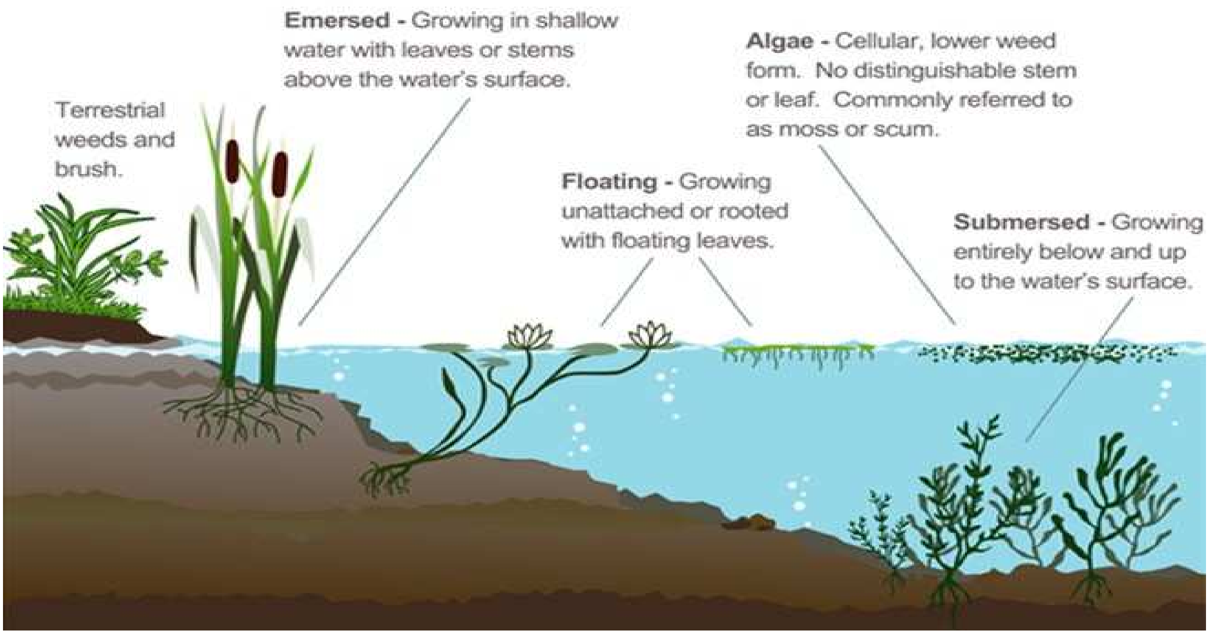


Fig: 9.6 Types of water weeds

The most noxious weed is water hyacinth (*Eichhorniacrassipes*). In India 60-70% of inland water is presently infested with aquatic weeds predominantly by water hyacinth. Water hyacinth registers 5% gain in weight every day. At least 80% of the plant body constitutes water and the loss through transpiration is also more and higher than the normal evaporation from the aquatic ecosystem.

9.3.2. Water weeds in tanks in Varahanadhi basin

Fig: 9.7 Weeds in Kazhuveli Anicut

In Varahanadhi sub basin, Parthenium and Ipomoea carneaweed are the most common water weeds predominant in the water bodies.

Parthenium is a fast-maturing weed with a deep tap root and an erect stem that becomes woody with age. It may eventually reach a height of 2m. Its leaves are pale green, branched and covered with soft fine hairs. Its large and persistent soil seed bank, fast germination rate and ability to undergo dormancy make it well adapted to semi-arid environments.

I carnea is a gregariously growing annual shrub found around tanks, ponds, puddles and wet places. It grows to a height of 1- 5m; the stem is thick and develops into a solid trunk over several years with many branches from the base. Due to its high adaptability and resistance towards adverse climatic conditions, it may grow in all types of climate and soils, marshy as well as dry. It can also survive with or without water for several months in the tanks. This weed propagates at a tremendous rate and is rooted on the marginal region of the surface layer of water and ramifies on the surface of water and also on the adjoining land.

9.3.3 Reasons for the abundance of waterweeds

Various reasons are attributed to the successful invasion of waterweeds.

1. Clearance of riparian vegetation along the bank of the river for industrialization and domestic purposes.
2. Invasion by exotic weeds.
3. Eutrophication of riverine ecosystem due to return flow and sewage entry.

4. Lack of proper waterweed management plan.
5. Lack of controlling measures of weed invasion.

9.3.4 Impact of waterweeds

The damage by waterweed invasions is both ecological and economic.

9.3.4.1 Effect of water weeds in the river system

- Decrease in water quality.
- Luxuriant growth of periphytes
- Increased evapo-transpiration.
- Rising of riverbed due to sedimentation.
- Narrowing of water ways
- Blockage of water canals and sluices.
- Competition for space
- Invasion in the agricultural fields.
- Clogging of drainage systems during flood season, causing breaching of rivers, drainages and supply channel as well as inundation in the river corridors which causes epidemic diseases.

9.3.4.2 Environmental effects of Weeds:

- Creates ideal situation for breeding of mosquitoes, responsible for the spread of Malaria, Yellow fever, river blindness and encephalitis.
- Provides shelter to predatory weed fishes and mollusks which play a crucial role in the life-cycle of blood and liver flukes (parasitic worms)
- Upsets the equilibrium of physico-chemical properties of water.
- Causes imbalance in the biological oxygen demand due to excessive organic loading.
- Displaces natural vegetation and destroys aquatic life.
- Affects the fish habitat in the water bodies.
- Increases emission of CO2 and CO into the atmosphere due to decomposition of huge volume of aquatic weeds creating foul smell that are unpleasant to public convenience.
- Organic matter content of water is increased which affects the strength of the concrete structures when used as curing and mixing water.
- Impedes water flow and increases flooding and erosion.

9.3.5 Methods for controlling the Water weeds

The water weeds have become a menace in different parts of the River Basin. Several methods are being recommended to suppress its growth.

9.3.5.1 Manual methods

Dredging: This is the most common method of clearing the weeds from drains and ditches. A dragline dredge may be equipped with a bucket or with a weed fork or other special tools.

Drying: The submerged weeds are exposed to sun by draining the water form ditches and ponds and allowed to dry. Drying may be repeated to control regrowth from roots which propagates in the bottom mud or sand.

Mowing: Mowing is a method of controlling weeds in the banks of the canal and ditches.

Hand cleaning: The men cut and remove the weeds with heavy knives and hooks.

Burning: It is used to control the weeds in the banks above the water line. Best results could be obtained by first searing the green vegetation and following it with complete burning in10 to 12 days. A hot flame is passed over the vegetation at such a rate that the plants wilt but are not charred. Burning can be combined with chemical or other mechanical methods. Mowing followed by burning the dried weeds may increase the effectiveness of mowing.

Chaining: A heavy chain is attached between two teams or tractors on opposite banks of the ditch. As they move, the chain drags over the weeds and breaks them off.

Cutting: A mechanical weed cutter is used to cut the aquatic weeds at 1 to 1.5 m deep in the water. It consists of a sharp cutter bar operated hydraulically from a boat. The harvested weeds float to the water surface and are removed manually or by sieve buckets. The beach groomer is a portable and free standing weed control device fitted with a handle that can take care of every undesired water weeds.

9.3.5.2Biological Methods

This method is more advantageous since the undesirable weeds are converted into fish flesh. It is cheap as no labour is involved and most suitable from the social and environmental point of view.

Grass carp serves as a valuable biological control for aquatic weeds. Grass carp control certain species of aquatic weeds better than others. They prefer to feed on succulent submerged weeds over the more fibrous weeds. A grass carp fish is considered as an excellent bio-agent directly fed on Hydrilla. A grass carp weighing 1.20kg was found to consume daily about 1.4 times its own weight of Hydrilla. Similarly, Tawes, *Puntiusgonionotus*, is also a good feeder of aquatic weeds. The Yamuna turtle consumes water hyacinth in the ponds

Fig: 9.8 Grass Carp &Tawes

9.4 Catchment Area Treatment

Catchment Area Treatment or Watershed management is the optimal use of soil and water resources within a given geographical area so as to enable sustainable production. It implies changes in land use, vegetative cover, and other structural and non-structural actions implemented in a watershed, to achieve specific watershed management objectives. The main aim of the catchment area treatment is to rejuvenate various potential and degraded ecosystems in the catchment area.

9.4.1. Objectives of Catchment area treatment

1. To facilitate the hydrological functioning of the catchment and to augment the 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. Demarcation of the priority of sub watersheds of treatment on the basis of soil erosion intensity in the catchment area.
4. Rehabilitation of degraded forest through afforestation.
5. Mitigation of landslide, landslip and rock falls.
6. Soil conservation through biological and engineering measures to reduce sediment load in river and tributaries and other water bodies, thus improving the quality of water.
7. Ecosystem conservation resulting from increased vegetative cover and water retaining properties of soil.
8. To reduce the silting of the reservoir by soil conservation methods in the catchment area.
9. 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 eroded sediment from catchment when deposited on streambeds and banks causes braiding of river reach. 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.

The lack of proper vegetal cover is a factor, which causes degradation and thereby results in severe run off/soil erosion, resulting in premature siltation of the reservoir. Thus, a well-designed Catchment Area Treatment (CAT) Plan is essential to ameliorate 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.

9.4.2 Catchment Area treatment Plan in Varahanadhi basin

Percentage of forest area in this basin is 7.7%, which is very low and this percentage is well below the prescribed national average of 33.3%. Due to the delay in the settlement process, large-scale encroachments took place even in the most remote areas and were converted into plantations illegally. Due to urbanization, the rehabilitation of people in the foothills of the watershed and the animals rearing by such people caused extensive damage to the forests and grasing land. Human settlement, illegal and commercial agricultural practices, cutting of trees and disappearance of vegetable cover caused soil erosion in the basin.

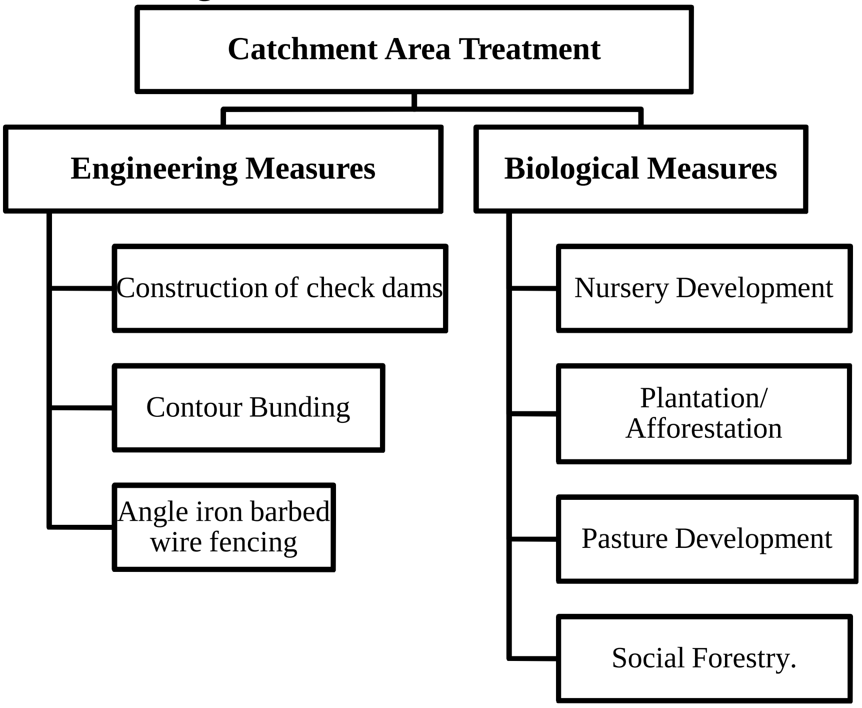
The catchment area mainly comprises under Gingeetaluk in Villupuram district, some area of Kancheepuram and Thiruvannamalai districts and the remaining areas are scattered hillock and plain in the above districts and no significant degradation is taking place in this area. The catchment areas of Varahanadhi basin include grassland eco systems, reed land eco systems and plantation eco systems. Protection of all these eco systems is important for preserving the integrity of the catchment area.

Vidur Reservoir is the only major reservoir located in Varahanadhi basin constructed across Varahanadhi river below the confluence of Thondiarriver in Tindivanamtaluk of Villupuram district. The catchment area of Vidur Reservoir is 1298 Sq.km (501 sq. miles). The main source of supply for the reservoir is Varahanadhi and Thondiar rivers. The first capacity survey was carried out in Vidur Reservoir during 7 / 2009 by the Watershed Management Board, Pollachi to study the sedimentation effects in the reservoir and it was recommended to adopt suitable catchment area treatment plan in the reservoir to reduce siltation.

9.4.2.1 Catchment Area Treatment Plan

The basis for formulating appropriate Catchment Area Treatment Plan depends upon the parameters of the watershed such as geology, geomorphology, topography, soil, land use/ land cover, climate, hydrology, drainage pattern, etc. Considering the topographic factors, soil type, climate, land-use/land-cover in the catchment area, the following Engineering and Biological measures may be undertaken with the aim to check soil erosion, prevent/check siltation of reservoir and to maintain its storage capacity in long run:

Fig 9.9 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 9.9 below.

Table 9.9 Catchment Area Treatment measures

Sl. No.	Basis for selection	Catchment Area Treatment measure
1.	Near settlements to control tree felling	Social forestry, fuel wood and fodder grass development
2.	Control of soil erosion from agricultural fields	Contour Bunding
3.	Open canopy, barren land, degraded surface	Pasture Development
4.	Open canopy, degraded surface, high soil erosion, gentle to moderate slope	Afforestation
5.	In the vicinity of afforestation work to protect it from grazing etc.	Barbed wire fencing
6.	To check soil erosion in small streams, steps with concrete base are prepared in sloppy area where silt erosion in the stream and bank erosion is high due to turbidity of current.	Step drain
7.	Centrally located points for better supervision of proposed afforestation, minimize cost of transportation of seedling and ensure better survival.	Nursery

9.4.3 Mitigation Measures :

The following mitigation measures can be adopted to control the catchment area problem.

- Prevention of mining in the forest areas.
- Prevention of soil erosion by preserving the forests and grasslands.
- Afforestation in the degraded forest areas by gap planting to create dense forests.
- Construction of contour stonewalls (stone terracing) and bench terracing.
- Construction of gully plugging and temporary check dams.
- Construction of major check dams and percolation ponds.
- Involving local people in catchment protection activities.
- Mechanical and soil conservation techniques may be adopted.

9.5 Sea Water Intrusion

9.5.1 Introduction

The sea water intrusion occurs in two modes i.e. direct and indirect. Direct sea water intrusion implies a direct transport of sea water from sea to hydraulically connected aquifer by reduction or reversal of water table gradients. Indirect intrusion implies transport of sea water first into a surface water body like river which are terminating into sea, followed by intrusion of a part of this transported water from the surface water body into a hydraulically connected aquifer. The extent of intrusion depends upon climatic conditions, the hydrogeology of the area and the extent and pattern of ground water development in and around the coastal stretch.

This report of Sea Water Intrusion Study of Varahanadhi basin is mainly based on water quality and hydrogeological data of sea water intrusion study wells, observation wells and piezometers in and around the study area of TamilNadu coast. Here an effort is made to bring the status of present sea water intrusion in the study area by simulating and comparing the water quality data which is collected from State Ground and Surface Water Resources data centre of Water Resources Department from the year 2012 to 2016.

9.5.2 Location and Extent

The study area of Varahanadhi River Basin is situated between Vadapuram village of Cuddalore District to Kadapattu village of Kancheepuram district covering a coastal length of 71.5 Kms and width 10 Kms from the coast. The study area exists in coastal stretch of Kancheepuram, Villupuram and Cuddalore districts of Tamilnadu State and a small part of Union territory of Puducherry covering a total area of 715 sq.Kms. The entire study area of the basin lies between the following co-ordinate.

Latitude : 11° 52' 01" N and 12° 26' 49" N

Longitude : 79° 43' 19''E and 80° 07' 41''E.

The GI Sheets which cover these area are 66D/3&4, 57 P/16, and 58 M/13

9.5.3 Hydrogeological Conditions

Major portion of the study area of sea water intrusion is a plain terrain comprising of sedimentary formations except small areas of Lattur and Chittamur blocks where in crystalline rocks are observed. Major sedimentary formations are alluvium, sandstone, clay, limestone and calcareous shale of Cretaceous to Recent age. The surplus water of Kaluveli swamp finds its way to feed Yedayanthittu Kaluveli swamp on the north by a tidal creak where the Ongur river confluences Bay of Bengal. During high tides sea water enters these swamps and thus ground water in and adjoining villages are deteriorated. Salt pans are observed surrounding Kaluveli tank to the north of Marakkanam.

Water level in general varies from 0.2meter to 7 meter in post monsoon period and it varies from 2 meter to 9.9 meter in pre monsoon periods as per records of the year 2016. However in Kanthadu area water level observed is 21.46 m in pre monsoon (Aug2016) reaching below mean sea level.

9.5.4 Methodology

By establishing a net work of observing wells spread over the entire coastal belt, the fluctuation in ground water level is monitored every month for sea water intrusion study by State Ground and Surface Water Resources Data Centre, WRD-PWD and water samples are also being analysed twice in a year for the months of January and July (Post Monsoon and Pre Monsoon). There are 23 numbers of Sea Water Intrusion study wells including 8 numbers of piezometers in the study area. The chemical analysis data for the year 2012 to 2016 are tabulated and given in annexure SW-1 and SW-2 for post and pre monsoon periods respectively. Apart from these, data available for other observation wells and piezometers in 23 locations falling in and around the study area are also taken for better interpolation. Chloride content and Total Dissolved Solids of water samples are taken as parameters of water quality for sea water intrusion study. With the results of all these 46 number of wells, spatial distribution of Chloride concentration and Total Dissolved Solids are arrived in the study area using GIS software. (Map-VAR 48A and VAR 48 B)

Chloride value less than 250 mg/lit is taken as safe and 250 mg/lit to 500 mg/lit as moderate value. The concentration more than 500 mg/lit is considered as poor quality indicating chances of sea water intrusion. (Map VAR 48A)

Similarly data of total dissolved solids of the water samples in and around the study area are simulated. (Map VAR 48B). The total dissolved solids ranging from 500 mg/lit to 1000 mg/lit are considered as good quality and concentration in the range of 1000 mg/lit to 2000 mg/lit are considered as moderate quality.

For comparison of quality variations, trend lines of Chloride and TDS concentration are drawn for the years from 2012 to 2016. Graph No. 1 & 2 shows the graphical representations of Chloride and TDS value and its variation with respect to time for both pre and post monsoon periods.

9.5.5 Observations and Limitations of the Study

It is observed that in majority of the study area, chloride content is within the safer limit ie. less than 250 mg/lit. However it must be noted that most of the observation wells are having depth below 10 meters below ground level and do not indicate quality variations below that depth. Moderate quality with respect to chloride is observed in eastern side of Marakkanam and north eastern part of Vanur blocks. Slightly higher values of chloride concentration varying between 500 mg/lit to 1000 mg/lit are observed in Alapakkam and Chettikuppam areas of Marakkanam block indicating moderate to poor quality of water. However in Alapakkam area chloride concentration is in decreasing trend from the year 2012 to 2016 indicating improvemets in quality. (Graph -1)

Most of the study area of Varahanadhi basin is covered by desirable and good quality of water with respect to total dissolved solids. In eastern coastal area of Marakkanam and eastern part of Vanur blocks moderate quality of water ie.TDS in the range of 1000 mg/lit to 2000 mg/lit is observed. In Alapakkam and Chettikuppam area of Marakkanam block TDS value is 1882 mg/lit and 1859 mg/lit respectively indicating moderate to poor quality of water. In Nesal village of Vanur block and in Kunimedu village of Marakkanam block moderate quality of water is observed.

Water quality trend lines of TDS value are decreasing from the year 2012 to 2016 indicating that there is no deterioration of quality of water with respect to time.(Graph -2)

By analyzing water quality with respect to Chloride and TDS value it is observed that there is no sign of sea water intrusion in the study area except Alapakkam, Kunimedu , Chettikuppam and surrounding areas of Marakkanam block. However these values are moderate in quality classification and may be due to marine formation or back water effect in Kaluveli Swamp during high tides finding its way from Ongur river confluence point. Presence of salt pans to the north of Marakkanam may also be a reason for deterioration of ground water quality.

9.5.6 Inferences

1.The net work of 23 numbers of sea water intrusion study wells including 8 numbers of piezometers in the study area and other 23 numbers of observation wells in and around the study area and its quality variations comprises data base of the study.

2.Water level in general varies from 0.2m to 7.0 meters in post monsoon periods and it is in the range of 2.0 meter to 9.9m in pre-monsoon periods during the year 2016.In Kanthadu area water level has reached below mean sea level indicating reduction or reversal of water table gradient.

3. Chloride concentration and Total Dissolved Solids are taken as criteria for delineating water quality zones for identifying sea water intrusion in the study area of the basin. However most of the water quality data are from shallow observation wells and do not represent deeper subsurface aquifers.

4. By analyzing water quality with respect to Chloride and TDS value it is observed that there is no sign of sea water intrusion in the study area except Alapakkam, Kunimedu , Chettikuppam and surrounding areas of Marakkanam block. However these values are moderate in quality classification and may be due to marine formation or back water effect in Kaluveli Swamp during high tides finding its way from Ongur river confluence point. Presence of salt pans to the north of Marakkanam village may also be a reason for deterioration of ground water quality.

5. Water quality trend lines of Chloride and TDS value are decreasing from the year 2012 to 2016 indicating that there is no deterioration of quality of water with respect to time.(Graph - 1&2).

6. However detailed analysis with more number of observation net work depicting different aquifer zones is necessary for sea water intrusion study.

9.5.7 Recommendations

- Majority of available data is from shallow open wells having depth of less than 10 meters below ground level which do not represent quality variations of aquifers at deeper depth. Hence it is prime requirement to have more number of observation well net work- mainly piezometers reflecting deeper depth of aquifers for sea water intrusion study.
- Vertical Electrical Sounding data are very much helpful for delineating sea water/freshwater interface line. Hence Geophysical survey using the electrical resistivity measurements may be conducted at proper intervals preferably in different profiles for every five kilometers in coastal line. In each profile it is suggested to conduct depth probes at 1km, 2km, 3km, 5km, and 10kms away from the sea so as to delineate sub surface layers and sea water/fresh water interface line approximately.
- Kaluveli tank water gets contaminated more often by the invasion of sea water during the periods of high tides, which in turn cause deterioration of ground water quality in and adjoining villages of Marakkanam block. Proper regulating arrangements may be done to prevent the entry of sea water in to swamps during high tides.

Fig 9.10 SEA WATER INTRUSION STUDY
VARIATION OF TOTAL DISSOLVED SOLIDS IN
OBSERVATION WELLS OF VARAHANADHI BASIN
(FROM THE YEAR 2012 TO 2016)

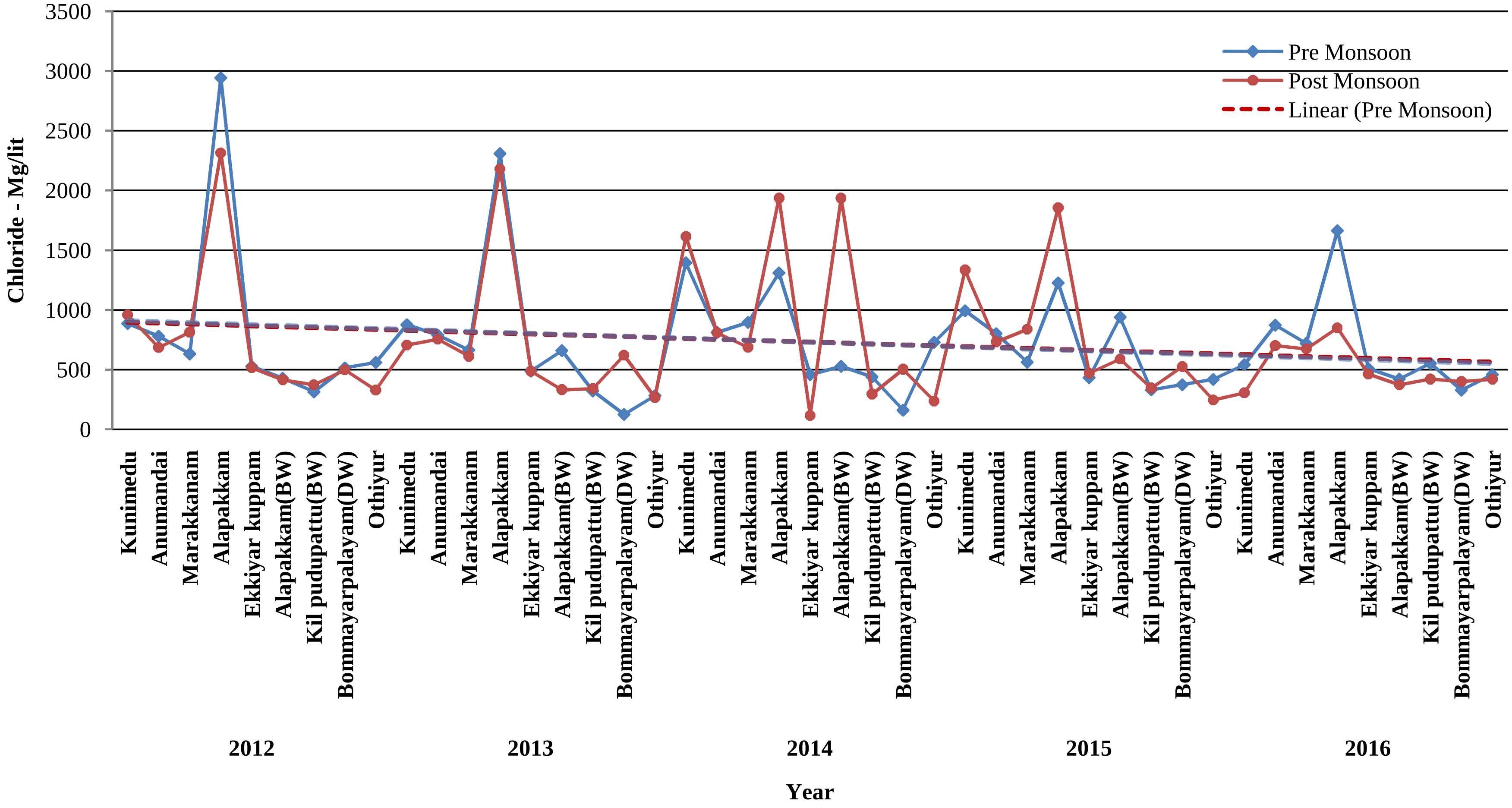
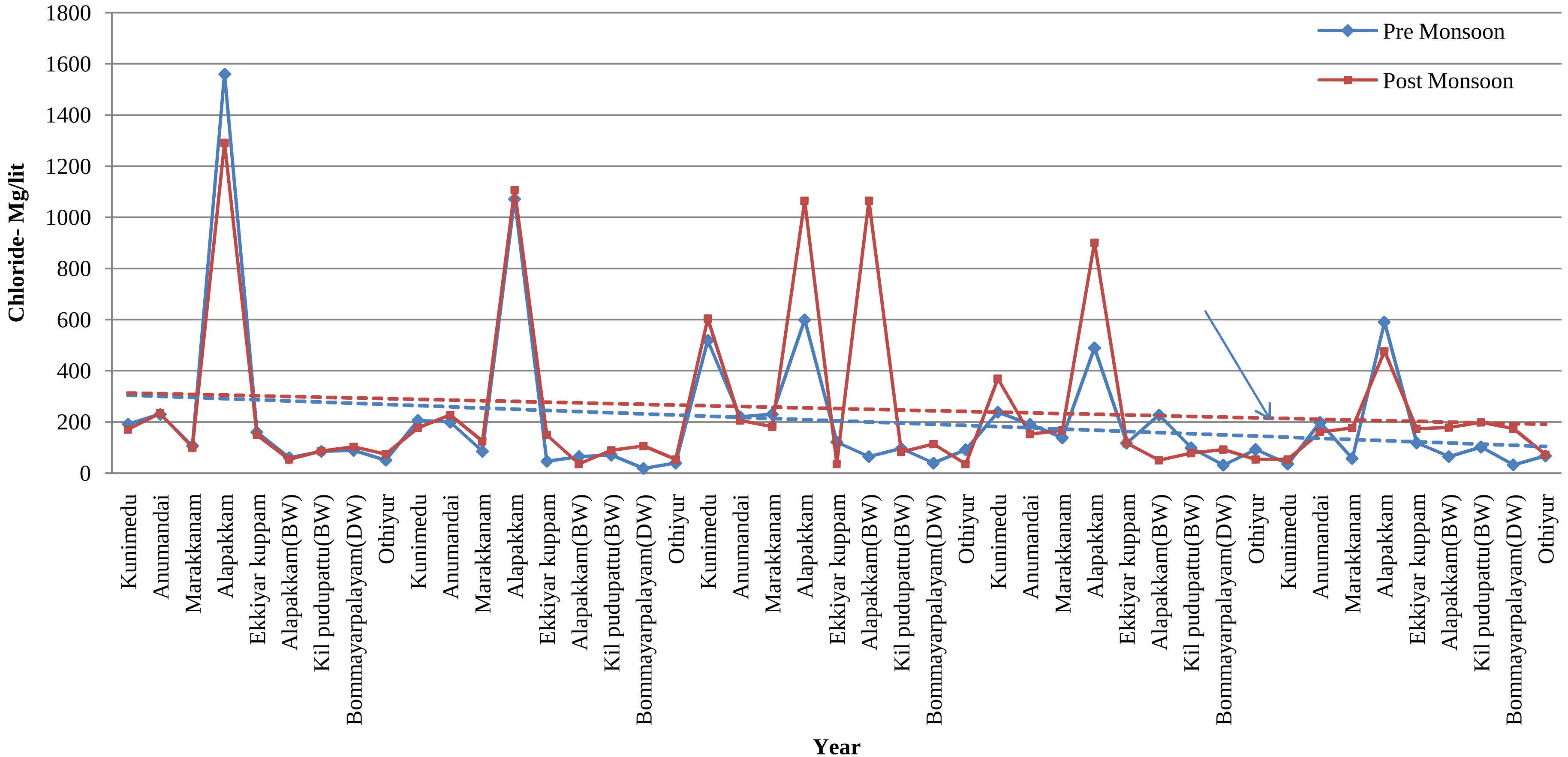
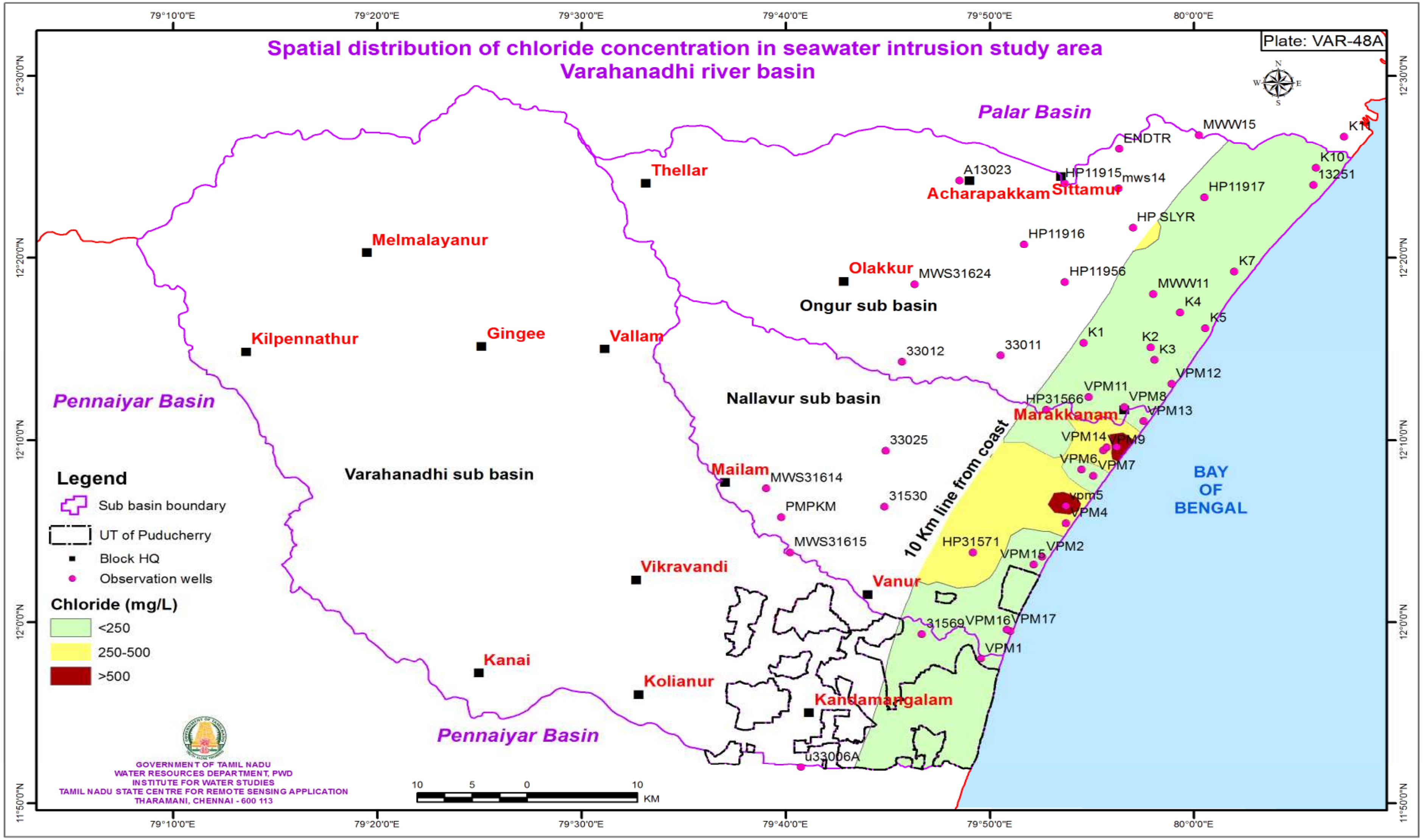


Fig 9.11 SEA WATER INTRUSION STUDY

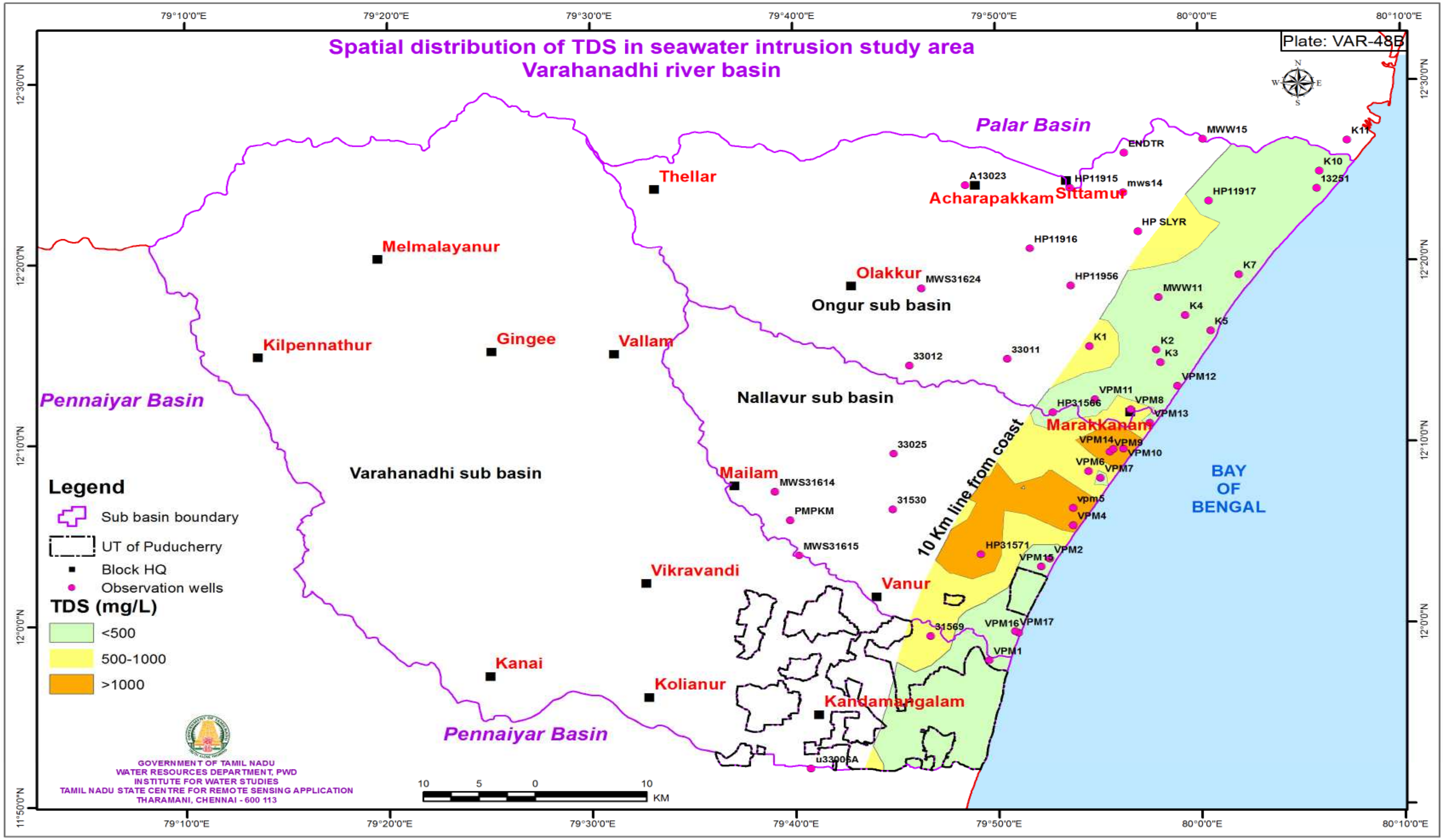
VARIATION OF CHLORIDE CONCENTRATION IN OBSERVATION WELLS OF VARAHANADHI BASIN

(FROM THE YEAR 2012 TO 2016)





Spatial distribution of chloride concentration in seawater intrusion study area
Varahanadhi river basin
Plate: VAR-48A
Palar Basin
Pennaiyar Basin
Pennaiyar Basin
BAY OF BENGAL
Varahanadhi sub basin
Ongur sub basin
Nallavur sub basin
10 Km line from coast
Thellar
Melmalayanur
Kilpennathur
Gingee
Vallam
Olakkur
Acharapakkam
Sittamur
Marakkanam
Mailam
Vikravandi
Vanur
Kanai
Kolianur
Kandamangalam
Legend
Sub basin boundary
UT of Puducherry
Block HQ
Observation wells
Chloride (mg/L)
<250
250-500
>500
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI - 600 113
KM



Spatial distribution of TDS in seawater intrusion study area
Varahanadhi river basin
Plate: VAR-48B
Palar Basin
Pennaiyar Basin
Pennaiyar Basin
BAY OF BENGAL
Varahanadhi sub basin
Ongur sub basin
Nallavur sub basin
10 Km line from coast
Melmalayanur
Kilpennathur
Gingee
Vallam
Thellar
Olakkur
Acharapakkam
Sittamur
Marakkanam
Mailam
Vikravandi
Vanur
Kanai
Kolianur
Kandamangalam
Legend
Sub basin boundary
UT of Puducherry
Block HQ
Observation wells
TDS (mg/L)
<500
500-1000
>1000
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI - 600 113

Table 9.10 (a) Chemical Analysis of water samples for Sea Water Intrusion Study in Varahanadhi River Basin - (2012- Pre Monsoon)															
Name of the location	**Well ID**	**Latitude**	**Longitude**	**pH**	**EC m.mhos/ cm**	**TDS**	**Ca Mg/lit**	**Mg Mg/lit**	**Na Mg/lit**	**K Mg/lit**	**Cl Mg/lit**	**SO4 Mg/lit**	**CO3 mg/lit**	**HCO3 Mg/lit**	**NO3 Mg/lit**
Chinnakottakuppam	VPM1	11 57 59	79 49 33	8.2	190	99	14	12	4	2	32	6	0	55	1
Kil pudupattu	VPM2	12 03 47	79 52 33	8.2	260	142	14	12	20	1	67	11	0	31	1
Kunimedu	VPM4	12 05 26	79 53 37	8	1390	887	40	40	147	86	191	144	0	244	117
Anumandai	VPM6	12 08 23	79 54 23	8.2	1360	780	50	40	175	7	230	72	0	305	53
Keelpettai	VPM7	12 08 01	79 55 04	7.6	490	260	26	34	17	2	78	22	0	122	20
Marakkanam	VPM8	12 11 48	79 56 35	8	1030	631	36	30	81	96	106	34	0	323	86
Alapakkam	VPM9	12 09 27	79 55 33	7.6	5300	2943	272	248	436	2	1560	341	0	116	26
Alapakkam	VPM10	12 09 38	79 56 13	8.3	2450	1375	80	97	285	4	638	139	0	189	25
Kanthadu	VPM11	12 12 22	79 54 44	8.1	470	276	20	27	24	17	78	19	0	92	45
Kaippanikuppam	VPM12	12 13 05	79 58 48	7.9	260	139	16	16	9	4	14	5	0	122	14
Ekkiyar kuppam	VPM13	12 11 03	79 57 31	7.9	930	527	40	40	88	7	160	39	0	195	55
Alapakkam(BW)	VPM14	12 09 37	79 55 37	8.2	740	429	32	24	50	63	60	6	0	311	38
Kil pudupattu(BW)	VPM15	12 03 09	79 52 08	8	530	314	20	24	30	39	85	5	0	146	38
Bommayarpalayam(DW)	VPM16	11 59 39	79 50 57	8.1	890	515	32	30	68	72	89	13	0	342	40
Bommayarpalayam(BW)	VPM17	12 09 37	79 55 37	6.9	220	126	18	10	11	2	43	10	0	43	10
Vennangupattu	K2	12 15 06	79 57 52	7.4	410	410	20	12	47	2	64	8	0	134	11
Thenpakkam	K3	12 14 24	79 58 04	7.8	260	260	6	9	35	2	67	8	0	43	1
Kadapakkam	K4	12 17 00	79 59 19	7.4	310	310	22	15	16	4	32	6	0	140	4
Alambaraikottai	K5	12 16 09	80 00 33	7.6	200	200	14	13	3	2	18	4	0	79	12
Vilambur	K6	12 18 29	80 00 04	7.8	310	310	10	9	40	5	89	5	0	31	1
Othiyur	K7	12 19 14	80 01 58	7.4	560	560	26	19	46	28	50	8	0	250	1
Thenpattinam	K10	12 24 57	80 05 58	7.7	470	470	24	22	21	30	32	19	0	214	1
Keelarkollai	K11	12 26 41	80 07 21	7.8	580	580	20	24	64	1	67	43	0	189	1

Table 9.10 (b) Chemical Analysis of water samples for Sea Water Intrusion Study in Varahanadhi River Basin - (2013- Pre Monsoon)															
Name of the location	**Well ID**	**Latitude**	**Longitude**	**pH**	**EC m.mhos/ cm**	**TDS**	**Ca Mg/lit**	**Mg Mg/lit**	**Na Mg/lit**	**K Mg/lit**	**Cl Mg/lit**	**SO4 Mg/lit**	**CO3 mg/lit**	**HCO3 Mg/lit**	**NO3 Mg/lit**
Chinnakottakuppam	VPM1	11 57 59	79 49 33	7.9	180	121	22	6	5	0	25	37	0	43	4
Kil pudupattu	VPM2	12 03 47	79 52 33	7.6	260	149	10	9	32	0	60	6	0	55	4
Kunimedu	VPM4	12 05 26	79 53 37	7.7	1420	876	48	27	176	76	206	169	0	189	80
Anumandai	VPM6	12 08 23	79 54 23	8	1410	788	96	26	166	0	199	152	0	183	58
Keelpettai	VPM7	12 08 01	79 55 04	8.7	570	280	50	28	21	0	67	2	0	189	18
Marakkanam	VPM8	12 11 48	79 56 35	8.1	1030	665	58	15	92	87	85	111	0	256	89
Alapakkam	VPM9	12 09 27	79 55 33	7.7	4230	2308	276	129	412	0	1071	198	0	366	18
Alapakkam	VPM10	12 09 38	79 56 13	7.9	2320	1320	104	49	322	0	503	141	0	366	18
Kanthadu	VPM11	12 12 22	79 54 44	7.8	460	279	32	9	42	19	96	33	0	43	27
Kaippanikuppam	VPM12	12 13 05	79 58 48	7.8	270	143	30	10	21	0	18	23	0	85	9
Ekkiyar kuppam	VPM13	12 11 03	79 57 31	7.8	890	488	48	23	106	0	46	138	0	183	35
Alapakkam(BW)	VPM14	12 09 37	79 55 37	8.3	1060	660	42	10	95	139	64	117	0	360	13
kil pudupattu(B. well)	VPM15	12 03 09	79 52 08	7.5	510	322	26	12	5	43	71	46	0	116	6
Bommayarpalayam(DW)	VPM16	11 59 39	79 50 57	7.6	260	125	26	9	11	4	18	2	0	92	9
Bommayarpalayam(BW)	VPM17	12 09 37	79 55 37	7.5	380	222	34	4	41	0	64	23	0	67	22
Vennangupattu	K2	12 15 06	79 57 52	8.3	550	288	44	12	53	0	67	12	0	183	16
Thenpakkam	K3	12 14 24	79 58 04	8.6	430	237	18	10	60	0	82	19	0	61	8
Kadapakkam	K4	12 17 00	79 59 19	8.2	340	195	34	7	25	0	46	3	0	134	14
Alambaraikottai	K5	12 16 09	80 00 33	8.3	430	267	50	11	8	22	32	23	0	171	27
Vilambur	K6	12 18 29	80 00 04	8.3	510	287	58	11	0	51	57	2	0	146	3
Othiyur	K7	12 19 14	80 01 58	8.3	460	283	34	9	19	53	39	19	0	201	8
Thenpattinam	K10	12 24 57	80 05 58	8.2	500	317	32	12	0	94	43	27	27	201	6
Keelarkollai	K11	12 26 41	80 07 21	8.1	670	358	58	10	69	0	82	42	42	177	3

Table 9.10 (c) Chemical Analysis of water samples for Sea Water Intrusion Study in Varahanadhi River Basin - (2014- Pre Monsoon)															
Name of the location	**Well ID**	**Latitude**	**Longitude**	**pH**	**EC m.mhos/ cm**	**TDS**	**Ca Mg/lit**	**Mg Mg/lit**	**Na Mg/lit**	**K Mg/lit**	**Cl Mg/lit**	**SO4 Mg/lit**	**CO3 mg/lit**	**HCO3 Mg/lit**	**NO3 Mg/lit**
Chinnakottakuppam	VPM1	11 57 59	79 49 33	8.2	350	179	46	6	12	0	28	9	0	156	0
Kil pudupattu	VPM2	12 03 47	79 52 33	8.1	440	237	32	9	44	0	57	7	0	159	9
Kunimedu	VPM4	12 05 26	79 53 37	8	2350	1395	84	38	322	59	518	178	0	232	80
Anumandai	VPM6	12 08 23	79 54 23	8	1400	813	84	35	170	0	220	77	0	348	53
Keelpettai	VPM7	12 08 01	79 55 04	7.5	590	286	56	21	28	0	58	6	0	207	13
Marakkanam	VPM8	12 11 48	79 56 35	7.9	1500	895	90	29	145	62	230	96	0	317	84
Alapakkam	VPM9	12 09 27	79 55 33	7.8	2500	1309	208	92	147	0	599	67	0	366	13
Alapakkam	VPM10	12 09 38	79 56 13	7.7	3320	1805	152	83	423	0	886	86	0	323	15
Kanthadu	VPM11	12 12 22	79 54 44	7.7	630	329	74	15	28	11	110	15	0	146	13
Kaippanikuppam	VPM12	12 13 05	79 58 48	7.7	240	147	26	9	7	0	18	4	0	122	22
Ekkiyar kuppam	VPM13	12 11 03	79 57 31	7.8	860	459	26	30	97	1	121	62	0	276	9
Alapakkam(BW)	VPM14	12 09 37	79 55 37	7.2	890	528	74	10	69	47	64	43	0	354	44
Kil pudupattu(BW)	VPM15	12 03 09	79 52 08	8.1	740	439	56	18	61	23	96	50	0	140	75
Bommayarpalayam(DW)	VPM16	11 59 39	79 50 57	7.4	300	161	52	1	5	0	39	9	0	92	9
Bommayarpalayam(BW)	VPM17	12 09 37	79 55 37	7.4	400	186	54	7	12	0	31	3	0	140	9
Vennangupattu	K2	12 15 06	79 57 52	7.9	590	308	42	13	51	0	64	10	0	238	9
Thenpakkam	K3	12 14 24	79 58 04	8.4	530	267	44	10	46	0	71	16	30	92	4
Kadapakkam	K4	12 17 00	79 59 19	7.7	280	137	18	19	7	0	15	4	0	122	13
Alambaraikottai	K5	12 16 09	80 00 33	7.5	370	190	30	10	32	0	18	12	0	122	27
Othiyur	K7	12 19 14	80 01 58	7.7	820	447	40	17	110	0	91	43	0	275	9
P.Keni Chathiram	K8	12 21 31	80 03 37	6.8	1200	729	86	30	87	39	62	50	0	378	186
Thenpattinam	K10	12 24 57	80 05 58	7.7	480	282	34	13	39	14	40	36	36	195	9
Keelarkollai	K11	12 26 41	80 07 21	7.9	670	369	60	16	48	0	92	48	48	201	4

Table 9.10 (d) Chemical Analysis of water samples for Sea Water Intrusion Study in Varahanadhi River Basin - (2015- Pre Monsoon)															
Name of the location	**Well ID**	**Latitude**	**Longitude**	**pH**	**EC m.mhos/ cm**	**TDS**	**Ca Mg/lit**	**Mg Mg/lit**	**Na Mg/lit**	**K Mg/lit**	**Cl Mg/lit**	**SO4 Mg/lit**	**CO3 mg/lit**	**HCO3 Mg/lit**	**NO3 Mg/lit**
Chinnakottakuppam	VPM1	11 57 59	79 49 33	8	260	151	26	9	14	0.1	35	13	1	87	1
Kil pudupattu	VPM2	12 03 35	79 52 33	7.9	240	137	8.4	6	35	0.1	25	5	1	87	4
Kunimedu	VPM4	12 05 26	79 53 43	7.5	1690	992	74	34	205	59	238	120	0	250	137
Chettikuppam	VPM5	12 6 23	79 53 43	7.6	3360	1859	192	68	423	0.1	723	170	0	531	18
Anumandai	VPM6	12 08 23	79 54 29	7.8	1390	802	86	26	173	0.1	191	89	0	342	66
Keelpettai	VPM7	12 08 01	79 55 04	7.9	570	281	68	15	25	0.1	50	17	1	144	18
Marakkanam	VPM8	12 11 48	79 56 35	7.6	1100	562	60	34	120	0.1	138	61	0	262	18
Alapakkam	VPM9	12 09 27	79 55 33	7.6	2350	1227	108	119	191	0.1	489	72	0	433	31
Alapakkam	VPM10	12 09 38	79 56 13	7.6	3330	1882	176	97	375	7	922	85	0	378	31
Kanthadu	VPM11	12 12 22	79 54 50	7.6	530	258	32	19	48	0.1	117	16	0	35	4
Kaippanikuppam	VPM12	12 13 05	79 58 54	7.6	240	141	19	17	2	0.1	21	6	0	110	9
Ekkiyar kuppam	VPM13	12 11 03	79 57 31	7.6	840	433	19	17	90	0.1	117	58	0	110	9
Alapakkam(BW)	VPM14	12 09 37	79 55 43	7.5	1710	940	42	29	161	47	227	81	0	171	22
Kil pudupattu(BW)	VPM15	12 03 09	79 52 08	7.4	560	331	104	45	46	18	99	30	3	414	8
Bommayarpalayam(DW)	VPM16	11 59 30	79 51 00	7.6	630	374	30	19	37	20	92	9	0	110	27
Bommayarpalayam(BW)	VPM17	11 59 35	79 50 50	7.6	190	126	60	15	14	0.1	31	2	1	174	31
Sunambedu	K1	12 15 20	79 54 35	7.9	1185	743	22	41	208	21	113	44	0	561	3
Vennangupattu	K2	12 15 06	79 57 52	7.7	680	378	34	17	85	0.1	82	18	1	224	4
Thenpakkam	K3	12 14 24	79 58 04	7.7	530	297	36	18	46	0.1	82	19	1	149	4
Kadapakkam	K4	12 17 00	79 59 19	7.2	280	168	32	4	21	0.1	35	3	0	55	40
Alambaraikottai	K5	12 16 09	80 00 33	7.3	350	176	40	16	5	0.1	28	14	0	120	12
Othiyur	K7	12 19 14	80 01 58	7.6	790	418	32	29	90	0.1	92	33	1	224	4
Thenpattinam	K10	12 24 57	80 05 58	7.5	400	225	36	7	35	5	28	18	0	150	4
Keelarkollai	K11	12 26 41	80 07 21	7.5	400	230	32	15	28	0.1	46	28	0	125	4

Table 9.10 (e) Chemical Analysis of water samples for Sea Water Intrusion Study in Varahanadhi River Basin - (2016- Pre Monsoon)															
Name of the location	**Well ID**	**Latitude**	**Longitude**	**pH**	**EC m.mhos/ cm**	**TDS**	**Ca Mg/lit**	**Mg Mg/lit**	**Na Mg/lit**	**K Mg/lit**	**Cl Mg/lit**	**SO4 Mg/lit**	**CO3 mg/lit**	**HCO3 Mg/lit**	**NO3 Mg/lit**
Chinnakottakuppam	VPM1	11 57 59	79 49 33	7.7	260	167	75	30	4	18	25	21	0	46	9
Kil pudupattu	VPM2	12 03 47	79 52 33	7.6	370	210	80	32	7	35	45	46	0	9	4
Kunimedu	VPM4	12 05 26	79 53 37	7.7	860	541	70	28	17	113	35	71	0	147	27
Anumandai	VPM6	12 08 23	79 54 23	7.6	1480	872	175	70	29	205	198	181	0	203	62
Keelpettai	VPM7	12 08 01	79 55 04	7.6	470	264	70	28	18	41	56	35	0	18	27
Marakkanam	VPM8	12 11 48	79 56 35	7.7	1230	720	130	52	30	133	57	121	0	126	18
Alapakkam	VPM9	12 09 27	79 55 33	7.5	3000	1663	330	132	78	368	590	744	0	176	58
Alapakkam	VPM10	12 09 38	79 56 13	7.8	2270	1270	130	52	68	334	880	518	0	140	18
Kanthadu	VPM11	12 12 22	79 54 44	7.6	910	499	120	48	35	87	112	174	0	46	35
Kaippanikuppam	VPM12	12 13 05	79 58 48	7.8	250	150	45	18	7	23	20	14	0	12	9
Ekkiyar kuppam	VPM13	12 11 03	79 57 31	7.8	890	508	95	38	24	115	118	89	0	148	9
Alapakkam(BW)	VPM14	12 09 37	79 55 37	8	670	422	90	36	10	94	64	96	0	84	22
Kil pudupattu(BW)	VPM15	12 03 09	79 52 08	8	850	552	95	38	19	55	102	43	0	90	22
Bommayarpalayam(DW)	VPM16	11 59 39	79 50 57	7.7	690	329	125	50	13	58	32	60	0	7	9
Bommayarpalayam(BW)	VPM17	12 09 37	79 55 37	7.8	580	338	120	48	11	58	58	74	0	55	22
Vennangupattu	K2	12 15 06	79 57 52	7.7	530	318	40	7	62	0	57	36	0	153	40
Thenpakkam	K3	12 14 24	79 58 04	7.6	490	304	30	1	76	0	92	57	0	79	9
Kadapakkam	K4	12 17 00	79 59 19	7.5	240	159	28	1	21	0	35	12	0	98	13
Alambaraikottai	K5	12 16 09	80 00 33	7.5	320	205	32	7	28	0	32	30	0	98	27
Vilambur	k6	12 18 29	80 00 04	8	430	229	22	10	55	0	96	5	0	73	4
Othiyur	k7	12 19 14	80 01 58	7.9	780	458	16	11	140	1	67	112	0	212	4
Thenpattinam	K10	12 24 57	80 05 58	7.7	300	202	16	10	30	5	25	61	0	92	9
Keelarkollai	K11	12 26 41	80 07 21	7.7	480	295	36	2	64	0	50	67	0	134	9

Table 9.10 (f) Chemical Analysis of water samples for Sea Water Intrusion Study in Varahanadhi River Basin - (2012- Post Monsoon)															
Name of the location	**Well ID**	**Latitude**	**Longitude**	**pH**	**EC m.mhos/ cm**	**TDS**	**Ca Mg/lit**	**Mg Mg/lit**	**Na Mg/lit**	**K Mg/lit**	**Cl Mg/lit**	**SO4 Mg/lit**	**CO3 mg/lit**	**HCO3 Mg/lit**	**NO3 Mg/lit**
Chinnakottakuppam	VPM1	11 57 59	79 49 33	8.5	330	192	44	10	7	12	43	24	6	92	0
Kil pudupattu	VPM2	12 03 47	79 52 33	8.2	260	218	24	61	16	20	57	5	0	61	4
Kunimedu	VPM4	12 05 26	79 53 37	8.1	1650	959	80	34	140	61	170	130	0	439	124
Anumandai	VPM6	12 08 23	79 54 23	8.6	1220	685	84	13	122	8	234	74	24	189	31
Keelpettai	VPM7	12 08 01	79 55 04	8.1	500	333	68	30	35	1	39	2	0	281	18
Marakkanam	VPM8	12 11 48	79 56 35	8.6	1140	814	50	156	122	67	99	69	48	281	62
Alapakkam	VPM9	12 09 27	79 55 33	8	4300	2313	336	38	327	4	1290	206	0	171	27
Alapakkam	VPM10	12 09 38	79 56 13	8.4	1370	746	82	15	150	3	333	58	6	171	13
Kanthadu	VPM11	12 12 22	79 54 44	8.1	480	273	40	2	28	18	124	13	0	43	27
Kaippanikuppam	VPM12	12 13 05	79 58 48	8	280	222	20	30	51	7	21	6	0	165	4
Ekkiyar kuppam	VPM13	12 11 03	79 57 31	8	920	516	46	15	97	8	149	64	0	177	49
Alapakkam(BW)	VPM14	12 09 37	79 55 37	8.6	660	416	58	17	51	38	53	46	42	195	13
kil pudupattu(B. well)	VPM15	12 03 09	79 52 08	8.4	670	373	36	15	46	41	85	37	18	110	40
Bommayarpalayam(DW)	VPM16	11 59 39	79 50 57	8.4	800	498	58	9	60	53	103	56	18	140	71
Bommayarpalayam(BW)	VPM17	11 59 35	79 50 45	8.4	800	498	58	9	60	53	103	56	18	140	71
Vennangupattu	K2	12 15 06	79 57 52	8.2	300	166	18	19	18	1	53	7	0	73	13
Thenpakkam	K3	12 14 24	79 58 04	8	260	122	20	6	0	1	64	15	0	31	0
Kadapakkam	K4	12 17 00	79 59 19	8.3	310	193	46	16	14	2	25	5	0	153	9
Alambaraikottai	K5	12 16 09	80 00 33	7.8	480	273	46	6	28	3	60	23	0	116	49
Vilambur	K6	12 18 29	80 00 04	8.4	380	233	46	16	30	4	43	0	12	146	9
Othiyur	K7	12 19 14	80 01 58	8.3	560	329	36	15	58	14	74	30	6	183	4
P.Keni Chathiram	K8	12 21 31	80 03 37	8.3	450	303	74	16	9	9	25	24	12	214	27
Thenpattinam	K10	12 24 57	80 05 58	8.5	460	274	52	11	21	12	21	39	12	195	9
Keelarkollai	K11	12 26 41	80 07 21	8.6	460	288	42	40	37	2	39	40	12	134	9

Table 9.10 (g) Chemical Analysis of water samples for Sea Water Intrusion Study in Varahanadhi River Basin - (2013- Post Monsoon)															
Name of the location	**Well ID**	**Latitude**	**Longitude**	**pH**	**EC m.mhos/cm**	**TDS**	**Ca Mg/lit**	**Mg Mg/lit**	**Na Mg/lit**	**K Mg/lit**	**Cl Mg/lit**	**SO4 Mg/lit**	**CO3 mg/lit**	**HCO3 Mg/lit**	**NO3 Mg/lit**
Chinnakottakuppam	VPM1	11 57 59	79 49 33	8.2	330	166	20	19	16	0	50	5	0	110	1
Kil pudupattu	VPM2	12 03 47	79 52 33	8.1	260	142	12	7	32	1	50	2	0	73	1
Kunimedu	VPM4	12 05 26	79 53 37	7.5	1190	706	36	28	145	59	177	67	0	287	50
Anumandai	VPM6	12 08 23	79 54 23	7.5	1340	755	40	56	154	4	227	69	0	287	50
Keelpettai	VPM7	12 08 01	79 55 04	7.8	410	214	24	24	20	1	35	11	0	177	10
Marakkanam	VPM8	12 11 48	79 56 35	7.8	1010	613	36	27	112	49	124	31	0	293	87
Alapakkam	VPM9	12 09 27	79 55 33	7.5	3900	2180	96	190	422	10	1106	259	0	140	33
Alapakkam	VPM10	12 09 38	79 56 13	7.7	1940	1076	60	75	230	8	510	77	0	214	9
Kanthadu	VPM11	12 12 22	79 54 44	8	560	338	30	19	46	20	124	25	0	73	37
Kaippanikuppam	VPM12	12 13 05	79 58 48	8	260	131	20	18	1	2	14	13	0	122	2
Ekkiyar kuppam	VPM13	12 11 03	79 57 31	7.8	850	488	38	27	98	5	149	58	0	165	30
Alapakkam(BW)	VPM14	12 09 37	79 55 37	7.9	590	333	22	23	57	16	35	10	0	250	45
kil pudupattu(B. well)	VPM15	12 03 09	79 52 08	7.9	590	342	18	24	59	16	89	15	0	153	44
Bommayarpalayam(DW)	VPM16	11 59 39	79 50 57	7.8	1060	621	22	38	106	70	106	88	0	342	20
Bommayarpalayam(BW)	VPM17	11 59 35	79 50 45	8.2	200	107	12	12	9	1	28	5	0	67	6
Vennangupattu	K2	12 15 06	79 57 52	8.1	360	195	12	16	38	2	53	6	0	122	7
Thenpakkam	K3	12 14 24	79 58 04	8.1	360	212	16	10	45	2	89	22	0	37	9
Kadapakkam	K4	12 17 00	79 59 19	8	240	131	14	13	13	1	32	20	0	31	7
Alambaraikottai	K5	12 16 09	80 00 33	7.9	450	259	26	22	32		57	6	0	128	51
Vilambur	K6	12 18 29	80 00 04	7.9	360	193	18	21	22	12	35	13	0	146	9
Othiyur	K7	12 19 14	80 01 58	7.8	500	267	24	21	41	13	53	15	0	196	2
P.Keni Chathiram	K8	12 21 31	80 03 37	7.9	510	267	44	22	2	8	25	12	0	244	22
Keelarkollai	K11	12 26 41	80 07 21	7.9	420	221	24	18	34	0	50	8	0	171	1

Table 9.10 (h) Chemical Analysis of water samples for Sea Water Intrusion Study in Varahanadhi River Basin - (2014- Post Monsoon)															
Name of the location	**Well ID**	**Latitude**	**Longitude**	**pH**	**EC m.mhos/cm**	**TDS**	**Ca Mg/lit**	**Mg Mg/lit**	**Na Mg/lit**	**K Mg/lit**	**Cl Mg/lit**	**SO4 Mg/lit**	**CO3 mg/lit**	**HCO3 Mg/lit**	**NO3 Mg/lit**
Chinnakottakuppam	VPM1	11 57 59	79 49 33	8	270	141	30	6	16	0	35	11	0	85	0
Kil pudupattu	VPM2	12 03 47	79 52 33	7.9	360	185	32	12	18	0	567	3	0	98	4
Kunimedu	VPM4	12 05 26	79 53 37	7.9	2830	1614	88	58	439	0	603	145	0	305	128
Anumandai	VPM6	12 08 23	79 54 23	7.9	1420	809	84	22	189	0	206	91	0	293	71
Keelpettai	VPM7	12 08 01	79 55 04	7.8	890	347	70	21	39	0	57	9	0	275	13
Marakkanam	VPM8	12 11 48	79 56 35	7.8	1270	688	64	92	44	0	181	68	0	256	111
Alapakkam	VPM9	12 09 27	79 55 33	7.6	3410	1935	488	24	177	0	1064	74	0	146	35
Alapakkam	VPM10	12 09 38	79 56 13	8.2	2750	1498	112	90	334	0	709	77	0	317	18
Kanthadu	VPM11	12 12 22	79 54 44	8.2	2750	1498	112	90	334	0	709	77	0	317	18
Kaippanikuppam	VPM12	12 13 05	79 58 48	8.1	600	331	40	19	46	16	106	14	0	110	35
Ekkiyar kuppam	VPM13	12 11 03	79 57 31	8.2	260	117	16	10	16	0	35	8	0	55	4
Alapakkam(BW)	VPM14	12 09 37	79 55 37	7.6	3410	1935	488	24	177	0	1064	74	0	146	35
kil pudupattu(B. well)	VPM15	12 03 09	79 52 08	7.3	530	296	24	12	71	0	82	17	0	110	35
Bommayarpalayam(DW)	VPM16	11 59 39	79 50 57	7.2	850	504	72	16	76	25	113	43	0	177	80
Bommayarpalayam(BW)	VPM17	11 59 35	79 50 45	6.2	200	112	22	6	8	0	35	3	0	49	13
Vennangupattu	K2	12 15 06	79 57 52	8.8	570	289	39	10	69	0	60	0	36	124	3
Thenpakkam	K3	12 14 24	79 58 04	8.8	500	275	33	8	62	0	89	0	31	60	5
Kadapakkam	K4	12 17 00	79 59 19	8.5	320	178	45	5	13	0	24	0	23	92	5
Alambaraikottai	K5	12 16 09	80 00 33	8.6	410	209	50	10	18	12	2	2	36	105	6
Vilambur	K6	12 18 29	80 00 04	8.4	480	260	53	10	27	7	39	0	37	112	7
Othiyur	K7	12 19 14	80 01 58	8.1	450	237	44	4	41	8	35	0	0	201	1
P.Keni Chathiram	K8	12 21 31	80 03 37	7.8	660	320	64	28	14	18	25	0	0	306	4
Perundaravur	K9	12 22 56	80 05 14	8	470	262	38	16	17	30	57	24	0	125	4
Thenpattinam	K10	12 24 57	80 05 58	8.2	350	184	34	22	9	4	25	18	0	126	2
Keelarkollai	K11	12 26 41	80 07 21	8	530	284	40	13	51	0	41	37	0	187	2

Table 9.10 (i) Chemical Analysis of water samples for Sea Water Intrusion Study in Varahanadhi River Basin - (2015 - Post Monsoon)															
Name of the location	**Well ID**	**Latitude**	**Longitutude**	**pH**	**EC m.mhos/cm**	**TDS**	**Ca Mg/lit**	**Mg Mg/lit**	**Na Mg/lit**	**K Mg/lit**	**Cl Mg/lit**	**SO4 Mg/lit**	**CO3 mg/lit**	**HCO3 Mg/lit**	**NO3 Mg/lit**
Chinnakottakuppam	VPM1	11 57 59	79 49 33	7.5	260	147	30	4	18	0	26	5	0	110	9
Kil pudupattu	VPM2	12 03 35	79 52 33	7.5	240	140	16	6	23	0	53	3	0	61	7
Kunimedu	VPM4	12 05 26	79 53 43	7.3	2210	1334	104	46	269	51	369	149	0	329	179
Anumandai	VPM6	12 08 23	79 54 29	7.7	1250	733	80	15	168	0	152	106	0	299	61
Keelpettai	VPM7	12 08 01	79 55 04	7.6	460	254	46	16	23	0	46	29	0	153	20
Marakkanam	VPM8	12 11 48	79 56 35	7.2	1390	838	78	29	138	63	167	77	0	360	104
Alapakkam	VPM9	12 09 27	79 55 33	7.5	3230	1855	100	56	522	0	900	91	0	256	56
Alapakkam	VPM10	12 09 38	79 56 13	7.5	2750	1556	84	58	426	1	759	91	0	238	19
Kanthadu	VPM11	12 12 22	79 54 50	7.9	620	341	60	12	51	5	57	10	0	238	28
Kaippanikuppam	VPM12	12 13 05	79 58 54	8	240	129	20	7	18	0	23	3	0	98	9
Ekkiyar kuppam	VPM13	12 11 03	79 57 31	7.5	820	471	48	22	92	0	117	67	0	232	7
Alapakkam(BW)	VPM14	12 09 37	79 55 43	7.5	1020	588	56	6	131	47	50	86	0	427	12
kil pudupattu(B. well)	VPM15	12 03 09	79 52 08	7.6	630	347	40	15	58	24	78	30	0	177	39
Bommayarpalayam(DW)	VPM16	11 59 30	79 51 00	7.7	930	526	62	13	94	39	92	34	0	305	99
Bommayarpalayam(BW)	VPM17	11 59 35	79 50 50	7.2	210	120	20	4	18	0	27	0	0	67	17
Sunambedu colony	K1	12 15 20	79 54 35	8	952	720	16	50	170	16	117	50	0	531	8
Vennangupattu	K2	12 15 06	79 57 52	8	570	299	18	19	69	0	82	24	0	165	4
Thenpakkam	K3	12 14 24	79 58 04	8.3	320	181	24	10	32	0	28	19	9	110	4
Kadapakkam	K4	12 17 00	79 59 19	8	290	153	24	27	23	0	22	1	0	116	19
Alambaraikottai	K5	12 16 09	80 00 33	8.1	410	225	20	24	25	0	43	14	0	153	22
Othiyur	K7	12 19 14	80 01 58	7.9	480	246	32	23	30	0	53	2	0	195	9
P.Keni Chathiram	K8	12 21 31	80 03 37	8.1	570	301	40	34	21	2	28	1	0	244	53
Thenpattinam	K10	12 24 57	80 05 58	8.1	350	188	22	13	30	3	25	19	0	134	10
Keelarkollai	K11	12 26 41	80 07 21	8.1	360	210	22	12	35	0	35	24	0	145	8

Table 9.10 (j) Chemical Analysis of water samples for Sea Water Intrusion Study in Varahanadhi River Basin-(2016- Post Monsoon)															
Name of the location	**Well ID**	**Latitude**	**Longitude**	**pH**	**EC m.mhos/cm**	**TDS**	**Ca Mg/lit**	**Mg Mg/lit**	**Na Mg/lit**	**K Mg/lit**	**Cl Mg/lit**	**SO4 Mg/lit**	**CO3 mg/lit**	**HCO3 Mg/lit**	**NO3 Mg/lit**
Chinnakottakuppam	VPM1	11 57 59	79 49 33	8	210	118	26	6	7	2	18	4	0	89	0
Kil pudupattu	VPM2	12 03 47	79 52 33	8.1	580	316	46	13	51	7	71	20	0	123	31
Kunimedu	VPM4	12 05 26	79 53 37	8	530	306	22	27	44	4	53	35	0	124	44
Anumandai	VPM6	12 08 23	79 54 23	8.2	1230	701	78	24	143	8	160	67	0	354	44
Keelpettai	VPM7	12 08 01	79 55 04	8	360	201	58	5	5	3	21	8	0	114	31
Marakkanam	VPM8	12 11 48	79 56 35	8.2	1180	674	58	22	113	84	177	47	0	329	9
Alapakkam	VPM9	12 09 27	79 55 33	8	1540	849	74	43	186	4	476	58	0	476	44
Alapakkam	VPM10	12 09 38	79 56 13	8.1	1740	947	82	41	223	5	482	58	0	482	13
Kanthadu	VPM11	12 12 22	79 54 44	8.1	710	399	50	29	44	11	173	17	0	173	31
Kaippanikuppam	VPM12	12 13 05	79 58 48	8	270	133	14	12	18	7	89	6	0	89	0
Ekkiyar kuppam	VPM13	12 11 03	79 57 31	8	840	464	36	23	101	9	173	53	0	173	0
Alapakkam(BW)	VPM14	12 09 37	79 55 37	8	660	373	48	27	41	7	178	32	0	178	9
kil pudupattu(B. well)	VPM15	12 03 09	79 52 08	8.1	790	421	30	41	48	35	198	37	0	198	9
Bommayarpalayam(DW)	VPM16	11 59 39	79 50 57	8	710	401	34	36	46	20	173	36	0	173	18
Bommayarpalayam(BW)	VPM17	11 59 35	79 50 45	8.1	200	143	16	9	10	3	44	5	0	44	44
Vennangupattu	K2	12 15 06	79 57 52	7.8	360	192	18	11	41	0.1	50	6	0	65	26
Thenpakkam	K3	12 14 24	79 58 04	7.8	460	233	36	7	51	0.1	53	15	0	109	4
Kadapakkam	K4	12 17 00	79 59 19	7.9	160	70	20	6	2	0.1	7	4	0	50	0
Alambaraikottai	K5	12 16 09	80 00 33	7.9	650	377	54	10	69	0.1	67	37	0	149	49
Vilambur	K6	12 18 29	80 00 04	8	560	316	60	6	46	1	64	9	0	168	26
Othiyur	K7	12 19 14	80 01 58	8.1	780	420	8	13	145	0.1	71	48	0	212	4
Thenpattinam	K10	12 24 57	80 05 58	8	500	281	30	21	37	6	53	34	0	149	9
Keelarkollai	K11	12 26 41	80 07 21	8	350	199	40	6	23	0.1	35	30	0	99	4

9.6 Salinity

Salinity refers to the presence of salts in the land surface (soil or rocks) or in water (rivers or groundwater). It is one of the major land degradation problems affecting the environment. Changes in landuse, seasonal variations in weather and long-term climatic changes affect the surface and groundwater and the amount of salt they contain. While small amount of dissolved salts in natural waters are vital for the life of aquatic plants and animals; higher levels of salinity alter the way the water can be used. Most hyper saline water can be used for some purposes. However, high levels of salinity and acidity (if present) are harmful to the overall sustainability of plants and animals.

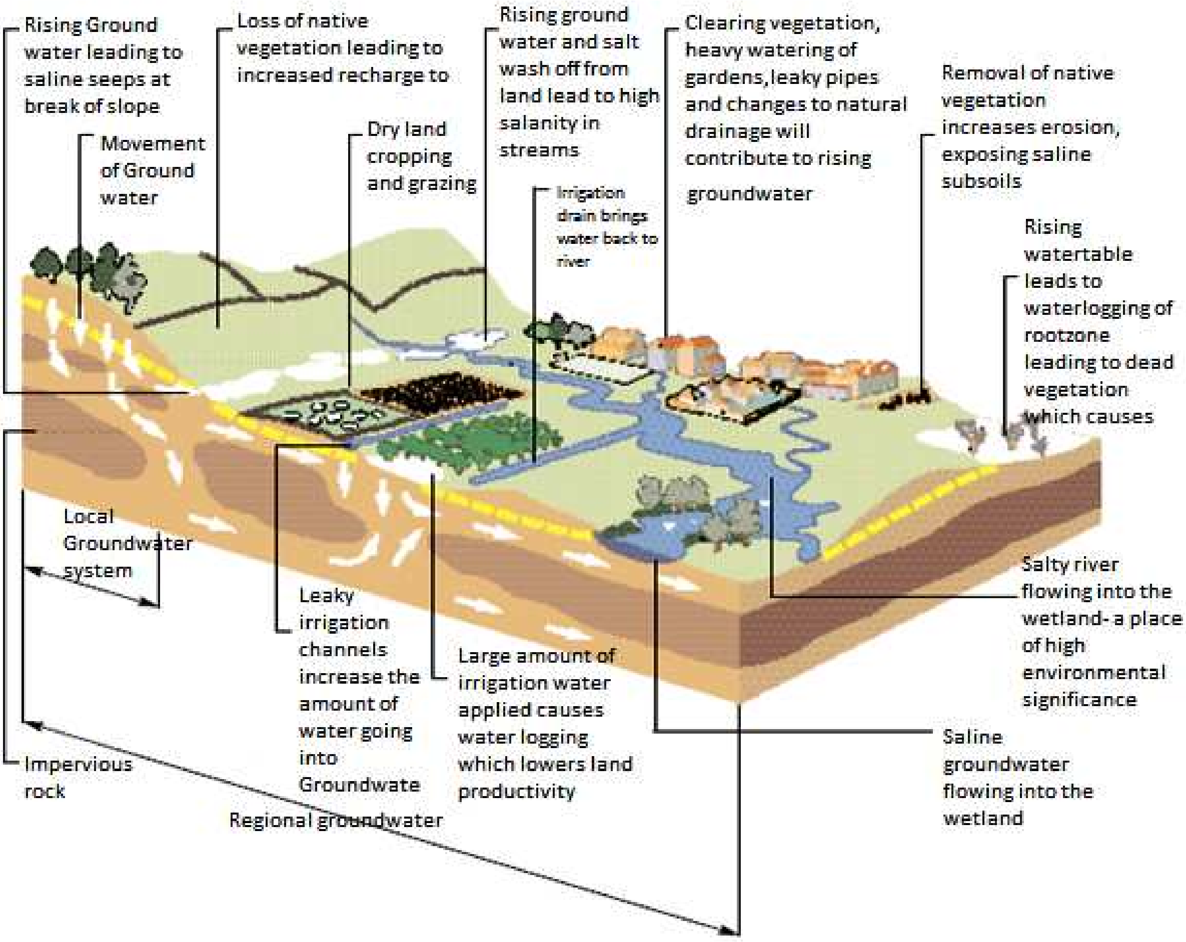


Fig: 9.12 Types of Salinity

Salinity can develop naturally, but where human intervention has disturbed the natural ecosystems and changed the hydrology of the landscape, the movement of salts into rivers and onto the lands has been accelerated. This will begin to dramatically affect the natural environment, reduce the viability of the agricultural sector and damage public and private infrastructure.

9.6.1 Types of Salinity

Salinity can be broadly classified as Dryland salinity, Irrigation salinity, Urban salinity, River salinity and Ground water salinity.

9.6.1.1 Dryland salinity

Dryland salinity occurs due to removal or loss of native vegetation and its replacement with crops having shallow roots, resulting in more water reaching the groundwater system. This results in rise in the groundwater which carries the dissolved salts from the underlying soil and bedrock material through which it travels. As saline groundwater comes close to the soil surface, salt enters the plant root zone. Even where the groundwater does not bring much salt with it, the 'water-logging' of the root zone alone can damage or kill vegetation. Dryland Salinity leads to death of native plants and crops that are not salt-tolerant and the development of totally bare patches of earth known as salt scalds. It may also affect the natural habitats and further risk the viability of plant and animal communities and vulnerable species.

9.6.1.2 Irrigation salinity

The main cause of this type of salinity is the application of large volumes of irrigation water, compounded by the replacement of native vegetation by plants with different water use patterns. Irrigation salinity problems occur soon after the establishment of the first irrigation scheme. Drainage systems can be constructed in irrigation schemes to mitigate the salinity problem, since these discharges ultimately enter into land disposal sites or to a river.

9.6.1.3 Urban salinity

Urban salinity is caused due to discharges from leakages of sewerage and drainage pipes, obstruction and modification of natural surface and sub-surface drainage paths and from watering of garden and parks. Urban salinity leads to damage to buildings, roads and pipe systems, shortens the life of infrastructure and increases the maintenance costs.

9.6.1.4 River salinity

River salinity is caused by saline discharges from dryland, irrigation and urban salinity into creeks and rivers. Over time as salinity within catchment worsens, the quality of river water declines, becoming more and more saline.

9.6.1.5 Coastal Salinity

Ground water in coastal areas occurs under unconfined to confined conditions in a wide range of unconsolidated and consolidated formations. Normally, saline water bodies owe their origin to entrapped sea water (connate water), sea water ingress and leachates from navigation canals constructed along the coast and from salt pans etc.

The most prevalent types of salinity are those caused by chlorides and sulphates of sodium and calcium. Higher content of soluble salts in soil results in salinity problems. Under conditions of high evaporation, the depth to which rain penetrates is limited and salts become concentrated in the root zone.

Salinity directly affects the productivity by making the soil unsuitable for crop growth and lowers productivity through its adverse effects on the availability of nutrients.

9.6.2 Impact of Salinity

- Increased salinity leads to lower agricultural production, lower profitability due to costs of mitigation, reduced yield, changed land use, and in extreme cases to the total removal of land from agricultural production.
- If the level of salts in the soil water is too high, water may flow from the roots of the plant back into the soil. This results in dehydration of the plant, causing yield decline and eventually death of the plant.
- Salinity affects production in crops, pastures and trees by interfering with nitrogen uptake, reducing growth and stopping plant reproduction.
- Dryland salinity is closely linked to other soil degradation issues, including soil erosion. Salinity is often associated with prolonged wetness and lack of surface cover and therefore increases the vulnerability of soils to erosion.
- Increasing salinity levels will put pressure on the provision of town water supplies and increase treatment and infrastructure costs
- Recovery of coastal aquifer is near impossible.

The water quality standards in India for Irrigation in respect of salinity are given in **Table 9.11.**

Table 9.11 Water quality standards in India for Irrigation in respect of salinity

Salinity	EC (micro mhos cm^{-1}) at 25^{0}C	Remarks
Low	0-250	Can be used for most crops on most soils with little likelihood of soil salinity development. Some leaching may be required in soils with low permeability

Salinity	EC (micro mhos cm^{-1}) at 25^0C	Remarks
Moderate	250-750	Can be used for all but extremely salt-sensitive crops when grown on soils of high to medium permeability. With soils of low permeability, some leaching and at times growing moderate salt tolerant crops are necessary.
Medium	750-2250	Can be used only on soils of moderate to good permeability. Regular leaching may be needed to prevent development of salinity, Crops with moderate to good salt tolerance should be grown.
High	2250-4000	Can be used only on soils of good permeability and where special leaching is provided to remove excess salts. Only salt tolerant crops should be grown.
Very High	4000-6000	Undesirable for irrigation and should be used only on highly permeable soils with frequent leaching and with plants of high salt tolerance
Excessive	Above 6000	Unsuitable for irrigation

Source: SG & SWRDC, WRD

9.6.3 Effects of salinity in Varahanadhi Basin

In Varahanadhi basin, the Electrical conductivity values with respect to the districts of the basin is given in **Table 9.12**

Table 9.12 Electrical Conductivity in Varahanadhi River Basin (µS/cm)

Sub Basin	District	Village	2013		2014		2015		Remarks
			Jan	July	Jan	July	Jan	July	
Nallavur	Villupuram	Kiliyanur	688	681	570	880	630	1239	Medium
		Kollar	1041	1539	1005	1977	983	1569	Medium
		Nadukkuppam	552	759	700	842	630	647	Medium
		Nesal	1839	1808	1969	2073	1853	2155	Medium
		Omandur	4752	NA	2672	1163	2189	1973	Medium
		Perumpakkam	1414	992	1773	NA	1270	861	Medium
		Vada Alapakkam	619	1005	545	745	508	684	Moderate
		Veliyanur	1116	1648	1367	2025	838	1994	Medium
Ongur	Kancheep uram	Orathi	506	547	533	383	441	445	Moderate
		Sengattur	1047	1188	758	842	728	752	Medium
		Vedal	581	644	806	464	695	434	Moderate
	Tiruvana-mmalai	Desur	2034	2028	1648	1206	1495	1531	Medium
		Osur	894	566	270	650	284	1075	Moderate

		Thellar	1555	NA	1650	1302	1170	1941	Medium
	Villupuram	Karanai	1089	1323	2495	777	508	508	Medium
Varaha-nadhi	Tiruvana-mmalai	Chetpet	1577	1580	1566	1213	447	1273	Medium
		Gangapuram	189	1959	428	373	506	903	Moderate
		Keekaloor	536	647	619	206	2164	1163	Medium
	Villupuram	Aviyur	858	508	766	1388	680	NA	Medium
		Chinnanolambai	1363	1281	1405	1089	1177	1817	Medium
		Kappalambadi	1177	1344	1022	1278	1422	719	Medium
		Kilperumpakkam	2280	2309	2414	2280	2152	2166	High
		Mel Karanai	2108	1464	797	1177	697	928	Medium
		Periyamur	1605	1383	1577	1658	1714	1708	Medium
		Sangeethaman galam	2505	2316	2059	2047	2169	2363	High

From the above table, it is inferred that salinity is high in Kilperumpakkam and Sangeethamangalam village of Varahanadhi sub basin and the water quality is not fit for irrigation as the Electrical conductivity values are in the range of 2000 µS/cm to 3000 µS/cm. Hence the above areas are suitable for the cultivation of salt tolerant crops only.

9.6.4 Mitigation Measures

The following mitigation measures are recommended to reduce the effects of salinity in the basin.

- Retaining existing native vegetation in good health and preventing further loss of native vegetation is a fundamental requirement for managing salinity.
- Adopting 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.
- Improvements in irrigation infrastructure and irrigation technology, as well as better matching of crops suitable to the soil types
- Construction of more Rainwater Harvesting structures.
- Adopting Engineering solutions such as surface levelling, lining drainage channels, sub soil drainage schemes, pumping to lower water tables and mixing saline water with water of better quality.
- Desilting of drainages annually before rainy season.
- Prevention of dumping garbage in ponds and channels.
- Construction of Artificial recharge structures such as sub surface dyke, check dams at vulnerable points to prevent seawater intrusion

9.7 Fisheries

Tamil Nadu is one of the leading States in India in fisheries development having a coastal length of 1076 km. The different types of aquatic resources like marine, freshwater, brackish water, riverine stretches and cold water streams in upland area are bestowed with rich biodiversity of aquatic fauna and flora. There are 2500 species of fishes found in different aquatic environment. The Department of Fisheries is entrusted with the marine and inland fish production in the state, implements fishermen welfare schemes like fisherman group accident insurance schemes, free housing schemes, funeral expenses, subsidy schemes towards the purchase of aluminium vessels, bicycle etc., infrastructure facilities like fishing harbours and jetties, aquaculture activities and training to fishermen.

9.7.1 Types of Fisheries Sector:

The fisheries sector in TamilNadu can be broadly categorized as Inland fisheries, Marine fisheries and Aquaculture.

9.7.1.1 Inland Fisheries

Tamil Nadu ranks eighth in inland fisheries production in the country. It has 3.7 lakh hectare of waterspread area, suitable for fish culture, comprising major reservoirs (52,000 ha.), Big/small Irrigation tanks (98000 ha.), small lakes and rural Fishery Demonstration tanks (158000 ha.) and Brackish water areas, swamps, estuaries (63,000 ha.) which are amenable to both capture and culture fisheries. Apart from this, 7400 km length of rivers and major canals offer good scope for fisheries development. The Inland Fisheries policy of the State focuses in maximizing the fish production utilizing available inland water resources by adopting scientific freshwater aquaculture management and quality fish seed production. The Inland Fishermen population of the State is 1.83 lakhs and there are 270 nos. of Inland Fishermen Co-operative Societies with total registered membership of 59,000 nos. actively engaged in fishing activities in the inland water spread areas.

9.7.1.2 Marine Fisheries

TamilNadu is one of the leading states in marine fish production with a coastal length of 1076 km (13% of the country’s coast line) and continental shelf of 41,412 sq.km.

The State has marine fishermen population of 2 lakhs who are actively engaged in fishing from 591 marine fishing villages scattered along the 13 coastal districts. The infrastructure facilities include 3 major fishing harbours, 3 medium fishing harbours and 363 fish landing centres. The marine fishing potential of TamilNadu is estimated at 0.72 million tonnes out of which 0.37 million tonnes comes from less than 50 m depth and 0.35 million tonnes from beyond 50 m depth. TamilNadu contributes 10-12 % of the total marine fish production in India.

9.7.1.3 Aquaculture

Aquaculture is the farming of fish, crustaceans, molluscs, aquatic plants, algae, and other aquatic organisms cultivated in freshwater and saltwater populations under controlled conditions. It includes fish farming, shrimp farming, oyster farming, mariculture, algaculture (such as seaweed farming), and the cultivation of ornamental fish.

Tamil Nadu is endowed with rich natural resources such as coastal zones in the form of brackish water / estuaries for shrimp culture. The brackish water resource of Tamil Nadu is about 56,000 ha. of which 18,000 ha. is identified as potential areas for farming. At present shrimp aquaculture has been developed in 12 maritime districts of Tamil Nadu in about 4455 ha. The tiger shrimp (P.monodon) and white shrimp (P.indicus) are the most common species cultured in shrimp ponds. Farmers are encouraged to adopt traditional and extensive farming methods for sustainable aquaculture.

9.7.2. Details of Fisheries in Varahanadhi sub basin

The fishermen in Varahanadhi sub basin are actively involved in inland fisheries, marine fisheries and shrimp farming.

Under TNIAMWARM Project, Fish seed rearing in cages were installed in Pombur village &Endiyur village of Nallavur sub basin. Fishing and farm ponds is functioning at Peramandur, Pattinam, Kizhsiviri and Endiyur villages in NallavurSubbasin. Aquaculture irrigation tank and seed rearing is in NallavurEri and AnnapakkamEri. The Fish Kiosk is successfully functioning at Vanur&Mailam blocks of Villupuram District. Hence Farmers were most benefited through TN-IAMWARM project. (*Source: Environmental Cell Division, Tharamani, Chennai-113)*

The details of Inland and Marine fish production and Shrimp farming in Varahanadhi Basin is given in given in Tables 9.13, 9.14 and 9.15.

Table 9.13 Year wise Inland Fish production in Varahanadhi River Basin (in Tonnes)

Sl. No	Districts	2004-05	2005-06	2006-07	2007-08	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
1	Cuddalore	6549.00	14631.19	14893.76	15206.37	15641.84	15548.13	16656.03	16848.01	17382.35	23435.34
2	Kancheepuram	3303.00	11044.91	11265.82	11486.72	11658.68	7948.54	8543.15	7666.48	8887.23	11567.69
3	Villupuram	180.00	180.50	159.88	190.57	290.87	1729.31	1791.93	1751.93	1934.09	3208.75

Table 9.14 Year wise Marine Fish production in Varahanadhi River Basin (inTonnes)

Sl.No	Districts	2004-05	2005-06	2006-07	2007-08	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
1	Cuddalore	35385	21380.61	29625.27	30503.21	22086.13	25531.73	25646.62	25820.68	25978.19	19021.30
2	Villupuram	7231	7637.67	8225.24	10731.50	14054.81	20457.02	15874.56	15982.66	16080.14	28493.68
3	Kancheepuram	10923	7817.66	12825.12	10570.42	20078.3	15822.95	20568.65	20708.7	20835.02	13023.36

Table 9.15 Shrimp Farming in Varahanadhi Basin

District	No of Active Farms	Water Spread Area in Hectare
Villupuram	44	64.70
Kancheepuram	3	8.88
Total	47	73.58

(Source: Coastal Aquaculture Authority)

From the above table, it is inferred that both the inland fish production and marine fish production in Varahanadhi River Basin has increased tremendously in all the districts except Cuddalore from the year 2005-06.

Similarly shrimp farming has increased in recent times with more and more farmers opting for aquaculture because of its export demand. Yet the process has its disadvantages, ranging from disease control to environmental hazards. The following are guidelines that are need to be followed, to reduce the harmful effects of these practices.

- Good water quality should be maintained by using water stable feed with minimal wastage.
- Water quality parameters should be monitored regularly and periodical water exchange is necessary to maintain optimal water quality conditions.
- Fertilisers and lime should be used in a responsible manner only when it is actually required.
- Use of freshwater to reduce the salinity of the cultured water should be avoided for sustainability reasons. Even though the shrimps can adapt and grow in a wide range of salinity, it is better to avoid salinity fluxes so as to avoid stress to the shrimps, which could make them more prone to diseases.
- Indiscriminate use of chemicals, bacteriological and enzyme preparations that supposedly enhance nutrient removal, organic matter, oxidation and removal of ammonia from water and soil should be avoided.

9.7.3. 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.
- Practicing of improved culture methods with low cost models to increase unit productivity by cage culture, closed & semi closed recirculation culture method, sewage fed fish culture, integrated fish farming with poultry, piggery & cattle and biomass based fish culture.
- Development of farm made fish feeds to reduce input cost as feed form 60-70% of input cost – use of organic manure to improve plankton & feeding.

- Development of hatcheries / seed rearing centres with proper technology through brood stock development programme, development of improved strains of established fish species, establishment of multi species breeding centers and backyard hatcheries. establishment of earthen fish seed rearing units and fish seed rearing in cages/pens.
- Promoting ornamental fish culture as a commercial activity.

9.8 Public health

Public health is the science of preventing disease, prolonging life and promoting human health through organized efforts of society, organizations, communities and individuals. It aims to improve the quality of life through prevention and treatment of disease, including mental health. The field of public health is constantly evolving in response to the needs of communities and populations around the world. The underlying mission of public health is to improve the conditions and behaviors that affect health so that all people can attain it.

Public health...

- Has a real and lasting positive effect on people.
- Helps promote a healthy environment.
- Is a moral and ethical imperative.

In TamilNadu, public health tasks are undertaken by the Department of Public Health and Preventive Medicine and their major activities include provisions of primary health care, which includes Maternity and Child Health Services, Immunization of children against vaccine preventable diseases, control of communicable diseases, Malaria, Filariasis, Japanese encephalitis, Iodine deficiency disorder and waterborne diseases like Acute Diarrheal Diseases, Typhoid, Dysentery, elimination of Leprosy, prevention of food adulteration, health checkup of school children, health education of the community, environmental sanitation and prevention and control of sexually transmitted diseases including HIV / AIDS.

Table 9.16 Water borne diseases and the cause for the diseases

Sl.No	Water Borne Diseases	Cause for Disease
1	Diarrohea	Discharge of water faces from the intestines containing blood and mucus.
2	Cholera	Caused due to the infection of the small intestine by bacterium Vibrio cholera. This disease happens when cholera bacterium present in drinking water or in the food that we eat.
3	Japanese Encephalitis	Mosquito borne zoonotic viral disease
4	Leptospirosis	A bacterial disease spread through the urine of infected animals.

Sl.No	Water Borne Diseases	Cause for Disease
5	Malaria	This is a parasitic disease transmitted from one person to another. It happens from the bite of female Anopheles mosquitoes.
6	Dengue Fever	An outbreak prone viral disease is transmitted by Aedes mosquitoes.
7	Chikengunya	Caused by a virus and is transmitted to humans by two species of mosquito (Aedes and Aegypti).

In Varahanadhi River Basin Taluk hospitals are located in Tindivanam, Gingee, vanur & Non taluk Hospitals are located in Marakkanam, Valavanur and Primary health centres are located in rural areas. Yearly Diseases Data for the blocks fall under Varahanadhi basin is given in Table 9.17 to Table 9.24 (Source: Public Health Department)

9.8.1 Mitigation measures

- The domestic and Trade effluents have to be treated properly to acceptable standards before letting into any sources after ascertaining the permissible limits.
- 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.
- 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
- Frequent surveillance should be carried out particularly during the rainy season to control the spread of diseases.
- The water containers should be washed and cleaned every day.
- The pipes and tanks that supply water should be maintained properly.

Finally awareness creation and education to the general public is the most cost effective way in improving health and better life.

Table 9.17 Malaria

Sl. No.	Block	2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015	
		C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D
1	Gingee	40	0	16	0	39	0	31	0	7	0	16	0	0	0	5	0	6	0	6	0	0	0
2	Melmalayanur	17	0	9	0	18	0	11	0	2	0	9	0	8	0	4	0	4	0	5	0	1	0
3	Vallam	11	0	7	0	0	0	1	0	0	0	0	0	2	0	2	0	1	0	1	0	1	0
4	Mailam	24	0	15	0	11	0	7	0	1	0	0	0	2	0	3	0	8	0	4	0	4	0
5	Olakkur	27	0	9	0	15	0	7	0	5	0	2	0	11	0	9	0	3	0	4	0	2	0
6	Vanur	9	0	11	0	27	0	11	0	5	0	0	0	2	0	5	0	5	0	2	0	0	0
7	Kanai	60	0	163	0	230	0	8	0	7	0	22	0	25	0	2	0	6	0	5	0	0	0
8	Kandamangalam	11	0	8	0	11	0	6	0	2	0	2	0	0	0	0	0	0	0	0	0	1	0
9	Koliyanur	11	0	11	0	11	0	4	0	3	0	4	0	8	0	4	0	1	0	1	0	1	0
10	Marakkanam	31	0	15	0	10	0	4	0	5	0	3	0	4	0	3	0	4	0	1	0	1	0
11	Vikravandi	104	0	77	0	76	0	26	0	15	0	21	0	21	0	9	0	8	0	7	0	2	0
12	Chitamur	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	4	0	12	0	1	0	3	0	1	0
13	Lattur	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	1	0	1	0	2	0	1	0	1	0
14	Acharapakkam	NA	NA	NA	NA	NA	NA	3	0	0	0	0	0	3	0	7	0	3	0	0	0	0	0
15	Maduranthagam	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	Cuddalore	NA	NA	NA	NA	NA	NA	NA	NA	63	0	50	0	56	0	31	0	34	0	17	0	NA	NA
17	Kalasapakkam	NA	NA	NA	NA	NA	NA	NA	NA	15	0	26	0	27	0	13	0	43	0	20	0	20	0
18	Chetpet	NA	NA	NA	NA	NA	NA	NA	NA	7	0	17	0	17	0	27	0	24	0	15	0	3	0
19	Kilpennathur	NA	NA	NA	NA	NA	NA	NA	NA	2	0	12	0	21	0	20	0	5	0	8	0	7	0
20	Turinjapuram	NA	NA	NA	NA	NA	NA	NA	NA	12	0	12	0	14	0	9	0	24	0	16	0	12	0

C- Cases D-Death NA-Data Not Available

Table 9.18 ADD (Acute Diarrohea Disease)

Sl. No	Block	2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015	
		C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D
1	Gingee	1345	0	2456	0	2215	0	3465	0	3568	0	1886	0	3852	0	6911	0	6882	0	4375	0	NA	NA
2	Melmalayanur	594	0	648	0	786	0	798	0	845	0	653	0	668	0	711	0	393	0	594	0	NA	NA
3	Vallam	1201	0	986	0	845	0	875	0	769	0	1401	0	937	0	837	0	718	0	450	0	NA	NA
4	Mailam	1034	0	1124	0	997	0	1035	0	1214	0	1091	0	1420	0	1401	0	1126	0	1787	0	NA	NA
5	Olakkur	1789	0	1824	0	1896	0	1968	0	1994	0	1982	0	6471	0	2992	0	1922	0	3521	0	NA	NA
6	Vanur	1243	0	1154	0	1024	0	987	0	986	0	1345	0	4109	0	3327	0	3559	0	939	0	NA	NA
7	Kanai	1245	0	1756	0	1432	0	1235	0	1426	0	1587	0	1330	0	1145	0	783	0	706	0	NA	NA
8	Kandamangalam	1256	0	1026	0	1346	0	1278	0	1054	0	2880	0	2657	0	2671	0	1823	0	1186	0	NA	NA
9	Koliyanur	2648	0	3452	0	2689	0	3456	0	1025	0	3441	0	19120	0	23688	0	20150	0	4165	0	NA	NA
10	Marakkanam	976	0	1240	0	1141	0	986	0	986	0	1924	0	1755	0	1458	0	1166	0	828	0	NA	NA
11	Vikravandi	1124	0	1234	0	1345	0	976	0	869	0	1865	0	1744	0	1509	0	1176	0	797	0	NA	NA
12	Chitamur	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
13	Lattur	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
12	Acharapakkam	NA	NA	NA	NA	NA	NA	869	0	1237	0	1590	0	1555	0	981	0	825	0	380	0	140	0
13	Maduranthagam	NA	NA	NA	NA	NA	NA	83	0	112	0	136	0	2998	0	2293	0	1749	0	1043	0	728	0
16	Cuddalore	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2488	0	3976	0	3097	0	2543	0
17	Kalasapakkam	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	180	0	140	0	204	0	151	0	524	0
18	Chetpet	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	98	0	119	0	99	0	113	0	117	0
19	Kilpennathur	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	265	0	259	0	198	0	174	0	203	0
20	Turinjapuram	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	281	0	316	0	369	0	370	0	604	0

C- Cases D-Death NA-Data Not Available

Table 9.19 Dengue

Sl. No	Block	2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015	
		C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D
1	Gingee	0	0	0	0	2	0	0	0	3	0	1	0	1	0	3	0	11	0	35	0	0	0
2	Melmalayanur	0	0	0	0	1	0	0	0	0	0	0	0	1	0	3	0	10	0	6	0	1	0
3	Vallam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	11	0	11	0	1	0
4	Mailam	0	0	0	0	2	0	0	0	0	0	1	0	0	0	6	0	26	0	17	0	4	0
5	Olakkur	0	0	0	0	1	0	4	0	0	0	0	0	0	0	2	0	8	0	5	0	2	0
6	Vanur	2	0	0	0	3	0	0	0	0	0	2	0	2	0	7	0	81	0	16	0	0	0
7	Kanai	0	0	2	0	2	0	0	0	0	0	1	0	0	0	16	0	28	0	65	0	0	0
8	Kandamangalam	1	0	1	0	1	0	1	0	0	0	0	0	0	0	9	0	18	0	12	0	1	0
9	Koliyanur	0	0	1	0	0	0	1	0	0	0	0	0	1	0	12	0	28	0	48	0	1	0
10	Marakkanam	1	0	0	0	2	0	0	0	0	0	1	0	0	0	6	0	26	0	17	0	1	0
11	Vikravandi	0	0	0	0	3	0	0	0	0	0	14	0	1	0	10	0	28	0	93	0	2	0
12	Chitamur	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	2	0	1	0	3	0	2	0	NA	NA
13	Lattur	NA	NA	NA	NA	NA	NA	0	0	0	0	1	0	0	0	1	0	4	0	3	0	NA	NA
14	Acharapakkam	NA	NA	NA	NA	NA	NA	0	0	0	0	2	0	2	0	2	0	2	0	1	0	2	0
15	Maduranthagam	NA	NA	NA	NA	NA	NA	0	0	0	0	1	0	0	0	20	0	7	0	10	0	2	0
16	Cuddalore	NA	NA	NA	NA	NA	NA	NA	NA	3	0	0	0	484	0	208	0	151	0	263	0	NA	NA
17	Kalasapakkam	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	12	0	11	0	33	0
18	Chetpet	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5	0	4	0	18	0
19	Kilpennathur	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5	0	4	0	20	0
20	Turinjapuram	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	17	0	58	0

C- Cases D-Death NA-Data Not Available

Table 9.20 Chikungunya

Sl. No	Block	2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015	
		C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D
1	Gingee	0	0	124	0	0	0	0	0	0	0	0	0	1	0	3	0	1	0	0	0	0	0
2	Melmalayanur	0	0	0	0	0	0	0	0	0	0	0	0	4	0	2	0	0	0	0	0	0	0
3	Vallam	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	1	0	0	0	0	0
4	Mailam	0	0	115	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	3	0	0	0
5	Olakkur	0	0	0	0	0	0	0	0	5	0	0	0	1	0	6	0	2	0	0	0	0	0
6	Vanur	0	0	68	0	0	0	0	0	3	0	0	0	0	0	0	0	2	0	1	0	0	0
7	Kanai	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0
8	Kandamangalam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	Koliyanur	0	0	0	0	0	0	0	0	4	0	1	0	0	0	0	0	2	0	0	0	0	0
10	Marakkanam	0	0	13	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	1	0	1	0
11	Vikravandi	0	0	79	0	0	0	0	0	1	0	5	0	2	0	5	0	2	0	1	0	1	0
12	Chitamur	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA
13	Lattur	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA
14	Acharapakkam	NA	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	0	0	NA	NA	0	0	0	0	0	0
15	Maduranthagam	NA	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	1	0	NA	NA	9	0	0	0	1	0
16	Cuddalore	NA	NA	NA	NA	NA	NA	NA	NA	1	0	2	0	0	0	1	0	3	0	1	0	NA	NA
17	Kalasapakkam	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5	0	9	0	0	0
18	Chetpet	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	0	2	0	0	0
19	Kilpennathur	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	7	0	4	0	1	0
20	Turinjapuram	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3	0	9	0	0	0

C- Cases D-Death NA-Data Not Available

Table 9.21 Leptospirosis

Sl. No	Block	2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015	
		C	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**	**C**	**D**
1	Gingee	2	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	1	0	0	0
2	Melmalayanur	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0
3	Vallam	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	1	0	0	0
4	Mailam	0	0	0	0	0	0	0	0	0	0	1	0	5	0	1	0	0	0	0	0	0	0
5	Olakkur	0	0	0	0	0	0	8	0	4	0	0	0	3	0	1	0	1	0	1	0	0	0
6	Vanur	0	0	2	0	2	0	0	0	1	0	0	0	1	0	0	0	3	0	0	0	0	0
7	Kanai	0	0	6	0	6	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0
8	Kandamangalam	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
9	Koliyanur	1	0	0	0	1	0	0	0	1	0	0	0	3	0	2	0	1	0	0	0	1	0
10	Marakkanam	2	0	14	0	1	0	0	0	0	0	0	0	3	0	2	0	0	0	0	0	0	0
11	Vikravandi	0	0	0	0	3	0	4	0	0	0	0	0	4	0	2	0	0	0	0	0	0	0
12	Chitamur	NA	NA	NA	NA	NA	NA	NA	1	0	0	0	0	0	0	1	0	0	0	1	0	NA	NA
13	Lattur	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	2	0	0	0	NA	NA
14	Acharapakkam	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	Maduranthagam	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	Cuddalore	NA	NA	NA	NA	NA	NA	NA	NA	0	0	2	0	3	0	1	0	1	0	1	0	NA	NA
17	Kalasapakkam	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3	0	6	0	1	0	4	0	3	0	0	0
18	Chetpet	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	0	1	0	1	0	4	0	0	0	1	0
19	Kilpennathur	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	0	0	0	0	0	1	0	1	0	0	0
20	Turinjapuram	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	0	3	0	2	0	2	0	1	0	2	0

C- Cases D-Death NA-Data Not Available

Table 9.22 Dysentry

Sl. No	Block	2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015	
		C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D
1	Gingee	12	0	6	0	8	0	10	0	17	0	6	0	7	0	5	0	5	0	4	0	NA	NA
2	Melmalayanur	2	0	1	0	4	0	3	0	2	0	0	0	0	0	0	0	0	0	4	0	NA	NA
3	Vallam	1	0	6	0	1	0	3	0	2	0	0	0	0	0	0	0	3	0	0	0	NA	NA
4	Mailam	1	0	1	0	3	0	5	0	2	0	2	0	0	0	2	0	0	0	1	0	NA	NA
5	Olakkur	4	0	5	0	10	0	15	0	22	0	4	0	0	0	12	0	23	0	14	0	NA	NA
6	Vanur	2	0	2	0	2	0	4	0	5	0	0	0	5	0	0	0	0	0	0	0	NA	NA
7	Kanai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA
8	Kandamangalam	1	0	2	0	3	0	3	0	2	0	1	0	0	0	0	0	0	0	0	0	NA	NA
9	Koliyanur	23	0	26	0	19	0	27	0	32	0	97	0	58	0	84	0	45	0	51	0	NA	NA
10	Marakkanam	2	0	1	0	4	0	3	0	2	0	0	0	0	0	0	0	0	0	4	0	NA	NA
11	Vikravandi	2	0	3	0	3	0	4	0	1	0	0	0	0	0	9	0	0	0	1	0	NA	NA
12	Acharapakkam	NA	NA	NA	NA	NA	NA	19	0	23	0	34	0	39	0	10	0	21	0	0	0	0	0
13	Maduranthagam	NA	NA	NA	NA	NA	NA	36	0	48	0	64	0	342	0	74	0	38	0	82	0	148	0
14	Kalasapakkam	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0
15	Chetpet	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0
16	Kilpennathur	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0
17	Turinjapuram	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0
18	Chitamur	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
19	Lattur	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
20	Cuddalore	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

C- Cases D-Death NA-Data Not Available

Table 9.23 Cholera

Sl. No	Block	2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015	
		C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D
1	Gingee	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	0
2	Melmalayanur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	0
3	Vallam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	0
4	Mailam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	0
5	Olakkur	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	NA	0
6	Vanur	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	NA	0
7	Kanai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	0
8	Kandamangalam	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	NA	0
9	Koliyanur	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	NA	0
10	Marakkanam	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	1	0	0	0	NA	0
11	Vikravandi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	NA	0
12	Acharapakkam	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA
13	Maduranthagam	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA
14	Kalasapakkam	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0
15	Chetpet	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0
16	Kilpennathur	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	NA
17	Turinjapuram	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0
18	Chitamur	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
19	Lattur	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
20	Cuddalore	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

C- Cases D-Death NA-Data Not Available

Table 9.24 Japanese Encephalitis

Sl. No	Block	2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015	
		C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D
1	Gingee	0	0	2	0	1	0	0	0	0	0	1	0	3	1	1	0	0	0	3	0	1	0
2	Melmalayanur	1	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Vallam	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
4	Mailam	1	0	1	0	0	0	2	0	1	0	0	0	2	0	2	0	1	0	0	0	2	0
5	Olakkur	0	0	0	0	3	0	1	0	0	0	2	0	2	0	1	0	1	0	1	0	1	0
6	Vanur	3	2	0	0	8	0	4	0	1	0	2	0	4	1	3	1	2	0	0	0	0	0
7	Kanai	2	1	0	0	2	0	1	0	2	0	2	1	1	0	0	0	2	1	0	0	0	0
8	Kandamangalam	2	1	0	0	2	0	0	0	1	1	0	0	1	0	1	0	0	0	0	0	1	0
9	Koliyanur	4	1	1	0	5	0	2	0	0	0	2	0	1	1	2	1	3	1	3	0	1	0
10	Marakkanam	2	1	0	0	4	0	2	1	2	0	0	0	2	0	3	1	1	1	1	0	0	0
11	Vikravandi	0	0	0	0	3	0	1	0	1	1	2	0	4	0	1	1	0	0	2	0	1	0
12	Chitamur	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA
13	Lattur	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA
14	Acharapakkam	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	Maduranthagam	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	Cuddalore	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA
17	Kalasapakkam	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	1	1	0	0	1	0	0	0
18	Chetpet	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	0	0	0	0	0	0	0	0	0
19	Kilpennathur	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	0	0	0	0	0	0	0	1	0
20	Turinjapuram	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	0	0	0	0	0	0	0	0	0

C- Cases D-Death NA-Data Not Available

9.9 Solid Waste Management

India's growing population and booming economy have contributed to the multifold increase in amount of solid waste generated and disposed. With this increasing population, management of Municipal Solid Waste (MSW) in the country has emerged as a severe problem not only because of the environmental and aesthetic concerns but also because of the sheer quantities generated every day.

According to Central Pollution Control Board 1, 27,486 TPD (Tons per day) of Municipal Solid Waste was generated in India during 2011-12, with an average waste generation of 0.11 kg/ capita/day. Of the total waste generated, approximately 89,334 TPD (70%) of MSW was collected and only 15,881 TPD (12.45%) was processed or treated. Segregation at source, collection, transportation, treatment and scientific disposal of waste was largely insufficient leading to degradation of the environment and poor quality of life.

9.9.1 Types and source of Solid Waste:

Solid Wastes can be broadly classified as Organic waste (Kitchen waste, Vegetables, fruits, flowers, leaves), Toxic waste (old medicines, paints, chemicals, bulbs, spray cans, batteries, shoe polish, fertilizers & pesticides containers), Hospital waste and Recyclable waste (paper, glass, metals, plastics). Basically depending upon their source, solid waste can be classified into the following different types.

Table 9.25 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 andhazardous wastes
Commercial	Stores, hotels, restaurants, markets, office buildings	Paper, cardboard, plastics, wood, food, glass, metals, special and hazardous wastes
Institutional	Schools, hospitals, prisons, government centres	Same as commercial
Construction and demolition	New construction sites, road repair, renovation sites, demolition of buildings	Wood, steel, concrete, dirt etc.,
Municipal services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants	Street sweepings, landscape and tree trimmings, general wastes from parks, beaches and other recreational areas, sludge

Source	Typical waste generators	Types of solid wastes
Process (manufacturing etc.,)	Heavy and light manufacturing, refineries, chemical plants, power plants, power plants, mineral extraction and processing.	Industrial process wastes, scrap materials, off-specification products, slay, tailings.
Agriculture	Crops, Orchards, Vineyards, dairies, feedlots, farms.	Spoiled food wastes, agricultural wastes, hazardous wastes

9.9.2 Impact of solid waste management

Due to lack of effective solid waste disposal system, people tend to litter their immediate surroundings and solid wastes are heaped up on the roads which affect the community including themselves. This type of dumping allows biodegradable materials to decompose under uncontrolled and unhygienic conditions producing foul smell and serve as a breeding ground for 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.

Various types of wastes like cans, pesticides, cleaning solvents, batteries (zinc, lead or mercury), radioactive materials, plastics and e-waste are mixed up with paper, scraps and other non-toxic materials which could be recycled. Burning of these materials produces dioxins, furans and polychlorinated biphenyls, which have the potential to cause various types of ailments including cancer.

9.9.3 Solid Waste Management in Varahanadhi basin

Varahanadhi basin falls in Villupuram, Cuddalore, Tiruvannamalai and Kancheepuram districts. The solid waste is being managed by the respective Local Bodies. The major type of waste in this basin is Residential wastes and the others being Commercial/Institutional wastes, Agricultural/Processing/Market wastes and health sector wastes.

Collection, Transportation and Disposal of solid waste is done by the local body administrations. At present open dumping is practiced throughout the basin. It is the responsibility of the local body to dispose the waste, where there is no habitation and no chance of contaminating the water resources.

Tindivanam municipality - the only municipality in the basin - generates 27.00 MT of Solid Waste per day out of this nearly 24.00 MT of the Solid Waste being collected, transported and disposed daily, which works to per capita generation of 400 g/day.

Table 9.26 Solid waste composition in Tindivanam Municipality

Waste Composition	Quantity	% Generation
Households, Petty Shops and Establishments	22	81
Vegetable, Fruit, Flower Market	3	11
Meat, Fish and Slaughter House	1	4
Construction	1	4
Total	**27**	**100**

Source: Tindivanam municipality website

The present mechanism is able to collect 88% of the total waste generated in the town. The Urban Local Body also carry out weekly mass waste cleaning programme to clear the left out wastes by utilizing extra vehicles trips in the town. Collection is done by the Municipal workers using tri-cycles, mini lorry, lorry etc, depending on their availability and the nature/quantity of the Municipal Solid Waste. The total garbage collected constitutes 48% of the domestic wastes, 42% commercial wastes and 10% of construction wastes. In Tindivanam municipality, the existing compost yard area is located at Salavathy road at an extent of 2.98 acre.

Table 9.27 Solid waste generation and collection in Tindivanam Municipality

Description of Services	Status
Total Solid Waste generation/day (in MT)	27.00
Total Solid Waste collection/day (in MT)	24.00
% of Coverage	88%
Frequency of collection	Daily
No. of dustbins provided in the town	50
Masonry Containers	Nil
Per Capita Waste Generation (Grams)	400
Per Capita Waste Collection (Grams)	350

Source: Tindivanam municipality website

9.9.4 Mitigation Measures

Solid waste management is one of the vital and persistent challenges faced by the State and the local governing body. The Integrated Solid Waste Management (ISWM) system. *(Source: Ministry of Urban Development, GoI - Municipal Solid Waste Management Manual, May 2014)* is one of the methods that can be adopted to mitigate the effects of solid waste**.**

9.9.4.1 Integrated Solid Waste Management (ISWM) system

The Integrated Solid Waste Management (ISWM) system is based on the 'waste management hierarchy', (see figure 9.1) with an aim to reduce the amount of waste being disposed, while maximizing resource recovery and efficiency. The hierarchy implies that all options of waste minimization should be exercised before treatment and disposal technologies are selected and implemented.

Based on this waste management hierarchy, an assessment of local needs and conditions should lead to the selection of an appropriate mix of processes and technologies.

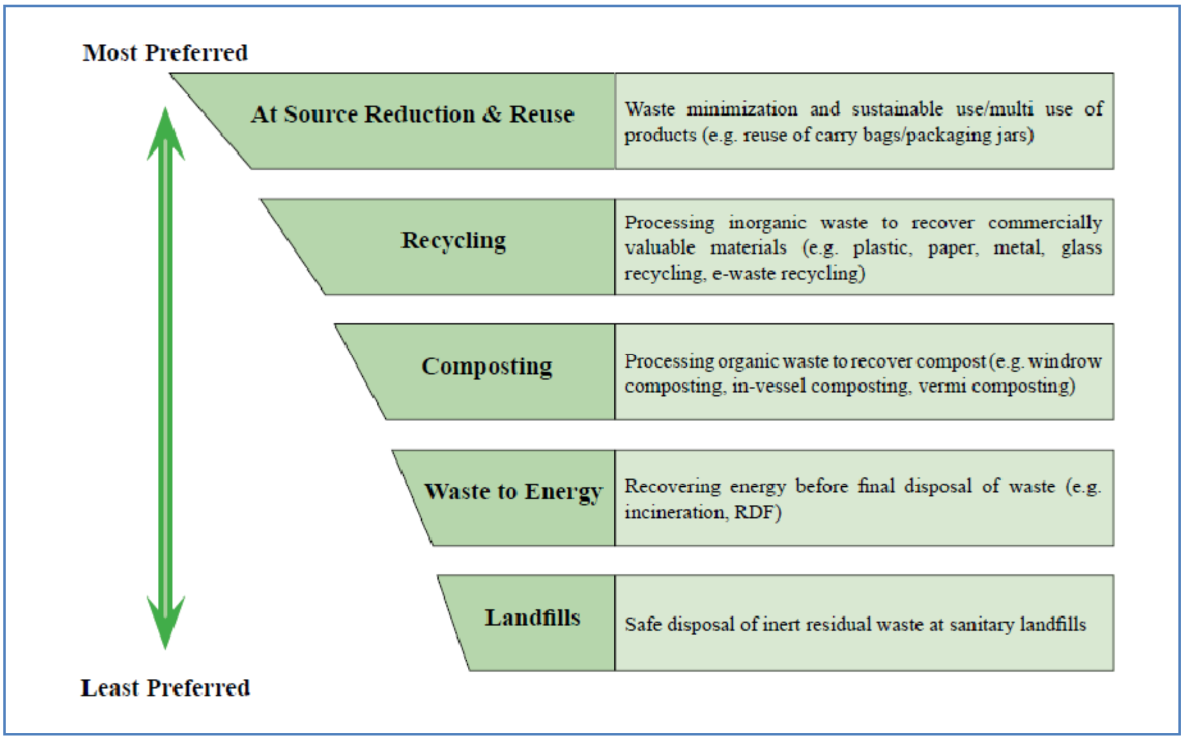


Figure 9.13: ISWM Hierarchy

The preferred waste management strategies within the hierarchy include:

1. **At source reduction and reuse:** The most preferred option for waste management is to prevent the generation of waste at various stages including at product design stage, production, packaging, use and reuse stages of a product. Waste prevention helps reduce handling, treatment, and disposal costs and reduces various environmental impacts such as leachate, air emissions and generation of greenhouse gases.
2. **Waste recycling:** Recovery of recyclable material resources through a process of segregation, collection and re-processing to create new products is the next preferred alternative. The following are the steps involved in waste recycling
   a. **Segregation at Source:** The municipality should create awareness among the public to encourage waste segregation and recycling at source. Separate waste

collection bins should be kept at each locality to dispose the bio and non bio-degradable wastes & dry and wet wastes separately.

b. **Collection**: Collection of segregated municipal waste from the source of its generation is an essential step in solid waste management. Inefficient waste collection service has an impact on public health and aesthetics of towns and cities. Collection of wet and dry waste separately enhances the potential of cost effective treatment of such wastes and of deriving optimum advantage from the recyclable material fed into the system.

c. **Recycling and recovery:** Recycling is a process by which materials that are otherwise destined for disposal are collected, processed and re-manufactured. Recycling diverts a significant fraction of municipal, institutional and business waste from disposal and, thereby, saves scarce natural resources as well as reduces environmental impacts and the burden on public authorities to manage waste. Recycling can generate revenues, which result in reducing can reduce the overall costs for municipal solid waste management

3. **Waste to Composting:** After waste minimisation and recycling systems, the ISWM hierarchy indicates adoption of composting as the third preferred waste management practice, ensuring that waste is processed appropriately to facilitate further use of the material.

   Composting is a controlled aerobic process of biologically "digesting" the municipal solid waste, so it may be recycled for other purposes – plant nutrient, stabilization of soil in remediation process or soil amendment for recovery of poor soils. Compost production can be carried out at the decentralized level (home composting/bin composting/box composting/vermin composting/in-vessel composting) or at a centralized level (windrow composting/in-vessel composting/aerated static pile), depending upon the feasibility of implementation. Both processes required significant pre-processing and only organic matter is to be composted. Compost produced should meet with quality criteria specified by the Municipal Solid Waste management Rules and the Fertilizer Control Order 2009 and 2013. A market for the compost should be ascertained before sizing the compost plants.

4. **Waste-to-Energy:** Where material recovery and composting from municipal solid waste is not possible or not desirable due to local conditions, energy recovery from waste through production of heat, electricity, or Refuse Derived Fuel (RDF) is preferred. When high calorific value fraction of the MSW is either incinerated or processed anaerobically

(biomethanation), the resultant energy, either as heat (incineration) or biogas (methane) can be reused either directly or converted to electricity using appropriate generators. Sale of this energy should result in the financial viability of waste to energy systems.

5. **Waste Disposal:** Remaining residual wastes at the end of the hierarchy, which are ideally comprised of inerts, are to be disposed in sanitary, lined landfills, which are constructed in accordance with stipulations of the MSW Management and Handling Rules, 2014.

   Sanitary landfills are facilities for final disposal of Municipal Solid Waste on land, designed and constructed with the objective of minimizing impacts to the environment. The Municipal-Solid Waste (Management and Handling) Rules 2000 and draft revised Rules 2013 provide comprehensive regulations on the site selection, design and operation of sanitary landfills. The site selection for the landfill is determined by its basic components as given in Figure 9.15

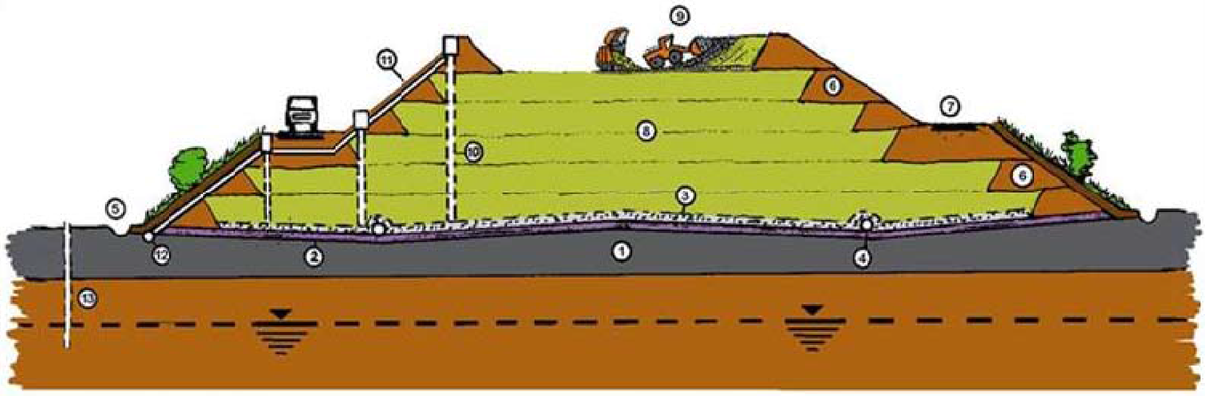


Figure 9.14: Basic Components of a Sanitary Landfill

1. Geological barrier 2. Impermeable base liner 3. Drainage layer 4. Leachate collection system 5. Storm-water drain ditch 6. Bordering dams 7. Circulation roads	8. Landfill body 9. Filling and compacting in layers 10. Gas venting system 11. Protective cover system 12. Gas collectors 13. Groundwater control 14. Re-planting

Wastes suitable for land filling:

Condition and composition of wastes suitable for disposal in a municipal sanitary landfill are regulated by the MSW Rules 2000 and draft 2013. Sanitary landfilling is necessary for the following types of waste:

i. Waste that is by its nature or through pre-treatment non-biodegradable and inert;

ii. Co-mingled waste (mixed waste) not found suitable for waste processing;

iii. Pre-processing and post-processing rejects from waste processing plants;

iv. Non-hazardous waste not being processed or recycled.

Sanitary Land filling is not allowed for the following waste streams in the municipal solid waste:

i. Bio-degradable waste/garden waste (it should preferably be composted);

ii. Dry recyclables (it should preferably be recycled);

iii. Hazardous wastes (needs hazardous waste sites with special equipment).

Finally for any schemes or plans to achieve the desired result, public participation is utmost important for attaining the desired goal. It is the duty of the governing body to educate the people about the ill effects of solid wastes and create awareness among the public to minimize waste, encourage waste segregation and recycling at source through various awareness programmes in the form of local media, newspapers, exhibitions at schools and colleges. The local resident welfare associations and non-governmental organizations should be encouraged to actively involved in the waste management program.

9.10 Forest and Wild Life

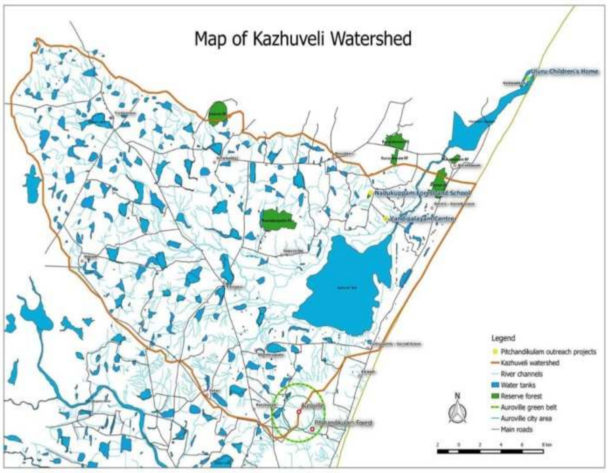
In order to cater to the needs of the booming population and rapid urbanization, the fertile swamps, marshes and many wetlands are being converted into agricultural lands and paddy fields the world over. In recent years, with the introduction of powerful dredging, draining and earthmoving machinery the conversion of wetland to farmland has become particularly profitable. The draining of wetlands not only eliminates wildlife, but also increases storm water surges and lowers the water tables.

9.10.1 Forest and Wild life scenario in Varahanadhi basin

The percentage of forest area in Varahanadhi basin is 7.7% which is mainly located around Gingee town. Though there are no significant Wild life and bird sanctuaries in this basin, a proposal for forming Bird's Sanctuary over an area of 4722.2.05 Ha in the Kazhuveli Bio-Region is under active consideration of the government.

9.10.2 Kazhuveli Wet land

The Kazhuveli bio-region lies along the Coromandel Coast of South India and covers a triangle between Pondicherry, Marakannam and Tindivanam. It was notified as Reserve Land under Tamil Nadu Forest Act 1882 of Section 26 in Villupuram District Gazette Dated 16.04.2001. It is named after the Kazhuveli Tank, the second-largest brackish water lake in South India, and a wetland of great diversity and ecological importance. The indigenous vegetation of this area is known as the Tropical Dry Evergreen Forest (TDEF), a forest type that is found only in South India and Sri Lanka and provides a rare biological richness due to its very high species abundance. It is also one of the 94 identified wetlands under National Wetland Conservation and Management Programme (NWCMP) operated by the Government of India in 1985-86 along with Point Calimere and Pallikaranai Marsh in the state of Tamil Nadu. It is now close to extinction, as only 0.01% survives.



a) Vegetation

Kazhuveli is an old mangrove forest and is one of the prioritized wetlands of Tamil Nadu which has been degraded over period of time. The biodiversity includes varied species of plants, birds, butterflies, fishes, amphibians, reptiles and mammals. Extensive sedges and grasses in the non-estuarine portion and the aquatic reeds also are seen. The entire ecosystem of this wetland is completely destroyed and denuded due to the human inference due to establishment of salt pans and extensive shrimp farming and fishing. This has increased the salinity and soil degradation resulting in vegetation loss in the nearby regions. Moreover the lands used for hatcheries become the dump yard for the fodders, chemical sediments and becomes the poisoning grounds for bird form which pecks on it.

b) Fauna

An important aspect for which Kazhuveli swap is sought to be declared as birds sanctuary is the wide variety of migratory waterfowls. Some 71 species of waterfowls are sighted in this area, including 13 species of Anatudal and 30 species of shorebirds. The area holds around 30,000 ducks, 20,000 - 40,000 shorebirds and 20,000 - 50,000 terns during winter. In March and April as the water level recedes, the lagoon attracts pelicans, herons, egrets, storks and ibises.

The area also serves as an important Corridor for the migratory birds which move to Point Calimere during winter. Every year during the months of October to February large congregations of water birds can be seen in thousands in this swamp. Since the swamp is adjacent to Bay of Bengal, large numbers of birds from foreign countries arrive and stay here in the winter as a refugee place. The conditions and climate prevailing in winter season in this swamp are highly suitable to the migratory birds from the foreign countries.

c) Tourism

The Kaluveli swamp is slowly gaining importance as a tourist spot as many Private parties have constructed modern cottages near the East Coast Road between Pondy and Marakanam. The local population and the tourists from various parts of country flock to this swamp during seasons for bird watching and for the Mangrove forests. Hence declaration of the area as Birds Sanctuary will not only prevent poaching and destruction of habitat of these migratory birds but also helps in conservation of this rare fragile ecosystem.

9.11 Tourism

Over the decades, tourism has experienced continued growth and deepening diversification to become one of the fastest growing economic sectors and main source of income in India. Modern tourism is closely linked to development and encompasses growing number of new destinations. These dynamics have turned tourism into a key driver for socio-economic progress.

Tamil Nadu is a State with several distinguished tourism genre and has its own unique culture and traditions. Due to its abundant tourism potential, tourists from all over the country and abroad flock the tourist spots in the State throughout the year.

Some of the distinguished tourist attractions in Varahanadhi sub basin are given below.

9.11.1 Gingee Fort

Fig 9.15 View of Gingee Fort

Gingee Fort (Senji Fort) is one of the few surviving forts in Tamil Nadu. It was called the "Troy of the East" by the British. Originally the site of a small fort built by the Chola dynasty in 9th century AD, it was later modified by the Vijayanagar empire and the GingeeNayaks in 13th to 16th century to elevate it to the status of an unbreachable citadel.

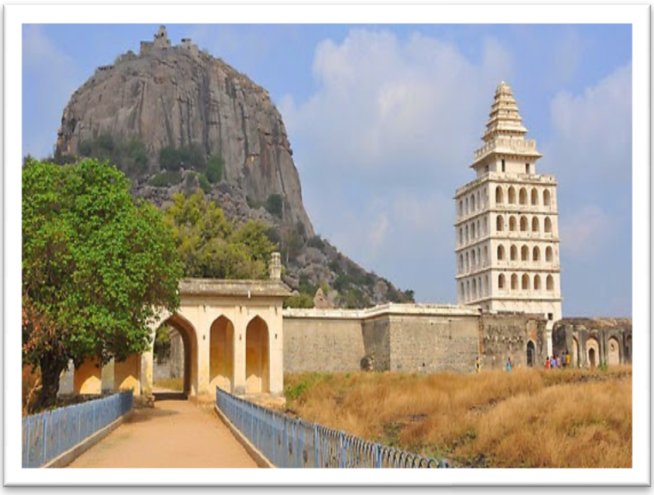


Fig. 9.16 Entrance to Gingee Fort

Fig. 9.17 Mandapam

Fig. 9.18 Anaikulam Pond

Fig. 9.19 Cannon at Gingee Fort

The Gingee Fort complex is on three hillocks - Krishnagiri to the north, Rajagiri to the west and Chandrayandurg to the southeast. The three hills together constitute a fort complex, each having a separate and self-contained citadel. The fort walls are 13 km long connecting the three hills enclosing an area of 11 square km. It is built at a height of 240 m and protected by a 24 m wide moat. The complex has a seven-storeyed KalyanaMahal (marriage hall), granaries, prison cells, Aanaikulam pond and a temple dedicated to Goddess Chenjiamman. The fort is currently maintained and administered by the Archaeological Survey of India. The fort is one of the prominent tourist destinations in Villupuram district.

9.11.2 Thiruvakkarai

a) Chandramowliswarar temple

Chandramowleeswarar Temple at Thiruvakkarai is dedicated to the Hindu god Shiva and classified as Paadal Petra Sthalam, revered in Tevaram, written by Tamil saint poets known as the Nayanmars in the 7th century. Constructed in the Dravidian style of architecture, the temple was built by the Chola king Aditya I (870 - 907 CE) and has received gracious Endowments from the Chola queen SembiyanMahadevi in 10th century Vakrakaliamman shrine in this temple is famous among devotees.

Fig. 9.20 Chandramowleeswar temple

Fig. 9.21 Vakrakaliamman shrine

b) National fossil wood park:

The National Fossil Wood Park is a notified National Geo-heritage Monument located in Thiruvakkarai, Villupuram District. The park was established in 1940 and is maintained by the Geological Survey of India. It contains petrified wood fossils approximately 20 million years old, scattered throughout the park, which covers about 1 sq.km. The park consists of nine enclaves. A small portion of it is open to the public.It is believed that the fossils were formed during massive flooding that occurred millions of years ago.

Fig 9.22 National Fossil Wood Park, Thiruvakarai

9.11.3 Melmalaiyanur

The AngalaParameswari temple in Melmalaiyanur is located 32km from Gingee in Villupuram District.The deity of the temple is the Sembadavars. There is an ancient snake pit in the inner sanctum of the temple.

Fig. 9.23 Melmalaiyanur temple

Fig. 9.24 Temple car festival, Melmalaiyanur

The festival SimimasanaKollai is celebrated here during February-March. During the festival many pilgrims cook large quantities of various kinds of grain and set it out in the burning ground. This offering to the goddess is believed to grant wishes. The New moon day (Ammavasai) and Full moon day are auspicious days in this temple and lakhs of devoteesthrong the temple during these days.

9.11.4. Melsittamur

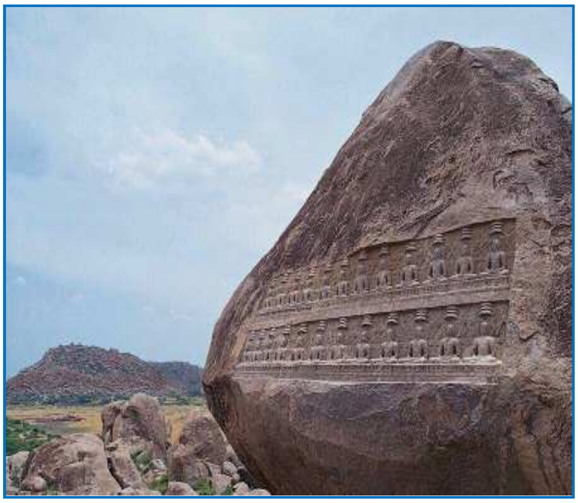
The JinaKanchi Jain Math located in Melsithamuris the primary religious center of the Tamil Jain community. There are two temples dedicated to Parshvanathar and to Malinathar. The carvings of 24 TirtankarasBahubali, Parshvanatha, Adinathbagavan, Mahavira and Yakshi Dharma Devi belonging to the 7th century sculptured on a single rock here is a testimony to the workmanship of those days.

Fig. 9.25 JinakanchiJain mutt at Melsittamur

Fig. 9.26 ParsvanatharTemple, Melsittamur

Fig. 9.27 Tirtankaras at Thirunatharkundru

Fig. 9.28 Parsvanathar deity



Parshvanatha temple's Raja Gopuram is a seven storey tower with a total height about 70 feet. Main idol of Parshvanatha temple is a black colored 14 feet idol of Parshvanatha in Padmasan posture. The 52 feet Manastambha in the temple is a monolith. **Malinatha Temple** is also known as ThiruvooramPalli or KattamPalli.

9.11.5 Mailam

Mailam is famous for the MayilamMurugan Temple. The temple, located on a hillock, was built and administered by Bommayapuramveerasaiva mutt. Lakhs of Devotees visit the temple from all over TamilNadu on Panguniuthiram festival.

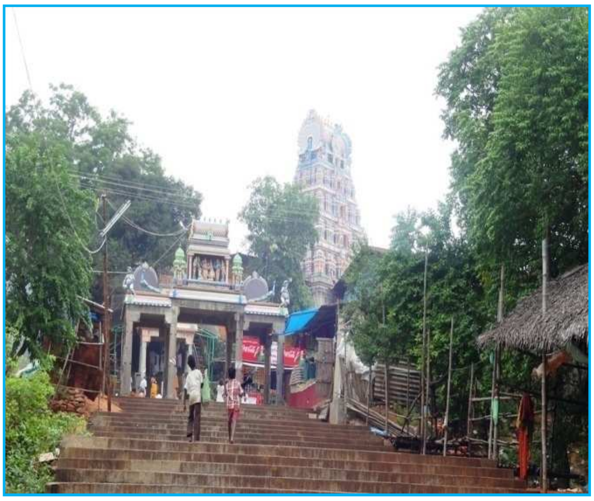


Fig. 9.29 Mailam temple

9.11.6 Vidur Dam:

Vidur dam which is situated near Vidur village in Tindivanamtaluk of Villupuram District was constructed during the year 1958-59, 800m below the confluence Point of rivers Sanakarabarani and Thondiar. Below the Dam, the river is called Varahanadhi. There is Children's park located close to NH45 near Vikravandi which makes it as a popular tourist destination in the district.

Fig. 9.30 Vidur Dam

Fig. 9.31 Vidur Dam Park

9.11.7 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. Unrestrained tourism leads to lot of major problems that could totally harm the environment, such as natural habitat loss, increased pollution, soil erosion, damage to the landscape, litter, erosion, disturbance to livestock, vandalism, traffic congestion and pollution. .

9.11.8 Mitigation measures

The mitigation measures recommended to reduce the negative impact of tourism are as follows

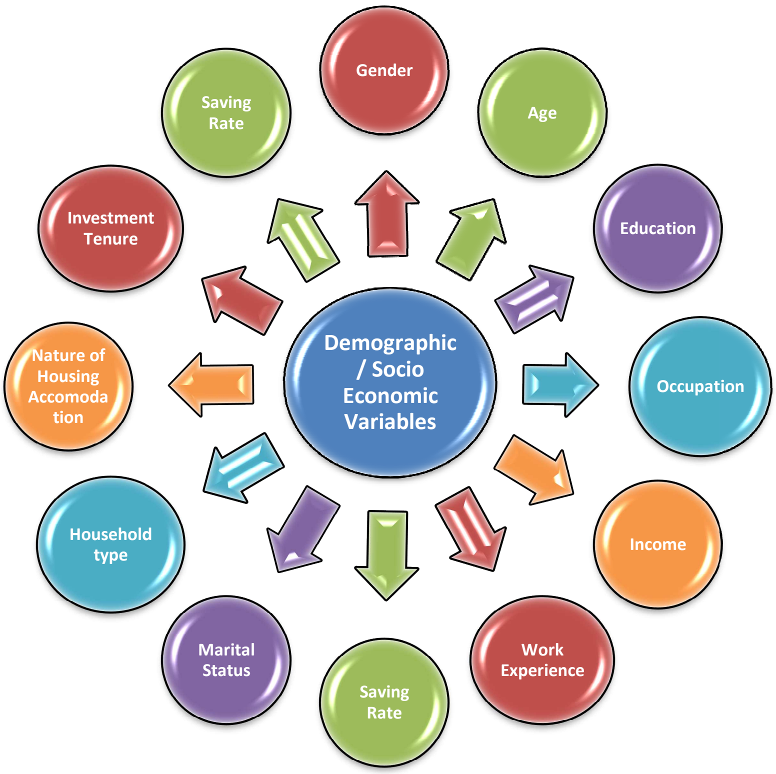
- Putting increased focus on Eco-tourism ie. tourism which is ecologically sustainable. The general principles of ecotourism are 1. Involvement of local community for the overall economic development of the area 2. Development of eco-tourism that is compatible with the environment and socio-cultural characteristics of the local community and 3. Proper planning as part of the overall area development strategy, guided by an integrated land-use plan avoiding inter-sectoral conflicts and ensuring sectoral integration.
- Encouraging Green tourism i.e., responsible, sustainable and ethical tourism. It not only places emphasis on protecting the environment but also involves local people in making decisions that affect their land and living. Total ban on non-biodegradable products such as plastics have an enormous positive impact on the planet's environment.
- Utilization of revenue from parks and other tourist spots for the overall development and management of environmentally sensitive areas.
- Implementation of regulatory measures such as restriction on the number of tourists per year and tourism activities within protected areas. Limitation on number of tourists not only reduces the environmental impacts on the natural ecosystem but also helps to maintain the integrity of the area. Limitations should be exercised after a thorough analysis on the maximum sustainable visitor capacity so that it does not affect the livelihood of the local people.
- Implementation of strict laws to reduce social conflict between different groups of people, caused due to tourism.

- Providing environmental information and raising awareness among tourists about the environmental consequences and their remedial actions.

9.12 Socio Economic Aspects & Legal Issues

Socioeconomics (also known as social economics) is the social science that studies how economic activity affects and is shaped by social processes. It is described as discipline studying the reciprocal relationship between economic science on the one hand and social philosophy, ethics, human dignity on the other toward social reconstruction and improvement. In general it analyzes how societies progress, stagnate, or regress because of their local or regional economy, or the global economy.

The factors that affect the socio economic aspects are depicted in the diagram below:



The total population of Varahanadhi basin is 2.392 million *(As projected to 2017)* out of which Urban population is 0.389 million and Rural population is 2.003 million. Overall literacy rate of Varahanadhi Basin is found to be 66.25 % *(Source: Census 2011)*.

Agriculture is being practiced throughout the basin and the crops cultivated widely are paddy, black gram, sugarcane, groundnut etc. The educational levels of farmers are favourable to adopt modern water management practices, cropping pattern etc. The Farmers Organisatons are vested with more powers and they actively participate in the developmental activities.

Fishing is another important source of livelihood and occupies a prime place in acceleration of socio-economic development in the basin. Besides being an employment provider and foreign exchange earner, this sector stimulates a number of subsidiary industries.

Fishermen residing in the villages along the coastal area of Villupuram and Kancheepuram districts undertake activities such as fishing, seaweed, coral reefs and firewood collection and diving for collection of chunks.

There are many small scale industries in the basin which generates employment to the local population.Participation of local people in planning, implementing and monitoring of these actions is decisive for sustainable outcomes.

9.12.1. Legal Issues

With the institutional and governance issues getting greater importance in the policy discourse in recent years, the relevance of legal aspects, which are an integral part of the governance system, is also increasing in many fields. Understandably, one of these fields relates to water a resource the scarcity or mismanagement of which could be a major constraint for food security and economic development.

9.12.2 Conservation laws

The following are the constitutional provisions available for protecting the environment.

Article 48-A: The State shall endeavor to protect and improve the environment and to safe guard the forests and wildlife of the country.

Article 51-A (g): It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers & wild life and to have compassion for living creatures.

9.12.3 Acts related to Water resources & Environment & Encroachment.

Over the years many revisions have been made to the policy of Environment, water bodies, their management and regulation. This is a compilation of Acts related to conservation of water bodies and the Environment. The list of major environmental acts and rules now in force in India can be found in the website: http:// www.envfor.nic.in.Some of the major Acts / rules prevalent is given in the Table 9.28 below:

Table 9.28 Name of Acts / Rules

Sl.No	Name of Acts / Rules
	Government of India Acts
1	Indian Forest Act 1927 (management of forests and biodiversity)
2	Wild Life (Protection) Act 1972
3	Water (Prevention and Control of Pollution) Act, 1974
4	Water (Prevention and Control of Pollution) Cess Act, 1977
5	Forest (Conservation) Act 1980

Sl.No	Name of Acts / Rules
6	Air (Prevention and Control of Pollution) Act, 1981
7	Biodiversity Act 2003
8	Environment protection Act 1986, amended for Environmental Impact Assessment notification, 2006
9	Coastal regulation Zone notification, 2011
10	Municipal-Solid Waste (Management and Handling) Rules 2000 and draft revised Rules 2013
11	**Government of TamilNadu Acts** TamilNadu Land encroachment act 1905
12	Tamil Nadu Protection of Tanks and Eviction of Encroachment Act, 2007
13	Tamil Nadu Farmers' Management of Irrigation Systems - Act, (TNFMIS) 2000
14	**Waste management Rules** Solid Waste Management Rules, 2016
15	E-Waste Management Rules, 2016
16	Bio-Medical Waste Management Rules, 2016
17	Hazardous and Other Waste (Management and Transboundary) Rules, 2016
18	Plastic Waste Management Rules, 2016

9.13 Public Awareness and Participation

Increasing population and urbanization have generated pressure on the natural resources and has lead to the degradation and pollution of the environment. 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.

Environmental Education sensitizes the society about environmental issues and challenges interested individuals to develop skills and expertise thereby providing appropriate solutions. Climate change, loss of biodiversity, declining fisheries, destruction of habitats, land degradation, depleting ground water supplies, introduction of alien species, environmental pollution, solid waste disposal, storm water and sewage disposal pose a serious threat to ecosystems in forest, rural, urban and marine ecosystems. Both formal and informal education on the environment will give the interested individual the knowledge, values, skills and tools needed to face the environmental challenges on a local and global level.

9.13.1 Awareness programmes in Varahanadhi basin

In Varahanadhi River Basin, various Awareness programmes such as seminars, motivational speeches, exhibitions / fairs, field visits etc. were conducted for the farmers, general public, schools and college students and to the local bodies by the Environmental Cell Division of Water Resources Department under Irrigation Agriculture Modernization and Water Bodies Restoration and Management (IAMWARM) Projectduring 2007-2015. The following are the Awareness programmes conducted in the Varahanadhi basin.

9.13.1.1 Awareness Programme for Farmers / Public

In Ongur and Nallavur sub basin, Environmental awareness programmes were conducted for farmers and public for efficient water use, promotion of sustainable organic agriculture as water-efficient agricultural practice, production of low cost organic manures as inputs and pesticides as a crop protection measure, natural farming and its growing market advantages, cultivation of herbal plants and preparation of herbal medicines as low cost health care for rural agricultural households and linkages, Preparation of vermi compost manure etc.

Fig. 9.32 NBRMarriage hall at Achirampattu for Nallavur Sub basin.

Fig. 9.33 Seminar on Environmental awareness at Maduranthagam for Ongur Sub basin Dt. 5.07.2012

9.13.1.2 Awareness Meeting for Motivating the Local Bodies

Awareness meetings to motivate the Local bodies were conducted in Ongur and Nallavur sub basin. In the meeting, the Local bodies were enlightened on the importance of

Solid waste management / Sewage Treatment, river management, elimination of disposal of effluents and solid wastes into the river, Installing solid waste recycling mechanism system including source, segregation, recycle of dry waste and linkage with user agencies, effluents discharged by sewage treatment plant, Global warming etc.

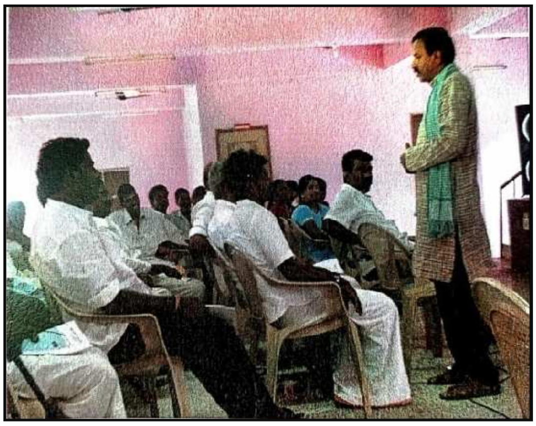


Fig. 9.34 NKV Mahal at Achirampakkam for Ongur Sub basin

Fig. 9.35 Village union office at Saram for Nallavur sub basin 04.02.2012

9.13.1.3 Awareness Programme for College / School Students - Conducting Fair/Exhibition in School and Institutions

Awareness Programme for School / College Studentswere conducted throughEnvironmental fair/exhibition, benchmarking, recognition of good eco-friendly practices, green awards – Input session/lecture, Audio/video visuals, Power point presentation, Models of Sound environment, Display of Charts and photography

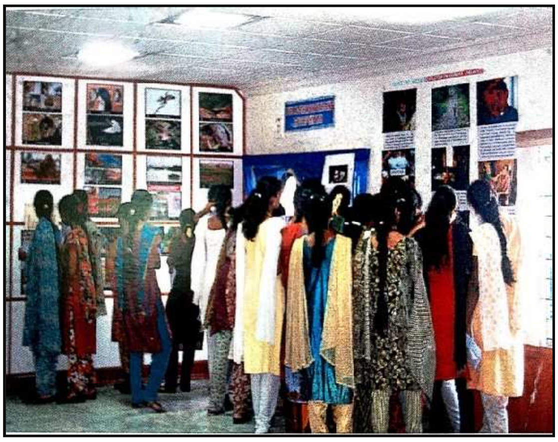


Fig. 9.36 KarpagaVinagayar College of Engg. And Technology, ChinnaKolampakkam Dt. 10.10.2012 for Ongur Sub basin

Fig. 9. 37 Thiru. A.Govindasamy Govt. Arts college, Tindivanam Dt. 26.09.2012 for Nallavur Sub basin

FIELD VISIT

Fig. 9.38 Exposure visit conducted for Precision farmers from Tindivanam of Nallavur sub basin to TNAU, Coimbatore, Dharmapuri and Sandayur

9.14 Summary

By now, we would have realized how important it is to protect and conserve the environment for our own survival. The natural resources are getting depleted at an alarming rate and environmental problems are increasing. It is, therefore, necessary to conserve and protect our environment, use alternate resources and minimize the environmental degradation. The possible measures for mitigating the problems of environmental degradation can be classified as 'preventive measures' and 'curative/remedial measures'. The preventive measures could be used to prevent or minimize the extent of degradation and the curative measures can be used to cure or remedy the damage caused by degradation. When identifying the alternatives for mitigating the problems of environmental degradation, we should aim at minimizing it, or at least restricting it to a level consistent with the society's objectives.

Some of the mitigation measures that can be adopted to reduce the environmental degradation are given below:

1. Implementing Institutional Changes which include Constitutional provisions, creation of new institutions, modification of existing institutions, enacting new laws, imposing new taxes, and provision of newly introduced subsidies.

2. Setting up of a permanent machinery comprising experts in all relevant disciplines to review the notified ambient and emissions standards and strengthening the network for monitoring ambient environmental quality by ensuring adequate participation of potentially involved local communities and industry associations.
3. Implementing strict laws to ensure adequate sewage treatment of Industrial and Domestic effluents before disposal and design of separate lines for carrying the sewage. The treated water can be used for landscaping, gardening and other industrial purposes. This practice will reduce the water scarcity and also improve the environmental status of the region.
4. Penalties to be imposed for dumping the domestic and industrial waste in the water bodies, river banks, river courses or drainage courses that lead to contamination of surface water and ground water.
5. Segregation of domestic waste into bio-degradable and non bio-degradable wastes and converting the bio-degradable wastes into compost to reduce the environmental degradation.
6. Control of water weeds in water bodies by introducing fish species like grass carp which destroys the water weeds.
7. Waterweeds as well as domestic waste can be effectively used as Protein source, as fertilizer, as Biogas source, as Soil additive and also as a source of income generation.
8. Silt sedimentation studies should be carried out periodically for major water bodies such as Reservoirs, tanks etc., and desilting should be done accordingly to restore the original/designed capacity.
9. Farmers to be encouraged to adopt Rotation of crops to prevent soil degradation.
10. Catchment area treatment to be carried out in the upper reaches of the water bodies to minimize the rate of sedimentation.
11. Environmental management of facilities to tourism spots can boost the revenue of Government and increase the benefits by careful planning for controlled development.
12. Rainwater harvesting projects have to be carried out effectively, to increase the ground water potential by reducing unstorable surface runoff flow into the sea.
13. The construction and demolition waste shall be recycled wherever possible and the wastes shall be utilized as modern landfill for solid waste management.
14. Alternative materials for sand in construction practices have to be introduced by conducting active research programmes.

15. Pollution of water bodies and degradation of land due to excessive use of chemicals in agriculture can be mitigated through the use of organic/bio-manures, organic/bio-pesticides and adoption of organic farming
16. Implementation of micro irrigation technologies such as sprinklers and drips and sub-surface drainage to reduce soil salinity and water-logging created by excessive irrigation
17. Increased use of renewable sources of energy such as animal power, solar energy, hydropower, and biogas to reduce air pollution by the increased use of fossil fuels.
18. Motivate the farmers to adopt the new eco-friendly technologies by educating that the new technologies are financially superior to the old environment-depleting ones and provide greater access to the farmers to the requisite credit facilities and technical information and guidance.
19. Afforestation of degraded lands is the most cost-effective and environment-friendly alternative for restoration, resulting in reduction in soil erosion, increased recharge of groundwater aquifers, carbon sequestration, moderation of micro climate, and improvement in the micro environment.
20. Viable and sustainable conservation of the environment requires the participation of multiple stakeholders', particularly local people's participation in planning, implementation, and monitoring of environmental projects. Environmental protection information has to be given to the people through viable media and other sources.

9.14.1 Conclusion

Environmental degradation is one of most urgent environmental issues faced in our country. Depending upon the damage, some environments may never recover and the plants and animals that once inhabited these places will be lost forever. In order to reduce any future impacts, city planners, industry and resource managers must consider the long term effects of development on the environment. We now have the requisite knowledge of tools, techniques and instruments of environment management and we also have a National Environment Policy in vogue. What we need is a strong political will at the National and State levels, a congenial political and economic environment and public awareness and community participation to use appropriate measures to mitigate the problems of environmental degradation in the larger interest of society as a whole. Finally if we do not alter the way we use our natural resources, it would be a greater injustice to the future generations of humans and animal who will inhabit after us.

CHAPTER - 10

PRESENT INSTITUTIONAL SETUP

CHAPTER–10

PRESENT INSTITUTIONAL SETUP

Institutional arrangements with 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.

As an initiative for this integrated approach in the state, the Tamil Nadu Water Resources Consolidation Project (WRCP) is a State-wide program implemented during 1995 – 2004 in selective sub basins to improve the productivity and sustainability of State's Irrigation sector, to introduce multi-sectoral water planning, to integrate farmers in irrigation management, and to strengthen the State's institutional and technical capacity in water development, management and planning.

As a multi-disciplinary approach on modernization of Irrigation and Agriculture, Tamil Nadu Irrigated Agriculture Modernization and Water bodies Restoration and Management **(TN IAMWARM)** project is being implemented by eight departments dealing with water viz., Water Resources Department, Agriculture Department, Agriculture Engineering Department, Horticulture Department, Tamil Nadu Agricultural University, Agricultural Marketing &Business, Animal Husbandry & Dairy Department and Fisheries Department. The TN IAMWARM project is implemented through the above stake holding agencies with Water Resources Department playing a leading role in a sub basin frame work, in four phases over a period of 8 years including the extended period upto 2015 in selected 61 sub basins of Tamil Nadu. The project aims at Modernization of Irrigation Systems, Agricultural Intensification and Diversification, Institutional modernization for Irrigated Agriculture., etc to improve benefits to farmers, farm labourers, landholders, fishermen and livestock owners.

The Varahanadhi River Basin is one of the major River Basin and is located in theVillupuram, Thiruvannamalai, Kancheepuram and Cuddalore districts of Tamil Nadu and Pondicherry. Varahanadhi River Basin Consists of Varahanadhi Sub Basin, Ongur Sub Basin and Nallavur Sub Basin. Varahanadhi Sub Basin is the larger sub basin among the above three sub basins which was taken for the modernization and rehabilitation under IAMWARM project.

Rehabilitation works have been completed in Tanks, Anicuts and Supply Channel in the Varahanadhi Sub Basin. This includes works such as Tank Bund Strengthening, Reconstruction/Repair of Tank Sluices, Reconstruction /Repair of Tank Weirs, Desilting of Supply Channels and lining the Vidur Dam main canal for 3km out of 17.10km.

10.1 Present Institutional Set Up in Varahanadhi River Basin

The various Departments / Institutions of the Government of Tamil Nadu / Government of India vested with different categories of responsibilities in water resources management and supply in Varahanadhi River Basin are detailed as below;

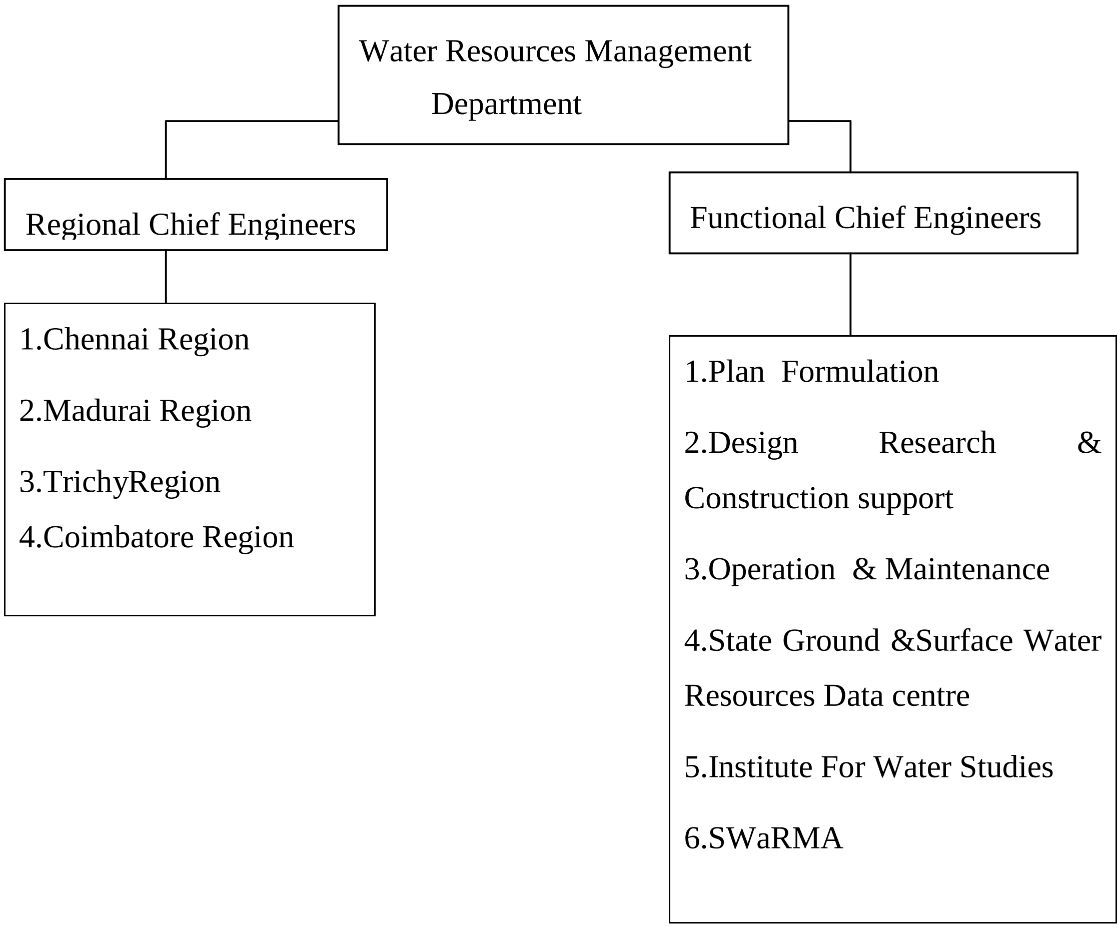
10.1.1 Water Resources Department (WRD)

The Water Resources Department is a part of the Public Works Department. The Water Resources Department is responsible for the maintenance & rehabilitation of all the Irrigation Structures and improving the irrigation infrastructure in Tamil Nadu 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 Engineer-in-Chief, WRD is the head of the Water Resources Department. The Engineer-in-Chief, WRD assists the Government as the technical and administrative head of the department, monitors and co-ordinates the functions of all the four Regional Chief Engineers and six functional Chief Engineers who are specialized in overall planning and execution of irrigation projects.

In Water Resources Department(WRD), the water management in the State has been decentralized along river basin lines and for effective control, the entire State has been divided into four Regions functioning under the control of Regional Chief Engineers viz., Chennai Region, Madurai Region, Trichy Region & Coimbatore Region. The Regional Chief Engineers are the Basin Managers of all the Basins falling in their Region. The Regional Chief Engineers develops goals and objectives for the Basin, co-ordinates all the Basin activities and responsible for the Infrastructure Development of the Basins. In addition to the above Regional Chief Engineers, there are six functional Chief Engineers viz., Chief Engineer, Plan Formulation, Chief Engineer, Design Research and Construction Support (DR&CS), Chief Engineer, Operation & Maintenance (O&M), Chief Engineer, State Ground and Surface Water Resources

Data Centre (SG & SWRDC) and the Chief Engineer & Director, Institute for Water Studies (IWS) and Chief Engineer & Director SWaRMA are functioning in Chennai.



Details regarding in-flow & out-flow of reservoirs, surplus flow particulars at gauging sites maintained by WRD and tank hydraulic particulars are collected from the territorial WRD offices and these details are used to arrive the surface water potential. Report on Sedimentation studies of tanks are collected from the Design Research and Construction Support (DR&CS) office and documented. Rain fall and climatic data, Artificial Recharge Schemes, sea water intrusion and salinity details are collected from the State Ground and Surface Water Resources Data Centre (SG & SWRDC) office and documented. Details recording activities of Environmental Cell Divisions such as collection of water samples, pollution points, Environmental awareness meetings & workshops, etc., are collected.

10.1.2 Institute for Water Studies (IWS)

The Government of Tamil Nadu in G.O.Ms.No.457/PWD dated 08.04.1974, established the Institute for Water Studies to plan, access and manage the Water Resources in Tamil Nadu in a scientific manner. It is a multi-disciplinary organization headed by a Director in the rank of Chief Engineer from the date of 31-05-1993 onwards, WRD with a team of Engineers, Hydro-geologists, Geo-chemists, Geophysicists, Environmental Engineers, Photo-geologists, Remote Sensing Scientists, Agro-Economist and Administrative Staff. The main objectives of Institute for Water Studies (IWS) are to develop broad principles for planning and management of water resources, to assist in the formulation of water management policies, to undertake research works related to water planning and policy making, to develop training programmes and to advice the Government, on specific policy matters related to it.

Tamil Nadu State Remote Sensing Centre at Institute for Water Studies is responsible for the delineation of River Basin and Sub Basin boundaries of all the rivers in Tamil Nadu and updating it, then and there. The Institute for Water Studies has grouped the 34 rivers in Tamil Nadu into 17 major River Basins. “Unique identification code” for all PWD/WRD tanks have been assigned using GIS, which enables easy access to the details of tanks viz., location, hydraulic particulars etc., taluk wise and district wise. The preparation of GIS based unique coding for all reservoirs and anicuts are in progress.

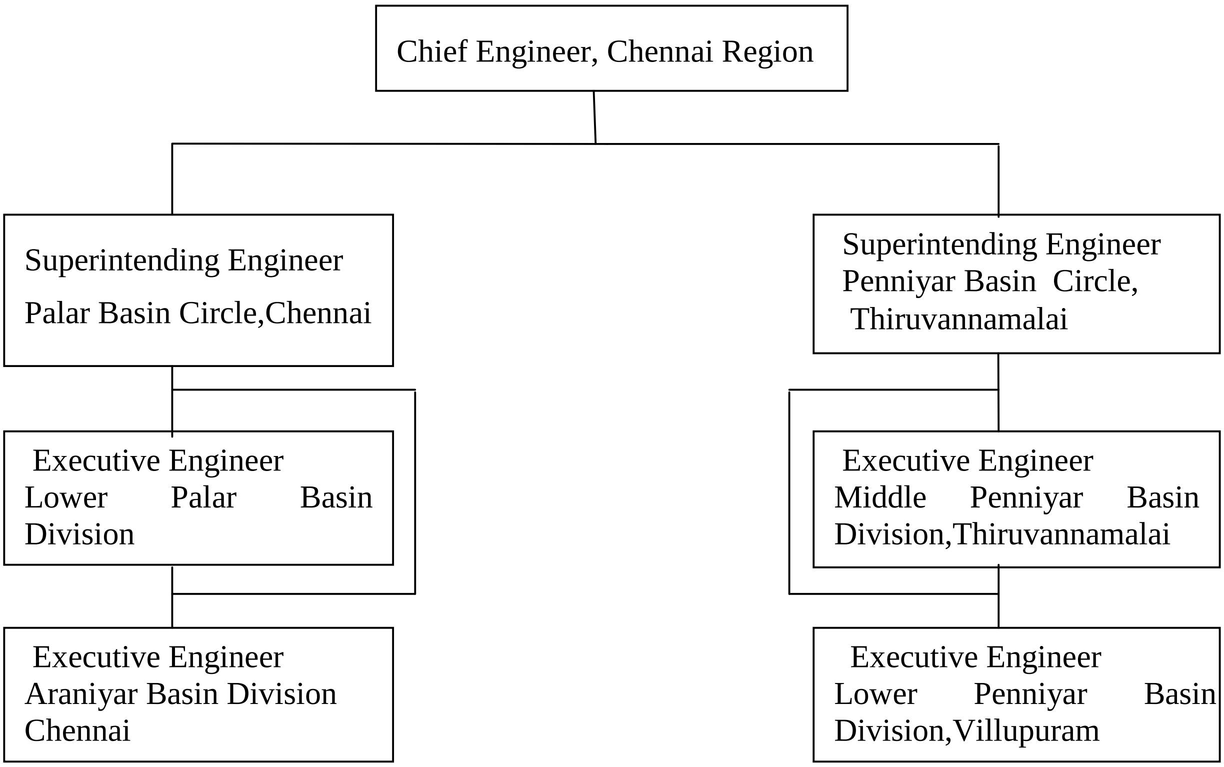
So far, Micro level studies have been completed for 16 River Basins except Cauvery River Basin

1.Chennai	5.Vellar	9.Pambar Kottakkaraiyar	13.Kallar
2.Palar	6.Paravanar	10.Vaigai	14.Tamiraparani
3.Varahanadhi	7.Parambikulam Aliyar	11.Gundar	15.Nambiyar
4.Pennaiyar	8.Agniyar	12.Vaippar	16.Kodaiyar

These Micro level study reports have been sent to all the Regional Chief Engineers of Water Resources Department and other line departments. To update the above reports with present data, Micro level Reappraisal studies were initiated.

Accordingly, Microlevel Reappraisal studies for 1.Kodaiyar, 2.Vaippar, 3.Vaigai, 4.Vellar, 5.Palar, 6.Tamiraparani, 7.Pennaiyar and 8.Paravanar River Basins have been taken up and completed during 2010 to 2016.This Micro level Reappraisal study of Varahanadhi River Basin is taken for the year 2017 – 2018. Necessary Study reports are prepared for further use in the Water Resource Department and respective user departments.

The Varahanadhi River Basin falls under the jurisdiction of the Chief Engineer, WRD, Chennai Region, Chennai. The Superintending Engineer, Palar Basin Circle, Chennai and The Superintending Engineer, Penniyar Basin Circle,Thiruvannamalai coordinates the management of water resources in Varahanadhi River Basin along with the Executive Engineers, Lower Palar Basin Division, Kancheepuram, Executive Engineer, Araniyar Basin Division, Chennai and Executive Engineer, Middle Penniyar Basin Division, Thiruvannamalai, Executive Engineer, Lower Penniyar Basin Division,Villupuram . The Executive Engineer along with the Sub Division and section officers are responsible for execution of all the works viz., maintenance and improvements to irrigation structures, water regulation for irrigation from dams / reservoirs / tanks in their jurisdiction as well as mitigation of floods, construction of new irrigation structures etc,.



Details regarding in-flow & out-flow of reservoirs and anicuts, surplus flow particulars at gauging sites maintained by WRD, tank hydraulic particulars and hydro-meteorological data are collected from the territorial WRD offices and these details are used to arrive the surface water potential and Ground water potential of River Basins. The various sectoral water demands are being found out and future water demand for River Basins are forecasted. For effective management of water resources and basin planning, Water Balance Studies are being carried out to access the surplus or deficit status of the river basin and giving suggestion on developmental action required in the River Basin.

10.1.3 Central Water Commission

The Central Water Commission is a Central Government organization functioning under the Ministry of Water Resources, Government of India. Varahanadhi River Basin falls under the jurisdiction of Cauvery & Southern Rivers Organization (C&SRO) of Central Water Commission. The organization is headed by a Chief Engineer head quarters at Coimbatore and the above functions are discharged through Superintending Engineer / District level officers in various offices such as Cauvery & Southern Rivers Circle, Bangalore, Monitoring Directorate, Coimbatore, Beach Erosion Section, Cochin. The Executive Engineer / Deputy Director level officers and his team of Assistant Executive Engineer, Sub Division Engineer, Assistant Director, Assistant Director – II level officers and Junior Engineers stationed across the Region execute the works under their jurisdiction.

10.1.4 TamilNadu Water Supply and Drainage Board (TWAD)

TamilNadu Water Supply and Drainage Board are responsible for implementation of Water Supply and Sewerage facilities to the public of the entire State of TamilNadu except for Chennai Metropolitan city. Varahanadhi River Basin falls under the jurisdiction of the Chief Engineer, Chennai; Superintending Engineer, Cuddalore-Villupuram under the control of Engineering Director, Chennai implements the various schemes in Varahanadhi River Basin, with the assistance of their Executive Engineers. Details of water supply schemes implemented in urban and rural areas of Varahanadhi River Basin are collected from the territorial TWAD Board.

10.1.5 Forest Department

Forest Department conserves the forest wealth, undertakes control measures in watersheds and is in charge of social forestry works. The Principal Chief Conservator of

Forest, the Chief Wild Life Warden, Chief Conservator of Forest (Social Forestry) is at Chennai who has control in their respective fields. The District Forests office at Kancheepuram Circle, Divisional office at Chengulpat and Assistant Conservator of Forests, Villupuram territorial division that forms the part of Villupuram and Cuddalore districts, Regional Manager , TamilNadu Forest Plantation Corporation Limited, Cuddalore Regional Manager, TamilNadu Forest Plantation Corporation, Tirukovilur are the Various forest offices operating in the Varahanadhi River Basin.

10.1.6 Agriculture Department

Agriculture Department is headed by the Commissioner of Agriculture, located at Chennai. The Joint Director, Agriculture at Cuddalore along with their team of officers implements and executes the schemes of this department in Varahanadhi River Basin. This department coordinates with Water Resources Department to increase the productivity for agriculture. The various development schemes and introduction of relevant technologies to step up the production are Intensive Integrated farming system, massive Wasteland Development Programme, comprehensive watershed development activities, water management through Micro irrigation systems, Organic farming, Soil health improvement through Bio-fertilizer including Green Manuring, adoption of Integrated Nutrient Management (INM) and Integrated Pest Management (IPM) technologies are given priority through various programmes, besides crop diversification and introduction of modern Irrigation system.

The aim of the Agriculture Department is to improve the agricultural productivity through modernization of irrigation system, upgraded water management and farmers participation. The components being taken as action plan by Agriculture Department are as follows, Paddy SRI (System of Rice Intensification) demonstration, Improve the existing coconut garden, Organic farming- green manure seed distribution, Distribution of hand operated sprayers, Technology demonstration, Coconut coir compost demonstration, Vermicompost demonstration, Conducting seminars to create awareness by means of publicity.

10.1.7 Agricultural Engineering Department

This department has been engaged in the conservation, development and management of the agricultural land and water resources of the State thereby contributing to the sustainable increase in agricultural production. The main focus of the department is on watershed development, water management and agricultural mechanization. Under Command Area Development and Water Management Programmes the field channels and supply channels are renovated, so as to improve the utilization of created irrigation potential and also to achieve optimum agricultural production.The main aim of the Agricultural Engineering Department works are as follows (i)To improve the productivity of water per unit per land, (ii)To improve the livelihood of farming and labour community (iii) To create an infrastructure base for water conservation techniques(iv) To train the engineers and farmers on effective water management towards sustainable development .

The Agricultural Engineering Department is headed by the Chief Engineer, located at Chennai. The Agricultural Engineering division offices are functioning at Cuddalore, Kanchipuram,Villupuram and Thiruvannamalai. The Executive Engineer is responsible for the implementation and management of the Agricultural Engineering activities in their division under the guidance of the respective Regional Superintending Engineer. The Executive Engineer is assisted by the Assistant Executive Engineers for implementation of all the scheme activities. Agricultural Engineering Department is implementing various schemes for soil & water conservation, water management through micro sprinkler irrigation and agricultural mechanization apart from hiring of Land Development & Minor Irrigation machinery to farmers

10.1.8 Public Health and Preventive Medicines Department

This department takes care of preventive and control measures in the event of outbreak of epidemics, undertakes the testing of water samples, educate the public on water borne and water related diseases. This department is headed by a Director (Public Health & Preventive Medicines) at Chennai. The Deputy Director of Health services at Kancheepuram, Cuddalore, and Villupuram covers Varahanadhi River Basin area. Details of vector-borne diseases and water borne diseases are collected from the territorial Public Health offices. These details are used to document the prevailing health conditions in Varahanadhi River Basin.

10.1.9 Animal Husbandry & Veterinary Science Department

Animal Husbandry Department is headed and governed by the Director, Animal Husbandry & Veterinary Sciences, Chennai. The Regional Joint Director at Cuddalore, Kancheepuram, Villupuram and Thiruvannamalai along with their Additional Directors are responsible for all the activities of this Department in Varahanadhi River Basin area.

The Livestock sector provides livestock based food products such as milk, egg, meat, raw materials like wool for industries, manure etc, The Animal Husbandry Department provides comprehensive veterinary assistance and health cover to all livestock and poultry across the State of Tamil Nadu. With the implementation of cross breeding programme and various other schemes by the department, livestock farming has become economically viable and remunerative to large number of rural households.The functions of department are as follows (i)Augmenting the production potentialities of livestock and poultry and thus increasing the production of milk, egg and meat(ii) Providing necessary and timely modern veterinary assistance and health cover to the livestock and poultry(iii) Implementing various central and state Government schemes for the upliftment of rural poor (iv)Providing information and training on basic and latest animal husbandry practices(v) Protecting human health by preventing major zoonatic diseases of animals.

The district wise of livestock census details in Varahanadhi River Basin are collected from the territorial Animal Husbandry & Verterinary Science Department offices. These details are used to arrive the Livestock Water demand at present and in future.

10.1.10 Fisheries Department

This department is concerned with the Marine and inland fish production in the State and implements fisherman welfare schemes and look after the infrastructure facilities like fishing harbour and jetties, aquaculture activities and training of fishermen.

Fisheries Department is headed by the Director of Fisheries, stationed at Chennai. As far as Varahanadhi River Basin is concerned, there is a Joint Director of Fisheries (Regional) at Chennai and under his control an Assistant Director, Fisheries (Inland Fisheries), Villupuram; Assistant Director, Fisheries (Marine), Cuddalore; Assistant Director Fisheries (Marine), Kancheepuram.

The fisheries sector of Varahanadhi River Basin may be categorized as Inland fishing and Marine fishing. Inland fishing is the main activity within the Basin. The different component of work executed under this are promoting fresh water aquaculture, reservoir fisheries, infrastructure development for fish seed production, promoting fish farming and cold water fisheries development.

10.1.11 Tamil Nadu Pollution Control Board (TNPCB)

TamilNadu Pollution Control Board is functioning with the Chairman as its head, Member Secretary, 2 Additional Chief Environmental Engineers, 10 Joint Chief Environmental Engineers, 32 District Environmental Engineers and 2 Assistant Environmental Engineers. The

Chief Environmental Engineers are implementing the Pollution Control Legislations and Rules and Notifications framed therein, collects and disseminates data relating to water, air and land pollution, lays down standards for sewage / trade effluent and emissions. This Board monitors the industrial effluents discharges into water bodies from pollution point of view. The Board has established 5 Advanced Environmental Laboratories, 10 District Environmental Laboratories to assist in the analytical and scientific side by experimental analysis and conducting research in abating pollutants. The District offices of TamilNadu Pollution Control Board functioning with the District Environmental Engineer as its head is located at Kancheepuram, Cuddalore, Thiruvannamalai and Villupuram. The District Environmental Engineer monitors and controls the Industrial Pollution in Varahanadhi River Basin. The District Environmental Engineers handles the issues regarding pollution in the District, issue renew the consent to orange & green industries, renews consent to red small industries, issues show cause notice to the erring industries.etc.

List of industries, type of industries, water requirement, treatment method adopted and sewage effluent are collected from the territorial TNPCB office. These details are used to arrive the industrial demand at present and in future.

10.2 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.

A **Technical Sub-Committee to Water Utilization Committee** was constituted with the Engineer-in-Chief WRD& Chief Engineer (General), PWD, as the Convener and the Chief Engineer, WRD, Plan Formulation; the Chief Engineer ,WRD, State Ground &Surface Water Resources Data Centre; the Chief Engineer, WRD, Design Research &Construction Support; the Chief Engineer, WRD, Operation &Maintenance; the Chief Engineer, WRD, Chennai Region; the Chief Engineer, WRD, Trichy Region; the Chief Engineer, WRD, Madurai Region; the Chief Engineer, WRD, Coimbatore Region; the Chief Engineer & Director, Institute for Water Studies; the Chief Engineer, Agriculture Engineering and the Chief Engineer, TWAD

Board are as members. The water supply schemes involving drawl of water of more than one(1) MGD should be placed before the said committee for consideration and clearance.

10.3 Participatory Irrigation Management (PIM) / Water User's Association

Under the Water Resources Consolidation Project & IAMWARM project, farmer's organizations are formed in the project implementation areas, to regulate the use of water among the various users, to manage the operation and maintenance of the irrigation systems. The farmer's organization comprises of Water User Association, Distributory Committee, Project Committee and Apex Committee with each having various functions.

Water Users Associations are delineated based on the command area of the major / medium irrigation system. Water Users Association at the primary level consists of all the water users in such association area as members. A Water User Association can be called by its local distinct name. Every Water User Association shall be divided into Territorial Constituencies (TC) which should not be less than four and not greater than ten. A Territorial Constituency means a contiguous block of command area of one or more sluices under a Water Users Association area. There is a Management Committee for every Water User Association and a President of the Management Committee is elected by the members of the Water Users Association.

A competent authority, an officer of the Water Resources Department is appointed by the Government to Farmers organization to implement and execute the decisions taken by the farmer's organization. The farmer's organization shall extend its assistance and co-operation to the competent authority.

The farmer's organization may, for carrying out the purposes of this Act, and or achieving the objects of such organization and performing its functions, levy and collect such fees not exceeding five hundred rupees per hectare per year from every water user, as prescribed, from time to time. The other sources of funds to the farmers organization are grants received from Government as a share of water charges, Central / State Government fund for development of that area, resources raised from any financial agency for undertaking any economical development activities, income from properties and assets attached to the irrigation system as granted by the Government.

10.3.1 Functions of WUA

1. To prepare and implement an operational plan and a rotational water supply for each irrigation season. consistent with the operational plan, prepared by the distributor committee and the project committee and based upon the entitlement area soil and cropping pattern as approved by the managing committee or as the case may be of the project committee.

2. To prepare a plan for the maintenance of irrigation system in the area of its operation at the end of each crop season and carry out the maintenance works of both distributary system. Water courses and field drains in its area of operation with the funds of the water users association from time to time.

3. To regulate the use of water among the various sluices under its area of operation according to the rotational water supply.

4. To assist the authorities of the revenue department of the government in the preparation of demand and collection of water charges.

5. To prepare and maintain an inventory of the irrigation system within the area of operation.

6. To resolve the disputes if any between the members of the water users association in its area of operation.

7. To conduct general body meeting in such a manner as may be prescribed.

8. To encourage avenue plantation on canal and tank poremboke 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 poremboke in the area of jurisdiction of the water users association.

10.3.2 Capacity Building Training

Under the IAMWARM phase I project the Capacity Building training to WUAs was given by Support Organisation namely “Gandhi Rural Education and Development Society - GREDS”. They started the Capacity Building Program by forming cluster of WUAs ranging from 5 WUAs to 9 WUAs for each Para Workers. The core training program contains two days

Capacity Building training followed by one day Capacity Building training program along with on-field training.

In the training programme, major topics covered were water management, water measurement, rotational water supply plan, Water Budget, preparation of work sheet for water distribution, operation and maintenance of tank, works to be carried out under O&M, community collaborative water management. The district wise WUA details of Varahanadhi Sub Basin is as below,

Table 10.1 Details of WUA's formed in Varahanadhi Sub Basin

Sl.No	Name of the subbasin	No of WUAs	District
1	**Varahanadhi Sub Basin**	**23**	**Tiruvannamalai**
		211	**Villupuram**

The programme was implemented by GREDS through Executive Engineer, PWD,WRD,Lower Pennaiayr Basin Division, Villupuram.

The aim of the programme is to empower the WUAs and facilitate farmers to take more responsibility for their own development and to realize the needs and responsibilities of farmers in water management and in irrigation.

10.3.3. Impact of the capacity building programme:

1. WUAs have started conducting regular meeting. WUA members are access to the line departments in availing technical guidance and benefits from.

2. WUA presidents, sub- committee members and the WUA members have realized the need and importance of the WUA and how to get the benefits to their ayacut from various Government departments and realized the need for strengthening their WUAs for sustainability of farming activities.

3. Even though the WUAs have started functioning, the expected output of the training was not attained, because of the continuous monsoon failure and drought over last three years. However some WUA's have done maintenance activities and many WUA's started to collect the subscription from the WUA's members for their O& M activities and put the money in their WUA account.

4. One of the positive impacts of the training program is that the WUAs are discussing their problems in their meetings and try to find the solution for the problems. Representatives from the WUAs in the farmer's grievance day are regular. The WUAs have

gained more exposure regarding the functioning of the WUAs. During the training and meetings, the success stories from the neighbour WUAs and neighbour states were shared. WUAs are maintaining the records prescribed in the TNFMIS Act. A minimum of following records are maintained in the WUA's

1. Membership register
2. Minutes note book.
3. Ledger
4. Cash book
5. Asset register
6. Water distribution register

At present only 34 numbers of TC members and 6 presidents are engaged in Varahanadhi SubBasin in Tiruvannamalai district and remaining WUA'S are closed in Varahanadhi River Basin due to the completion of project period.

10.4 Agencies Responsible for Various activities in Varahanadhi River Basin

The agencies responsible for the various main activities related to Water Resources Management in the Varahanadhi River Basin are given in **Table 10.2**

Table 10.2 - Main Activities for Basin Management and Agencies Responsible

Sl. No	Main Activity	Department / Agency Responsible	Key functions
1	Water Resources Management.	Water Resources Department	Planning, Designing and Execution of New Irrigation Projects. Operation and Maintenance of Irrigation systems including tanks. Collection of Surface and Ground Water Data for effective Water Resources Management.
		Central Water Commission	Planning, Designing and Execution of New Irrigation Projects sanctioned by Central Government. Collection of Surface and Ground Water Data for effective Water Resources Management.

		Ministry of Water Resources (MoWR) & Ministry of Environment Forest (MoEF), Government of India.	Clearance for New Irrigation Projects.
		Institute for Water Studies, WRD.	Develop broad principles for planning and management of water resources. Assist in the formulation of water management policies. Fostering or undertaking research, relating to water planning and policy making. Develop training programmes. Advice the Government, on specific policy matters referred to it.
		State Water Resources Management Agency (SWaRMA)	Advise the Government of TamilNadu in water policies. Advise in regulating water allocation for bulk users. Review and approve state and River Basin master plans and to appraise all surface water resources in the hydrological boundaries. Develop a State water allocation data base. Prepare an annual Water Audit for each river basin in the state and to publish the same. Support and aid the enhancement and preservation of water quality within the State.

2	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. Accords Ground Water clearance for environmental, Institutional and financial point of view.
		Central Ground Water Board	Monitors Ground Water Level and Quality
3	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.
		Indian Meteorological Department (IMD)	Observation of Rainfall & Hydro meteorological data.
4	Providing Drinking Water and Sanitation facilities.	TamilNadu Water Supply and Drainage Board	Planning, Designing and Execution of New Drinking Water Schemes. Planning, Designing and Execution of New Under Ground Sewerage Schemes. Providing water supply for Rural, Urban and industrial needs.

5	Protecting the forest cover, according clearance for forest area, protecting the flora and fauna, Environmental protection.	Forest Department	Conserving the forest wealth. Undertaking control measures in watersheds. In charge of social forestry works. Raising "Social Forestry" on tank bunds, Field boundaries, construction of check dams and growing vegetation in the catchment area
6	Agricultural Development.		Providing facilities to the farmers including supply of subsidies like fertilizers, pesticides, seeds etc and suggests for suitable crop pattern. Monitors the Agricultural activities.
7	Command area development including On Farm Development (OFD) works.	Agricultural Engineering Department	Executes watershed management works and control measures on soil conservation. Water Management through micro and sprinkler irrigation.
8	Pollution Prevention.	Tamil Nadu Pollution Control Board	Monitoring the proper functioning of Industrial Effluent Treatment Plant. Monitoring the quality of treated effluents released by industries. Collection and Testing Water Sample from rivers at selected locations. Issue / Renewal of consent to different categories of industries. Effecting standards for Safe disposal of effluents to land and water bodies.
9	Assessment of cultivated area and collection of water charges.	Revenue department.	Monitoring the natural calamities of Flood & Drought Management.

10	Preventive and control measures of epidemics, testing of water samples and educate the public on water borne diseases.	Public Health Department	Providing infrastructure facilities to health services. Monitoring the health status. Collection of statistics on disease prevalence Conducting special medical camp at the time of outbreak of epidemics.
11	Comprehensive Veterinary assistance and health cover to all livestock.	Animal Husbandry &Veterinary Sciences	Providing infrastructure facilities to Veterinary health services. Planning for development of livestock and livestock based products. Conducting special medical camp for livestock.
12	Development of inland and marine fish farming, fish seeding and other activities	Fisheries Department	Implementation of fishermen welfare schemes. Development of Aquaculture activities, reservoir fishing and fishermen training. Aquaculture in farm ponds, village ooranies and tanks, to provide additional income to the farmers

CHAPTER - 11

CONCLUSION AND ACTION PLAN

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CONCLUSION AND ACTION PLAN

11.1 Conclusion

11.1.1 Introduction, Scope of the Study and Methodology

Water is a fundamental resource for all life on earth, Managing the demand and supply of water in present scenario is a challenging task for the water managers. Tamilnadu is a water stressed state due to extreme hydrological condition like heavy flood and severe drought.

River basin based assessment, planning and management is the core scope of this study. In Tamilnadu 34 major rivers are grouped into 17 river basins and these basins encompass 127 sub-basins.

The Institute for Water Studies has completed micro level study for 16 river basins, except Cauvery basin. Reappraisal study is being carried out and completed for Kodaiyar, Vaippar, Vaigai, Vellar, Palar, Tamiraparani, Pennaiyar and Paravanar river basins and at present Varahanadhi river basin has been taken up for micro level reappraisal study.

11.1.2 Description of the Basin

Varahanadhi river basin is the third among the 17 river basins of Tamil Nadu having an aerial extent of 4536.51 Sqkm in Tamil Nadu State and 220.119 sq.km in Union Territory of Puducherry. Varahanadhi basin spread over parts of Villupuram, Thiruvannamalai, Kancheepuram and Cuddalore districts in Tamil Nadu and Union Territory of Puducherry.

Three major rivers namely Ongur, Nallavur and Varahanadhi drain in this basin with individual catchment areas, flow independently. Varahanadhi basin is sub divided into three sub basins namely Varahanadhi, Nallavur and Ongur.

Varahanadhi basin is composed of hard (Igneous and Metamorphic) and soft (Sedimentary) rocks.

Regarding land use pattern in this basin, whilst comparing changes with the year 1998 and year the 2015, settlements has increased to 213.86 Sqkm, agriculture land has increased from 2292.67 Sqkm to 3304.14 s Sqkm, barren land has decreased from 1712.37 Sqkm to 301.255 Sqkm and the water bodies (tank, river and water logged area) has increased from 496.32 Sq.km to 516.17 Sq.km.

Total population in Varahanadhi river basin as per **2011 Census** is **2.233 million** of which 85% of people live in rural area and the projected population in the year **2017** is **2.392 million** at a growth rate of 1% in rural area and 2% in urban area.

11.1.3 Hydro-meteorology

Rainfall data were acquired from fourteen (14) rain gauge stations located within the Varahanadhi basin for a period of 39 years. Climatic data was acquired from Kilnatchipatu weather station (full climate stations) which is located in adjacent Pennaiayar basin was considered based on the availability of data.

Probable Mean Areal rainfall analysis for 25%, 50%, 75% & 90% dependability and the average rainfall for southwest, northeast, winter, summer and annual for all the sub basins have been analysed.

- The **annual average rainfall of Varahanadhi basin is 1054.19 mm** (data period 1977 to 2016).
- In previous appraisal study of Varahanadhi basin carried out in 2004, the annual average rainfall was reported as 1089.30mm (data period 1971 to 2003).
- Varahanadhi basin receives more rainfall in North-East monsoon than South-West monsoon.

Kiladayalam weather station is situated within Varahanadhi river basin boundary but the data acquired from this station was not considered for the study due to discontinuity in data. Therefore data from Kilnatchipatu weather station located in adjacent Pennaiyar river basin, was considered for the study where the data is available for long term period.

Drought frequency analysis has been done for 15 years period (2001-02 to 2015-16).

11.1.4 Irrigation and Agriculture

In the year 2015-16, gross area irrigated was 1,98,758 ha and gross area sown was estimated as 2, 60,583 ha. The main crops cultivated in this basin are paddy, blackgram, sugarcane, groundnut, coconut, fruits and vegetables. Major source of irrigation in this basin are wells.

. The total number of land holding is 4,01,847.

- Marginal farmers (area less than 1 Ha) – 3,25,528
- Small farmers (1 to 2 Ha) – 52,399

- Semi-medium farmers (2 to 4 Ha) – 18,869
- Medium farmers (4 to 5 Ha) – 2,176
- Large farmers (more than 5 Ha) – 2,875

- Net Irrigation demand of this basin at 75% dependable rainfall is **1702.22 Mcum.**
- Net Irrigation demand of this basin at 90% dependable rainfall is **1717.37 Mcum**.
- In the total irrigated area, the major crop paddy is being cultivated in 60% of area. Sugarcane in 14% area & groundnut in 10% area are the secondary dominant crops being cultivated in this basin. Pulses, coconut and millets are the other crops being cultivated in this basin.
- Varahanadhi sub-basin has the maximum irrigated area of 1,26,042 Ha which accounts for about 63% of the total irrigated area.

Environmental friendly organic farming is being adopted in this basin and the area under this farming is gradually increasing and eventually, the area of crops cultivated in organic farming during 2014-15 was 340 Ha. Applying bio-fertilizer in agriculture fields in this basin was started during the year 2014-15 and crops covered under this area is 47,331 Ha. Vermicomposting process to fertilize the soil was also started in this basin and during the year 2014-15 an area of 1,478 Ha was under this process.

By adopting modern water saving cultivation techniques water could be saved in Varahanadhi basin is as stated below:

Sl. No.	Crop	Cultivating area in Ha	Water requirement in conventional method (MCM)	% of water saving by adopting modern water saving cultivation techniques	Water Saving in (MCM)
1	SRI-Paddy	1,20,668	1,105.320	40.00	442
2	SSI-Sugarcane	28,539	356.975	40.00	143
3	Coconut	2,177	19.000	63.00	12
4	Groundnut	18,954	83.000	49.40	41
5	Vegetables	7,230	67.000	29.00	20
				Total	**658**

11.1.5 Surface Water

Varahanadhi river basin encompasses three sub-basins namely Varahanadhi, Ongur and Nallavur. Vidur reservoir is the only reservoir in Varahanadhi basin was constructed across Varahanadhi river with a storage capacity of **17.132 Mcum. A maximum inflow of 3,115 Cumecs** was measured **during November 1985 due to heavy flood** against the **designed discharge of 1,907 Cumecs**. Subsequently studies were done on the basis of hydrological review and eventually an additional spillway with 3 vents and a fuse plug were constructed.

There are 60 anicuts and 614 tanks in this basin and among the tanks, 22 are system tanks and 592 are non-system tanks. The total capacity of all the tanks is **2,128.34 Mcum.**

The Surface Water Potential estimated at 75% dependability rainfall by the following methods:

1. **Rainfall – Run-off Co-efficient Method: 575.59 Mcum**
2. **MRS Model: 583.99 Mcum**
3. **NWDA Approach: 681.42 Mcum**

Tank irrigation is one of the ancient irrigation systems in India, has a excellent record for functioning and water management. At present the overall efficiency of tank irrigation system is low. The capacity of tanks are reduced due to siltation, foreshore encroachment and damaged tank components. Water losses in the unlined canals are 30 percent and the canals of some tanks are lined to reduce the water losses by 15 percent.

Parameswaramangalam Anicut was constructed across Poigai Maduvu in Cheyyar Taluk of Kancheepuram, district was completely damaged during 1985 flood. Subsequently flood protection wall was constructed for a length of 3,000 M.

There is an off-take point at Thirukoilur anicut from Pennaiyar river called Pambai vaikkal which confluences with Pambai Aru at Malliyapattu village which in turn confluences with Varahanadhi river at Amanakuppam village.

For domestic purpose, there was an inter basin transfer of subsurface water for a quantum of 4 Mcum per annum from the adjoining Pennaiyar basin to this basin. At present the system is not functioning.

Pillaiyarkuppam anicut is the last anicut constructed across Varahanadhi course before it confluences with the Bay of Bengal, but located in Pondicherry Union Territorry. Hence, the flow data of the Vidur reservoir for the period from 1962-63 to 2015-16 (54 years) is taken for assessing the quantity of surplus flow to sea.

In Varahanadhi basin all the parameters of surface water quality are well within the limits and the water can be used for both domestic and agriculture purposes.

11.1.6 Groundwater Resources and Water Quality

In Varahanadhi basin an inventory of about 83 observation wells spread over entire Varahanadhi Basin has been analyzed based on the availability of data, period ranging from four (4) years to forty four (44) years.

High rise in groundwater level (more than 3.00m) found in 12 wells and high depletion in groundwater level (more than 3.00m) found in 8 wells.

Varahanadhi basin encompassed with 76 revenue firkas either fully or partially area falling in the basin and the categorization summary is as stated below:

Sl.No	Category	As per 2013 Assessment
1	Safe	11
2	Semi Critical	18
3	Critical	11
4	Over Exploited	36

Net annual groundwater availability is **989.33 Mcum,** total groundwater extraction for all sectoral demands is **1,009.45 Mcum** and the balance groundwater available for further development is **116.91 Mcum**. Groundwater extraction for agriculture in Varahanadhi basin is **947.55 Mcum** which constitute a very high proportion of **93.87%** in total extraction for all sectoral demands.

Comparison of groundwater resources: 2003 and 2013

Net Annual Groundwater Availability (Mcum)		Gross Annual Groundwater Extraction (Mcum)		Balance Annual Groundwater Availability (Mcum)		Stage of Development (%)	
2003	**2013**	**2003**	**2013**	**2003**	**2013**	**2003**	**2013**
1,255.72	989.33	1,345.87	1,009.45	86.39	116.91	107.18	102.03
Decreased: 21.21%		**Decreased: 25.00%**		**Increased: 35.33%**			

The groundwater quality in Varahanadhi is generally “good to moderate”. Recharging rain water into the aquifers helps in utilizing the primary source of groundwater and thereby improving the quality and quantity of existing groundwater through dilution.

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. The domestic water requirement may increase in future due to increase in population, development in living standards of the people etc. The annual growth rate norms adopted in this basin for estimation of population growth is as given below:-

Sector	Annual Growth rates
Urban	2 % per year
Rural	1% per year

Irrigation sector water demand is 93.94% in total demand in Varahanadhi basin which is exorbitantly high proportion.

The number of Small Scale Industry (SSI) in this basin has been decreased at present whilst comparing with previous report prepared in 2005. The number of large & medium scale industries has been found to be increased. The demand for the large & medium scale industries (L&MI) are projected at the rate of 8% per annum.

The various sectoral demands in Varahanadhi basin for the year 2017

- Domestic - 80.502 Mcum
- Irrigation - 1,702.220 Mcum
- Livestock - 17.266 Mcum
- Industrial - 11.779 Mcum
- Aquaculture - 0.299 Mcum
- **Total Damand - 1,812.066 Mcum**

11.1.8 Water Balance Study

The present water potential of Varahanadhi Basin:

- Surface water potential - 583.99 Mcum (At 75% dependability rainfall)
- Ground water availability - 989.33 Mcum
- **Total Potential - 1,573.32 Mcum**

Total sectoral water demand in Varahanadhi river basin at 75% dependability

- Domestic - 80.50 Mcum
- Irrigation (including losses at the rate of 33% = 1702.22*1.33) - 2,263.95 Mcum
- Livestock - 17.27 Mcum
- Industrial - 11.78 Mcum
- Ecological - 2.92 Mcum
- Aquaculture - 0.30 Mcum
- **Total Damand - 2,376.72 Mcum**

Water Balance

- Water Potential for the year 2017 - **1,573.32 Mcum**
- Water demand for the year 2017 - **2,376.72 Mcum**
- **Deficit - 803.40 Mcum**

Varahanadhi basin is a deficit basin with 803.40 Mcum (51.10%) of water at present, i.e., for the year 2017 at 75% dependability rainfall.

11.1.9 Environmental Aspects

Trade and domestic effluents are the major issues concern with environmental degradation that affects water resources and surroundings. The other related issues which are having environmental impacts are sedimentation, water weeds, salinity, fishing, and tourism. The major pollution sources are agriculture, industries and domestic.

Agriculture pollution is due to leaching of pesticides, herbicides and other agro-chemicals, consumption of excess nutrients and spraying of pesticides. Consumption of fertilizers has increased in Varahanadhi basin from 2,18,607 MT in 2006-2007 to 3,46,427 MT in 2014-2015. Consumption of liquid form pesticides increased from 6,59,000 litres in 2005-2006 to 11,94,000 litres in 2014-2015 but solid from pesticides decreased from 1,48,006 MT in 2005-2006 to 1,18,382 MT in 2014-2015. Organic farming is an eco-friendly farming method and will increase the soil fertility condition.

There are 54 large industries and 852 small & medium industries in this basin and the waste water generated from the industries is as stated below:

Waste water from Large Industries	: 6.353Mcum per year
Waste water from Small & Medium Industries	: 3.070Mcum per year
Total	: **9.423Mcum per year**

Domestic sewage generated in Villupuram Municipality falling in Varahanadhi basin is treated at two Sewage Treatment Plants (STP) and domestic sewage generated in villages are independently let out in small trenches.

Sedimentation cause reduction in storage capacity of water bodies and the effect of sedimentation in Vidur reservoir constructed in Varahanadhi basin is as stated below:

Year of completion of the dam	Original capacity in Mcum.	Capacity Survey done during the Year	Present capacity in Mcum	Capacity loss in Mcum	Average Annual silting rate in M.Cum/ year	Average annual silting rate in %	Average annual silting load/sq.km	
							catchment Mm^3/sq. km	water spread Mm^3/sq. km
1959	17.132	2009 (First)	14.40	2.732	0.0546	0.32	0.0000420	0.0070

In Varahanadhi basin, Parthenium and Ipomoeacarnea weed are the most common water weeds found on the water bodies.

According to Chloride and TDS value observed in water quality analysis, that there is no sign of sea water intrusion in the study area except Alapakkam, Kunimedu , Chettikuppam and surrounding areas of Marakkanam block. However these values are moderate in quality classification and may be due to marine formation or back water effect in Kaluveli Swamp during high tides.

Salinity is one of the major land degradation problems affecting the environment. Salinity is high in Kilperumpakkam and Sangeethamangalam village in Varahanadhi sub basin and the water quality is not fit for irrigation as the electrical conductivity values are in the range of 2000 µS/cm to 3000 µS/cm.

Inland fishing, marine fishing and shrimp farming are active in Varahanadhi sub basin. Fish seed rearing in cages were installed in Pombur village & Endiyur village of Nallavur sub-basin under World Bank funded IAMWARM project. Shrimp farming has increased in recent times which affect disease control and leads to environmental hazards and those adverse impacts have to be controlled.

In Varahanadhi basin, diseases like Malaria and Acute Diarrohea are prevalent public health issues but the number of cases reduced comparing with year 2005 and 2014. Dengue, Chikungunya and Japanese Encephalitis diseases are the other public health issues but the number cases reported are very less.

There are many tourist places available in Varahanadhi basin. Gingee Fort at Gingee, Chandramowleeswarar Temple at Thiruvakkarai, National Fossil Wood Park at Thiruvakkarai in Villupuram District, Angala Parameswari temple in Melmalaiyanur, Jina Kanchi Jain Math at Melsithamur, Murugan Temple at Mayilam and Vidur dam near Vidur village in Tindivanam taluk are the prominent tourist places.

11.1.10 Present Institutional Setup

Water Resources Department of PWD is the apex organization in overall management of Water Resources in Tamilnadu State with the technical guidelines from Central Water Commission, and support from Central Ground Water Board functioning under Ministry of Water Resources, New Delhi. The other departments, Agricultural Department, Agricultural Engineering Department, Department of Statistics and Economics, Tamil Nadu Water Supply and Drainage Board, Forest Department, Tamil Nadu Pollution Control Board, Directorate of Industries & Commerce, Department of Animal Husbandry & Veterinary Services, Directorate of Medical & Rural Health Services, Directorate of Census Operation, Department of Fisheries and Tamil Nadu Generation and Distribution Corporation are the line departments connected with water resources and data were obtained from those departments for Varrahanadhi Basin Micro Level Reappraisal Study.

Government of Tamilnadu has constituted the Water Utilization Committee and the Technical Sub-Committee to Water Utilization Committee to take decision on the proposals seeking permission for drawl of surface/groundwater by various Boards, institutions and organizations.

Water Users Association (WUA) is being formed in Varahanadhi basin to implement the Participatory Irrigation Management (PIM) system and till date 234 WUAs were formed in this basin. Capacity Building training to WUAs was imparted by Support Organisation namely “Gandhi Rural Education and Development Society (GREDS) under the World Bank funded IAMWARM project.

11.2 Recommendations

- Erect a sign board with brief river particulars at the origin of Varahanadhi river, Ongur river and Nallur river and at Varahanadhi river crossing point across the Chennai – Tiruchy highway to facilitate the public to know the information.

- ❖ Water Resources Department field Engineers working in Varahanadhi basin are requested to monitor and update the land-use changes in the Land-use map attached in the report.
- ❖ Water Resources Department field Engineers working in Varahanadhi basin are requested to test the surface water quality regularly and disseminate the test results to all line departments and all stake holders for their use.
- ❖ Water Resources Department field Engineers working in Varahanadhi basin are requested to measure the water level and capacity of all the tanks regularly, record the data in a register and maintain the register for each tank separately.
- ❖ It is observed that the Varhanadhi is almost pollution free basin since major area is encompassed with rural habitation. The Water Resources Department field Engineers working in Varahanadhi basin are requested to ensure its pollution free environment and issue certificate once in three months regarding the basin pollution level for effective monitoring.

11.3 Strategic Objectives and Action Plan

- ➢ **Strategic Objective 1: Weather Station Data Collection at Regular Interval**

Sl. No	Issues	Strategies Recommended	Action to be Taken by
1.1	Found discontinuity in data that was collected from the Kiladayalam weather station located in Varahanadhi basin.	Suggested to entrust proper and adequate staff for data collection at regular interval and data accuracy may be ensured. The accurate weather data is essential for rainfall runoff calculation and eventually will be applied in SWAT model to calculate the surface water potential.	**The Chief Engineer, SG&SWRDC, Chennai**

- ➢ **Strategic Objective 2: Augmentation of Groundwater**

Sl. No	Issues	Strategies Recommended	Action to be Taken by
2.1	Groundwater extraction in Varahanadhi is over exploited condition at 102%.	To improve the groundwater potential Artificial Recharge Structure (ARS) like Check Dam and Recharge Shaft are proposed (Ref Table 6.16) In Over Exploited Firkas: 10 ARS In Critical Firkas : 3 ARS In Safe Firkas : 2 ARS	**The Chief Engineer, Chennai Region &** **The Chief Engineer, SG&SWRDC**

Sl. No	Issues	Strategies Recommended	Action to be Taken by
2.2	Groundwater extraction is rampant in Siruvadi firka in Nallaur sub-basin and in Rettychavadi & Sathiyamangalam firkas firkas in Varahanadhi sub-basin	Judicious control over groundwater extraction has to be ensured to control further exploitation of groundwater.	**The Chief Engineer, SG&SWRDC and Agriculture Department**

➢ **Strategic Objective 3: Harvesting Water during Raining period.**

Sl. No	Issues	Strategies Recommended	Action to be Taken by
3.1	Abandonment of Kazhuveli swamp and sea water entering the Kazhuveli swamp during high tide period.	1. Economically and technically viably method to arrest seawater intrusion into the swamp. 2. Construct a pumping scheme to harvest 28 Mcum of water during raining season.	**The Chief Engineer, Chennai Region**

➢ **Strategic Objective 4: Reduce the Irrigation Sector Demand**

Sl. No	Issues	Strategies Recommended	Action to be Taken by
4.1	Excess water used in flood irrigation method in sugarcane cultivation.	Apply drip irrigation in sugarcane cultivation and saving of 40% (143 Mcum) water may be achieved.	**Agriculture Department and Water Resources Department**
4.2	Water wastage in conventional cultivation method	658 Mcum of water may be saved in irrigation demand if 70% area of conventional paddy cultivation practice is changed to SRI cultivation method.	**Agriculture Department**

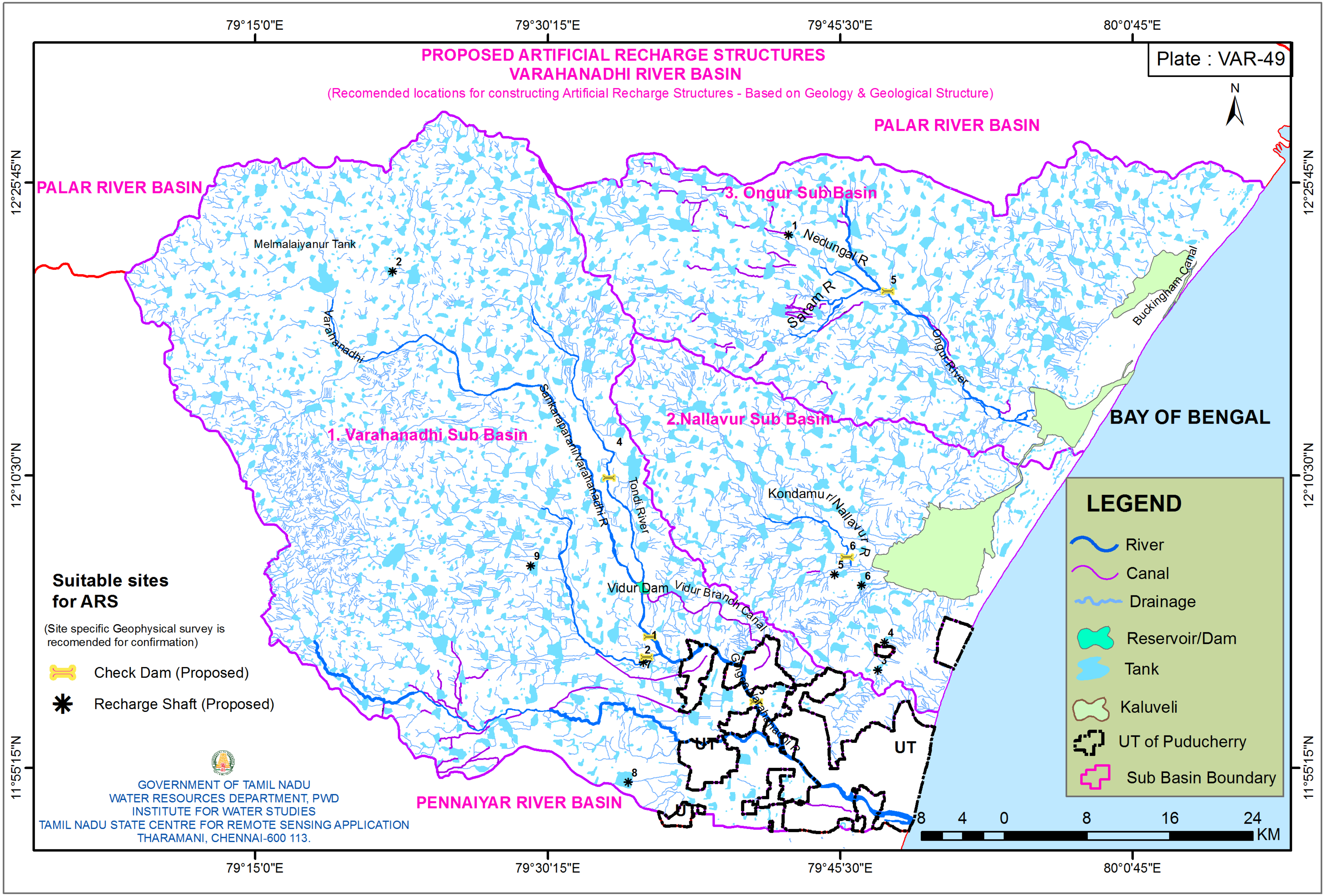
- **Strategic Objective 5: Sustainability of Environment**

Sl. No	Issues	Strategies Recommended	Action to be Taken by
5.1	Excessive use of fertilizer.	1. Educate the farmers about reducing the nutrient loads entering the water bodies by ensuring better management of household and live stock waste in the villages and crop nutrient management. 2. Encourage farmers shifting to organic farming.	**Agriculture Department**
5.2	Generation of waste water from industries.	Treat the waste water and reuse the treated water for industrial purpose.	**TWAD Board and Tamilnadu Pollution Control Board**
5.3	Reduction in storage capacity of Vidur reservoir due to sedimentation.	1. Construction of dykes, check dams and formation of detention basins in the upstream stretch of main river and tributaries which will help in reducing the muddy flood peaks by detaining sediment. 2. Formation of Gullies control and stream bank protection measures may be adopted	**The Chief Engineer, Chennai Region**

Varahanadhi River Basin is a deficit basin and in order to sustain the management and development of the basin, the aforesaid suggestions action plans are to be implemented with full sprit by the **Water Resources Department** in co-ordination with **Tamil Nadu Water Supply and Drainage Board**, **Tamil Nadu Pollution Control Board** and **Agriculture Department.**

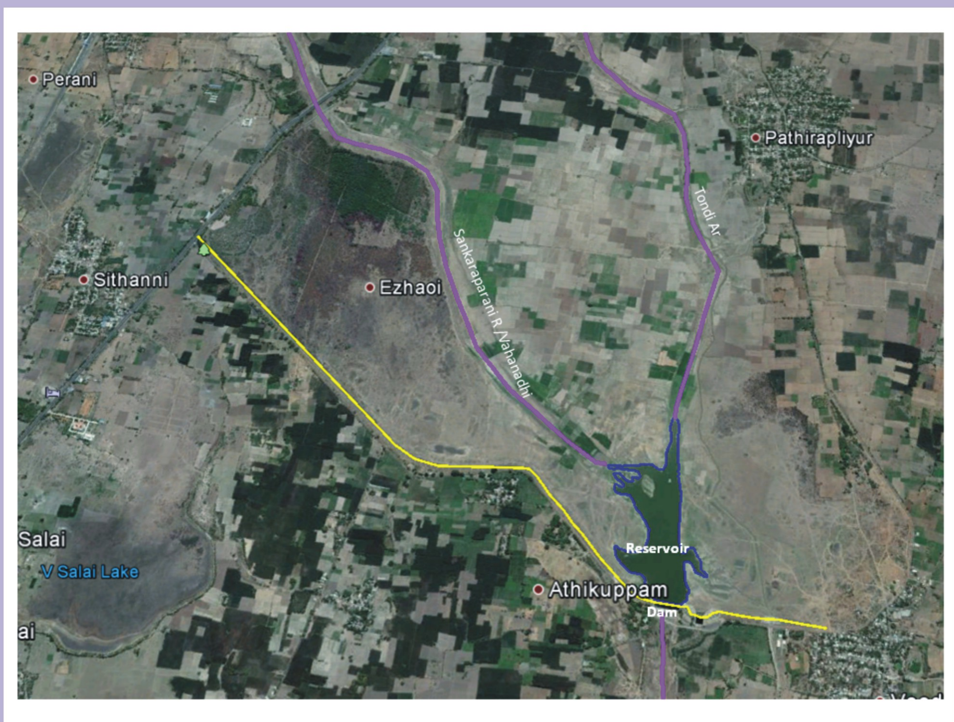
WATER IS A FUNDAMENTAL RESOURCE.
JUDICIOUS, EFFECTIVE AND EFFICIENT
USE IS NEED OF THE TIME.

Chief Engineer & Director, WRD
Institute for Water Studies.


PROPOSED ARTIFICIAL RECHARGE STRUCTURES
VARAHANADHI RIVER BASIN
(Recomended locations for constructing Artificial Recharge Structures - Based on Geology & Geological Structure)
Plate : VAR-49
79°15'0"E
79°30'15"E
79°45'30"E
80°0'45"E
12°25'45"N
12°10'30"N
11°55'15"N
N
PALAR RIVER BASIN
PALAR RIVER BASIN
PENNAIYAR RIVER BASIN
BAY OF BENGAL
1. Varahanadhi Sub Basin
2.Nallavur Sub Basin
3. Ongur Sub Basin
Melmalaiyanur Tank
Varahanadhi
Sankarabarani/Varahanadhi R
Tondi River
Vidur Dam
Vidur Branch Canal
Nedungal R
Salam R
Ongur River
Buckingham Canal
Kondamur/Nallavur R
UT
UT
Suitable sites for ARS
(Site specific Geophysical survey is recomended for confirmation)
Check Dam (Proposed)
Recharge Shaft (Proposed)
LEGEND
River
Canal
Drainage
Reservoir/Dam
Tank
Kaluveli
UT of Puducherry
Sub Basin Boundary
8 4 0 8 16 24 KM
GOVERNMENT OF TAMIL NADU
WATER RESOURCES DEPARTMENT, PWD
INSTITUTE FOR WATER STUDIES
TAMIL NADU STATE CENTRE FOR REMOTE SENSING APPLICATION
THARAMANI, CHENNAI-600 113.

Nerkunam Tank in Ongur Subbasin

Thailapuram Tank in Nallavur Subbasin



Vidur Reservoir from space

Melmalaiyanur Tank in Varahanadhi Subbasin

Sevalappurai Anicut in Varahanadhi Subbasin

For Further details Please Contact

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