केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

KODAYAR AQUIFER SYSTEM, Tamil Nadu

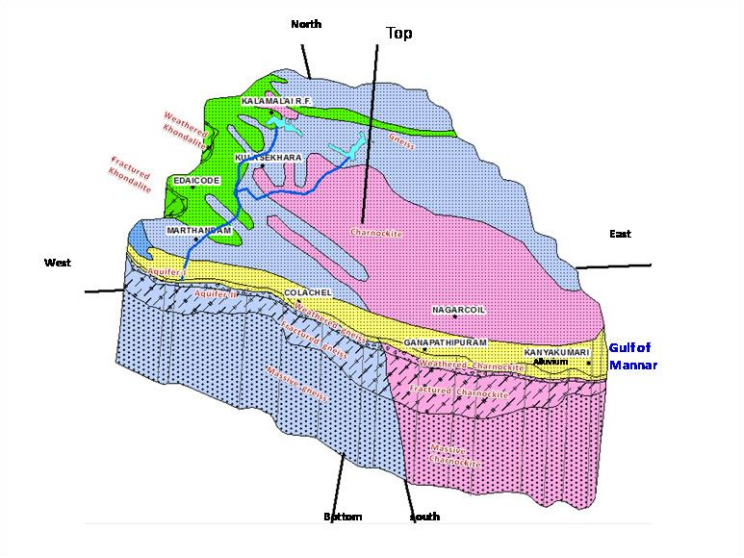
दक्षिण पूर्वी तटीय क्षेत्र, चेन्नई

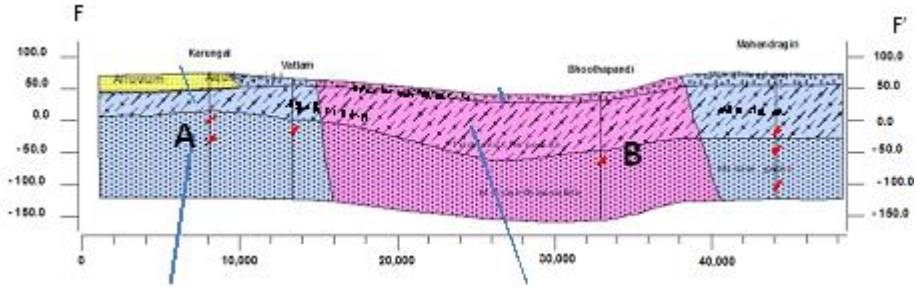
South Eastern Coastal Region, Chennai

सरकारी उपयोग के लिए

कोदयार एक्वीफर सिस्टम, तमिल नाडु पर जलभृत मानचित्रण और जलभृत प्रबंधन योजना

REPORT ON AQUIFER MAPPING AND AQUIFER MANAGEMENT PLAN OF KODAYAR AQUIFER SYSTEM, TAMIL NADU





भारत सरकार
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दक्षिण पूर्वी तटीय क्षेत्र
चेन्नई

GOVERNMENT OF INDIA
MINISTRY OF JAL SHAKTI
DEPARTMENT OF WATER RESOURCES
RIVER DEVELOPMENT AND GANGA REJUVENATION
CENTRAL GROUND WATER BOARD
SOUTH EASTERN COASTAL REGION
CHENNAI

EXECUTIVE SUMMARY

Integrated hydrogeological studies were conducted in the Kodaiyar Aquifer system wherein large number of existing data pertinent to geology, geophysics, hydrogeology, hydrology, hydrochemistry were collected, synthesised and analysed to bring out this report. This report mainly comprises the lateral and vertical extents of the aquifers with their geometry, aquifer properties of the study area which are considered to be measuring scales for groundwater availability and potentiality. Keeping these parameters in view a sustainable management plan has been suggested through which the groundwater needs can be fulfilled in a rational way.

The Kodaiyar aquifer system experiences semi-arid climate with 1456 mm annual normal rainfall covering 1205 km^2 (mappable) area in Kaniyakumari district of Tamil Nadu. About 56% of the geographical area is under agricultural activity of which a major part is provided by surface water irrigation& minimal part is contributed by ground water irrigation. The main crops irrigated are- paddy, black gram, coconut rubber bannanna & tapioca

(The major formation is hard 80% and Sedimentary 20% Charnocite Gneiss, Granite, Alluvium, Sandy clay, Marine deposits in the studies areas).

Groundwater occurs under unconfined condition in the weathered zone and in the alluvial formation and unconfined to semi-confined conditions in the hard rock formations like pegmatites/garnetiferous quartzofelspathic gneiss and fractured/fissured calc granulitic zone. The predominant water levels are in the range of 5 to 20 m bgl during pre-monsoon season and 2 to 10 mbgl during post-monsoon season of 2017-18. The net annual ground water availability is 235.92 MCM and the gross groundwater draft is 60.14 MCM and the stage of groundwater development is 25.49%.

The major issues in the aquifer systems are low sustainabilitydue to the highly slopy terrain, threat of sea water intrusion along the coastal part of the aquifer system, and high concerntration of nitrate, fluoride and insitu salinity.

In hard rock regions aquifer systems can be conceptualized as weathered zone down to ~30m with average thickness of 18 m and fractured zone between 30 to 80 m bgl. Fast growing urban agglomerations share groundwater which otherwise is being used for irrigation purpose resulting

in either shortage for irrigation needs or creates excessive draft to meet both the demands in groundwater potential areas.

REPORT ON AQUIFER MAPPING AND AQUIFER MANAGEMENT PLAN FOR KODAIYAR AQUIFER SYSTEM

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AQUIFER MAPPING AND AQUIFER MANAGEMENT PLAN FOR KODAIYAR AQUIFER SYSTEM

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1.0 INTRODUCTION

National Project on Aquifer Mapping (NAQUIM) initiated by Ministry of Jal Shakti, Department of Water Resources, River Development and Ganga Rejuvenation, Government of India with a vision to identify and map the aquifers at the micro level with their characteristics, to quantify the available groundwater resources, propose plans appropriate to the scale of demand and institutional arrangements for participatory management in order to formulate a viable strategy for the sustainable development and management of the precious resource which is subjected to depletion and contamination due to indiscriminate development in the recent past.

The water demand for domestic, irrigation, industries, livestock, power generation and other uses is governed by socio-economic and agricultural factors, including the present and future population size, income level, urbanization, market facilities, remunerative prices, cropping patterns, etc. The rationale of choosing a river basin as the unit for the planning is to optimize 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 forms the core of a river basin plan. As groundwater continues to play an important role in the development of the human civilization, there arises a strong need for protecting groundwater from increasing threat of over extraction and contamination. The development activities over the years have adversely affected the ground water regime in many parts of the country. Hence, it is important to understand the aquifer system and its hydrodynamics so as to properly manage the groundwater resources. There is a need for scientific planning in development of groundwater under different hydrogeological situations and to evolve effective management practices with involvement of community for better groundwater governance.

Aquifer Mapping has been taken up in the Kodaiyar- Aquifer system in a view to formulate strategies for sustainable management plan for the aquifer system in accordance with the nature of the aquifer, the stress on the groundwater resource and prevailing groundwater quality which will help in drinking water security and improved irrigation facility. It will also result in better management of groundwater resources and vulnerable areas.

1.1 Objectives

The objectives of the aquifer mapping project in the Kodaiyar aquifer system can broadly be stated as

- To define the aquifer geometry, type of aquifers and their lateral and vertical extents
- To determine the groundwater regime scenario
- To determine the hydrogeochemical characteristics of the aquifer units
- To decipher 2D and 3-D dispositions of the aquifer units.
- To estimate the availability of groundwater resources in the aquifer system
- To develop an sustainable groundwater management plan for the aquifer system.

1.2. Scope of the Study

The important aspect of the aquifer mapping programme is the synthesis of the large volume of data already generated during specific studies carried out by Central Ground Water Board and various Government organizations with a new data set generated that broadly describe the aquifer system. The available generated data are assembled, analysed, examined, synthesized and interpreted from available sources. These sources are predominantly non-computerized data, which is to be converted into computer based GIS data sets. Data gaps have been identified after proper synthesis and analysis of the available data collected from different state organisations like Tamilnadu Water supply and Drainage Board (TWAD), Public Works Department (PWD) and Agricultural Engineering Department (AED).

In order to bridge the data gap, data generation programme has been formulated in an organised way in the basin. Groundwater exploration work has been carried out in different segments of the regions and aquifer parameters have been estimated. Groundwater monitoring regime has been strengthened by establishing additional monitoring wells. 2D and 3D sections have been prepared twice, one prior to the generation of data based on the data collected, assembled and synthesized through different sources and second, after generation of data at identified gaps. The later prepared maps are of more realistic as the data points are more closure.

Issues

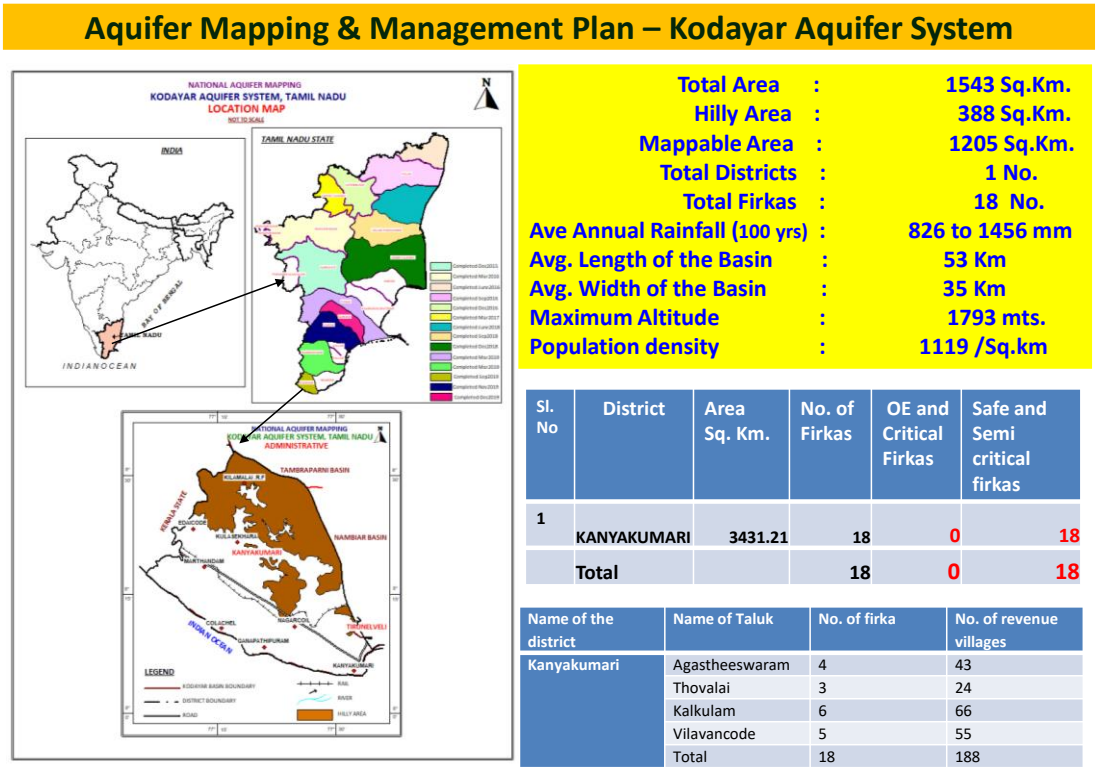
During aquifer mapping studies in the Kodaiyar –aquifer syatem, the major issues/threat identified (**Figure 1.1**) in the aquifer system are

i. In-situ salinity.

ii. Threat of sea water intrusion along coast.

iii. Highly compact – Low yielding aquifer units.

iv. N itrate fluoride Contamination in areas along the coast



Sl. No	District	Area Sq. Km.	No. of Firkas	OE and Critical Firkas	Safe and Semi critical firkas
1	KANYAKUMARI	3431.21	18	0	18
	Total		18	0	18

Name of the district	Name of Taluk	No. of firka	No. of revenue villages
Kanyakumari	Agastheeswaram	4	43
	Thovalai	3	24
	Kalkulam	6	66
	Vilavancode	5	55
	Total	18	188

Figure 1.1: Issues in Kodayar Aquifer System

In-situ salinity

High values electrical conductivity values obsereved at deeper depths, from 80m to 200m

(Suchindram, Kaniyakumari)

Threat of sea water intrusion along coast

There is sea water intrusion threat along the coastal part of the aquifer system. Seawater intrusions observed in Colachel, Kaniyakumari & Thengappattinam areas. Sea water intrusion study in Kanyakumari district is restricted to 10 km width of the entire coast line to the entire area of 830 sq,km. High salinity values are observed at Suchindram and Agastheeshwaram

Highly compact - Low yielding aquifer units

Low yielding aquifers, low yield due absence of primary, secondary porosity and compactness in Granite, Charnockite, and Quatrzite. Very less discharge observed in both weathered and fractured aquifers. The transmissivity values weathered and fractured aquifers are in the range 0.1 to 2.0 m^2/day. The specific yield values weathered and fractured aquifers ranges between 0.01 to 0.1.Mainly observed in areas having high slope

Nitrate Contamination

The source of Nitrate in groundwater includes surface leaching from wastewater and and N-based fertilizers. Isolated pockets of Nitrate contamination above 45 mg/l observed near Gnapatipuram near Nagercoil . The source of Nitrate contamination in this pocket is due to applied fertilizers in agricultural field and urban sewerage.

1.3 Approach & Methodology

Integrated multi-disciplinary approach involving geological, geophysical, hydrological and hydrogeological and hydrogeochemical components were taken up in 1:50000 scale to meet the objectives of study. Geological map of the basin has been generated based on the GSI maps, geophysical data has been generated through vertical electrical soundings and geoelectrical layers with different resistivity have been interpreted in corroboration with the litho-stratigraphy of the observation wells and exploratory wells down to depths of 200 and 300 m bgl for hard rock & soft rock respectively. Hydrological and hydrometerological data has been collected from state PWD and Indian Meteorological Department (IMD). Drainage, Soil and Geomorphology of the sub basin was prepared based on the IRS –IC data, obtained from Institute of Remote Sensing, Anna University, Chennai.

Based on the data gap analysis, data generation process has been planned through establishing key observation wells, pinpointing exploratory sites for drilling through in-house and outsourcing, collecting geochemical samples in order to study groundwater regime, geometry of the aquifer and aquifer parameters, and quality of the groundwater. Groundwater recharge and draft have been computed through different methods and resources of the basin estimated through groundwater balance and management plans have been formulated for sustainable management of the groundwater resource.

The ongoing activities of NAQUIM include toposheet wise micro-level hydrogeological data acquisition supported by hydrogeological, geophysical and hydro-chemical investigations supplemented with ground water exploration down to the depth of 200 / 300 meters.

Considering the objectives of the NAQUIM, the data on various components was segregated, collected and brought on GIS platform by geo-referencing the available information for its utilisation for preparation of various thematic maps.

The approach and methodology followed for Aquifer mapping is as given below:

Compilation of existing data
(Central & State Govt.)

↓

Identification of Primary Aquifer

↓

Identification of data gaps

↓

Data generation

(Water level, exploration, geophysical, hydro-chemical, hydrogeological etc.)

↓

Data integration and Aquifer Maps with 2D & 3D disposition

↓

Generation of different thematic layers

↓

Firka wise Aquifer Management Plan

1.4 Study area

Among the 20 aquifer systems, the Kodaiyar river basin is the most densely populated after Chennai. The total area of the basin is 1543 sq.km and the hilly area occupies 388 sq.km. The total mappable area is 1205 sq.km. 18 Firkas are fully covered falling in the major part of Kaniyakumari district. District and Firka wise area falling in the basin are furnished in **Table 1.1.**

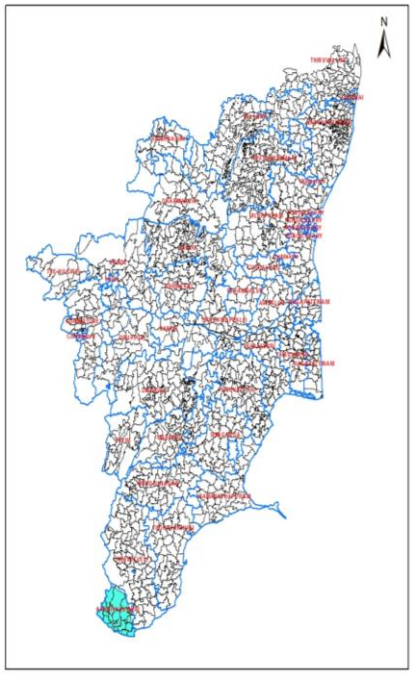
The basin is bounded by Tamirabarani & Nambiyar basin in the east, Kerala state in the North, Indian Ocean in the South and landlocked in the west.

The basin area is well connected with roads and railway lines. All the towns and villages are connected with village roads, district roads, State highways and National highways. The National Highway-NH 7 is passing through the study area .The Tirunelveli Kaniyakumari railway line passes through the study area. Nagerkoil , the district Capital is a part of the basin.

Sl. No.	Name of the division	Name of taluk		No. of firka	No. of revenue villages
1	Nagercoil	1	Agastheeswaram	4	43
		2	Thovalai	3	24
2	Padmanabhapuram	3	Kalkulam	6	66
		4	Vilavancode	5	55
			Total	18	188

Table 1.1: Districts and Firkas of the Kodaiyar - aquifer system

Sl. No.	District	Area (sq.km.)	No. Of Firkas	Areaof basin excluding hilly area(sq.km)	No. of OE and Critical Firkas
1	Kaniyakumari	3431.21	18	1205	-



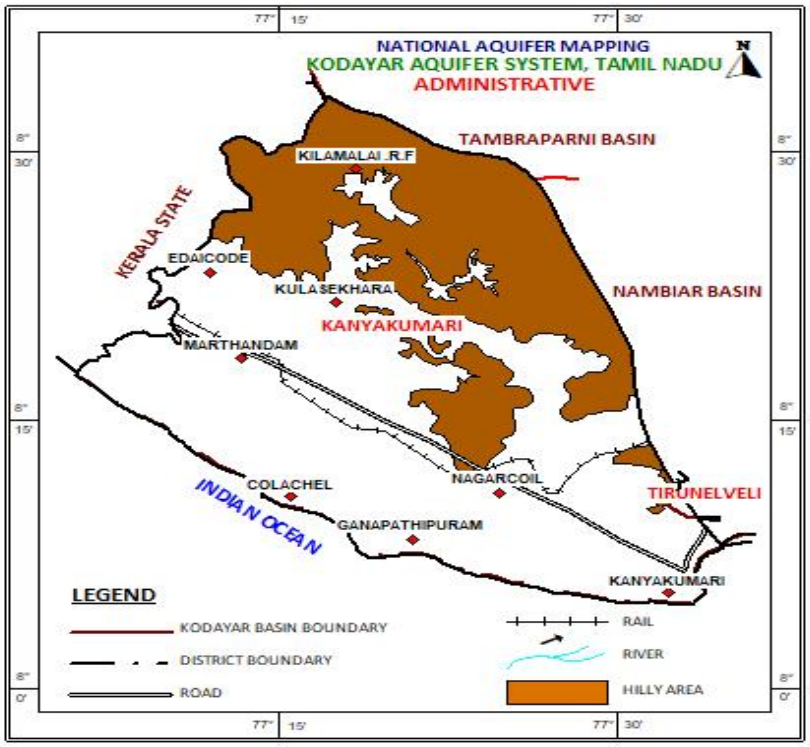


Figure 1.2: Administrative setup of the Kodaiyar –Aquifer System

1.5. Data Adequacy and Data Gap Analysis

The available data such as Exploratory wells, Vertical Electrical Sounding (VES), ground water monitoring stations and ground water quality stations of Central Ground Water Board, South Eastern Coastal Region, Tamil Nadu Water Supply and Drainage Board (TWAD), State Surface and Ground Water Resources Data Centre of Public Works Department, Government of Tamil Nadu were compiled and analysed as per the nomenclature for adequacy of the data. The summarised detail on Data Adequacy and Data Gap Analysis.

Rainfall

The average annual rainfall Normal of the Kodaiyur basin is 973.8 mm and the average annual rainfall actual of the Kodaiyur basin is 1312.5 mm. It has a rainfall both during the south west and the north East monsoons. The south west monsoon period stars from the month of June and ends in September(32.6%).the North east monsoon period starts from October and ends in the middle of December(42.5% , winter season (3.3%) and summer being 21.6% of total rainfall.

Rain gauge stations:

Thukalay, Pechiparai, Aralvoimozhi, Bothapandi, Nagarkovil, kalial, Karipareri, Eranieal, Mulagumooda, Kottaram, Kuzhithurai, Meekodu, Puthur dam

Distribution of Rainfall	
Season	Percentage of rainfall
Southwest Monsoon	32.6
Northeast Monsoon	42.5
Winter	03.3
Summer	21.6

1.6. Physiography and Drainage

The three major rivers of this aquifer system are Kodaiyar, Paralaiyar & Chittar.The drainage is dendritic and general slope is towards the south east..Pechiparai reservoir, one of the largest in the district falls within the study area. Three major dams, namely Perunchani, Kodaiyar 1&Kodaiyar ii also fall within the study area.

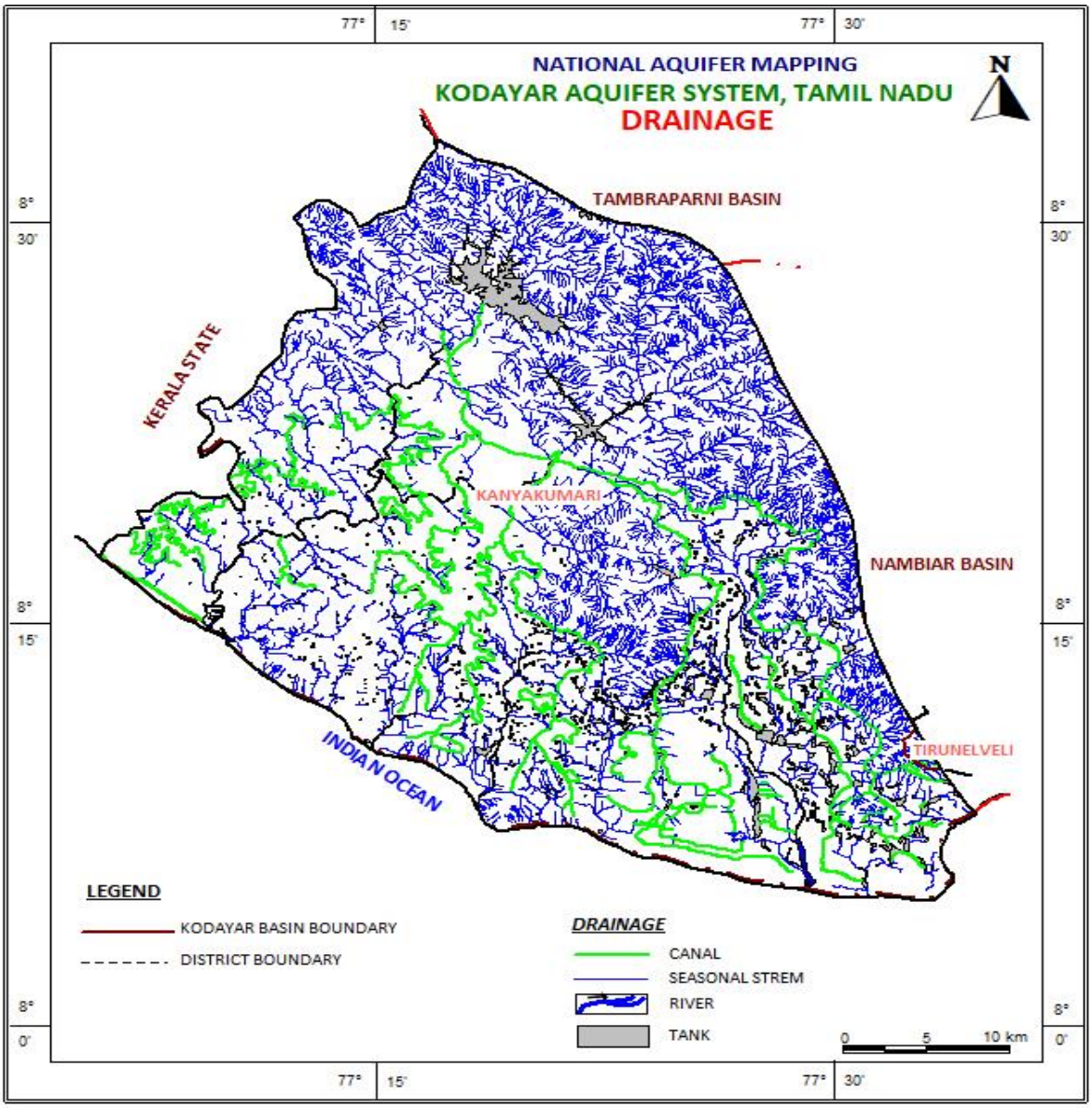
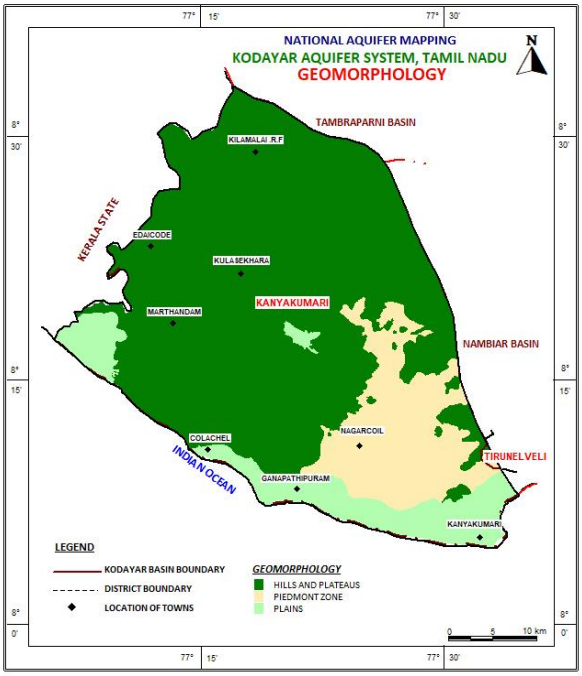
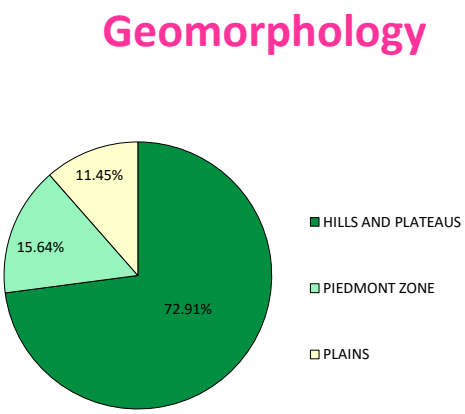


Figure 1.3: Drainage of the Kodaiyar - aquifer system

1.7. Geomorphology

Almost 70% of the area is covered by hills and plateus while about 15% is covered by piedmont zone while the rest of the area is covered by plains





Coastal line has narrow stretches of Beaches and sand dunes

Figure 1.4: Geomorphology of Kodaiyar basin

Landforms of Structural Origin

The structural landforms in Kodaiyar basin includes structural hills and linear and curvilinear ridges.The structural landforms are noticed in the western part of the basin where the geology is of hard rock origin. There are sand dunes along the coastal tract of the basin

Landforms of Denudation Origin

The Denudation landforms are occurred in western and middle part of the basin and divided into various geomorphic units such as denudational hills, residual hills, pedimentinselberg complex, pediment, buried pediplain, shallow and moderate, weathered pediplain - shallow and moderate and laterite plain. The denudation process is active in these landforms. The denudation hills are formed, due to differential erosion and weathering, so that, a more resistant formation or intrution stand as mountains / hills with varying hard rock lithology. The groundwater prospects in inselberg is poor. Pediment is gently sloping smooth There will be no geologic structures over the terrain.The lithology is mainly laterites as capping over granite or

meta sediments. Groundwater prospects will be poor since the capping is compact and immpermeable.

Coastal Landform

The coastal plain is a regional land of low relief bounded seaward by the shore and landward by highlands, mainly formed due to coastal action.The lithology in Coastal Plain are sand, silt and clay. Groundwater prospects is promising. The groundwater is saline. The quality of ground water will be saline except the groundwater occurring as perched water table. Tidal flat is a widened flat surface parallel to coast, primarily comprises of unconsolidatedmaterials like gravels, sands and silt with fine texture.Thequality of water will be poor / saline. Swale is a geomorphic unit of coastal origin .It is a shallow depression, sometimes swampy, in the midst of generally level land in an undulating ground. It is a long, narrow shallow trough like depression between two beach ridges and alinged roughly parallel to the coastline.

1.8. Land use and Land cover

The land use study of Kodaiyar basin reveals that built land comprises of rural and urban settlement pattern, industries, etc appears in the imagery as a dark brown tone. Built upland category covers an area of 60 s.km covers about 5 percent total geographical area. Agricultural practices are observed in the major parts of the basin. 24 sq.km area comes under agricultural waste land covers about 2 percent of the total area. About 33% of the land area is enveloped by thick forests while 4% land is made up of water bodies like the Peunchani resevoir

Surface water and groundwater are conjunctively used in this basin for irrigation. Paddy, Banana and sugarcane are the major wet crops and sesame, groundnut, cholam, ragi etc are the major dry crops. Wet crops cultivation in the tune of 1754.52 sq.km and dry crops 514.25 sq.km.

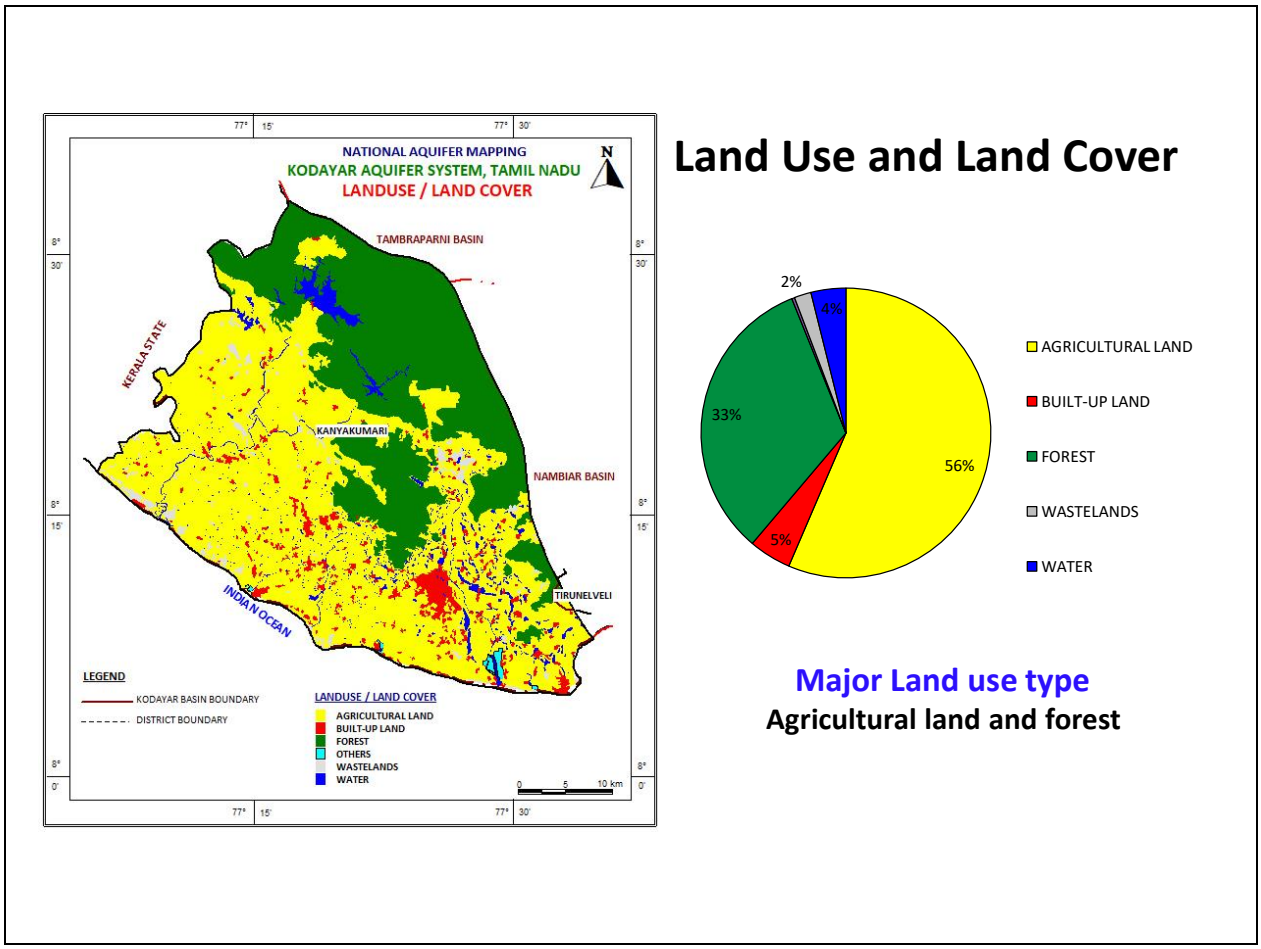


Figure 1.5: Land Use/Land Cover of Kodaiyar Aquifer System

1.9. Soils

Soils play a major role in hydrologic control of the infiltrating water. Soils are generally classified by taking their colour, texture, fertilities and chemical combinations includes salts, minerals and the solution effect over them. The major soil types in the study area are red soil, black cotton soil, sandy loam and forest loam **.** Red soils are the major soil group found in the study area and consists of the red sandy to brownish clayey soil fragments derived from parent rock and is spread all along the westward side. The red soils are suitable for agricultural hold moderate groundwater reserves.

Black cotton soil is clayey soil with high specific water retention capacity but poor in supporting agriculture. The rate of infiltration varies is very low in this type and ranges from 1 to 3 cm / hr for fine red sandy clay, clayey sand, sandy clay, sand fine to medium, sand

medium to coarse and very coarse and gravel and for weathered rock, fractured and jointed rock it varies from 0.2 to 0.5 cm / hr. which normally occurs in the study area. Sandy loam is alluvial soils comprising sand and sandy materials occurring on the beaches and at the confluence of rivers and by the side of the rivers & channels. Because of their permeability, these soils while being good storehouses of groundwater are not fit for paddy cultivation. Forest loam found where the area covered by forest and reserve forest.

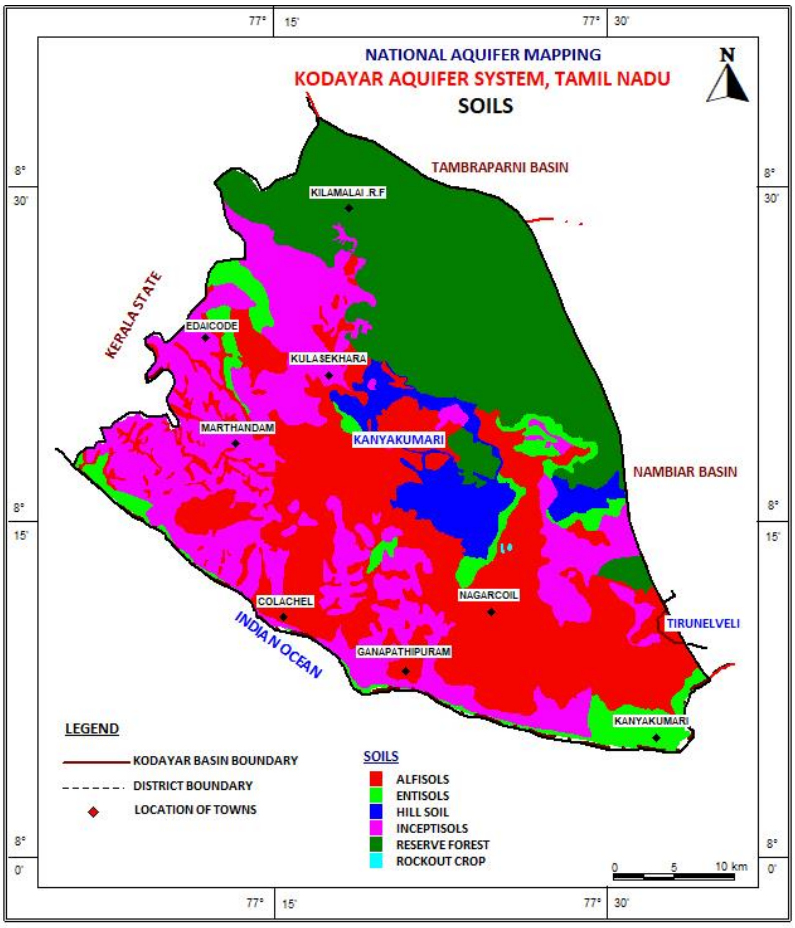


Figure 1.6: Soil of Koadaiyar Aquifer System

The northern portion of the study area is mainly reserve forest area comprising of kilamalai RF while the southern portion of the study area comprises alfisols which are moderately leached soils that have relative high fertility.These soils have formed under the forest regionand have a subsurface horizon in which clays have accumulated.Inceptisols are soils of newer origin and are characterised by lack of clays, iron oxides,aluminium oxide or organic matter.Inceptisols can develop on young or old geologic material.

Very good groundwater potential exists in the study area except in areas where rocky outcrop is exposed. the groundwater potential is very poor.

Agriculture is the main stay of the rural population in the entire study area.

As per the data of the Department of Agriculture , Govt .of Tamilnadu,the study area incorporates the whole of Kaniyakumari district with an agricultural area of 1,67,200 hectareswith a net sown area of 74,712 hectares.Paddy is the main food crop of the area and is grown twice a year.

The study area occupies a horticultural area of 65804 hectares in which plantation crops occupy 84 % followed by fruits,spices, vegetables and flowers.

The forest lands include reserved forest, open forest with forest blanks are observed in the area. Some of the land area not suitable for either agriculture or for any other uses. Such land are unproductive because alkaline nature of the soil. Such types of landforms are also observed in the basin.

1.10. Irrigation

Paddy is the major food crop in the study area

Two major reservoirs namely Pechiparai and Perunchani exist in the study area. Both impound the tributary water of Tambirabarani area.

Perunchani Dam can store water upto 36 metres, Pechiparai reservoir was built across the Kodaiyar river which is a tributary of the Tambirabarani river. With a total capacity of 123TMC and details are gven below **Table.1.2.**

Table.1.2: Irrigated crops of the Kodaiyar aquifer system

Area and production of major crops

Sl. No.	Crops	Area (ha)	Production (Metric Tonnes)	Productivity kg/ha	% to the total area
A.	**Cereals and millets**				
1	Paddy	21158	0.9990	4721	26.67
2	Pulses	1761	0.1267	600	2.22
B.	**Oilseeds**				
	Coconut	24200	27.5 crore nuts	11375 nuts/ha	30.5
C.	**Other crops**	42562	--	--	40.61

Comparison of cropped area of paddy for the last 5 years.

SLNO	Crop	2011-12	2012-13	2013-14	2014-15	2015-16
1	Paddy (Kar)	8250	5976	7023	6564	6472
2	Paddy (samba)	8366	6435	6596	6610	6485
3	**Total (Paddy)**	16617	12411	13619	13175	12957

IRRIGATION

SOURCES OF WATER SUPPLY –BLOCKWISE

Year: 2015-16

Sl.No	Name of the Block	Canals		Wells used for irrigation purpose only	Tube Wells	Wells used for Domestic Purpose only	Resorvoirs	Tanks (Nos.)
		Number	Length (Km)					
1	2	3	4	5	6	7	8	9
1	Agasteeswaram	17	28	597	432	2095	0	134
2	Rajakamangalam	19	35	401	1038	2901	0	113
3	Thovalai	6	97	289	76	1387	1	272
4	Kurunthancode	1	132	521	16	3101	0	592
5	Thuckalay	3	92	48	1	3060	0	329
6	Thiruvattar	3	35	11	-	2101	2	296
7	Killiyoor	0	58	182	6	3003	0	361
8	Munchirai	2	35	90	29	3126	-	203
9	Melpuram	2	28	6	-	6142	2	323
Total		**53**	**540**	**2145**	**1598**	**26916**	**5**	**2623**

Source : G Return Fasli 1425 (2015-16)

The Kodaiyar basin is one of the oldest irrigation systems in the state comprising Pazhayar and Paralayar rivers along with the Tambirabarani or Kuzhithuraiyur in which Kodaiyar is the major tributary.This is the only basin which has its coastal border adjoining the Arabian sea,Indian Ocean and Gulf of Mannar,The entire basin falls in the Kaniyakumari district and a small portion of Radhapuram block of Tirunelveli district. The kodaiyar basin is spreading over 4 taluks in Kaniyakumari district and six blocks of the district

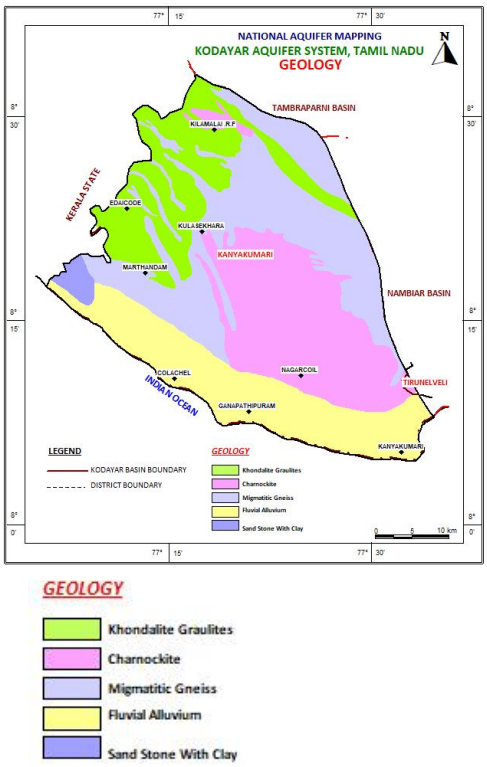
The river Tambirabrani (Kuzhithuraiyur) originates from the Western Ghats and flows towards the west and drains into the Arabian sea near Thengappattinam. The Kodaiyar river has three

tributaries namely Kodaiyar, Paralaiyar and Chittar. After the confluence of Kodaiyar with Paralaiyar, the river Kuzhithuraiyur river flows towars the sea.The Kodaiyar basin is sloping towards southeastern direction with a rugged topographical relief and undulating terrain. The drainage of the bain is dendritic in nature. The Kodaiyar 1&II dam are situated west of Pechiparai reservoir. Kuttiar is another major tributary of Kodaiyar

1.11. Geology

The geology of the Kodaiyar basin is based on the maps published by the Geological Survey of India, interpretation of satellite data and the inferences derived from the lithology of investigation boreholes. The Kodaiyar basin is underlain by gneissic terrain of hard crystalline rocks which includes Charnockites and Khonalites. Migmatites and Granites overlain the hard rocks and are identified s Warkalai Sandstonewhich is equivalent to Cuddalore sandstone. The coastal plain hosts rocksof Miocene, Quaternary and Recent age. In thespouthern part of the basin along the west coast.placer depositsof heavy minerals including illemanite, rutile,garnet and monazite occur as localized pockets between Kolachel and Kaniyakumari. Beach sands are exposed west of Kaniyakumari,Rajakkamangalam,Manavalakurichi.Marthandam and Kuzhithurai along the west coast. Of these Manavalakurichi is well known for illemenite Significant concerntration of placer deposits occur between Vattakkotai and Lipipuram of a length of 5-6 km and width of 3-5 km

Geology



Period	Age	Lithology
Quaternary	Holocene to Recent	Soils, River alluvium, Kankar, laterite. Warkalai Sandstone
Archaean	Acid intrusives	Pegmatites, Quartz veins, pink Granites grey granites, leucogranites
	Basic intrusives	Basic dykes - dolerites
	Migmatite complex	Garnetiferous-quartzo-feldspathiic gneisses, hornblende biotite gneiss.
	Charnockite group	Charnockites, pyroxene granulites,
	Khondalite group	Calc Granulites, garnetiferous biotite-Sillimanite graphite-gneiss, granulites, quartzites

Figure 1.7: Geology of Kodaiyar Aquifer System with stratigraphic sequence of Kodaiyar Aquifer System

2.0. DATA COLLECTION AND GENERATION

After the data gap analysis, additional key wells establishment, water samples collections and other hydrogeological data are collected in filed. During aquifer mapping studies, periodical data pertaining to groundwater levels, quality, pumping tests and slug tests were collected. In addition, geophysical data has been generated through conducting geo-electrical soundings after evaluation of data gap analysis. The data collected are synthesised and analysed for aquifer mapping studies.

2.1. Hydrogeological Data

The periodical monitoring of groundwater levels implies the groundwater recharge and discharge (natural and manmade) occurring in the aquifer systems. It also reveals that the interaction between surface and sub-surface water systems.

2.2. Hydrochemical data

The groundwater quality of the Kodaiyar - aquifer system was studied by collecting water samples from dug wells and bore wells. Groundwater samples were collected for 63 locations, the sample locations in the Kodaiyar aquifer system is presented in **Figure .In addition** to exisiting water quality details with CGWB, groundwater quality data has been collected from TWAD Board and State Ground and Surface Water Resources Data Centre (SG&SWRDC), Government of Tamil Nadu.

2.3. Geophysical data

The geophysical survey was conducted in the study area consisting of Vertical Electrical Soundings (VES) by employing Schlumberger configuration with maximum half current electrode separation of 300m. The objective of the study area is to decipher the sub surface conditions such as weathered and fractured layer resistivity and thicknesses and massive formations up to the depth of 200 m. A total number of 85 VES were carried out and geo-electric layers inferred through interpretation of the results obtained. The locations of the VES are presented in the following Figure.. The interpreted VES data are used in preparing aquifer disposition and other hydrogeological intrepreatation during the study.

2.4. Groundwater Exploration data

Data of 53 exploratory wells drilled in the Kodaiyar - aquifer system (17 Nos. CGWB and 36 Nos. State department wells) prior to National Aquifer Mapping project were compiled and analysed Baseded on the data requirements, 12 Nos. of exploratory wells includes 9 wells in hard rock and 3 wells in soft rocks have been recommended for drilling through outsourcing activity as part of the data generation. The data such as lithology, fracture depth, yield, water level, aquifer properties were generated and utilised to depict the prevailing aquifer systems of the basin. Similarly wells drilled by state department, 36 Nos. wells drilled upto to the depth of 60 to 100 m bgl were used for deciphering the first aquifer.

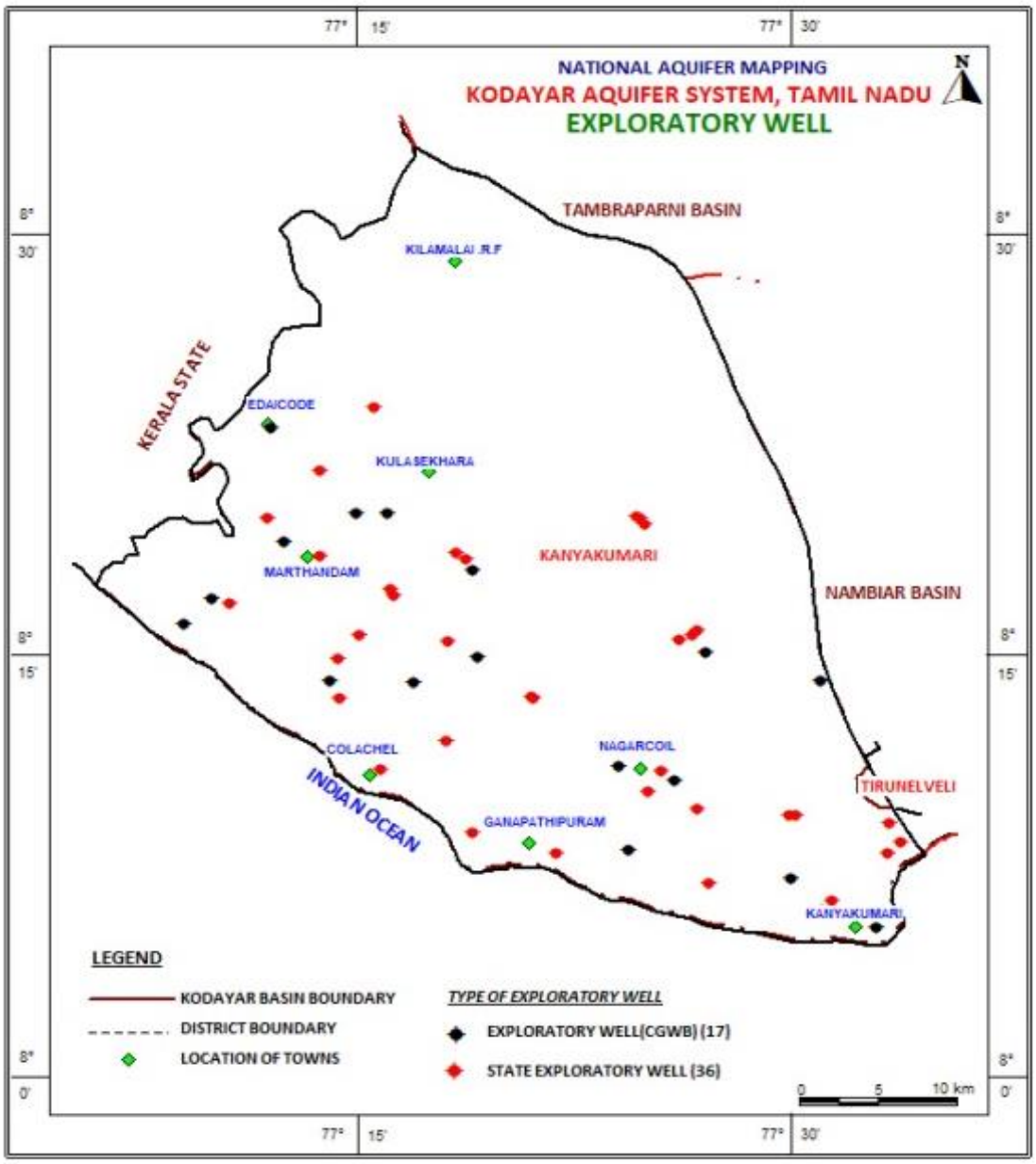


Figure 2.1: Location of exploratory wells

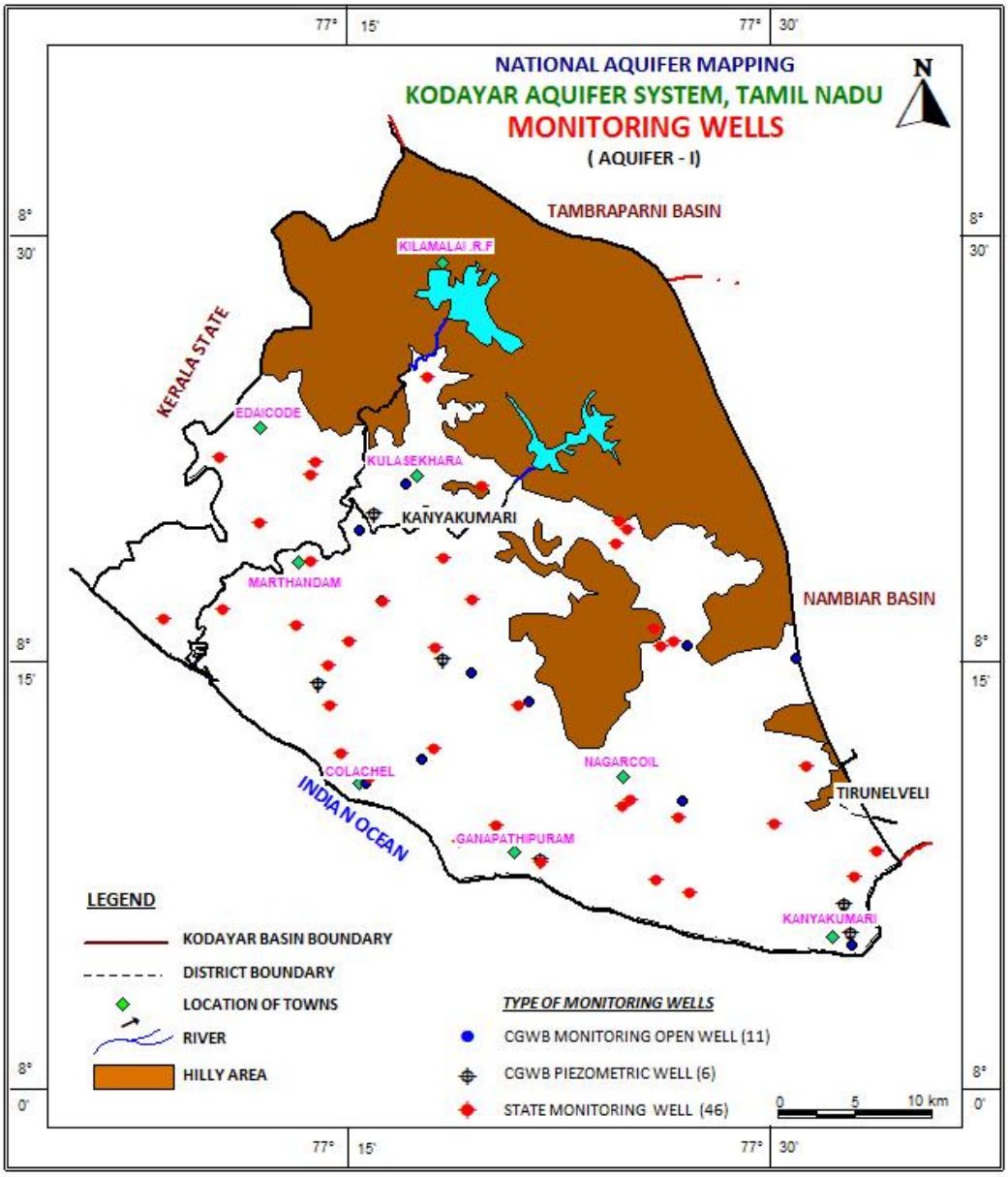


Figure 2.2: Location of monitoring wells

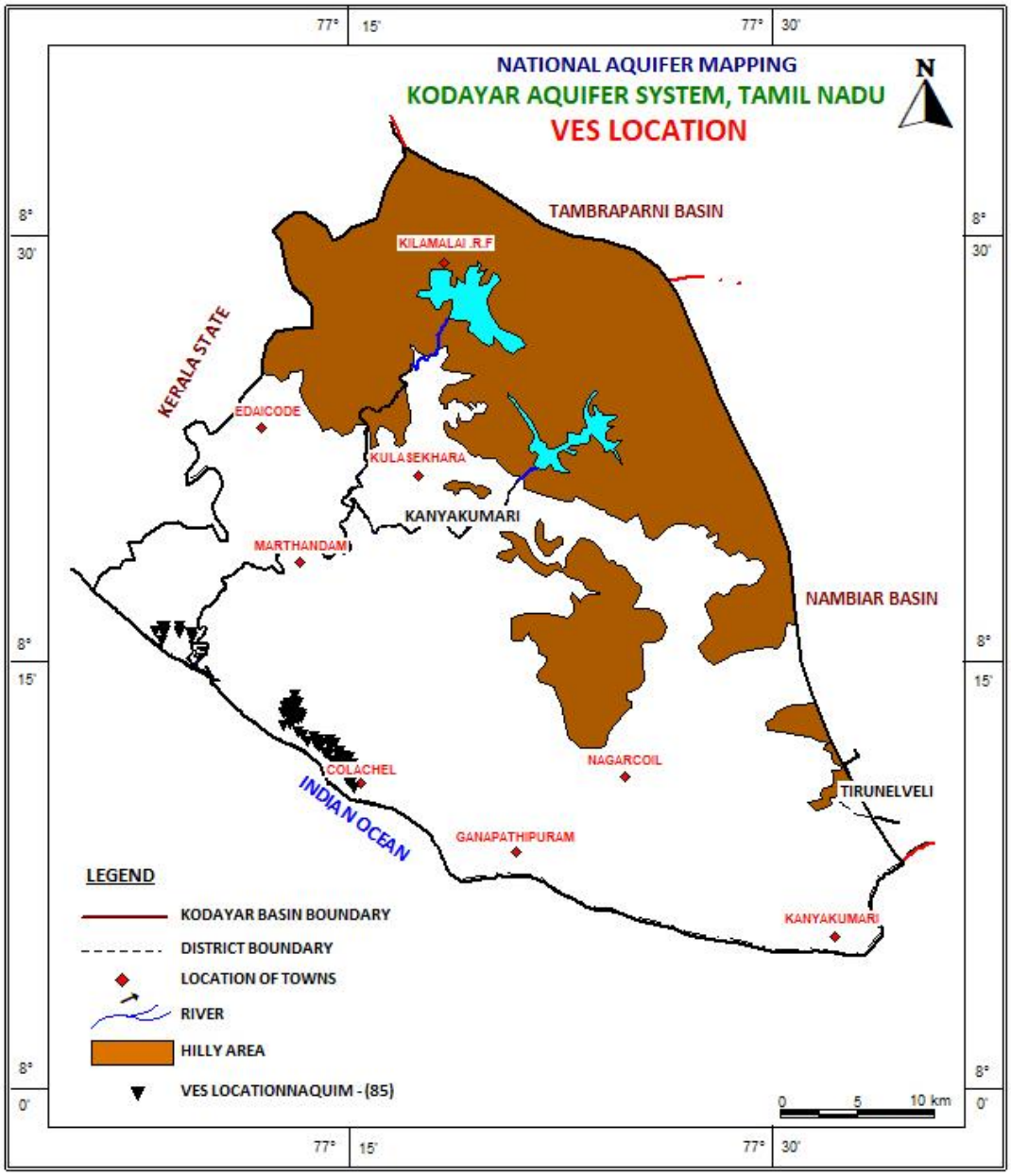


Figure 2.3: Locations of Vertical electrical sounding conducted

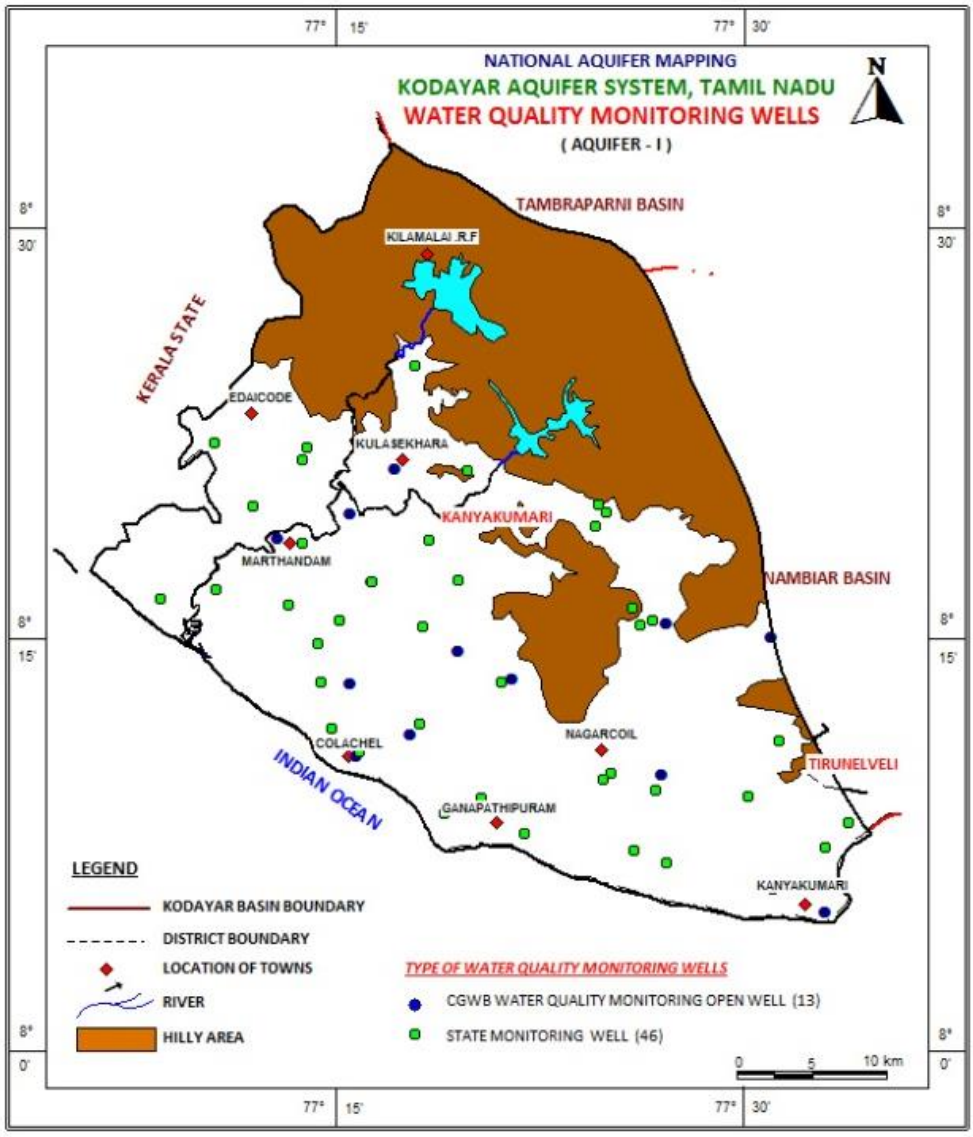


Figure 2.4: Location of water quality monitoring wells (aquifers-I)

3. 0 DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1. Hydrogeological Data Interpretation

I. HARD ROCK REGION

Hard rock region comprising of gneissic, charnockite, quartzite and other intrusive rocks is found in the Kodaiyar basin system. The Gniessic formation and Charnockites formation (hard rocks) form two aquifer units namely the weathered and fracture/jointed aquifer unit. The details hard rock aquifers (Aquifer unit I - Weathered and Aquifer unit II – Fractured) are described below.

Aquifer Unit I – Weathered

The weathered aquifer unit occurs from the groundwater level and has a minimum thickness of 5 m and maximum thickness of 20 m with average thickness of 12 m. 2D disposition along west to south eas**(shows** the vertical and lateral distribution of the gneissic charnockitic and khondalite formations. Yield of this weathered aquifer unit ranges from 1.5 to 15 m^3/hr. During monsoon period the wells tapping this aquifer unit sustain pumping for 2 to 4 hrs/day while during non-monsoon period (April to June) sustains for less than 1-2 hour/day. Groundwater occurs in unconfined condition. The aquifer parameter such as transmissivity in this aquifer unit ranges from 1.0 to 22.4 m^2/day. The Specific yield of this aquifer unit ranges from 1 to 1.5% with highly potable groundwater quality. The general EC of this aquifer unit ranges from 640 to 2200 µS/cm and is suitable for domestic uses.

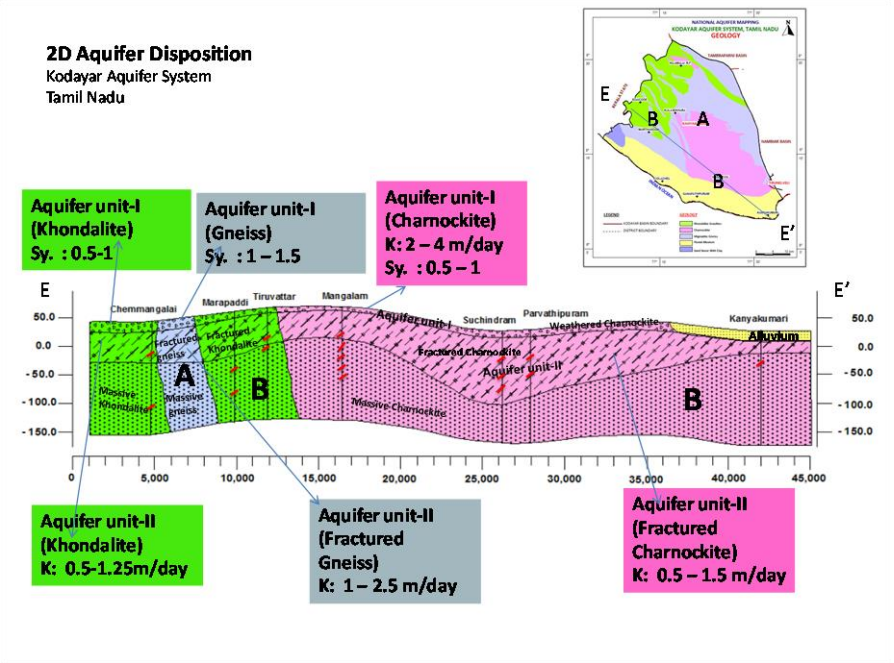


Figure 3.1: Two dimension aquifer disposition of hard rock in Kodayar Aquifer System between Chemmangalai and Kanyakumari

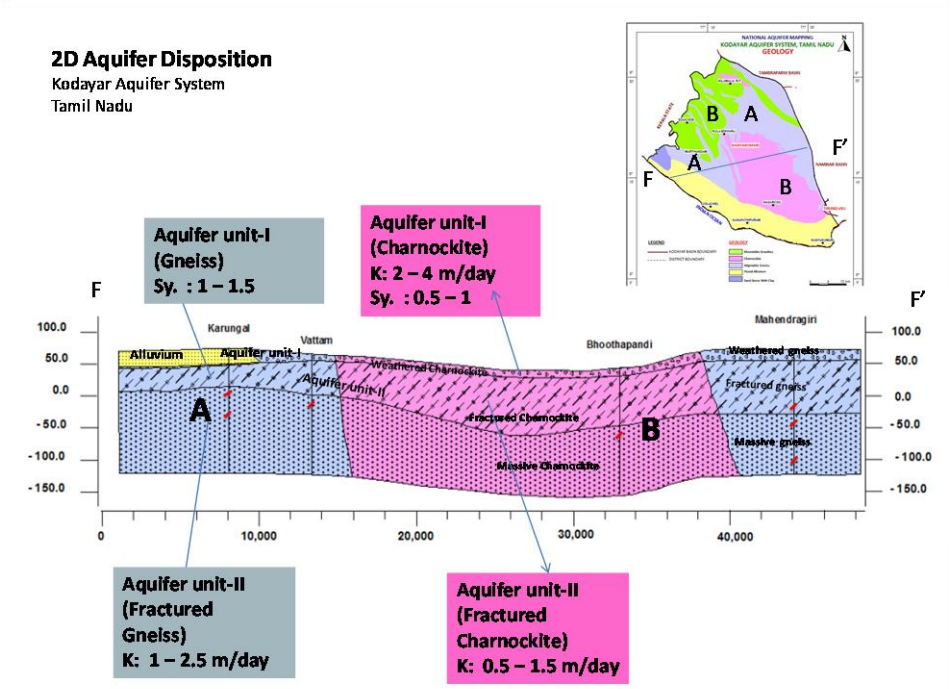


Figure 3. 2: Two dimension aquifer disposition of hard rock in Kodayar Aquifer System between Karungal and Mahendragiri

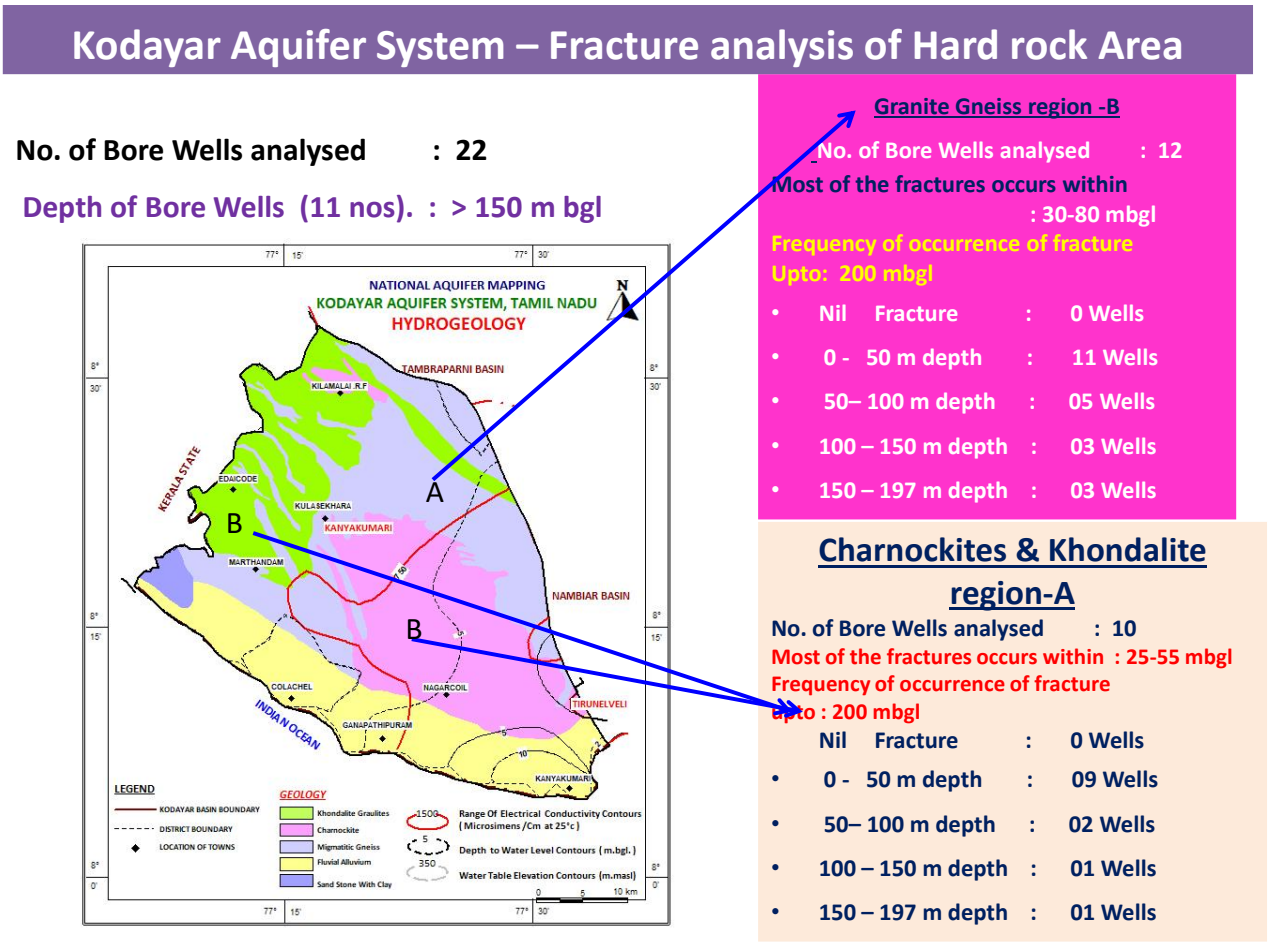
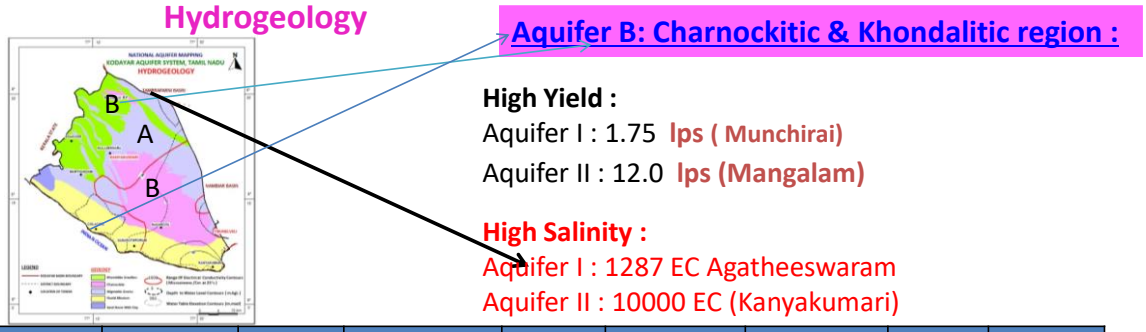


Figure 3.3: Hydrogeology of Kodaiyar Aquifer System

Aquifer Unit II (Fractured/Jointed):

This aquifer unit comprises of fractured and jointed gneissic, charnockites other intrusives formed due to tectonic activity. Top of this aquifer unit occurs from 12 to 30 m bgl. Based on the analysis of the 120 wells it is observed that there is a possibility of occurrence of 3 to 4 fractures/joints exists upto 180 m bgl in the gneissic region. In Charnockites region 3 to 4 fractures are likely to be encountered and they exist only upto 120 m bgl. The yield of this aquifer unit II ranges from 1 to 51 m^3/hr. During monsoon period the wells tapping this aquifer unit sustains pumping for 3 to 5 hrs /day while during non-monsoon period (April to June)

sustains for 1 to 3 hour/day. Transmissivity of this aquifer unit ranges from 1.2 to 140 m^2/day.



Type of Aquifer	Formation	Top of the aquifers (mbgl)	Thickness/ occurrence of fractures (m)	Range of Yield (lps)	Sustainability (hrs)	Aquifer parameter (Transmissivity – m2/day)	Groundwater quality EC values (µs/cm)	Suitable for Drinking
Aquifer unit – A-I	Alluvium/Weathered Charnockites & Khondalite	G.L- 2	4.0 – 31.45 (Avg. -11 -28 m)	0.014-1.75 Majority (< 1)	Monsoon : 1-2 hrs & Non monsoon: (May, Jun &July) < 1 to 2	0.1-90	128 - 1287 (Avg 700-1000)	Yes – except Saline pockets
Aquifer Unit – A-II	Jointed & Fractured Charnockite& Khondalite	6– 30.5 Nil at some places	17-189 (Avg. 25 -55 m) (2 to 3 fractures exist) Mostly confined to 50 m bgl. Nil at few places	0.4 – 12 (Majority < 2)	Monsoon: 1-3 hrs & Non monsoon 1 to 2 hrs	0.1 -5.5	353-10000 (Avg 600-1200)	Yes - except Saline areas

Figure 3.4: Aquifer Unit II (Fractured/Jointed) of Kodaiyar Aquifer System

3.2. Aquifer Maps

3.2.1. Aquifer Disposition

Based on the lithologs of the exploratory wells, VES data and the well inventory details collected during field studies as part of Aquifer Mapping studies, 3D and 2D models of the aquifer system of the basin has been deciphered by using Rockworks software. The data input for Rockworks is prepared in rockworks table format to generate 2D models of the basin along different selected sections.

The aquifer mapping study in the basin reveals that the presence of two distinct aquifer systems in the hard rock

Sedimentary formation is exposed along the coast only

3.2.2. 3D Aquifer disposition

Fence diagram of the aquifer system of the basin was prepared and shown in Fig-3.14. The thickness of the Aquifer-I is almost same in the aquifer basin. The thickness of the aquifer-II is not uniform in thickness. The thickness of the Aquifer-II is high occurring at NW and SE parts of the aquifer basin. Aquifer-II is extending latterly in uniform thickness and it fallow the general topography of the area. Low thickness is indicating the shallow fracture depth and high thickness is indicating depth of occurrences of fracture at much deeper level. This indicates that the shallow fractures can be recharged faster than deeper fracture in the area. The recharging of deeper aquifer is mainly depending upon the amount of water available for groundwater recharge.

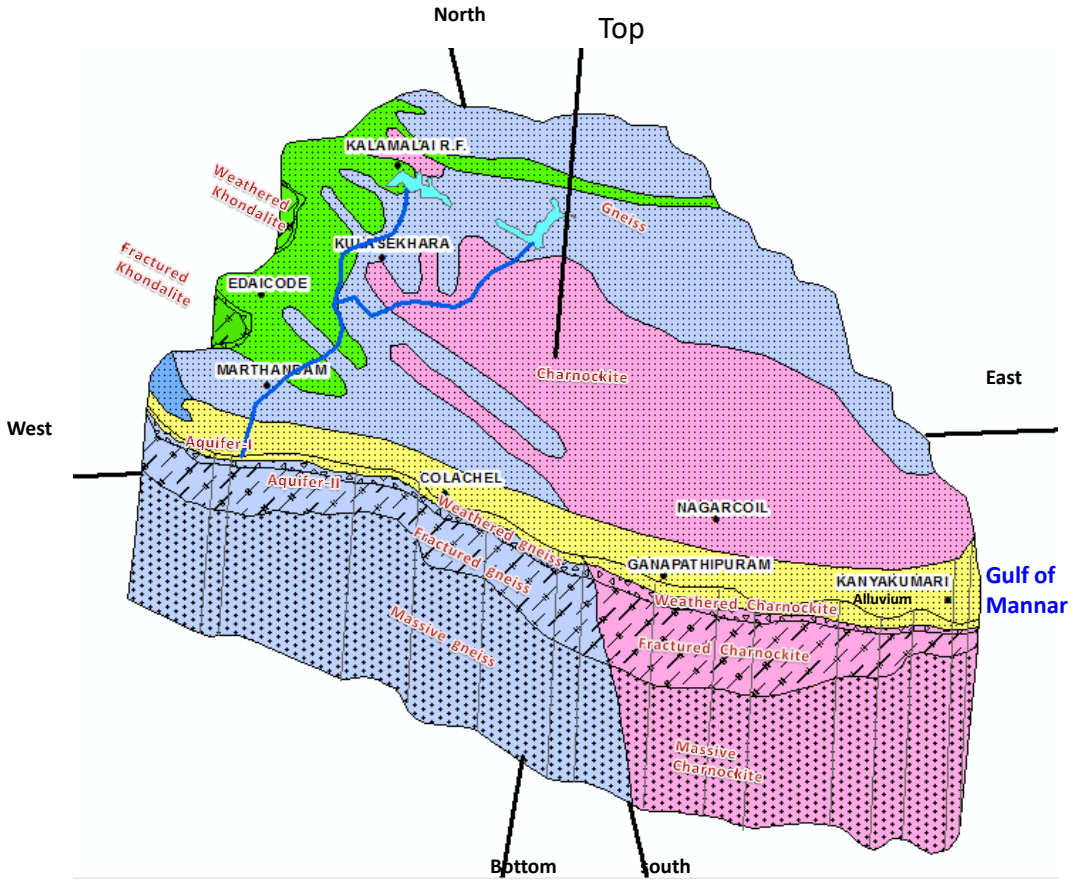


Figure 3.5: Three dimensional Spatial Distribution of Kodaiyar Aquifer System

3.3. Groundwater Level Monitoring well

Groundwater level monitoring well as observation well was established to monitor the groundwater level four times in a year for shallow aquifer (water table aquifer) and fractured aquifers separately which will give clear picture about the groundwater recharge in aquifer system by CGWB, SECR Chennai. Dug wells which represents water table aquifer are being monitored for water level in the area. The fractured aquifer of water level is also being monitored using the bore well called piezometers. SSGWRDC of PWD and TWAD Board are also monitoring the groundwater level monthly in each district for water table aquifer as well fractured aquifer. The water level data monitored by CGWB and other departments were collected for analysing pre-and post-monsoons water level for aquifer mapping. The data were incorporated for analysing the recharge to groundwater in the study area. In the study area, 18nos of dug well were monitored for water table aquifer and 03nos of piezometer were monitored for fractured well. The groundwater level monitoring well locations are shown in Fig-3.5 and 3.6. A major portion of the study area shows depth to water levels ranging from 5 to 10 m during **May 2018**, while a very small portion in the south western portion shows depth to water levels ranging from 10-20m.

During the post monsoon period the depth to water levels ranged from 2-5m and 5-10m for a major part of the study area.A small portion in the eastern portion of the study area shows deeper depth to water levels ranging from 10-20m

During **May, 2018**, 33% wells show depth to water levels ranging between 2-5m,40% wells show depth to water levels ranging from 5-10m and 27% show depth to water levels ranging from 10-20m of the total wells used for analysis.

During **January 2019**, 7% show depth to water levels ranging from 0-2m,13% of wells analysed show depth to water level ranging from2-5m and 10-20m while 67% wells show depth to water levels ranging from 5-10m.

3.3.1. Water Level Fluctuation

Decadal fluctuation between Decadal mean water & water level

The fluctuation of water level recored during the particular period with respect to decardal mean of the same period indicate the impact of ground water development and ground water

recharge during the decarde. Positive fluctuation indicate improved recharge over and above ground water development and negative fluctuation indicate increased ground water development over and above the recharge.

Mean water level for the priod May 2008-2017 May 2018

Uncnfined Aquifer

The water level data for May 2018 were compared with mean water level for the period May 2008-2017. The study areas distribution of ground water monitoring wells falling in different ranges of water level fluctuation. rise in the waterlevel in the range of 0-2m has been observed in 26% of wells analysed , spread all over the study area.

Period	Percentage of wells showing Average depth to Water Level (mbgl)			
	0-2	2-5	5-10	10-20
	%	%	%	%
Pre monsoon (2008-17)	0	27	40	33
Post monsoon (2009-18)	13	20	60	7

Annexure:1.

1.0 .Depth to water level in kodaiyur basin areas durig period May 2018 to January 2019

SL_ No.	STATE_ NAME	DISTRICT	BLOCK NAME	SITE ID	SITE_NAME	LATTITUDE	LONGITUDE	SITE_ TYPE	Depth to Water Level (m bgl)			
									May-18	Aug-18	Nov-18	Jan-19
327	Tamil Nadu	Kancheepuram	KANCHEEPURAM	W1246300794930O1	Walajabad	12°46'30"	79°49'30"	Dug Well	6.25	6.85	5.2	5.45
328	Tamil Nadu	Kanyakumari	THOVALA	W081500077310001	Aralvaimozhi	08°15'00"	77°31'00"	Dug Well	4.55	4.3	3.9	4.45
329	Tamil Nadu	Kanyakumari	TIRUVATTAR	W081930077153001	Attur	08°19'30"	77°15'30"	Dug Well	11.1	7.75	8.19	9.3
330	Tamil Nadu	Kanyakumari	THOVALA	W081530077271001	Boothapandy	08°15'30"	77°27'10"	Dug Well	4.3	4.1	4.35	4.43
331	Tamil Nadu	Kanyakumari	KURUNDANKODU	W081130077174301	Chettiarmadam DW	08°11'30"	77°17'43"	Dug Well	11.28	6	6.85	8.35
332	Tamil Nadu	Kanyakumari	AGASTHEESWARAM	W080500077330001	Kanyakumari1	08°05'00"	77°33'00"	Dug Well	7.72	6	2.6	4.93
333	Tamil Nadu	Kanyakumari	TIRUVATTAR	W081702077161901	Kattudurai DW	08°17'02"	77°16'19"	Dug Well	7.3	4.9	5.28	8.7
334	Tamil Nadu	Kanyakumari	KURUNDANKODU	W081040077154501	Kolachal	08°10'40"	77°15'45"	Dug Well	11.9	11.28	11.13	11.68
335	Tamil Nadu	Kanyakumari	TIRUVATTAR	W082108077170901	Kulasekharan DW	08°21'08"	77°17'09"	Dug Well	7.1	6.3	6.4	8.8
336	Tamil Nadu	Kanyakumari	AGASTHEESWARAM	W080610077323801	Kundal(West) PZ	08°06'10"	77°32'38"	Bore Well	24	7.7	4.92	7.4
337	Tamil Nadu	Kanyakumari	MELPURAM	W081835077125101	Marthandam	08°18'35"	77°12'51"	Dug Well	7.49	7.65	8.12	13.77
338	Tamil Nadu	Kanyakumari	AGASTHEESWARAM	W081000077270001	Nagarkoil1	08°10'00"	77°27'00"	Dug Well	3.16	1.74	1.31	1.56
339	Tamil Nadu	Kanyakumari	RAJAKKAMANGALAM	W080755077220001	Rajakamangalam	08°07'55"	77°22'00"	Bore Well	2.8	2.3	2.1	2.4
340	Tamil Nadu	Kanyakumari	TAKKALAI	W081430077193001	Takkalai	08°14'30"	77°19'30"	Dug Well	7.05	5.4	2.75	4.96
341	Tamil Nadu	Kanyakumari	TAKKALAI	W081455077183001	Thakkalai1	08°14'55"	77°18'30"	Bore Well	6.5	8.31	5.52	6.04
342	Tamil Nadu	Kanyakumari	AGASTHEESWARAM	W080700077334501	Variyoor	08°07'00"	77°33'45"	Dug Well	1.4	0.75	0.7	1.05
343	Tamil Nadu	Kanyakumari	KILLIYUR	W081320077153001	Vellaivilai	08°13'20"	77°15'30"	Dug Well	12.3	10	8.9	9.2
344	Tamil Nadu	Kanyakumari	KURUNDANKODU	W081330077213001	Villukuri	08°13'30"	77°21'30"	Dug Well	9.25	5.4	3.9	8.25

2. Depth to water level of semi confined and confined in kodaiyur basin areas durig period May 2018 to January 2019

SL_ No	STATE_ NAME	DISTRICT	BLOCK NAME	SITE ID	SITE_NAME	LATTITUDE	LONGITUDE	SITE_ TYPE	Depth to Water Level (m bgl)			
									May-18	Aug-18	Nov-18	Jan-19
155	Tamil Nadu	Kanyakumari	AGASTHEESWARAM	W080520077330001	Kanyakumari PZ	8.089	77.550	Bore Well	12.71	11.05	7.1	9.26
156	Tamil Nadu	Kanyakumari	THOVALA	W081405077140502	Karungal pz	8.235	77.235	Bore Well	13.25	11.73	12.45	13.09
157	Tamil Nadu	Kanyakumari	TIRUVATTAR	W082000077160401	Thiruvattar	8.333	77.268	Bore Well	6.72	7.6	9.72	8.6

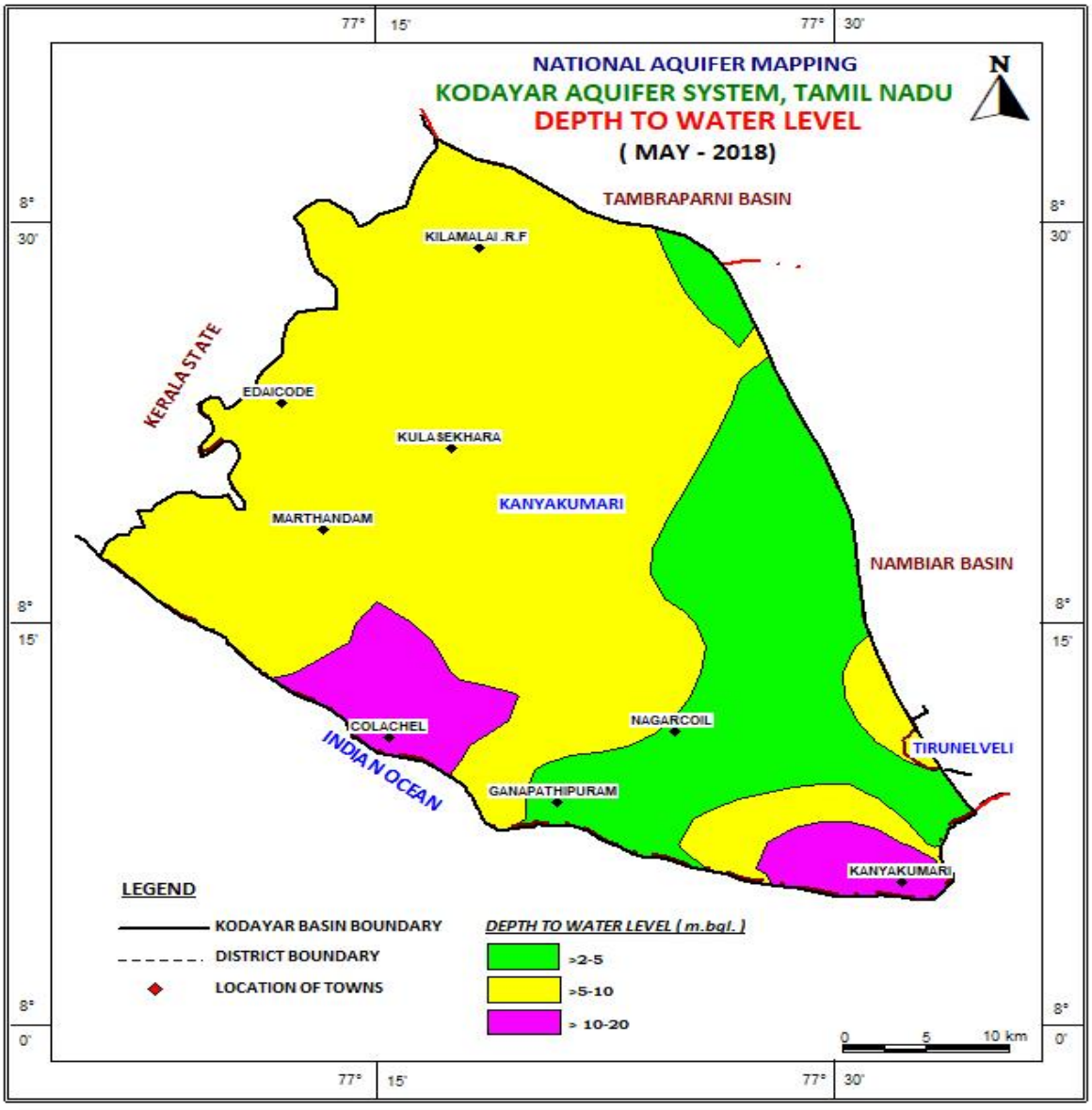


Figure 3.6: Depth to water level during May 2018

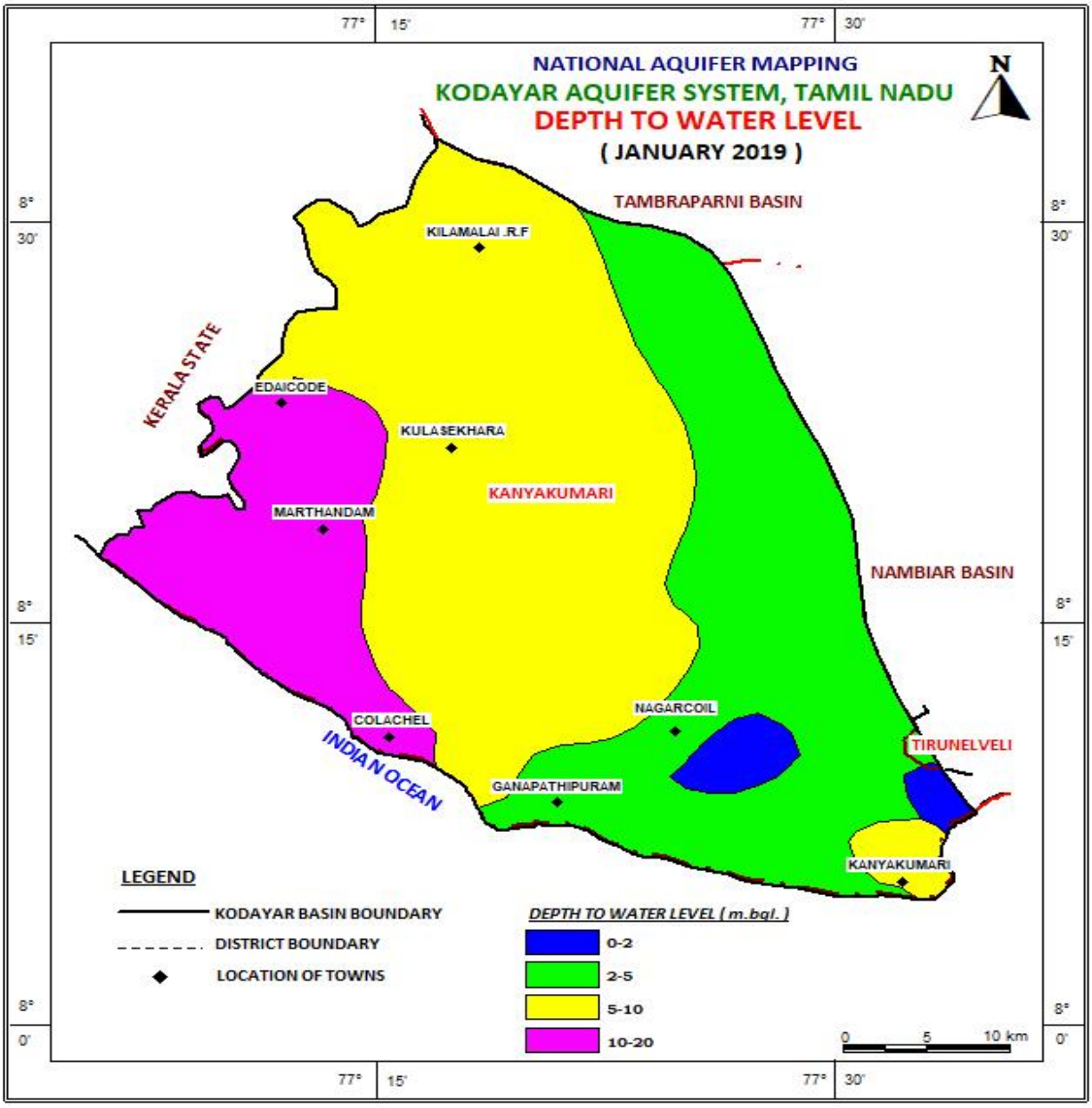


Figure 3.7: Depth to water level during January 2019

4.0. HYDROCHEMICAL DATA AND INTERPRETATION

Groundwater quality monitoring wells were established by CGWB, SECR, Chennai to monitor the groundwater quality of shallow aquifer once in a year. SSGWRDC of PWD and TWAD Board are also monitoring the groundwater quality of water table aquifer mainly of dug well.in each district. All the groundwater quality data are incorporated for analysing the groundwater

quality issues. In the study area, 12 nos of well were monitored for groundwater quality. The groundwater quality monitoring well is shown in **Figure 4.1**

The groundwater samples were collected from 311 dug wells and analysed pH, EC, anion, cation and fluoride and nitrate concentrations. The EC of groundwater is discussed in the report. 42% of the sample is showing EC between 750-2250 µS/cm at 25 °C which is considered as moderately fresh water. More than 50% of the sample is falling EC of 2250 - >3000 µS/cm at 25 °C which is showing the groundwater is high concentration mineralisation. Only less than 10% of sample is showing the EC less than 750 µS/cm at 25 °C and this groundwater is considered as fresh.

S.No	Parameters	Range
1	Electrical Coductivity µs/cm at 25°c	< 750
		751- 2250
		2251- 3000
		> 3000
2	Chloride mg/l	< 250
		251-1000
		> 1000
3	Fluoride mg/l	< 1.0
		1.1- 1.5
		>1.5
4	Nitrate mg/l	<45
		> 45

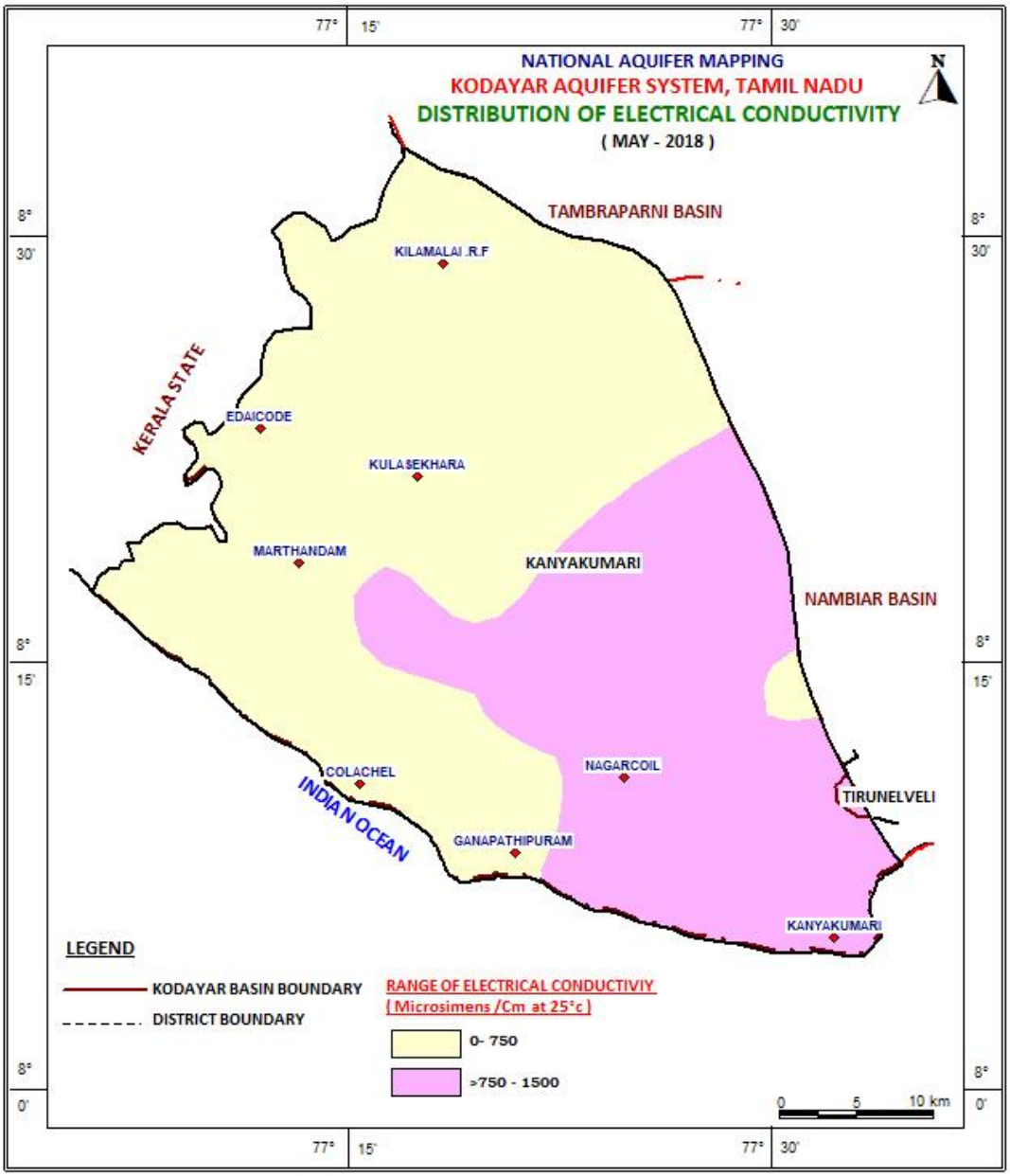


Figure 4.1: Electrical conductivity map of Kodaiayar Aquifer System

Chloride:

Distribution of Chloride is shown in Fig:4.2. The chloride content is less than 250 mgl/l in about 100% of the sample analysed in the study areas.

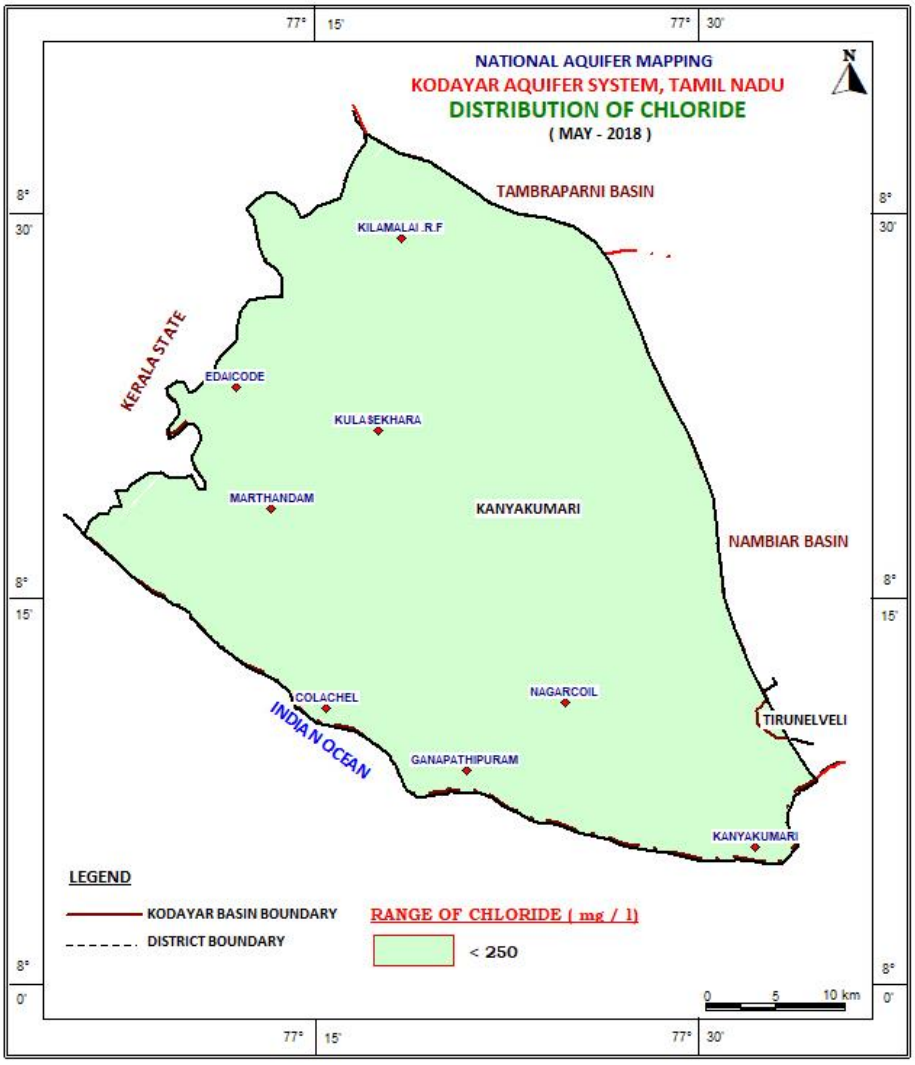


Figure 4.2: Chloride map of Kodaiayar Aquifer System

Fluoride:

The fluoride content is less than 1.5 mg/l in about 87% of the sample analyzed about 13% of the sample shows morethan 1.5 mg/l which are from Aravaimozhi, Boothapandy, Villukuri in the study areas is shown in Fig:4.3.

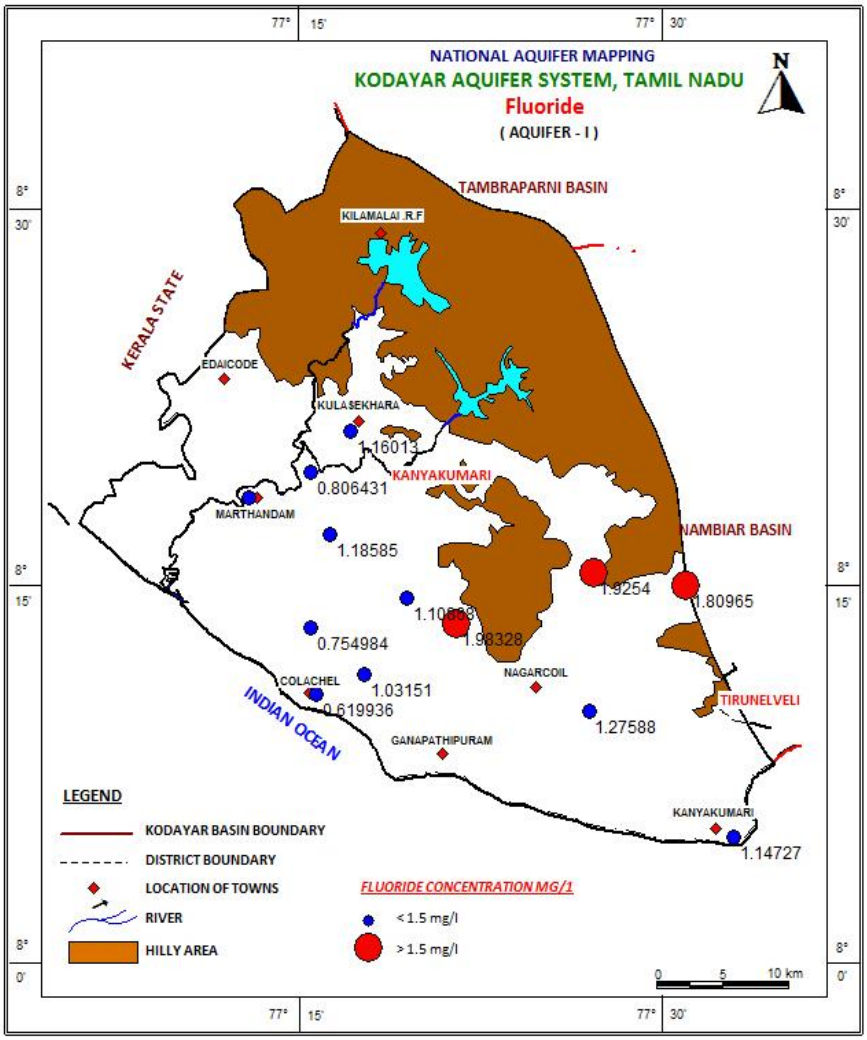


Figure 4.3: Fluoride map of Kodaiayar Aquifer System

Nitrate

Predominantly the study area shows nitrate concerntration of less than 250 mg Firkas with high Nitrate, Kanyakumari, Thuckalay, Midalam & Kurunthuncode is shown in Figure 4.3.

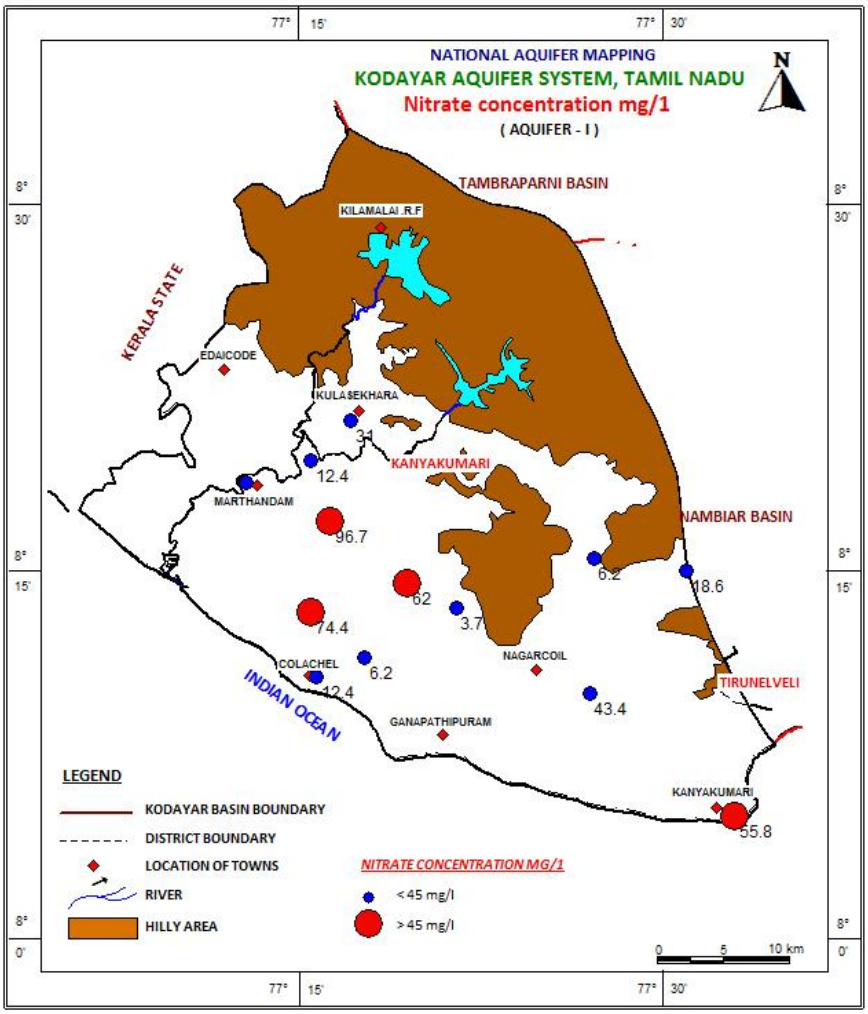


Figure 4.4: Nitrate map of Kodaiayar Aquifer System

- High Nitrate concentration in groundwater is reported in firkas namely Kanyakumari, Thuckalay, Midalam & Kurunthuncode.
- **Nitrate concentration mainly due to the urban activity and fertilizers used for coconut plantation.**
- **Proper disposal of Municipal waste and proper lined severage drain system construction is needed**

Practicing of natural farming practice has to be encouraged.

- High fluoride concentration in groundwater is reported in firkas namely Thovalai, Bhoothapandi & Kurunthuncode. Fluoride concentration is due to geogenic and

process of the rock water integration, particularly in the area where pegmatite intrusion is found.

- **In these area alternate water supply for groundwater has to be identified for drinking water.**
- High saline concentration is reported in deeper zones of few exploratory wells constructed by CGWB, Suchindram, Kanyakumari, Bhoothapandi, Marthandam.
- Drilling of Borewell more than 100 mts., in these area has to be restricted to stop the upconing of salinewater.
- Quality monitoring station need to be strengthen by constructing Piezometers with quality monitoring probes to monitor the seawater groundwater quality.

Annexsure:3

3. The chemical analsiyed data ground water samples collected during May 2018

Sl_ NO	DHQ_NAME	FirkaName	LOCATION	LAT	LONG	DOC	PH	EC	TH	Ca	Mg	Na	K	HCO 3	Cl	SO4	NO3	F
247	KANNIYAKUMARI	Thiruvattar	Attur	8.325	77.258	01/05/18	6.6	202	80	16	10	9	2	49	25	19	12	0.81
248	KANNIYAKUMARI	Bhoothapandy	Boothapandy	8.258	77.453	01/05/18	7.4	1047	270	52	34	115	2	384	113	38	6	1.93
249	KANNIYAKUMARI	KURUNTHENCODE	Chettiarmadam DW	8.192	77.295	01/05/18	6.8	128	45	16	1	7	2	37	14	10	6	1.03
250	KANNIYAKUMARI	Kanniyakumari	Kanyakumari1	8.083	77.550	01/05/18	7.3	1287	370	92	34	110	23	372	170	48	56	1.15
251	KANNIYAKUMARI	Thiruvithancode	Kattudurai DW	8.284	77.272	01/05/18	6.8	958	130	24	17	145	19	43	241	15	97	1.19
252	KANNIYAKUMARI	Colachel	Kolachal	8.178	77.263	01/05/18	6.8	613	100	12	17	92	4	79	142	29	12	0.62
253	KANNIYAKUMARI	Thiruvattar	Kulasekharan DW	8.352	77.286	01/05/18	7	415	100	28	7	46	8	37	92	24	31	1.16
254	KANNIYAKUMARI	Vilavancode	Marthandam	8.310	77.214	01/05/18	6.6	202	80	24	5	10	7	61	28	10	12	1.11
255	KANNIYAKUMARI	Nagercoil	Nagarkoil1	8.167	77.450	01/05/18	6.8	886	200	44	22	110	2	128	184	41	43	1.28
256	KANNIYAKUMARI	Thuckalay	Takkalai	8.242	77.325	01/05/18	6.5	788	200	44	22	87	8	79	177	38	62	1.11
257	KANNIYAKUMARI	Midalam	Velliavilai	8.222	77.258	01/05/18	6.8	606	110	20	15	92	7	79	106	38	74	0.75
258	KANNIYAKUMARI	KURUNTHENCODE	Villukuri	8.225	77.358	01/05/18	7.4	1050	290	52	39	108	1	391	131	24	4	1.98

5.0. GROUNDWATER RESOURCES

The gross groundwater draft has been assessed by using Unit draft method for irrigation draft component and by adopting formula suggested by GEC 1997 for domestic and industrial draft components.

5.1. Net Groundwater Availability

Groundwater Resources as on March 2017 has been estimated using GEC 2015 methodology. The Net Annual Ground Water Availability of the district is 9680 ham and existing gross groundwater draft for all uses in the district is 4640 ham. The stage of groundwater development is 24.49% and the district falls in safe category.

Ground water resources

Total Firkas – 18
Semi Critical - 1
Safe - 17

District	2013			2017		
	Resources	Draft		Resources	Draft	
Total Basin (ham)	23958.611	4252.91	17.75	23591.92	6014.04	25.49
Total Basin (MCM)	239.58	42.53		235.92	60.14	

Table 5.1 Groundwater Resources of Kodaiyar Aquifer System

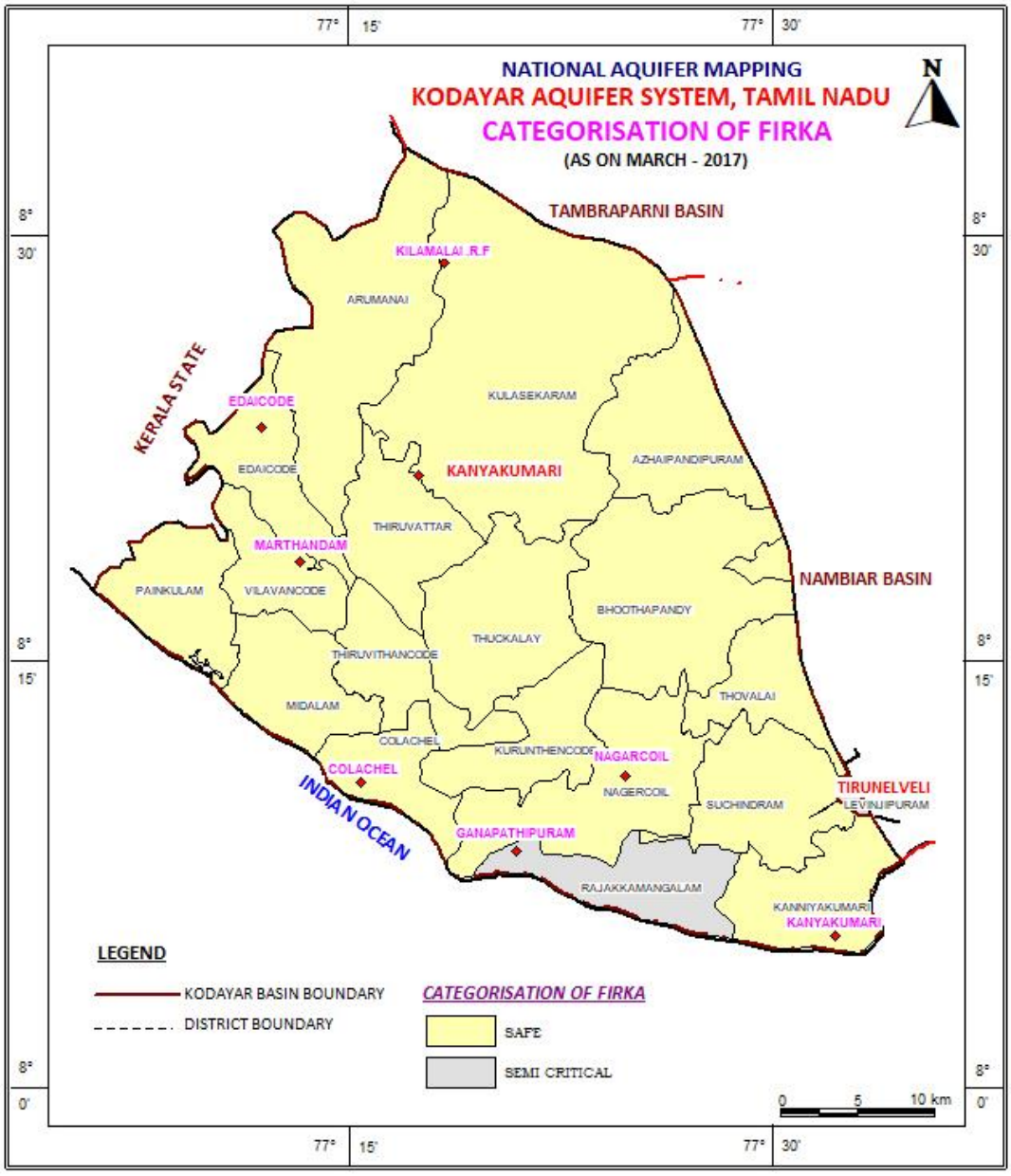


Figure 5.1: Categorisation of firkas in Kodaiyar Aquifer System

5.2 Stage of Development and Categorization

The stage of development is defined by stage of groundwater development (%) = (Existing groundwater draft/ Net Groundwater availability) x 100

The stage of groundwater development is calculated for all the 18 firkas of the basin The **Categorization has been done by considering the two factors as suggested by GEC 97, viz.,** Stage of DevelopmentLong-term trend of pre and post monsoon water levels.

The following FOUR categories have been suggested by GEC-97 based on the above two factors.

a) Safe b) Semi-critical c) Critical and d) Over-exploited

- Based on the above categorization 17 firkas fall under safe category while 1 firka falls under semi critical category. A perusal of the table shows 17.75 % during 2013 as the stage of development which has increased to 25.49 % during 2017. **Groundwater resources: Stage of groundwater development** of the aquifer system is only 26% and there exist sample scope for groundwater development.
- Considering the fact that 73% of the area is hilly and plateaus groundwater development has to be enhanced only based on the local hydrogeological conditions.
- conjunctive use of surface and groundwater is need of the hour.
- Utilization of surface water resources has to be encouraged as it is available in adequate quantity through canal network.
- Soil conservation methods like contour bunding and terrace bunding techinques to be adopted to conserve soil moisture and minimize the surface water runoff.
- It helps groundwater recharge and increase the sustainability of the groundwater abstraction structure in the region.
- In upland areas, where depth to water level is deep, artificial recharge method can be taken up.
- Series of gabion structures has to constructed along the streams .

Table 5.2: Water balancing for Kodaiyar River basin at 75% dependability

Year	Total demand of water in various sector (Mcm)					Water availability (Mcm)				Gap (Mcm)
	Irrigation	Domestics	Industries	Live stock	Total demand	Surface water potential	Ground water potential	Quantity of water from desalting	Total	
2010	748	44.16	41.23	0	813.98	916	239.59	62.27	1217.86	404.46
2017	748	50.12	70.28	14.57	862.98	916	239.59	-	1155.59	292.61
2020	748	52.93	89.01	14.6	884.54	916	239.59	-	1155.59	271.05
2030	748	63.49	192.07	14.83	998.39	916	239.59	-	1155.59	157.2
2040	748	76.22	415.07	15.29	1234.58	916	239.59	-	1155.59	-79

Industrial water demand present in the Kodaiyar basin there are 44 numbers of large and medium industries and 1179 numbers of small scale industries. The norms for water requirement as per the recommendations of industries department are 2500 Mcum / day / unit for large and medium industries and 2.5 Mcum / day / unit for small scale industries. Accordingly, the yearly requirement of water for small scale industries during the year 2017 is calculated as 1.84 Mcum and for the large and medium scale industries is calculated as 68.44 Mcum. Hence, the total annual water requirement for industries in the basin is 70.28 Mcum. For forecasting the water demand of Industries for future years, a simple arithmetic increase of 8% per annum over the present requirement has been adopted. The annual water demand for the Industries during the planning periods for each sub basin is given in the table below**:**

6.0. GROUND WATER RELATED ISSUES

Groundwater is under utilized for irrigation in the entire basin area for the past two decades, However sufficient scope exists for more utilisation of groundwater except in the saline intruded areas like Suchindram, Kaniyakumari

Sea water has intruded coastal area of Kaniyakumari, town and adjoining areas due to the over exploitation of groundwater to meet the water supply needs.

Following measures can be taken up in the coastal region.

- The study area was natural disaster prone and was one of the worst affected areas in India during the Tsunami that ravaged the coasts in south and south east Asia on 26 December 2004
- Stopping of heavy pumping of GW in the seawater intruded area.
- Coconut and saline resistance crops are to be grown in areas having TDS 1500– 2500 mg/l) **Seawater intrusion threat exist along the coast**
- Coastal line has narrow stretches of beaches, sand dunes and coastal alluvial cover.
- Urbanization is happening faster rate in these area.
- Groundwater development rate increased by constructing numbers of borewells may invite seawater intrusion. Hence seawater intrusion threat is always exist along the coast.
- Groundwater development by constructing borewells need to be restricted up to 2kms from the coast particularly in the alluvium area.

7.0. MANAGEMENT STRATEGIES

The groundwater management strategies are inevitable either when there is much demand to the resource than the available quantity or when the quality of resource deteriorates due to contamination in a given geographical unit.. So, the urbanization has a impact on the food production as well as grabbing the employment of the agricultural laborers. Hence, it is the need of the hour to formulate sustainable management of the groundwater resource in a more rational and scientific way.

7.1. Sustainable Management Plan

Augmentation of groundwater can be achieved through construction of percolation ponds with recharge shafts where the top soil zone is clayey which does not allow infiltration. Normally it can be achieved through capturing surface runoff. Surface water transfer also can be planned in the absence of surface runoff during droughts. It needs uncommitted runoff from the adjoining localities to transport to the needy areas through diversion channels.

7.2. Future Demand Stress Aspects

In views of rapid urbanization the domestic water needs are increasing multifold. In this urbanization process the water wastage component is increasing mainly because of leakages through distributor system. Whereas in the agricultural irrigation sector the water demand mainly due to the enthusiasm of the farmers to increase the crop irrigation area.

Hence, the policy makers at higher administrative level and rural development authorities at block level should educate the farmers in their jurisdiction in such a way that they should not venture to increase the farm irrigation area. Rather these authorities have to suggest high yielding crop varieties and high-value crops to grow with minimum water requirement with the technical guidance of local agricultural/ agronomic experts.

7.3. Strategies to overcome the future stresses

Future stresses are only hypothetical. If the sustainable management is taken up in a true spirit in consultation with local village level bodies the groundwater depletion will not occur in future. However, it is very difficult to overcome gluttonous user attitude thrives for fullest use of the resource to get maximum output. In this process the vital resource is lost. Therefore, a thorough understanding of the consequences of indiscriminate usage of the water should be propagated among users mainly among farmers as they are bulk users of the resource in the study area.

The demand side strategies to overcome future stresses are mainly

Promoting irrigation pattern change, Agronomic Water Conservation, Reducing water use, reduction in urban areas.

Annexure:

Ground water Exploration wells data collected during year 1993-94 for **Kodaiyar River basin**

											Type of Wells	EW	OW	PZ
											No. of Wells Drille	14	4	--
						DISTRICT : KANYAKUMARI								
HARD ROCK AREA														
Sl. No.	Location, Well number Co-ordinates Toposheet Number and R.L. of G.L. (mamsl)	Year of Drilling	Depth drilled Casing Pipe Lowered (mbgl)	Lithology	Fracture zones encountered (mbgl) / Discharge (lps)	Type of preliminary yield Test & Results (*)	Results of aquifer performance test SWL (mbgl) Date	Discharge (lps) Drawdown (m)	Specific capacity (lpm/m of Draw down)	T (m^2/ day)	S	EC	Cl	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	**MAHENDRAGIRI (EW)-2013** (08° 17' 30";77° 33' 45"-58 H/11) 96.281	1993	190.00 24.70	Gneiss	26.40-27.40/2.44 58.90-59.90/3.28 87.40-88.40/5.40 127.00-128.00/8.23	Air Test T:103.0	11.64 2.10.93	7.46 2.05	61.57	134.35	1.42 x 10^{-2}	590	60	
2	**MAHENDRAGIRI (OW)** (08°17' 30";77° 33' 45"-58 H/11) 94.287	1993	200.00 27.70	Gneiss	32.50-33.50/0.75 108.70-109.70/2.44 138.20-139.20/3.28 157.50-158.50/5.42	Air Test T : 56.0	11.30 2.11.93	6.05 3.40	153.74	298.56	--	620	67	
3	**MAHENDRA GIRI (EW)-2011** (Liquid - Hydrogen) (08° 17' 50"; 77° 33' 45"-58 H/11) 98.750	1993	200.00 38.00	Gneiss	39.00-40.00/0.75	Slug Test T=14.33	17.72 24.8.93	--	--	--	--	466	50	
4	**ARAMBOLI (EW) - 2008** (08° 14' 58";77° 31' 45"-58 H/12) 98.120	1993	190.00 14.00	Gneiss & Khondalite	24.20-25.20/0.21 66.90-67.90/0.75	Air Test Q = 0.75 DD=12.12 Sp.Cap=3.69 T = 7.2	5.41 27.8.93	--	--	--	--	570	60	
5	**BHOOTHAPANDI (EW)-2007** (08° 15' 35" ;77° 27' 30"-58 H/7) 29.780	1993	200.00 9.00	Gneiss and Khondalite	76.80-77.80/0.43 at 200/- 0.96	Air Test Q=1.19 DD = 18.0 Sp.cap:3.96 T=2.00	5.07 25.9.93	--	--	--	--	5200	1524	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
6	**SUCHINDRAM (EW) -2009** (08° 12' 24";77° 24' 02" - 58 H/8) 16.210	1993	62.60 17.20	Khondalite, Pegmatite	21.90-22.90-Meagre 43.30-46.30 /9.9	Air Test Q =10.81 DD=4.62 Sp.cap=140.38 T=63	2.23 30.9.93	--	--	--	--	21200	7480	
7	**SUCHINDRAM (OW)** (08° 12' 20"; 77° 24' 00" -58 H/8) 16.405	1993	191.00 13.57	Khondalite	27.90-28.90/0.58 165.10-166.10/1.19 at 191.00-2.44	Air Test Q = 1.19 DD=14.00 Sp.cap=5.1 T=0.98	2.20 14.10.93	--	--	--	--	11270	3616	
8	**KANYAKUMARI (EW)-2012** (08° 05' 00" ;77° 33' 10"- 58 H/8) 20.990	1993	195.00 11.00	Gneiss and Khondalite	43.50-44.50/0.58 119.80-120.80/1.75	Slug Test Q = 1.75 T = 14.00	12.27 1.11.93	--	--	--	--	4900	1347	
9	**MARAPADDI(EW)-2005** (08° 20' 20"; 77° 15' 05"- 58 H/7) 53.430	1993	184.40 11.50	Gneiss Khondalite	53.20-54.20-Meagre 110.10-111.20/0.430	Slug Test Q = 0.75 T = 2.0	2.70 2.12.93	--	--	--	--	--	--	
10	**MANGALAM(EW)-2006** (08° 18' 00";77° 19' 00"-58 H/7) 74.280	1994	49.10 7.50	Gneiss	16.60-17.60-Meagre 21.70-22.70/1.75 30.80-31.80/11.76 48.10-49.10/14.00	--	1.60 24.6.95	12.00 12.95	55.59	21.86	5.693x 10^{-3}	353	11	
11	**MANGALAM (OWI)** (08° 18' 00";77° 19' 00"-58 H/7) 73.310	1994	43.00 5.50	Gneiss	27.80-28.80/3.28 40.00-41.00/14.00	"	2.9 24.6.95	-- 11.61	--	--	--	310	11	
12	**VATTAM (EW) - 2010** (08° 14' 00";77° 17' 05" - 58 H/7) 61.480	1994	62.40 4.50	Gneiss	17.60-18.60/0.21	Slug Test T= 6.3	9.60 28.1.94	--	--	--	--	--	--	
13	**CHEMMANGALAI (EW)-2002** (08° 23' 10";77° 12' 20"-58 H/3) 53.320	1994	180.00 18.40	Gneiss	18.20-19.20 Meagre 180.00 Meagre	Slug Test T=0.85	10.67 21.2.94	--	--	--	--	--	--	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
14	**PARVATHIPURAM (EW)-2014** (08° 11' 15";77° 24' 45"-58 H/8) 29.165	1994	200.00 10.50	Gneiss	24.80-25.80-Meagre 200.00/0.21	Slug Test T=10.50	2.20 4.3.94	--	--	--	--	--	--	
15	**MARTHANDAM (E.W.)-2003** (08° 17' 02";77° 10' 01"-58 H/3) 84.460	1994	135.60 21.30	Gneiss	24.80-25.80/0.75 87.80-88.80/2.44 135.60/3	APT	14.59 20.6.94	1.6 33.13	2.89	11.87	1.16 x 10^{-3}	695	131	
16	**MARTHANDAM (OW)** (08° 17' 02" ;77° 10' 01"-58 H/3) 85.010	1994	111.30 20.50	Gneiss	12.50-13.60/Meagre 67.40-68.50/1.19 111.30/2.44	Air Test Q : 2.44 DD=2.3 Sp.cap.63.65 T=16.25	13.10 17.3.94	1.0	--	--	--	710	160	
17	**MUNCHIRAI (EW)-2001** (08° 23' 10";77° 12' 20"-58 H/3) 22.320	1994	36.00 23.30	Khondalite	19.00-20.00-0.75 34.00-35.00 - 4.27	--	3.73 22.3.94	---	--	--	--	--	--	
18	**ANANDMANGALAM (EW)-2004** (08° 16' 45";77° 09' 40" -58 H/3) 19.885	1994	160.00 41.60	Gneiss	53.00-54.00-Meagre 80.60-81.60-0.75	Slug Test T=5.57	8.60 27.10.94	--	--	--	--	--	--	

Q - Discharge (lps)
DD - Drawdown (m)
Sp.Cap - Specific Capacity (lpm/m of DD)
T - Transmissivity (m^2/day)

S - Storativity
EC - Electrical Conductance (microsiemens/cm at 25° C)
Cl - Chloride (mg/l)

EW - Exploratory Well
OW - Observation Well
PZ - Piezometer
TDS - Total Disolved Solids (mg/l)

Basic data of piezometers constructed under hydrology project for **Kodaiyar River basin**

HYDROLOGY PROJECT

BASIC DATA OF PIEZOMETERS CONSTRUCTED UNDER HYDROLOGY PROJECT

Sl No	Well No/Village	Block	Topo-sheet No	Latitude	Longitude	RL (magl)	Date of Drilling	Geology	Depth of Bore hole (mbgl)	Weathered Residuim (mbgl)	Fracture zones encountered (mbgl)	Dis-charge (lps)	Water level (mbgl)	EC (umho s/cm)
1	1601PZ KANYAKUMARI	Agasteeswaram	58H/12	08°05'20"	77°33'00"	22.34	26/08/1999	Gneiss	40.60	17	30.0-30.1	0.020	13.00	10000
2	1602PZ RAJAKKAMANGALAM	Rajakamangalam	58H/12	08°07'55"	77°22'00"	22.07	25/08/1999	Alluvium	14.65	_	9.3-13.5	0.014	6.10	-
3	1603PZ THAKKALAI	Thakkalai	58H/12	08°14'55"	77°18'30"	42.97	23/08/1999	Alluvium	31.45	_	19.75-22.0	0.078	10.00	1955
4	1604PZ KARUNGAL	Thovalai	58H/08	08°14'05"	77°14'05"	134.71	25/08/1999	Granite Gneiss	54.40	28.5	28.5-34.2; 51.2-52.3	0.078	16.80	1190
5	1605PZ MARTHANDAM	Melpuram	58H/07	08°19'00"	77°12'30"	84.57	24/08/1999	Alluvium	28.15	_	10.0-14.0	0.215	15.00	16000
6	1606PZ TIRUVATTAR	Thiruvattar	58H/07	08°20'00"	77°16'04"	77.51	23/08/1999	Granite Gneiss	48.60	6.1	16.25-16.35; 39.0-39.2	0.078	22.50	15360
7	1607PZ NAGERKOIL	Nagarkoil	58H/08	08°10'30"	77°26'00"	11.92	28/08/1999	Alluvium	17.80	_	11.65-17.0	0.014	9.20	-