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

KANNUR DISTRICT, KERALA

केरल क्षेत्र, त्रत्रवेंद्रम

Kerala Region, Trivandrum

CGWB/KR/TR SERIES/2022-17

केंद्रीय भूजल बोर्ड, केरल क्षेत्र
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग
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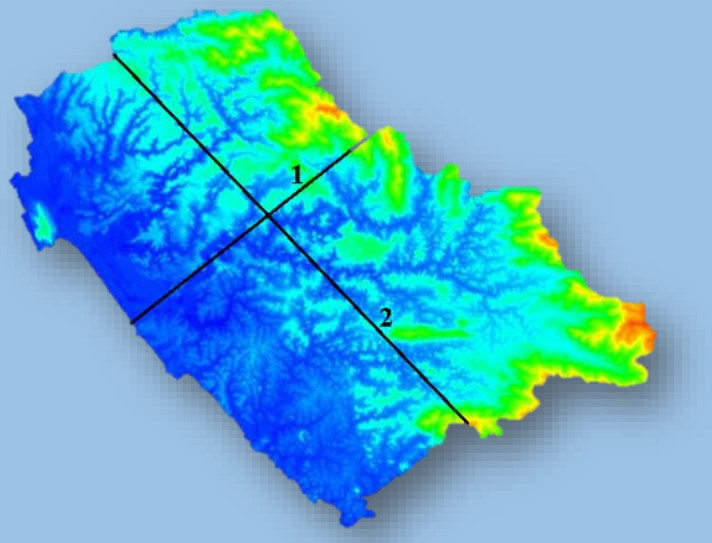
CENTRAL GROUND WATER BOARD, KERALA REGION
MINISTRY OF JAL SHAKTI
DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT AND GANGA REJUVENATION
GOVERNMENT OF INDIA

AQUIFER MAPPING AND MANAGEMENT PLAN OF KANNUR DISTRICT, KERALA

(AAP: 2021-22)



VIJESH V.K
SCIENTIST-C

तिरुवनंतपुरम/**THIRUVANATHAPURAM**
फ़रवरी **2023/FEBRUARY 2023**

केंद्रीय भूजल बोर्ड, केरल क्षेत्र
जल शक्ति मंत्रालय
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FOREWARD

The National Project on Aquifer Mapping (NAQUIM) is an initiative of the Ministry of Jal Shakti, Department of Water Resources, River Development & Ganga Rejuvenation, Government of India, for mapping and managing the entire aquifer systems in the country. The aquifer systems in Kerala are being mapped as part of this Programme. The target scale of investigation is 1:50,000 and envisages detailed study of the aquifer systems up to 200 m depth in hard rock and 300 m depth in sedimentary rock, to ascertain their resource, water quality, sustainability, and finally evolve an aquifer management plan. This report pertains to aquifer mapping and management plan of Kannur district.

The report titled "Aquifer Mapping and Management plan, Kannur district, Kerala" gives a complete and detailed scientific account of the various aspects of the hard rock and soft rock aquifers in the district including its vertical and horizontal dimensions, flow directions, quantum and quality of the resources, of both - the shallow and deeper zones in the aquifer systems. Voluminous data generated on ground water regime, ground water quality, ground water exploration, geophysical studies etc. for detailed analysis. The information is further supplemented by various data collected from Central and State departments. It portrays the various ground water issues pertaining to the area along with recommendation for suitable interventions and remedial measures. Thus, it provides a holistic solution to the water security problems in Kannur district.

This document has been compiled by Shri. Vijesh V.K., Scientist C under the overall guidance of Dr. N. Vinayachandran, Scientist D & Nodal Officer and Shri. M. Santhana Subramani, Scientist D & Team leader. The painstaking efforts of field hydrogeologist Shri. Vijesh V.K. in carrying out the aquifer mapping and preparation of this report is well appreciated. Shri. Roopesh G. Krishnan, Scientist C & Smt. Anu V, Scientist B deserves appreciation for the meticulous scrutiny of this report before printing. I am thankful to the Chairman and Members of CGWB, Faridabad for their valuable guidance in finalizing this report. I am thankful to Shri. Sunil Kumar, Chairman and Dr. A. Subburaj, Member of CGWB, Faridabad for their valuable guidance in finalizing this report. I am also thankful to the officers of CGWB, Kerala Region, Thiruvananthapuram for their technical support in preparation of report. Thanks, are due to various organizations of Government of Kerala such as Ground Water Department, Irrigation Department, Agriculture Department, Land Use Board etc. and Central Government Departments such as GSI, IMD and Survey of India for providing data for aquifer mapping studies.

This report evolved in the present form through incorporations and modifications as suggested during the presentation of the report before the State Ground Water Coordination Committee (SGWCC), Chaired by the Water Resources Secretary, Kerala State, Sh.Pranab Jyoti Nath, IAS and is subject to approval of National Level Expert Committee (NLEC). The contribution of the committee in improvising the content of this report are acknowledged with gratitude.

I hope that this compilation will be of much help to the planners, administrators and stakeholders in the water sector for the optimal and sustainable management of ground water resources in Kannur district.

Thiruvananthapuram,
November 2022

(T.S. Anitha Shyam)
Regional Director

AQUIFER MAPPING AND MANAGEMENT PLAN OF KANNUR DISTRICT, KERALA

(AAP 2021-22)

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AQUIFER MAPPING AND GROUND WATER MANAGEMENT PLAN, KANNUR DISTRICT, KERALA

1. INTRODUCTION

In XII five-year plan, National Aquifer Mapping (NAQUIM) has been taken up by CGWB to carry out detailed hydrogeological investigation on topographic sheet scale (1:50,000). Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical analyses is applied to characterize the quantity, quality and sustainability of ground water in aquifers.

The vagaries of rainfall, inherent heterogeneity of hard rock aquifers, over exploitation and lack of regulation mechanisms had a detrimental effect on ground water scenario of the country in last decade or so, demanding a paradigm shift from "traditional groundwater development concept" to "modern groundwater management concept".

Varied and diverse hydrogeological settings demand precise and comprehensive mapping of aquifers down to the optimum possible depth at appropriate scale to arrive at robust and implementable ground water management plans. The proposed management plans will provide the "Road Map" ensuring sustainable development of ground water resources, thereby primarily improving drinking water security and irrigation requirement. Thus, the crux of NAQUIM is not merely mapping, but reaching the goal of community participation in ground water management.

By understanding the goals of NAQUIM, during the Annual Action Plan of 2021-22, Kannur district of Kerala state covering a geographical area of 2966 sq.km. has been taken up. The aquifer maps and management plans formulated subsequently by this study will be shared with the Kannur district administration for its effective implementation.

1.1 Objective and Scope

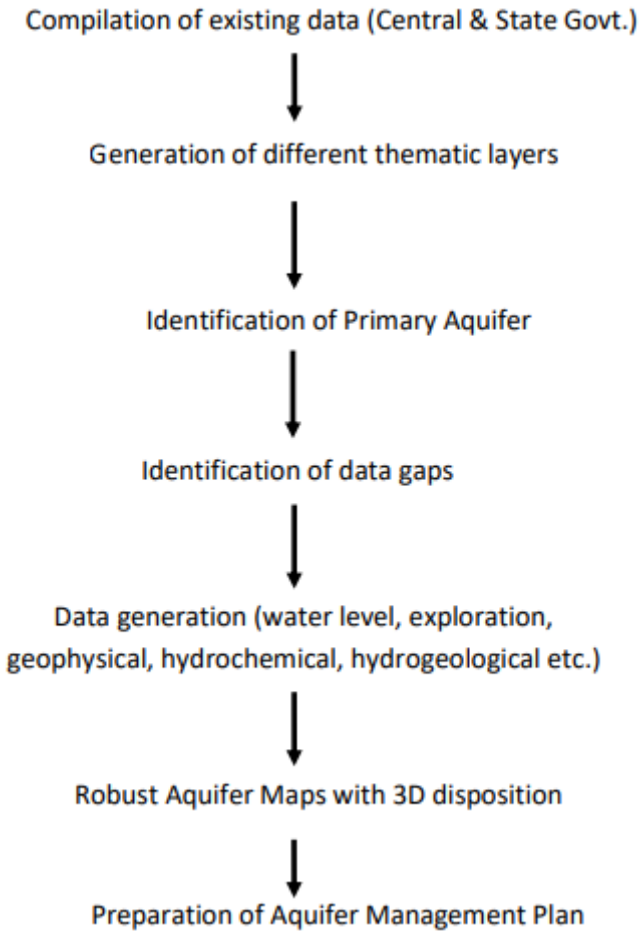
Aquifer mapping itself is an improved form of groundwater management – recharge, conservation, harvesting and protocols of managing groundwater. These protocols will be the real derivatives of the aquifer mapping exercise and will find a place in the output i.e, the aquifer map and management plan. The activities under NAQUIM are aimed at:

- Identifying the aquifer geometry,
- Aquifer characteristics and their yield potential
- Quality of water occurring at various depths
- Aquifer-wise assessment of ground water resources
- Preparation of aquifer maps and
- Formulate ground water management plan.

This clear demarcation of aquifers and their potential will help the agencies involved in water sector to ascertain the volume of water available for various uses as well as the need of management measures implemented to achieve a sustainable development goal.

1.2. Approach and Methodology

The ongoing activities of NAQUIM include topographic sheet wise micro-level hydrogeological data acquisition, geophysical and hydro-chemical investigations, supplemented by ground water exploration down to the depth of 200/300 meters. The data on various components thus collected were brought on GIS platform by geo-referencing for its utilisation in the preparation of various thematic maps. The approach and methodology followed for Aquifer mapping is as given below:



1.3 Study area

Kannur is the one of the northern districts in Kerala state covering an area of 2966 sq.km, constituting 7.63 % of the total area of the state covering parts of Survey of India toposheets 49M and 48P. The district is covered with dense tropical forests, plantations, scrublands and agricultural lands situated along and at the foot hills of Western Ghats with a mappable area of 1351 sq.km. The district is bounded by North latitudes 11^0 40' and $12^0$48' and East longitudes $74^0$52' and $76^0$07'. It is bounded by Kasaragod district in the north, Kozhikode district in the south, Coorg district of Karnataka and Wayanad district in the east and the Lakshadweep Sea in the west. The Census data for the year 2011 reveals that the district has total population of 25,23,003 persons with 11,81,446 males and 13,41,557 females and a literacy rate of 95.1%.

Kannur district is served by the National Highway-17 (NH-17) connecting it with all major towns in the state. Besides, the Kannur district is connected by a number of all-weather state

highways passing through the district. One International airport and 3 minor ports at Thalasseri Kannur and Azhikkal are also present in the district. The Cochin-Mangalore broad gauge line passing through the district enables ample connectivity by rail means also. Administratively, the district is divided into 5 taluks (Taliparamba, Kannur, Thalassery, Iritty and Payyannur), 11 development blocks (Payyannur, Kallyassery, Taliparamba, Irikkur, Kannur, Edakkad, Thalassery, Koothuparamba, Panur, Iritty and Peravoor) 1 Corporation (Kannur) 9 Municipalities (Koothuparamba, Mattannur, Payyannur, Thalassery, Taliparamba, Anthoor, Panur, Iritty, and Sreekantapuram) and 71 Gramapanchayaths. The Census data for the year 2011 reveals that the district has total population of 25, 23,003 persons with 11, 81,446 males and 13,41,557 female's population with a literacy rate of 95.1%. The administrative map of Kannur district is shown in figure 1.1

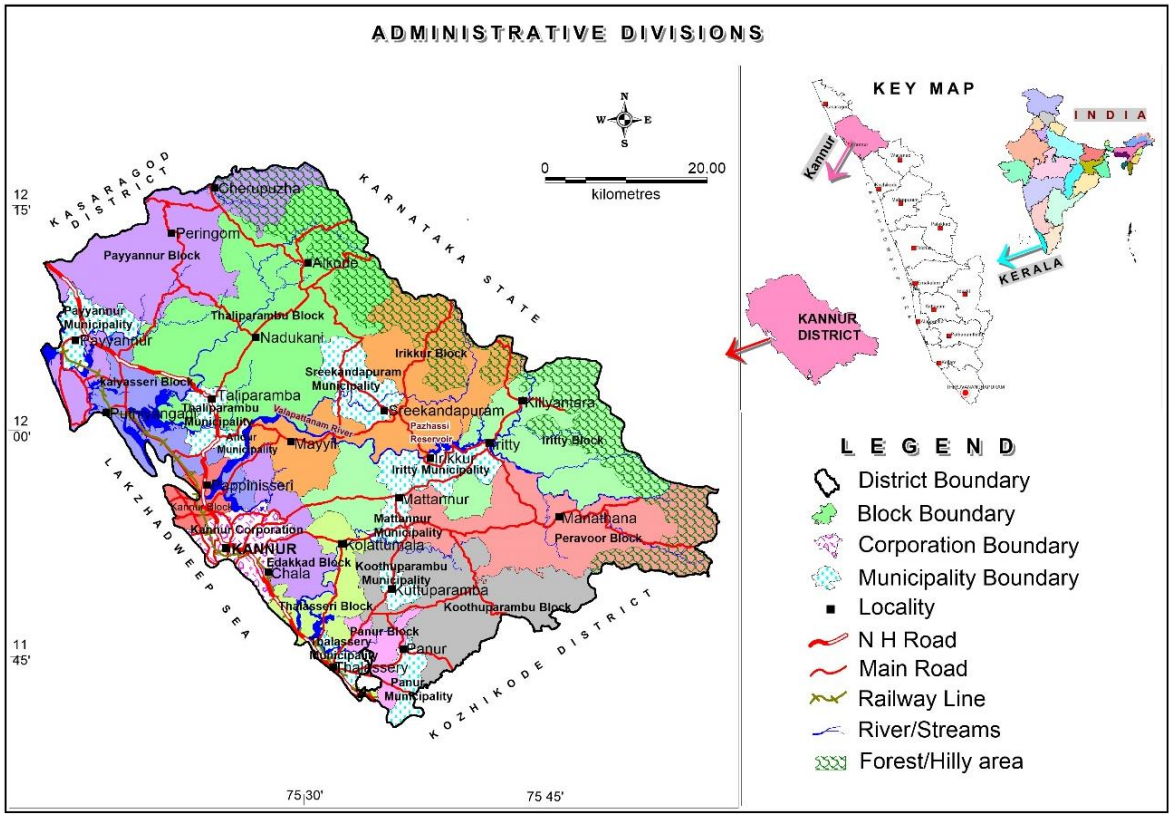


Figure 1.1 Administrative set-up, Kannur district

1.4 Data Adequacy and Data Gap Analysis and Data Generation:

The available data on Exploration activities, Geophysical Surveys, Ground water monitoring and ground water quality of Central Ground Water Board were compiled and analysed for aquifer mapping studies. In addition to these, data on ground water monitoring and ground water quality from State Ground Water Department, Govt. of Kerala (GWD) were also utilised. The data adequacy and data gap analysis were carried out for each quadrant of topographic sheet as per the criteria suggested in the manual of Aquifer Mapping in respect of the following primary and essential data requirements and the same is shown in table 1.1 viz.

- Exploratory Wells
- Geophysical Surveys
- Ground Water Monitoring and
- Ground Water Quality

Table 1.1 Data Gap Analysis

Sl.No.	Items	Data available with State govt. Agency	Data available with CGWB	Data Requirement/ Data gap identified	Data generated	Total
1	Ground water level data	36 DW+28 PZ	93 DW+15 PZ	24 DW	24 DW	196
2	Ground water quality Data	36 DW+28 PZ	DW 22 + BW 12	6 DW+1 BW	6 DW+1 BW	105
3	Borehole Lithology Data	--	16 EW	Nil	Nil	16
5	Pumping Test (EW)	--	9 (T value)	Nil	Nil	9
6	Land use and Land Cover, Drainage	Kerala State Land Use Board				
7	Geology	Geological Survey of India				
8	Soil	National Bureau of Soil Survey (NBSS)				
9	Rainfall / Meteorological data	Indian Meteorological Department / Irrigation Design and Research Board (IDRB)				

1.5 Rainfall and Climate

Kannur experiences a very wet tropical monsoon climate (Am under the Köppen climate classification.) In the months of April and May, the average daily maximum temperature is about 35 °C (95 °F). Temperatures are moderate in December and January: about 24 °C or 75.2 °F. Like other areas on the Malabar Coast, this city receives heavy rainfall during the Southwest monsoon. To understand the characteristics of climate, knowledge of physiography is very important. The movement of monsoon current is normally blocked by the mountain ranges. Consequently, uplifting and condensation of air takes place, which provide rainfall on windward side and scarcity of rainfall on the leeward side. Thus, orographic precipitation is responsible for most of the rains in Kannur and the precipitation varies in different altitudinal ranges that subjects to fluctuation of wind by orientation of hill. Generally, climate varies from east to west with the descending elevation of landscapes.

The normal annual rainfall in the district varies from less than 3000 mm (along NW coastal plains) to above 4500 mm (SE hilly tracts). The average annual rainfall of the district is 3229 mm (2006 to 2020 period). Based on weather and climatic situation in Kannur, year is broadly divided in to four seasons:

- Winter (January-February)

- Hot Weather Period (March-May)
- South West Monsoon (June-September)
- North East Monsoon (October-December)

The south west monsoon contributes a major share (83 %) of the rainfall in Kannur district whereas the northeast monsoon season accounts for about 10%. The balance 7 % is contributed during the period from January to May. The isohyets of normal annual rainfall in Kannur district is depicted in figure 1.2. The monthly rainfall during the last five years from 2016 to 2020 is given in table 1.2 and graphical representation of the same is given in figure 1.3.

Table 1.2. Monthly rainfall (2014-18)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2016	0	0	0.8	1	138.4	801.8	616.1	436.5	136.6	45.1	22	17.3	2215.6
2017	11.5	0	6.1	48.2	181.2	694.3	623.6	553	430.4	170.9	69.4	5.9	2794.5
2018	2	0	12.6	86.2	346.1	975.3	969.5	685.4	11.9	256	25.6	23	3393.6
2019	0	0	0.8	31.9	40.2	516.9	1020.1	1107.2	489.9	416.7	127.6	65.8	3817.1
2020	0	1	4.3	56.4	154.2	987.8	856.2	803.7	718.2	259.1	39	46.5	3926.4

Relative humidity is more during south west monsoon season (i.e., June to September). It is more during morning hours and is less during evening hours. Humidity ranges from 77 to 88 % in the district. Evaporation is more during summer months of March to May and low during the months of June to November. The mean evaporation ranges from 2.6 to 5.7 mm/day. The monthly PET ranges from 124.5 to 170.6 mm. PET values are lower than the monthly rainfall during the months of May to October indicating water surplus for possible recharge into groundwater regime during these months.

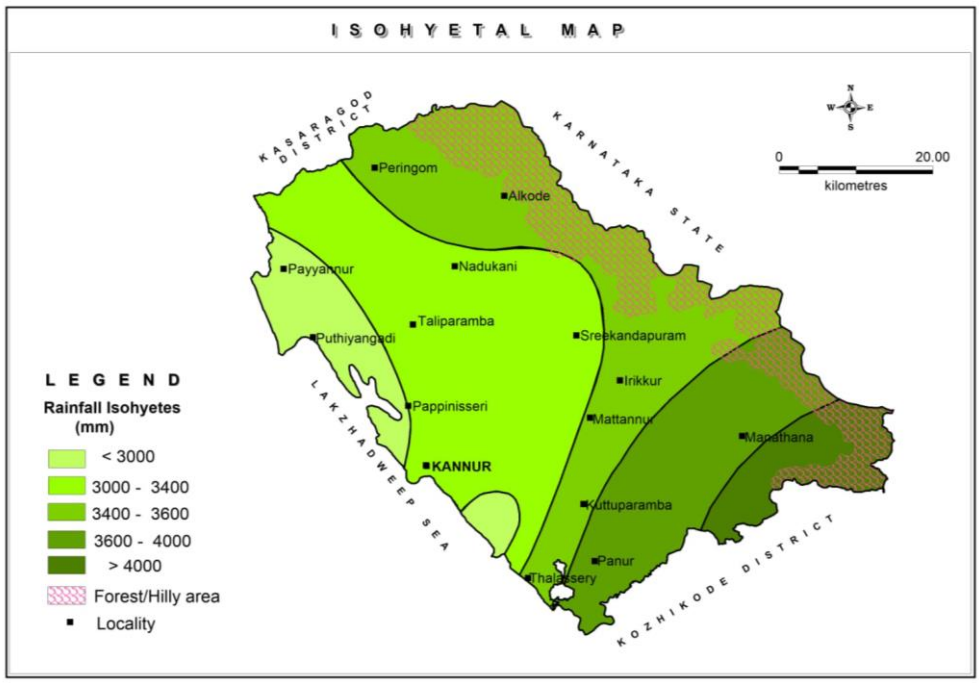


Figure 1.2. Isohyets of Normal Annual Rainfall in Kannur district

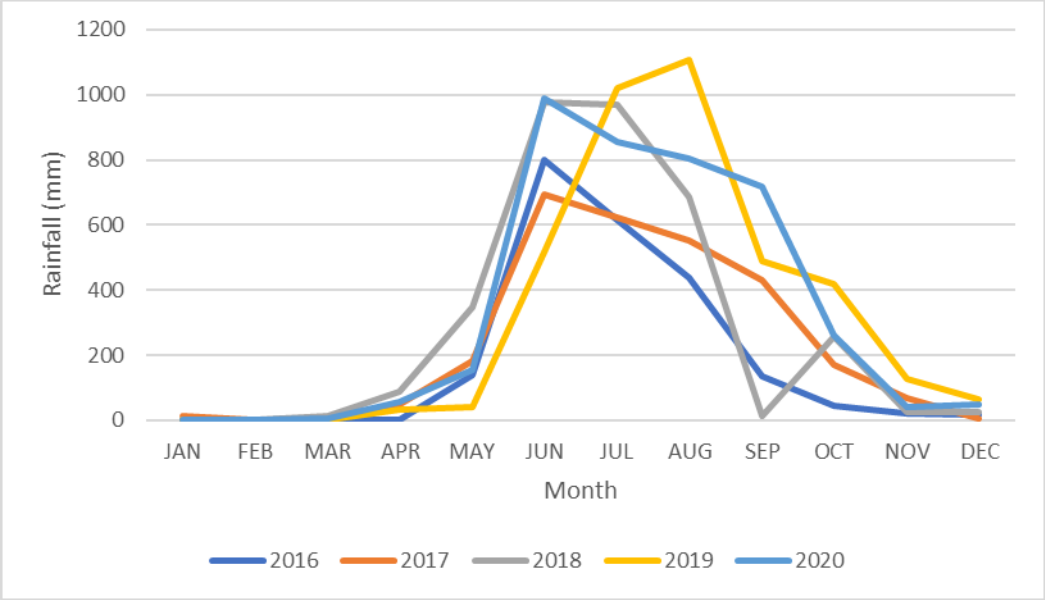


Figure 1.3. Monthly rainfall variation-Histogram (2014-18)

1.6 Physiography and Geomorphology

Kannur district can be divided physiographically into three distinct geomorphologic units viz the coastal plains and lowlands in the western part (less than 7.5 mamsl elevation), the central undulating terrain comprising the midland region (7.5 to 75 m amsl elevation) and eastern highland region (above 75 m amsl elevation). The coastal plains occur as a narrow belt of alluvial deposits running parallel to the coast with a maximum width of about 15 km. The Midland region forms a plateau land at certain places covered by a thick cover of laterites. The hilly tract in the eastern part consists of highly rugged terrains. The Ezhimala peak (259.69 m) with the characteristic N-S alignment is a distinct physiographic unit in the coastal plains. Minor cliffs of laterite generally rising to an elevation of 50 to 60 m above mean sea level are found at Mahe and Thalasserry. This is immediately to the east of the coastal strip, rising from 40 to 100 m above msl. The valleys in the plateau are gorge like and V shaped cut by youthful streams. The hilly tract along the eastern part of the district constitutes the highland region and is highly rugged. Development of bad land topography along the margins of the valley is a common feature observed in the district.

Around 51 % of the district falls under the midland category and 45% under highlands and the remaining under lowlands, mostly occupying coastal plains. A digital elevation model (SRTM-USGS) depicting the major physiographic features in the district given in figure 1.4

The major geomorphic features present in the district are carved out by denudational and fluvial activities, including denudational hill, dissected plateau, lateritic plateau, valleys, Piedmont zones and river channels. Denudational hills are the remnants of the natural dynamic process of denudation and weathering. The ground water potential of these geomorphologic features is limited and if any, depends on the presence of secondary porosity instigated by tectonic process and subsequent deformations. Denudational hills are prominent along the eastern hilly tracts of the district.

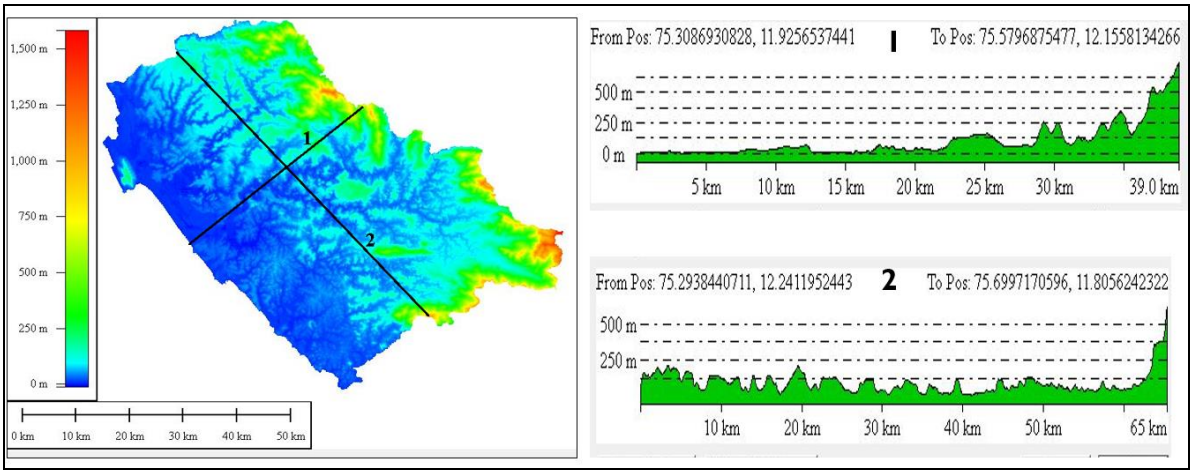


Figure 1.4. Digital Elevation Model of Kannur district

Plateaus forms the most prominent and widespread geomorphological unit in the district and has moderate ground water potential (upto 10000 lpd). The Plateaus are mostly tapped through dug wells having depth range of around 10-15 m below ground levels. Coastal plains are prominent along the western parts of the district, which holds very good ground water potential up to 30000 lpd and are mostly abstracted through small diameter dug wells and filter point wells. The geomorphological map of the district is given in figure 1.5.

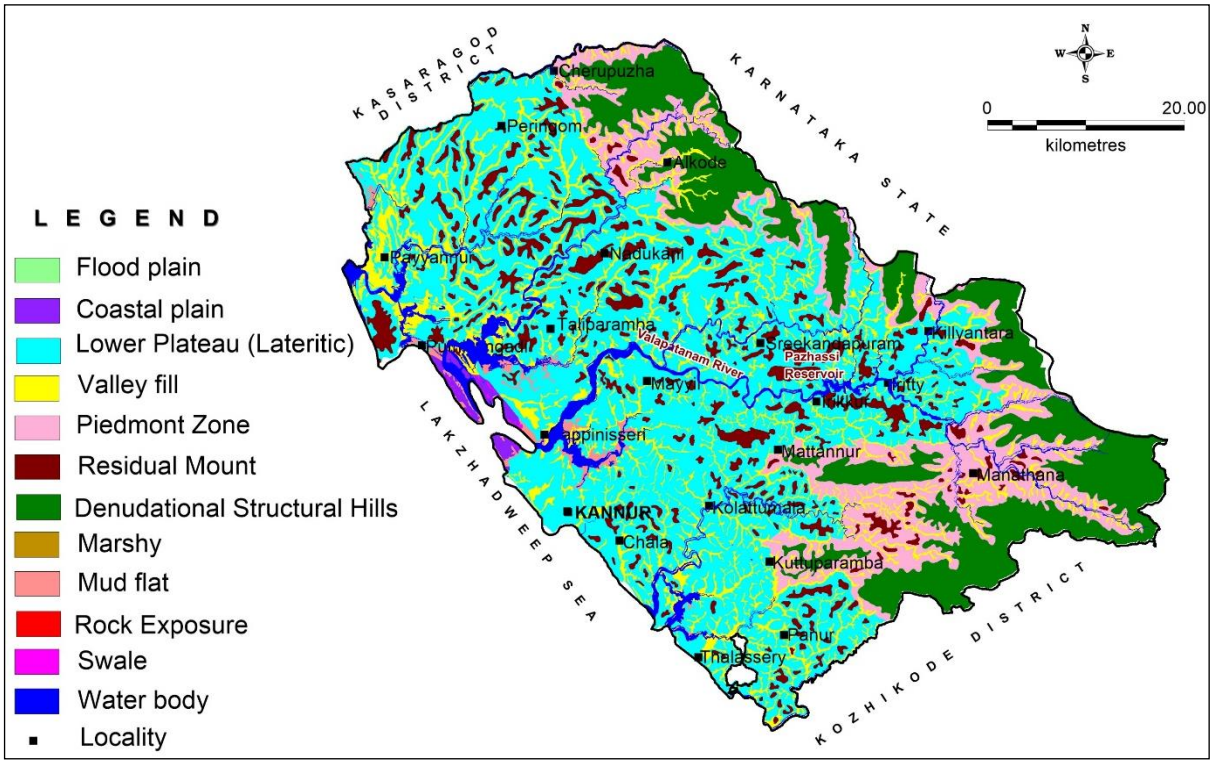


Figure 1.5. Geomorphology map

1.7 Land Use, Soil, Agriculture, Irrigation and Cropping Pattern

An understanding of land use/ land cover is important as it has a direct relation with ground water resource availability and utilisation. As per Agricultural Statistics 2019-20, 16.40 % of Kannur district comes under forest area (487.34 Km^2). Summarised land use pattern and cropped area of the district is given in table 1.3. The land use map of the district is shown in figure 1.6. The major crops raised in the district are Coconut, pepper, rubber, banana, arecanut, cashew etc. The area under different crops is given in table 1.4.

Table 1.3. Land use pattern

Item	Area (Ha)	Percentage to total district area
Forest	48734	16.40
Land put to non-agricultural use	40133	13.51
Barren and uncultivable land	1169	0.39
Land under miscellaneous tree crops	173	0.06
Cultivable waste land	6424	2.16
Fallow other than current fallow	3443	1.16
Current fallow	2504	0.84
Still water	6484	2.18
Water logged area	372	0.13
Social forestry	73	0.02
Net area sown	187601	63.14
Area sown more than once	39680	13.36
Total Area Cropped	227281	76.50

Table 1.4. Area under different crops

Crop	Area (Ha)	Percentage of total cropped area
Paddy	5715	2.51
Pulses	546	0.24
Pepper	4742	2.09
Rubber	48050	21.14
Coconut	86877	38.22
Tapioca	1608	0.71
Other tubers	496	0.22
Vegetables	3250	1.43
Nutmeg	302	0.13
Arecanut	9612	4.23

(Source: Agricultural Statistics 2019-20, Kerala)

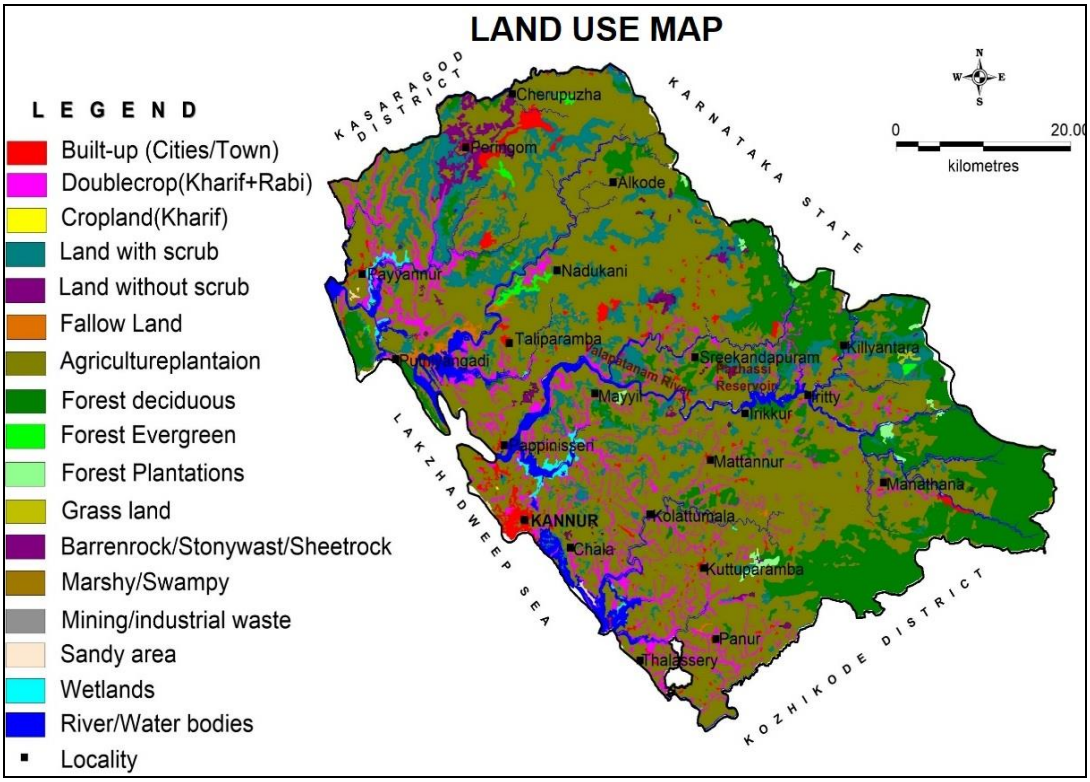


Figure 1.6. Land use/ Land cover – Kannur district

The source wise area irrigated as per Agricultural Statistics 2019-20 is given in table 1.5.

Table 1.5. Sources of Irrigation

Source	Area irrigated (Ha)	Percentage of net irrigated area
Small Stream (Thodu/Canal)	524	4.24
Pond	896	7.26
Well	7513	60.85
Bore well	573	4.64
Lift & Minor Irrigation	12	0.10
From River and Lake	696	5.64
Other sources	2232	18.08
Grand Total	**12343**	

(Source: Agricultural Statistics 2019-20, Kerala)

There are mainly four types of soil observed in the district. Lateritic soil, Brown hydromorphic soil, Coastal and river alluvium and Forest Loam

Lateritic soil – The predominant soil in the district is lateritic soil, which is the weathered product derived under humid tropical monsoonal conditions. It occurs mainly in the midland and hilly areas characterized by rugged topography. They range from sandy loam to red loam.

Brown hydromorphic soil – These are confined to the valleys between undulating topography in the midlands and in the low-lying areas of the coastal strip in the district. These soils are brown in colour and the surface texture varies from sandy loam to clay. They have been formed as a result of transportation and deposition of materials from adjoining hill slopes and also through deposition by rivers.

Coastal and riverine alluvium – The coastal alluvium is seen in the western coastal tract of the district. The coastal plain is characterized by secondary soils, which are sandy with poor water holding capacity. The width of the zone is more in the central part i.e., in the Kannur area and it is almost narrow in both north and southern areas of the district. The marshy soil in the coastal plain supports mangrove vegetation and is found at the estuaries and backwater extending inland along their courses. The soil is composed of recent deposits predominantly marine with some fluvial sediments along the coastline. These soils are immature with high sand content. Riverine alluvium is found along river valleys cutting across the extensive lateritic soils. The soil is very deep with surface texture ranging from sandy loam to clay. It is fertile, having water holding capacity and plant nutrients which are regularly replenished during floods.

Forest Loam – These soils are found in the eastern hilly areas of the district and are characterized by a surface layer rich in organic matter. They are generally acidic and are dark reddish brown to black in colour with loam to silty loam texture. Soil map of the district based on textural classification is given in figure 1.7

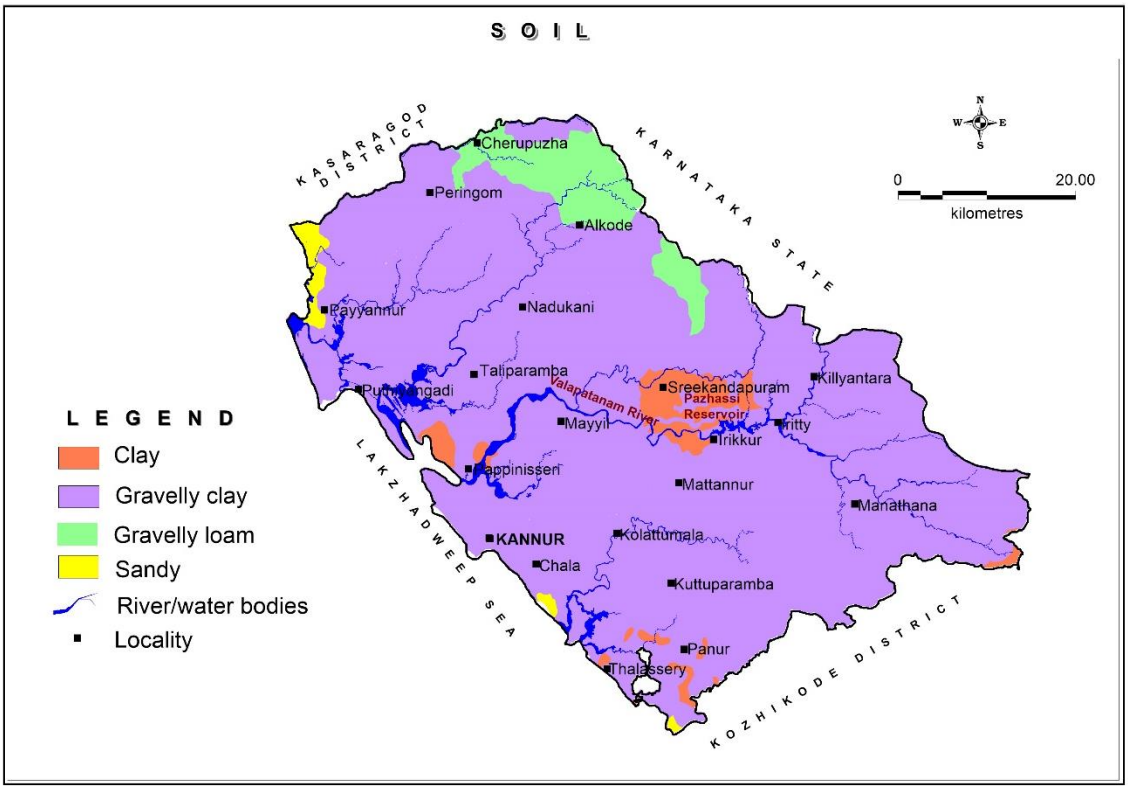


Figure 1.7. Textural classification of soils – Kannur district

1.8 Hydrology and Drainage

There exist 9 river basins in the district, viz. Mahe, Thalassery, Anjarakandy, Valapattanam, Kuppam, Ramapuram, Perumba, Kavvayi, and Karingote. Drainage map of the district is given in figure 1.8.

Kannur district is mainly drained by the Valapattanam and Anjarakandy rivers. Dendritic is the common drainage pattern. The Valapattanamriver, which is the longest in the district originates from Brahmagiri Reserve Forest in Coorg district of Karnataka. The drainage area of the river in Kerala is 1321 sq.km. The Anjarakandyriver originates from the Kannoth Reserve Forest. The drainage area of the river is 412 sq.km.

Kannur district has 12346 ha. area under irrigation, which accounts about 3.1 % of the net irrigated area of the state. Kannur district is provided with one major irrigation project along with some minor irrigation projects. The major irrigation scheme of the district is Pazhassi project. The Pazhassi Irrigation Project, the first major irrigation project in Northern Kerala, Partially Commissioned in 1979, is intended to raise the water level of the dam (barrage) at Kuyilur across the Valapattanam River in Kannur district. The Pazhassi project is spread over a total length of 413.123 km in the Taliparamba, Kannur and Thalassery Taluks of Kannur district with 46.26 km of main canal, 78.824 km of trenches, 142.039 km of distribution and 150 km of reservoirs. The project aims to irrigate two to three crops in the 11525 hectares of the district. Kerala Water Authority relies on Pazhassi Project as a source of water in Kannur district. In addition, the Japan Drinking Water Project and the Kannur International Airport are using water from Pazhassi Reservoir. In addition, the Kerala State Electricity Board (KSEB) has envisaged utilization of the water in this project for a small Hydro Project and the work is in the initial stage.

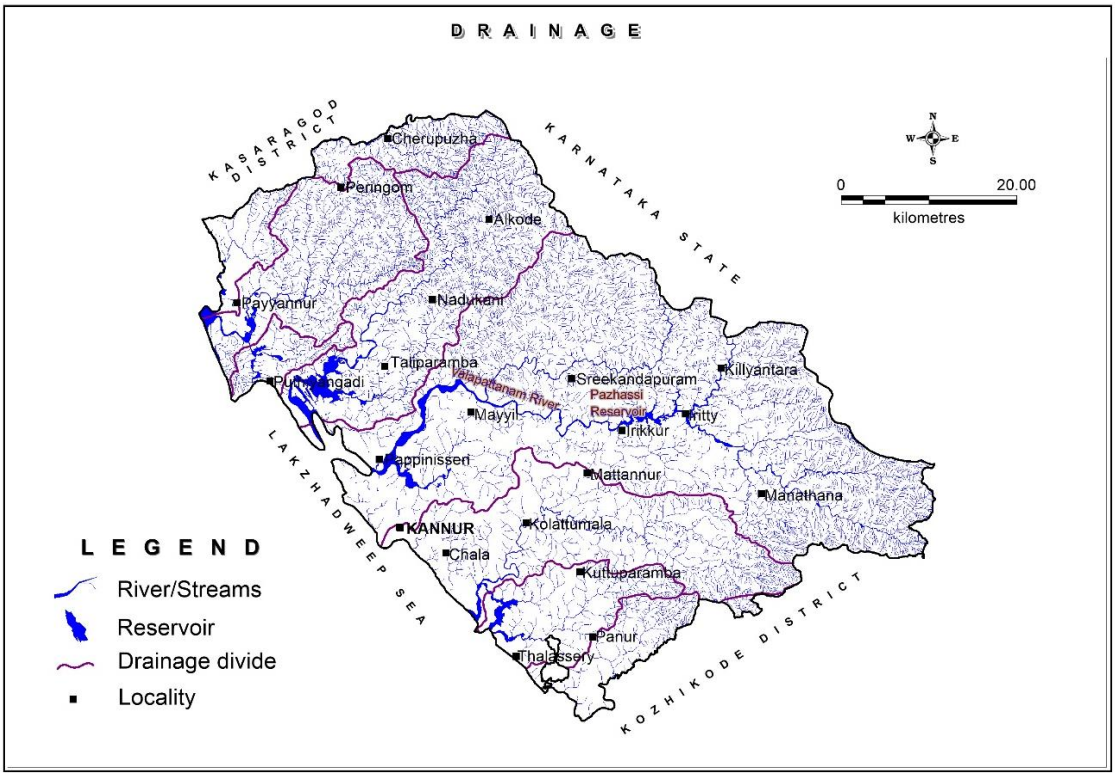


Figure 1.8. Drainage map

1.9 Prevailing Water Conservation and Recharge Practices

The State Ground Water department, Department of agriculture development and farmers welfare, Department of soil survey and soil conservation, Department of irrigation and Forests etc., are carrying out extensive water conservation and artificial recharge activities in the district. Watershed wise soil conservation activities are carried out in the district by soil conservation department in watersheds like Adakkathodu, Namboothirithodu, Monthal, Kanjirakkolly, Edappuzha-Manchodu, Kuzhikkalthode , Aadampara, Ambayathodu, Kolanchithode etc. Almost all government buildings are fitted with rooftop rainwater harvesting and dug well recharge schemes by the State ground water department. Social forestry schemes are practiced by forest department for the effective conservation of the water resources in the district. Department of irrigation has constructed many check dams, Nala bunds etc. in the district to ensure water conservation. Also, protection of springs which is a major source of water for domestic use are undertaken by the Irrigation department.

2.0 DATA COLLECTION AND GENERATION

The primary data such as water levels, quality, and lithological inputs available with CGWB as well as GWD, Govt. of Kerala has been collected and utilised as baseline data. However, ancillary data such as numbers of ground water abstraction structures, irrigation facilities, rainfall, etc. have been collected from the various State/Central govt. departments and compiled.

2.1 Data Collection and Compilation and Generation

The data collection and compilation for various components were carried out as given below.

- **i.** Hydrogeological Data – Current and historical water level data from 196 (153) Dug wells (DW) and 43 piezometers (PZ)) monitoring wells in Kannur district representing Aquifer-I (Weathered crystallines). The water levels of 16 exploratory wells (EW) in Kannur district representing Aquifer-II (Deeper Fractured crystallines) were also collected and compiled.
- **ii.** Hydrochemical Data - Ground water quality data from 92 (existing Ground Water Monitoring Stations of CGWB and GWD, Kerala) wells in Kannur district representing Aquifer-I and data of 13 Bore wells in Kannur district representing Aquifer-II were also collected and compiled.
- **iii.** Exploratory Drilling – Ground water exploration data of 16 existing exploratory wells in Kannur district were complied.
- **iv.** Geophysical Data –No available Vertical Electric Sounding (VES) data.
- **v.** Hydrology Data – Data on various irrigation projects, their utilisation status, number of ground water abstraction structures, and area irrigated from irrigation department were compiled.
- **vi.** Hydrometeorological Data – Long-term rainfall data of all rain gauge stations (Both of IMD and State Government) in the district were collected and compiled.
- **vii.** Water Conservation Structures – Numbers, type and storage potential of water conservation structures prevailing in the area were complied.
- **viii.** Cropping Pattern Data – Data on prevailing cropping pattern from Agriculture Dept. were complied.

2.2 Data Generation

After taking into consideration, the data available with CGWB on Ground Water Exploration, Geophysical survey, Ground Water Monitoring Wells (GWMW) and Ground Water Quality, the data adequacy were compiled. The requirement and data availability are analysed and based on gap analysis additional data were generated and the details are given in table 1 and discussed below:

2.2.1 Ground Water Exploration

Historic data of exploratory wells drilled by CGWB indicated the presence of 16 wells in Kannur district. The details of existing and newly constructed exploratory and observation wells are given in Annexure-I and in figure 2.1.

2.2.2 Ground Water Monitoring Wells

Data gap analysis revealed the existence of 172 GWMWs (129 DW+43 PZ) in Kannur district. Additional 24 KOWs wells were fixed for regime monitoring and micro-level data acquisition pertaining to Aquifer-1. Previously there existed deeper water level data for 16 EWs (Aquifer-II). The details of GWMWs and KOWs are given in Annexure-II and in figure 2.2

2.2.3 Ground Water Quality

As stated in table 1 already there existed 86 water quality data for Aquifer-1. Additionally, 6 samples were collected from KOWs for major element analysis. Also, 28 acidified samples were collected for trace metal analysis. For Aquifer-II the existing quality data from the exploratory wells drilled by CGWB was 12, besides additionally, 1 quality data was generated. The details of quality monitoring stations are given in Annexure-III and in figure 2.3

2.2.4 Thematic Layers

The following five thematic layers were also generated on the GIS platform, which supported the primary database and provided precise information to assess the present ground water scenario and also to propose the future management plan.

1. Drainage
2. Physiography/Dem
3. Geomorphology
4. Soil
5. Land Use – Land Cover
6. Geology and Structure

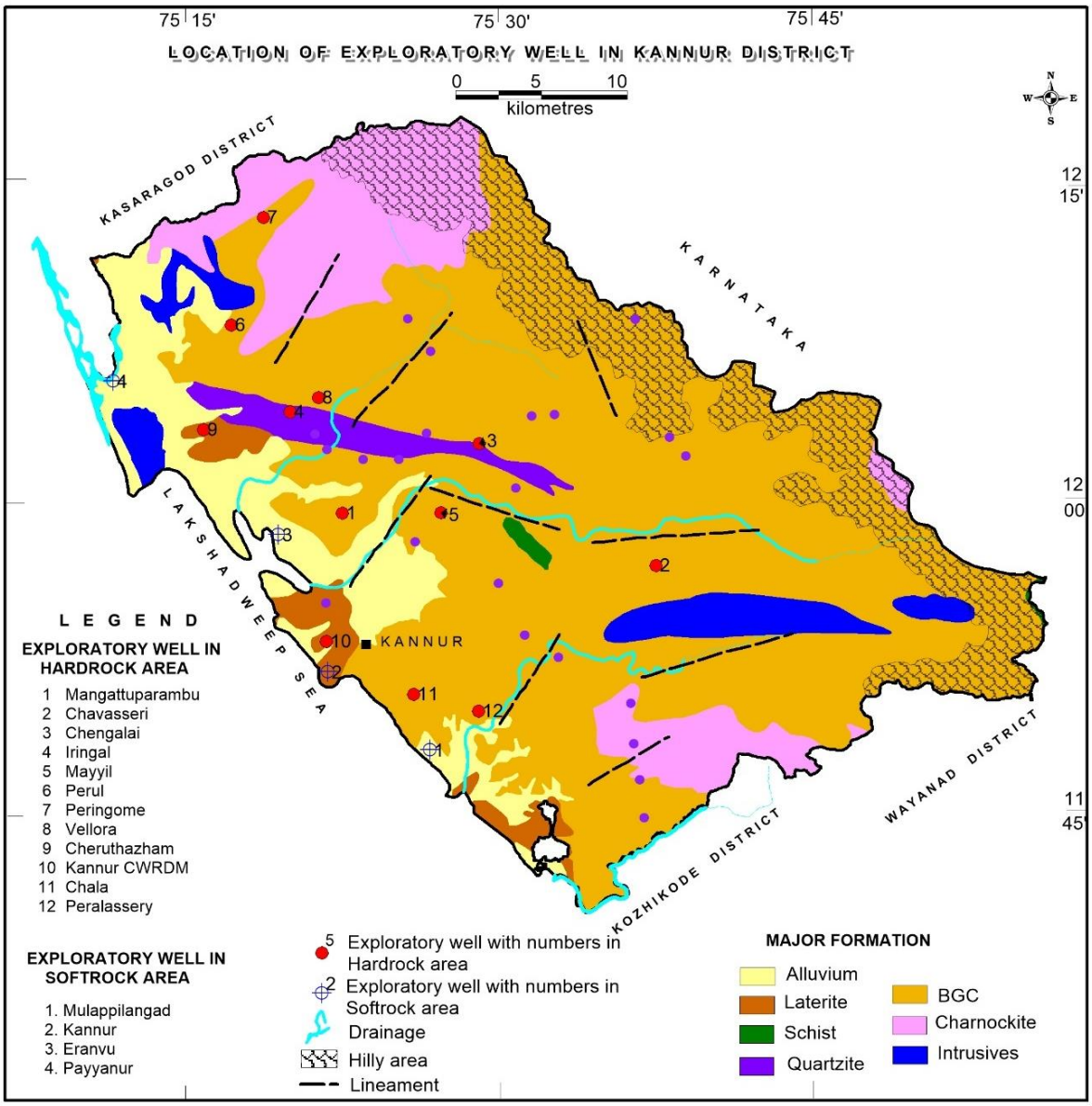


Figure 2.1. Location of EWs drilled in the study area

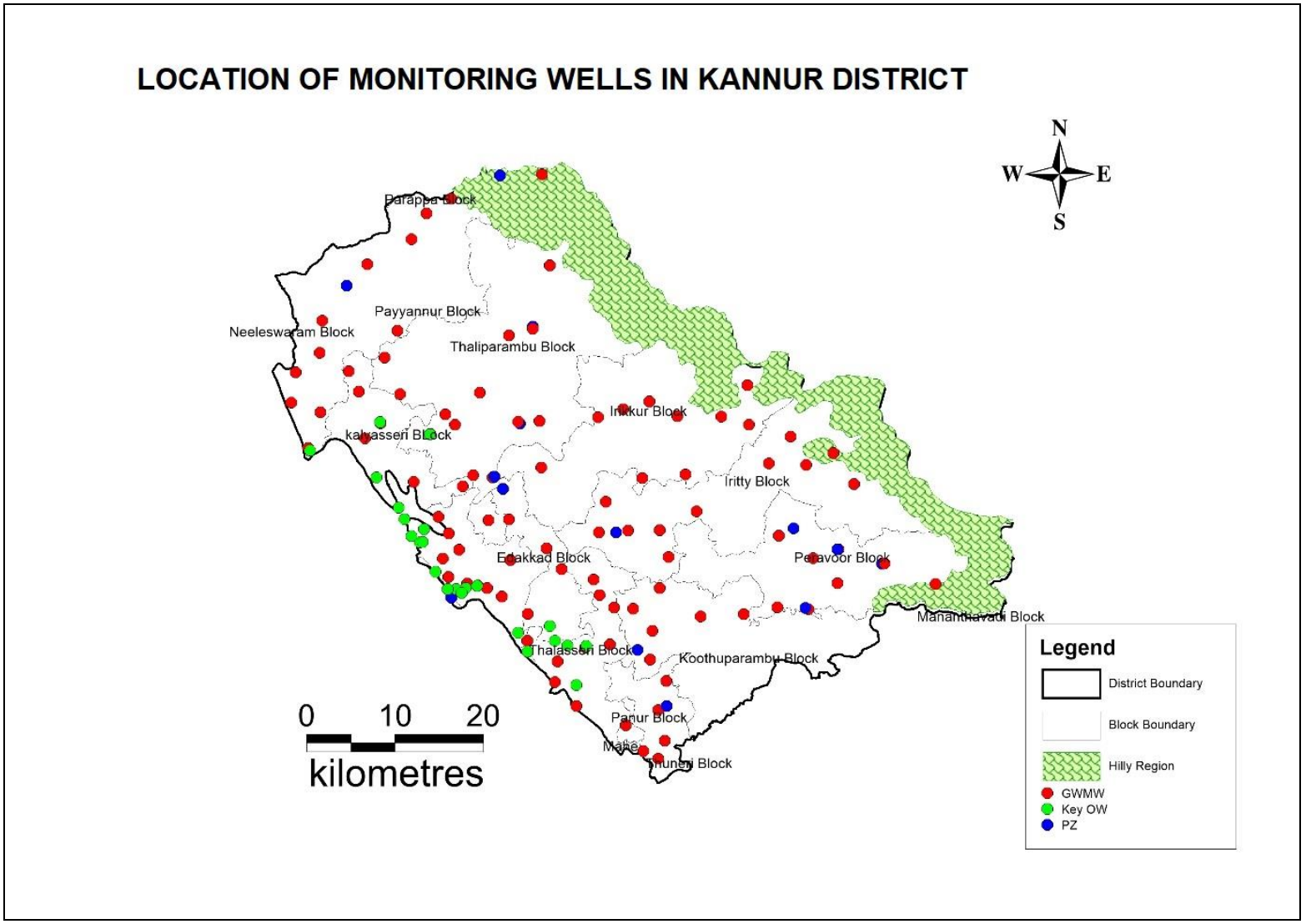


Figure 2.2 Location of water level monitoring stations (DWs) in the study area

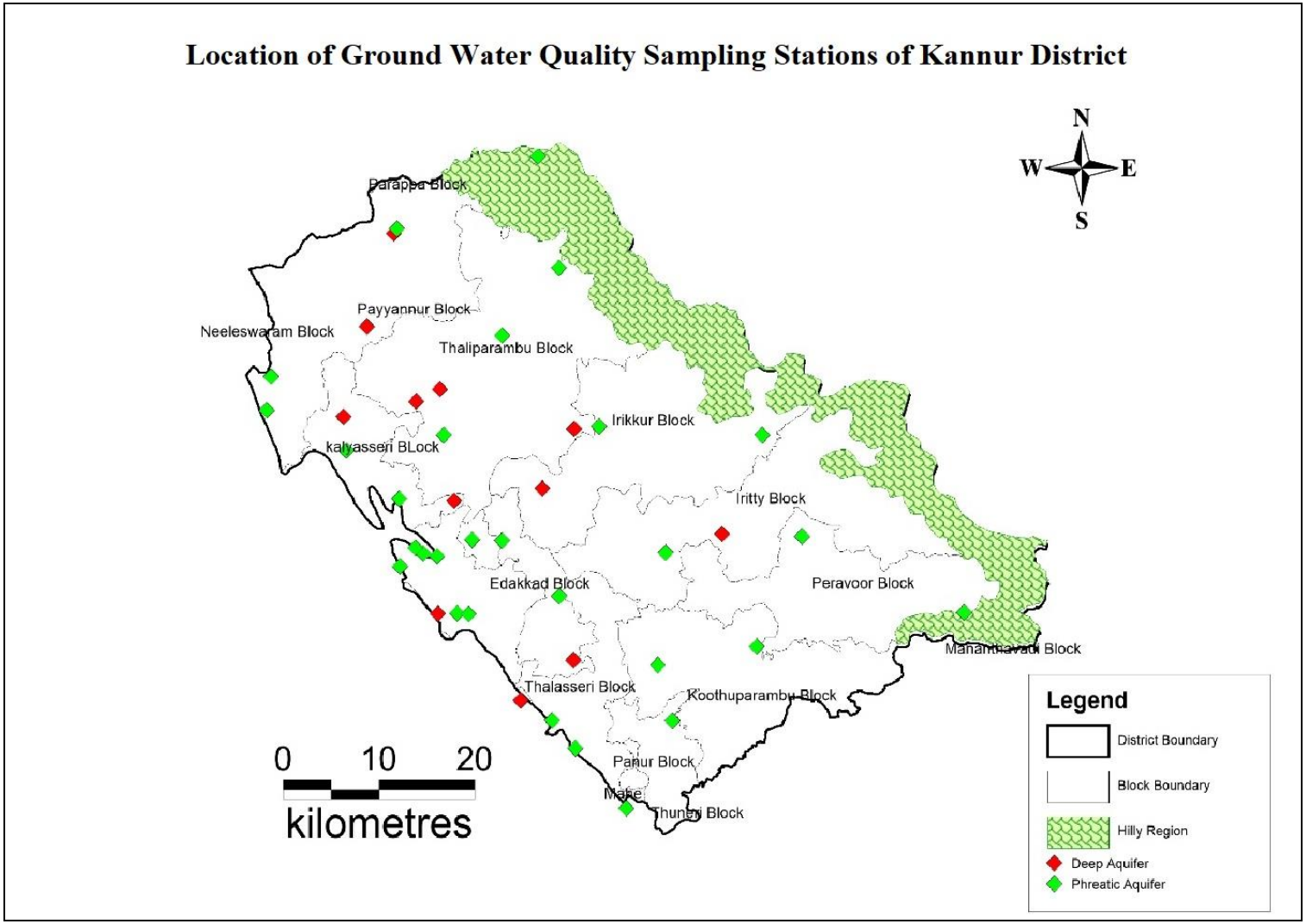


Figure 2.3 Location of water quality sampling stations

3.0 Data Interpretation, Integration and Aquifer Mapping

Various data pertaining to hydrogeology, geophysics and exploratory drilling were collected and validated. Using this data maps of ground water level scenario, quality aspects, 2-D and 3-D sub-surface aquifers disposition, yield potential etc. were prepared. Finally, aquifer maps were generated and their characteristics are discussed in detail below.

3.1 Geology

The lithology of Kannur district is grouped under Precambrian, Late Tertiary and Quaternary periods, and the Precambrian rocks dominate over the other two. Charnockite Group, includes Pyroxene granulite, Charnockites (hypersthene granite) and Hornblende – Diopside Granulite, while Gornblende Granulite and Charnockites occupy large areas, Pyroxene Granulite occurs as linear bodies in the southeast. Hornblende-Biotite Gneiss constitutes the litho unit of Migmatite complex. It has a large areal extent along the coast, south of Kannur. Towards east and southeast, discrete metasedimentary and ultramafic sequences occur which have been designated as Wynad schist complex and are considered equivalent of Sargur Group of Karnataka. They occur as isolated bands within Charnockites and Gneiss. Their contacts are generally concordant due to later folding, metamorphism and migmatisation. The group comprises Quartzite, Magnetite quartzite, Garnet –Kyanite-Sillimanite Gneiss, Quartz – Mica-Kyanite-Sillimanite Gneiss/Schist is widespread in the east, Whereas the other members of Wayanad complex occur as linear bands, lensoidal bodies and vestiges to the west Peninsular Gneissic Complex, represented by Hornblende – Biotite Gneiss comprises a complex suite of gneisses and Granites, representing the anatectic phase of migmatisation of the Schist Complex, east of Kannur and extending up to Thalassery in the south, a large body of Quartz-mica schist is separated from other schistose rocks by a conglomerate horizon extending over 8 km. This litho unit known as Vengad formation, characterised by lack of migmatisation, presence of primary structures and absence of high-grade minerals is correlatable with other rocks of Dharwar Supergroup. Large bodies of Anorthosite, Gabbro, Granite and ranophyre from the post Vengad basic and acid intrusives. Dolerite Dykes trending NW-SE represent the younger basic intrusives. Late Tertiary sedimentary rocks (Warkalli Beds) occur as isolated patches along the coast near Kannur. Pazhayangadi and east of Payyannur. They comprise variegated clays and friable sandstone. At Kannur and Pazhayangadi, carbonaceous clay with thin seams of lignite is reported towards the bottom of the sedimentary sequence. The Tertiaries as well as the basement rocks are extensively lateritised. The pebble bed reported near Valapattanam along the bank of Valapattanam River, is considered to be of Quaternary age. Quaternary alluvial deposit occurs along the coast and in the valleys. They constitute palaeo marine deposit (Guruvayur Formation) fluvial deposit (Periyar Formation) of Valappattanam and Dharmadom rivers, fluvio-marine deposits (Viyyam Formation) and beach deposits (Kadappuram Formation). The grology map of the district is given in figure 3.1.

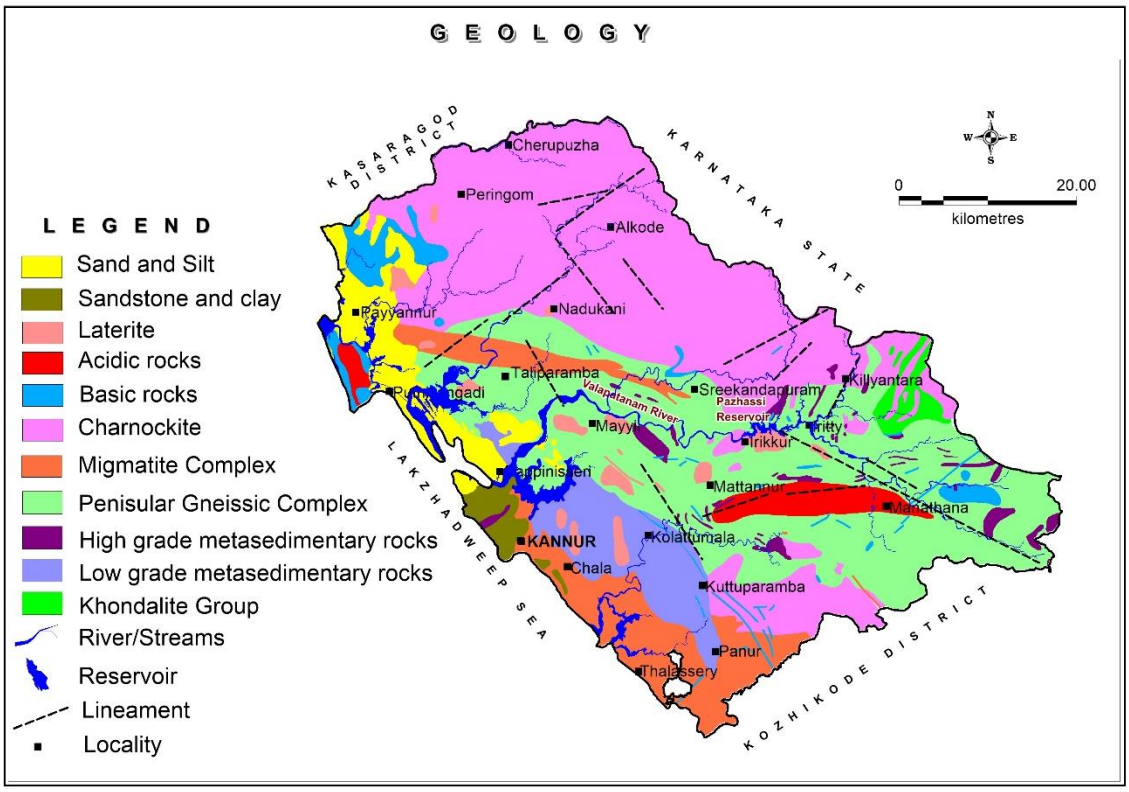


Figure 3.1. Geology-Kannur district.

3.2 Hydrogeology

Ground water occurs in *phreatic conditions* in the weathered crystallines, laterites and alluvial deposits (Aquifer-I) throughout the district. Laterites occur in western and central parts of Payyannur, Kalliassery, Taliparamba, Kannur, Irikkur, Edakkad, Thalassery, Koothuparamba and Panur blocks along gentle slopes and valleys. In many parts of these blocks falling in the western parts of the district the laterites are developed after the weathering of Tertiary sediments are characterised by relict features of layering. The thickness of weathering and laterization ranges from 3 to 40 m bgl. The weathered thickness is maximum (goes above 30 m) in midlands at some parts (Neruvambram,Vayyakara-Payyanur Block, Oduvally and Parassinikadavu-Taliparamba, parts of Kannur, Edakkad and Panunda-Thalassery blocks) where laterisation copious. Along steep slopes and high ranges in the district, pedogenesis is limited; soil occurs as very thin veneer and sometimes devoid of any perennial phreatic aquifer (Mostly in eastern hilly parts of Payyannur, Taluparamba, Irikkur, Iritty and Peravoor blocks). The depth to weathering map of the district is given in figure 3.2.

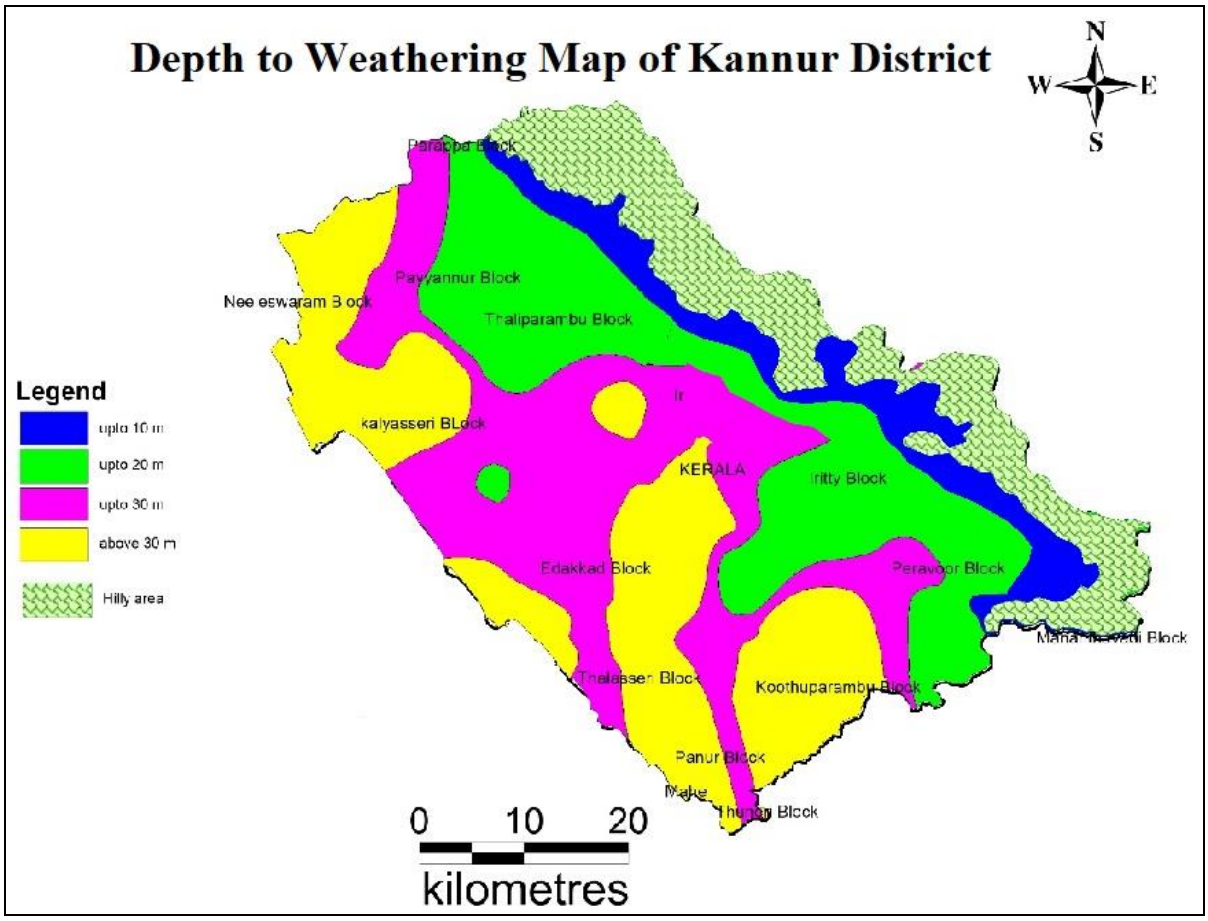


Figure 3.2. Depth to weathering map-Kannur district.

In the deeper aquifers, the occurrence and movement of ground water is controlled by the incidence and inter-connection of fractures or joints. The ground water in deeper aquifer occurs under *semi-confined to confined* conditions. Based on the available data with state government agencies, it is observed that the depth of bore wells in the district ranges from 35-120 m depth with average between 50-70 m bgl. The yield of bore wells generally ranges from 0.2 to 3 lps. Occasionally, bore wells yielding as high as above 8 lps are encountered at Chavassery (Iritty block), Chengalai (Sreekantapuram Municipality) and Mayyil (Irikkur).

The phreatic aquifers in the district are controlled mostly by local geomorphology rather than geologic structures. Hence, dug wells tapping the weathered crystallines/ laterites located in valley portion and flats are perennial, whereas those along hill slopes dry up during summer, especially where the thickness of overburden is limited, as in the case of Charnockite terrain.

3.2.1 Occurrence of Ground Water in Aquifer-I

Ground water occurs under atmospheric pressure conditions in aquifer-I. The shallow phreatic aquifers of weathered crystallines and laterites are generally developed through dug wells. The depth of dug wells ranges from 4 to 22 mbgl. Generally, dug wells tapping aquifers in charnockites are found to be shallower than that of in gneisses. The yield of dug wells ranges between 500-6000 lpd (along hill slopes and high ranges) to 10000-20000 lpd

(along valleys and lower lateritic plateau portions). In acute summer months wells located along hill slopes dries up.

3.2.2 Occurrence of Ground Water Deeper Aquifer-II

The deeper fractured aquifers are under confined to semi-confined conditions. As evident from the drilling activities carried out by Ground Water Department, Kerala potential fractures are encountered up to 80 mbgl, though generally confined within 60 mbgl. Besides, exploratory drilling carried out by CGWB indicated the presence of occasional fractured aquifers down to the depth of 150 mbgl. However potential fractures in the district are generally confined within the depth range of 40-80 m bgl. Generally, drilling borewells beyond the depth of 120 m bgl is a pointless exercise.

3.3 Ground Water Dynamics

To decipher the ground water dynamics of shallow Aquifer-I, other than the existing GWMWs of CGWB, 24 additional key observation wells were established. Also, to understand the ground water dynamics of the deeper Aquifer-II, water level data from the existing 16 EWs drilled by CGWB were used. The water level data from the monitoring wells during pre and post monsoon seasons (2021) were collected and analysed. The ground water level scenarios for Aquifer-I and Deeper Aquifer-II are described in the following section.

3.3.1 Depth to water level (Shallow Aquifer-I)

To understand the depth to water level scenario in Kannur district, water level measurement from all the observation wells were carried out in the month of April (pre-monsoon) and November (post-monsoon). The pre and post monsoon data collected from these KOWs along with the data collected by CGWB from there network monitoring stations have been used to ascertain the water level scenario and preparation of depth to water level maps of the area.

3.3.1.a Pre-monsoon Depth to Water Level (April 2021)

The depth to water levels in Kannur during April 2021 ranges between 0.6 (Thazhe Chovva, Kannur Block) and 19.5 (Vayyakara, Payyannur Block) mbgl. Shallow water levels in the range of 0-2 mbgl are noticed along valleys, river channels and coastal plains in Dharmadam (Thalassery block), Edakkad (Edakkad block); Pappinissery, Pazhayangadi & Kannapuram (Kalliassery block), Kotty & Kunnaru (payyannur block), Pattiyam (Koothuparamba block) and Thazhe-Chovva (Kannur Block). Deeper water levels above 10 mbgl are recorded at Alacode, Vayyakara & Oduvally (Payyannur Block), Cheleri (Edakkad block), Parassinikkadavu (Taliparamba block) and Vengad (Thalassery block). However, generally water level range ranges between 5-7 m bgl in the district during pre-monsoon season. Details of the analysis are given in table 3.1 and figure 3.3.

3.3.1.b Post-monsoon Depth to Water Level (November 2022)

The depth to water levels in Kannur during November 2021 ranges between 0.06 (Thazhe Chovva, Kannur Block) and 18.87 (Vayyakara, Payyannur Block) m bgl. Shallow water levels in the range of 0-2 mbgl are noticed around places like Thazhe Chovva (Kannur Block), Edakkad (Edakkad Block), Pappinissery West & Kannapuram (Kalliassery Block); Kunnaru, Echilamvayal, Kotty, Pazhayangadi & Mathamangalam (Payyannur Block),

Pattiyam (Koothuparamba Block), Muzhakunnu (Peravoor Block), Anthoor (Taliparamba Block); and Kuppam & Dharmadom (Thalassery Block). During pot-monsoon season, deeper water levels above 10 mbgl are noticed at Ezhilode & Vayyakara (Payyannur Block), Pinarayi & Vengad (Thalassery block), Meruvambayi (Mattannur Block), Parassinikkadavu and Oduvally (Taliparamba Block. During post-monsoon the water level become shallower and major part of the district is characterised by water levels in the range of 2-5 mbgl. Details are given in table 3.2 and figure 3.4.

Table 3.1. Percentage of wells & depth to water level range (Aquifer-I, Pre-Monsoon, 2019)

Depth to Water Level Range (mbgl)	No. of Wells	Percentage of Wells
0 to 2	10	16
2 to 5	20	31
5 to 10	28	44
Above 10	6	9
Total	64	100

Table 3.2 Percentage of wells & depth to water level range (Aquifer-I, Post-Monsoon, 2019)

Depth to Water Level Range (mbgl)	No. of Wells	Percentage of Wells
0 to 2	15	15
2 to 5	35	36
5 to 10	41	42
Above 10	7	7
Total	98	100

3.3.2 Depth to water level (Deeper Aquifer-II)

The Aquifer –II in the district mostly encompasses fractured crystalline aquifers and Tertiary-Vaikom formations. The depth to water levels in the deeper aquifers were analysed using the water level data from EWs and Slim holes drilled by CGWB (16 Nos.). Details are tabulated in table 11. Twelve exploration wells were drilled down to a depth of 200 m bgl. The deeper fractures in Charnockites are more productive compared to the limited fractures in gneisses. The yield of the bore wells range from negligible discharge to 840 lpm. Thickness of overburden ranges from 11 to 34 m bgl. The quality of water is generally good and potable. Generally, electrical conductivity is found to be less than 300 µs/cm at 25^{o}C and fluoride content less than 0.4 mg/l. The EC was around 700 µs/cm at 25^{o}C at Peringome and Cheruthazham sites. The water levels in the EWs drilled in crystalline formations ranged between 0.85 to 22.5 mbgl. In all EWs drilled in hard rock terrains, water levels are generally within 15 mbgl except for 1 well at Kannur-CWRDM where it is 21.7 mbgl.

The depth of Tube wells/ Slim holes constructed by CGWB in Tertiary aquifers ranges from 28.95 (Irnavu, Kalliassery block) to 38.9 (Kannur) m bgl. The thickness of Vaikom formation in these wells ranges from 25.92 (Irnavu, Kalliassery Block) to 31.56 (Payyannur). The depth to Water level in Vaikom formation is recorded as 13 mbgl at Kannur with a discharge of 0.4 lps. Generally, the water quality is not good and found to be brackish to saline.

3.3.3 Water Level Fluctuation, Shallow Aquifer-I

The pre to post monsoon fluctuation of water level is an important parameter in understanding the storage capacity of an aquifer. It has been observed in Kannur district that, even after having a quiet good amount of rainfall, about 78% of the wells analysed, indicated water level fluctuations in the range of 0-2 m. It directly implies the limited storage capacity of the aquifer, due to steep terrain gradients prevalent in the area. The water level fluctuation map of the area is given in figure 3.5.

The range of pre to post water level fluctuation ranges between -2.01 m (Manathana, Peravoor Block) and 5.1 (Anthoor, Taliparamba Block). Analysis of water level fluctuations in aquifer-I revealed that 90 percentage of the wells showed rise in water level after monsoon season. Only 10 percentage was found under falling water levels conditions in the range of 0 to -2m (at locations Manathana, Ramanthali, Thalassery, Elambara, Payyannur and Mokeri) even after monsoon and it may be attributed to localized extraction, high rates of baseflow etc. Positive fluctuation (rise) between above 2 m was noticed in 7 wells at locations Vengad, Kolacherym Taliparamba, Nayattupara, Muzhakunnu, Alacode, and Anthoor may be due to the contributions from surface run-off to the GWMW from external water sources and limited ground water extraction during rainy season. The analysis details of water level fluctuations and their ranges are given in table 3.3.

Table 3.3 Details of water level fluctuation

Water level fluctuation (m)					
Rise			Fall		
Range of fluctuation (m)	No of wells	Percentage	Range of fluctuation (m)	No of wells	Percentage
0 to 2	46	78	0 to 2	6	10
2 to 4	6	10	2 to 4	0	0
4 to 8	1	2	4 to 8	0	0
Total	95	90	Total	6	10

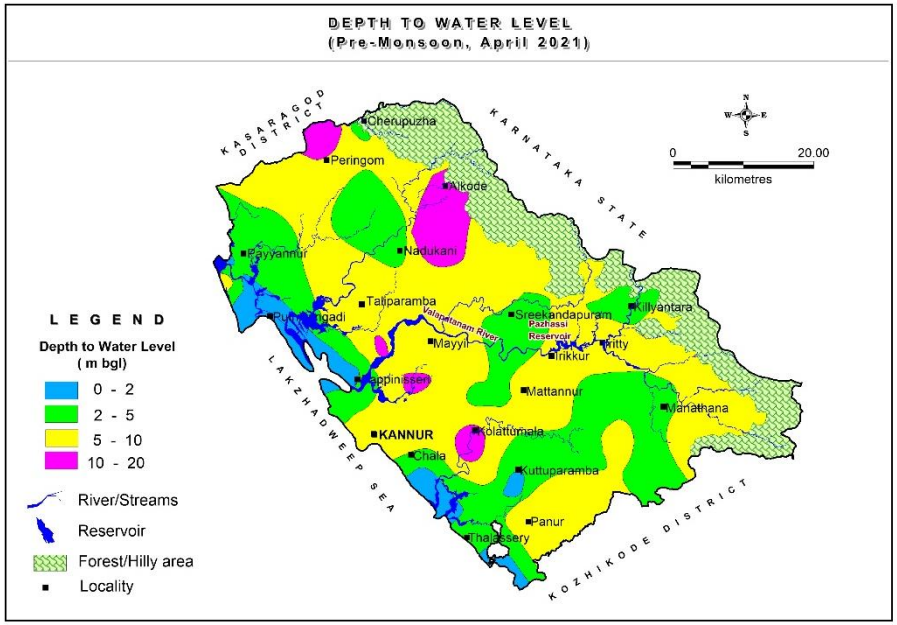


Figure 3.3. Pre-monsoon depth to water level map, Kannur district.

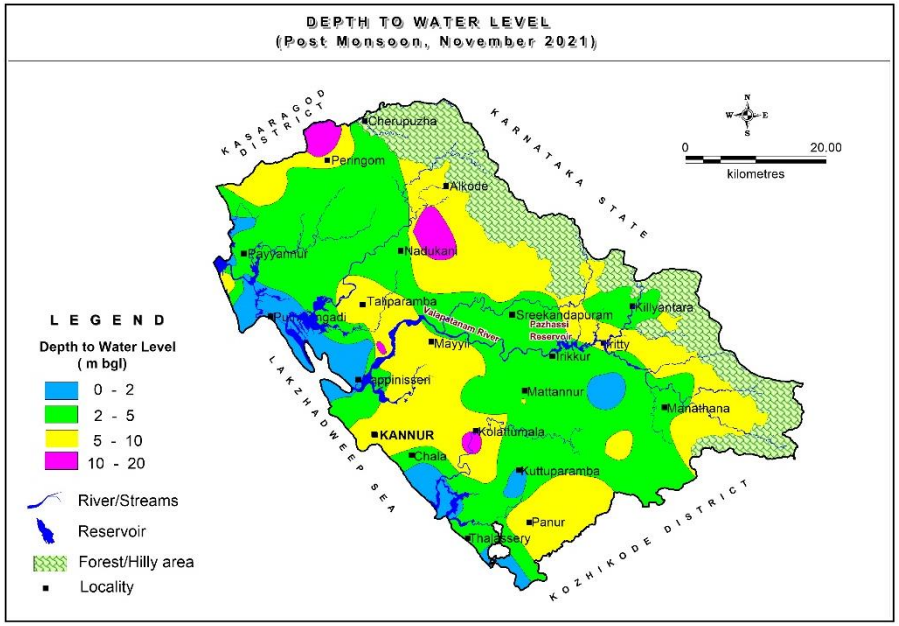


Figure 3.4. Post-monsoon depth to water level map, Kannur district.

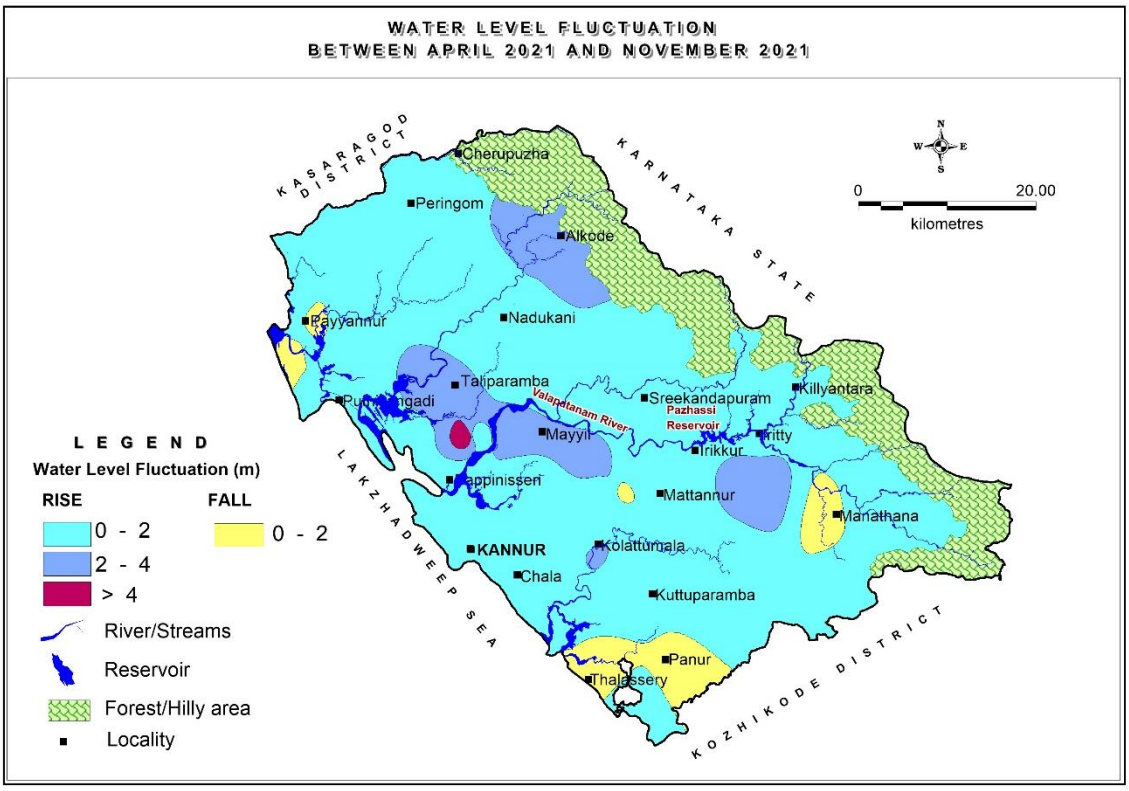


Figure 3.5. Water level fluctuation map, Kannur district

3.3.4 Long Term Water Level Trend (2012-2021) and Hydrograph analysis

The variation in water level with reference to time and space is the net result of groundwater extraction and recharge. The long-term change in water level is apparent from the trend of water levels over a period of time and is best reflected in a hydrograph. The decadal trend (2012-2021) of groundwater levels, for pre-monsoon and post-monsoon periods is has been analysed for the present study. Analysis of decadal trend shows that there is no significant rise or fall in water level trends during both the seasons. Details are given in table 3.4 below:

Table 3.4 Decadal water level trend of GWMWs

Sl.No	Location	Trend (m/year)			
		Pre-monsoon		Post-monsoon	
		Rise	Fall	Rise	Fall
1	Adimaly	0.0263			0.0679
2	Alacode-PZ		0.0055	0.0238	
3	Cheenikuzhi		0.0381		0.0081
4	Elappara	0.0165		0.0049	
5	Kannur	0.0188			0.0109
6	Vellilamkandam		0.0142		0.0702
7	Vandiperiyar	0.0155		0.0144	
8	Thumbachi		0.0312		0.0019
9	Thankamoni-PZ		0.0762	0.0359	
10	Santhanpara		0.2510		0.0102
11	Pooppara		0.0255		0.0078
12	Peruvanthanam	0.1916			0.1020

Sl.No	Location	Trend (m/year)			
		Pre-monsoon		Post-monsoon	
		Rise	Fall	Rise	Fall
13	Pambadumpara		0.1005	0.0079	
14	Kuttikkanam	0.1918			0.1497
15	Mundieruma-PZ	0.1317		0.0489	
16	Kulamavu	0.0637		0.0000	
17	Kattappana DW	0.0187		0.0077	
18	Karumannoor-PZ	0.0850			0.0301
19	Karimkunnam-PZ		0.0718		0.0475

3.3.5 Ground Water Flow

Equipotential lines, the lines joining points of equal head on the potentiometric surface, were drawn for pre-monsoon period, based on the variation of the head in the aquifer. Based on the Water table elevation, ground water flow directions can be identified (Figure 3.6). It has been observed that the topography of the area is the main controlling factor in determining ground water flow direction. Also, the effluent nature of streams (gaining streams) is evident from the contour pattern. The general flow direction is towards west following the terrain slope

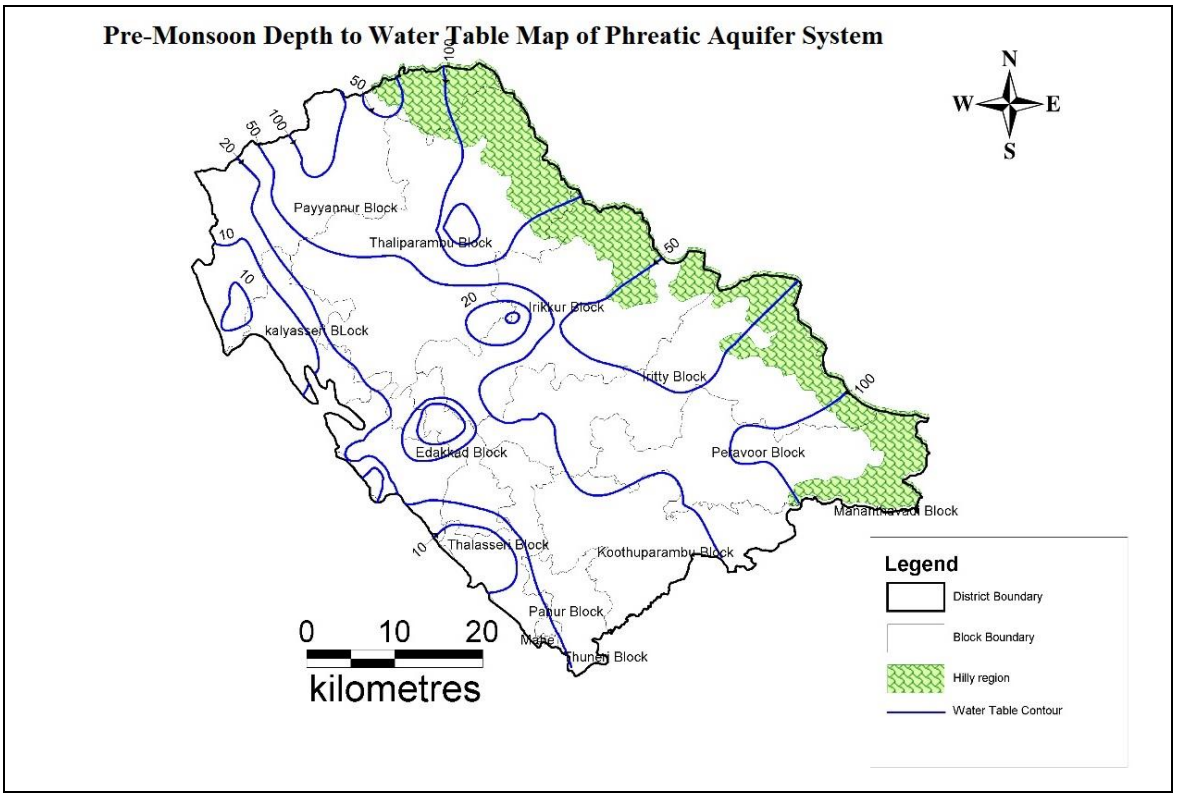


Figure 3.6. Pre-monsoon DTWT map (mamsl)-Phreatic aquifer system

3.4 Ground Water Quality

The suitability of ground water for drinking/irrigation and industrial purposes is determined by the abundance of various chemical constituents in water. Though many ions are very essential for the growth of plants and human body, when present in excess, have an adverse effect on health. For estimation of the quality of ground water, ground water samples from 28

samples from dug wells dug wells representing phreatic aquifer have been collected during pre-monsoon. Similarly, for Aquifer – II, the ground water samples (13 Nos.) were collected from bore wells. Also, 28 acidified samples were collected from dug wells for heavy metal analysis. The aquifer wise ranges of different chemical constituents present in ground water are given in Table 3.5. All the major ions are within permissible limits, except for nitrate (> 45 mg/l) in 2 samples from Koothuparamba and Sreekantapuram. Also, iron concentration in many of the samples are above the acceptable limit of 0.3 mg/l (Alacode, Chapparapadavu, Dharmadam, Koothuparamba, Mattannur, Mokeri, Muzhakunnu, Payyannur, Peringome, Ramanthali, Sreekantapuram, Taliparamba, Ulikkal and Valapattanam). At two sampling locations (Cheleri and Kannavam) iron exceeds the permissible limit (allowable threshold in the absence of an alternative source) of above 1 mg/l.

Generally, the Irrigation suitability is good except for 2 sample each from Aquifer-I (Naduvatt and Azhikkal) and for aquifer-II (Cheruthazham Muzhuppilangad) where *high* salinity hazard (EC >750 µS/cm) is noticed. One sample at Peringome is unsuitable for irrigation due to *high* sodium hazard. USSL plot depicting the classification of irrigation water quality with respect to salinity hazard and sodium hazard for both the aquifers are given in figure 3.7.

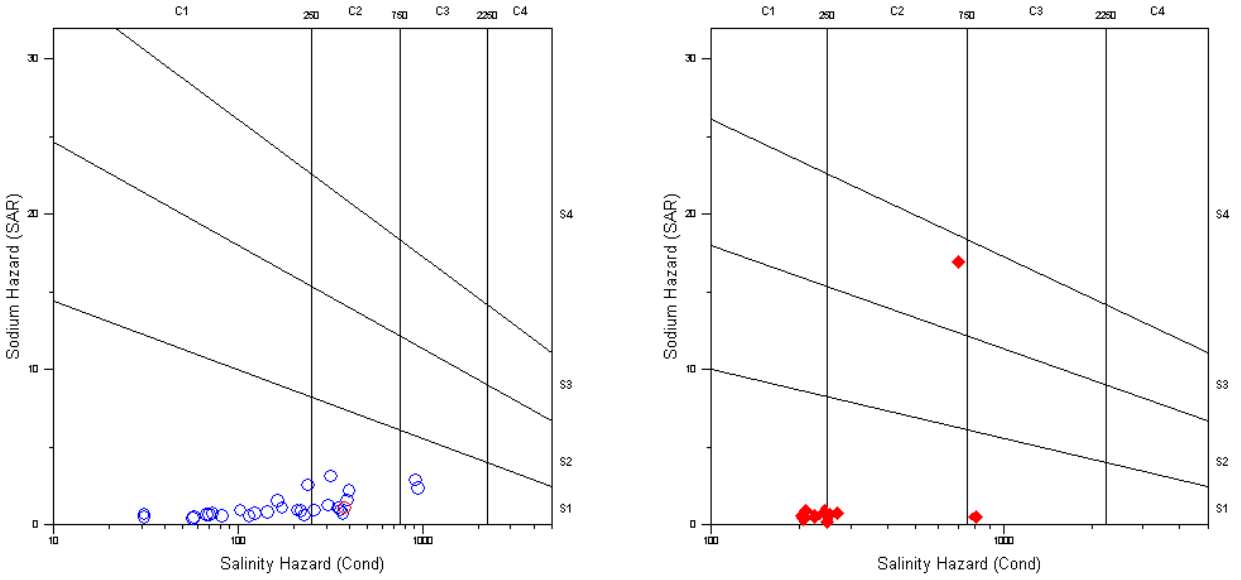


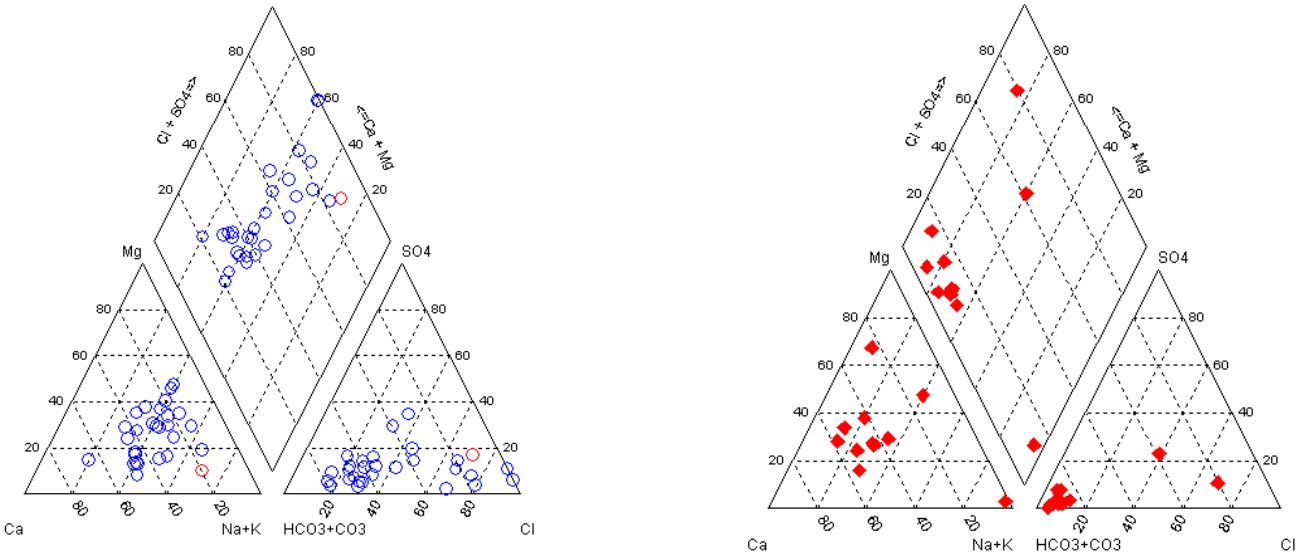
Figure 3.7. Classification of irrigation based on USSL diagram

To understand the hydrochemical facies, Hill piper diagrams were prepared separately for both the aquifers. In the current study it has been observed that the water samples from aquifer-I shows no-dominant cation predominance, whereas the anions are mostly dominated by $HCO_3+CO_3>Cl>SO_4$. The order of predominance of anions can be attributed to the high

rainfall recharge followed by natural flushing out process existing in the phreatic aquifer system. In Aquifer II, the general trend of cation abundance can be represented as Ca>Mg>Na+K and anions as $HCO_3+CO_3>SO_4>Cl$. The specific cation copiousness in aquifer-II is due to relatively higher residence time of ground water in the deeper aquifer system and increased rock water interactions. Hill piper diagrams for both the aquifers are given in figure 3.8.

Table 3.5 Aquifer wise ranges of chemical constituents in Kannur district

Constituents	Aquifer-I		Aquifer-II	
	Min	Max	Min	Max
pH	3.3	8.6	7.41	8.54
EC (µS/cm)	31	950	304	14600
TH (mg/l)	15.9	326.97	15	314
Calcium (mg/l)	2.1	101.2	2	76
Magnesium (mg/l)	1.3	18.1	2.4	30
Potassium (mg/l)	0.89	14.19	1.2	7.75
Sodium (mg/l)	4.2	99.67	5	150
Carbonate (mg/l)	13.32	31.9	19	
Bi carbonate (mg/l)	16	314.1	43.3	329
Chloride (mg/l)	3.3	217	4.3	5112
Sulphate (mg/l)	0.56	38.39	0.4	40
Nitrate (mg/l)	0.4	60.6	0.05	20.5
Fluoride (mg/l)	0.01	0.14	0.8	0.62



Aquifer-1 **Aquifer-II**

Figure 3.8. Hill piper Diagram

3.5 3-D and 2-D Aquifer Disposition

Based on the analysis of existing and generated data through hydrogeological surveys and ground water exploration, following two types of aquifer systems were identified in Kannur district. The details of ground water exploration are given in Annexure-I. The litholog data from ground water exploration data has been used to generate the 2D and 3D disposition aquifers. The aquifer disposition models clearly depict the vertical and horizontal extension of various litho-units and the zones tapped, forming aquifers. Based on the ground water exploration and micro-level hydrogeological survey, lithological fence diagrams and cross sections were prepared and are given in figure 3.10 and 3.11 respectively. The 3D lithological view of Kannur district is shown in figure 3.9.

The aquifer units in each of the formation are listed below:

- Aquifer I – Aquifer I consists of Alluvium and weathered crystallines/laterites and associated shallow fractures. The thickness of the first aquifer ranges up to 50 m and the thickness is highly variable. Along hill slopes it is virtually absent; thickness is maximum along valleys and plateau regions. The thickness of aquifer I is more in gneissic terrains, when compared with that of charnockites due to the susceptibility to weathering.

- Aquifer-II – Aquifer II consists of massive crystallines and associated fractures. As per drilling data by GWD, Kerala, potential fractures are limited down up to 80 mbgl. Also, most of the potential fractures are found within 60 mbgl limit. However, exploratory drilling studies carried out by CGWB revealed rare instances of occurrence of, potential fractures upto 150 mbgl. Hence ground water drilling beyond 120 m bgl may be a pointless exercise.

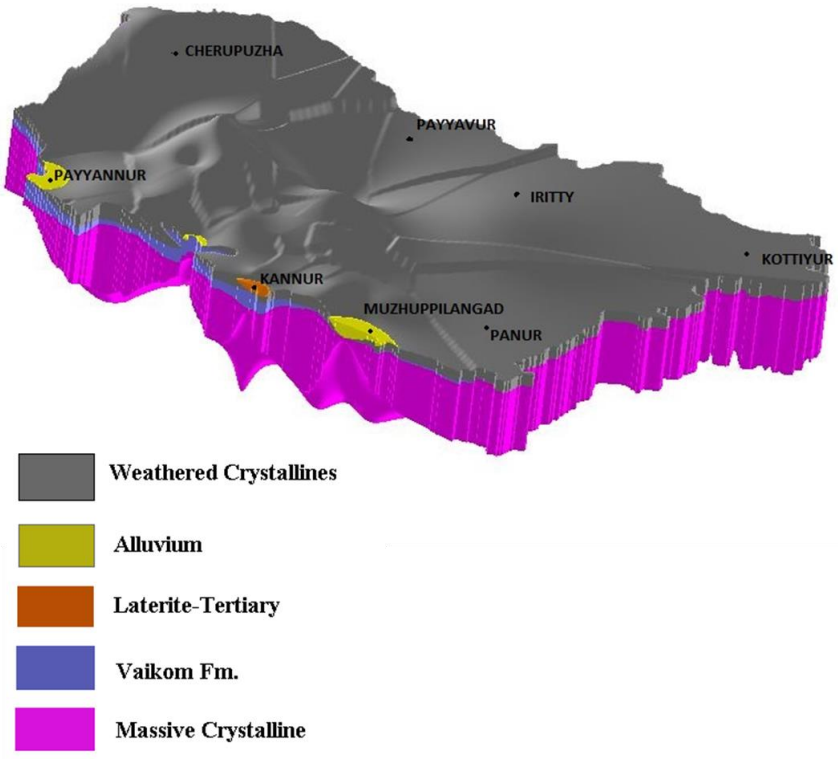


Figure 3.9. 3D Diagram of Kannur District

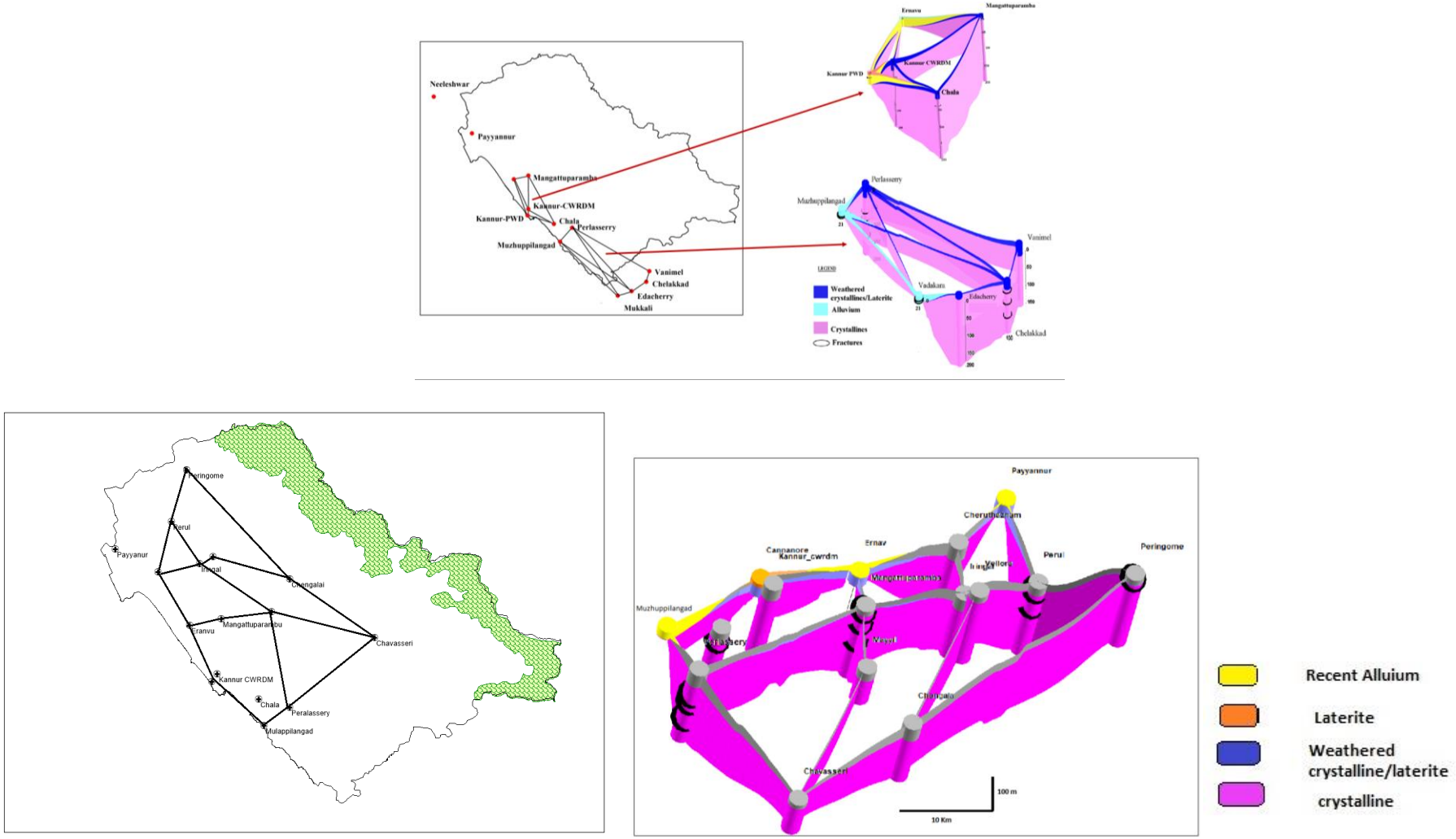


Figure 3.10. 3D Fence Diagram

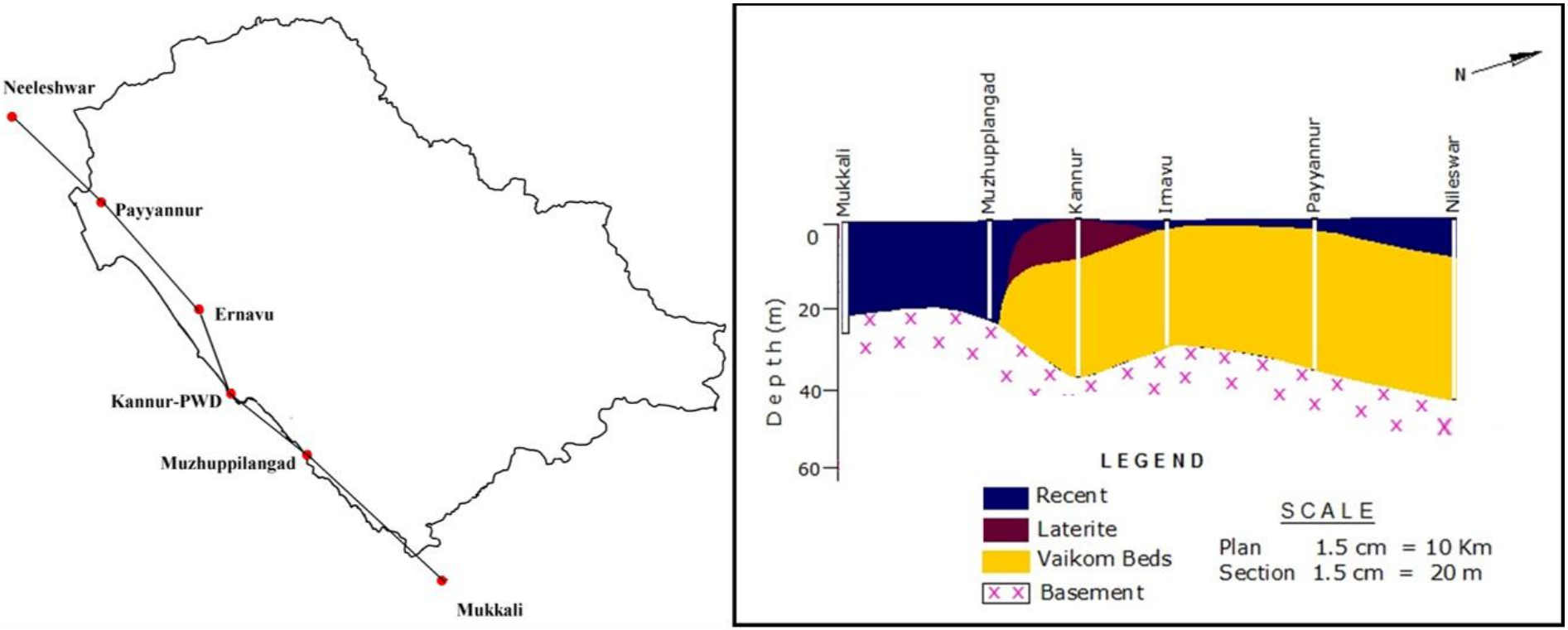


Figure 3.11. 2D cross sections

3.6 Aquifer Characteristics

The salient features of the two aquifer systems in the district is summarized in table 3.6 and is given below:

Table 3.6. Salient features of the aquifer systems in Kannur district.

Type of aquifer	**Aquifer-I**	**Aquifer-II**
Formation	Weathered Crystallines/Laterite/Alluvium	Fractured Crystallines/Vaikom Fm.
Maximum vertical limit (mbgl)	Up to 50 m (including in storage part of unconfined aquifer)	Generally, up to 80 m. rare chances of getting potential fractures beyond 150 m mbgl)
SWL	Generally, 5-7 mbgl	Range between 0.85-22 mbgl. Generally, below 15 mbgl
Thickness	1.5 to 10	1 to 15 m
Weathered/Fractured zones encountered	Mostly weathered formations up to 15 mbgl; Shallow fractures may extend up to 30 m (as part of phreatic aquifer system) and rarely up to 50 mbgl	Up to 150 mbgl. Potential Zones between 40-80 mbgl
Yield	1000-5000 lpd (along hill slopes and high ranges) to 20000 lpd (along valley portions and lateritic plateaus). In acute summer months dug wells along hill slopes yield poor/dries up. In alluvium yield may go up to 30000 lpd	Generally, up to 2 lps (Dry wells occasional). Rare instances of getting zones with yield above 10 lps.
Sustainability	less than 1 hour to 3 hours	<1 to 6 hours
Aquifer Parameter (Transmissivity- m^2/day)	up to 30 m^2/day	1.44 to 81.3; mostly less than 50 m^2/day
Sy/S	0.02 to 0.09	0.0001 to 0.003
Suitability for drinking & irrigation	Yes	Yes
Remarks	Suitable abstraction structure: Dug wells; Up to 10-20 m in lateritic plateaus and valley portions with diameter of 3m; Up to 10-15 m bgl along foothills with diameter 2-3 ; Small diameter(1-1.5 m) dug wells and filter point wells in alluvial tracts	Borewells: 100 mm dia for hand pumps and 152 mm for energisation; Optimum depth recommended up to 80 mbgl.

3.7 Structural analysis

In order to understand relationship between geologic structures and yield/discharge characteristics of bore wells tapping Aquifer-II, structural analysis was carried out. On analysis of the data obtained from SGWD and data available with CGWB (120 bore wells) it has been found that, only 10 % of the wells are high yielding (Discharge > 3 lps). The prominent lineament directions are ENE, NE and NW. It has also been observed from lineament analysis that, EWs falling along the general trend of NE-SW and NW-SE found to comparatively higher yields when compared with wells along other lineament directions. The rose diagram depicting major lineament direction in the study area is given in figure 3.12.

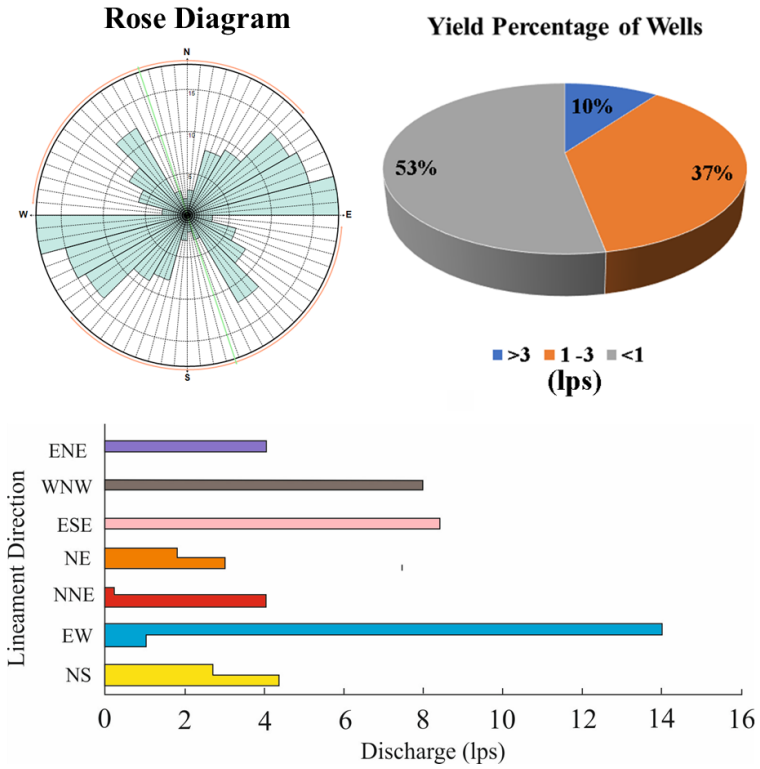


Figure 3.12. Fracture analysis of lineaments in Kannur district with potential lineament directions.

3.8 Aquifer maps

An aquifer map of the area is evolved out finally, based on aquifer geometry, aquifer characteristics, ground water resources, yield characteristics and water quality. The aquifer map of the phreatic (Aquifer-I) and fracture aquifer systems (Aquifer-II) are shown in figures 3.13 and 3.14 respectively. In phreatic aquifer system, along the western coastal tracts and alluvial plains yield up to 30 m^3/ day is noticed. In the mid land area, dug wells tapping laterite aquifers are found to have discharge up to 10 m^3/day. Along hills slopes in the eastern part of the district discharge is negligible and found to be within 5 m^3/day. In the deeper crystalline aquifers discharge is generally found to be within 2 lps. Rare instances of wells with yield above 3 lps is noticed at Mangattuparamba, Chavasserry, Chengalayi, Iringal, Mayyil, Perul, and Cheruthazham. In the deeper Vaikom formation in the western part of the district yield up to 2 lps is noticed, However the water quality is found to be poor because of the inherent salinity in the aquifer system.

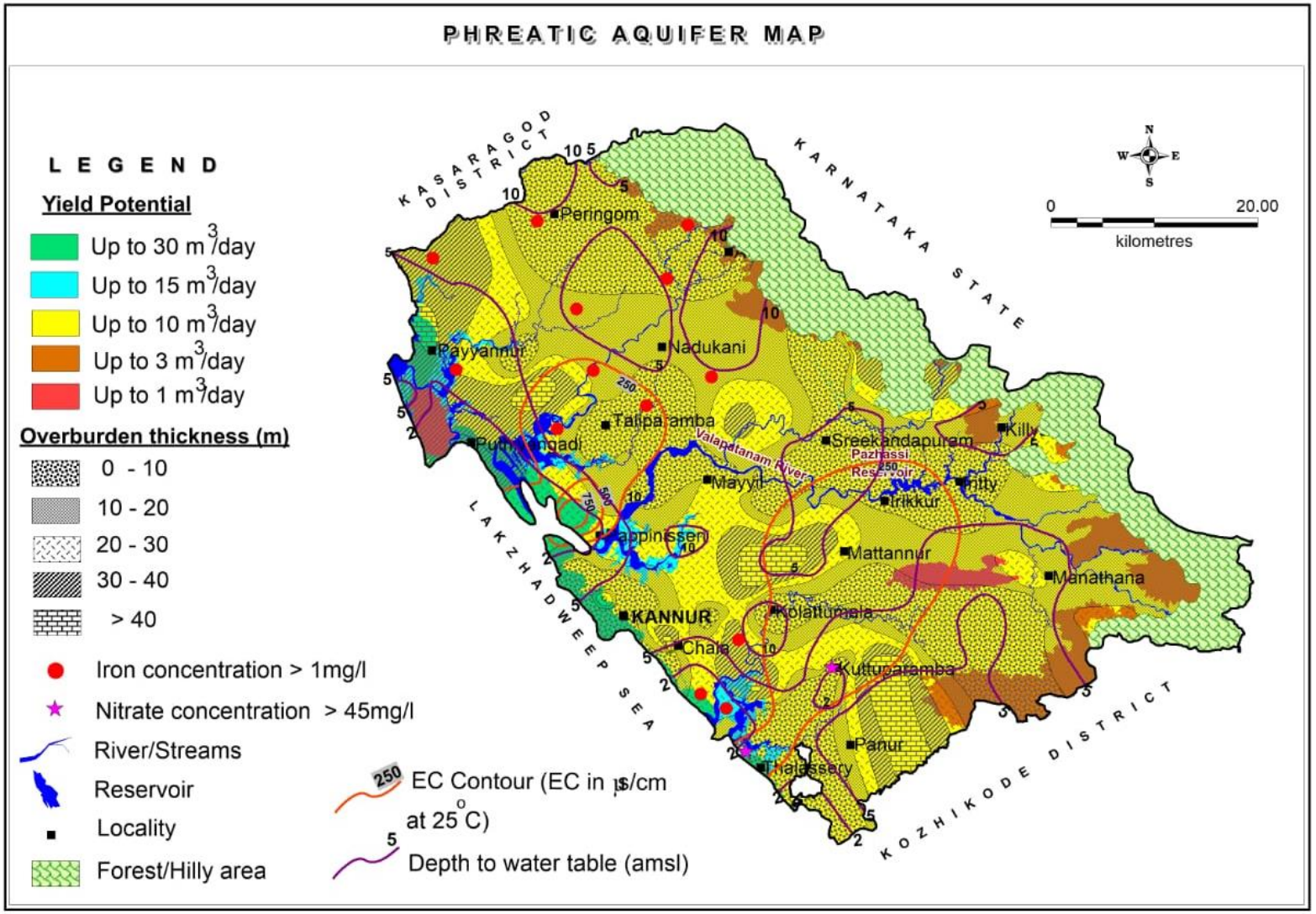


Figure 3.13. Aquifer map-Phreatic aquifer system

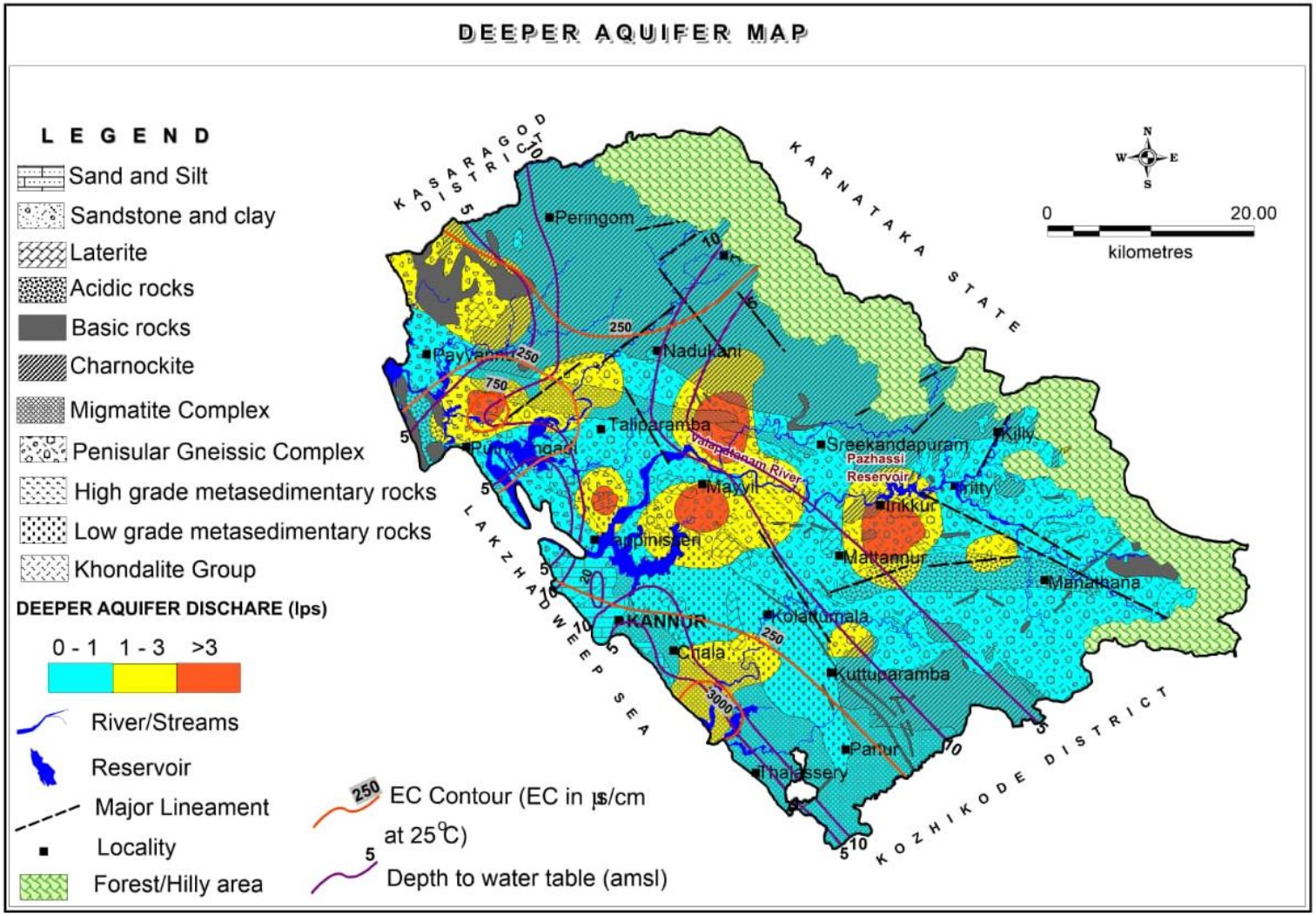


Figure 3.14. Aquifer map-Deeper aquifer system

4.0 Ground Water Resources

Aquifer wise and block-wise estimation of ground water resources have been carried out for the 2 aquifers existing in the area i.e., Aquifer-I (the phreatic aquifer) and Aquifer-II (the fractured aquifer system) using GEC-2015 methodology. The details of the assessment are discussed below.

4.0.1 Recharge parameters used in the phreatic aquifer (Aquifer-I)

The outcomes of the ground water resource assessment as on March 2020 carried out for all the blocks as per GEC-2015 and the details of block-wise resources are given in tables 16 and 17 respectively.

During monsoon season, the rainfall recharge is the main recharge component, which is estimated as the sum of the change in storage and gross extraction. The change in storage is computed by multiplying groundwater level fluctuation between pre and post monsoon periods with the area of assessment and specific yield. Monsoon recharge is calculated both by rainfall infiltration factor method and by water table fluctuation method. For Water table fluctuation it is calculated as follows:

$$\mathbf{R = (h \times Sy \times A) - GE}$$ where,

h = rise in water level in the monsoon season,

Sy = specific yield

A = area for computation of recharge,

GE = gross ground water extraction

The existing specific yield values as evident from various studies conducted by CGWB has been used in the estimation. The specific yield values used for the current study ranges between 0.025 to 0.09 (for unconfined aquifer in the zone of fluctuation) and a value of 0.004 to 0.012 is used for the in-storage part of unconfined aquifer. The maximum limit of fluctuation in phreatic aquifer used for the current estimation is 7-10 mbgl. The groundwater resource in the below the dynamic zone (i.e. the zone of water level fluctuation) in the phreatic aquifer is the in-storage, the thickness of which varies between 26-33 m in the area. The monsoon ground water recharge has two components viz; the rainfall recharge and the recharge from other sources. The other sources of groundwater recharge during monsoon season include seepages from canals, surface water irrigation, tanks and ponds, ground water irrigation, and water conservation structures. During the non-monsoon season, rainfall recharge is computed by using Rainfall Infiltration Factor (RIF) method. Recharge from other sources is then added to get total non-monsoon recharge. As the area is occupied by crystalline rocks, the RIF values applied varies from 0.06 to 0.084 depending on soil characteristics, extend of weathering etc.

4.0.2 Recharge parameters used in the fracture aquifer system (Aquifer-II)

The ground water resource of the Aquifer – II was also estimated to have a correct quantification of resources so that proper management strategy can be framed.

In order to estimate the resources of aquifer-II, the following equation was used:

Ground Water Resource, **GWR = Area x Thickness of aquifer x Storativity**

Values ranging between 0.001 to 0.003 were used as Storativity values as observed from the pump tests conducted by CGWB. The thickness of the aquifer-II used in the estimation ranges between 110-115 m.

4.1 Ground water resources in the Phreatic aquifer (Aquifer-I)

The annual extractable ground water recharge of aquifer-I was estimated to be 406.38 mcm. As per estimation the annual gross extraction for all uses is 189.36 mcm with extraction for domestic requirement being the major consumer having a draft of 105.12 mcm. The annual draft for domestic and industrial uses together accounts for about 484.24 mcm. The allocation for domestic use up to 2025 is about 142.57 mcm (Table 12 and 13). Out of the 11 blocks Kannur, Panur and Thalassery falls under semi-critical category and the remaining 8 viz.Edakkad, Irikkur, Iritty, Kallyasseri, Koothuparamba, Payyannur, Peravoor and Taliparamba under safe category. Hence, as per estimation there is enough potential for future ground water development in the district. The total in-storage ground water resources of unconfined aquifer was estimated and it came to about 491.80 mcm. The categorisation of blocks of Kannur district is shown in figure 4.1 and table 4.1

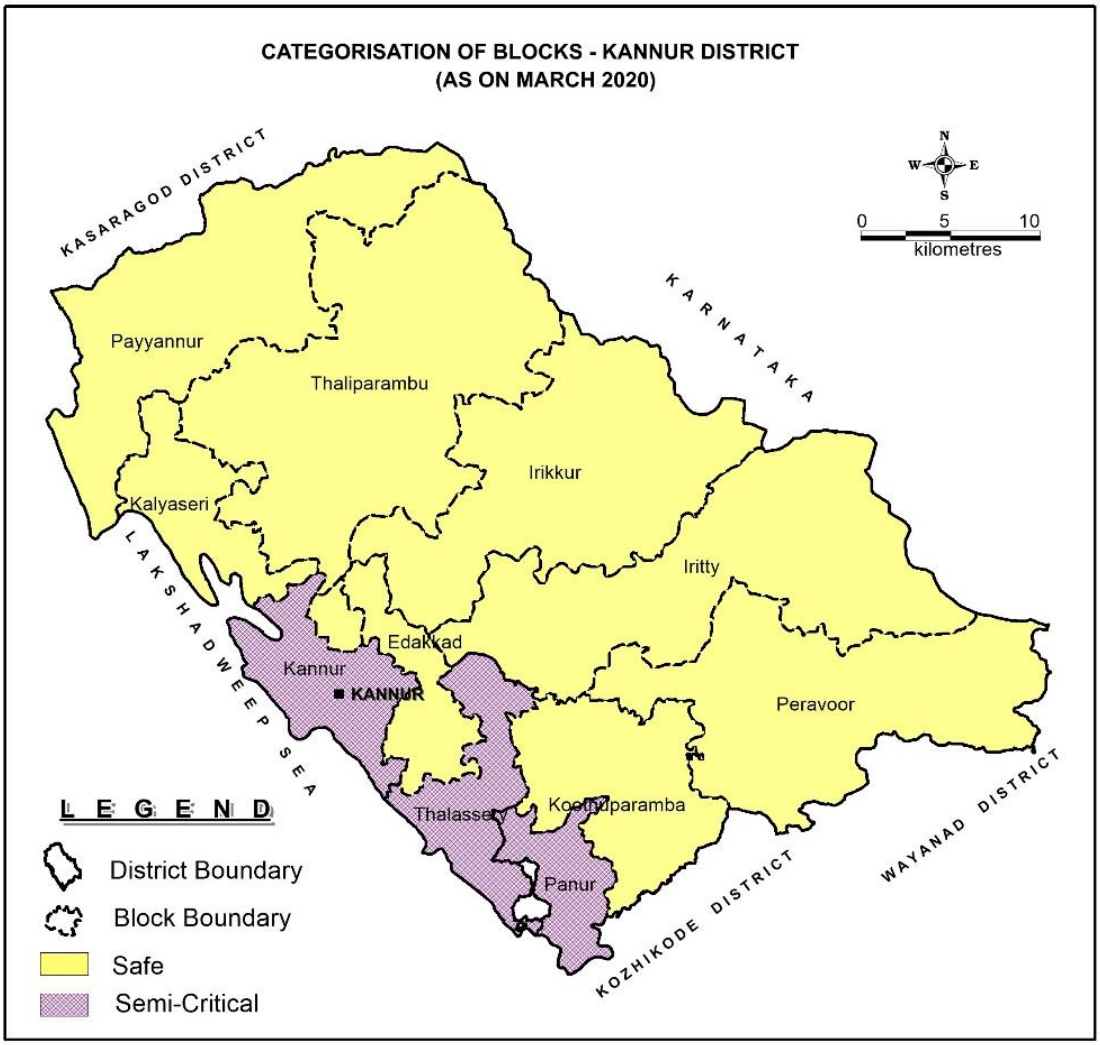


Figure 4.1: Categorization of blocks of Kannur District

4.2 Ground Water Resources in the fracture aquifer system – Aquifer-II

By applying above formula (section 4.1.2), the ground water resources of Aquifer-II were estimated and presented below in Table-4.2. The total resources of Aquifer-II have been computed to be 596.38 mcm and the aquifer wise total ground water resources of study area is shown in table 4.2.

The total ground water resources of the entire aquifer system (Aquifer-I and II) was estimated to about 1494.56, out of which 898.18 mcm is from Aquifer-I and the remaining 596.38 mcm is accounted in aquifer-II.

Table 4.1. Ground water resources in the phreatic zone of Kannur district (Aquifer-I; Dynamic and in-storage)

Sl. No.	Assessment Unit/ Block	Command / Non-Command	Annual Extractable GroundWater Recharge (Ham)	Current Annual Ground Water Extraction (Ham)				Annual Groundwater Allocation for Domestic use as on 2025	Net Ground Water Availability for future use (4-5-6-9)	Stage of Ground Water Extraction (%) (8/4)*100
				Irrigation Use	Industrial Use	Domestic Use	Total Extraction (5+6+7)			
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
1	Edakkad	Non-command	1925.63	379.68	0.00	505.72	885.40	685.85	860.10	45.98
2	Irikkur	Non-command	6345.74	977.11	0.02	1224.48	2201.61	1660.64	3707.97	34.69
3	Iritty	Non-command	5213.32	1145.27	0.01	1060.68	2205.98	1438.49	2629.53	42.31
4	Kallyasseri	Non-command	2537.20	696.02	0.00	724.24	1420.26	982.22	858.96	55.98
5	Kannur	Non-command	2807.47	1175.96	10.14	853.62	2039.73	1157.68	463.68	72.65
6	Kuthuparamba	Non-command	2055.73	693.34	0.00	639.24	1332.58	866.94	495.45	64.82
7	Panur	Non-command	1197.66	458.56	0.00	588.20	1046.76	797.71	150.90	87.40
8	Payyannur	Non-command	5805.15	678.76	0.00	1291.01	1969.77	1750.88	3375.51	33.93
9	Peravoor	Non-command	3414.14	918.10	0.02	717.84	1635.97	973.54	1522.47	47.92
10	Taliparamba	Non-command	7227.98	897.26	11.22	1677.11	2585.59	2274.49	4045.01	35.77
11	Thalassery	Non-command	2107.95	377.72	4.72	1230.03	1612.47	1668.16	57.35	76.49
	TOTAL (ha.m)		**40637.97**	**8397.78**	**26.13**	**10512.18**	**18936.12**	**14256.60**	**18166.93**	**46.60**
	TOTAL (MCM)		**406.38**	**83.98**	**0.26**	**105.12**	**189.36**	**142.57**	**181.67**	**46.60**

Table 4.2. Aquifer wise total ground water resources of the study area

Annual Extractable Ground Water Recharge of unconfined Aquifer (mcm)	Dynamic GroundWater Recharge-Aquifer I (Ham)	In storage Ground Water Resources of Unconfined Aquifer(Ham)	Ground Water Resources – Phreatic Aquifer-I (Ham)(1+2)	Ground Water Resources-Fracture Aquifer-II (Ham)	Total Ground Water Resources (Ham)(3+4)
	1	2	3	4	5
Edakkad	1925.63	2290.69	4216.32	2594.92	6811.24
Irikkur	6345.74	3774.16	10119.90	5443.50	15563.40
Iritty	5213.32	3529.01	8742.33	4726.35	13468.68
Kallyasseri	2537.20	3785.50	6322.70	4014.92	10337.62
Kannur	2807.47	4868.35	7675.82	5324.76	13000.58
Kuthuparamba	2055.73	2328.30	4384.03	2716.35	7100.38
Panur	1197.66	1196.05	2393.71	1661.18	4054.88
Payyannur	5805.15	11495.23	17300.38	15395.40	32695.78
Peravoor	3414.14	2731.78	6145.92	2987.88	9133.80
Taliparamba	7227.98	10094.34	17322.32	11396.84	28719.16
Thalassery	2107.95	3086.59	5194.54	3375.96	8570.50
Total (Ham)	**40637.97**	**49179.99**	**89817.96**	**59638.06**	**149456.01**
Total (MCM)	**406.38**	**491.80**	**898.18**	**596.38**	**1494.56**

5.0 GROUND WATER RELATED ISSUES

The extraction of ground water resources in Kannur district has been increasing over the years. It is evident from the comparison of ground water resources carried out as on 2013,2017 and 2020 by CGWB and GWD, Kerala. In 2013, The SOE was 39.61 % and in 2020 it come up to 46.60%, through 46.0 % in 2017. In 2013 'the existing gross draft for all uses' was estimated to be 185.79 mcm, followed by a rise in 2017 to 187.85 mcm and in 2020 it was 198.39 mcm. The major ground water related problems observed in the district are detailed below:

5.1 Water Scarcity during summer

Many parts of the district experiences shortage for ground water due to the drying up of dug wells and springs in highlands due to high rates of base flow which is attributed to limited aquifer and/soil thickness, high gradients of the terrain. Other localized problems are associated with cropping and indiscriminate quarrying activities.

5.1.a Shortage of water during summer season*:* The shortage of water during summer season is more evident in many parts of the district. The problem aggravates in the absence of summer showers. Areas thrust areas where this problem noticed are in the hilly tracts of Peravoor (Kelakam, Kottiyur, Kanichar panchayaths), Payyannur (Cherupuzha, Peringome-Vayakkara, Eramam Kuttoor), Iritty (Payam, Ayyankunnu, Aralam), Taliparamba (Udayagiri, Alacode, Naduvil,) and Irikkur (Eruvessy, Payyavur,Ulikkal) blocks.

5.1.b Problems associated with quarrying*:* Quarrying for laterite bricks and rocks in parts of eastern hilly areas of the district especially in Payyannur block (Pedena, Madakkampoyyil and Odamuttu), Peravoor (Kottiyur and Kelakam areas) and in parts of Iritty, Irikkur and Taliparamba blocks causes localised ground water issues (reduction in yield) in shallow aquifers due to reduced recharge and discontinuity in groundwater flow resulting from the removal of overburden and drainage through exposed fractures.

5.2 Quality Problems

Generally, the ground water quality in the district is good. However, some isolated problems are reported from parts of the district and are described below:

5.2.a Geogenic Problems*:* As per the water quality analysis carried out by CGWB high concentrations of Iron (Above 0.3 mg/l) in ground water is reported from few places as discussed in section 3.5

5.2.b Anthropogenic Problems*:* Anthropogenic water quality problems reported in the district are nitrate and bacteriological contamination. Nitrate above 45 mg/l is seen in the observation wells of CGWB at Sreekantapuram and Koothuparamba

Again, from the water quality data published by the National Drinking Water Programme, Department of Drinking Water & Sanitation, Ministry of Jal Shakti, the major quality problems reported in the district are bacteriological, iron and nitrate contamination in pockets in the order of prevalence. The anthropogenic contamination may be attributed to the improper waste disposal measures and leakage from septic tanks.

A comprehensive map depicting the major ground water related issues is given in figure 5.1 below:

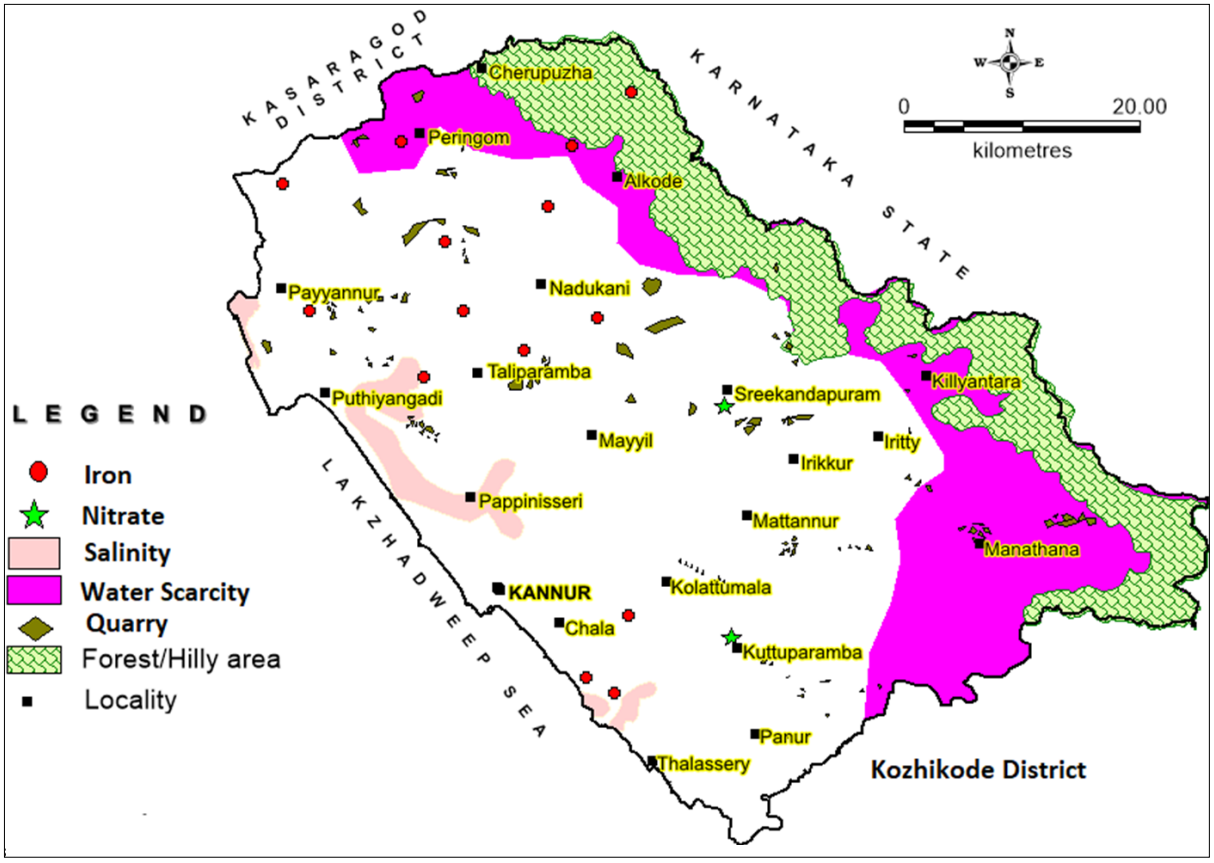


Figure 5.1. Major ground water related issues in Kannur district

6.0 MANAGEMENT STRATEGIES & AQUIFER MANGEMENT PLAN

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 each geographical unit. Hence, it is the need to formulate sustainable management of the groundwater resource in a more rational and scientific way. In the present study, in Kannur district, the sustainable management plan for aquifer is being proposed after a detailed understanding of the aquifer disposition down to a depth of 200 m bgl.

Even though the study area receives good annual rainfall of above 3000 mm, it has been experiencing increasing incidents of water scarcity in summer for meeting the irrigation as well as domestic requirements. This ironic situation is mainly attributed by natural reasons such as undulating topography with steep slopes and the limited thickness of aquifer material. Subsequently, these factors resulted in high run-off and low recharge. Besides this, the shallow depth to massive bed rock along hill slopes of the area limits groundwater storage in the aquifer system. Hence, development of water resources in this area demands a scientific management system coordinating the efforts of all concerned agencies for a swift development in the agricultural sector of the area. While formulating various ground water development and management strategies, geology of the area should be given importance.

6.1 Sustainable plan

An effective ground water management practice must be preceded by an accurate assessment of the total available resources. Even though there exists scope for resource development, the main limitation in this district is the non-uniform distribution of the groundwater resources because of its typical undulating topography with steep slopes and limited thickness of aquifer. From the ground water resource estimation, out of 11 development blocks, three blocks (Panur, Thalassery and Kannur) are categorized as semi-critical and the remaining as safe. So, there is scope for further ground water development for irrigation in these safe blocks, where the stage of extraction is low. Also, the usage of groundwater has to be reduced by 20 percent of the existing extraction for the sustainability of the resource in the 3 semi-critical blocks. Otherwise, the availability has to be augmented through artificial recharge methods to bridge the gap between extraction and availability. The dependence on groundwater can be reduced through application of water efficiency methods in irrigation sector like drip and or sprinkler irrigation especially in the semi-critical blocks to contrive the gap in availability and extraction.

6.2. Supply Side Management Plan

Augmentation of groundwater can be achieved through construction of additional recharge structures like check dams, vented cross bars, percolation ponds etc. Normally it can be attained through capturing surface runoff. Artificial Recharge and Water Conservation Plans proposed for the district utilizing the uncommitted surface run-off will improve the current water scarcity especially in the semi-critical blocks. Groundwater development should be coupled with management of water resources through the implementation of new rainwater harvesting and artificial recharge schemes and by the maintenance and desilting of

the existing structures to ensure proper recharge. Periodic de-siltation as well as cleaning of existing Panchayath ponds and irrigation tanks, check dams/Vented cross bars, individual and community ponds has to be carried out in the study area to increase the storage capacity as well as infiltration rate.

6.2.1. Artificial Recharge and water conservation Plan

Based on the water level monitoring in different seasons across the district, as well as after having better understanding of the disposition and extent of the aquifer system through exploratory drilling, pumping tests etc., recharge/ conservation structures suiting the area are suggested. It has been proposed to implement additional 80 check dams and 100 vented cross bars, 125 percolation ponds and 10 sub-surface dykes at the identified placed in the district (with limited field check. Site selection for new water conservation/recharge structures should be dealt with utmost caution as the area is highly undulating and susceptible for landslides and other earthflows. Again, Nala bunds and contour terracing may be attempted at suitable places considering the slope, geology and weathering thickness of the terrain. The expected recharge through these artificial recharge structures is in the order of 10.40 mcm. The details of feasible recharge/conservation structures and area suitable for AR in the district is given in figure 6.1.

Due to steep slope with shallow depth to bed rock, springs emerges in various parts of the district, which can be developed to meet the requirements during summer season especially in Taliparamba, Irikur, and Koothuparamba blocks. By incorporating the present mapping with previous surveys, a total of 34 perennial springs in the district has been identified. Out of this 15 can be developed and if developed in a scientific manner, it is expected to conserve 0.75 mcm of water by means of spring development. The details of springs that can be developed are given in table 6.1

Table 6.1. Details of springs in Kannur district

Location details	Spring Name	Storage structure	Spring Elevation (a msl)	Spring water use	Approximate discharge in Summer	Spring rejuvenation required
Kandakky	Manattypara	Tank	80 m	Irrigation	60 LPM	Can be developed
Kuveri	Edakkom	Tank	120 m	Irrigation & Domestic	20 LPM	Can be developed
Sivapuram	Kanjileri Temple	Tank	116 m	Irrigation & Domestic	30 LPM	Can be developed
Kishur	Payyancherry mukku	Nil	200 m	Irrigation & Domestic	20 LPM	Can be developed
Mondal	Arriyara	Tank	20 m	Irrigation & Domestic	24 LPM	Can be developed
Kunnathur	Kunnathurpate	Tank	100 m	Irrigation & Domestic	30 LPM	Can be developed
Kuttiyatur	Chattukapara	Nil	50 m	Irrigation & Domestic	12 LPM	Can be developed
Parivangur	Manjatty	Nil	70 m	Irrigation & Domestic	30 LPM	Can be developed
Manveri	Pathamkundu	Nil	45 m	Irrigation & Domestic	200 LPM	Can be developed
Taliparamba	Marathakkad	Nil	25 m	Irrigation & Domestic	235 LPM	Can be developed
Kanichur	Elapeediya	Nil	650 m	Irrigation	12 LPM	Can be developed

Location details	Spring Name	Storage structure	Spring Elevation (a msl)	Spring water use	Approximate discharge in Summer	Spring rejuvenation required
Nilamuttam	Kaniyur Vayal	Tank	80 m	Irrigation	30 LPM	Can be developed
Sivapuram	Thanolichalil	Nil	122 m	Irrigation	12 LPM	Can be developed
Sivapuram	Koroth Paramba	Tank	120 m	Irrigation & Domestic	480 LPM	Can be developed
Pariyaram	Muttikkanam	Nil	70 m	Irrigation & Domestic	200 LPM	Can be developed

Abandoned quarries in the district, especially in the water scarce areas of Irikkur and Taliparamba block can be converted to rainwater storage tanks that can be further utilized for domestic and irrigation purpose during lean period after proper treatment. Presently, these quarries are the site for the inflow of polluted water from adjoining areas. These activities need to be discontinued and appropriate fencing to be done. Finally, the maintenance of these quarries to be entrusted to local people for proper functioning. A total area of 106 Ha of abandoned quarries are present in the district; about 2 MCM of water can be stored in these quarries for use during lean period.

Large scale implementation of roof-top rainwater harvesting through existing dug wells in highland areas to be taken up on priority based on vulnerability of the area in terms of water scarcity. Recharge of monsoon rainfall through many such wells is expected to improve ground water availability over a period. Since the aquifer system is thin with high gradient leads to fast drain, rainwater harvesting as storage cum recharge is highly recommended.

Community based roof top rainwater harvesting (preferably storage) is suggested in large diameter wells and/or tanks are suggested in the water scarce areas. Dug well recharge should be promoted in all panchayaths and the filter medium of the existing schemes must be cleaned annually before the onset of every monsoon season.

Use of existing yielding bore wells drilled by Central Ground Water Board with potable water quality may be handed over to LSGDs to address the drinking water needs of the populace especially during summer season.

It is also suggested for the enhancement of water utilization capacity of Pazhassi Irrigation Project by maintenance and renovation of the existing irrigation canal network system block to improve irrigation potential.

6.3. Demand side Management Plan

Demand side management can be accomplished through change in irrigation pattern. Farmers may be encouraged to adopt modern irrigation techniques like drip and micro irrigation to have optimal use of the available resources especially in semi-critical blocks – Panur, Kannur and Thalassery block. An area of 4208 Ha can be brought for adopting drip/ sprinkler irrigation to increase the water-use efficiency by saving a substantial amount of water. Since it supplies water directly to the crop, rather than the land around, water losses occurring through evaporation and distribution are significantly reduced. There is water saving up to 50% and productivity improvement in the range of 30-60% for different crops

like coconut, arecanut, banana, vegetables under drip method of irrigation. Block wise details of area proposed under drip and Sprinkler irrigation area given in table 6.2

Table 6.2 Block wise details of drip/Sprinkler irrigation feasible in the area

S.No	Name of Block	Drip Irrigation (Ha)	Sprinkler irrigation (Ha)	Total Area (Ha)
1	Edakkad	9.5	9	18.5
2	Irikkur	56	59	115
3	Iritty	452.5	413	865.5
4	Kallyasseri	294	103	397
5	Kuthuparamba	132	165	297
6	Kannur	1188	916	2104
7	Panur	22	24	46
8	Payyannur	34	34	68
9	Peravoor	52	27	79
10	Taliparamba	119	72	191
11	Thalassery	17	10	27
	Total	**2376**	**1832**	**4208**

6.3.1 Creation of irrigation potential through ground water

Additional irrigation potential can be created in the district considering the relatively low stage of ground water development in the blocks. This will promote the financial stability and economic growth of the farmers in the district. Details are given in table 6.3 and 6.4 respectively.

6.3.1.(a). General suggestions for the creation of irrigation potential through ground water

Creation of irrigation potential through groundwater depends upon yield potential of underlying aquifers. Hence, any new construction of groundwater well should be based on the data/ knowledge available for the area with the Central/ State Agencies involved in groundwater development and management. Some of the important points to be considered while planning any groundwater development are as below:

- The groundwater management schemes should not be planned in areas classified as over-exploited, critical and semi critical areas. Further eligibility criteria has been laid down in subsequent paras.
- Groundwater development will be carried out preferably through Dug wells and or BWs in hard rock areas whereas shallow/deep tube wells are recommended alluvial areas. Bore wells are to be taken up in areas where hydro-geological setup and groundwater aquifers justifies their suitability.
- Promotion and adoption of water use efficiency & conservation practices viz. drip/sprinkler, diversification to low water demand crops, promoting on-farm rainwater harvesting etc shall be encouraged by the State Govt/ Project Authorities.
- The State agencies involved in planning and execution of ground water schemes shall formulate the proposals in consultation with State Ground Water Department & CGWB duly considering nature of aquifer system in the area, spatio-temporal behaviour of water level, ground water resource availability, artificial recharge structures suitable for that area, sites for their construction etc.

- To minimize the failure of wells geophysical and hydro-geological investigations may be carried out for proper site selection.

6.3.1.(b). Eligibility criteria

1. Ground Water irrigation facility through Dug wells, Dug cum Bore wells, Tube wells and Bore wells etc. can be funded for schemes in areas other than Over Exploited (OE), Critical or Semi-Critical meeting the following criteria:

- Less than 60 per cent of the annual replenishable groundwater resources have been developed.
- Average annual rainfall of 750 mm or more should be received to enable enough water for recharge.
- Shallow groundwater levels within range of 15m below ground level or less during pre-monsoon period. Ground water development for irrigation can be planned in such a way that after implementation of the project, stage of Ground Water Development (SOD) in an area should not exceed 70% at any time. However, as already mentioned Scheme in unclassified areas shall be considered on case to case basis depending upon various criterions laid down in the guidelines.

2. The beneficiary under this scheme shall be small and marginal farmers only with priority to be given to SC/ST and Women farmers
3. The scheme is applicable for individual farmer, group of farmers/ cooperatives, Govt. Scheme utilising Govt. Land etc

Considering the above guidelines, creation of additional irrigation potential through ground water can be admissible only in 7 blocks viz., Edakkad, Irikkur, Iritty, Kalliassery, Payyannur, Paeravoor and Taliparamba. The details of the tentative number of new abstraction structures feasible in these blocks are given in table 6.3. Even though, groundwater availability for constructing 13154 Dug Wells (DWs) and 8211 Bore Wells (BWs) are possible in these 7 blocks, considering undulating topography and availability of cultivable waste land only limited abstraction structures are feasible and is shown in table 6.4.

Since groundwater is an invisible common pool resource, it brings with it a set of complexities about who uses and who provides. When a potential user overuses groundwater for personal consumption, it leads to a situation where it decreases the availability of water for a community. Similarly, dilemmas arise about who develops and manages the water and who uses it because with a common pool resource it becomes difficult to exclude users. Participation brings a discipline into this process of management. It brings users together to arrive at mutually agreed decisions on usage and recharge. Simultaneously, it builds in an ethos of self-regulation and sustainable use of groundwater to be followed by all..

Some of the local educated people may be identified and imparted basic training on ground water occurrence and its management, thus bringing a participatory approach to the management of this precious resource. These trained persons, called para- hydrogeologists will be responsible for basic data collection like water level monitoring, well inventory,

awareness raising etc. They can also be entrusted with activities like water budgeting, assessment of crop water requirements etc.

Participatory Ground Water Management (PGWM) should be carried out on aquifer-wise and community-centric approach has to be developed as an alternative for managing groundwater as a common pool resource. The units of groundwater management should be aquifers, watersheds and/or habitations.

In views of rapid urbanization, the domestic water needs are escalating and the water wastage component is increasing and thereby causes localised anthropogenic contamination (Nitrate and coliform bacteria). In order to address this, double chamber soak pits and proper waste disposal strategies are to be implemented.

Local people go in search of deeper aquifers when the available one becomes dry in many parts of the district especially in the hilly areas, and thereby, there is a high emergence in the number of bore wells. The guideline that bore wells should not be dug within 30 metres of public wells and ponds too is flouted. Henceforward, stringent law enforcement may be enforced against the indiscriminate sinking of bore wells to safeguard the drinking water requirements of the local population. The area feasible for Artificial Recharge and suitable water conservation structures in the study area is mentioned in figure 6.1 & figure 6.2 respectively.

Table 6.3. Additional abstraction structures possible in the 4 blocks, where SOE <60%

Sl. No.	Assessment Unit/ Block	Annual Extractable GroundWater Recharge (Ham)	Total Extraction (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	60% of the Annual extractable GWR (Ham)	GW Resource available for Development (Ham)	GW Resource to be developed through DW (Ham)	GW Resource to be developed through BW (Ham)	No. of DW to be feasible	No. of BW to be feasible
1	**Edakkad**	1925.63	885.40	860.10	45.98	1155.38	269.98	161.99	107.99	540	337
2	**Irikkur**	6345.74	2201.61	3707.97	34.69	3807.44	1605.83	963.50	642.33	3212	2007
3	**Iritty**	5213.32	2205.98	2629.53	42.31	3127.99	922.01	553.21	368.80	1844	1153
4	**Kallyasseri**	2537.20	1420.26	858.96	55.98	1522.32	102.06	61.24	40.82	204	128
5	**Payyannur**	5805.15	1969.77	3375.51	33.93	3483.09	1513.32	907.99	605.33	3027	1892
6	**Peravoor**	3414.14	1635.97	1522.47	47.92	2048.48	412.51	247.51	165.01	825	516
7	**Taliparamba**	7227.98	2585.59	4045.01	35.77	4336.79	1751.20	1050.72	700.48	3502	2189
Total					**296.58**	**19481.50**	**6576.92**	**3946.15**	**2630.77**	**13154**	**8221**

Table 6.4. Additional abstraction structures recalculated as per the availability of cultivable waste land.

Block	Area of cultivable waste to develop (Ha)	Area Proposed for irrigation by BW/TW (Ha)	Area Proposed for irrigation by DW (Ha)	No of BW/TW	No of DW
Edakkad	175.97	52.79	123.18	35	82
Irikkur	259.91	77.97	181.94	52	121
Iritty	2.12	0	2.12	0	2
Kallyasseri	135.45	40.64	94.82	27	63
Kuthuparamba	56.29	16.89	39.4	11	26
Kannur	39.13	11.74	27.39	8	18
Panur	27.35	8.21	19.15	5	13
Payyannur	532.92	159.88	373.04	107	249
Peravoor	62.64	18.79	43.85	13	29
Taliparamba	446.6	133.98	312.62	89	208
Thalassery	24.33	7.3	17.03	5	11
Total	**1762.71**	**528.81**	**1233.9**	**353**	**823**

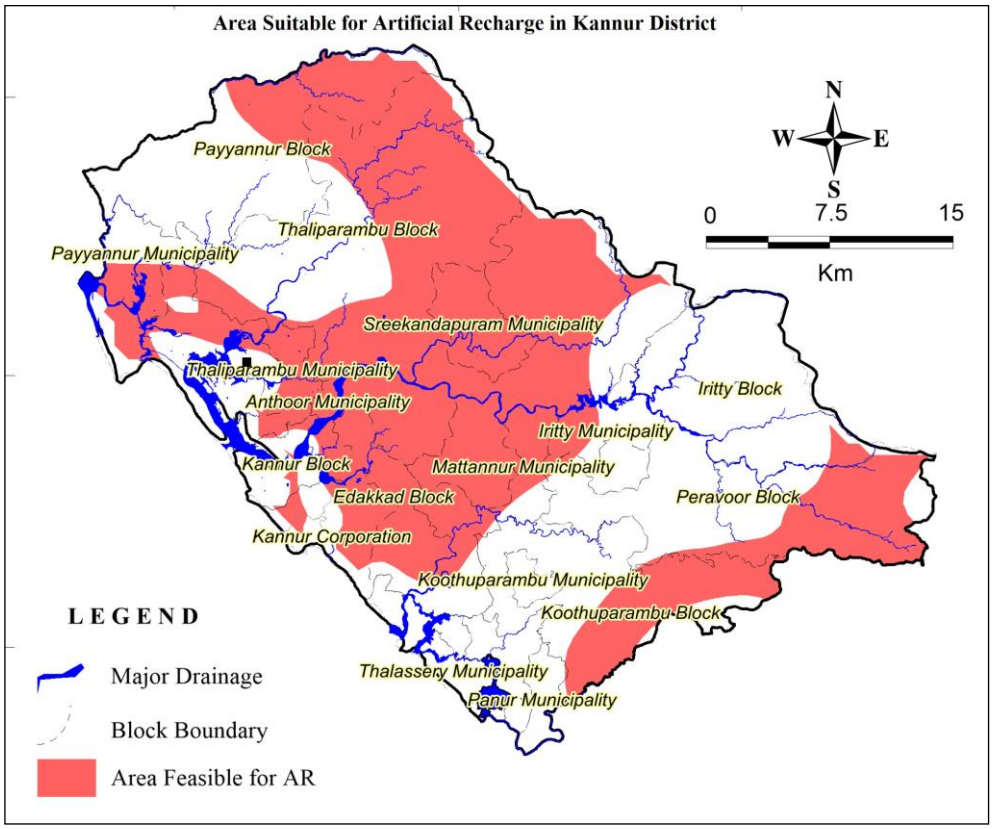


Figure 6.1: Area suitable for AR in the study area

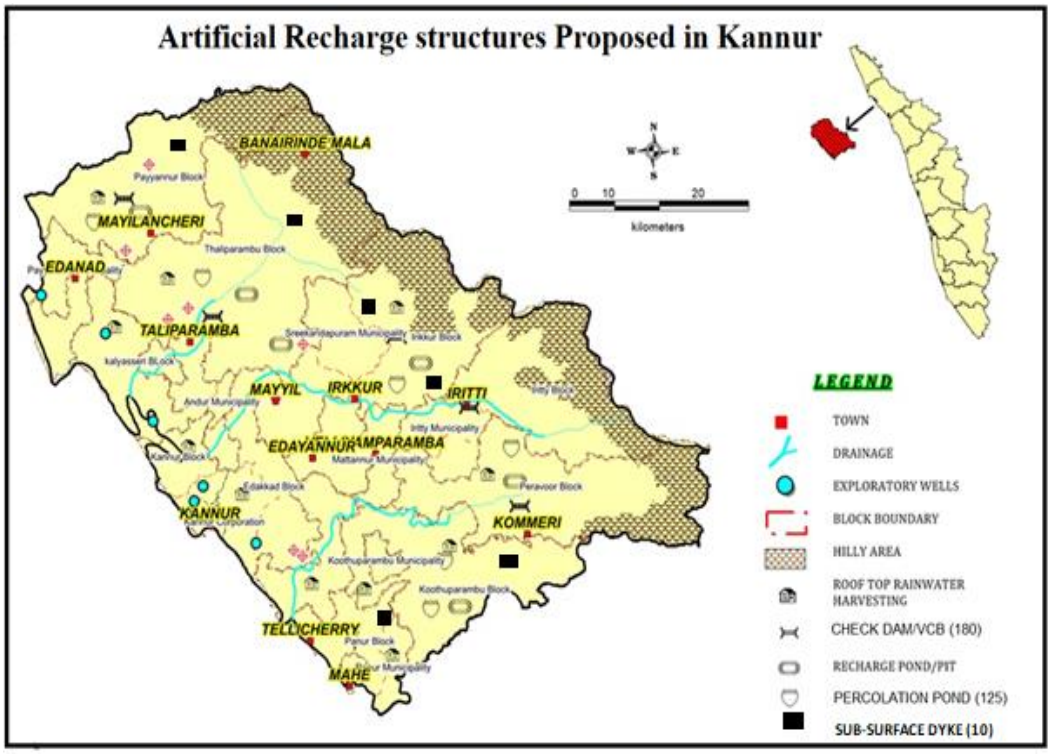


Figure 6.2: Feasible water conservation structures

ANNEXURES

Annexure-I: Details of ground water exploration by CGWB in Kannur district

Sl. No	Location	Block/Muncipality	Latitude	Longitude	Year of construction	Depth drilled (mbgl)	Major lithology encountered	Depth to bed rock (casing depth)	Fracture zones with yield lpm	SWL mbgl	Discharge (lps)	Draw down (m)	T m^2/day	S	Remarks
1	**Mangattuparambu**	Anthoor(M)	11.9776	75.3697	1998-99	200	Charnockite	13.7	15.0-17.0 50.5-54.0 103.0-106.0	15.64	4	12.05	5.7		1 OW
2	**Chavasseri**	Iritty	11.9472	75.6264	1999-00	86.8	Syenite	11.9		3.85	14	14.67	41.19		# 2 OW
3	**Chengalai**	Srikandapuram(M)	12.0431	75.4847	1999-00	157	Garnet gneiss	34.2		0.85	8	12.99	81.27		
4	**Iringal**	Taliparamba	12.0681	75.3333	1999-00	175	Garnet gneiss	33		11.24	3	25.36	1.44		
5	**Mayyil**	Irikkur	11.9889	75.4542	1999-00	92.9	Charnockite	22.8		12.77	8.4				
6	**Perul**	Payyannur	12.1364	75.2861	1999-00	200	Hornblende Bio-Gneiss	22.2	26.0-28.0 71.0-80.0	3.27	4	13.38	11.38		
7	**Peringome**	Payyannur	12.2214	75.3119	1999-00	200	Granite Gneiss		16.5-18.5	10.24	0.2				
8	**Vellora**	Payyannur	12.0792	75.3561	1999-00	200	Charnockite Gneiss	17.8		13.59	1.79		19.53		
9	**Cheruthazham**	Kalliasseri	12.0542	75.2639	1999-00	187	Hornblende Bio- Gneiss	36.6		10.04	4.36	29.96	5.57		
10	**Kannur CWRDM**	Kannur Corporation	11.8875	75.3625	1999-00	200	Biotite Gneiss	31.5		22.48	0.01				
11	**Chala**	Edakkad	11.8458	75.4322	1999-00	200	Biotite Gneiss	21.7	40 -43	8.77	1		1.61		
12	**Peralassery**	Edakkad	11.8325	75.4842	1999-00	200	Quartz Mica Schist	35	78.0-79.0 99.0-100.0 148.0-	14.35	2.7		2.37		

Sl. No	Location	Block/Muncipality	Latitude	Longitude	Year of construction	Depth drilled (mbgl)	Major lithology encountered	Depth to bed rock (casing depth)	Fracture zones with yield lpm	SWL mbgl	Discharge (lps)	Draw down (m)	T m^2/day	S	Remarks
									150.0						
13	**Mulappilangad**	Kannur Corporation	11.7958	75.4333	1996	22	sand, clay	21	16.75-20.75(Recent)	2.09	1.5	NA	NA	NA	
14	**Kannnur**	do	11.8750	75.3542	1996	38.75	sand, clay		18-20	13	0.4		NA		
15	**Eranvu**	Kalliyasseri	11.9667	75.3167		28.95	sand, clay	28.5	NA		NA		NA		
16	**Payyanur**	Payyannur	12.0917	75.1917		35.52	sand, clay	35.5	NA		NA		NA		

Annexure-II: Details of Ground Water Monitoring Wells, Piezometers and Key Observation Wells in Kannur district

Sl No	DISTRICT	Location	Block	Type	Latitude	Longitude	April 2021 WL (mbgl)	November 2021 WL (mbgl)	Fluctuation (m)
1	KANNUR	Kakkeyamkadu	Peravoor	PZ/GWMW	11.936	75.706		1.23	
2	KANNUR	Kankole1	Payyannur	PZ/GWMW	12.158	75.231	6.9	6.06	0.84
3	KANNUR	Karumathur	Thaliparamba	PZ/GWMW	12.038	75.408		5.87	
4	KANNUR	Kizhallur	Iritty	PZ/GWMW	11.908	75.443	3.05	4.11	-1.06
5	KANNUR	Kolacheri	Edakkad	PZ/GWMW	11.972	75.411		6.91	
6	KANNUR	Kommery	Peravoor	PZ/GWMW	11.850	75.736	3.55	3.1	0.45
7	KANNUR	Kottayampoyil	Koothuparamba	PZ/GWMW	11.802	75.546		9.35	
8	KANNUR	Manathana	Peravoor	PZ/GWMW	11.909	75.756	5.8	4.4	1.4
9	KANNUR	Munderi	Kannur	PZ/GWMW	11.899	75.348	3.25	3.18	0.07
10	KANNUR	Panoor	Panur	PZ/GWMW	11.750	75.579		2.46	
11	KANNUR	Parassinikadavu	Thaliparamba	PZ/GWMW	11.975	75.400	20.8	19.99	0.81
12	KANNUR	Pulingome	Payyannur	PZ/GWMW	12.291	75.407	6.7	4.76	1.94
13	KANNUR	Pulingome1	Payyannur	PZ/GWMW	12.283	75.417		4.7	
113	KANNUR	Cannanore1	Thalassery	PZ/GWMW	11.875	75.354		6.8	
14	KANNUR	Alacode (R1)	Thaliparamba	Dug Well/GWMW	12.194	75.465	10.2	6.35	3.85
15	KANNUR	Alavil	Kannur	Dug Well/GWMW	11.901	75.347	4.2	2.88	1.32
16	KANNUR	Ambilad	Thalassery	Dug Well/GWMW	11.826	75.512		3.05	
17	KANNUR	Andoor	Thaliparamba	Dug Well/GWMW	11.986	75.379	6.5	1.4	5.1
18	KANNUR	Anjarakandi	Thalassery	Dug Well/GWMW	11.883	75.537	6.75	5.3	1.45
19	KANNUR	Chakkarakkale	Edakkad	Dug Well/GWMW	11.883	75.475	7.3	6.85	0.45
20	KANNUR	Chala	Edakkad	Dug Well/GWMW	11.846	75.435		7.61	
21	KANNUR	Chavassery	Iritty	Dug Well/GWMW	11.947	75.610		2.58	
22	KANNUR	Cheleri	Edakkad	Dug Well/GWMW	11.940	75.425	10.5	9.95	0.55
23	KANNUR	Chepparapadavu	Thaliparamba	Dug Well/GWMW	12.125	75.414	2.8	2.1	0.7
24	KANNUR	Cherupuzha	Payyannur	Dug Well/GWMW	12.267	75.355	4.4	3.97	0.43
25	KANNUR	Cheruthazam	Kalliasseri	Dug Well/GWMW	12.075	75.267		6.83	

Sl No	DISTRICT	Location	Block	Type	Latitude	Longitude	April 2021 WL (mbgl)	November 2021 WL (mbgl)	Fluctuation (m)
26	KANNUR	Chundaparambu	Irikkur	Dug Well/GWMW	12.061	75.561	6.61	5.75	0.86
27	KANNUR	Chural	Payyannur	Dug Well/GWMW	12.203	75.296	5.88	3.95	1.93
28	KANNUR	Dharmadam	Thalassery	Dug Well/GWMW	11.783	75.481	1.72	1.55	0.17
29	KANNUR	Echilamvayal	Payyannur	Dug Well/GWMW	12.143	75.223	2.05	1.75	0.3
30	KANNUR	Edakkad	Thalassery	Dug Well/GWMW	11.808	75.442	1.11	0.46	0.65
31	KANNUR	Edayannur	Iritty	Dug Well/GWMW	11.931	75.517	4.05	3.36	0.69
32	KANNUR	Edoor	Iritty	Dug Well/GWMW	11.996	75.724		2.45	
33	KANNUR	Elambara	Iritty	Dug Well/GWMW	11.929	75.540	3	3.25	-0.25
34	KANNUR	Ettikkulam	Payyannur	Dug Well/GWMW	12.014	75.208		8.05	
35	KANNUR	Ezhilode	Kalliasseri	Dug Well/GWMW	12.092	75.249		10.31	
36	KANNUR	Irikkur	Iritty	Dug Well/GWMW	11.981	75.533	4.05	3	1.05
37	KANNUR	Kadannapally	Thaliparamba	Dug Well/GWMW	12.106	75.287		9.1	
38	KANNUR	Kakkathodu	Irikkur	Dug Well/GWMW	12.046	75.590	3.48	3.2	0.28
39	KANNUR	Kalliassery	Kalliasseri	Dug Well/GWMW	11.975	75.368	6.2		
40	KANNUR	Kallumutty	Iritty	Dug Well/GWMW	11.998	75.686	6.9	6.15	0.75
41	KANNUR	Kanhirangad	Thaliparamba	Dug Well/GWMW	12.069	75.384		8.9	
42	KANNUR	Kannapuram	Kalliasseri	Dug Well/GWMW	11.978	75.308	1.56	1.23	0.33
43	KANNUR	Kannavam	Peravoor	Dug Well/GWMW	11.847	75.675	4.75	4.6	0.15
44	KANNUR	Kannur	Kannur	Dug Well/GWMW	11.875	75.364	7.6	6.8	0.8
45	KANNUR	Kannur-Thana	Kannur	Dug Well/GWMW	11.874	75.383	8.58	7.45	1.13
46	KANNUR	Karikottakari	Iritty	Dug Well/GWMW	12.009	75.753		4.85	
47	KANNUR	Kelakam	Peravoor	Dug Well/GWMW	11.896	75.803	8.48	7.85	0.63
48	KANNUR	Kizhpalli	Iritty	Dug Well/GWMW	11.976	75.774		4.55	
49	KANNUR	Kolachery	Edakkad	Dug Well/GWMW	11.972	75.410	8.01	5.7	2.31
50	KANNUR	Kolakkad	Peravoor	Dug Well/GWMW	11.877	75.757		6.28	
51	KANNUR	Kolayad	Peravoor	Dug Well/GWMW	11.852	75.694	7.2	6.6	0.6
52	KANNUR	Kommeri	Peravoor	Dug Well/GWMW	11.849	75.731	4.1	3.7	0.4
53	KANNUR	Koothuparamba	Koothuparamba	Dug Well/GWMW	11.827	75.565	5.43	7.2	-1.77

Sl No	DISTRICT	Location	Block	Type	Latitude	Longitude	April 2021 WL (mbgl)	November 2021 WL (mbgl)	Fluctuation (m)
54	KANNUR	Koottumukham	Irikkur	Dug Well/GWMW	12.053	75.535		5.2	
55	KANNUR	Kottayampoil	Koothuparamba	Dug Well/GWMW	11.808	75.551		6.1	
56	KANNUR	Kottiyur	Peravoor	Dug Well/GWMW	11.861	75.861		7.01	
57	KANNUR	Kotty	Payyannur	Dug Well/GWMW	12.091	75.194	1.9	1.8	0.1
58	KANNUR	Kozhichal	Payyannur	Dug Well/GWMW	12.289	75.451	5.1	4.4	0.7
59	KANNUR	Kunnaru	Payyannur	Dug Well/GWMW	12.049	75.221	0.85	0.65	0.2
60	KANNUR	Kunnoth	Iritty	Dug Well/GWMW	12.025	75.708	4.2	2.72	1.48
61	KANNUR	Kuppam	Thaliparamba	Dug Well/GWMW	12.048	75.350		1.45	
62	KANNUR	Kuyilur	Peravoor	Dug Well/GWMW	11.904	75.599		2.4	
63	KANNUR	Mahe (R1)	Mahe (UT)	Dug Well/GWMW	11.711	75.542	1.17	0.95	0.22
64	KANNUR	Manantheri	Koothuparamba	Dug Well/GWMW	11.848	75.610		6.1	
65	KANNUR	Manattana	Peravoor	Dug Well/GWMW	11.908	75.758	2.75	4.76	-2.01
66	KANNUR	Mathamangalam (R1)	Payyannur	Dug Well/GWMW	12.133	75.301		1.83	
67	KANNUR	Mathil	Payyannur	Dug Well/GWMW	12.175	75.235	7.35	6.85	0.5
68	KANNUR	Mattanur	Iritty	Dug Well/GWMW	11.917	75.571	5.8	5	0.8
69	KANNUR	Mayyil	Irikkur	Dug Well/GWMW	11.992	75.450		7.85	
70	KANNUR	Mekunnu	Panur	Dug Well/GWMW	11.715	75.576		4.6	
71	KANNUR	Mele Chovva	Kannur	Dug Well/GWMW	11.872	75.393	7.85	7	0.85
72	KANNUR	Melepukkom	Panur	Dug Well/GWMW	11.743	75.572		7.15	
73	KANNUR	Melur	Thalassery	Dug Well/GWMW	11.797	75.466		2.11	
74	KANNUR	Meruvambayi	Koothuparamba	Dug Well/GWMW	11.872	75.576		11.22	
75	KANNUR	Mokeri	Panur	Dug Well/GWMW	11.777	75.579	7.85	7.9	-0.05
76	KANNUR	Munderi	Kannur	Dug Well/GWMW	11.899	75.348	6.55	6.11	0.44
77	KANNUR	Muzhakunnu	Peravoor	Dug Well/GWMW	11.933	75.683	4.41	1.21	3.2
78	KANNUR	Nayattupara	Iritty	Dug Well/GWMW	11.959	75.517	8.8	5.9	2.9
79	KANNUR	Nellunni	Iritty	Dug Well/GWMW	11.903	75.582		3.3	
80	KANNUR	Neruvambram	Kalliasseri	Dug Well/GWMW	12.040	75.282		6.58	
81	KANNUR	Nuchiyad	Irikkur	Dug Well/GWMW	12.045	75.637	7.3	6.2	1.1

Sl No	DISTRICT	Location	Block	Type	Latitude	Longitude	April 2021 WL (mbgl)	November 2021 WL (mbgl)	Fluctuation (m)
82	KANNUR	Oduvalli	Thaliparamba	Dug Well/GWMW	12.135	75.441	16.3	14.8	1.5
83	KANNUR	Palleri	Kalliasseri	Dug Well/GWMW	11.941	75.395	5.12	4.52	0.6
84	KANNUR	Palloor (Mahe)	Panur	Dug Well/GWMW	11.766	75.538		7.28	
85	KANNUR	Pannoor	Panur	Dug Well/GWMW	11.752	75.579		2.2	
86	KANNUR	Panunda	Thalassery	Dug Well/GWMW	11.812	75.521		9.78	
87	KANNUR	Pappinissery West	Kannur	Dug Well/GWMW	11.950	75.342	0.95	0.5	0.45
88	KANNUR	Parassinikadavu DW	Thaliparamba	Dug Well/GWMW	11.985	75.385	13.25	12.7	0.55
89	KANNUR	Pariyaram	Thaliparamba	Dug Well/GWMW	12.068	75.306		8.02	
90	KANNUR	Pathiriyad	Thalassery	Dug Well/GWMW	11.825	75.531	6.4	5.92	0.48
91	KANNUR	Pattiyam	Koothuparamba	Dug Well/GWMW	11.799	75.564	1.05	0.91	0.14
92	KANNUR	Pattuvam	Thaliparamba	Dug Well/GWMW	12.011	75.334		9.9	
93	KANNUR	Payyannur	Payyannur	Dug Well/GWMW	12.111	75.219	4.05	4.13	-0.08
94	KANNUR	Pazhayangadi	Kalliasseri	Dug Well/GWMW	12.017	75.267	1.43	0.7	0.73
95	KANNUR	Peravoor	Peravoor	Dug Well/GWMW	11.908	75.773	4.75	3.01	1.74
96	KANNUR	Peringome (R1)	Payyannur	Dug Well/GWMW	12.292	75.413	7.5	5.95	1.55
97	KANNUR	Pinarayi	Edakkad	Dug Well/GWMW	11.813	75.496		10.31	
98	KANNUR	Pukkundu	Thaliparamba	Dug Well/GWMW	12.032	75.428		4.6	
99	KANNUR	Pulingome	Payyannur	Dug Well/GWMW	12.292	75.414	6.23	5.2	1.03
100	KANNUR	Puthiyatheru	Kannur	Dug Well/GWMW	11.911	75.364	4.7	3.55	1.15
101	KANNUR	Ramantalai	Payyannur	Dug Well/GWMW	12.067	75.183	6	6.9	-0.9
102	KANNUR	Sreekandapuram	Irikkur	Dug Well/GWMW	12.042	75.508	5.65	4.5	1.15
103	KANNUR	Taliparamba	Thaliparamba	Dug Well/GWMW	12.033	75.365	8.65	6.05	2.6
104	KANNUR	Thalassery	Thalassery	Dug Well/GWMW	11.749	75.488	2.55	3	-0.45
105	KANNUR	Thazhe Chovva	Kannur	Dug Well/GWMW	11.863	75.408	0.6	0.06	0.54
106	KANNUR	Ulikkal (R1)	Irikkur	Dug Well/GWMW	12.033	75.665	4.3	3.35	0.95
107	KANNUR	Vaaram	Kannur	Dug Well/GWMW	11.900	75.417	3.85	2.7	1.15
108	KANNUR	Valakkai	Thaliparamba	Dug Well/GWMW	12.042	75.448		3.05	
109	KANNUR	Valapattanam (R1)	Kannur	Dug Well/GWMW	11.927	75.353	3.98	4.28	-0.3

Sl No	DISTRICT	Location	Block	Type	Latitude	Longitude	April 2021 WL (mbgl)	November 2021 WL (mbgl)	Fluctuation (m)
110	KANNUR	Vattiyamthodu	Peravoor	Dug Well/GWMW	11.902	75.731		4.25	
111	KANNUR	Vayyakara	Payyannur	Dug Well/GWMW	12.250	75.317	19.5	18.87	0.63
112	KANNUR	Vengad	Thalassery	Dug Well/GWMW	11.864	75.509	13.65	11.4	2.25
114	KANNUR	Kannur town (S.N. Park)	Kannur	Dug Well/KOW	11.871	75.361	10.14	7.70	2.44
116	KANNUR	Vaiparambu	Kannur	Dug Well/KOW	11.918	75.324	10.51	9.30	1.21
117	KANNUR	Parapram	Thalassery	Dug Well/KOW	11.813	75.477	4.01	2.23	1.78
118	KANNUR	Kadachira	Edakkad	Dug Well/KOW	11.833	75.458	8.20	6.95	1.25
119	KANNUR	Mammakunnu	Edakkad	Dug Well/KOW	11.818	75.464	7.10	5.95	1.15
120	KANNUR	Kannur town (Thavakkara)	Kannur	Dug Well/KOW	11.872	75.371	8.95	7.75	1.20
121	KANNUR	Kannur town(Thalap)	Kannur	Dug Well/KOW	11.867	75.367	11.20	10.10	1.10
122	KANNUR	Azhikkal 1	Kannur	Dug Well/KOW	11.932	75.328	2.35	0.65	1.70
123	KANNUR	Vadakkumbad	Thalassery	Dug Well/KOW	11.773	75.486	6.01	2.45	3.56
124	KANNUR	Mattool North	Kalliasseri	Dug Well/KOW	11.984	75.278	1.81	0.55	1.26
125	KANNUR	Azhikkal 2	Kannur	Dug Well/KOW	11.942	75.308	2.29	1.50	0.79
126	KANNUR	Mattool South	Kalliasseri	Dug Well/KOW	11.953	75.301	1.53	1.20	0.33
127	KANNUR	Edakkad Beach	Edakkad	Dug Well/KOW	11.807	75.435	2.15	1.3	0.85
128	KANNUR	Edakkad	Edakkad	Dug Well/KOW	11.826	75.425	13.1	10.5	2.60
129	KANNUR	Kannur-Corporation	Kannur	Dug Well/KOW	11.871	75.352	2.23	2.2	0.03
130	KANNUR	Ettikkulam	Payyannur	Dug Well/KOW	12.011	75.210	2.2	1.5	0.70
131	KANNUR	Palliyammoola	Kannur	Dug Well/KOW	11.888	75.339	2.96	2.05	0.91
132	KANNUR	Vayiparamba	Kannur	Dug Well/KOW	11.919	75.326	10.1	7.9	2.20
133	KANNUR	Azhikod-Chal	Kannur	Dug Well/KOW	11.924	75.315	3	1.6	1.40

Annexure-III: Details of Quality monitoring Stations in Kannur district

#	Block	Village	Lat	Lon	Source	pH	EC	CO3	HCO3	SO4	Cl	NO3	F	TH	Ca	Mg	Na	K
								mg/l										
1	Taliparamba	Alacode	12.19	75.47	DW	5.92	31	0	16	3.72	5.15	5.9	0.01	15.9	2.1	2.6	6.23	1.05
2	Kannur	Chakkarakkal	11.8909	75.4703	DW	5.8	165	0	16	6.06	28.8	15.3	0	48	6.4	7.8	24.29	6.86
3	Irikkur	Chelery	11.9413	75.4158	DW	6.13	31	0	22	0.82	5.7	2.7	0.02	15.9	2.1	2.6	4.2	1.12
4	Taliparamba	Chapparapadavu	12.1281	75.4157	DW	6.4	58	0	22	1.87	5	11.4	0.02	32	6.4	3.9	5.83	0.89
5	Thalassery	Dharmadom	11.7776	75.4635	DW	7.2	103	0	49	2.91	13.7	2.1	0	43	8.5	5.2	13.85	1.63
6	Taliparamba	Kannapuram	11.9794	75.3169	DW	8.6	260	26.6	41	11.19	18.4	23.9	0.05	75	21.4	5.2	18.35	4.76
7	Koothuparamba	Kannavam	11.845	75.6597	DW	3.3	230	0	0	1.092	6.8	40.6	0	26.5	4.2	3.9	6.97	1.57
8	Koothuparamba	Koothuparamba	11.8279	75.5649	DW	6.7	360	0	49	20.99	35.5	60.6	0.04	128	30	13	23.59	12.17
9	Peravoor	Kottiyur Phc	11.876	75.8587	DW	7	70	0	49	2.56	5.78	2.9	0	32	6.4	3.9	8.08	2.46
10	Thalassery	kozhichal	11.6973	75.5348	DW	6.98	57	0	16	1.12	3.3	13.3	0.02	26.2	6.4	2.6	4.33	0.9
11	Mattannur	Mahe	11.9305	75.5724	DW	8.3	390	13.32	102	19.02	35.6	24.9	0.08	106	19.2	14.3	36.79	9.29
12	Panur	Mattannur	11.7772	75.5791	DW	3.92	174	0	16	0.88	21	34.4	0.04	42.5	8.5	5.2	16.12	7.43
13	Peravoor	Mokeri	11.9453	75.7033	DW	4.4	240	0	16	2.67	43.2	33.7	0.09	48	8.5	6.5	40.42	4.4
14	Payyanur	Muzhakkunnu Dw	12.0909	75.1943	DW	6.6	73	0	32	1.91	8.4	9.3	0.03	26.5	4.2	3.9	8.69	1.66
15	Payyannur	Payyanur	12.2258	75.3148	DW	3.95	145	0	16	14.52	11.1	20.5	0	37.2	12.8	1.3	10.71	4.65
16	Payyannur	Peringome	12.0602	75.19	DW	4.69	124	0	22	4.2	11.44	31	0	42.5	8.5	5.2	10.85	5.05
17	Irikkur	Ramanthali	12.0452	75.5085	DW	3.8	82	0	0	0.56	6.52	13.1	0.01	21.3	2.1	3.9	5.7	1.22
18	Thalasserry	Sreekandapuram	11.752	75.4858	DW	4.3	310	0	22	12.86	44.1	52.7	0	96.2	30	5.2	27.99	6.58
19	Taliparamba	Thalasserry	12.0374	75.3598	DW	7.5	380	0	200	18.9	24.38	11.3	0.04	117	34.2	7.8	26.62	12.81
20	Irikkur	Taliparamba	12.0376	75.6651	DW	7.5	220	0	54	9.1	18.92	41	0	74.6	23.5	3.9	16.75	10.44
21	Taliparamba	Ullikkal	11.9272	75.3534	DW	7.6	68	0	27	5.02	6.92	14.8	0.02	26.5	4.2	3.9	7.12	1.36
22	Payyannur	Valapattanam	12.2917	75.4501	DW	4	320	0	16	18.38	57.39	25.4	0.05	48	12.8	3.9	49.34	5.22
23	Kannur	Kannur-Collectorate	11.8753	75.3725	BW	7.13	210	0	43.3	25.56	20.24	20.5	0	74.7674	6.4	14.3	18.15	7.75
24	Kannur	Kannur-Thana	11.8744	75.3835	DW	7.3	115	0	43.3	6.18	8.4	9.6	0	47.9346	8.5	6.5	8.32	4.05

#	Block	Village	Lat	Lon	Source	pH	EC	CO3	HCO3	SO4	Cl	NO3	F	TH	Ca	Mg	Na	K
								mg/l										
25	Kalliassery	Naduvatt	11.9422	75.3871	DW	7.65	920	0	81.2	29.74	217	3.5	0.05	229.42	64.1	16.9	99.67	6.59
26	Kannur	Mill Rd-Valapattanam	11.9298	75.3401	DW	8.32	350	31.9	97.5	31.6	27.7	6.8	0.09	154.326	40.1	13.2	30.93	4.05
27	Kannur	Azhikkal	11.9347	75.3324	DW	8.39	950	21.3	314.1	38.39	120.1	8.9	0.14	326.971	101.2	18.1	96.5	14.19
28	Payyannur	Pazhayangadi	12.0235	75.2665	DW	8.1	400	0	81.2	24.27	60.1	14.7	0.04	109.935	28.9	9.2	52.59	6.03
29	Kannur	Chal-Beach	11.9179	75.3178	DW	8.3	370	31.9	157	7.35	29.8	0.4	0.05	221.625	72.5	9.92	24.37	1.76

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