DYNAMIC GROUND WATER RESOURCES OF KERALA, 2024

Central Ground Water Board
Department of Water Resources,
River Development & Ganga Rejuvenation
Ministry of Jal Shakti
Government of India

Trivandrum
March, 2025

BISHWANATH SINHA IAS
ADDITIONAL CHIEF SECRETARY
GOVERNMENT OF KERALA

WATER RESOURCES & CSIN DEPTS.
GOVERNMENT SECRETARIAT
THIRUVANANTHAPURAM-695 001
Phone { Office : 0471-2333174
0471-2518455
E-mail : acs.wrd@kerala.gov.in

19.02.2025

FOREWORD

Groundwater is a vital component of the freshwater resources available in the State providing drinking water for millions, supporting agricultural productivity, and sustaining industrial growth. It is integral in maintaining ecological balance and ensuring socio-economic development. Considering the important role in ensuring water and food security, its regular assessment becomes vital for sustainable management and development.

Effective ground water management begins with a clear understanding of its availability, usage and challenges. Every year, Central Ground Water Board (CGWB), Ministry of Jal Shakti, Department of Water Resources, River Development & Ganga Rejuvenation, Government of India along with the State Ground Water Department, Government of Kerala undertakes systematic assessment of the State's ground water resources. The report on Dynamic Ground Water Resources of Kerala, 2024 consolidates these findings, offering a comprehensive overview of the block wise ground water scenario. This report provides a strong scientific foundation for crafting effective policies, management strategies and regulatory measures.

The efforts of CGWB and the State Ground Water Department in preparing this valuable report is commendable. The resource assessment particulars provided in this report will serve as a valuable aid for formulating region-specific groundwater management strategies, ensuring that the State's groundwater resources are utilized judiciously, equitably, and sustainably. I am confident that this document will contribute to the broader objective of water security towards a resilient and water sufficient future.

(BISHWANATH SINHA)

टी. एस. अनीता श्याम
सदस्य (दक्षिण)
T. S. Anitha Shyam
Member (South)

सत्यमेव जयते

भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास
और गंगा संरक्षण विभाग
केंद्रीय भूमि जल बोर्ड
Government of India
Ministry of Jal Shakti
Department of Water Resources,
River Development and Ganga Rejuvenation
Central Ground Water Board

MESSAGE

The report entitled "Dynamic Ground Water Resources of Kerala, 2024" has been prepared by the Central Ground Water Board (CGWB), Kerala Region office for the year 2024. As the Member of Central Ground Water Board concerned with overseeing the activities of Kerala Region, and also being Member Secretary of the Central Level Expert Group (CLEG) which oversees the preparation of the national report on Ground Water Resources of India, I am immensely pleased to observe the intensive and rigorous scientific efforts made for compiling the report. The report shall aid in the sustainable management of groundwater resources of Kerala state

Groundwater plays an important role in the Nation's economic growth and forms a vital component of our ecological system. India's agricultural productivity, industrial output and domestic water supply are heavily reliant on groundwater. However rising water demands have led to excessive groundwater extraction in many parts of India, exceeding the annual replenishment leading to decline in groundwater level. A thorough assessment of this hidden resources is essential for developing strategies for management and regulatory measures. Since 2022, it has been decided to carry out the estimation of the Dynamic Groundwater Resources of the nation annually and provided to the planners, decision makers and all stakeholders with reliable data/information for taking timely measures for sustainable management of groundwater resources.

This assessment based on Groundwater Estimation Methodology of 2015 (GEC – 2015), underscores the critical interplay between rainfall recharge, evapotranspiration, irrigation, industrial and human demand in shaping the groundwater scenario of State. The assessment is a collaborative effort involving both the State Groundwater Department and Central Ground Water Board, Kerala Region by utilizing the IN-GRES Software.

I commend the team at CGWB, Kerala Region, for their dedication and precision in delivering this report, which serves as a cornerstone for informed policymaking and sustainable water resource management. My gratitude extends to the State-level committee and all stakeholders who have contributed to this endeavor. It is my earnest hope that the insights herein will guide administrators, planners, and the island communities toward a future where water security and environmental integrity coexist harmoniously in the State of Kerala.

Faridabad
March, 2025

(T. S. Anitha Shyam)
Member (South)

Bhujal Bhawan, NH-IV, Faridabad – 121001 (Haryana)
Tele. : 0129-2477204 Email : msouth-cgwb@gov.in Website : cgwb.gov.in

SMT. RINI RANI. S
Director (I/C), Ground water department

PREFACE

The Groundwater Resource Assessment of Kerala State is a joint exercise conducted annually by the Central Ground Water Board (CGWB) in collaboration with the State Ground Water Department and in coordination with other members/departments of State Level Committee (SLC). This systematic evaluation plays a crucial role in monitoring and managing the groundwater resources of the state, which are of paramount importance for various sectors, including agriculture, domestic water supply, and industry.

Kerala, known for its diverse geography and climatic conditions, faces challenges in managing its groundwater resources, particularly in the face of urbanization, agricultural demand, and climate variability. The state's groundwater systems are influenced by factors such as rainfall patterns, recharge rates, and extraction levels, making it essential to continuously assess and monitor these resources

A key tool in this assessment is INGRES software, which plays a pivotal role in assisting with the computational aspects of the groundwater resource evaluation. By leveraging INGRES for computation, the assessment process has become more streamlined and reliable quantifying block wise resources in the state.

The assessment is based on a comprehensive set of input and output parameters, including groundwater levels, quality, recharge from various sources, and extraction patterns. The report contains blocks-wise - total ground water recharge, current annual gross ground water extraction and existing gross ground water extraction for various uses. The stage of groundwater extraction in the State is in Safe Category. The report also documents the future ground water availability for various uses including irrigation and the domestic sectors.

Thus, the Ground Water Resources of Kerala, 2024 has the Total Annual Ground Water Recharge of the State assessed as 5.67bcm and Annual Extractable Ground Water Resources as 5.13bcm. The Annual Ground Water Extraction is 2.76 bcm and the Stage of Ground Water extraction is 53.78 %. There are 29 semi critical blocks, 3 critical blocks and 120 safe blocks in the state and there is no saline block in the state.

As we present the findings of this joint groundwater resource assessment, we hope to contribute towards a more resilient and sustainable water future for Kerala. The collaborative approach between the CGWB and the State Ground Water Department underscores the importance of cooperation in addressing the complex challenges posed by groundwater management in the region. The report will be a valuable guide to the User Agencies.

Place : Ambalamukku
Date : 26.03.2025

Director (I/C)
DIRECTOR
Directorate of Ground Water
Jala Vijnana Bhavan
Ambulamukku, Kowdiar P.O
Trivandrum.

भारत सर्कार /GOVERNMENT OF INDIA
जल शक्ति मंत्रालय /MINISTRY OF JAL SHAKTI
जल संसाधन, नदी विकासऔर गंगा संरक्षण विभाग /DEPARTMENT OF WATER RESOURCES, RD & G R
केंद्रीय भूमिजल बोर्ड, केरल क्षेत्र /CENTRAL GROUND WATER BOARD, KERALA REGION

Phone: 0471-2442191/2442175
E-mail: *rdkr-cgwb@nic.in*
Kerala – 695 004

Thiruvananthapuram
Date: 13/02/2025

PREFACE

The State of Kerala has a total area of about 38,863 sq.km which is only 1.2 percent of the geographical area of India. The State has about 3 percent of the population of the country. Though richly endowed with surface water resource such as rivers, tanks and ponds and having average annual rainfall of about 3000 mm, the peculiar topographic and geomorphic settings of the State allow utilization of only a small portion of the available resources. Nearly 88 percent of the total geographical area of the State is underlain by crystalline rocks devoid of any primary porosity, with limited ground water prospects; in the alluvial formations having multiple aquifer systems, quality is sometimes a constraint in the utilization of available resources.

Increasing population, rapid urbanization and industrialization has resulted in increase in use of ground water resource over the last few decades in the State. Judicious and planned development of ground water and its scientific management have become necessary to ensure long-term sustainability of this precious natural resource. This requires realistic estimates of the availability of ground water resources and the current status of its utilization.

The Dynamic Ground Water Resources of the State are being periodically assessed jointly by the State Ground Water Department, Government of Kerala and the Central Ground Water Board, Ministry of Jal Shakti, Department of Water Resources, River Development & Ganga Rejuvenation, Government of India following the methodology recommended by the Ground Water Estimation Committee (GEC) constituted by the Government of India. The previous assessment was carried out in 2023. As per government policy, the estimation of ground water resources is to be undertaken annually. The salient features of GWRA 2024 as per modified GEC 2015 methodology are presented in this report. The report was approved by the state level committee in the second meeting convened on 29.08.2024 under the chairmanship of Dr. B. Ashok I.A.S, Principal Secretary, Agricultural Production Commissioner & Link Officer of Water Resources Department, Govt. of Kerala and the Chairman of the Committee and subsequently submitted to CGWB Headquarters

This report has been prepared through the sincere and painstaking efforts of the officers of the Central Ground Water Board, Kerala Region, Thiruvananthapuram and Ground Water Department, Government of Kerala, Thiruvananthapuram. I take this opportunity to thank every one of them for their help and cooperation in the preparation of this report. I am also thankful to the Chairman and members of the State Level Committee for Re-estimation of the Ground water Resources of Kerala for their valuable guidance and encouragement during the estimation and for finalizing the report. Thanks are due to various organizations of Government of Kerala and Government of India for fruitful discussions and for providing data required for the assessment of ground water resources of the State. All possible care has been taken to assess various components of the ground water resource of the State as realistically as possible. I hope this compilation will be of help to the planners, administrators and all stake holders in Kerala and will serve as a useful guide for the optimal and sustainable management of the limited ground water resources of Kerala.

13/2/25

(Mini Chandran)
Head of Office

DYNAMIC GROUND WATER RESOURCES OF KERALA, 2024

Contents

List of Figures

List of Tables

List of Annexures

DYNAMIC GROUND WATER RESOURCES OF KERALA, 2024

AT A GLANCE

1.	Total Annual Ground Water Recharge	:	5669.17 ha
2.	Annual Extractable Ground Water Resources	:	5129.67 ha
3.	Annual Ground Water Extraction	:	2758.88 ha
4.	Stage of Ground Water Extraction	:	53.78 %

CATEGORIZATION OF ASSESSMENT UNITS

(Blocks)

Sl.No	Category	Number of Assessment Units		Recharge worthy Area		Annual Extractable Ground Water Resource	
		Number	%	in sq. km	%	(in bcm)	%
1	Safe	120	78.95	22161.1	81.93	4.24	82.66
2	Semi Critical	29	19.08	4109.06	15.19	0.75	14.67
3	Critical	3	1.97	777.38	2.87	0.14	2.67
4	Over-Exploited	0	0	0	0	0	0
5	Saline	0	0	0	0	0	0
	TOTAL	**152**		**27047.53**		**5.13**	

EXECUTIVE SUMMARY

Ground Water Resource Assessment is carried out at periodical intervals jointly by State Ground Water Department and Central Ground Water Board under the guidance of the respective State Level Committee on Ground Water Assessment and under the overall supervision of the Central Level Expert Group (CLEG). Such joint exercises have been taken up earlier in 1980, 1995, 2004, 2009, 2011, 2013, 2017, 2020, 2022, and 2023. From the year 2022, the exercise is being carried out annually. The assessment involves computation of dynamic ground water resources or Annual Extractable Ground Water Resource, Total Current Annual Ground Water Extraction (utilization) and the percentage of utilization with respect to annual extractable resources (stage of Ground Water Extraction). The assessment units (blocks) are categorized based on Stage of Ground Water Extraction, which are then validated with long-term water level trends. The assessment prior to that of year 2017 were carried out following Ground Water Estimation Committee (GEC) 97 Methodology, whereas from 2017 onwards assessment is based on norms and guidelines of the GEC 2015 Methodology. The main source of replenishable ground water resources is recharge from rainfall, which contributes to nearly 82 % of the total annual ground water recharge. Over 69% of the annual rainfall is received in the four rainy months for June to September only thereby leading to large variations on temporal scale. Rainfall is the main source of ground water recharge in the State. However, distribution of rainfall has a wide variation both in space and time. Kerala State receives an annual rainfall of 2884 mm. Type of rock formations and their storage and transmission characteristics have a significant influence on ground water recharge. Porous formations such as the alluvial formations generally have high specific yields and are good repositories of ground water. Ground water occurrence is limited to the weathered, jointed and fractured portions of the rocks. In the present assessment, the total annual groundwater recharge in the state has been assessed as 5.67 bcm. Keeping an allocation for natural discharge, the annual extractable ground water resource has been assessed as 5.13 bcm. The annual groundwater extraction (as in 2024) is 2.76 bcm. The stage of groundwater extraction for the state is 53.78 %. Out of the total 152 assessment units (Blocks) in the state, 3 (1.97 %) assessment units, the stage of groundwater extraction is between 90-100% and have been categorized as 'Critical'; 29 (19.08 %) "Semi-critical'' units, where the stage of ground water extraction is between 70 % and 90 % and 120 (78.95 %) 'Safe' units, where the stage of Ground water extraction is less than 70 %. Similarly, out of 27047.53 sq km recharge worthy area of the state, 777.38 sq km (2.87 %) are under 'Critical', 4109.06 sq km (15.19%) are under 'Semi-Critical', 22161.1 sq km (81.93 %) are under 'Safe'. Out of 5.13 bcm of Total Annual Extractable Resources of the state, 0.14 bcm (2.67%) are under 'Critical', 0.75 bcm (14.67%) are under 'Semi-Critical', 4.24 bcm (82.66%) are under 'Safe' category assessment units. In comparison to Dynamic Ground Water Resource Assessment 2023, the total annual ground water recharge has increased marginally from 5.53 bcm to 5.67 bcm. The change is attributed mainly to change in recharge from mainly from Rainfall and also recharge from 'Other Sources'. Accordingly, the annual extractable ground water resources have increased marginally from 5.005 to 5.13 bcm. The ground water extraction has marginally increased from 2.73 bcm to 2.76 bcm. The overall stage of groundwater extraction has marginally decreased from 54.55 % to 53.78 %. The critical assessment units are mostly concentrated in Chittur, Malampuzha blocks of Palakkad district and Kasaragod block of Kasaragod district where due to inherent characteristics of crystalline aquifers. In some areas of the state, good continuous rainfall and management practices like ground water augmentation and conservation measures taken up under Central and State Government initiatives have resulted in improvement in ground water situation.

CHAPTER 1

1.0 INTRODUCTION

Kerala is a tiny strip of land, located in the southwestern tip of India between north latitudes 8^0 18'and 12^0 48' and east longitudes 74^0 52' and 77^0 22', occupying only 1.2 percent of India's land area. Geographically, an elongated strip of land, cushioned between the Western Ghats on the east and the sandy shores of the Arabian Sea along west. Its land area is 38,863 sq.km, stretching 580 km in length and varying in width from 30 to 120 km. Even though Kerala has got only 1.2% of the total area of India (3,287,263 sq. km), 3 percent of country's population inhabits the state. The state is subdivided into 14 districts and 152 community development blocks for administrative convenience.

The occurrence and availability of ground water vary considerably from place to place within the state depending on the prevailing climatic, geomorphological and hydrogeological conditions. About 88 percent of the total geographical area of the state is underlain by crystalline rocks devoid of any primary porosity, with limited ground water prospects. In the alluvial formations having multiple aquifer systems, quality is sometimes a constraint in the optimal development of available resources. Increasing population and rapid urbanization has resulted in increasing use of ground water resources over the last few decades in the state. Judicious and planned development of ground water and its scientific management have become necessary to ensure long-term sustainability of this precious natural resource of Kerala. The ground water resources of the state are being periodically assessed jointly by the Central Ground Water Board (CGWB) with the State Ground Water Department and other Central Government as well as State Government agencies according to the methodology recommended by the Groundwater Estimation Committee constituted by Govt. of India from time to time. The previous assessment was carried out in 2023. Salient features of the estimation of dynamic ground water resources of Kerala on 2024, as per GEC-2015 recommendations are detailed in this report.

In order to improve the GEC assessment a new 'INDIA-GEC Software/Web Based Application namely, Automation of Estimation of Dynamic Ground Water Resources using GEC-2015' was used in this assessment (developed by CGWB through Vassar labs in collaboration with by IIT-Hyderabad). India GEC system will take data input through Excel as well as through other forms, compute various ground water components (recharge, draft, flux, etc.), classify the assessment unit into appropriate categories, develop visibility of dashboards for each of the components. System allows user to view the data in both MIS as well as GIS view. User can also download the reports in required formats.

1.1 Background

The first attempt to estimate the groundwater resources of the country on a scientific basis date back to the year 1979, when the 'Ground Water Over-Exploitation Committee' was constituted by Agriculture Refinance and Development Corporation (ARDC) of Reserve Bank of India for the purpose. The ground water resources of India were assessed based as per the norms recommended by the above committee. Subsequently, with the objective of refining the assessment methodology, the "Groundwater Estimation Committee (GEC)" headed by the Chairman, Central Ground Water Board (CGWB) came into existence. Based on the information gathered during the studies carried out by CGWB, the committee formulated the detailed methodology for estimation of

groundwater resources in 1984 (GEC-84). The methodology was reviewed in 1997 in the light of feedback from different agencies and information gathered from various studies by the departments, a modified methodology was formulated in 1997(GEC-97) for computation of groundwater resources. Dynamic groundwater resources were assessed using GEC 1997 methodology for base years 2004, 2009, 2011, and 2013. This GEC-1997 methodology was modified subsequently, and GEC-2015 norms were issued. Comprehensive revisions led to the GEC 2015 methodology, which has been used for assessments since 2017 (2017, 2020, 2022 & 2023). In response to the rapidly changing patterns of groundwater extraction, the formulation of management strategies, and the need for regulatory interventions to address short term fluctuations in groundwater resources, the Ministry of Jal Shakti has proposed the annual estimation of groundwater resources for the state, starting from the year 2022 onwards. For the current analysis methodology as per GEC-2015 is being used with the aid of INDIA-GEC Software.

In the present assessment, the total annual groundwater recharge in the state has been assessed as 5.67 bcm. Keeping an allocation for natural discharge, the annual extractable ground water resource has been assessed as 5.13 bcm. The annual groundwater extraction (as in 2024) is 2.76 bcm. The average stage of groundwater extraction for the state works out to be 53.78 %. Out of the total 152 assessment units (Blocks) in the state, 3(1.97 %) assessment units the stage of groundwater extraction is between 90-100% and have been categorized as 'Critical'. There are 29 (19.08 %) "Semi-critical'' units, where the stage of ground water extraction is between 70 % and 90 % and 120 (78.95 %) 'Safe 'units, where the stage of Ground water extraction is less than 70 %.

1.2 Ground Water Assessment and Management Initiatives

The findings from groundwater resource assessments are used by planners and stakeholders for managing and optimizing groundwater use. The Government of India has planned and implemented several measures based on these assessments,

1. CGWB has taken up National Aquifer Mapping & Management Programme (NAQUIM), for mapping of major aquifers, their characterization and formulation of Aquifer Management Plans to ensure sustainability of the resources, prioritizing Over-exploited, Critical and Semi-critical assessment units. CGWB has also initiated NAQUIM 2.0 under which mapping is being taken up at even finer scale in identified priority areas to address groundwater management issues in challenging areas.
2. Master Plan for Artificial Recharge to Groundwater- 2020 has been prepared by CGWB in consultation with the State which is a macro level plan indicating various structures for the different terrain conditions of the country including estimated cost.
3. State Government are implementing watershed development programmes, in which, ground water conservation forms an integral part. Water conservation measures are also taken up as a part of the MGNREGA.
4. Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) Ground Water Component is implemented by the Ministry of Jal Shakti, Government of India, to create irrigation potential through groundwater in Safe assessment units where there is sufficient scope for further future ground water development.

The assessment results form the foundation for planning, implementing management schemes, projects, and regulating groundwater resources for various State Governments.

1.2. Constitution of the State Level Committee

Directions were issued by the Ministry of Water Resources; Government of India vide D.O. No.3/16/2008-GW dated 5.1.2010 to all States/Union Territories for the constitution of state Level Committees for co-ordination of various activities related to estimation of dynamic ground water resources as in 2009. Subsequently, a request (vide letter No.11(T20)10-11/561 dated 29.4.2010) was made for constitution of the committee by the Regional Director, Central Ground Water Board, Kerala Region, Thiruvananthapuram also for the constitution of the committee. In response, Water Resources Department, Government of Kerala issued orders vide G.O. (Rt) No.590/2010/WRD dated 18.05.2010 constituted the State Level Committee for Re-estimation of Ground Water Resources of Kerala. The committee had continued for the estimation of dynamic ground water resources of Kerala in the years 2011, 2013, 2017, 2020,2022,2023.

Currently, as per the direction from Central Head quarter of Central Ground Water Board, ground water Resources estimation has to be carried out as per the methodology GEC-2015 as on 2024. In this regard the committee was again re-constituted (in accordance with the request from the Regional Director, CGWB) by vide G.O. (Rt) No.GW1/309/2021-WRD dated 10.06. 2022.The members of the committee are as enlisted:

Additional Chief Secretary, Water Resources Department	Chairman
The Director Ground Water Department	Member
The Director, Agriculture Department	Member
The Managing Director, Kerala Water Authority	Member
The Chief engineer, Irrigation and Administration	Member
The Director, Dept. of Industry & Commerce	Member
The Executive Director, Centre for Water Resources Development & Management	Member
Regional Director, CGWB, Thiruvananthapuram	Member Secretary

The assessment of the dynamic resources of Kerala as on 2024 was approved by the committee and the Chairman directed Regional Director/HOO, CGWB to share the report/presentation with all members. Copy of the minutes of the meeting of 1st and 2nd SLC is presented in **Annexure VII.**

1.3 Ground Water Estimation Procedure

As per directions of the Central Ground Water Board, dedicated Ground Water Resource Assessment Cells were constituted at both Central Ground Water Board and State Ground Water Department to facilitate realistic and co-ordinated estimation of ground water resources. The exercise of resource estimation commenced with the collection, collation, compilation, and validation of relevant data from various sources. A critical evaluation of the results of the ground water resource assessment taken up during 2017 was undertaken with focus on assessment units categorized as “Over-exploited” and “Critical”. The present ground water scenario in these assessment units were reviewed with the help of field data.

The estimation of ground water resources as on 2024 was undertaken as per the GEC-2015 methodology and ground water resources were computed for all the assessment units. The results were validated

in consultation with field professionals of CGWB and State Ground Water Department. Additional field data was collected and incorporated into the computations wherever required before finalizing the report.

As the ground water resources are to be computed block-wise, the basic data pertaining to the blocks were computerized initially such as geographic area, command and non-command area, recharge worthy area etc. As per available statistics on agriculture appears to indicate no significant increase in ground water extraction for the purpose of irrigation of food-crops. On the other hand, there is increase in the ground water extraction for drinking and domestic uses consequent of the population growth. The ground water extraction data collected during 6th Minor Irrigation census and the additional data available from Ground water Department, Agricultural Department and local government bodies are utilized for the ground water resources computations. It is assumed that there is not much variations in ground water irrigations in the state and a proportional increase in the number of structures for homestead irrigation in the blocks as per the available field data were also incorporated. The dependency on domestic ground water extraction had some changes due to the availability of new surface water schemes in some of the cities and adjoining areas in the state.

CHAPTER 2

2.0 GROUND WATER RESOURCE ESTIMATION METHODOLOGY

Ground water resource as in 2024 have been estimated following the guidelines mentioned in the GEC 2015 methodology using appropriate assumptions depending on data availability. The principal attributes of GEC 2015 methodology are given below:

It is also important to add that as it is advisable to restrict the groundwater development as far as possible to annual replenishable resources, the categorization also considers the relation between the annual replenishment and groundwater development. An area devoid of ground water potential may not be considered for development and may remain safe whereas an area with good groundwater potential may be developed and may become over exploited over a period. Thus, water augmentation efforts can be successful in such areas, where the groundwater potential is high and there is scope for augmentation.

2.1. Ground Water Assessment of Unconfined Aquifer

Though the assessment of ground water resources includes assessment of dynamic and in-storage resources, the development planning should mainly focus on dynamic resource as it gets replenished on an annual basis. Changes in static or in-storage resources normally reflect long-term impacts of ground water mining. Such resources may not be replenishable annually and may be allowed to be extracted only during exigencies with proper planning for augmentation in the succeeding excess rainfall years.

2.1.1. Assessment of Annually Replenishable or Dynamic Ground Water Resources

The methodology for ground water resources estimation is based on the principle of water balance as given below –

$$\boldsymbol{Inflow - Outflow = Change\ in\ Storage(of\ an\ aquifer)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Equation (1) can be further elaborated as –

$$\boldsymbol{\Delta S = R_{RF} + R_{STR} + R_C + R_{SWI} + R_{GWI} + R_{TP} + R_{WCS} \pm VF \pm LF - GE - T - E - B} \ldots\ldots\ldots (2)$$

Where,

- ΔS - Change is storage
- R_{RF} - Rainfall recharge
- R_{STR} - Recharge from stream channels
- R_C - Recharge from canals
- R_{SWI} - Recharge from surface water irrigation
- R_{GWI} - Recharge from ground water irrigation
- R_{TP} - Recharge from Tanks & Ponds
- R_{WCS} - Recharge from water conservation structures
- VF - Vertical flow across the aquifer system
- LF - Lateral flow along the aquifer system (through flow)
- GE - Ground Water Extraction
- T - Transpiration
- E - Evaporation
- B - Base flow

Due to lack of data for all the components in most of the assessment units, at present the water budget has been assessed based on major components only, taking into consideration certain reasonable assumptions. The estimation has been carried out using lumped parameter estimation approach keeping in mind that data from many more sources if available may be used for refining the assessment.

2.1.1.1 Rainfall Recharge

Ground water recharge has been estimated on ground water level fluctuation and specific yield approach since this method considers the response of ground water levels to ground water input and output components. In units or subareas where, adequate data on ground water level fluctuations are not available, ground water recharge is estimated using rainfall infiltration factor method only. The rainfall recharge during non-monsoon season has been estimated using rainfall infiltration factor method only.

2.1.1.1.1. Ground Water Level Fluctuation Method

The ground water level fluctuation method is used for assessment of rainfall recharge in the monsoon season. The ground water balance equation in non-command areas is given by

$$\Delta S = R_{RF} + R_{STR} + R_{SWI} + R_{GWI} + R_{TP} + R_{WCS} \pm VF \pm LF - GE - T - E - B \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where,

- ΔS - Change is storage
- R_{RF} - Rainfall recharge
- R_{STR} - Recharge from stream channels
- R_{SWI} - Recharge from surface water irrigation
- R_{GWI} - Recharge from ground water irrigation
- R_{TP} - Recharge from Tanks& Ponds
- R_{WCS} - Recharge from water conservation structures
- VF - Vertical flow across the aquifer system
- LF - Lateral flow along the aquifer system (through flow)
- GE - Ground water extraction
- T - Transpiration
- E - Evaporation
- B - Base flow

Whereas the water balance equation in command area have another term i.e., Recharge due to canals (R_C) and the equation is as follows:

$$\Delta S = R_{RF} + R_{STR} + R_C + R_{SWI} + R_{GWI} + R_{TP} + R_{WCS} \pm VF \pm LF - GE - T - E - B \ldots\ldots\ldots\ldots (4)$$

The change in storage has been estimated using the following equation:

$$\Delta S = \Delta h \times A \times S_Y \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where,

- ΔS - Change is storage
- **Δ**h - rise in water level in the monsoon season
- A - Area for computation of recharge
- S_Y - Specific Yield

Substituting the expression in equation (5) for storage increase ΔS in terms of water level fluctuation and specific yield, the equations (3) & (4) becomes (6) & (7) for non-command and command sub-units,

$$\boldsymbol{R_{RF} = \Delta h \times A \times S_Y - R_{STR} - R_{SWI} - R_{GWI} - R_{TP} - R_{WCS} \pm VF \pm LF + GE + T + E + B} \ldots\ldots\ldots\ldots\ldots..(6)$$

$$\boldsymbol{R_{RF} = \Delta h \times A \times S_Y - R_{STR} - R_C - R_{SWI} - R_{GWI} - R_{TP} - R_{WCS} \pm VF \pm LF + GE + T + E + B} \ldots\ldots\ldots.(7)$$

Where base flow/ recharge to/from streams have not been estimated, the same is assumed to be zero. The rainfall recharge obtained by using equation (6) and (7) provides the recharge in any particular monsoon season for the associated monsoon season rainfall. This estimate has been normalized for the normal monsoon season rainfall as per the procedure indicated below.

Normalization of Rainfall Recharge

Let R_i be the rainfall recharge and r_i be the associated rainfall. The subscript "i" takes values 1 to N where N is the number of years for which data is available. This should be at least 5. The rainfall recharge, R_i is obtained as per equation (6) & equation (7) depending on the sub-unit for which the normalization is being done.

After the pairs of data on R_i and r_i have been obtained as described above, a normalisation procedure is carried out for obtaining the rainfall recharge corresponding to the normal monsoon season rainfall. Let r(normal) be the normal monsoon season rainfall obtained as the average of recent 30 to 50 years of monsoon season rainfall. Two methods are possible for the normalisation procedure. The first method is based on a linear relationship between recharge and rainfall of the form

$$\boldsymbol{R = ar} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..\ldots\ldots\ldots.(8)$$

Where,

R = Rainfall recharge during monsoon season

r = Monsoon season rainfall

a = a constant

The computational procedure is followed in the first method is as given below:

$$\boldsymbol{R_{RF}(normal) = \frac{\sum_{i=1}^{N}\left[R_i \frac{r(normal)}{r_i}\right]}{N}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..\ldots\ldots\ldots\ldots\ldots\ldots..(9)$$

Where,

R_{RF}(normal) - Normalized Rainfall Recharge in the monsoon season

R_i- Rainfall Recharge in the monsoon season for the i^{th}year

r(normal) - Normal monsoon season rainfall

r_i- Rainfall in the monsoon season for the i^{th} year

N - No. of years for which data is available

The second method is also based on a linear relation between recharge and rainfall. However, this linear relationship is of the form,

$$\boldsymbol{R_{RF}(normal) = a \times r(normal) + b} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(10)$$

Where,

R_{RF}(normal) - Normalized Rainfall Recharge in the monsoon season
r(normal) - Normal monsoon season rainfall
a and b - Constants.

The two constants 'a' and 'b' in the above equation are obtained through a linear regression analysis. The computational procedure has been followed in the second method is as given below:

$$\boldsymbol{a = \frac{NS_4 - S_1S_2}{NS_3 - S_1^2}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \boldsymbol{(11)}$$

$$\boldsymbol{b = \frac{S_2 - aS_1}{N}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \boldsymbol{(12)}$$

Where,

$$\boldsymbol{S_1 = \sum_{i=1}^{N} r_i \ , \quad S_2 = \sum_{i=1}^{N} R_i \ , \quad S_3 = \sum_{i=1}^{N} r_i^2 \ , \quad S_4 = \sum_{i=1}^{N} R_i r_i}$$

2.1.1.1.2. Rainfall Infiltration Factor Method

The rainfall recharge estimation based on Water level fluctuation method reflects actual field conditions since it takes into account the response of ground water level. However, the ground water extraction estimation included in the computation of rainfall recharge using water level fluctuation approach is often subject to uncertainties. Therefore, the rainfall recharge obtained from water level fluctuation approach has been compared with that estimated using rainfall infiltration factor method. Recharge from rainfall is estimated by using the following relationship –

$$\boldsymbol{R_{RF} = RFIF \times A \times \frac{(R - a)}{1000}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \boldsymbol{(13)}$$

Where,

R_{RF} - Rainfall recharge in ham
A - Area in hectares
RFIF - Rainfall Infiltration Factor
R- Rainfall in mm
a - Minimum threshold value above which rainfall induces ground water recharge in mm

The threshold limit of minimum and maximum rainfall event which can induce recharge to the aquifer is considered while estimating ground water recharge using rainfall infiltration factor method. The minimum threshold limit is in accordance with the relation shown in equation (13) and the maximum threshold limit is based on the premise that after a certain limit, the rate of storm rain is too high to contribute to infiltration and they will only contribute to surface runoff. Thus, 10% of Normal annual rainfall has been taken as minimum rainfall threshold and 3000 mm as maximum rainfall limit. While computing the rainfall recharge, 10% of the normal annual rainfall has been deducted from the monsoon rainfall and balance rainfall is considered for computation of rainfall recharge. The same recharge factor is used for both monsoon and non-monsoon rainfall, with the condition that the recharge due to non-monsoon rainfall is taken as zero, if the normal rainfall during the non-monsoon season is less than 10% of normal annual rainfall. In using the method based on the specified norms, recharge due to both monsoon and non-monsoon rainfall has been estimated for normal rainfall, based on recent 30 to 50 years of data.

2.1.1.1.3. Percent Deviation

After computing the rainfall recharge for normal monsoon season rainfall using the ground water level fluctuation method and rainfall infiltration factor method these two estimates is compared with each other. A term, Percent Deviation (PD) which is the difference between the two expressed as a percentage of the later is computed as

$$\boldsymbol{PD = \frac{R_{RF}(normal, wtfm) - R_{RF}(normal, rifm)}{R_{RF}(normal, rifm)} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots.\ldots\ldots\ldots.(14)}$$

Where,

R_{RF} (normal, wlfm) = Rainfall recharge for normal monsoon season rainfall estimated by the ground water level fluctuation method

R_{RF} (normal, rifm) = Rainfall recharge for normal monsoon season rainfall estimated by the rainfall infiltration factor method

The rainfall recharge for normal monsoon season rainfall is finally adopted as per the criteria given below:

- If PD is greater than or equal to -20%, and less than or equal to +20%, R_{RF} (normal) is taken as the value estimated by the ground water level fluctuation method.
- If PD is less than -20%, R_{RF} (normal) is taken as equal to 0.8 times the value estimated by the rainfall infiltration factor method.
- If PD is greater than +20%, R_{RF} (normal) is taken as equal to 1.2 times the value estimated by the rainfall infiltration factor method.

2.1.1.2. Recharge from Other Sources

Recharge from other sources constitutes recharges from canals, surface water irrigation, ground water irrigation, tanks & ponds and water conservation structures in command areas where as in non-command areas it constitutes the recharge due to surface water irrigation, ground water irrigation, tanks & ponds and water conservation structures. The methods of estimation of recharge from different sources are used in the assessment as follows.

Sl. No.	Source	Estimation Formula	Parameters
1	Recharge from Canals	$R_C = WA \times SF \times Days$	R_C = Recharge from Canals WA = Wetted Area SF = Seepage Factor Days = Number of Canal Running Days

Sl. No.	Source	Estimation Formula	Parameters
2	Recharge from Surface Water Irrigation	$R_{SWI} = AD \times Days \times RFF$	R_{SWI} = Recharge due to applied surface water irrigation AD = Average Discharge Days = Number of days water is discharged to the Fields RFF = Return Flow Factor
3	Recharge from Ground Water Irrigation	$R_{GWI} = GE_{IRR} \times RFF$	R_{GWI} = Recharge due to applied ground water irrigation GE_{IRR} = Ground Water Extraction for Irrigation RFF = Return Flow Factor
4	Recharge due to Tanks & Ponds	$R_{TP} = AWSA \times N \times RF$	R_{TP} = Recharge due to Tanks & Ponds AWSA = Average Water Spread Area N = Number of days Water is available in the Tank/Pond RF = Recharge Factor
5	Recharge due to Water Conservation Structures	$R_{WCS} = GS \times RF$	RWCS = Recharge due to Water Conservation Structures GS = Gross Storage = Storage Capacity multiplied by number of fillings. RF = Recharge Factor

2.1.1.3. Evaporation and Transpiration

Evaporation is estimated for the aquifer in the assessment unit if water levels in the aquifer are within the capillary zone. For areas with water levels within 1.0mbgl, evaporation is estimated using the evaporation rates available for other adjoining areas. If depth to water level is more than 1.0mbgl, the evaporation losses from the aquifer is taken as zero.

Transpiration through vegetation has been estimated if water levels in the aquifer are within the maximum root zone of the local vegetation. If water levels are within 3.5mbgl, transpiration is estimated using the transpiration rates available for other areas. If it is greater than3.5m bgl, the transpiration has been taken as zero.

2.1.1.4. Recharge During Monsoon Season

The sum of normalized monsoon rainfall recharge and the recharge from other sources and lateral and vertical flows into & out of the sub unit and stream inflows & outflows during monsoon season is the total recharge/ accumulation during monsoon season for the sub unit. Similarly, this is to be computed for all the sub units available in the assessment unit.

2.1.1.5. Recharge During Non-Monsoon Season

The rainfall recharge during non-monsoon season is estimated using rainfall infiltration factor Method only when the non-monsoon season rainfall is more than 10% of normal annual rainfall. The sum of non-monsoon rainfall recharge and the recharge from other sources and lateral and vertical flows into & out of the sub unit and stream inflows & outflows during non-monsoon season is the total recharge/ accumulation during non-monsoon season for the sub unit. Similarly, this is to be computed for all the sub units available in the assessment unit.

2.1.1.6. Total Annual Ground Water Recharge

The sum of the recharge/ accumulations during monsoon and non-monsoon seasons is the total annual ground water recharge/ accumulations for the sub unit. Similarly, this is computed for all the sub units available in the assessment unit.

2.1.1.7. Annual Extractable Ground Water Resource (EGR)

The Annual Extractable Ground Water Resource (EGR) is computed by deducting the Total Annual Natural Discharge from Total Annual Ground Water Recharge.

In the water level fluctuation method, a significant portion of base flow is already accounted for by taking the post monsoon water level one month after the end of rainfall. The base flow in the remaining non-monsoon period is likely to be small, especially in hard rock areas. In the assessment units, where river stage data are not available and neither the detailed data for quantitative assessment of the natural discharge are available, allocation of unaccountable natural discharges to 5% or 10% of annual recharge is considered. If the rainfall recharge is assessed using water level fluctuation method this has been taken 5% of the annual recharge and if it is assessed using rainfall infiltration factor method, 10% of the annual recharge is considered. The balance is account for Annual Extractable Ground Water Resources (EGR).

2.1.1.8. Estimation of Ground Water Extraction

Ground water draft or extraction is assessed as follows.

$$\boldsymbol{GE_{ALL} = GE_{IRR} + GE_{DOM} + GE_{IND}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (\mathbf{15})$$

Where,

GE_{ALL} = Ground water extraction for all uses
GE_{IRR} = Ground water extraction for irrigation
GE_{DOM} = Ground water extraction for domestic uses
GE_{IND} = Ground water extraction for industrial uses

2.1.1.8.1. Ground Water Extraction for Irrigation (GE_{IRR})

The methods for estimation of ground water extraction are as follows.

Unit Draft Method: – In this method, season-wise unit draft of each type of well in an assessment unit is estimated. The unit draft of different types (eg. Dug well, Dug cum bore well, shallow tube well, deep tube well, bore well etc.) is multiplied with the number of wells of that particular type to obtain season-wise ground water extraction by that particular structure.

Crop Water Requirement Method: – For each crop, the season-wise net irrigation water requirement is determined. This is then multiplied with the area irrigated by ground water abstraction structures. The database

on crop area is obtained from Revenue records in Tehsil office, Agriculture Census and also by using Remote Sensing techniques.

Power Consumption Method: –Ground water extraction for unit power consumption (electric) is determined. Extraction per unit power consumption is then multiplied with number of units of power consumed for agricultural pump sets to obtain total ground water extraction for irrigation.

2.1.1.8.2. Ground Water Extraction for Domestic Use (GE_{DOM})

There are several methods for estimation of extraction for domestic use (GE_{DOM}). Some of the commonly adopted methods are described here.

Unit Draft Method: – In this method, unit draft of each type of well is multiplied by the number of wells used for domestic purpose to obtain the domestic ground water extraction.

Consumptive Use Method: – In this method, population is multiplied with per capita consumption usually expressed in litre per capita per day (lpcd). It can be expressed using following equation.

$$\boldsymbol{GE_{DOM} = Population \times Consumptive\ Requirement \times L_g} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (16)$$

Where,

L_g = Fractional Load on Ground Water for Domestic Water Supply.

The Load on Ground water can be obtained from the Information based on Civic water supply agencies in urban areas.

2.1.1.8.3. Ground Water Extraction for Industrial Use (GE_{IND})

The commonly adopted methods for estimating the extraction for industrial use are as below:

Unit Draft Method: - In this method, unit draft of each type of well is multiplied by the number of wells used for industrial purpose to obtain the industrial ground water extraction.

Consumptive Use Pattern Method: – In this method, water consumption of different industrial units is determined. Numbers of Industrial units which are dependent on ground water are multiplied with unit water consumption to obtain ground water extraction for industrial use.

$$\boldsymbol{GE_{IND} = Number\ of\ Industrial\ Units \times Unit\ Water\ Consumption \times L_g} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (17)$$

Where,

L_g = Fractional load on ground water for industrial water supply.

The load on ground water for industrial water supply can be obtained from water supply agencies in the Industrial belt.

Ground water extraction obtained from different methods need to be compared and based on field checks, the seemingly best value may be adopted. At times, ground water extraction obtained by different methods may vary widely. In such cases, the value matching the field situation should be considered. The storage depletion during a season, where other recharges are negligible can be taken as ground water extraction during that particular period.

2.1.1.9. Stage of Ground Water Extraction

The stage of ground water extraction is defined by,

$$\textbf{\textit{Stage of GW Extraction}} = \frac{\textbf{\textit{Existing Gross GW Extraction for all Uses}}}{\textbf{\textit{Annual Extractable GW Resources}}} \times \mathbf{100} \ldots\ldots\ldots\ldots\ldots (\mathbf{18})$$

The existing gross ground water extraction for all uses refers to the total of existing gross ground water extraction for irrigation and all other purposes. The stage of ground water extraction should be obtained separately for command areas, non-command areas and poor ground water quality areas.

2.1.1.10. Validation of Stage of Ground Water Extraction

The assessment based on the stage of ground water extraction has inherent uncertainties. In view of this, it is desirable to validate the 'Stage of Ground Water Extraction' with long term trend of ground water levels. Long term Water Level trends are prepared for a minimum period of 10 years for both pre-monsoon and post-monsoon period. If the ground water resource assessment and the trend of long-term water levels contradict each other, this anomalous situation requires a review of the ground water resource computation, as well as the reliability of water level data. The mismatch conditions are enumerated below.

SOGWE	Ground Water Level Trend	Remarks
≤ 70%	Significant decline in trend in both pre-monsoon and post-monsoon	Not acceptable and needs reassessment
> 100%	No significant decline in both pre-monsoon and post-monsoon long term trend	Not acceptable and needs reassessment

2.1.1.11. Categorisation of Assessment Unit

2.1.1.12. Categorisation of Assessment Unit Based on Quantity

The categorisation based on status of ground water quantity is defined by Stage of Ground Water Extraction as given below:

Stage of Ground Water Extraction	Category
≤ 70%	Safe
> 70% and ≤90%	Semi-critical
> 90% and ≤100%	Critical
> 100%	Over Exploited

2.1.1.13. Categorisation of Assessment Unit Based on Quality

As it is not possible to categorize the assessment units in terms of the extent of quality hazard, based on the available water quality monitoring mechanism and database on ground water quality, the Committee recommends that each assessment unit, in addition to the Quantity based categorization (safe, semi-critical, critical and over-exploited) should bear a quality hazard identifier. If any of the three quality hazards in terms of Arsenic, Fluoride and Salinity are encountered in the assessment sub unit in mappable units, the assessment sub unit has been tagged with the particular Quality hazard.

2.1.1.14. Allocation of Ground Water Resource for Utilisation

The Annual Extractable Ground Water Resources are to be apportioned between domestic, industrial and irrigation uses. Among these, as per the National Water Policy, requirement for domestic water supply is to be accorded priority. This requirement based on population has been projected to the year 2025, per capita requirement of water for domestic use, and relative load on ground water for urban and rural water supply. In situations where, adequate data is not available to make this estimate, the following empirical relation has been utilized.

$$\boldsymbol{Alloc = 22 \times N \times L_g mm\ per\ year} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(\mathbf{19})$$

Where,

Alloc = Allocation for domestic water requirement

N = population density in the unit in thousands per sq. km.

L_g= fractional load on ground water for domestic water supply (≤ 1.0)

2.1.1.15. Net Annual Ground Water Availability for Future Use

The water available for future use is obtained by deducting the allocation for domestic use and current extraction for Irrigation and Industrial uses from the Annual Extractable Ground Water Recharge. The resulting ground water potential is termed as the net annual ground water availability for future use. The Net annual ground water availability for future use is calculated separately for non-command areas and command areas. As per the recommendations of the R&D Advisory committee, the ground water available for future use can never be negative. If it becomes negative, the future allocation of Domestic needs can be reduced to current extraction for domestic use. Even then if it is still negative, then the ground water available for future uses has been projected as zero.

2.1.1.16. Additional Potential Resources under Specific Conditions

2.1.1.16.1. Potential Resource Due to Spring Discharge

Spring discharge occurs at the places where ground water level cuts the surface topography. The spring discharge is equal to the ground water recharge minus the outflow through evaporation and evapotranspiration and vertical and lateral sub-surface flow. Thus, Spring Discharge is a form of 'Annual Extractable Ground Water Recharge'. It is a renewable resource, though has not been used for Categorisation. Spring discharge measurement has been carried out by volumetric measurement of discharge of the springs. Spring discharges multiplied with time in days of each season will give the quantum of spring resources available during that season.

$$\boldsymbol{Potential\ ground\ water\ resource\ due\ to\ springs} \\ = \boldsymbol{Q \times No.of days} \ldots\ldots\ldots\ldots..\ldots\ldots.(\mathbf{20})$$

Where,

Q = Spring Discharge

No of days = No of days spring yields.

2.1.1.16.2. Potential Resource in Waterlogged and Shallow Water Table Areas

In the area where the ground water level is less than 5m below ground level or in waterlogged areas, the resources up to 5m below ground level are potential and would be available for development in addition to the annual recharge in the area. The computation of potential resource to ground water reservoir in shallow water table areas has been done by adopting the following equation:

$$\boldsymbol{Potential\ groundwater\ resource\ in\ shallow\ water\ table\ areas} = (\mathbf{5} - \boldsymbol{D}) \times \boldsymbol{A} \times \boldsymbol{S_Y} \ldots\ldots\ldots\ldots (\mathbf{21})$$

Where,

D = Depth to water table below ground surface in pre-monsoon period in shallow aquifers.

A = Area of shallow water table zone.

S_Y = Specific Yield

2.1.1.16.3. Potential Resource in Flood Prone Areas

Ground water recharge from a flood plain is mainly the function of the following parameters-

- Areal extent of flood plain
- Retention period of flood
- Type of sub-soil strata and silt charge in the river water which gets deposited and controls seepage

Since collection of data on all these factors is time taking and difficult, in the meantime, the potential resource from flood plain may be estimated on the same norms as for ponds, tanks and lakes. This has been calculated over the water spread area and only for the retention period using the following formula.

$$\boldsymbol{Potential\ groundwater\ resource\ in\ Flood\ Prone\ Areas} = \mathbf{1.4} \times \boldsymbol{N} \times \frac{\boldsymbol{A}}{\mathbf{1000}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (\mathbf{22})$$

Where,

N = No. of Days Water is Retained in the Area

A = Flood Prone Area

2.1.1.17. Apportioning of Ground Water Assessment from Watershed to Development Unit

Where the assessment unit is a watershed, there is a need to convert the ground water assessment in terms of an administrative unit such as block. This has been done as follows.

A block may comprise of one or more watersheds, in part or full. First, the ground water assessment in the subareas, command, non-command and poor ground water quality areas of the watershed has been converted into depth unit (mm), by dividing the annual recharge by the respective area. The contribution of this subarea of the watershed to the block, is now calculated by multiplying this depth with the area in the block occupied by this sub-area.

The total ground water resource of the block has been presented separately for each type of sub-area, namely for command areas, non-command areas and poor ground water quality areas, as in the case of the individual watersheds.

2.2. Ground Water Assessment in Urban Areas

The Assessment of Ground Water Resources in urban areas is similar to that of rural areas. Because of the availability of draft data and slightly different infiltration process and recharge due to other sources, the following few points are to be considered.

- Even though the data on existing ground water abstraction structures are available, accuracy is somewhat doubtful and individuals cannot even enumerate the well census in urban areas. Hence the difference of the actual demand and the supply by surface water sources as the withdrawal from the ground water resources has been considered for the assessment.

- The urban areas are sometimes concrete jungles and rainfall infiltration is not equal to that of rural areas unless and until special measures are taken in the construction of roads and pavements. Hence, 30% of the rainfall infiltration factor has been taken into consideration for urban areas as an adhoc arrangement till field studies in these areas are done and documented field studies are available.

- Because of the water supply schemes, there are many pipelines available in the urban areas and the seepages from these channels or pipes are huge in some areas. Hence this component has been included in the other resources and the recharge has also been considered. The percent losses have been collected from the individual water supply agencies, 50% of which has been considered as recharge to the ground water system.

- In the urban areas in India, normally, there is no separate channels either open or sub surface for the drainage and flash floods. These channels also recharge to some extent the ground water reservoir. As on today, there is no documented field study to assess the recharge. The seepages from the sewerages, which normally contaminate the ground water resources with nitrate also contribute to the quantity of resources and hence same percent as in the case of water supply pipes has been taken as norm for the recharge on the quantity of sewerage when there is sub surface drainage system. If estimated flash flood data is available, the same percent has been used on the quantum of flash floods to estimate the recharge from the flash floods.

- Urban areas with population more than 10 lakhs, has been considered as urban assessment unit while assessing the dynamic ground water resources.

2.3. Ground Water Assessment in Water Level Depletion Zones

There are areas where ground water level shows a decline even in the monsoon season. The reasons for this may be any one of the following: (a) There is a genuine depletion in the ground water regime, with ground water extraction and natural ground water discharge in the monsoon season (outflow from the region and base flow) exceeding the recharge. (b) There may be an error in water level data due to inadequacy of observation wells.

If it is concluded that the water level data is erroneous, recharge assessment has been made based on rainfall infiltration factor method. If, on the other hand, water level data is assessed as reliable, the ground water level fluctuation method has been applied for recharge estimation. As ΔS in equation 3& 4 is negative, the estimated recharge will be less than the gross ground water extraction in the monsoon season. It must be noted that this

recharge is the gross recharge minus the natural discharges in the monsoon season. The immediate conclusion from such an assessment in water depletion zones is that the area falls under the over-exploited category which requires micro level study.

2.4. Norms has been Used in The Assessment

2.4.1. Specific Yield

Recently under Aquifer Mapping Project, Central Ground Water Board has classified all the aquifers into 14 Principal Aquifers which in turn were divided into 42 Major Aquifers. Hence, it is required to assign Specific Yield values to all these aquifer units. The values recommended in the ***Table-2.1*** has been followed in the present assessments, unless sufficient data based on field studies are available to justify the minimum, maximum or other intermediate values

Table-2.1: Norms Recommended for Specific Yield

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
1	Alluvium	AL01	Younger Alluvium (Clay/Silt/Sand/ Calcareous concretions)	Quaternary	10	8	12
2	Laterite	LT01	Laterite / Ferruginous concretions	Quaternary	2.5	2	3
3	Granite	GR02	Acidic Rocks (Pegmatite, Granite, Syenite, Rhyolite etc.) - Weathered, Jointed	Proterozoic to Cenozoic	3	2	4
4	Granite	GR02	Acidic Rocks (Pegmatite, Granite, Syenite, Rhyolite etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	0.35	0.2	0.5
5	Schist	SC01	Schist - Weathered, Jointed	Azoic to Proterozoic	1.5	1	2
6	Schist	SC01	Schist - Massive, Poorly Fractured	Azoic to Proterozoic	0.35	0.2	0.5
7	Quartzite	QZ01	Quartzite - Weathered, Jointed	Proterozoic to Cenozoic	1.5	1	2
8	Quartzite	QZ01	Quartzite - Massive, Poorly Fractured	Proterozoic to Cenozoic	0.3	0.2	0.4
9	Charnockite	CK01	Charnockite - Weathered, Jointed	Azoic	3	2	4
10	Charnockite	CK01	Charnockite - Massive, Poorly Fractured	Azoic	0.3	0.2	0.4

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
11	Khondalite	KH01	Khondalites, Granulites - Weathered, Jointed	Azoic	1.5	1	2
12	Khondalite	KH01	Khondalites, Granulites - Mssive, Poorly Fractured	Azoic	0.3	0.2	0.4
13	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Weathered, Jointed	Azoic	1.5	1	2
14	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Massive, Poorly Fractured	Azoic	0.3	0.2	0.4
15	Gneiss	GN02	Gneiss -Weathered, Jointed	Azoic to Proterozoic	3	2	4
16	Gneiss	GN02	Gneiss-Massive, Poorly Fractured	Azoic to Proterozoic	0.3	0.2	0.4
17	Intrusive	IN01	Basic Rocks (Dolerite, Anorthosite etc.) - Weathered, Jointed	Proterozoic to Cenozoic	2	1	3
18	Intrusive	IN01	Basic Rocks (Dolerite, Anorthosite etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	0.35	0.2	0.5
19	Intrusive	IN02	Ultrabasics (Epidiorite, Granophyre etc.) - Weathered, Jointed	Proterozoic to Cenozoic	2	1	3
20	Intrusive	IN02	Ultrabasics (Epidiorite, Granophyre etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	0.35	0.2	0.5

2.4.2. Rainfall Infiltration Factor

The values mentioned in ***Table-2.2*** has been used in the present assessment. The recommended Rainfall Infiltration Factor values has been used for assessment, unless sufficient data based on field studies are available to justify the minimum, maximum or other intermediate values.

Table-2.2: Norms Recommended for Rainfall Infiltration Factor

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
1	Alluvium	AL01	Younger Alluvium (Clay/Silt/Sand/ Calcareous concretions)	Quaternary	22	20	24
2	Laterite	LT01	Laterite / Ferruginous concretions	Quaternary	7	6	8
3	Granite	GR02	Acidic Rocks (Pegmatite, Granite, Syenite, Rhyolite etc.) - Weathered, Jointed	Proterozoic to Cenozoic	11	10	12
4	Granite	GR02	Acidic Rocks (Pegmatite, Granite, Syenite, Rhyolite etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3
5	Schist	SC01	Schist - Weathered, Jointed	Azoic to Proterozoic	7	5	9
6	Schist	SC01	Schist - Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3
7	Quartzite	QZ01	Quartzite - Weathered, Jointed	Proterozoic to Cenozoic	6	5	7
8	Quartzite	QZ01	Quartzite - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3
9	Charnockite	CK01	Charnockite - Weathered, Jointed	Azoic	5	4	6
10	Charnockite	CK01	Charnockite - Massive, Poorly Fractured	Azoic	2	1	3
11	Khondalite	KH01	Khondalites, Granulites - Weathered, Jointed	Azoic	7	5	9
12	Khondalite	KH01	Khondalites, Granulites - Mssive, Poorly Fractured	Azoic	2	1	3
13	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Weathered, Jointed	Azoic	7	5	9

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
14	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Massive, Poorly Fractured	Azoic	2	1	3
15	Gneiss	GN02	Gneiss -Weathered, Jointed	Azoic to Proterozoic	11	10	12
16	Gneiss	GN02	Gneiss-Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3
17	Intrusive	IN01	Basic Rocks (Dolerite, Anorthosite etc.) - Weathered, Jointed	Proterozoic to Cenozoic	7	6	8
18	Intrusive	IN01	Basic Rocks (Dolerite, Anorthosite etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3
19	Intrusive	IN02	Ulrta Basics (Epidiorite, Granophyre etc.) - Weathered, Jointed	Proterozoic to Cenozoic	7	6	8
20	Intrusive	IN02	Ulrta Basics (Epidiorite, Granophyre etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3

2.4.3. Norms for Canal Recharge

The Norms suggested in ***Table-2.3*** has been used for estimating the recharge from Canals, where sufficient data based on field studies are not available.

Table-2.3: Norms Recommended for Recharge due to Canals

Formation	Canal Seepage factor ham/day/million square meters of wetted area		
	Recommended	Minimum	Maximum
Unlined canals in normal soils with some clay content along with sand	17.5	15	20
Unlined canals in sandy soil with some silt content	27.5	25	30
Lined canals in normal soils with some clay content along with sand	3.5	3	4
Lined canals in sandy soil with some silt content	5.5	5	6
All canals in hard rock area	3.5	3	4

2.4.4. Norms for Recharge Due to Irrigation

The Recommended Norms are presented in ***Table-2.4***.

Table-2.4: Norms Recommended for Recharge from Irrigation

DTW m bgl	Ground Water		Surface Water	
	Paddy	Non-paddy	Paddy	Non-paddy
≤ 10	45.0	25.0	50.0	30.0
11	43.3	23.7	48.3	28.7
12	40.4	22.1	45.1	26.8
13	37.7	20.6	42.1	25.0
14	35.2	19.2	39.3	23.3
15	32.9	17.9	36.7	21.7
16	30.7	16.7	34.3	20.3
17	28.7	15.6	32.0	18.9
18	26.8	14.6	29.9	17.6
19	25.0	13.6	27.9	16.4
20	23.3	12.7	26.0	15.3
21	21.7	11.9	24.3	14.3
22	20.3	11.1	22.7	13.3
23	18.9	10.4	21.2	12.4
24	17.6	9.7	19.8	11.6
≥ 25	20.0	5.0	25.0	10.0

2.4.5. Norms for Recharge due to Tanks & Ponds

As the data on the field studies for computing recharge from Tanks & Ponds are very limited, for Seepage from Tanks & Ponds has been used as 1.4 mm / day in the present assessment.

2.4.6. Norms for Recharge due to Water Conservation Structures

The data on the field studies for computing recharge from Water Conservation Structures are very limited, hence, the norm recommended by GEC-2015 for the seepage from Water Conservation Structures is 40% of gross storage during a year which means 20% during monsoon season and 20% during non-monsoon Season is adopted.

2.4.7. Unit Draft

The methodology recommends to use well census method for computing the ground water draft. The norm used for computing ground water draft is the unit draft. The unit draft can be computed by field studies. This method involves selecting representative abstraction structure and calculating the discharge from that particular type of structure and collecting the information on how many hours of pumping is being done in various seasons and number of such days during each season. The Unit Draft during a particular season is computed using the following equation:

$$\boldsymbol{Unit\ Draft = Discharge\ in\ m^3/hr \times No.of\ pumping\ hours\ in\ a\ day \times No.of\ days} \ldots\ldots\ldots (\mathbf{29})$$

But the procedure that is being followed for computing unit draft does not have any normalization procedure. Normally, if the year in which one collects the draft data in the field is an excess rainfall year, the abstraction from ground water will be less. Similarly, if the year of the computation of unit draft is a drought year the unit draft will be high. Hence, there is a requirement to devise a methodology that can be used for the normalization of unit draft figures. The following are the two simple techniques, which are followed for normalization of Unit Draft. Areas where, unit draft values for one rainfall cycle are available for at least 10 years second method shown in equation 31 is followed or else the first method shown in equation 30 has been used.

$$\boldsymbol{Normalised\ Unit\ Draft} = \frac{\boldsymbol{Unit\ Draft} \times \boldsymbol{Rainfall\ for\ the\ year}}{\boldsymbol{Normal\ Rainfall}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (\mathbf{30})$$

$$\boldsymbol{Normalised\ Unit\ Draft} = \frac{\sum_{i=1}^{n} \boldsymbol{Unit\ Draft_i}}{\boldsymbol{Number\ of\ Years}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (\mathbf{31})$$

2.5. INDIA -GROUNDWATER RESOURCE ESTIMATION SYSTEM (IN-GRES)

"INDIA-GROUNDWATER RESOURCE ESTIMATION SYSTEM (IN-GRES) is a Software/Web-based Application developed by CGWB in collaboration with IIT-Hyderabad. It provides common and standardized platform for Ground Water Resource Estimation for the entire country and its pan-India operationalization (Central and State Governments). The system takes 'Data Input' through Excel as well as Forms, compute various ground water components (recharge, extraction etc.) and classify assessment units into appropriate categories (safe, semi-critical, critical and over-exploited). The Software uses GEC 2015 Methodology for estimation and calculation of Groundwater resources. It allows for unique and homogeneous representation of groundwater fluxes as well as categories for all the assessment units (AU) of the country.

URL of IN-GRES → http://ingres.iith.ac.in

CHAPTER 3

3.0 RAINFALL

3.1 Rainfall

Rainfall is the main source of ground water recharge in the state. For climatological purposes especially for rainfall, a year is divided into 4 seasons: Winter (January and February), Pre-monsoon (March to May), South West Monsoon (June to September) and Post Monsoon (October to December). The rainfall has direct impact on ground water regime. Groundwater table is usually deeper during pre-monsoon and before the onset of the monsoon and it becomes shallow during monsoon and shortly before the cessation of monsoons. The extraction of groundwater is not extensive for irrigation during the monsoons and in subsequent month after the monsoon, as sufficient moisture remains in the root zone from the monsoon rainfall. After the end of monsoon, as the ground water extraction increases, the groundwater table begins to decline. Based on these dynamics, the ground water assessed in a groundwater year (April to March for Kerala) comprises both monsoon season. It is pertinent to mention that, the assessment of groundwater resources for monsoon period in a ground water year includes southwest monsoon months and one subsequent and one previous month for Kerala, that is from May to October. The amount of rainfall received shows a gradual decrease from North to South. The spatial distribution of normal annual rainfall in the State is shown in **Figure 3.1.**

The climate of Kerala, as per Koppen's classification, is tropical monsoon with seasonally excessive rainfall and hot summer. The annual normal rainfall of Kerala state for the period 1994-2023 varies from 3606.9 mm in Idukki district to 1808.7 mm in Thiruvananthapuram district with state average of 2884.1mm. The Southwest monsoon season contributes around 69% percentage of annual normal rainfall and Northeast monsoon (Post Monsoon) season contributes 17% of annual normal rainfall of the state.

The state received a deficient annual rainfall of 2246.1 mm (22% below normal) during the calendar year 2023. The district wise annual rainfall varied from 1581.9 mm in Palakkad district to 3198 mm in Pathanamthitta district. The departure percentage from normal rainfall varied from -47% in Wayanad district to 15% in Pathanamthitta district. Nine districts of the state (Wayanad, Kozhikode, Idukki, Thrissur, Malappuram, Palakkad, Kannur, Kottayam & Kasaragod) received deficient rainfall and remaining 5 districts (Pathanamthitta, Thiruvananthapuram, Alappuzha, Kollam & Ernakulam) received normal rainfall in 2023 as per IMD classification.

During the groundwater assessment year 2023-24, Kerala received 2270.1 mm rainfall (21% below normal). The district wise rainfall pattern showed a similar trend to that of calendar year 2023. District wise rainfall varied from 1594.6 mm in Palakkad district to 3110 mm in Pathanamthitta district. Departure from normal varied from -47% in Wayanad district to 12% in Pathanamthitta district. Eight districts of the state received deficient rainfall (-20% to -59% departure from normal) and remaining six districts received normal rainfall (-19% to +19% departure). Hilly districts of the state Wayanad (-47%) and Idukki (-39%) received significantly less rainfall from normal during the groundwater assessment year 2023-24. **Table 3.1 & Figure 3.2** shows the district wise rainfall annual, Monsoon, non – Monsoon rainfall distribution for the assessment year 2023-24. **Figure 3.3** shows the comparison of actual rainfall received during Assessment year with its normal value for a period of 30 years from 1994 to 2023.

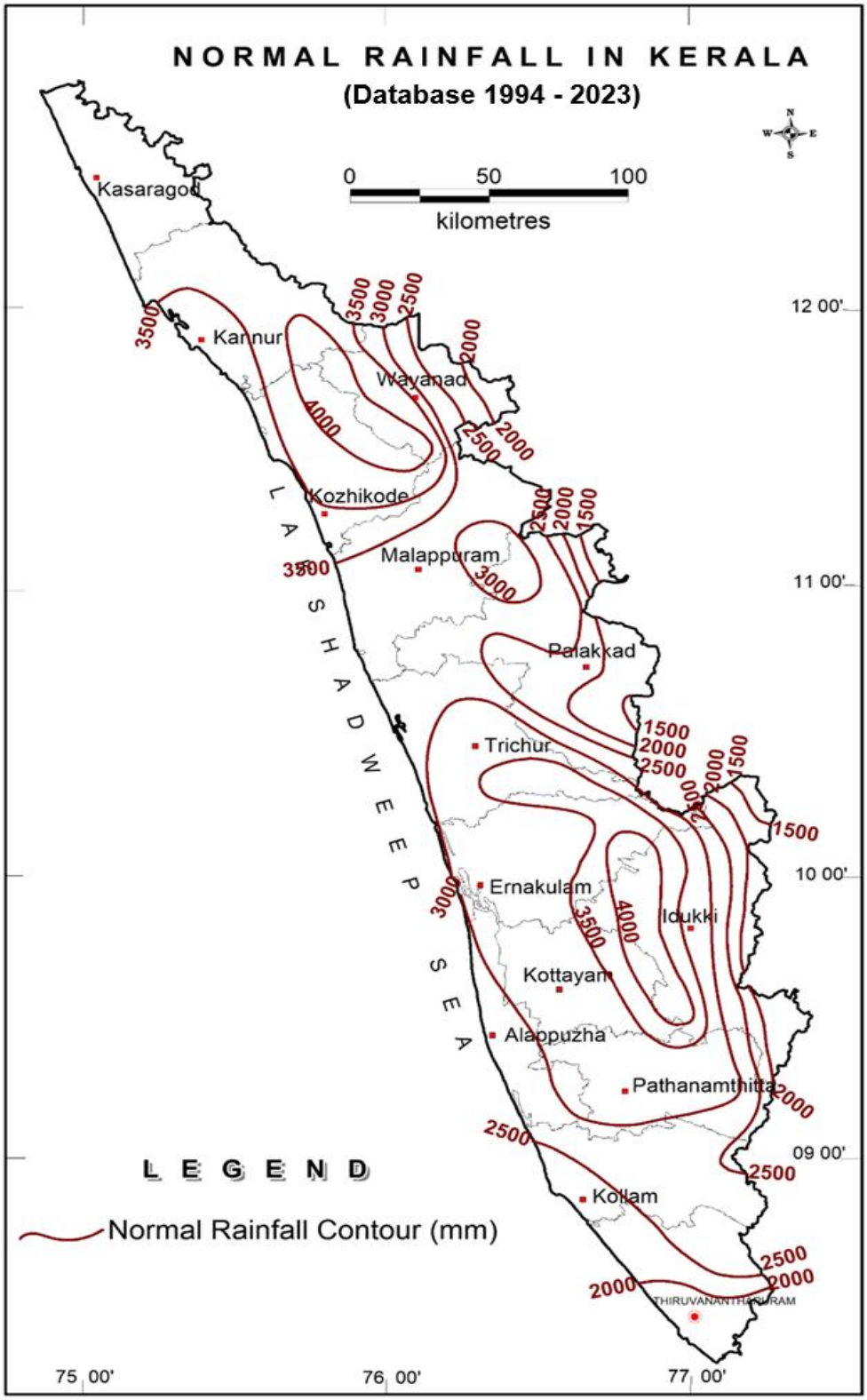

Figure 3.1. Spatial Distribution of Normal Annual Rainfall Kerala

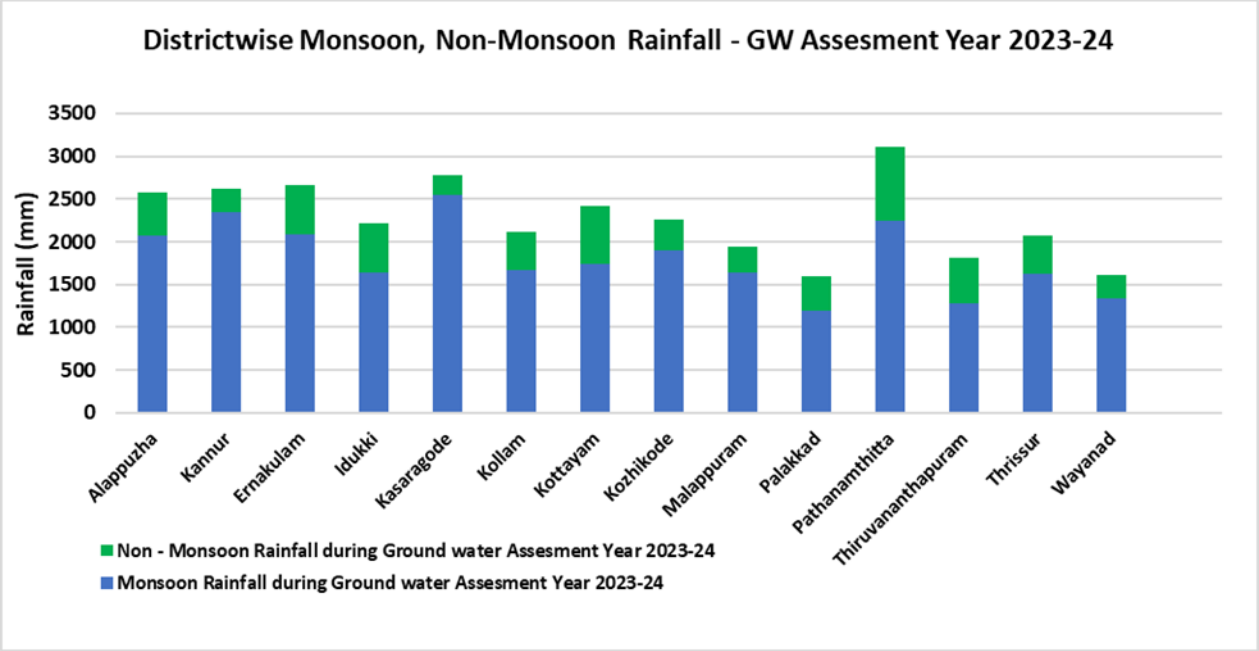

Figure 3.2 District wise Annual, Monsoon, Non-Monsoon Rainfall during Groundwater Assessment Year 2023-2024

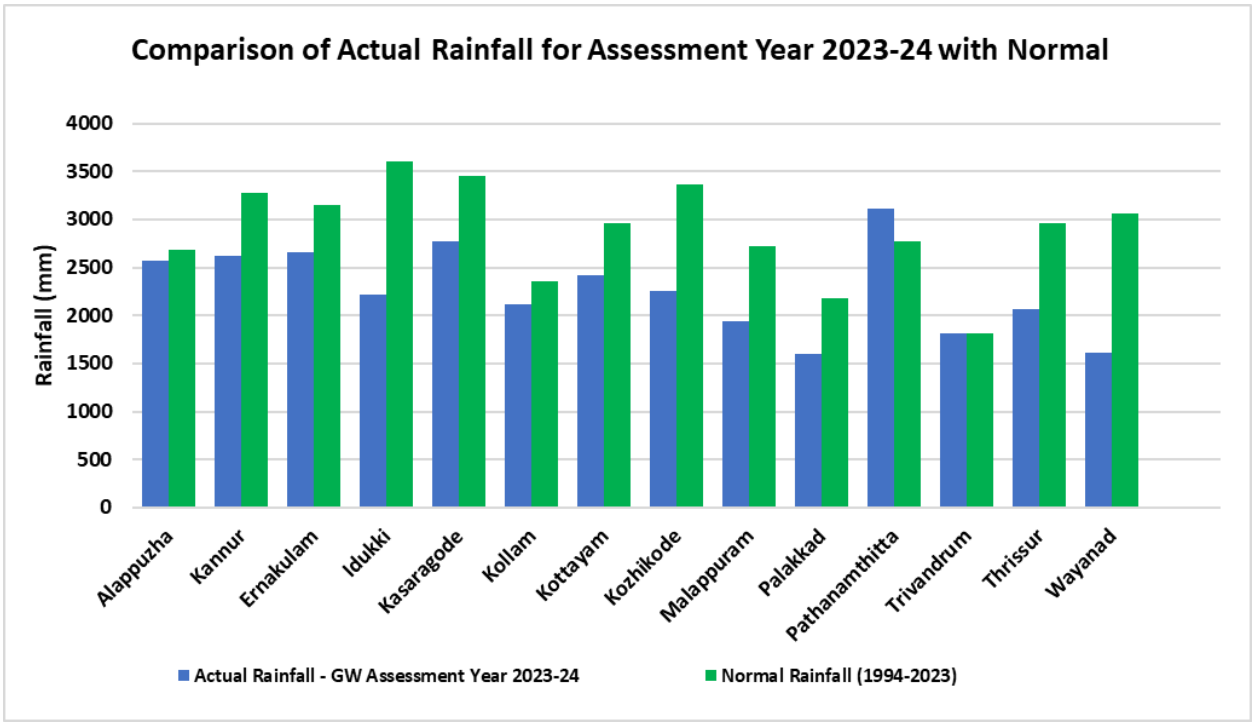

Figure 3.3: Comparison of Actual Rainfall for GW Assessment Year 2023-24 with Normal (1994 - 2023)

Table 3.1: District wise Actual, Monsoon and Non-Monsoon rainfall for GW Assessment Year 2023-24 and Annual Normal Rainfall (1994-2023)

Districts	District - wise Monthly Rainfall (mm) - Year 2023												District - wise Monthly Rainfall (mm) - Year 2024			Annual Normal Rainfall (mm)	Rainfall during Calendar Year 2023 (mm)	Rainfall during the Ground water assessment year 2023-24 (mm)	Monsoon Rainfall during the Ground water assessment year 2023-24 (mm)	Non - Monsoon Rainfall during the Ground water assessment year 2023-24 (mm)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar					
Alappuzha	18.7	5.5	27.1	101.7	175.6	333.9	484.3	105.9	521.4	454	228.9	105.8	34.6	0	27.8	2688.5	2562.8	2573.9	2075.1	498.8
Kannur	0	0	0	14.6	102.6	367.1	1055.8	135.8	489.1	202	153.8	21.4	73.2	0.3	0	3277	2542.2	2615.7	2352.4	263.3
Ernakulam	17.4	2.6	28.8	100.5	114.6	364.7	630.2	47.7	556.2	374.8	294.1	51.5	115.9	0.8	13.2	3146.2	2583.1	2664.2	2088.2	576
Idukki	16	5.6	62.3	93.2	166.8	210.2	537.1	79.6	366.1	281.1	268	118.2	93.1	0	4.6	3606.9	2204.2	2218	1640.9	577.1
Kasaragod	0	0	2.1	2	75.4	376.1	1226.5	127.8	542.0	195.4	141.7	37.1	48.6	0	0.2	3453	2726.1	2772.8	2543.2	229.6
Kollam	15.3	7.1	42.4	104.5	196.3	274.6	358.0	32.3	393.3	418.3	195.5	100	10.2	4.1	35.1	2361	2137.6	2122.2	1672.8	449.4
Kottayam	24.7	3.2	67.4	119.8	172	261.4	461.0	46.5	433.1	364.6	290.7	136.8	87.5	0.1	39.4	2960.6	2381.2	2412.9	1738.6	674.3
Kozhikode	10.8	0	1.4	37.8	91.2	229.2	693.5	67.9	574.0	243.4	196.5	47.3	75.6	0	0	3364.4	2193	2256.4	1899.2	357.2
Malappuram	1.5	0	3.1	35	80.2	231.9	599.9	43.7	407.3	275.6	207.8	25.9	31	0	0	2726.2	1911.9	1938.3	1638.6	299.7
Palakkad	4.8	0	19.2	49.3	92.3	155	442.1	29.7	271.4	198.4	267.1	52.6	35.4	0	1.3	2182.7	1581.9	1594.6	1188.9	405.7
Pathanamthitta	37.1	4.9	125	175.1	266.5	344.3	493.3	21.1	510.5	605.8	440.3	174.1	35.2	0	43.8	2776.4	3198	3110	2241.5	868.5
Trivandrum	31.1	6.3	8.9	122.4	112.9	165.6	173.5	17.0	334.3	474	227.6	135	26.9	2.8	23.5	1808.7	1808.6	1815.5	1277.3	538.2
Thrissur	8.6	0	4	76.5	69.6	285.4	559.5	43.4	392.9	278.2	229.3	45.6	87.9	1.5	1.1	2965.9	1993	2070.9	1629	441.9
Wayanad	4.3	0	43.7	68.8	128.2	152.6	689.0	43.4	181.6	140.2	153.2	16.2	43.1	0	0	3060.4	1621.2	1616.3	1335	281.3
State Average	**13.6**	**2.5**	**31.1**	**78.7**	**131.7**	**268.0**	**600.3**	**60.1**	**426.7**	**321.8**	**235.3**	**76.3**	**57.0**	**0.7**	**13.6**	**2884.1**	**2246.1**	**2270.1**	**1808.6**	**461.5**

CHAPTER 4

4.0 HYDROGEOLOGICAL SETUP

4.0 Hydrogeology

The occurrence and movement of groundwater in various litho-units underlying the State are mainly controlled by the physiography, geological setting, and structural features.

4.1 Physiography

The state can be sub-divided into three major units based on their Physiographic characteristics viz. the coastal plains/Lowlands, the midlands and the hill ranges/Highlands. The coastal plains have an elevation of less than 7.6m above mean sea level (a.m.s.l). The elevation of the midland region ranges from 7.6 to 76 m amsl and that of the hill ranges is more than 76 m above mean sea level. Along the hill ranges two distinct plateau regions are seen, the important being the Wayanad plateau, covering major part of Wayanad district, with elevations above 700 m. amsl and the Munnar plateau, located along the northern part of Idukki district with a general elevation of about 1000 m. amsl are the prominent plateaus in the hilly region of the state.

4.2 Geology

As much as 88% of the State is underlain by crystalline rocks of Archaean age comprising schistose formations, Charnockites, Khondalites and gneisses. All these formations are intruded by dykes of younger age. The sedimentary formations of Tertiary age occurring along the western parts of the State comprise four distinct beds viz. Alleppey, Vaikom, Quilon and Warkali. The crystalline and the Tertiary formations are lateralized along the midland area. Alluvial deposits of recent origin are seen along the coastal plains. The general stratigraphic sequence is given in **Table 4.1.**

Table 4.1: Stratigraphic Succession of Geological Formations in Kerala

AGE	FORMATION	LITHOLOGY
Recent	Alluvium	Sand, clay, riverine alluvium etc.
Sub-recent	Laterite	Derived from crystalline and sedimentaries
Tertiary	Warkali	Sandstone, clays with lignite
	Quilon	Limestone, marl and clay
	Vaikom	Sandstone with pebbles, clay and lignite
	Alleppey	Carbonaceous clay and fine sand
Undated	Intrusives	Dolerite, Gabbro, Granites, Quartzo - feldspathic Veins.
Archaean	Wayanad group	Granitic gneiss, Schists etc.
	Charnockites	Charnockites and associated rocks
	Khondalites	Khondalites suite of rocks and its associates

4.3 Occurrence of Groundwater

A generalized Hydro-geological Map of Kerala is given in **Figure 4.1.** In hard rock terrain, comprising weathered crystallines and laterites, ground water occurs under phreatic conditions in the weathered residuum and the shallow fractures hydraulically connected to it; below this semi-confined to confined conditions prevails in the deep fracture zones. In the alluvial terrain, ground water in the shallow systems is in phreatic condition. Granular zones in the Tertiary sedimentary formations at deeper levels and forms potential confined to semi-confined aquifers.

4.3.1 Crystalline Rock Aquifers

The shallow aquifers of the crystalline rocks are made up of the highly decomposed weathered zone or partly weathered and fractured rocks. Thick weathered zone is seen along the midland area either beneath the laterites or exposed. In the hill ranges thin weathered zone is seen along topographic lows and area with lesser elevation and gentle slope. In areas along the hill ranges generally rock exposures are seen. The depth to water level in this aquifer varies from 2 to 16 mbgl and the yield of the well ranged between 2 to 10 m^3 per day.

Exploratory drilling carried out by Central Ground Water Board in the state in the crystalline formations has indicated that the fractures are encountered at depths ranging between 30 to 175 m.bgl with yield varying from less than 1 to as much as 35 litres per second (lps). In Charnockites, more than 40% of the wells have yielded more than 10 lps or above indicating that in Kerala, Charnockite suite of rocks are better aquifers compared to Khondalite group.

4.3.2 Tertiary Rock Aquifers

Groundwater occurs under phreatic condition in the shallow zone and under semi-confined to confined conditions in the deeper aquifers. The Tertiary formation of Kerala coast is divided into four distinct beds viz. Alleppey, Vaikom, Quilon and Warkali. These formations except the Alleppey beds seen as outcrops are lateritized wherever they are exposed. The maximum thickness of Tertiary sediments is found between Karunagapally and Kattoor and all the four beds are found in this area.

Groundwater is commonly developed through dug wells tapping the sandy zones at shallow depth in the Tertiary sediments. The depth to water level in this shallow zone ranges from 2.0 to 27 m.bgl and the yield of the wells range from 500 lpd to 10 m^3 per day.

The Vaikom and Warkali beds form the most potential aquifers in the Tertiary group. The Alleppey bed has been encountered at deeper levels in the bore holes drilled in the coastal tract of Alappuzha district and the formation water is found to be saline and hence, no tube well has been constructed tapping this formation.

In the Vaikom aquifers, the piezometric level is between 2 and 20 m above msl. The yield of the tube wells constructed in this formation ranges from 1 to 57 lps. This bed forms auto flow zones along the coast between Karunagapally in Kollam district and Nattika and Kaipamangalam in Thrissur district. The water is generally fresh south of Karuvatta in Alappuzha district. Also, exploration by CGWB proved that good quality groundwater pockets are in existence in this formation in and around Cochin and NW of Kottayam around Kallara-Udayanapuram areas.

Warkali aquifers are the most developed aquifer system among the Tertiary group. The urban and rural water supply in the coastal area between Kollam and Alappuzha is mostly dependent on this. The piezometric head is

about 3 m. above msl along the eastern part of the sedimentary basin whereas it is 10 m. below msl in and around Alappuzha. The yield of the wells tapping this formation ranges from 3 to 14 lps. The hydrogeological information on Quilon beds is very limited. The formation is a poor aquifer compared to Vaikom and Warkali beds.

4.3.3 Laterite Aquifers

Laterites are the most widely distributed lithological unit in the state and the thickness of this formation varies from a few meters to about 30 m. Laterite forms potential aquifers along topographic lows and valleys. The depth to water level in this formation ranges from 2 to 25 mbgl and the yield ranges from 0.5 to 30 m^3 per day. The occurrence and movement of groundwater in the laterites are mainly controlled by the topography. Laterite is a highly porous rock formation, which can form potential aquifers along topographic lows. However, due to the porosity, groundwater is drained from elevated places and slopes immediately after monsoon and hence water scarcity is experienced in the elevated places and hill slopes.

4.3.4 Alluvial Aquifers

The alluvial deposits form potential aquifer along the coastal plains and groundwater occurs under phreatic and semi-confined conditions in this aquifer. The thickness of this formation varies from few meters to above 100 m and the depth to water level ranges from less than a meter to 6 mbgl. Filter point wells are feasible wherever the saturated thickness exceeds 5m. This potential aquifer is extensively developed by dug wells and filter point wells throughout the state and the yield ranges from 5 to 35 m^3 per day.

The depth to water level is being monitored from 1610 monitoring wells distributed throughout the state during the months of April, August, November and January. The water level measured during the month of April is taken as pre-monsoon water level and the data of August and November are taken as post-monsoon water level depending on the rainfall distribution. The depth to water level mostly depends on the hydrogeological conditions of the area as well as topography, rainfall pattern etc. In coastal plains the depth to water level is generally restricted to 6 mbgl. In midland areas, where the undulating topography is seen, the depth to water level generally varies from near ground level to 25 mbgl. The variation is mostly due to topographical variations, thickness of lateritic overburden etc. In areas where laterites are underlain by sedimentary aquifers of Tertiary age, the water level goes very deep, even to the extent of 55 mbgl. In highlands the depth to water level is in the range of few cm to 10 mbgl depending on the topography and thickness of overburden (weathered zone).

4.4 Quality of Ground Water

Ground water in phreatic aquifers in Kerala, in general, is fresh and suitable for domestic, irrigation and industrial uses. About 84 % observation wells tapping the phreatic zone have electrical conductivity below 500 µS/cm at 25^0C. Isolated occurrence of brackish/saline ground water has been observed, mainly in the coastal districts and in the vicinity of tidal estuaries and streams. Fluoride above permissible limit of 1.5 mg/l has been observed in parts of Palakkad district in the phreatic zone and around Alappuzha town in the deeper zones and presence of Iron more than permissible limits in parts of most of the districts, especially in the mid land areas. Nitrate is another constituent present above permissible limit in isolated pockets of most of the districts in the State. Bacterial contamination is observed in parts of most of the districts and is found more in Alappuzha district.

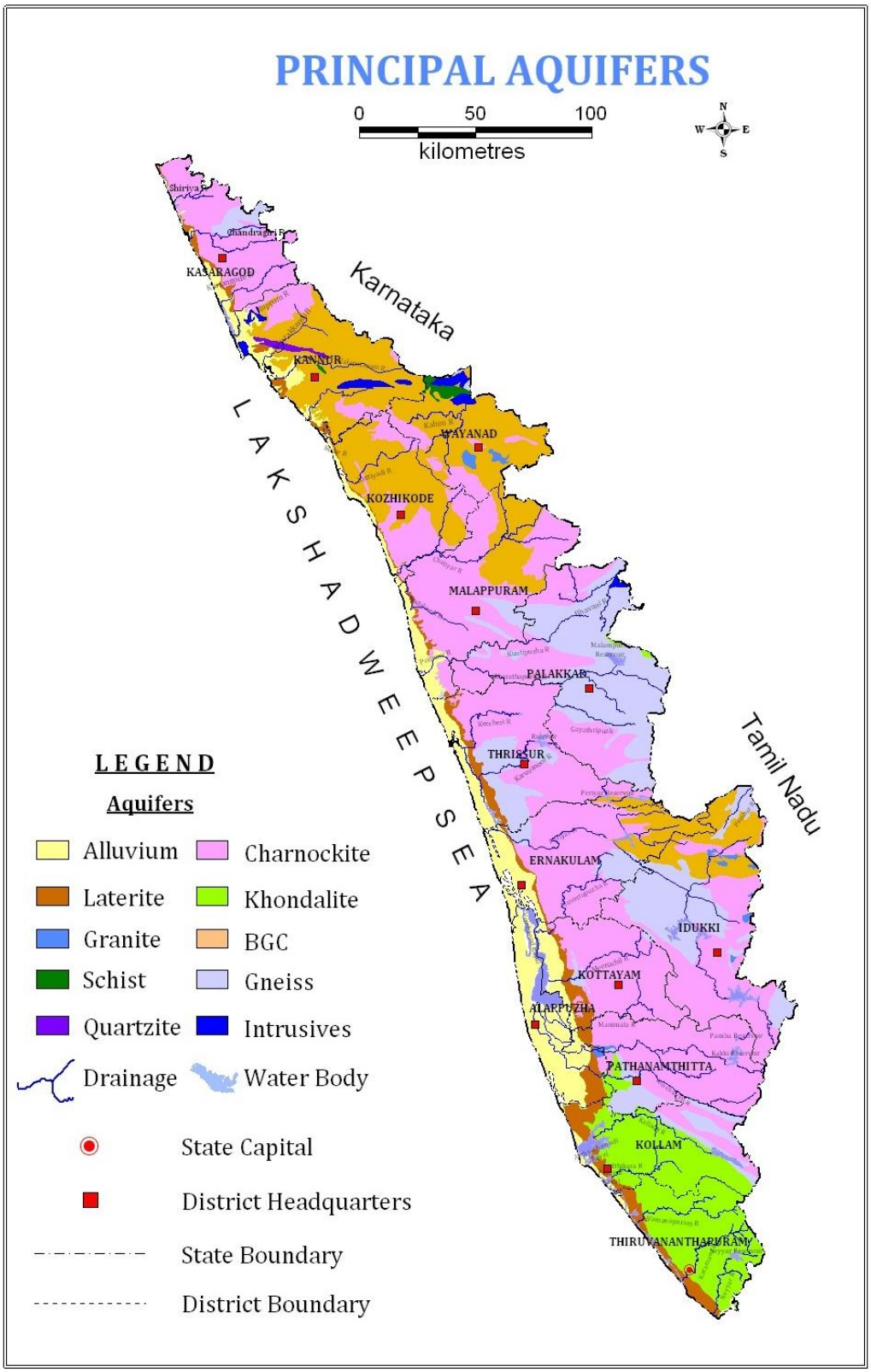

Figure 4.1 Principal Aquifers of Kerala

CHAPTER-5

5.0 GROUND WATER LEVEL SCENARIO

Groundwater level is one of the basic data elements, which reflects the groundwater regime in an area. Central Ground Water Board (CGWB) monitors groundwater levels four times a year during January, April, August and November through a network of fixed observation wells spreading throughout the state. The periodicity of groundwater level monitoring by the State Governments varies is for all months. The primary objective of monitoring the groundwater level is to record the response of groundwater regime to the natural and anthropogenic stresses on recharge and discharge components which are governed by geology, climate, physiography, land use pattern and hydrologic characteristics. Natural conditions affecting the regime include climatic parameters like rainfall, evapotranspiration etc. Anthropogenic influences include pumpage from the aquifer, recharge due to irrigation systems and other practices like waste disposal etc. Water level data generated and archived by CGWB along with data from State Groundwater department have been used for assessment of groundwater resources. An outline of groundwater scenario during the period of assessment is given below.

5.1 Ground Water Level Scenario (2023)

Groundwater level during Pre-monsoon Period (April 2023)

The Ground Water data of pre-monsoon 2023 (April 2023) reveals that the depth to water level in the State ranges from 0.07 mbgl (Alappuzha district) to 53.45 mbgl (Thiruvananthapuram district). The salient feature of the analysis is that the depth to water level over the major part of the State lies within 10 m bgl. 83% of analyzed wells show water level within 10 m bgl, while 17% of wells show depth to water level more than 10 m bgl. Shallow water level in the range of 0 to 2 m bgl is observed in about 9% of monitoring wells in parts of almost all districts of the State, except for Kasaragod district. Water level in the range of 2 to 5 m bgl is observed for 32 % of the analysed wells in the State. Water level in the range of 5 to 10 m bgl is observed for about 42% of the analysed wells which covers almost all the districts of the State. Water level in the range of 10 to 20 m bgl is recorded for about 16% of the analysed wells and observed in almost all districts except Idukki district. Water level in the range of more than 20 m bgl is recorded for about 1% of wells and observed in Kasaragod, Kollam and Thiruvananthapuram districts. Spatial variation of ground water levels in Kerala during pre-monsoon season (April 2023) is given in **Figure 5.1.**

Groundwater level during Post-monsoon Period (November 2023)

The Ground Water scenario during November 2023 reveals that the depth to water level in the State ranges from 0.01 m bgl (Alappuzha district) to 51.38 m bgl (Thiruvananthapuram district). The salient feature of the analysis is that the depth to water level over major part of the State lies within 10 m bgl. 93% of analysed wells show water level within 10 m bgl, while 7% of wells show depth to water level more than 10 m bgl. Shallow water level in the range of 0 to 2 m bgl is observed in about 24% of analysed wells in parts of almost all districts of the State, except for Kasargod district. Water level in the range of 2 to 5 m bgl is observed for 34 % of the analysed wells in the State. Water level in the range of 5 to 10 m bgl is observed for about 35% of the analysed wells which covers almost all the districts of the State. Water level in the range of 10 to 20 mbgl is recorded for about 6% of the analysed wells and observed in almost all districts except Idukki district. Water level more than 20 mbgl is

recorded in 1% of wells and observed in Kasaragod and Thiruvananthapuram districts. Spatial variation of ground water levels in Kerala during post-monsoon season (Nov-2023) is given in **Figure 5.2.**

5.1.0 Fluctuation of Groundwater Level

Comparison of Pre-monsoon 2023 to Pre-monsoon 2022

A comparison of depth to water level of Pre-monsoon 2023 with Pre-monsoon 2022 (**Figure 5.3**) indicates that about 31% of the analysed wells shows rise in the water level and 69% of the analysed wells are having fall in water level. Analysis shows a general fall in the range of 0 to 2 m is noticed in major part of the state. The Comparison of data shows that water level rise is in the range of 0.01 to 8.7 m and fall is in the order of 0.01 to 9.79 m. The rise and fall in water levels were mainly in the range of 0 to 2 meters. Rise in the water level in the range of 0 to 2 m has been observed in 27% of wells analysed and observed in all over the State. Fall in water level in the range of 0 to 2 m has been observed in 63% of wells analysed and noted in the entire State. All the districts of the state except Kollam showed declining trend in more than 50% wells and more than 75% percent of wells in Ernakulam, Kozhikode, Malappuram and Thrissur districts showed declining trend in water level. Rising trend in water level observed in 55% wells in Kollam district and 50% wells in Alappuzha district.

Comparison of Post-monsoon 2023 to Post-monsoon 2022

A comparison of water level of post-monsoon 2023 with post-monsoon 2022 shows that about 70% of the analysed wells shows rise in the water level and 30% of the analysed wells are having fall in water level. The map of Kerala showing fluctuation between November 2023 and November 2022 is given in **Figure 5.4**. Analysis shows a general rising trend in the range of 0 to 2 m in major part of the area. The Comparison of data shows that water level rise is in the range of 0.01 to 4.85 m and fall is in the order of 0.01 to 4.67 m. Rise in the water level in the range of 0 to 2 m has been observed in 64% of wells analysed and observed in all over the State. Rise in the water level of more than 2 m has been observed in 6% of wells analysed and noted in almost all districts except Idukki and Wayanad districts. Rising trend of water level observed in more than 80% of analysed wells in Ernakulam, Kannur, Kasaragod, Malappuram and Thrissur districts. Fall in water level in the range of 0 to 2 m has been observed in 27% of wells analysed and observed in the entire State. Declining trend is observed in 69% wells in Wayanad district and 65% wells in Idukki district.

Comparison of Pre-monsoon 2023 with decadal mean of Pre-monsoon (2013 to 2022)

A comparison of water level of pre-monsoon 2023 with pre-monsoon (2013 – 2022) **(Figure 5.5)** shows that a rise in the water level is recorded in 62% of wells analysed, while 38% recorded fall. The rise and fall in water levels are primarily is in the range of 0 to 2 m. Rise in the water level in the range of 0 to 2 m has been observed in 59% of wells analysed and observed in all over the State. Rise in the water level more than 2 to 4 m has been observed in 3% of wells analysed and observed almost all the districts except Alappuzha, Idukki and Kozhikode districts. The fall in water level in the range of 0 to 2 m has been observed in 36% of wells analysed and noted in all the districts of Kerala State. The fall in water level in the range of 2 to 4 m has been observed in 2% of wells analysed and observed in almost all districts except Alappuzha, Ernakulam, Kollam and Palakkad districts.

Comparison of Post-Monsoon 2023 with decadal mean of Post-Monsoon (2013 to 2022)

A comparison of water level of pre-monsoon 2023 with pre-monsoon (2013 – 2022) **(Figure 5.6)** shows that a rise in the water level is recorded in 74% of wells analysed, while 26% recorded fall. The rise and fall in water levels are primarily is in the range of 0 to 2 m. Rise in the water level in the range of 0 to 2 m has been observed in 70% of wells analysed and observed in all the districts of the State. Rise in the water level more than 2 to 4 m has been observed in 4% of wells analysed and observed mainly as isolated pockets in all districts except Alappuzha, Kannur and Kozhikode districts. Fall in water level in the range of 0 to 2 m has been observed in 25% of wells analysed and observed in all the districts of the State. Fall in the range of 2 to 4 m is observed in 2% wells as isolated pockets mainly in Kannur, Kasaragod, Palakkad, Thiruvananthapuram and Wayanad districts.

5.2 Quality of Ground Water

Ground water in phreatic aquifers in Kerala, in general, is fresh and suitable for domestic, irrigation and industrial uses. About 84 % observation wells tapping the phreatic zone have electrical conductivity below 500 µS/cm at 25^0C. Isolated occurrence of brackish/saline ground water has been observed, mainly in the coastal districts and in the vicinity of tidal estuaries and streams. Fluoride above permissible limit of 1.5 mg/l has been observed in parts of Palakkad district in the phreatic zone and around Alappuzha town in the deeper zones and presence of Iron more than permissible limits in parts of most of the districts, especially in the mid land areas. Nitrate is another constituent present above permissible limit in isolated pockets of most of the districts in the State. Bacterial contamination is observed in parts of most of the districts and is found more in Alappuzha district. The quality problems in Assessment units (as in 2024) is given in **Annexure IV (B)** and the list of saline assessment units is given in **Annexure IV (C).**

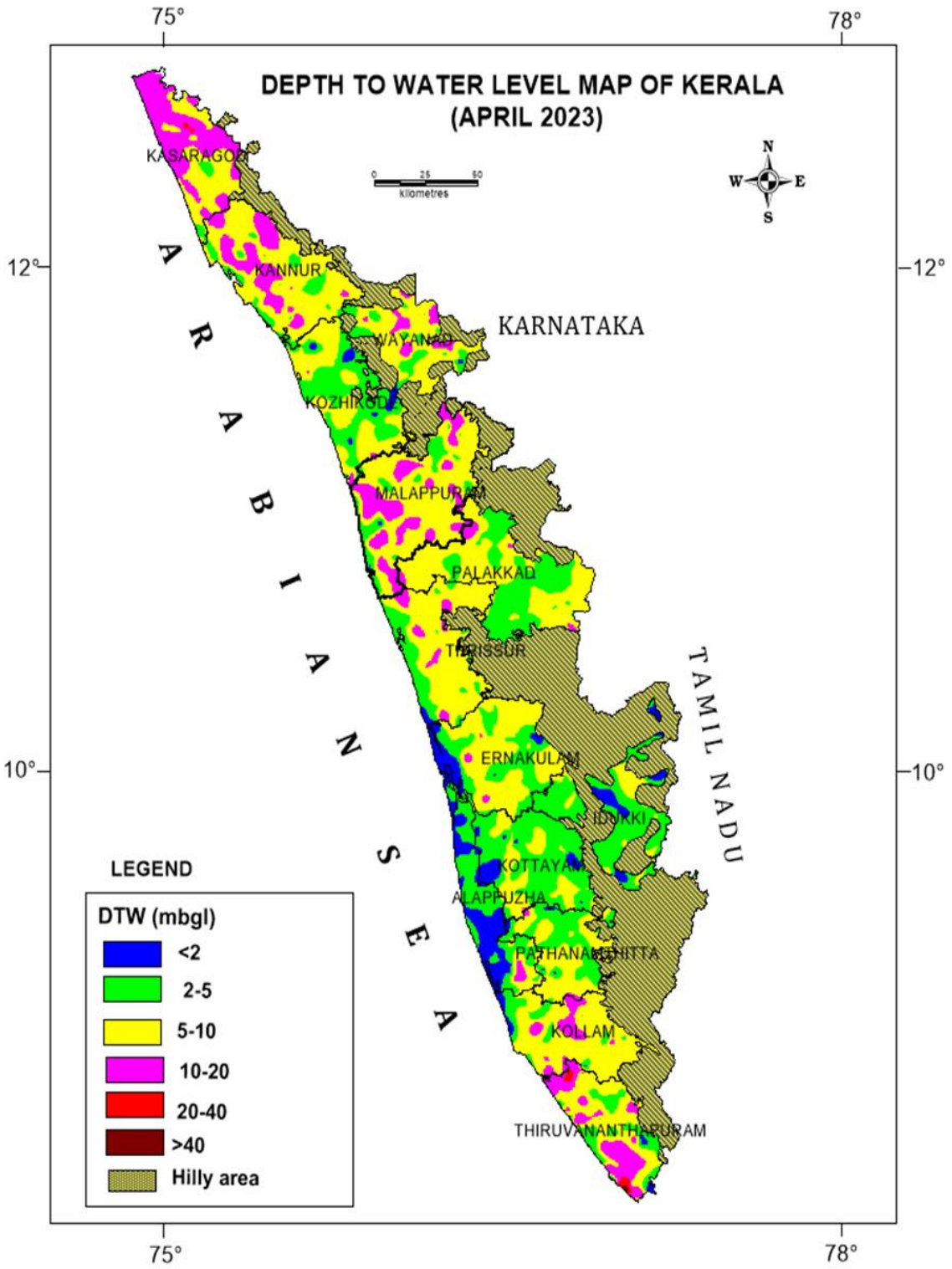

Figure 5.1 Spatial Distribution of Ground Water Levels in Kerala (April 2023)

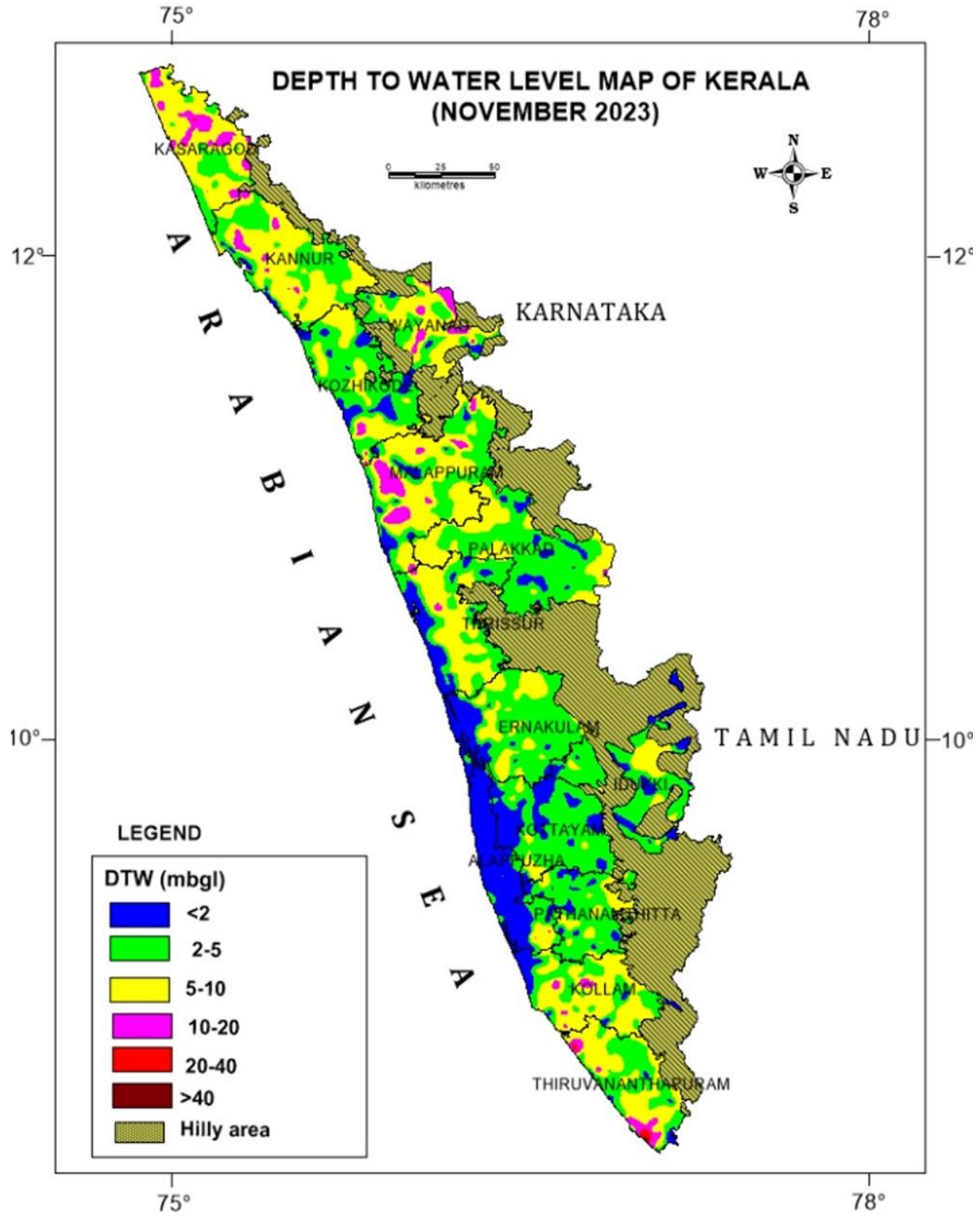

Figure 5.2 Spatial Distribution of Ground Water Levels in Kerala (November 2023)

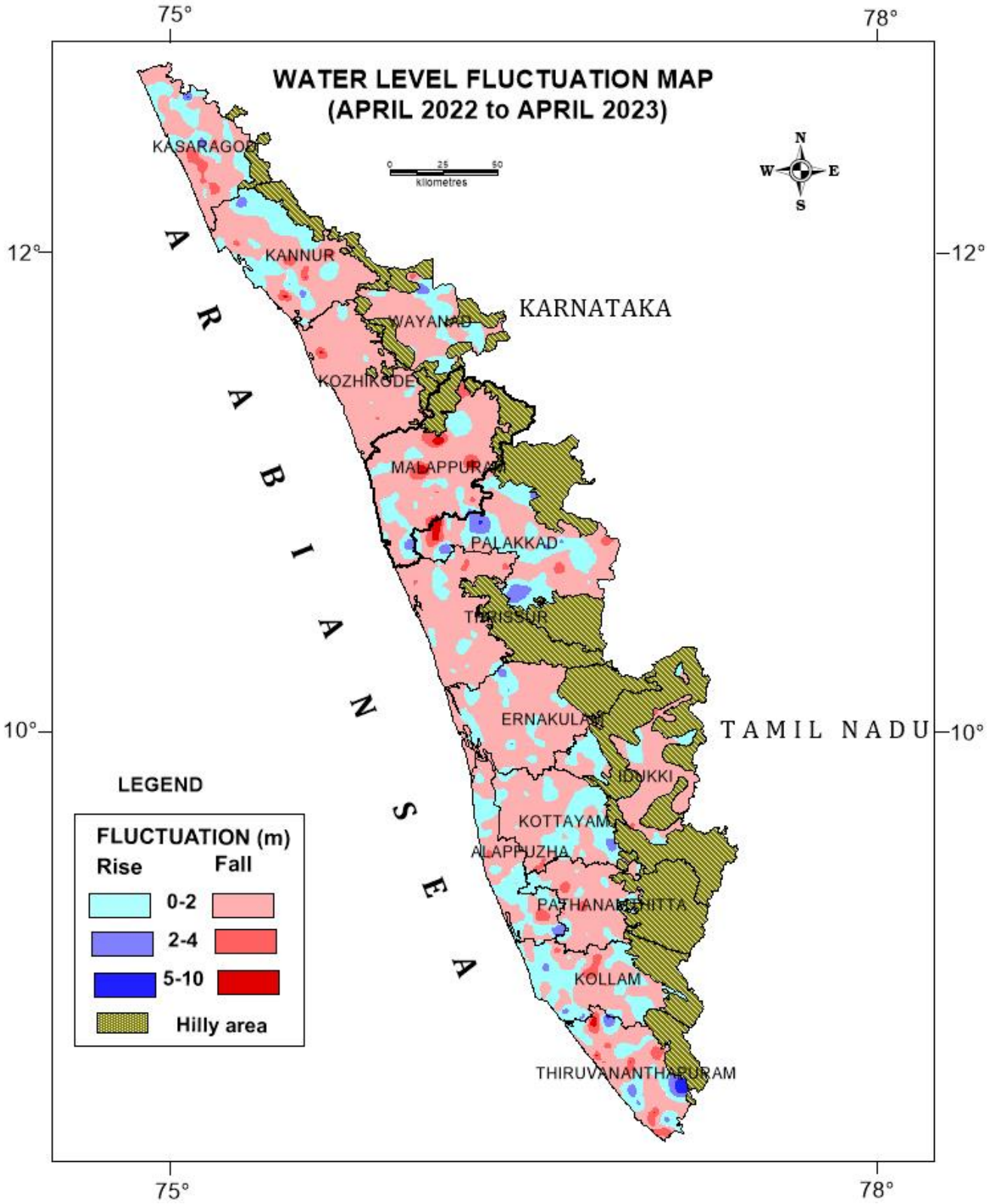

Figure 5.3 Groundwater Level Fluctuation: Pre-monsoon 2022 compared to Pre-monsoon 2023

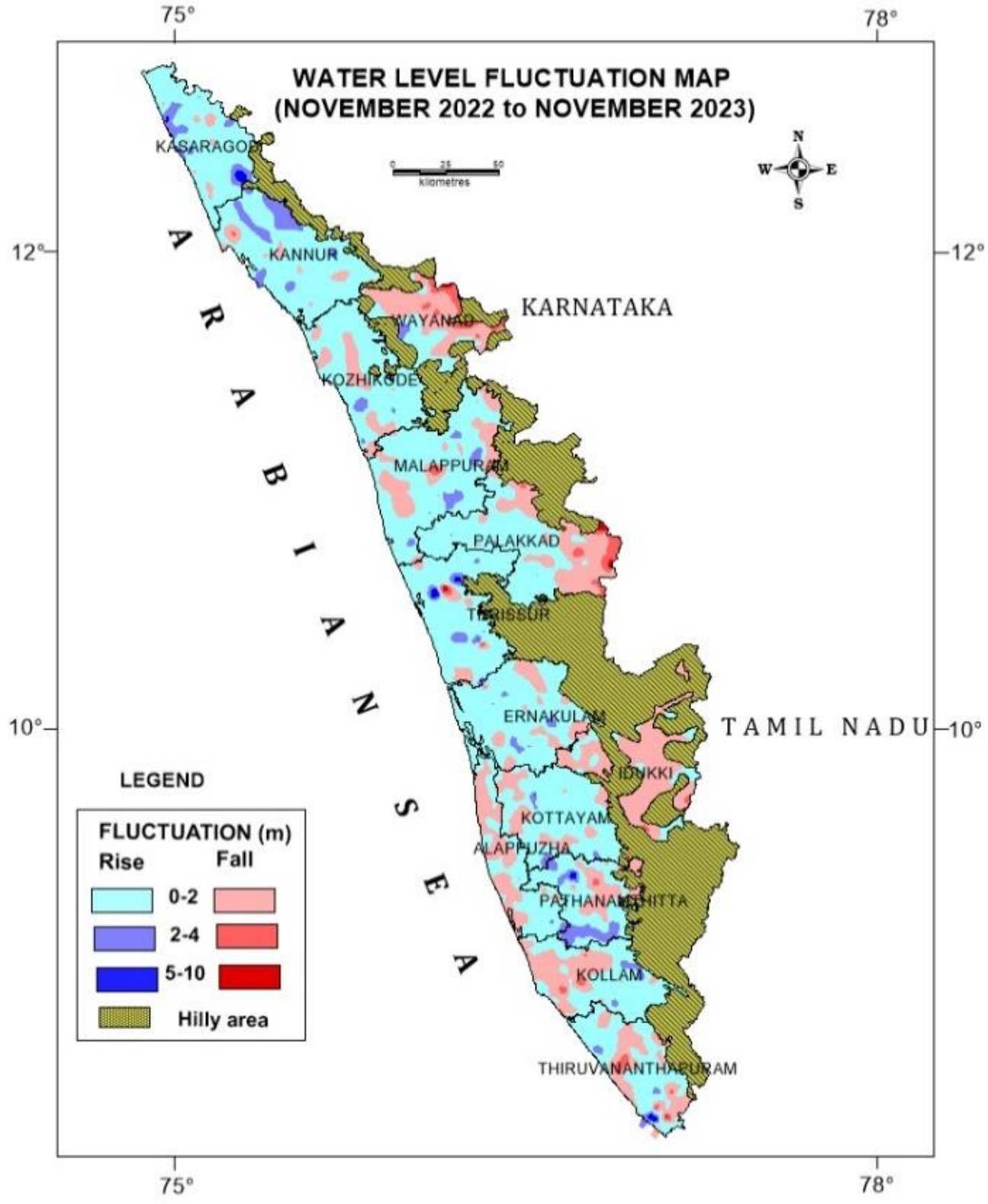

Figure 5.4 Groundwater Level Fluctuation: November 2022 compared to November 2023

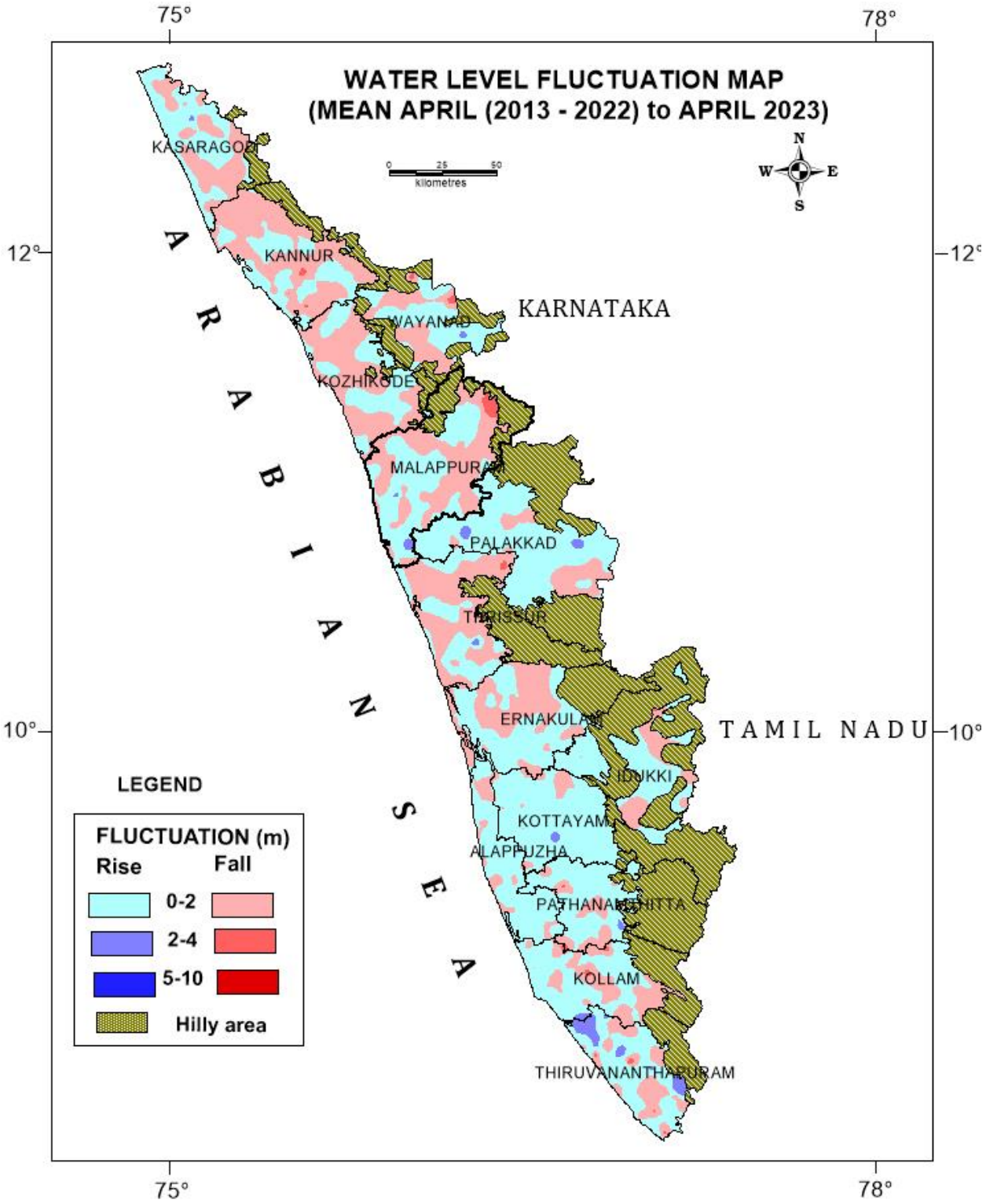

Figure 5.5 Decadal water level fluctuation with mean Pre-Monsoon (2013 to 2022) and Pre- Monsoon 2023

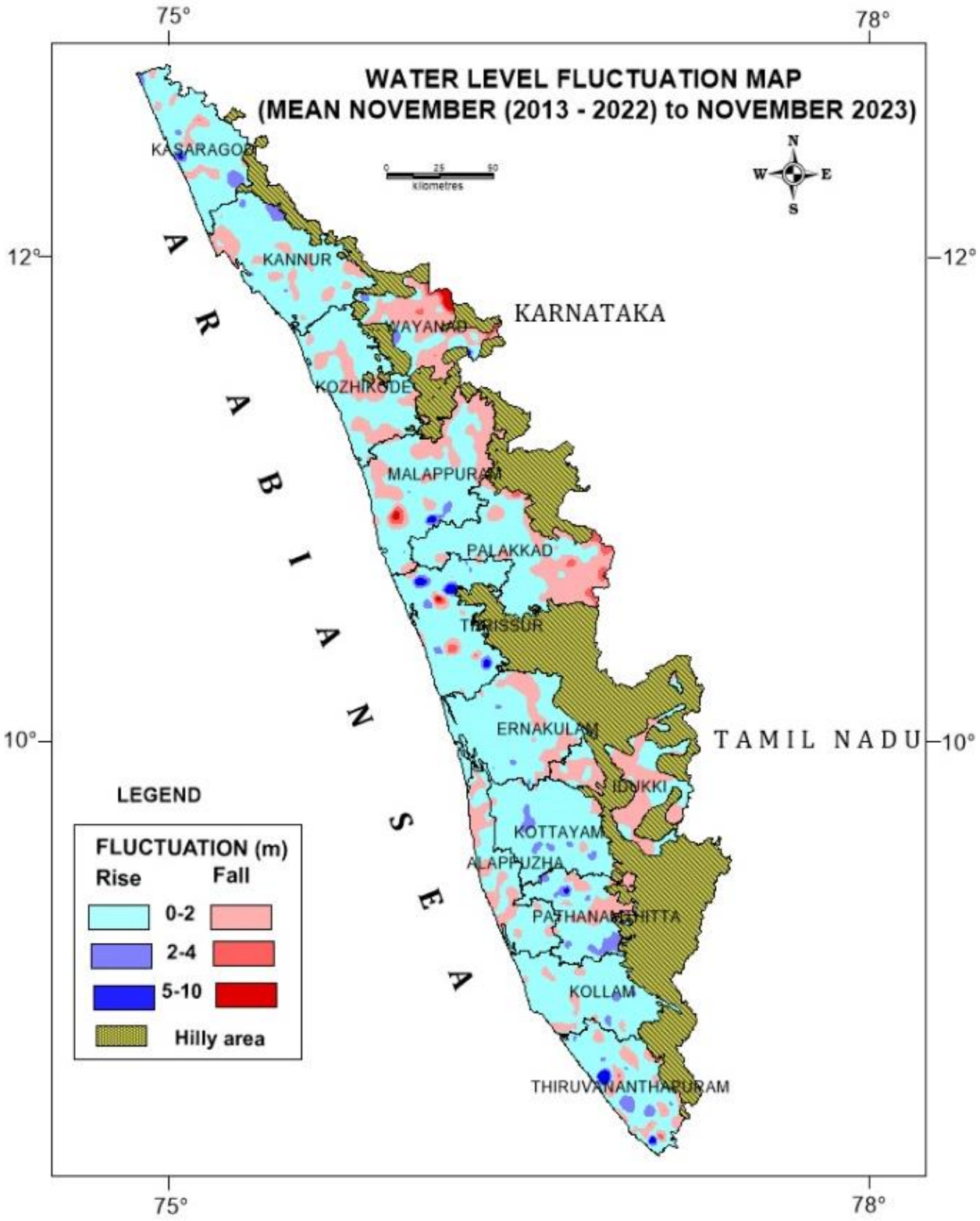

Figure 5.6 Decadal water level fluctuation with mean Pre-Monsoon (2013 to 2022) and Pre- Monsoon 2023

CHAPTER 6

6.0 GROUND WATER RESOURCES OF KERALA STATE

The Dynamic ground water resources (as in 2024) of the Kerala State have been assessed jointly by CGWB and State Ground Water Department under the supervision of the State level Committee. The dynamic ground water resources are also known as Annual Ground Water Recharge, since it gets recharged every year from rainfall and other secondary sources such as applied irrigation water, surface water bodies, water conservation structures, etc. Methodology adopted for the assessment has been outlined in Chapter-2 of this report. This section provides a summary of the Ground water Resources Assessment 2024 (GWRA-2024) made for the Kerala State.

6.1. Annual Ground Water Recharge

As per the 2024 assessment of Dynamic Ground Water Resources, the Total Annual Ground Water Recharge for the Kerala state has been assessed as **5.67 billion cubic meter (bcm)** and the Annual Extractable Ground Water Resources **is 5.13 bcm** with total natural discharges at 0.54 bcm. Rainfall recharge during monsoon and non-monsoon period is the major contributor of total annual groundwater recharge of the state, which is 4.68 bcm or 82.60 % of the total recharge (Monsoon season: 73.93%, Non-monsoon season: 8.67%) and the remaining 17.40 % (Monsoon season: 2.37%, Non-monsoon season: 15.03%) or 0.97 bcm is from 'Other sources' viz. return flow from irrigation, recharge from tanks, ponds and water conservation structures taken together. **(Figure 6.1)**. The contribution in annual ground water recharge from rainfall during monsoon season is more than 70% in Kerala. **(Figure 6.2*).*** The overall contribution of rainfall (both monsoon & non-monsoon) recharge is 82.6% and the share of recharge from 'Other sources' viz. return flow from irrigation, recharge from tanks, ponds and water conservation structures taken together is 17.4%. Ground water resources availability, utilization and stage of ground water extraction of Kerala State as in 2024 is given in **Annexure-I.** District wise ground water resources availability, utilization and stage of groundwater extraction (as on 2024) is given in **Annexure-II.**

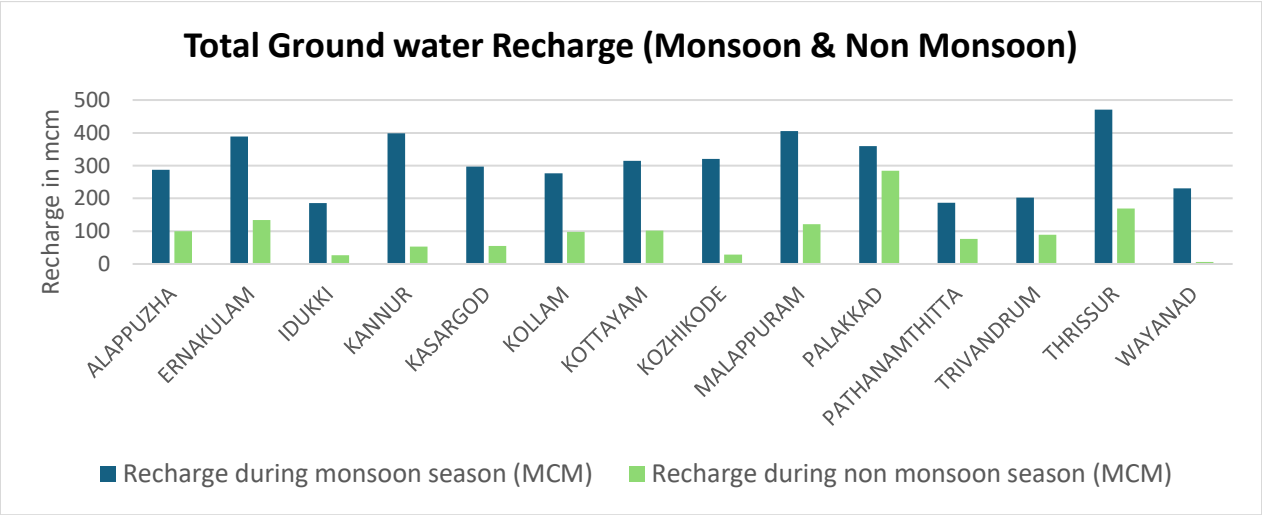

Figure 6.1 Total Annual Ground Water Recharge, Kerala State, 2024

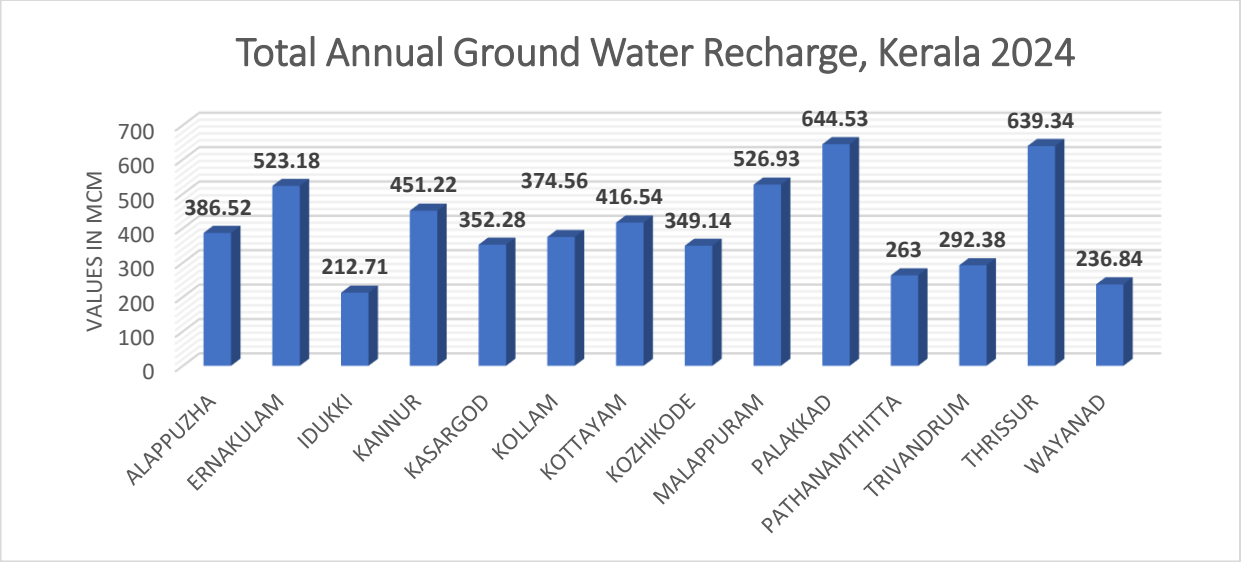

Figure 6.2 Total Annual Ground Water Recharge, Kerala State, 2024

6.2. Annual Extractable Ground Water Resources

The annual extractable ground water recharge was calculated as per the norms recommended in the 2015 methodology by deducting un-accounted losses and natural discharge (Environmental Flows) during the non-monsoon season from the Total Annual Recharge available. Such losses were considered to account for 10% of the total annual recharge in assessment units where the monsoon rainfall recharge was calculated using Rainfall Infiltration Factor Method and 5% in assessment units where the monsoon rainfall re-charge was calculated by Water Table Fluctuation Method. As per the computation, Annual Extractable Ground Water Recharge for the entire State is **5.13 billion cubic metre (BCM**). The district-wise availability in the State ranges from **191.44 MCM** in Idukki district to **584.17 MCM** in Palakkad district. The spatial distribution of unit annual ground water recharge in Kerala as on 2024 in depth units (m) is shown in **Figure 6.3.** Annual Extractable Ground Water Resources of assessments units under different category and district wise assessment is given in **Annexure III-C** and **Annexure III-D.**

6.3. Annual Total Ground Water Extraction

Ground water Extraction in Kerala is mainly for domestic uses and for irrigation. There are several methods for the computation of extraction for domestic use (GE_{DOM}), irrigation use (GE_{IRR}) and industrial use (GE_{IND}). In view of the non-availability of data on the number of wells being used for domestic purposes, the ground water Extraction for domestic uses has been computed using consumptive use method in which block-wise based on 2011 population for Urban and Rural areas, projected to the year of assessment (2024). Domestic requirement of water in the State has been computed as the product of the population and the per-capita water requirement (assumed as 150 litres per capita per day). The assessment of ground water extraction is carried out considering the 6th Minor Irrigation Census data and sample surveys carried out by the State Ground Water Departments. The Extraction for Industrial uses is very less when compared to Domestic and Irrigation use, and has been estimated using unit draft and consumptive use pattern method, in which assessment unit wise number of wells, industrial units & type and season wise unit draft of each type of well collected by the State Ground Water

Dept., Government of Kerala. The spatial distribution of annual ground water extraction in Kerala as on 2024 in depth units (m) is shown in **Figure 6.4.**

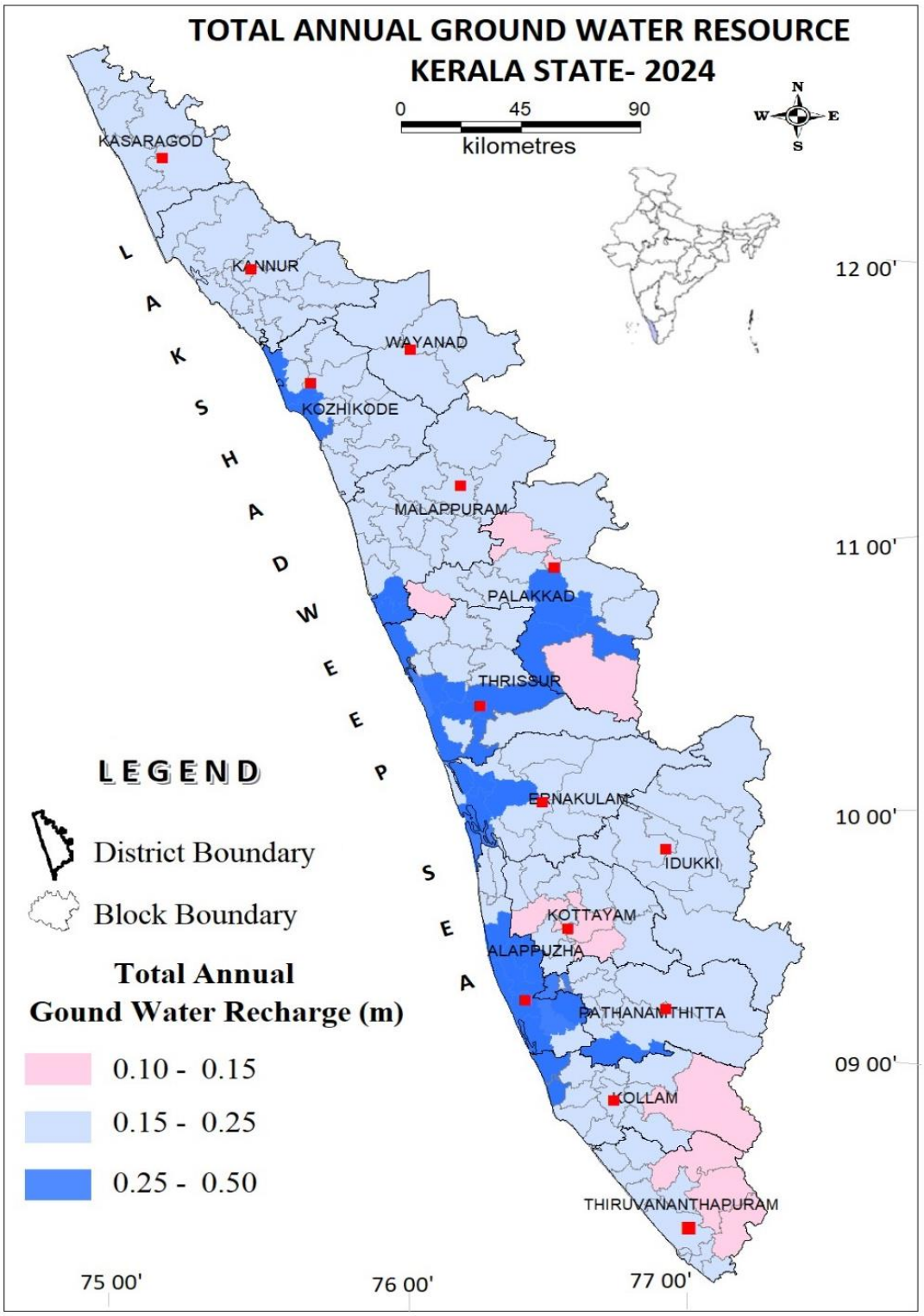

Figure 6.3. Spatial Distribution of annual unit ground water recharge in Kerala

The status of annual extractable ground water resources and annual ground water extraction is given in **Figure 6.5.**

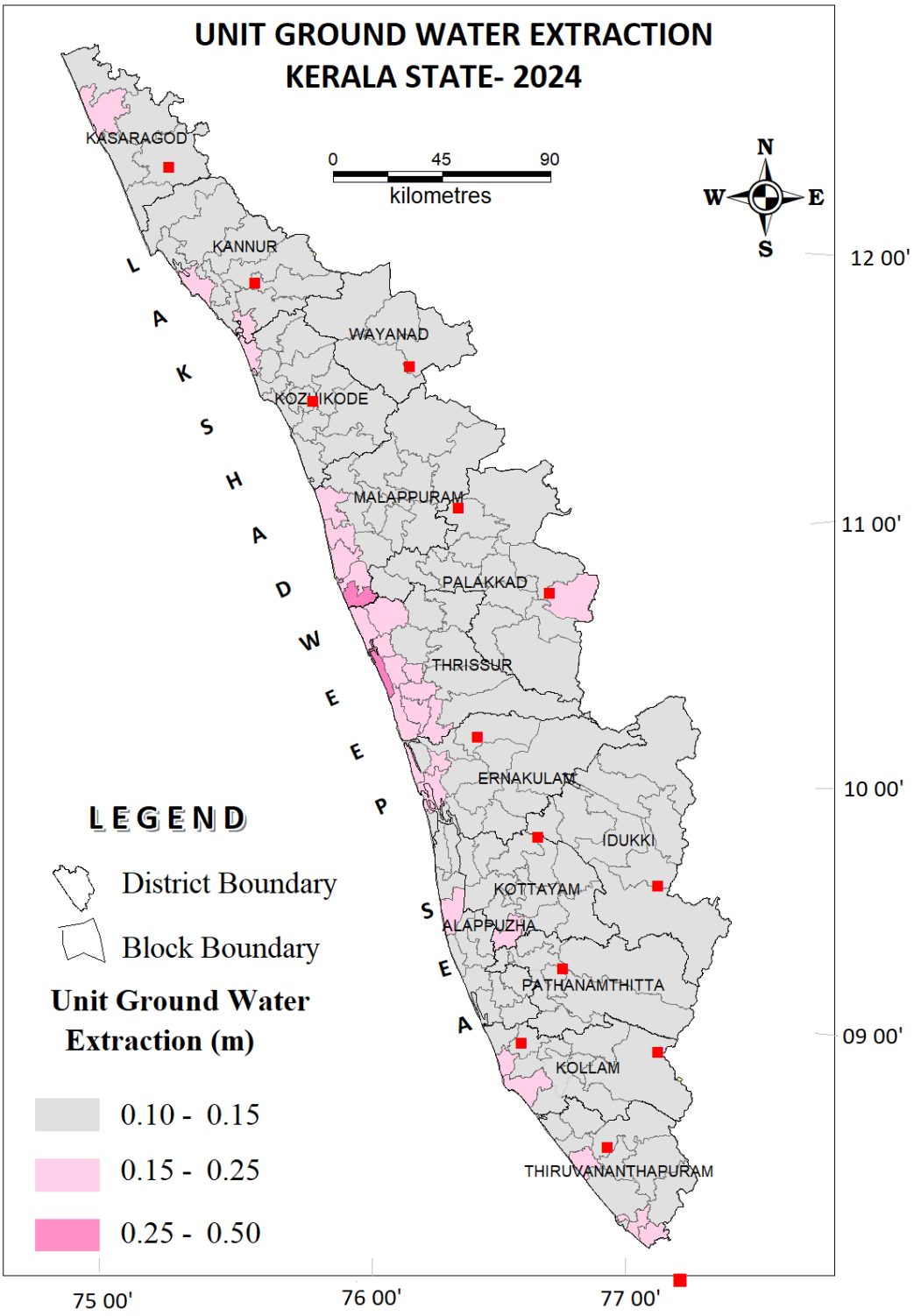

Figure 6.4. Spatial Distribution of ground water extraction in Kerala

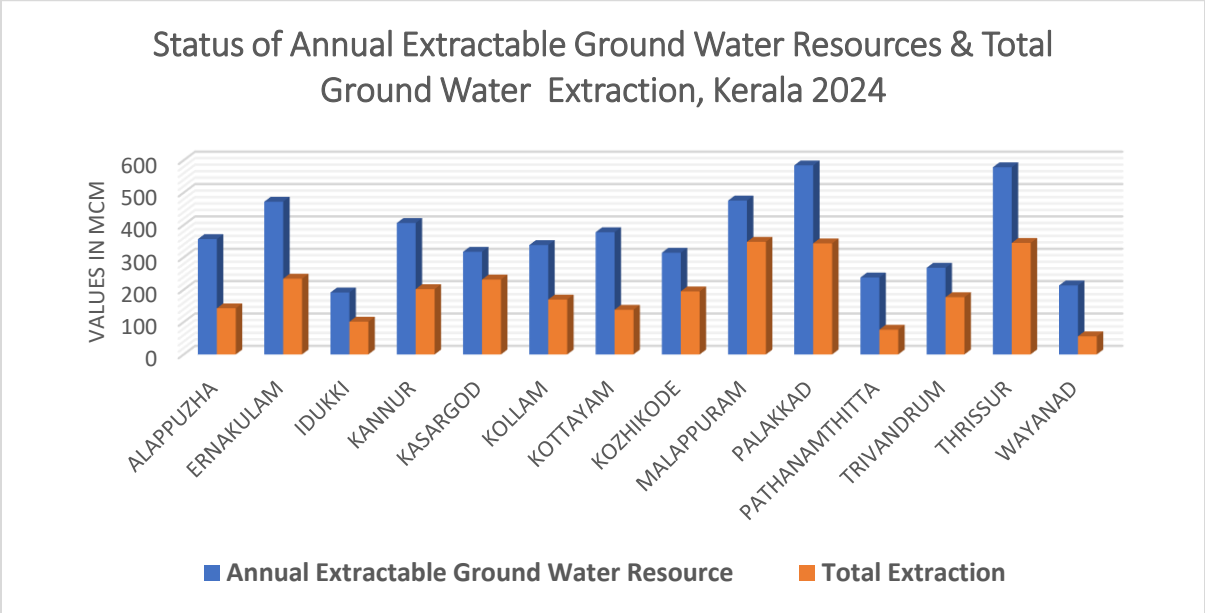

Figure 6.5 Total Annual Ground Water Recharge, Kerala State, 2024

The Total Annual Ground Water Extraction of the state for the year 2024 has been estimated as **2.76 bcm** and ranges from **56.04 MCM** in Wayanad district to **348.11 MCM** in Malappuram district. The domestic use is the largest consumer of groundwater resources, accounting for **59.06 %** of the total annual groundwater extraction, which amounts to **1.63 bcm** followed by the agriculture sector which accounts for **40.58% (1.12 bcm),** while industrial use represents **0.36% (0.01 bcm)** of total annual groundwater extraction of the Kerala State. **(Figure 6.6 and Figure 6.7).**

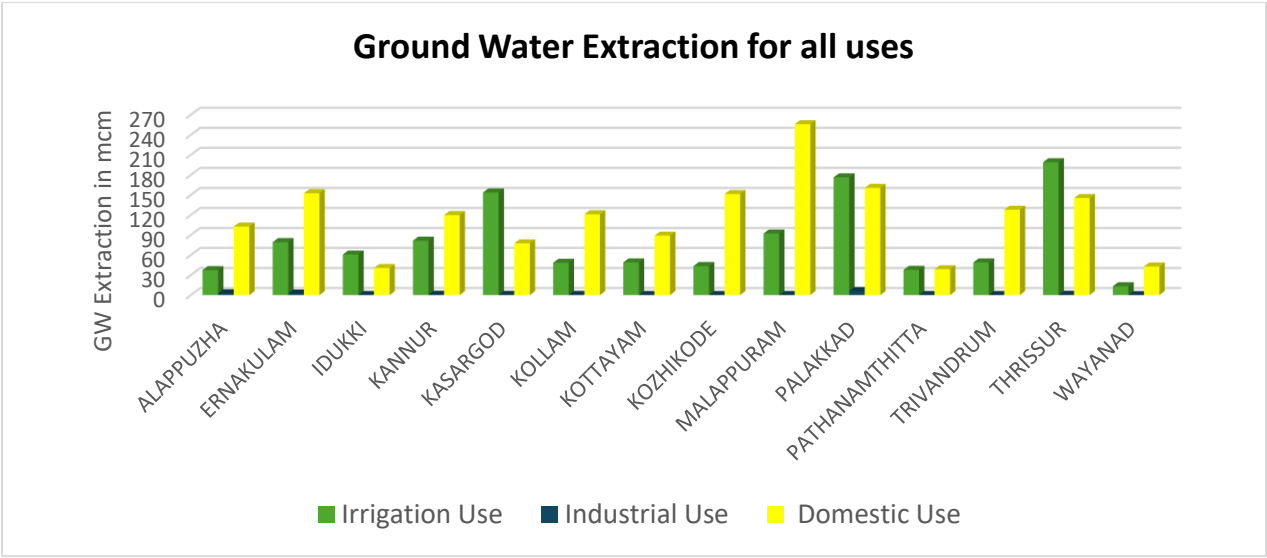

Figure 6.6 Ground Water Extraction for all uses, Kerala State, 2024

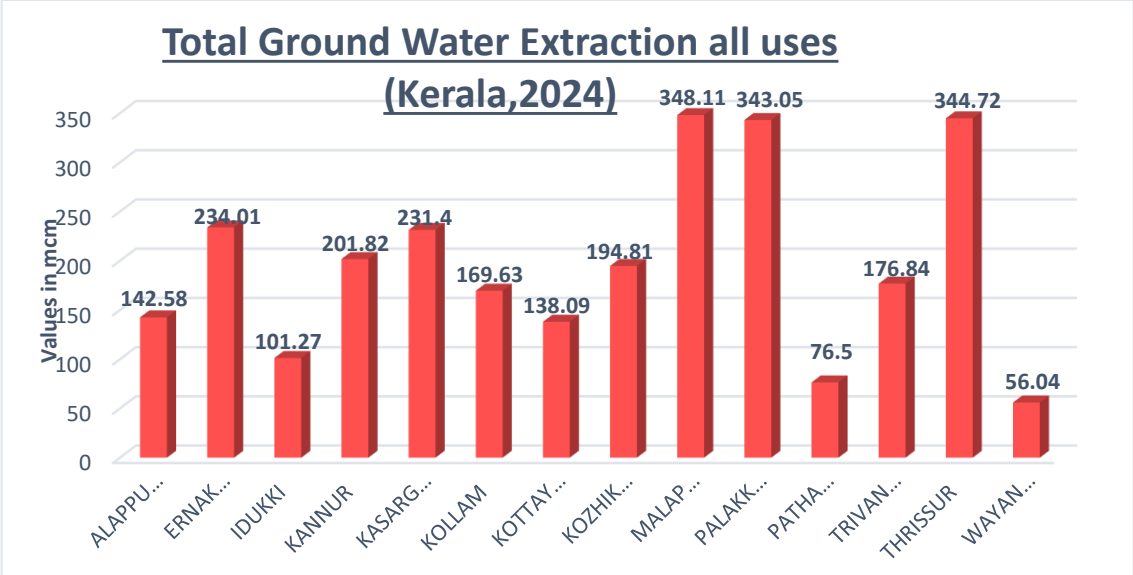

Figure 6.7 Total Annual Ground Water Extraction, Kerala State, 2024

6.4. Stage of Ground Water Extraction

The Stage of Ground Water Extraction of assessment units computed as the ratio of Existing Gross Ground Water Extraction for all uses and the Annual Extractable Ground Water Recharge expressed in percentage. Long term water level trends of ground water levels are prepared for a minimum period of 10 years for both pre-monsoon and post-monsoon period. The average water level trend as obtained from the different observation wells in the area is validated with the 'Stage of Ground Water Extraction'. The stage of Ground water extraction for the Kerala State is **53.78** %. The Stage of Ground Water Extraction is the highest in Malappuram district **(73.19%)** and the lowest in Wayanad district **(26.29%).** The stage of ground water extraction of Kerala State, 2024 is shown in **Figure 6.8.**

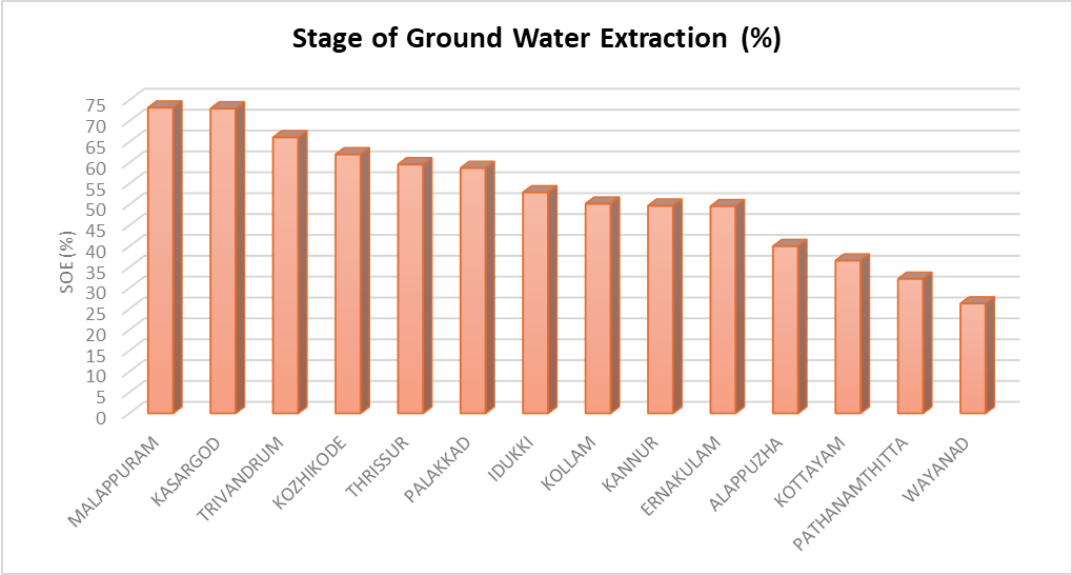

Figure 6.8 Stage of Ground Water Extraction, Kerala State, 2024

6.5. Categorization of Assessment Units

The Assessment units have been categorized as “Over-exploited”, “Critical”, “Semi-critical” and “Safe” based on Stage of Ground Water Extraction and the long-term decline of average ground water levels in the observation wells in the assessment unit, as per the criteria suggested in GEC-2015 methodology. After that the analysis has to be validated. If in a safe block (SOE≤70%) decadal water level trends are showing falling patterns, then the calculation is unacceptable and re-calculation needs to be made. Again, reassessment is necessary if in an OE block (SOE >100%) long term water level trends in observation wells are showing rising pattern.

Out of 152 assessed units in the State, 3 blocks (Chittur & Malampuzha blocks of Palakkad district and Kasaragod block of Kasaragod district) have been categorized as “Critical”; 29 blocks are “Semi-critical” and 120 blocks are in “Safe” category. The Stage of Ground Water Extraction and the block-wise long-term (2014-2023) water level trends of the observation wells being monitored by Central Ground Water Board and the State Ground Water Department for pre and post-monsoon were considered for categorization of the blocks. The spatial distribution of different categories of assessment units is given in **Figure 6.9.** The district- wise and block-wise numbers of assessment units under different categories are given in **Annexure III-(A)** and **Annexure III-(B)** respectively. Categorization of Critical and Semi critical blocks as in 2024 is given in **Annexure IV (A).** The attribute table of assessment unit wise report of Kerala State is given in **Annexure VI.**

6.6. Comparison with Previous Assessment

A comparison of the major components of dynamic ground water resources of Kerala during 2023 and 2024, along with justification is given in Table. 8. A comparative analysis of the components of dynamic ground water resources during 2023 and 2024 shows that the annual extractable ground water recharge for Kerala during 2024 has increased by 2.57 %. The annual ground water Extraction for all uses has slightly increased during the period (1.06%). The net ground water availability for future use in the state shows an increase of 5.12 % in 2024 when compared to the corresponding figures computed in 2023. The Stage of Ground Water Extraction in the State shows a decrease from 54.55 % during 2023 to 53.78 % during 2024. The variation in the spatial distribution of various recharge and discharge components resulting from changes in the precipitation (also during summer periods), increase in recharge from other sources and consequent water level fluctuations and attributed due to increased dependency on surface water sources for irrigation and domestic uses with increase in population has resulted in the change in the number of blocks in various categories when compared to the previous assessment. The number of ‘Semi-critical’ blocks in the State has decreased from 30 to 29 whereas the number of ‘Safe’ blocks increased from 119 to 120. There is no change in the number of Critical blocks. There are no overexploited category blocks.

District-wise and Block/assessment unit-wise details recharge worthy area under different category are given in **Annexure III-(E)** and **Annexure III-(F)** respectively. The state wise summary of assessment units improved or deteriorated from 2023 to 2024 assessment and detailed comparison of categorization of assessment units from 2023 and 2024 are given in **Annexure V-(A)** and **Annexure V-(B)** respectively

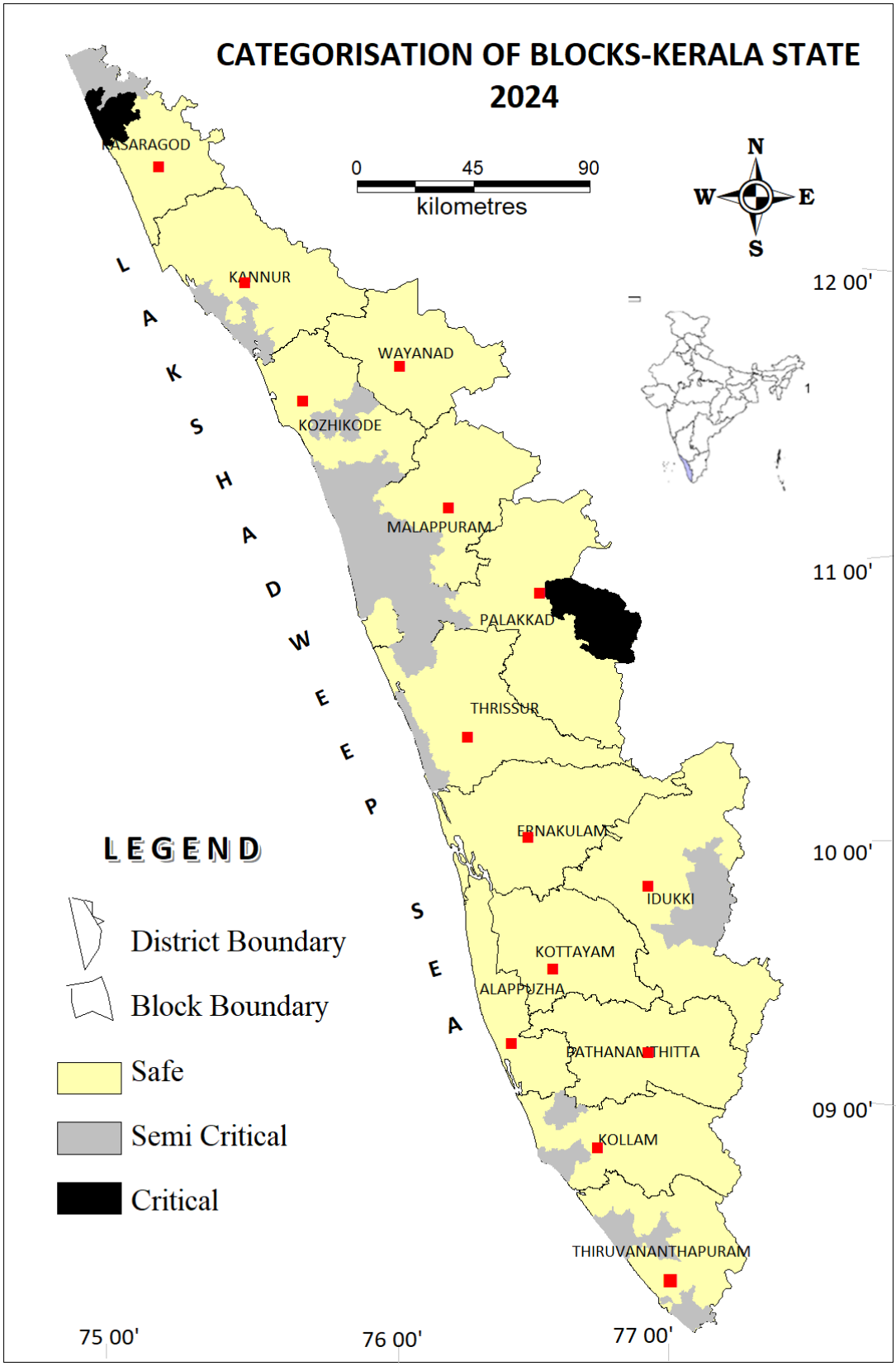

Figure 6.9. Categorization of Blocks in Kerala (2024)

CHAPTER 7

7.0 CONCLUSIONS

In the present assessment, the total annual groundwater recharge in the state has been assessed as 5.67 bcm. Keeping an allocation for natural discharge, the annual extractable ground water resource has been assessed as 5.13 bcm. The annual groundwater extraction (as in 2024) is 2.76 bcm. The stage of groundwater extraction for the Kerala State is 53.78 %. Out of the total 152 assessment units (Blocks) 3 units (Chittur & Malampuzha blocks of Palakkad district and Kasaragod block of Kasaragod district) in various States/ UTs (1.97%) the stage of groundwater extraction is between 90-100% and have been categorized as 'Critical'. There are 29 (19.08 %) "Semi critical'' units, where the stage of ground water extraction is between 70 % and 90 % and 152 (78.95 %) 'Safe' units, where the stage of Ground water extraction is less than 70 %.

Similarly, out of 27447.53 sq km recharge worthy area of the state, 777.38 sq km (2.87%) are under are under 'Critical', 4109.06 sq km (15.19%) are under 'Semi-Critical', 22161.1 sq km (81.93%) are under 'Safe' category assessment units. Out of 5.13 bcm of Total Annual Extractable Resources of the state, 0.136 bcm (2.67%) are under 'Critical', 0.752 bcm (14.67%) are under 'Semi-Critical', 4.24 bcm (82.66%) are under 'Safe' category assessment units. The critical and semi critical in the states could be attributed mainly to the low storage and transmission capacities of aquifers of the hard rock terrains, which results in reduced availability of the resource.

In comparison to Dynamic Ground Water Resource Assessment 2023, the total annual ground water recharge has increased marginally from 5.53 bcm to 5.67 bcm where major decreases are noticed in Malappuram and Kasaragod Districts and increases are noticed in Pathanamthitta , Palakkad and Kollam Districts and the change is attributed mainly to change in recharge from mainly from Rainfall and also recharge from 'Other Sources'. Accordingly, the annual extractable ground water resources have increased marginally from 5.005 to 5.13 bcm. The ground water extraction has marginally increased from 2.73 bcm to 2.76 bcm. The overall stage of groundwater extraction has marginally decreased from 54.55 % to 53.78 %. The critical assessment units are mostly concentrated in Chittur, Malampuzha blocks of Palakkad district and Kasaragod block of Kasaragod district were due to inherent characteristics of crystalline aquifers. It is also pertinent to add that as it is advisable to control over the ground water extraction as far as possible to annual replenishable resources, the categorization also reflects the relation between the annual replenishment and ground water extraction.

"INDIA-GROUNDWATER RESOURCE ESTIMATION SYSTEM (IN- GRES) is a Software/Web-based Application developed by CGWB in collaboration with IIT-Hyderabad. It provides common and standardized platform for Ground Water Resource Estimation for the entire country and its pan-India operationalization (Central and State Governments). The Software uses GEC 2015 Methodology for estimation and calculation of Groundwater resources. It allows for unique and homogeneous representation of groundwater fluxes as well as categories for all the assessment units (AU) of the state. An analysis of assessment results leads us to the following inferences as the way forward in the assessment of Ground water resources.

1. WATER BALANCE STUDIES: Studies for determining the Base flow and lateral flow components in the Water Balance equation need to be taken up to bring more accuracy to the Ground water Resources Assessment.

2. AQUIFER CHARACTERIZATION AND PARAMETER ESTIMATION: It is recommended that more experimental studies be taken up for refining the norms of RIF, return flow from irrigation based on soil types and agro-climatic zone, recharge from water conservation and water bodies and more field studies for evaluation of specific yield values as well as its variation with depth.
3. CASE STUDIES LINKING ASSESSMENT WITH MANAGEMENT: It is recommended to take up case studies in various assessment units wherein quantitative evaluation of the ground water management interventions and consequent changes in the assessment results could be analysed. Such studies would help bring out the efficacy of various management interventions on the ground water regime.
4. TEMPORAL AVAILABILITY OF GROUND WATER RESOURCES: Even though the GEC 2015 methodology advocates season-wise resource assessment, the estimation of recharge during monsoon and non-monsoon seasons may not be sufficient. Temporal variations in groundwater availability, particularly in hard rock terrain are not reflected in present practices. Hence, the assessment of temporal availability of ground water resources on the basis of available water columns can be attempted by considering the water levels measured frequently using Digital Water Level Recorders (DWLRs).
5. CREATION OF DATABASE FOR GROUND WATER RESOURCES ASSESSMENT AND ITS REGULAR UPDATING: GEC 2015 has devised the data structure of all the data elements (like water level, rainfall etc.) and norms (like Specific Yield, Rainfall Infiltration Factor etc.) with its name, type of data and its precision. The templates (excel sheets) for data collection/compilation for assessment through IN-GRES using GEC 2015 has also been devised. However, major challenges are lack of dedicated manpower as well as presence of State GW/Nodal Departments at District level for understanding/analysis of data/information to be collected/compiled from different State Departments (like Agriculture, Irrigation, Water Supply, Industries, Water Conservation etc.). Of particular importance in this regard are data/information related to recharge from water bodies, water conservation/harvesting structures, return flow from applied irrigation and details of ground water extraction structures in use for irrigation, domestic and industrial purpose. These need to be collected/compiled and regularly updated at district/block level so that more realistic assessment of ground water resources could be accomplished.
6. AQUIFER-STREAM INTERACTIONS: Additional studies on aquifer-stream interactions are required to understand the contribution of ground water to streams and the requirement of environmental flows for sustainability of water resources and surrounding ecosystem.
7. GROUND WATER MODELLING AND PREDICTIVE SIMULATION: Besides the assessment of the dynamic ground water resources using norms prescribed in GEC 2015 methodology through automation, the concept of Ground water modelling must be included where predictive simulation can also be done. This would give an idea of the future availability of Ground water resources with respect to the changing climate and extraction patterns.

Annexure-I

Ground water resources availability, utilization and stage of extraction of Kerala State (as in 2024)

KERALA STATE

S. NO	State	Ground Water Recharge					Total Natural Disch-arges	Annual Extrac-table Ground Water Resource	Current Annual Ground Water Extraction				Annual GW Allocation for Domestic use as on 2025	Net Ground Water Availability for future use	Stage of Ground Water Extraction (%)
		Monsoon Season		Non-Monsoon Season		Total Annual Ground Water Recharge			Irriga-tion	Indus-trial	Dome-stic	Total			
		Rech-arge from rainfall	Rech-arge from other Sources	Rech-arge from Rainfall	Rech-arge from other Sources										
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
1	**KERALA**	4.19	0.13	0.49	0.85	5.67	0.54	5.13	1.12	0.01	1.63	2.76	2.14	2.12	53.78
	Total(bcm)	4.19	0.13	0.49	0.85	5.67	0.54	5.13	1.12	0.01	1.63	2.76	2.14	2.12	53.78

Bcm: Billion Cubic meter

Annexure-II

District-wise ground water resources availability, utilization and stage of extraction of Kerala (as in 2024)

KERALA STATE															
#	Name of District	Ground Water Recharge					Total Natural Discharges	Annual Extractable Ground Water Resource	Current Annual Ground Water Extraction				Annual GW Allocation for Domestic use as on 2025	Net Ground Water Availability for future use	Stage of Ground Water Extraction(%)
		Monsoon Season		Non-Monsoon Season		Total Annual Ground Water Recharge			Irrigation	Industrial	Domestic	Total			
		Recharge from rainfall	Recharge from other Sources	Recharge from Rainfall	Recharge from other Sources										
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
1	ALAPPUZHA	28421.44	269.4	3336.99	6624.29	38652.12	3014.71	35637.41	3737.24	261.52	10259.14	14257.91	10454.89	21183.76	40.01
2	ERNAKULAM	38013.43	887.6	6802.15	6614.99	52318.17	5123.02	47195.15	7933.27	220.75	15247.35	23401.37	19007.47	20033.69	49.58
3	IDUKKI	18309.47	254.94	907.18	1799.7	21271.29	2127.12	19144.17	6066.22	13.27	4047.48	10126.96	4115.09	8949.59	52.9
4	KANNUR	38954.9	886.11	1489.06	3791.65	45121.72	4512.19	40609.53	8149.02	48.72	11984.61	20182.31	14322.08	18219.94	49.7
5	KASARGOD	28314.46	1369.38	1307.66	4236.1	35227.6	3522.76	31704.84	15371.64	22.76	7745.39	23139.78	11365.26	5781.15	72.99
6	KOLLAM	26854.83	836.88	7056.17	2708.07	37455.95	3646.22	33809.73	4843.89	22.28	12096.87	16963.06	12609.6	16333.94	50.17
7	KOTTAYAM	30715.51	765.51	4619.14	5553.53	41653.69	3885.68	37768.01	4897.69	15.81	8895.35	13808.85	9183.52	23670.99	36.56
8	KOZHIKKODE	31488.68	570.45	1316.31	1538.64	34914.08	3491.4	31422.68	4344.7	7.09	15128.77	19480.57	20923.94	7434.56	62
9	MALAPPURAM	39433.15	1124.34	4181.42	7954.32	52693.23	5133.21	47560.02	9214.83	6.04	25590.55	34811.41	49258.69	10735.33	73.19
10	PALAKKAD	32001.81	3994.02	3920.21	24537.19	64453.23	6036.69	58416.54	17634.8	612.77	16057.64	34305.25	22322.49	19891.98	58.73
11	PATHANAMTHITTA	18204.33	495.57	5680.16	1919.88	26299.94	2526.49	23773.45	3776.15	4.07	3869.51	7649.73	4195.98	15797.24	32.18
12	THIRUVANANTHAPURAM	19674.25	598.56	6292.27	2673.09	29238.17	2470.5	26767.67	4892.46	7.09	12784.77	17684.3	13568.35	8299.79	66.07
13	THRISSUR	46070.79	980.46	2248.65	14634.1	63934	6092.28	57841.72	19901.98	39.11	14531.16	34472.21	17127.38	20773.29	59.6
14	WAYANAD	22654.22	396.88	0	633.01	23684.11	2368.42	21315.69	1324.38	1.84	4277.88	5604.11	5047.47	14941.99	26.29
	Total (Ham)	**419111.3**	**13430.1**	**49157.37**	**85218.56**	**566917.3**	**53950.69**	**512966.6**	**112088.3**	**1283.1**	**162516.5**	**275887.8**	**213502.21**	**212047.24**	**53.78**
	Total (Mcm)	**4191.11**	**134.30**	**491.57**	**852.19**	**5669.17**	**539.51**	**5129.67**	**1120.88**	**12.83**	**1625.16**	**2758.88**	**2135.02**	**2120.47**	**53.78**
	Total (Bcm)	**4.19**	**0.13**	**0.49**	**0.85**	**5.67**	**0.54**	**5.13**	**1.12**	**0.01**	**1.63**	**2.76**	**2.14**	**2.12**	**53.78**

Ham: Hectare meter
Mcm: Million Cubic meter
Bcm: Billion Cubic meter

Annexure-III (A)

Categorization of blocks in Kerala State (as in 2024)

KERALA STATE												
S.No	State	Total No. of Assessed Units	Safe		Semi-Critical		Critical		Over-Exploited		Saline	
			Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%
1	**KERALA**	152	120	78.95	29	19.08	3	1.97	-	-	-	-
	Total	152	120	78.95	29	19.08	3	1.97	-	-	-	-

Annexure-III (B)

District Wise Categorization of blocks for the Kerala State (as in 2024)

KERALA STATE												
S.No	Name of District	Total No. of Assessed Units	Safe		Semi-Critical		Critical		Over-Exploited		Saline	
			No	%	No.	%	No.	%	No.	%	No.	%
1	ALAPPUZHA	12	12	100	-	-	-	-	-	-	-	-
2	ERNAKULAM	14	14	100	-	-	-	-	-	-	-	-
3	IDUKKI	8	6	75	2	25	-	-	-	-	-	-
4	KANNUR	11	8	72.73	3	27.27	-	-	-	-	-	-
5	KASARGOD	6	4	66.67	1	16.67	1	16.67	-	-	-	-
6	KOLLAM	11	9	81.82	2	18.18	-	-	-	-	-	-
7	KOTTAYAM	11	11	100	-	-	-	-	-	-	-	-
8	KOZHIKKODE	12	9	75	3	25	-	-	-	-	-	-
9	MALAPPURAM	15	7	46.67	8	53.33	-	-	-	-	-	-
10	PALAKKAD	13	9	69.23	2	15.38	2	15.38	-	-	-	-
11	PATHANAMTHITTA	8	8	100	-	-	-	-	-	-	-	-
12	THIRUVANANTHAPURAM	11	6	54.55	5	45.45	-	-	-	-	-	-
13	THRISSUR	16	13	81.25	3	18.75	-	-	-	-	-	-
14	WAYANAD	4	4	100	-	-	-	-	-	-	-	-
	Total	**152**	**120**	**78.95**	**29**	**19.08**	**3**	**1.97**	**-**	**-**	**-**	**-**

Annexure-III (C)

Annual Extractable Ground Water Resource of Assessment Units under Different Category for the Kerala State (as in 2024)

KERALA STATE												
S.No	State	Total Annual Extractable Resource of Assessed Units (in mcm)	Safe		Semi-Critical		Critical		Over-Exploited		Saline	
			Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%
1	**KERALA**	5129.67	4240.06	82.66	752.74	14.67	136.86	2.67	-	-	-	-
	Total (Mcm)	5129.67	4240.06	82.66	752.74	14.67	136.86	2.67	-	-	-	-
	Grand Total (Bcm)	5.13	4.24	82.66	0.75	14.67	0.14	2.67	-	-	-	-

Mcm: Million Cubic meter

Bcm: Billion Cubic meter

Annexure-III (D)

District Wise Annual Extractable Ground Water Resource of Assessment Units under Different Category for the Kerala State (as in 2024)

KERALA STATE												
S.No	Name of District	Total Annual Extractable Resource of Assessed Units (in mcm)	Safe		Semi-Critical		Critical		Over-Exploited		Saline	
			Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%
1	ALAPPUZHA	356.37	356.37	100	-	-	-	-	-	-	-	-
2	ERNAKULAM	471.95	471.95	100	-	-	-	-	-	-	-	-
3	IDUKKI	191.44	147.12	76.85	44.32	23.15	-	-	-	-	-	-
4	KANNUR	406.1	345.3	85.03	60.8	14.97	-	-	-	-	-	-
5	KASARGOD	317.05	211.23	66.63	59.56	18.79	46.25	14.59	-	-	-	-
6	KOLLAM	338.1	284.81	84.24	53.28	15.76	-	-	-	-	-	-
7	KOTTAYAM	377.68	377.68	100	-	-	-	-	-	-	-	-
8	KOZHIKKODE	314.23	233.19	74.21	81.04	25.79	-	-	-	-	-	-
9	MALAPPURAM	475.6	253.8	53.36	221.8	46.64	-	-	-	-	-	-
10	PALAKKAD	584.17	439.74	75.28	53.81	9.21	90.61	15.51	-	-	-	-
11	PATHANAMTHITTA	237.73	237.73	100	-	-	-	-	-	-	-	-
12	THIRUVANANTHAPURAM	267.68	188.76	70.52	78.92	29.48	-	-	-	-	-	-
13	THRISSUR	578.42	479.2	82.85	99.21	17.15	-	-	-	-	-	-
14	WAYANAD	213.16	213.16	100	-	-	-	-	-	-	-	-
	Total(Mcm)	5129.67	4240.06	82.66	752.74	14.67	136.86	2.67	-	-	-	-
	Total(Bcm)	5.13	4.24	82.66	0.75	14.67	0.14	2.67	-	-	-	-

Mcm: Million Cubic meter
Bcm: Billion Cubic meter

Annexure-III (E)

Recharge Worthy Area of Assessment unit under Different Category for the Kerala State (as in 2024)

KERALA STATE													
S.No	**State**	**Total Geographical Area of Assessed Units (in sq km)**	**Recharge Worthy Area (in sq km)**	**Safe**		**Semi-Critical**		**Critical**		**Over-Exploited**		**Saline**	
				Recharge Worthy Area in sq km	**%**	**Recharge Worthy Area in sq km**	**%**	**Recharge Worthy Area in sq km**	**%**	**Recharge Worthy Area in sq km**	**%**	**Recharge Worthy Area in sq km**	**%**
1	**KERALA**	38695.21	27047.53	22161.1	81.93	4109.06	15.19	777.38	2.87	-	-	-	-
	Total (Sq.km)	38695.21	27047.53	22161.1	81.93	4109.06	15.19	777.38	2.87	-	-	-	-
	Grand Total (thousand Sq.km)	0.0039	0.0027	0.0022	81.93	0.0004	15.19	7.774E-05	2.87	-	-	-	-

Annexure-III (F)

District Wise Recharge Worthy Area of Assessment unit under Different Category for the Kerala State (as in 2024)

KERALA STATE												
S.No	Name of District	Total Recharge Worthy Area of Assessed Units (in sq.km)	Safe		Semi-Critical		Critical		Over-Exploited		Saline	
			Recharge Worthy Area of Assessed Units (in sq.km)	%	Recharge Worthy Area of Assessed Units (in sq.km)	%	Recharge Worthy Area of Assessed Units (in sq.km)	%	Recharge Worthy Area of Assessed Units (in sq.km)	%	Recharge Worthy Area of Assessed Units (in sq.km)	%
1	ALAPPUZHA	1414.03	1414.03	100	-	-	-	-	-	-	-	-
2	ERNAKULAM	2269.47	2269.47	100	-	-	-	-	-	-	-	-
3	IDUKKI	1088.91	854.63	78.48	234.28	21.52	-	-	-	-	-	-
4	KANNUR	2323.96	2002.78	86.18	321.18	13.82	-	-	-	-	-	-
5	KASARGOD	1648.3	1058.18	64.2	331.36	20.1	258.76	15.7	-	-	-	-
6	KOLLAM	2112	1837.06	86.98	274.94	13.02	-	-	-	-	-	-
7	KOTTAYAM	1970.88	1970.88	100	-	-	-	-	-	-	-	-
8	KOZHIKKODE	1661.8	1188.82	71.54	472.98	28.46	-	-	-	-	-	-
9	MALAPPURAM	2541.81	1327.05	52.21	1214.76	47.79	-	-	-	-	-	-
10	PALAKKAD	2982.28	2084.06	69.88	379.6	12.73	518.62	17.39	-	-	-	-
11	PATHANAMTHITTA	1296.65	1296.65	100	-	-	-	-	-	-	-	-
12	THIRUVANANTHAPURAM	1942.97	1452.78	74.77	490.19	25.23	-	-	-	-	-	-
13	THRISSUR	2366.85	1977.08	83.53	389.77	16.47	-	-	-	-	-	-
14	WAYANAD	1427.62	1427.62	100	-	-	-	-	-	-	-	-
	Total (Sq.km.)	27047.53	22161.1	81.93	4109.06	15.19	777.38	2.87	-	-	-	-

Annexure IV (A)

Categorization of Over Exploited, Critical and Semi Critical blocks (as in 2024)

KERALA STATE							
S.NO	**Name of District**	**S.NO**	**Name of Semi-Critical Assessment Units**	**S.NO**	**Name of Critical Assessment Units**	**S.NO**	**Name of Over-Exploited Assessment Units**
1	**IDUKKI**	1	KATTAPPANA				
		2	NEDUMKANDAM				
2	**KANNUR**	1	THALASSERY				
		2	KANNUR				
		3	PANUR				
3	**KASARGOD**	1	MANJESWAR	1	KASARAGOD		
4	**KOLLAM**	1	MUKHATHALA				
		2	SASTHAMKOTTA				
5	**KOZHIKKODE**	1	KOZHIKODE				
		2	KUNNAMANGALAM				
		3	BALLUSSERY				
6	**MALAPPURAM**	1	KONDOTTY				
		2	MANKADA				
		3	MALAPPURAM				
		4	TIRUR				
		5	THRIURANGADI				
		6	KUTTIPPURAM				
		7	THANUR				
		8	VENGARA				
7	**PALAKKAD**	1	PATTAMBI	1	CHITTUR		
		2	THRITHALA	2	MALAMPUZHA		
8	**THIRUVANANTHAPURAM**	1	NEDUMANGAD				
		2	ATHIYANNUR				
		3	POTHENCODE				
		4	PARASSALA				
		5	CHIRAYINKIL				
9	**THRISSUR**	1	CHOWANNUR				
		2	MATHILAKOM				
		3	THALIKKULAM				

ABSTRACT			
Total No. of Assessed Units	**Number of Semi critical Assessment Units**	**Number of Critical Assessment Units**	**Number of Over Exploited Assessment Units**
152	29	3	0

Annexure IV (B)

Quality problems in Assessment units (as in 2024)

KERALA STATE							
S.NO	**Name of District**	**S.NO**	**Name of Assessment Units affected by Fluoride**	**S.NO**	**Name of Assessment Units affected by Arsenic**	**S.NO**	**Name of Assessment Units affected by Salinity**
1	**ERNAKULAM**						
2	**IDUKKI**						
3	**KOZHIKKODE**						
4	**MALAPPURAM**	1	AREACODE				
5	**PALAKKAD**						
6	**THRISSUR**					1	THALIKKULAM
7	**WAYANAD**						

ABSTRACT

Total No. of Assessed Units	Number of Assessment Units affected by Fluoride	Number of Assessment Units affected by Arsenic	Number of Assessment Units affected by Salinity
2	1	0	1

Annexure IV (C)

List of Saline Assessment units in Kerala State (2024)

NIL

Annexure V (A)

Summary of Assessment units improved or deteriorated from 2023 to 2024 assessment

S.No	Name of State	Number of Assessment Units Improved	Number of Assessment Units Deteriorated	Number of Assessment Units With No Change
1	**KERALA**	1	0	151

Annexure V (B)

Comparison of categorization of assessment units (2023 to 2024)

KERALA STATE									
S.No	**Name of District**	**Name of Assessment Unit**	**Stage of Ground Water Extraction (%)2023**	**Categori-zation in2023**	**Name of District**	**Name of Assess-ment Unit**	**Stage of Ground Water Extraction (%)2024**	**Categori-zation in 2024**	**Remark**
1	**THIRUVANANTHAPURAM**	VARKALA	70.55	semi critical	**THIRUVANANTHAPURAM**	VARKALA	69.52	safe	Improved

Annexure VI a

Assessment Unit Wise Report of Kerala State (as in 2024)

KERALA STATE (KL)													
#	State_District_Code	State_District_Block_Code	District	Assessment _Unit Name	Total Geographical Area	Recharge Worthy Area	Recharge from Rainfall-MON	Recharge from Other Sources-MON	Recharge from Rainfall-NM	Recharge from Other Sources-NM	Total Annual Ground Water (Ham) Recharge	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)
1	KL01	KL010100	ALAPPUZHA	AMBALAPPUZHA	6890	6890	1639.71	0.09	126.71	346.56	2113.07	211.31	1901.76
2	KL01	KL010200	ALAPPUZHA	ARYAD	8772	8772	2096.07	15.06	390	128.03	2629.16	131.46	2497.7
3	KL01	KL010300	ALAPPUZHA	BHARANIKKAVU	12995	12995	1849.55	52.68	205.55	1001.31	3109.09	155.45	2953.64
4	KL01	KL010400	ALAPPUZHA	CHAMPAKKULAM	15383	15383	2440.61	1.08	282.89	1124.68	3849.26	384.93	3464.33
5	KL01	KL010500	ALAPPUZHA	CHENGANNUR	14996	14996	3568.81	0.43	275.78	564.06	4409.08	440.9	3968.18
6	KL01	KL010600	ALAPPUZHA	HARIPPAD	11439	11439	2722.3	72.1	210.36	837.48	3842.24	384.22	3458.02
7	KL01	KL010700	ALAPPUZHA	KANJIKKUZHY	11013	11013	2075.95	0.14	202.53	180.97	2459.59	122.98	2336.61
8	KL01	KL010800	ALAPPUZHA	MAVELIKKARA	10044	10044	2704.53	76.18	446.56	415.92	3643.19	364.32	3278.87
9	KL01	KL010900	ALAPPUZHA	MUTHUKULAM	11651	11651	2679.95	29.62	518	189.07	3416.64	170.83	3245.81
10	KL01	KL011000	ALAPPUZHA	PATTANAKKAD	10871	10871	2253.43	9.99	199.92	78.78	2542.12	127.11	2415.01
11	KL01	KL011100	ALAPPUZHA	THYCATTUSSERY	14159	14159	2507.12	11.95	260.38	73.88	2853.33	142.66	2710.67
12	KL01	KL011200	ALAPPUZHA	VELIYANAD	13190	13190	1883.41	0.08	218.31	1683.55	3785.35	378.54	3406.81
13	KL02	KL020100	ERNAKULAM	ALANGAD	7331	7331	1472.17	53.14	245.15	406.1	2176.56	108.83	2067.73
14	KL02	KL020200	ERNAKULAM	ANGAMALY	23197	21197	3721.58	76.08	683.22	811.9	5292.78	529.28	4763.5
15	KL02	KL020300	ERNAKULAM	EDAPPALLY	16053	16053	3523.06	18.66	646.78	249.73	4438.23	443.82	3994.41
16	KL02	KL020400	ERNAKULAM	KOOVAPPADY	38560	35560.5	4682.55	64.11	859.64	943.87	6550.17	655.02	5895.15
17	KL02	KL020500	ERNAKULAM	KOTHAMANGALAM	82997	22997	3532.91	50.55	648.58	561.53	4793.57	479.36	4314.21
18	KL02	KL020600	ERNAKULAM	MOOVATTUPUZHA	21480	19980	3069.42	107.28	563.5	296.63	4036.83	403.68	3633.15
19	KL02	KL020700	ERNAKULAM	MULAMTHURUTHY	16327	16327	2508.23	49.32	460.47	272.82	3290.84	329.09	2961.75
20	KL02	KL020800	ERNAKULAM	PALLURUTHY	6651	6651	1459.66	0	267.97	0	1727.63	172.77	1554.86
21	KL02	KL020900	ERNAKULAM	PAMPAKKUDA	18740	17740	2725.3	46.57	500.32	768.91	4041.1	404.11	3636.99

KERALA STATE (KL)													
#	State_District_Code	State_District_Block_Code	District	Assessment _Unit Name	Total Geographical Area	Recharge Worthy Area	Recharge from Rainfall-MON	Recharge from Other Sources-MON	Recharge from Rainfall-NM	Recharge from Other Sources-NM	Total Annual Ground Water (Ham) Recharge	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)
22	KL02	KL021000	ERNAKULAM	PARAKKADAVU	11881	11881	2085.96	27	382.95	211.43	2707.34	270.74	2436.6
23	KL02	KL021100	ERNAKULAM	PARAVOOR	7665	7665	1682.19	47.2	308.82	144.93	2183.14	218.32	1964.82
24	KL02	KL021200	ERNAKULAM	VADAVUKODU	18595	18595	3060.7	116.97	561.89	899.73	4639.29	463.93	4175.36
25	KL02	KL021300	ERNAKULAM	VAZHAKKULAM	19328	19328	3393.44	226.49	622.98	1030.48	5273.39	527.34	4746.05
26	KL02	KL021400	ERNAKULAM	VYPEEN	5642	5642	1096.26	4.23	49.88	16.93	1167.3	116.73	1050.57
27	KL03	KL030100	IDUKKI	ADIMALI	51914	21200	3092.87	71.27	153.24	176.4	3493.78	349.37	3144.41
28	KL03	KL030200	IDUKKI	AZHUTHA	107442	14542	2807.91	33.29	139.12	182.96	3163.28	316.33	2846.95
29	KL03	KL030300	IDUKKI	DEVIKULAM	96343	16043	2340.51	9.68	115.97	57.64	2523.8	252.38	2271.42
30	KL03	KL030400	IDUKKI	ELAM DESOM	18722	9722	1668.64	32.95	82.68	277.92	2062.19	206.22	1855.97
31	KL03	KL030500	IDUKKI	IDUKKI	73482	13482	2603.23	38.8	128.98	177.72	2948.73	294.87	2653.86
32	KL03	KL030600	IDUKKI	KATTAPPANA	37238	11238	1928.84	49.86	95.57	409.04	2483.31	248.33	2234.98
33	KL03	KL030700	IDUKKI	NEDUMKANDAM	34190	12190	2092.23	0.44	103.66	244.45	2440.78	244.08	2196.7
34	KL03	KL030800	IDUKKI	THODUPUZHA	16474	10474	1775.24	18.65	87.96	273.57	2155.42	215.54	1939.88
35	KL04	KL040100	KANNUR	EDAKKAD	8948	8948	1546.21	68.45	126.27	337.23	2078.16	207.82	1870.34
36	KL04	KL040200	KANNUR	IRIKKUR	41290	36290	6051.41	256.22	0	739.96	7047.59	704.76	6342.83
37	KL04	KL040300	KANNUR	IRITTY	42709	31509	5388.9	47.26	0	350.2	5786.36	578.64	5207.72
38	KL04	KL040400	KANNUR	KALLYASSERI	14339	14339	2574.98	32.22	0	207.38	2814.58	281.46	2533.12
39	KL04	KL040500	KANNUR	KANNUR	12678	12678	2434.18	82.95	198.79	327.09	3043.01	304.3	2738.71
40	KL04	KL040600	KANNUR	KUTHUPARAMBA	18235	12935	1862.64	48.64	152.12	180.05	2243.45	224.35	2019.1
41	KL04	KL040700	KANNUR	PANUR	7383	7383	1259.84	16.66	0	95.37	1371.87	137.19	1234.68
42	KL04	KL040800	KANNUR	PAYYANNUR	39212	34212	5747.62	48.41	469.39	237.83	6503.25	650.32	5852.93
43	KL04	KL040900	KANNUR	PERAVOOR	42542	21342	3513.19	34.87	0	240.37	3788.43	378.85	3409.58

KERALA STATE (KL)														
#	State_District_Code	State_District_Block_Code	District	Assessment _Unit Name	Total Geographical Area	Recharge Worthy Area	Recharge from Rainfall-MON	Recharge from Other Sources-MON	Recharge from Rainfall-NM	Recharge from Other Sources-NM	Total Annual Ground Water (Ham) Recharge	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)
44	KL04	KL041000	KANNUR	TALIPARAMBA	57403	40703	6642.73	133.09	542.49	786.08	8104.39	810.44	7293.95
45	KL04	KL041100	KANNUR	THALASSERY	12057	12057	1933.2	117.34	0	290.09	2340.63	234.06	2106.57
46	KL05	KL050100	KASARGOD	KANHANGAD	24508	24508	4346.74	74.02	303.73	530.9	5255.39	525.54	4729.85
47	KL05	KL050200	KASARGOD	KARADKA	37247	26247	4469.34	362.89	312.3	970.9	6115.43	611.54	5503.89
48	KL05	KL050300	KASARGOD	KASARAGOD	25876	25876	4177.89	293.74	0	667.36	5138.99	513.9	4625.09
49	KL05	KL050400	KASARGOD	MANJESWAR	34136	33136	5422.37	324.56	0	871.17	6618.1	661.81	5956.29
50	KL05	KL050500	KASARGOD	NILESWARAM	19695	19695	3540.37	123.91	247.38	381.35	4293.01	429.3	3863.71
51	KL05	KL050600	KASARGOD	PARAPPA	54668	35368	6357.75	190.26	444.25	814.42	7806.68	780.67	7026.01
52	KL06	KL060100	KOLLAM	ANCHAL	94622	64622	6457.13	170.05	1577.88	335.78	8540.84	854.09	7686.75
53	KL06	KL060200	KOLLAM	CHADAYAMANGALAM	24903	24903	2580.51	51.15	890.08	235.03	3756.77	375.68	3381.09
54	KL06	KL060300	KOLLAM	CHAVARA	7490	7490	1517.63	9.82	382.44	77.92	1987.81	99.39	1888.42
55	KL06	KL060400	KOLLAM	CHITTUMALA	12125	12125	2019.25	21.3	464.33	126.86	2631.74	263.18	2368.56
56	KL06	KL060500	KOLLAM	ITHIKKARA	12573	12573	2261.37	30.71	368.39	174.08	2834.55	283.46	2551.09
57	KL06	KL060600	KOLLAM	KOTTARAKKARA	13310	13310	1418.62	66.69	489.32	325.3	2299.93	229.99	2069.94
58	KL06	KL060700	KOLLAM	MUKHATHALA	14703	14703	2644.47	135.09	430.8	340.84	3551.2	355.12	3196.08
59	KL06	KL060800	KOLLAM	OACHIRA	11641	11641	2533.16	22.95	582.5	176.14	3314.75	331.47	2983.28
60	KL06	KL060900	KOLLAM	PATHANAPURAM	27995	20095	2290.52	75.24	790.06	227.09	3382.91	338.3	3044.61
61	KL06	KL061000	KOLLAM	SASTHAMKOTTA	12791	12791	1401.17	151.97	483.3	332.66	2369.1	236.91	2132.19
62	KL06	KL061100	KOLLAM	VETTIKKAVALA	16947	16947	1731	101.91	597.07	356.37	2786.35	278.63	2507.72
63	KL07	KL070100	KOTTAYAM	ERATTUPETTA	27560	14560	2131.37	14.81	482.55	97.28	2726.01	272.6	2453.41
64	KL07	KL070200	KOTTAYAM	ETTUMANOOR	21460	21460	2542.76	16.44	227.18	396.65	3183.03	318.3	2864.73
65	KL07	KL070300	KOTTAYAM	KADUTHURUTHY	15806	15806	2599.03	190.64	588.43	1408.97	4787.07	478.71	4308.36

KERALA STATE (KL)														
#	State_District_Code	State_District_Block_Code	District	Assessment _Unit Name	Total Geographical Area	Recharge Worthy Area	Recharge from Rainfall-MON	Recharge from Other Sources-MON	Recharge from Rainfall-NM	Recharge from Other Sources-NM	Total Annual Ground Water (Ham) Recharge	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)
66	KL07	KL070400	KOTTAYAM	KANJIRAPPALLY	35290	23290	3502.72	18.57	793.02	158.2	4472.51	447.25	4025.26
67	KL07	KL070500	KOTTAYAM	LALAM	19110	19110	2534.67	63.45	226.45	242.81	3067.38	306.74	2760.64
68	KL07	KL070600	KOTTAYAM	MADAPPALLY	11950	11950	4133.63	20.94	623.91	578.07	5356.55	535.66	4820.89
69	KL07	KL070700	KOTTAYAM	PALLOM	17802	17802	3462.89	61.94	801.29	1267.61	5593.73	279.69	5314.04
70	KL07	KL070800	KOTTAYAM	PAMPADY	20550	20550	2616.64	17.21	233.78	98.66	2966.29	296.62	2669.67
71	KL07	KL070900	KOTTAYAM	UZHAVOOR	22460	22460	2939.28	42.35	262.6	776.63	4020.86	402.08	3618.78
72	KL07	KL071000	KOTTAYAM	VAIKOM	13190	13190	2099.36	308.04	187.56	517.54	3112.5	311.25	2801.25
73	KL07	KL071100	KOTTAYAM	VAZHOOR	16910	16910	2153.16	11.12	192.37	11.11	2367.76	236.78	2130.98
74	KL08	KL080100	KOZHIKKODE	BALLUSSERY	27853	13953	2447.55	62.98	0	244.05	2754.58	275.46	2479.12
75	KL08	KL080200	KOZHIKKODE	CHELANNUR	13866	13866	2499.73	46.47	62.51	101.33	2710.04	271	2439.04
76	KL08	KL080300	KOZHIKKODE	KODUVALLY	39048	27298	4711.67	38.15	0	160.09	4909.91	490.99	4418.92
77	KL08	KL080400	KOZHIKKODE	KOZHIKODE	16351	16351	2550.76	41.76	281.11	150.3	3023.93	302.39	2721.54
78	KL08	KL080500	KOZHIKKODE	KUNNAMANGALAM	33794	16994	2980.43	62.08	0	183.22	3225.73	322.57	2903.16
79	KL08	KL080600	KOZHIKKODE	KUNNUMMAL	26252	13152	2648.33	40.94	0	103.46	2792.73	279.28	2513.45
80	KL08	KL080700	KOZHIKKODE	MELADY	8407	8407	2143.78	16.33	195.51	48.5	2404.12	240.41	2163.71
81	KL08	KL080800	KOZHIKKODE	PANTHALAYANI	9855	9855	3193.02	90.79	234.6	139.75	3658.16	365.82	3292.34
82	KL08	KL080900	KOZHIKKODE	PERAMBRA	27502	17902	3136.43	39.76	345.66	132.86	3654.71	365.47	3289.24
83	KL08	KL081000	KOZHIKKODE	THODANNUR	9677	9677	1697.16	14.76	0	58.75	1770.67	177.07	1593.6
84	KL08	KL081100	KOZHIKKODE	TUNERI	14397	11497	1693.06	108.08	0	159.13	1960.27	196.02	1764.25
85	KL08	KL081200	KOZHIKKODE	VADAKARA	7228	7228	1786.76	8.35	196.92	57.2	2049.23	204.92	1844.31
86	KL09	KL090100	MALAPPURAM	AREACODE	33357	28357	4044.77	135.01	602.05	553.19	5335.02	533.5	4801.52
87	KL09	KL090200	MALAPPURAM	KALIKAVU	68912	24412	3731.8	82.15	526.3	370.83	4711.08	471.1	4239.98

KERALA STATE (KL)													
#	State_District_Code	State_District_Block_Code	District	Assessment _Unit Name	Total Geographical Area	Recharge Worthy Area	Recharge from Rainfall-MON	Recharge from Other Sources-MON	Recharge from Rainfall-NM	Recharge from Other Sources-NM	Total Annual Ground Water (Ham) Recharge	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)
88	KL09	KL090300	MALAPPURAM	KONDOTTY	18624	18624	2692.82	92.28	127.84	514.68	3427.62	342.76	3084.86
89	KL09	KL090400	MALAPPURAM	KUTTIPPURAM	17868	17868	2210.54	75.71	44.78	1131.12	3462.15	346.22	3115.93
90	KL09	KL090500	MALAPPURAM	MALAPPURAM	18032	18032	2756.51	59.06	388.76	555.51	3759.84	375.99	3383.85
91	KL09	KL090600	MALAPPURAM	MANKADA	15245	15245	2149.9	72.41	38.2	461.8	2722.31	136.12	2586.19
92	KL09	KL090700	MALAPPURAM	NILAMBOOR	62120	21820	3162.23	63.87	64.05	543.22	3833.37	383.34	3450.03
93	KL09	KL090800	MALAPPURAM	PERINTHALMANNA	28203	27203	3998.51	137.52	563.92	764.37	5464.32	546.43	4917.89
94	KL09	KL090900	MALAPPURAM	PERUMPADAPPU	5899	5899	1734.16	82.26	163.05	491.43	2470.9	247.09	2223.81
95	KL09	KL091000	MALAPPURAM	PONNANI	9706	9706	2373.33	41.47	214.62	540.06	3169.48	316.95	2852.53
96	KL09	KL091100	MALAPPURAM	THANUR	12756	12756	2131.4	65	289.11	374.51	2860.02	286	2574.02
97	KL09	KL091200	MALAPPURAM	THRIURANGADI	13001	13001	2119.35	36.38	287.48	556.08	2999.29	299.93	2699.36
98	KL09	KL091300	MALAPPURAM	TIRUR	11105	11105	1810.27	57.27	245.55	358.4	2471.49	247.15	2224.34
99	KL09	KL091400	MALAPPURAM	VENGARA	14845	14845	2117.46	36.92	287.22	348.72	2790.32	279.03	2511.29
100	KL09	KL091500	MALAPPURAM	WANDOOR	25308	15308	2400.1	87.03	338.49	390.4	3216.02	321.6	2894.42
101	KL10	KL100100	PALAKKAD	ALATHUR	31447	23447	2886.84	600.53	45.58	4640	8172.95	408.65	7764.3
102	KL10	KL100200	PALAKKAD	ATTAPPADI	70323	22323	3795.27	104.14	615.6	201.75	4716.76	471.68	4245.08
103	KL10	KL100300	PALAKKAD	CHITTUR	31468	31468	2431.85	441.41	394.45	3207.89	6475.6	647.56	5828.04
104	KL10	KL100400	PALAKKAD	KOLLENGODE	21411	19911	2260.74	542.84	147.82	3261.98	6213.38	621.34	5592.04
105	KL10	KL100500	PALAKKAD	KUZHALMANNAM	19212	19212	2078.58	437.57	337.15	5108.48	7961.78	796.18	7165.6
106	KL10	KL100600	PALAKKAD	MALAMPUZHA	40394	20394	1576.05	179.12	255.64	1581.45	3592.26	359.23	3233.03
107	KL10	KL100700	PALAKKAD	MANNARKKAD	45535	29535	2570.54	291.36	233.74	661.54	3757.18	375.72	3381.46
108	KL10	KL100800	PALAKKAD	NENMARA	79847	23953	2221.31	104.24	360.3	515.37	3201.22	320.13	2881.09
109	KL10	KL100900	PALAKKAD	OTTAPPALAM	27306	27306	2954.29	418.93	479.19	636.79	4489.2	448.92	4040.28

KERALA STATE (KL)													
#	State_District_Code	State_District_Block_Code	District	Assessment _Unit Name	Total Geographical Area	Recharge Worthy Area	Recharge from Rainfall-MON	Recharge from Other Sources-MON	Recharge from Rainfall-NM	Recharge from Other Sources-NM	Total Annual Ground Water (Ham) Recharge	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)
110	KL10	KL101000	PALAKKAD	PALAKKAD	20706	20706	2240.22	386.11	363.37	3190.99	6180.69	618.07	5562.62
111	KL10	KL101100	PALAKKAD	PATTAMBI	20744	20744	2649.74	149.11	173.25	551.38	3523.48	352.34	3171.14
112	KL10	KL101200	PALAKKAD	SREEKRISHNAPURAM	22013	22013	2381.63	243.51	386.31	701.78	3713.23	371.32	3341.91
113	KL10	KL101300	PALAKKAD	THRITHALA	17216	17216	1954.75	95.15	127.81	277.79	2455.5	245.55	2209.95
114	KL11	KL110100	PATHANAMTHITTA	ELANTHOOR	10622	10622	1315.23	51.75	420.32	168.46	1955.76	195.58	1760.18
115	KL11	KL110200	PATHANAMTHITTA	KOIPURAM	12367	12367	1531.3	58.55	489.37	185.22	2264.44	226.45	2037.99
116	KL11	KL110300	PATHANAMTHITTA	KONNI	86477	25977	3630.07	66.41	1160.1	226.03	5082.61	508.26	4574.35
117	KL11	KL110400	PATHANAMTHITTA	MALLAPPALLY	15418	15418	1909.08	28.69	610.11	169.31	2717.19	271.72	2445.47
118	KL11	KL110500	PATHANAMTHITTA	PANDALAM	11641	11641	1441.41	117.29	460.65	353.94	2373.29	237.33	2135.96
119	KL11	KL110600	PATHANAMTHITTA	PARAKODE	27152	22642	3804.84	120.49	1215.95	578.17	5719.45	571.94	5147.51
120	KL11	KL110700	PATHANAMTHITTA	PULIKEEZH	6866	6866	1584.34	31.2	368.73	85.95	2070.22	103.51	1966.71
121	KL11	KL110800	PATHANAMTHITTA	RANNI	92132	24132	2988.06	21.19	954.93	152.8	4116.98	411.7	3705.28
122	KL12	KL120100	THIRUVANANTHAPURAM	ATHIYANNUR	7629	7629	1030.28	24.04	314.31	110.74	1479.37	147.94	1331.43
123	KL12	KL120200	THIRUVANANTHAPURAM	CHIRAYINKIL	10151	10151	1177.34	78.55	359.17	247.25	1862.31	186.23	1676.08
124	KL12	KL120300	THIRUVANANTHAPURAM	KILIMANOOR	17977	17977	1961.29	34.52	487.71	427.93	2911.45	291.14	2620.31
125	KL12	KL120400	THIRUVANANTHAPURAM	NEDUMANGAD	15603	15603	1381.35	32.8	417.74	143.73	1975.62	98.78	1876.84
126	KL12	KL120500	THIRUVANANTHAPURAM	NEMOM	33727	33727	4072.49	51.58	1242.41	149.37	5515.85	551.59	4964.26
127	KL12	KL120600	THIRUVANANTHAPURAM	PARASSALA	8221	8221	1175.54	31.66	358.62	176.04	1741.86	174.19	1567.67
128	KL12	KL120700	THIRUVANANTHAPURAM	PERUMKADAVILA	28538	27038	1811.31	189.52	675.62	508.14	3184.59	318.46	2866.13
129	KL12	KL120800	THIRUVANANTHAPURAM	POTHENCODE	7415	7415	1024.94	12.68	312.68	249.67	1599.97	160	1439.97
130	KL12	KL120900	THIRUVANANTHAPURAM	VAMANAPURAM	42115	27115	2314.47	90.14	619.47	280.73	3304.81	165.24	3139.57
131	KL12	KL121000	THIRUVANANTHAPURAM	VARKALA	10209	10209	1265.16	37.91	385.97	187.2	1876.24	187.63	1688.61

KERALA STATE (KL)													
#	State_District_Code	State_District_Block_Code	District	Assessment _Unit Name	Total Geographical Area	Recharge Worthy Area	Recharge from Rainfall-MON	Recharge from Other Sources-MON	Recharge from Rainfall-NM	Recharge from Other Sources-NM	Total Annual Ground Water (Ham) Recharge	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)
132	KL12	KL121100	THIRUVANANTHAPURAM	VELLANAD	37212	29212	2460.08	15.16	1118.57	192.29	3786.1	189.3	3596.8
133	KL13	KL130100	THRISSUR	ANTHIKKAD	9904	9904	2348.77	45.05	0	1729.1	4122.92	412.29	3710.63
134	KL13	KL130200	THRISSUR	CHALAKKUDY	61069	20369	3141.84	114.6	0	1132.11	4388.55	438.85	3949.7
135	KL13	KL130300	THRISSUR	CHAVAKKAD	9917	9917	3154.93	55.38	0	320.61	3530.92	353.09	3177.83
136	KL13	KL130400	THRISSUR	CHERPU	8448	8448	1566.23	115.21	0	1843.17	3524.61	176.23	3348.38
137	KL13	KL130500	THRISSUR	CHOWANNUR	17774	17774	3152.81	23.55	0	1076.71	4253.07	425.31	3827.76
138	KL13	KL130600	THRISSUR	IRINGALAKKUDA	12073	12073	2281.22	78.33	0	902.53	3262.08	326.21	2935.87
139	KL13	KL130700	THRISSUR	KODAKARA	29812	20812	4055.89	28.3	485.5	1010.58	5580.27	558.03	5022.24
140	KL13	KL130800	THRISSUR	MALA	12713	12713	2890.46	194.22	346	1025.54	4456.22	445.62	4010.6
141	KL13	KL130900	THRISSUR	MATHILAKOM	14635	14635	3377.52	8.94	433.05	314.11	4133.62	413.37	3720.25
142	KL13	KL131000	THRISSUR	MULLASSERY	6585	6585	2245.78	9.43	179.22	1059.05	3493.48	349.35	3144.13
143	KL13	KL131100	THRISSUR	OLLUKKARA	31572	20572	3173.16	27.22	0	310.04	3510.42	351.04	3159.38
144	KL13	KL131200	THRISSUR	PAZHAYANNUR	23695	23695	4203.1	17.41	0	486.22	4706.73	470.67	4236.06
145	KL13	KL131300	THRISSUR	PUZHAKKAL	22892	22892	3531.01	129.44	0	1920.3	5580.75	558.08	5022.67
146	KL13	KL131400	THRISSUR	THALIKKULAM	6568	6568	2051.4	6.39	177.05	263.28	2498.12	124.91	2373.21
147	KL13	KL131500	THRISSUR	VADAKKANCHERRY	23659	18659	3057.4	53.91	392.01	649.24	4152.56	415.26	3737.3
148	KL13	KL131600	THRISSUR	VELLANGALLUR	11069	11069	1839.27	73.08	235.82	591.51	2739.68	273.97	2465.71
149	KL14	KL140100	WAYANAD	KALPETTA	58351	41351	6806.44	26.48	0	85.08	6918	691.8	6226.2
150	KL14	KL140200	WAYANAD	MANANTHAVADY	66651	41051	5912.43	206.29	0	236.79	6355.51	635.55	5719.96
151	KL14	KL140300	WAYANAD	PANAMARAM	35086	23286	3832.91	67.16	0	120.66	4020.73	402.08	3618.65
152	KL14	KL140400	WAYANAD	SULTHANBATHERY	52974	37074	6102.44	96.95	0	190.48	6389.87	638.99	5750.88

Contd.

Annexure VI b

Assessment Unit Wise Report of Kerala State (as in 2024)

KERALA STATE (KL)														
#	State_District_Code	State_District_Block_Code	District	Assessment Unit Name	Annual Extractable Ground Water Resource (Ham)	Irrigation Use (Ham)	Industrial Use (Ham)	Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (OE/Critical/ Semicritical/ Safe)
1	KL01	KL010100	ALAPPUZHA	AMBALAPPUZHA	1901.76	144.602	8.1968	686.31	839.1	699.4	1049.57	44.12	safe
2	KL01	KL010200	ALAPPUZHA	ARYAD	2497.7	260.548	0.5288	1478.61	1739.69	1506.82	729.8	69.65	safe
3	KL01	KL010300	ALAPPUZHA	BHARANIKKAVU	2953.64	417.02	0.27	814.89	1232.17	830.44	1705.92	41.72	safe
4	KL01	KL010400	ALAPPUZHA	CHAMPAKKULAM	3464.33	73.49	0.02	551.67	625.18	562.2	2828.62	18.05	safe
5	KL01	KL010500	ALAPPUZHA	CHENGANNUR	3968.18	769.222	1.502	902.89	1673.61	920.11	2277.35	42.18	safe
6	KL01	KL010600	ALAPPUZHA	HARIPPAD	3458.02	741.855	82.3928	763.69	1587.94	778.26	1855.51	45.92	safe
7	KL01	KL010700	ALAPPUZHA	KANJIKKUZHY	2336.61	278.02	0.11445	796.49	1074.63	811.69	1246.78	45.99	safe
8	KL01	KL010800	ALAPPUZHA	MAVELIKKARA	3278.87	202.09	0.75	877.85	1080.69	894.59	2181.44	32.96	safe
9	KL01	KL010900	ALAPPUZHA	MUTHUKULAM	3245.81	451.6	98.474	1140.43	1690.52	1162.2	1533.52	52.08	safe
10	KL01	KL011000	ALAPPUZHA	PATTANAKKAD	2415.01	133.88	68.37	1028.12	1230.38	1047.74	1165.01	50.95	safe
11	KL01	KL011100	ALAPPUZHA	THYCATTUSSERY	2710.67	172.82	0.9008	759.94	933.65	774.44	1762.52	34.44	safe
12	KL01	KL011200	ALAPPUZHA	VELIYANAD	3406.81	92.09	0	458.26	550.35	467	2847.72	16.15	safe
13	KL02	KL020100	ERNAKULAM	ALANGAD	2067.73	388.9355	46.87	1008.80	1444.59	1257.57	374.37	69.86	safe
14	KL02	KL020200	ERNAKULAM	ANGAMALY	4763.5	720.795	46.1096	1147.97	1914.86	1431.07	2565.54	40.20	safe
15	KL02	KL020300	ERNAKULAM	EDAPPALLY	3994.41	163.58	10.8939	2403.22	2577.7	2995.87	824.06	64.53	safe
16	KL02	KL020400	ERNAKULAM	KOOVAPPADY	5895.15	743.93	13.021	982.81	1739.76	1225.18	3913.02	29.51	safe
17	KL02	KL020500	ERNAKULAM	KOTHAMANGALAM	4314.21	628.74	9.344	1317.37	1955.46	1642.24	2033.88	45.33	safe
18	KL02	KL020600	ERNAKULAM	MOOVATTUPUZHA	3633.15	969.823	11.1302	1362.79	2343.74	1698.87	953.33	64.51	safe
19	KL02	KL020700	ERNAKULAM	MULAMTHURUTHY	2961.75	669.38	10.2425	1370.09	2049.72	1707.96	574.16	69.21	safe

KERALA STATE (KL)													
#	State_District_Code	State_District_Block_Code	District	Assessment Unit Name	Annual Extractable Ground Water Resource (Ham)	Irrigation Use (Ham)	Industrial Use (Ham)	Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (OE/Critical/ Semicritical/ Safe)
20	KL02	KL020800	ERNAKULAM	PALLURUTHY	1554.86	145.42	11.103	228.85	385.37	285.28	1113.06	24.78	safe
21	KL02	KL020900	ERNAKULAM	PAMPAKKUDA	3636.99	731.72	7.484	765.59	1504.8	954.39	1943.39	41.37	safe
22	KL02	KL021000	ERNAKULAM	PARAKKADAVU	2436.6	738.36	8.1136	916.31	1662.79	1142.28	547.84	68.24	safe
23	KL02	KL021100	ERNAKULAM	PARAVOOR	1964.82	578.78	14.4	351.47	944.65	438.14	933.5	48.08	safe
24	KL02	KL021200	ERNAKULAM	VADAVUKODU	4175.36	484.66	25.0349	952.66	1462.35	1187.58	2478.09	35.02	safe
25	KL02	KL021300	ERNAKULAM	VAZHAKKULAM	4746.05	920.832	6.62	1760.77	2688.21	2194.99	1623.62	56.64	safe
26	KL02	KL021400	ERNAKULAM	VYPEEN	1050.57	48.312	0.38325	678.68	727.37	846.05	155.83	69.24	safe
27	KL03	KL030100	IDUKKI	ADIMALI	3144.41	843.73	1.1801	450.86	1295.77	458.39	1841.11	41.21	safe
28	KL03	KL030200	IDUKKI	AZHUTHA	2846.95	711	6.3002	515.04	1232.34	523.65	1606	43.29	safe
29	KL03	KL030300	IDUKKI	DEVIKULAM	2271.42	240.42	0	434.13	674.55	441.38	1589.62	29.70	safe
30	KL03	KL030400	IDUKKI	ELAM DESOM	1855.97	758.12	1.0832	459.62	1218.82	467.3	629.47	65.67	safe
31	KL03	KL030500	IDUKKI	IDUKKI	2653.86	658.13	0.368	413.24	1071.73	420.14	1575.23	40.38	safe
32	KL03	KL030600	IDUKKI	KATTAPPANA	2234.98	1050.38	1.32	674.90	1726.61	686.18	497.09	77.25	semi_ critical
33	KL03	KL030700	IDUKKI	NEDUMKANDAM	2196.7	1100.68	1.182	583.10	1684.96	592.84	502	76.70	semi_ critical
34	KL03	KL030800	IDUKKI	THODUPUZHA	1939.88	703.76	1.834	516.58	1222.18	525.21	709.07	63.00	safe
35	KL04	KL040100	KANNUR	EDAKKAD	1870.34	367.75	0	573.92	941.67	685.85	816.74	50.35	safe
36	KL04	KL040200	KANNUR	IRIKKUR	6342.83	949.17	6.351	1389.61	2345.13	1660.64	3726.67	36.97	safe
37	KL04	KL040300	KANNUR	IRITTY	5207.72	1112.544	3.819	1203.72	2320.07	1438.49	2652.88	44.55	safe
38	KL04	KL040400	KANNUR	KALLYASSERI	2533.12	675.6	0	876.71	1552.31	1047.7	809.82	61.28	safe
39	KL04	KL040500	KANNUR	KANNUR	2738.71	1141.1	10.14	968.74	2119.98	1157.68	429.79	77.41	semi_ critical

KERALA STATE (KL)													
#	State_District_Code	State_District_Block_Code	District	Assessment Unit Name	Annual Extractable Ground Water Resource (Ham)	Irrigation Use (Ham)	Industrial Use (Ham)	Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (OE/Critical/ Semicritical/ Safe)
40	KL04	KL040600	KANNUR	KUTHUPARAMBA	2019.1	672.54	0	725.45	1397.98	866.94	479.63	69.24	safe
41	KL04	KL040700	KANNUR	PANUR	1234.68	441.14	0	667.52	1108.66	797.71	126.02	89.79	semi_ critical
42	KL04	KL040800	KANNUR	PAYYANNUR	5852.93	659.171	0	1465.12	2124.29	1750.88	3442.88	36.29	safe
43	KL04	KL040900	KANNUR	PERAVOOR	3409.58	891.5	5.475	814.65	1711.61	973.54	1539.08	50.20	safe
44	KL04	KL041000	KANNUR	TALIPARAMBA	7293.95	872	17.3375	1903.27	2792.61	2274.49	4130.12	38.29	safe
45	KL04	KL041100	KANNUR	THALASSERY	2106.57	366.5	5.6	1395.90	1768	1668.16	66.31	83.93	semi_ critical
46	KL05	KL050100	KASARGOD	KANHANGAD	4729.85	1901.41	1.71	1392.12	3295.24	2065.96	760.77	69.67	safe
47	KL05	KL050200	KASARGOD	KARADKA	5503.89	3048.922	3.48	771.60	3823.99	1129.39	1322.11	69.48	safe
48	KL05	KL050300	KASARGOD	KASARAGOD	4625.09	2453.138	1.4864	1802.78	4257.4	2638.74	367.69	92.05	critical
49	KL05	KL050400	KASARGOD	MANJESWAR	5956.29	3397.04	2.9663	1404.15	4804.15	2055.26	501.03	80.66	semi_ critical
50	KL05	KL050500	KASARGOD	NILESWARAM	3863.71	1396.83	11.4009	1176.91	2585.15	1722.65	732.82	66.91	safe
51	KL05	KL050600	KASARGOD	PARAPPA	7026.01	3174.3	1.7127	1197.83	4373.85	1753.26	2096.73	62.25	safe
52	KL06	KL060100	KOLLAM	ANCHAL	7686.75	585.24	0.09	529.92	1115.25	552.37	6549.05	14.51	safe
53	KL06	KL060200	KOLLAM	CHADAYAMANGALAM	3381.09	560.258	1.221	1077.98	1639.47	1123.68	1695.92	48.49	safe
54	KL06	KL060300	KOLLAM	CHAVARA	1888.42	262.83	0.872	1057.06	1320.77	1101.86	522.85	69.94	safe
55	KL06	KL060400	KOLLAM	CHITTUMALA	2368.56	453.69	12.2	1132.89	1598.78	1180.91	721.76	67.50	safe
56	KL06	KL060500	KOLLAM	ITHIKKARA	2551.09	324.82	1.309	1215.34	1541.46	1266.85	958.12	60.42	safe
57	KL06	KL060600	KOLLAM	KOTTARAKKARA	2069.94	450.66	1.381	923.47	1375.51	962.61	655.29	66.45	safe
58	KL06	KL060700	KOLLAM	MUKHATHALA	3196.08	379.044	3.5215	1917.65	2300.21	1998.94	814.58	71.97	semi_ critical

KERALA STATE (KL)													
#	State_District_Code	State_District_Block_Code	District	Assessment Unit Name	Annual Extractable Ground Water Resource (Ham)	Irrigation Use (Ham)	Industrial Use (Ham)	Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (OE/Critical/ Semicritical/ Safe)
59	KL06	KL060800	KOLLAM	OACHIRA	2983.28	439.898	0.114	1123.60	1563.62	1171.23	1372.03	52.41	safe
60	KL06	KL060900	KOLLAM	PATHANAPURAM	3044.61	472.588	0.4178	1010.98	1484	1053.83	1517.76	48.74	safe
61	KL06	KL061000	KOLLAM	SASTHAMKOTTA	2132.19	422.7	0.97	1075.64	1499.31	1121.23	587.29	70.32	semi_ critical
62	KL06	KL061100	KOLLAM	VETTIKKAVALA	2507.72	492.164	0.1854	1032.34	1524.68	1076.09	939.29	60.80	safe
63	KL07	KL070100	KOTTAYAM	ERATTUPETTA	2453.41	444.104	2.555	623.37	1070.01	642.2	1364.57	43.61	safe
64	KL07	KL070200	KOTTAYAM	ETTUMANOOR	2864.73	311.703	0.94	972.73	1285.37	1002.13	1549.96	44.87	safe
65	KL07	KL070300	KOTTAYAM	KADUTHURUTHY	4308.36	616.7	0	757.53	1374.23	780.43	2911.23	31.90	safe
66	KL07	KL070400	KOTTAYAM	KANJIRAPPALLY	4025.26	566.31	0.05475	987.17	1553.53	1017	2441.9	38.59	safe
67	KL07	KL070500	KOTTAYAM	LALAM	2760.64	288.459	0.365	597.98	886.82	616.06	1855.74	32.12	safe
68	KL07	KL070600	KOTTAYAM	MADAPPALLY	4820.89	573.342	7.154	1279.20	1859.7	1317.85	2922.54	38.58	safe
69	KL07	KL070700	KOTTAYAM	PALLOM	5314.04	506.007	0	1457.16	1963.17	1501.2	3306.83	36.94	safe
70	KL07	KL070800	KOTTAYAM	PAMPADY	2669.67	262.48	0	647.08	909.56	666.64	1740.55	34.07	safe
71	KL07	KL070900	KOTTAYAM	UZHAVOOR	3618.78	538.1215	0	781.49	1319.61	805.11	2275.55	36.47	safe
72	KL07	KL071000	KOTTAYAM	VAIKOM	2801.25	423.372	1.095	209.58	634.05	235.25	2141.53	22.63	safe
73	KL07	KL071100	KOTTAYAM	VAZHOOR	2130.98	367.093	3.65	582.06	952.8	599.65	1160.59	44.71	safe
74	KL08	KL080100	KOZHIKKODE	BALLUSSERY	2479.12	816.634	0	1356.98	2173.6	1876.78	305.52	87.68	semi_ critical
75	KL08	KL080200	KOZHIKKODE	CHELANNUR	2439.04	327.4	0	1376.31	1703.71	1903.51	208.13	69.85	safe
76	KL08	KL080300	KOZHIKKODE	KODUVALLY	4418.92	499.666	5.548	1843.27	2348.49	2549.35	1364.35	53.15	safe
77	KL08	KL080400	KOZHIKKODE	KOZHIKODE	2721.54	401.298	1.03	1556.02	1958.35	2152.06	167.15	71.96	semi_ critical
78	KL08	KL080500	KOZHIKKODE	KUNNAMANGALAM	2903.16	595.67	0.1825	2004.48	2600.33	2772.31	302.83	89.57	semi_

KERALA STATE (KL)														
#	State_District_Code	State_District_Block_Code	District	Assessment Unit Name	Annual Extractable Ground Water Resource (Ham)	Irrigation Use (Ham)	Industrial Use (Ham)	Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (OE/Critical/ Semicritical/ Safe)
													critical
79	KL08	KL080600	KOZHIKKODE	KUNNUMMAL	2513.45	322.092	0	1264.74	1586.83	1749.2	442.16	63.13	safe
80	KL08	KL080700	KOZHIKKODE	MELADY	2163.71	180.14	0.1825	756.88	937.21	1046.81	936.57	43.31	safe
81	KL08	KL080800	KOZHIKKODE	PANTHALAYANI	3292.34	238.925	0	1122.48	1361.41	1552.45	1500.96	41.35	safe
82	KL08	KL080900	KOZHIKKODE	PERAMBRA	3289.24	373.518	0.146	1050.36	1424.03	1452.71	1462.86	43.29	safe
83	KL08	KL081000	KOZHIKKODE	THODANNUR	1593.6	161.9025	0	859.02	1020.93	1188.08	243.61	64.06	safe
84	KL08	KL081100	KOZHIKKODE	TUNERI	1764.25	242.082	0	922.11	1164.19	1275.33	246.84	65.99	safe
85	KL08	KL081200	KOZHIKKODE	VADAKARA	1844.31	185.37	0	1016.11	1201.49	1405.35	253.58	65.15	safe
86	KL09	KL090100	MALAPPURAM	AREACODE	4801.52	710.486	1.96	2559.71	3272.16	4927.13	1529.36	68.15	safe
87	KL09	KL090200	MALAPPURAM	KALIKAVU	4239.98	554.423	0.219	2002.36	2557.02	3854.3	1682.96	60.31	safe
88	KL09	KL090300	MALAPPURAM	KONDOTTY	3084.86	777.766	0	1950.66	2728.43	3754.79	356.43	88.45	semi_critical
89	KL09	KL090400	MALAPPURAM	KUTTIPPURAM	3115.93	818.885	0.1825	1819.64	2638.7	3502.59	477.23	84.68	semi_critical
90	KL09	KL090500	MALAPPURAM	MALAPPURAM	3383.85	516.84	0.292	2174.54	2691.67	4185.73	692.18	79.54	semi_critical
91	KL09	KL090600	MALAPPURAM	MANKADA	2586.19	686.815	0	1262.22	1949.03	2429.61	637.16	75.36	semi_critical
92	KL09	KL090700	MALAPPURAM	NILAMBOOR	3450.03	450.45	0.73	1501.33	1952.51	2889.88	108.97	56.59	safe
93	KL09	KL090800	MALAPPURAM	PERINTHALMANNA	4917.89	1006.47	0	2208.82	3215.29	4251.72	1702.6	65.38	safe
94	KL09	KL090900	MALAPPURAM	PERUMPADAPPU	2223.81	855.975	0.292	675.48	1531.74	1300.21	67.34	68.88	safe
95	KL09	KL091000	MALAPPURAM	PONNANI	2852.53	338.08	0.292	1491.10	1829.48	2870.19	1023.05	64.14	safe
96	KL09	KL091100	MALAPPURAM	THANUR	2574.02	724.23	1.06	1555.63	2280.92	2994.4	293.1	88.61	semi_critical

KERALA STATE (KL)														
#	State_District_Code	State_District_Block_Code	District	Assessment Unit Name	Annual Extractable Ground Water Resource (Ham)	Irrigation Use (Ham)	Industrial Use (Ham)	Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (OE/Critical/ Semicritical/ Safe)
97	KL09	KL091200	MALAPPURAM	THRIURANGADI	2699.36	640.251	0	1665.28	2305.53	3205.46	393.83	85.41	semi_critical
98	KL09	KL091300	MALAPPURAM	TIRUR	2224.34	398.84	0.146	1530.61	1929.59	2946.23	294.75	86.75	semi_critical
99	KL09	KL091400	MALAPPURAM	VENGARA	2511.29	378.96	0.365	1783.33	2162.65	3432.69	348.64	86.12	semi_critical
100	KL09	KL091500	MALAPPURAM	WANDOOR	2894.42	356.36	0.504	1409.83	1766.69	2713.76	1127.73	61.04	safe
101	KL10	KL100100	PALAKKAD	ALATHUR	7764.3	2167.8	1.092	1683.62	3852.52	2340.49	3254.91	49.62	safe
102	KL10	KL100200	PALAKKAD	ATTAPPADI	4245.08	742.08	0	359.03	1101.11	499.1	3003.9	25.94	safe
103	KL10	KL100300	PALAKKAD	CHITTUR	5828.04	4190.68	174.18	1383.00	5747.86	1922.58	80.18	98.62	critical
104	KL10	KL100400	PALAKKAD	KOLLENGODE	5592.04	1504.265	2.774	818.02	2325.07	1137.17	2947.82	41.58	safe
105	KL10	KL100500	PALAKKAD	KUZHALMANNAM	7165.6	1161.35	72.0156	1087.16	2320.54	1511.32	4420.9	32.38	safe
106	KL10	KL100600	PALAKKAD	MALAMPUZHA	3233.03	1451.84	259.44	1343.36	3054.64	1867.47	178.39	94.48	critical
107	KL10	KL100700	PALAKKAD	MANNARKKAD	3381.46	662.728	3.236	1615.55	2281.52	2245.85	469.64	67.47	safe
108	KL10	KL100800	PALAKKAD	NENMARA	2881.09	993.112	0	792.66	1785.77	1101.91	786.07	61.98	safe
109	KL10	KL100900	PALAKKAD	OTTAPPALAM	4040.28	898.164	1.896	1497.63	2397.7	2081.93	1058.28	59.34	safe
110	KL10	KL101000	PALAKKAD	PALAKKAD	5562.62	869.28	14.6	1812.44	2696.32	2519.56	2159.18	48.47	safe
111	KL10	KL101100	PALAKKAD	PATTAMBI	3171.14	1466.54	0	1330.91	2797.45	1850.16	373.69	88.22	semi_critical
112	KL10	KL101200	PALAKKAD	SREEKRISHNAPURAM	3341.91	874.36	72	1148.51	2094.87	1596.6	798.95	62.68	safe
113	KL10	KL101300	PALAKKAD	THRITHALA	2209.95	652.6	11.534	1185.74	1849.88	1648.35	360.07	83.71	semi_critical
114	KL11	KL110100	PATHANAMTHITTA	ELANTHOOR	1760.18	350.795	0.876	306.08	657.75	331.91	1076.6	37.37	safe
115	KL11	KL110200	PATHANAMTHITTA	KOIPURAM	2037.99	408.235	0.5475	388.97	797.76	421.79	1207.41	39.14	safe

KERALA STATE (KL)													
#	State_District_Code	State_District_Block_Code	District	Assessment Unit Name	Annual Extractable Ground Water Resource (Ham)	Irrigation Use (Ham)	Industrial Use (Ham)	Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (OE/Critical/ Semicritical/ Safe)
116	KL11	KL110300	PATHANAMTHITTA	KONNI	4574.35	421.18	0.292	577.39	998.86	626.1	3526.78	21.84	safe
117	KL11	KL110400	PATHANAMTHITTA	MALLAPPALLY	2445.47	327.294	0.9855	445.42	773.7	483	1634.19	31.64	safe
118	KL11	KL110500	PATHANAMTHITTA	PANDALAM	2135.96	720.195	0.7519	415.21	1136.15	450.24	964.78	53.19	safe
119	KL11	KL110600	PATHANAMTHITTA	PARAKODE	5147.51	868.482	0.2555	758.86	1627.6	822.89	3455.88	31.62	safe
120	KL11	KL110700	PATHANAMTHITTA	PULIKEEZH	1966.71	323.348	0.219	450.38	773.96	488.38	1154.75	39.35	safe
121	KL11	KL110800	PATHANAMTHITTA	RANNI	3705.28	356.62	0.146	527.19	883.95	571.67	2776.85	23.86	safe
122	KL12	KL120100	THIRUVANANTHAPURAM	ATHIYANNUR	1331.43	331.08	0.0603	832.29	1163.42	883.3	117	87.38	semi_ critical
123	KL12	KL120200	THIRUVANANTHAPURAM	CHIRAYINKIL	1676.08	324.54	0.1004	1051.39	1376.02	1115.83	235.62	82.10	semi_ critical l
124	KL12	KL120300	THIRUVANANTHAPURAM	KILIMANOOR	2620.31	435.41	0.73	1162.14	1598.28	1233.36	950.81	61.00	safe
125	KL12	KL120400	THIRUVANANTHAPURAM	NEDUMANGAD	1876.84	432.4	0	1147.07	1579.47	1217.38	227.06	84.16	semi_ critical
126	KL12	KL120500	THIRUVANANTHAPURAM	NEMOM	4964.26	450.9	1.6602	2999.69	3452.25	3183.54	1328.16	69.54	safe
127	KL12	KL120600	THIRUVANANTHAPURAM	PARASSALA	1567.67	576.409	0.411	706.48	1283.31	749.78	241.06	81.86	semi_ critical
128	KL12	KL120700	THIRUVANANTHAPURAM	PERUMKADAVILA	2866.13	501.04	0.32	1096.30	1597.66	1163.49	1201.28	55.74	safe
129	KL12	KL120800	THIRUVANANTHAPURAM	POTHENCODE	1439.97	564.839	2.17	701.08	1268.09	744.05	128.91	88.06	semi_ critical
130	KL12	KL120900	THIRUVANANTHAPURAM	VAMANAPURAM	3139.57	473.856	1.64	1048.11	1523.6	1112.35	1551.73	48.53	safe
131	KL12	KL121000	THIRUVANANTHAPURAM	VARKALA	1688.61	254.5	0	919.45	1173.95	975.8	458.31	69.52	safe
132	KL12	KL121100	THIRUVANANTHAPURAM	VELLANAD	3596.8	547.484	0.0012	1120.77	1668.25	1189.47	1859.85	46.38	safe
133	KL13	KL130100	THRISSUR	ANTHIKKAD	3710.63	1016.67	2.03525	759.96	1778.66	895.73	1796.2	47.93	safe
134	KL13	KL130200	THRISSUR	CHALAKKUDY	3949.7	1637.816	10.8496	1040.65	2689.31	1226.58	1074.46	68.09	safe

KERALA STATE (KL)														
#	State_District_Code	State_District_Block_Code	District	Assessment Unit Name	Annual Extractable Ground Water Resource (Ham)	Irrigation Use (Ham)	Industrial Use (Ham)	Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (OE/Critical/ Semicritical/ Safe)
135	KL13	KL130300	THRISSUR	CHAVAKKAD	3177.83	1105.192	0.0072	1029.74	2134.93	1213.72	858.92	67.18	safe
136	KL13	KL130400	THRISSUR	CHERPU	3348.38	1133.482	0.009	553.41	1686.9	652.29	1562.6	50.38	safe
137	KL13	KL130500	THRISSUR	CHOWANNUR	3827.76	1348.8	0.84	1671.37	3021.01	1969.99	508.13	78.92	semi_ critical
138	KL13	KL130600	THRISSUR	IRINGALAKKUDA	2935.87	1000.035	0.74	824.19	1824.96	971.44	963.66	62.16	safe
139	KL13	KL130700	THRISSUR	KODAKARA	5022.24	1617.25	3.803	1015.87	2636.92	1197.37	2203.82	52.50	safe
140	KL13	KL130800	THRISSUR	MALA	4010.6	1708.27	0.007	835.06	2543.33	984.26	1318.07	63.42	safe
141	KL13	KL130900	THRISSUR	MATHILAKOM	3720.25	1394.67	0	1517.63	2912.3	1788.77	536.81	78.28	semi_ critical
142	KL13	KL131000	THRISSUR	MULLASSERY	3144.13	915.276	0.0001	508.61	1423.89	599.48	1629.37	45.29	safe
143	KL13	KL131100	THRISSUR	OLLUKKARA	3159.38	636.94	3.6	893.25	1533.79	1052.85	1465.99	48.55	safe
144	KL13	KL131200	THRISSUR	PAZHAYANNUR	4236.06	1031.58	0.0049	958.09	1989.67	1129.26	2075.22	46.97	safe
145	KL13	KL131300	THRISSUR	PUZHAKKAL	5022.67	1698.2	10.8051	613.22	2322.22	722.78	2590.89	46.23	safe
146	KL13	KL131400	THRISSUR	THALIKKULAM	2373.21	1024.518	0	701.84	1726.36	827.24	521.45	72.74	semi_ critical
147	KL13	KL131500	THRISSUR	VADAKKANCHERRY	3737.3	1591.044	6.41	957.58	2555.04	1128.67	1011.17	68.37	safe
148	KL13	KL131600	THRISSUR	VELLANGALLUR	2465.71	1042.234	0	650.69	1692.92	766.95	656.53	68.66	safe
149	KL14	KL140100	WAYANAD	KALPETTA	6226.2	285.7	0.72	1218.20	1504.62	1437.35	4502.43	24.17	safe
150	KL14	KL140200	WAYANAD	MANANTHAVADY	5719.96	315.26	0	1115.08	1430.34	1315.69	4089.01	25.01	safe
151	KL14	KL140300	WAYANAD	PANAMARAM	3618.65	254.02	0	953.21	1207.23	1124.69	2239.94	33.36	safe
152	KL14	KL140400	WAYANAD	SULTHANBATHERY	5750.88	469.4	1.123	991.39	1461.92	1169.74	4110.61	25.42	safe

Annexure VII

Minutes of the Meeting of the SLC Committee

First SLC

MINUTES OF THE FIRST STATE LEVEL MEETING ON RE-ESTIMATION OF GROUND WATER RESOURCES OF KERALA STATE AS ON 2024

The First State Level Meeting on 'Re-estimation of Ground Water Resources of Kerala State, 2024' was held in the chamber of the Secretary, Water Resources, Govt. of Kerala on 25-04-2024 at 11.00 hours under the Chairmanship of Shri. Ashok Kumar Singh, IAS, the Chairman of Ground Water Re-Estimation Committee. The following Members attended the meeting.

1.	**Smt. D. Dharmalakshri,** IAS, Director, GWD, Kerala	Member
2.	**Dr. Dinesan Cheruvat**, Joint Managing Director, KWA	Member
3.	**Sh. Mini Chandran**, Head of Office, CGWB, KR, Trivandrum	Member Secretary
4.	**Shri. H. Manoj**, GM, NABARD, Thiruvananthapuram	Member
5.	**Sh. Sivadasan,** CE, Irrigation (I&A)	Member
6.	**Smt. Beena Thankan PL,** Dy. CE, Irrigation (I&A)	Member
7.	**Shri. A G Gopakumar**, Superintending Hydrogeologist, GWD	Member
8.	**Smt. Simi CS.**, Joint Director Directorate of Industries and Commerce, Govt. of Kerala	Member
9.	**Smt. Preetha Paul,** Joint Director (WM), Department of Agriculture & FW	Member
10.	**Smt. Suseela R,** Executive Engineer Planning, Irrigation (I&A)	Member
11.	**Dr. Raicy MC**, Scientist, CWRDM, Kozhikode	Member
12.	**Sh. Roopesh G.Krishnan**, Sc-D, CGWB, Trivandrum	Invitee
13.	**Smt. Saritha A**, Sc-C, CGWB, Trivandrum	Invitee

At the outset, the Chairman welcomed the members. Then, Chairman invited the Head of Office, CGWB to deliver a presentation on Ground Water Resources Estimation of Kerala State. In the presentation the Head of Office, CGWB detailed the methodology adopted for the estimation of ground water resources and appraised the status of ground water resource in Kerala as per the latest assessment carried out during 2023. After the presentation, The HOO, CGWB requested the

line Departments to provide the following data required for re-assessing the ground water resource as on 2024:

- Block wise water level and water quality data (GWD, Kerala)
- Economics and statistics block wise data like cropping pattern, crop water requirement, number of irrigation wells, area irrigated by irrigation wells, extraction from dug/bore/tube wells. Surface and groundwater recharge area, MI Census data (Agriculture, Irrigation)
- Data pertaining to Extraction: -domestic, industrial and irrigation (Dept: Irrigation & Industries; GWD).
- Data on command and non-command area, irrigation canal outlay, area under irrigation, crop water requirement, canal seepage, status of tanks, ponds and water conservation structures, surface and ground water irrigation recharge. Status of Structures and its capacity constructed under Jal Shakthi Abhiyaan. (Dept: Agriculture & Irrigation, GWD)
- Block wise location, discharge and water quality of Springs, Hydrology data, Groundwater Quality data (CWRDM, Kozhikode)
- Details of piped water supply with its source and seepage factor including population benefitted; Block wise list of defunct/abandoned bore/tube wells of KWA. (Dept: KWA)
- Station wise Rain fall data (Dept: IMD& IDRB)

The committee approved the commencement of Re-estimation of Ground water Resources of Kerala for 2024 jointly by CGWB and State GWD. The HOO, CGWB requested cooperation from line Departments and creation of WhatsApp group exclusively for data sharing.

The members from different line Departments assured the timely submission of required data from the respective departments. Meanwhile, the Chairman instructed to provide various data required for the reassessment of ground water at the earliest. The Chairman assured the full-hearted involvement of all line

departments and instructed CGWB to share the report as well as presentation with all the committee members.

The meeting ended with thanks to the Chair.

Approved for issuance

Ashok Kumar Singh, IAS
Secretary, Water Resources
Govt. of Kerala

ASHOK KUMAR SINGH IAS
PEN : 325215
Principal Secretary to Government
Water Resources & CSIN Department
Government Secretariat
Thiruvananthapuram

Second SLC

MINUTES OF THE 2nd MEETING OF THE PERMANENT STATE LEVEL COMMITTEE (SLC) ON RE-ESTIMATION OF GROUND WATER RESOURCES OF KERALA STATE AS ON 2024

The Second meeting of the State Level Committee (SLC) for the re- estimation of Ground Water Resources of Kerala as on 2024 was held on 29.8.2024 under the Chairmanship of **Dr. B. Ashok IAS,** Principal Secretary, Agricultural Production Commissioner, & Link Officer of Water Resources Department, Govt. of Kerala and the Chairman of the committee at 11.00 am. The following Members attended the meeting:

1	**Smt. Mini Chandran** Head Of Office, CGWB, Kerala Region	Member Secretary
2	**Smt. Dharamalashri IAS,** Director, GWD	Member
3	**Shri Sivadasan M** CE, I & A, Trivandrum	Member
4	**Shri. Sharon Herbert,** Assistant General Manager, NABARD, Thiruvananthapuram	Member
5	**Dr Dipu S.,** Scientist, CWRDM	Member
6	**Smt. Beena Thankan P.L.,** DCB, CE (I & A)	Member
7	**Shri. Manu R.,** Asst. Executive Engineer, Irrigation Dept	Member
8	**Shri. A. G. Gopakumar,** Superintending Hydrogeologist (General), GWD	Invitee
9	**Shri. Roopesh G Krishnan** Scientist. D, CGWB, Kerala Region	Invitee
10	**Shri. Rakhi U R,** Scientist. D, CGWB, Kerala Region	Invitee
11	**Smt. Indu P Nair** Junior Hydrogeologist, GWD	Invitee
12	**Shri. Hareesh Madhu,** Asst. Engineer, Irrigation Dept	Invitee

At the outset, the Chairman welcomed the members and stressed the importance of periodic re- assessment of ground water resources in proper planning and optimum utilization. The Chairman then invited the Head of office, CGWB to present the salient outcomes of the assessment carried out as on 2024. Shri. Roopesh G Krishnan, Scientist. D, CGWB, Kerala Region, Trivandrum briefed the methodology adopted for the estimation of ground water resources and appraised the status of ground water resource of Kerala state as on 2024, along with the comparison from 2017 to 2024 and also discussed the highlights of the Resource assessment 2024.

The ground water resources have been computed jointly by State GWD and CGWB for administrative units in the State, with community development blocks as assessment units. Accordingly, the computations have been made for 152 assessment units spread across 14 districts in the State. The ground water resources of urban habitations comprising 6 Municipal

Corporations, 87 Municipalities and 1 Township have been combined with the adjoining blocks based on their hydrogeological set up.

- Annual Extractable Groundwater Resource for the entire State is **5129.67 MCM** (ranges from **191.44 MCM** in Idukki district to **584.17 MCM** in Palakkad district).
- The Annual Ground Water Extraction for all uses is of the order of **2758.88 MCM** (ranges from **56.04 MCM** in Wayanad district to **348.11 MCM** in Malappuram)
- The Net Ground Water Availability for future use is of the order of **2120.47 MCM** (ranges from **57.81 MCM** in Kasaragod district to **236.71 MCM** in Kottayam district).
- The Stage of ground water extraction of assessment units is of the order of **53.78 %** for the State (highest in Malappuram district **(73.19 %)** and the lowest in Wayanad district **(26.29 %).**
- 3 assessment units (blocks) (Chittur & Malampuzha blocks of Palakkad district and Kasaragod block of Kasaragod district) have been categorized as "Critical". Out of the remaining blocks, 29 blocks are "Semi-critical" and 120 blocks comes under "Safe" category.
- One assessment unit, has improved its category from Semi-critical to Safe viz. Varkala (Thiruvananthapuram district) from the previous assessment.
- While comparison with GWRA2017, out of **8 assessment units, 5** has improved its category i.e; 4 from Semi critical to Safe and 1 from Overexploited to Critical viz. Chittur (Palakkad District) and **3** has deteriorated its category from Safe to Semi critical.

After the presentation, the Chairman of the committee emphasized the importance of proper data documentation and sharing of the outcomes in report format with State government agencies for prioritizing their water conservation and artificial recharge activities in Critical and Semi- critical blocks. Also enquired about the error percentage of the *Ingres* web-based application used for ground water resource estimation which will be crucial to determine the reliability of the data.

The assessment of dynamic ground water resources of Kerala as on 2024 was approved by the Committee after discussions and deliberations by the members. The meeting ended with thanks to the chair.

OFFICE OF THE PRINCIPAL SECRETARY & APC * GOVERNMENT OF KERALA * AGRICULTURE DEPARTMENT

Dr. B. Ashok IAS,
Principal Secretary,
Agricultural Production Commissioner,
& Link Officer (WRD), Govt. of Kerala

Dr. B. ASHOK IAS
Principal Secretary &
Agricultural Production Commissioner
Agricultural Department

CONTRIBUTORS PAGE

I COMPUTATION OF GROUND WATER RESOURCES

CENTRAL GROUND WATER BOARD

1.	**Roopesh G. Krishnan**	**Scientist-D (HG)**
2.	**Rakhi U. R.**	**Scientist-D (HG)**
3.	**Saritha S.**	**Scientist-D (HG)**
4.	**Dr. Aneesh Kumar V.**	**Scientist-C (HG)**
5.	**Anu V.**	**Scientist-C (HG)**
6.	**Arun Kumar A.V.**	**Scientist-B (HG)**

GROUND WATER DEPARTMENT

1.	**A.G. Gopakumar**	**Superintending Hydrogeologist (Gen.)**
2	**Bindhu Gopinath**	**Superintending Hydrogeologist (NHP) I/C**
3	**Dr. Anseena Beegom A.S.**	**Hydrogeologist (NHP)**
4	**Santy S.R.**	**Hydrogeologist**
5	**Arun Chand C.**	**Jr. Hydrogeologist**
6	**Niyas A.F.**	**Jr. Hydrogeologist**
7.	**Indu P. Nair**	**Jr. Hydrogeologist**

II SCRUTINY

1.	**Roopesh G. Krishnan**	**Scientist-D (HG)**

III FINALISATION OF REPORT

1.	**Mini Chandran**	**Head of Office, CGWB, Kerala Region, Thiruvananthapuram**
2	**D. Dharmalashri IAS**	**Director, Ground Water Department, Thiruvananthapuram**