DYNAMIC GROUND WATER RESOURCES OF MANIPUR, 2024

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

Guwahati
January, 2025

Ningthoujam Geoffrey,
Commissioner,
Minor Irrigation Department &
Chairman
State level Committee (GWRA), Manipur

Chief Minister's Secretariat
Imphal 795001
Government of Manipur
Phone:0385-2450048
E-Mail: secretary2cm@gmail.com

Foreword

Groundwater is an important resource for meeting the water requirements for irrigation, domestic and industrial uses. The increasing reliance on groundwater as a dependable source of water has led to its extensive and sometimes unplanned exploitation. To ensure the sustainability of this critical resource, planning and implementation of proper management strategies and regulatory measures is the need of the hour. It is rightly said that "we can only manage what we can measure," highlighting the importance of proper monitoring and assessment in groundwater management.

The annual dynamic groundwater resources of Manipur, 2024 has been assessed by using the 'Ground Water Estimation Methodology - 2015' (GEC-2015) through "India Groundwater Resource Estimation System" (IN-GRES), a GIS based web platform. This report on Dynamic Groundwater Resource Assessment of 2024(GWRA-2024) is a collaborative effort of Minor Irrigation Department (State Nodal Department), Government of Manipur and the Central Ground Water Board, North Eastern Region, Guwahati. The annual assessment is providing a clear understanding of groundwater dynamics, its recharge, extraction and serves as the foundation for planning and implementation of strategies for sustainable management of groundwater resources across the State.

I congratulate the dedicated efforts of CGWB, NER for their pivotal role in compiling this report and MID, the State Ground Water Nodal Department in conducting the assessment. I also appreciate the valuable contributions of the State Level Committee (SLC), Manipur for their guidance in timely completion of the assessment and Compilation. I believe that, this comprehensive report will serve as an important document for planners, decision-makers and stakeholders in securing the groundwater resources for Viksit Bharat in the state of Manipur.

27.01.2025

Imphal
January 2025

Ningthoujam Geoffrey, IAS
Commissioner, MI & Chairman
State level Committee (GWRA), Manipur

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

भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग
केन्द्रीय भूमि जल बोर्ड
Government of India
Ministry of Jal Shakti
Dept. of Water Resources, RD & GR
Central Ground Water Board

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 every year to provide the planners, decision makers and all stakeholders with reliable data/information for taking timely measures for sustainable management of groundwater resources.

The assessment of dynamic groundwater resources of **Manipur, 2024** is based on the Groundwater Estimation Methodology of 2015 (GEC-2015), which comprehensively factors in all relevant parameters contributing to groundwater recharge and extraction. The Dynamic Groundwater Resource Assessment of 2024 (GWRA-2024) of **Manipur** is a collaborative effort involving both the **State Nodal Department of Ground Water** and the Central Ground Water Board, North Eastern Region by utilizing the INDIA-Ground Water Resource Estimation System (IN-GRES) Software.

I extend my heartfelt appreciation to the dedicated officers of CGWB, NER for their significant role in compiling the state-level data. My gratitude also goes to the officers of CGWB and State Ground Water Nodal Departments of **Manipur** for their relentless efforts in conducting assessments according to the planned schedule.

The valuable contributions of the SLC members in refining the State Report of **Manipur** are also acknowledged. I hope this State level compilation will serve as an important document for planners, decisionmakers, and all concerned stakeholders in prioritizing actions necessary to ensure the sustainability of groundwater resources in the state.

Faridabad
January, 2025

(**T. S. Anitha Shyam**)
Member (East)

Sri N Varadaraj
Member (East)

भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग
केन्द्रीय भूमि जल बोर्ड
Government of India
Ministry of Jal Shakti
Dept. of Water Resources, RD & GR
Central Ground Water Board

Groundwater is considered the "backbone" of India's water security, fulfilling nearly 80% of the country's drinking water needs and providing around two-thirds of the water required for irrigation, making it a critical resource for both rural and urban populations. India’s agricultural productivity, industrial output, and domestic water supply are heavily reliant on groundwater. Rapid rise in population increases demand for water. Rise in urban population increases load on management of waste and polluted water. India is the largest user of groundwater accounting for approximately 25% of the total global withdrawal. Indian cities cater to about 48% of their water supply from groundwater. With rise in population, groundwater use is expected to rise further.

A systematic 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 Manipur every year to provide the planners, decision makers and all stakeholders with reliable data/information for taking timely measures for sustainable management of groundwater resources.

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N. Varadaraj

Faridabad
January, 2025

(Sri N Varadaraj)
Member (East)

तपन चक्रवर्ती
क्षेत्रीय निदेशक
Tapan Chakraborty
Regional Director

भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग
केन्द्रीय भूमि जल बोर्ड, पूर्वोत्तर क्षेत्र
Government of India
Ministry of Jal Shakti
Dept. of Water Resources, RD & GR
Central Ground Water Board
North Eastern Region

PREFACE

The State of Manipur is characterized by hilly terrain with steep slopes. Only about one tenth part of the state has valley areas, which are found as repository of groundwater in state. The valleys covered with unconsolidated alluvial deposits and semi-consolidated Tertiary sedimentary formations are having fairly good scope for groundwater development.

For rapidly expanding urban and agricultural water requirement of the state, groundwater utilization is of fundamental importance. For proper planning and management of groundwater, reliable assessment of groundwater resource in the state is prime necessity. Keeping this objective in view, the groundwater resource potential of Manipur has been reassessed based on ‘Ground Water Resource Estimation Methodology – 2015 (GEC 2015).

Ground Water Resources of Manipur has been carried out jointly by Central Ground Water Board, NER and Minor Irrigation Department, Manipur (State Nodal Department) in coordination with other members/departments of State Level Committee (SLC) on Ground Water Resource Assessment of Manipur.

Earlier Dynamic Groundwater Resource Assessment was done manually throughout the country. Later it was observed that some minor computational error might have occurred in calculating the resource, as the process of Dynamic Groundwater Resource Assessment is a complicated and lengthy. So, to overcome this human error, computation of dynamic ground water resources of Manipur was carried out through IN-GRES software which is a software/web-based application developed by CGWB in collaboration with Vassar Lab, IIT-Hyderabad.

The computation has been done based on the field data generated by Central Ground Water Board and statistical information compiled by the state government departments. The report contains blocks-wise - total ground water recharge, current annual gross ground water extraction and existing gross groundwater extraction for various uses. Stage of groundwater extraction in the State is in Safe stage. The report also throws light on the future ground water availability for various uses including irrigation and domestic sectors.

The Ground Water Resources of Manipur,2024 have been assessed block-wise for the recharge worthy area. Total Annual Ground Water Recharge of the State has been assessed as 0.52 bcm and Annual Extractable Ground Water Resources as 0.47 bcm. The Annual Ground Water Extraction is 0.04 bcm and Stage of Ground Water extraction is 8.00 %. All the assessment units and districts have been categorized as ‘Safe’ and there is no saline area in the state. The comparison with previous assessment shows there is no major changes in the Ground Water Resources of Manipur. As such all the assessment units fall under Safe category.

The report will be very helpful for the user agencies.

चक्रवर्ती

Guwahati
January, 2025

(Tapan Chakraborty)
Regional Director,CGWB NER &
Member Secretary,SLC

DYNAMIC GROUND WATER RESOURCES OF MANIPUR, 2024

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DYNAMIC GROUND WATER RESOURCES OF MANIPUR, 2024

AT A GLANCE

1.	Total Annual Ground Water Recharge	:0.52 bcm
2.	Annual Extractable Ground Water Resources	:0.47 bcm
3.	Annual Ground Water Extraction	:0.04 bcm
4.	Stage of Ground Water Extraction	:8.00%

CATEGORIZATION OF ASSESSMENT UNITS

(Blocks/ Mandals/ Taluks)

Sl.No	Category	Number of Assessment Units		Recharge worthy Area		Annual Extractable Ground Water Resource	
		Number	%	in lakh sq. km	%	(in bcm)	%
1	Safe	9	100	2559	100	466.08	100
2	Semi Critical						
3	Critical						
4	Over-Exploited						
5	Saline						
	TOTAL	**9**	**100**	**2559**	**100**	**466.08**	**100**

EXECUTIVE SUMMARY

Ground Water Resource Assessment is carried out at periodical intervals jointly by State Ground Water Departments and Central Ground Water Board under the guidance of the respective State Level Committee on Ground Water Assessment at State Levels 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. Assessment of Dynamic Ground Water Resources of Manipur is being carried out jointly by Central Ground Water Board and Minor Irrigation Department, the State Nodal Department periodically as per the Ground Water Estimation Committee-2015 (GEC-2015) methodology.

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 (Talukas/blocks/mandals) 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 more than 90 % of the total annual ground water recharge. Over 75% 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.

Rainfall recharge during monsoon and non-monsoon period is the major contributor of total annual groundwater recharge of Manipur, which is 0.51 bcm or 98 % of the total recharge (Monsoon season 78%, non-monsoon season: 22%) and the remaining 2% (Monsoon season: 91%, non-monsoon season:9 %) or 0.011 bcm is from ‘Other sources’ viz. canal seepage, return flow from irrigation, recharge from tanks, ponds and water conservation structures taken together. The overall contribution of rainfall (both monsoon & non-monsoon) recharge to state’s total annual ground water recharge is 98% and the share of recharge from ‘Other sources’ viz. canal seepage, return flow from irrigation, recharge from tanks, ponds and water conservation structures taken together is 2 %.

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 in Imphal Valley generally have high specific yields and are good repositories of ground water. Ground water occurrence in the fissured formations occupying nearly two-thirds of the state, on the other hand, is mostly limited to the weathered, jointed and fractured portions of the rocks.

As per the 2024 assessment of Dynamic Ground Water Resources, the Total Annual Ground Water Recharge of Manipur has been assessed as 0.52 billion cubic meter (bcm) and the Annual Extractable Ground Water Resources for the state is 0.47 bcm with total natural discharges at 0.05 bcm.

CHAPTER 1

1.0 INTRODUCTION

Groundwater is an important resource for meeting the water requirements for irrigation, domestic and industrial uses. The groundwater is available in the zone of water level fluctuation which is active recharge zone and replenished annually, i.e., dynamic as well as in the deeper zone below the water level fluctuation i.e., in in-storage condition. The dynamic groundwater resources, which are being used regularly, are reflected in the fluctuation of water levels. Apart from this, there are huge groundwater reservoirs in the deeper zones below the active recharge zone and in the confined aquifers in the areas covered by alluvial sediments of river basins, coastal and deltaic tracts constituting the unconsolidated formations and productive fracture zones in hard rock areas. The in-storage groundwater resource can be considered for development only during the period of extreme drought condition, and that too probably only to meet drinking water supply.

Groundwater is the backbone of India's agriculture and drinking water security, contributing nearly 62% to irrigation, 85% to rural water supply, and 50% to urban water supply. Although groundwater is replenished annually, its availability is uneven across different locations and times. The groundwater in the zone of water level fluctuation is primarily recharged annually with rainfall being the main contributor.

The National Water Policy of 2012 emphasizes periodic, scientifically-based assessments of groundwater resources, including evaluating trends in water availability due to factors such as climate change during water resource planning. To meet growing water demands, the policy advocates for direct rainfall use, desalination, and minimizing unnecessary evapotranspiration to augment usable water resources. Additionally, the policy prioritizes safe water for drinking and sanitation, followed by other domestic needs (including animals), food security, subsistence agriculture, and minimum ecosystem needs. Any remaining water should be allocated to promote conservation and efficient use. Therefore, sustainable groundwater utilization requires a realistic and scientifically sound quantitative assessment of its availability.

Assessment of Dynamic Ground Water Resources of Manipur is being carried out jointly by Central Ground Water Board and Minor Irrigation Department, the State Nodal Department periodically as per the Ground Water Estimation Committee-2015 (GEC-2015) methodology under the guidance of the State Level Committees (SLC) and overall supervision of Central Level Expert Group (CLEG). As part of the assessment, 'Annual Extractable Ground Water Resource' as well as 'Annual Ground Water Extraction are assessed for each assessment unit (block). The 'Stage of Ground Water Extraction' is then computed as the ratio of 'Annual Ground Water Extraction' with respect to 'Annual Extractable Ground Water Resource' and is usually expressed in percentage. Based on the stage of extraction, the assessment units are categorized as Safe (<= 70 %), Semi-Critical (>70 % and <=90 %), Critical (>90 % and <=100%) and Over-Exploited (>100 %).

1.1 PREVIOUS ASSESSMENTS

The assessment of water resources in India began in 1901 with the First Irrigation Commission estimating surface water resources at 144 million hectare-meters (M.ham). In 1949, Dr. A.N. Khosla estimated the total average annual runoff, including both surface and groundwater, as 167 M.ham. Various committees and task forces have since assessed groundwater resources in response to development needs. The National Commission on Agriculture in 1976 estimated total groundwater resources at 67 M.ham, with 26 M.ham available for irrigation.

The first systematic groundwater assessment methodology was developed in 1979 by the Ground Water Over-Exploitation Committee, estimating the gross recharge at 47 M.ham and net recharge at 32 M.ham. In 1982, the Ground Water Estimation Committee (GEC) was formed, and its recommendations led to the GEC 1984 methodology for assessing dynamic groundwater resources. In 1995, India's total replenishable groundwater was assessed at 432 billion cubic meters (bcm), with 361 bcm available for irrigation and a groundwater development level of 32%.

In 1995, a new committee reviewed and revised the methodology, resulting in GEC 1997. To address challenges in hard rock terrains, further revisions were made in 2001. Dynamic groundwater resources were assessed using GEC 1997 methodology for base years 2004, 2009, 2011, and 2013. 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 country, starting from the year 2022 onwards.

In the present assessment, the total annual groundwater recharge in Manipur has been assessed as 0.52 bcm. Keeping an allocation for natural discharge, the annual extractable ground water resource has been assessed as 0.47 bcm. The annual groundwater extraction (as in 2024) is 0.04 bcm. The stage of groundwater extraction for the state is 8.0 %. All assessment units (Blocks/ Mandals/ Talukas) in the state are categorized as **'Safe '**units, where the stage of Ground water extraction is less than 70 %. Salient details of status of ground water resources and categorization of assessment units in 2004, 2009, 2011, 2013, 2017, 2020.2022, 2023 and 2024 are shown in ***Table-1.1*** and ***Table-1.2*** respectively.

In the present report, the smallest administrative unit viz. block is considered for resources assessment unit (AU). Area with more than 20% slope has been excluded for the resource assessment (as per GEC 2015). The total area considered for the resources estimation of Manipur state is 2559 sq.km, which covered Imphal West, Imphal East, Thoubal, Bishnupur and parts of Churachandpur district. The remaining four hill districts of Manipur (i.e., Chandel district, Senapati district, Ukhrul district and Tamenglong district) were excluded from the resource assessment.

Since the poor-quality groundwater is only a localized phenomenon, the block-wise poor-quality area have been taken as Nil. The sub-unit demarcation into command and non-command is not carried out since the data for the same are not available.

Table-1.1: Ground water Resources assessment 2004 to 2024

S. No	Ground Water Resource Assessment	2004	2009	2011	2013	2017	2020	2022	2023	2024
1	Annual Ground Water Recharge (bcm)	0.38	0.44	0.44	0.47	0.43	0.51	0.517	0.52	0.52
2	Annual Extractable Ground Water Resource (bcm)	0.342	0.40	0.396	0.42	0.386	0.46	0.466	0.47	0.47
3	Annual Ground Water Extraction for Irrigation, Domestic & Industrial Uses (bcm)	0.0025	0.0037	0.004	0.0043	0.0055	0.024	0.037	0.04	0.04
4	Stage of Ground Water Extraction (%)	0.02	1.01	1.02	1.02	1.44	5.12	7.95	7.99	8.00

Table-1.2: Categorization of assessment units from 2004 to 2024

		2004		2009		2011		2013		2017		2020		2022		2023		2024	
S. No	**Categorization of Assessment Units**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
1	Total Assessed units	9		9		9		9		9		9		9		9		9	
2	Safe	9	0.02	9	1.01	9	1.02	9	1.02	9	1.44	9	5.12	9	7.95	9	7.99	9	8.0
3	Semi -Critical																		
4	Critical																		
5	Over-Exploited																		
6	Saline																		

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) in Manipur by covering all identified mappable areas of the state, for mapping of major aquifers, their characterization and formulation of Aquifer Management Plans to ensure sustainability of the resources. 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. The Ministry of Jal Shakti has issued a Model Bill to States/UTs for groundwater regulation and initiated the National Aquifer Mapping & Management Programme (NAQUIM) to map and manage major aquifers, focusing on over-exploited areas.
3. CGWB has taken up high resolution mapping of the aquifers through the state-of-the-art heliborne geophysical surveys prioritizing the water stressed Over Exploited, Critical and Semi Critical areas. So far, nearly 1.0 lakh sq km area has been covered under this survey in arid parts of NW India. The results of the Heliborne Survey are being used for preparing village/ panchayat level aquifer maps and suitable management interventions.
4. Atal Bhujal Yojana (ATAL JAL) with focus on community participation and demand side interventions for sustainable ground water management in identified water stressed areas has been taken up by DoWR RD &GR. This scheme is expected to contribute significantly towards the water and food security of the participating States. The scheme was launched by the Hon'ble Prime Minister on 25.12.2019 and is being implemented from 01.04.2020 for a period of 5 years. The scheme is being taken up in 8220 water stressed Gram Panchayats of 229 administrative blocks/ Talukas in 80 districts of seven states, viz. Haryana, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh spread over Northern, Central and Southern Parts of the Country.
5. Master Plan for Artificial Recharge to Groundwater- 2020 has been prepared by CGWB in consultation with States/UTs which is a macro level plan indicating various structures for the different terrain conditions of the country including estimated cost. The Master Plan envisages construction of about 1.42 crore Rainwater harvesting and artificial recharge structures in the Country to harness 185 Billion Cubic Metre (BCM) of monsoon rainfall.
6. Several State Governments 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.
7. 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.
8. Jal Shakti Abhiyan-I (JSA-I) launched in 2019 across 1592 blocks in 256 water-stressed districts, focused on water conservation, rainwater harvesting, and resource management through targeted interventions. Expanded in 2021 as "Catch the Rain," it covered all districts nationwide, continuing through 2022, 2023 and 2024.

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

1.3 RE-ASSESSMENT OF GROUND WATER RESOURCES, 2024

Ministry of Jal Shakti, Department of Water Resources, River Development & Ganga Rejuvenation, constituted a permanent Central Level Expert Group (CLEG) for over-all supervision of the re-assessment of ground water resources in the entire country as in 2024. The terms of reference of the committee include supervision of assessment of annual replenishable ground water resources and the status of utilization for reference year 2023 onwards.

Groundwater resources assessment for reference year 2024 at the State level have been carried out jointly by Minor Irrigation Department, Manipur and Central Ground Water Board, NER, Guwahati under the supervision of State Level Committee (SLC), Manipur with technical guidance from Central Level Expert Group (CLEG). The assessment carried out during 2024 was approved by the State Level Committee on GWRA, Manipur. The state report on Dynamic Ground Water Resources of Manipur,2024 provides 'Annual Extractable Ground Water Resource' as well as 'Annual Ground Water Extraction for each assessment unit (block). The 'Stage of Ground Water Extraction' is then computed as the ratio of 'Annual Ground Water Extraction' with respect to 'Annual Extractable Ground Water Resource' and is usually expressed in percentage. Based on the stage of extraction, the assessment units are categorized as Safe (<= 70 %), Semi-Critical (>70 % and <=90 %), Critical (>90 % and <=100%) and Over-Exploited (>100 %).

Based on the assessment provided by the State Level Committee, Manipur as well as others states/UTs of the country, the *National Compilation of Dynamic Ground Water Resources of India, 2024* has been compiled. The National compilation report provides summary and analysis of ground water resources in different States. The report was reviewed and deliberated upon during the meeting of CLEG held on 08.09.2024 and was approved.

CHAPTER 2

GROUND WATER RESOURCE ESTIMATION METHODOLOGY

Ground water resource of Manipur as in 2024 has 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 –

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

Equation (1) can be further elaborated as –

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

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

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

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:

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

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

$$\Delta \boldsymbol{S} = \Delta \boldsymbol{h} \times \boldsymbol{A} \times \boldsymbol{S_Y} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (\mathbf{5})$$

Where,

ΔS - Change is storage

Δh - 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,

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

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

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

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

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:

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

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,

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

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:

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

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

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 –

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

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
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 (e.g., 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 (GEDOM). 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.

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

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.

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

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,

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

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. Categorization of Assessment Unit

2.1.1.11.1. Categorization of Assessment Unit Based on Quantity

The categorization 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

2.1.1.11.2. Categorization 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.

2.1.1.12. 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.

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

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)

2.1.1.13. 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.

2.1.1.14. Additional Potential Resources under Specific Conditions

2.1.1.14.1. 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 Categorization. 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.

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

Where,

Q = Spring Discharge

No of days = No of days spring yields.

2.1.1.14.2. 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:

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

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

2.1.1.14.3. 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.

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

Where,

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

A = Flood Prone Area

2.1.1.15. 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/ taluka/ mandal. 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. NORMS HAS BEEN USED IN THE ASSESSMENT

2.2.1. 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	Alluvium	AL02	Pebble / Gravel/ Bazada/ Kandi	Quaternary	16	12	20
3	Alluvium	AL03	Older Alluvium (Silt/Sand/Gravel/Lithomargic clay)	Quaternary	6	4	8
4	Alluvium	AL04	Aeolian Alluvium (Silt/ Sand)	Quaternary	16	12	20
5	Alluvium	AL05	Coastal Alluvium (Sand/Silt/Clay)	Quaternary	10	8	12
6	Alluvium	AL06	Valley Fills	Quaternary	16	12	20
7	Alluvium	AL07	Glacial Deposits	Quaternary	16	12	20
8	Laterite	LT01	Laterite / Ferruginous concretions	Quaternary	2.5	2	3
9	Basalt	BS01	Basic Rocks (Basalt) - Weathered, Vesicular or Jointed	Mesozoic to Cenozoic	2	1	3
10	Basalt	BS01	Basic Rocks (Basalt) - Massive Poorly Jointed	Mesozoic to Cenozoic	0.35	0.2	0.5
11	Basalt	BS02	Ultra Basic - Weathered, Vesicular or Jointed	Mesozoic to Cenozoic	2	1	3

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
12	Basalt	BS02	Ultra Basic - Massive Poorly Jointed	Mesozoic to Cenozoic	0.35	0.2	0.5
13	Sandstone	ST01	Sandstone/Conglomerate	Upper Palaeozoic to Cenozoic	3	1	5
14	Sandstone	ST02	Sandstone with Shale	Upper Palaeozoic to Cenozoic	3	1	5
15	Sandstone	ST03	Sandstone with shale/ coal beds	Upper Palaeozoic to Cenozoic	3	1	5
16	Sandstone	ST04	Sandstone with Clay	Upper Palaeozoic to Cenozoic	3	1	5
17	Sandstone	ST05	Sandstone/Conglomerate	Proterozoic to Cenozoic	3	1	5
18	Sandstone	ST06	Sandstone with Shale	Proterozoic to Cenozoic	3	1	5
19	Shale	SH01	Shale with limestone	Upper Palaeozoic to Cenozoic	1.5	1	2
20	Shale	SH02	Shale with Sandstone	Upper Palaeozoic to Cenozoic	1.5	1	2
21	Shale	SH03	Shale, limestone and sandstone	Upper Palaeozoic to Cenozoic	1.5	1	2
22	Shale	SH04	Shale	Upper Palaeozoic to Cenozoic	1.5	1	2
23	Shale	SH05	Shale/Shale with Sandstone	Proterozoic to Cenozoic	1.5	1	2
24	Shale	SH06	Shale with Limestone	Proterozoic to Cenozoic	1.5	1	2
25	Limestone	LS01	Miliolitic Limestone	Quaternary	2	1	3
26	Limestone	LS01	Karstified Miliolitic Limestone	Quaternary	10	5	15
27	Limestone	LS02	Limestone / Dolomite	Upper Paleozoic to Cenozoic	2	1	3
28	Limestone	LS02	Karstified Limestone / Dolomite	Upper Palaeozoic to Cenozoic	10	5	15

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
29	Limestone	LS03	Limestone/Dolomite	Proterozoic	2	1	3
30	Limestone	LS03	Karstified Limestone/Dolomite	Proterozoic	10	5	15
31	Limestone	LS04	Limestone with Shale	Proterozoic	2	1	3
32	Limestone	LS04	Karstified Limestone with Shale	Proterozoic	10	5	15
33	Limestone	LS05	Marble	Azoic to Proterozoic	2	1	3
34	Limestone	LS05	Karstified Marble	Azoic to Proterozoic	10	5	15
35	Granite	GR01	Acidic Rocks (Granite, Syenite, Rhyolite etc.) - Weathered , Jointed	Mesozoic to Cenozoic	1.5	1	2
36	Granite	GR01	Acidic Rocks (Granite, Syenite, Rhyolite etc.)- Massive or Poorly Fractured	Mesozoic to Cenozoic	0.35	0.2	0.5
37	Granite	GR02	Acidic Rocks (Pegmatite, Granite, Syenite, Rhyolite etc.) - Weathered, Jointed	Proterozoic to Cenozoic	3	2	4
38	Granite	GR02	Acidic Rocks (Pegmatite, Granite, Syenite, Rhyolite etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	0.35	0.2	0.5
39	Schist	SC01	Schist - Weathered, Jointed	Azoic to Proterozoic	1.5	1	2
40	Schist	SC01	Schist - Massive, Poorly Fractured	Azoic to Proterozoic	0.35	0.2	0.5
41	Schist	SC02	Phyllite	Azoic to Proterozoic	1.5	1	2
42	Schist	SC03	Slate	Azoic to Proterozoic	1.5	1	2
43	Quartzite	QZ01	Quartzite - Weathered, Jointed	Proterozoic to Cenozoic	1.5	1	2
44	Quartzite	QZ01	Quartzite - Massive, Poorly Fractured	Proterozoic to Cenozoic	0.3	0.2	0.4
45	Quartzite	QZ02	Quartzite - Weathered, Jointed	Azoic to Proterozoic	1.5	1	2
46	Quartzite	QZ02	Quartzite- Massive, Poorly Fractured	Azoic to Proterozoic	0.3	0.2	0.4
47	Charnockite	CK01	Charnockite - Weathered, Jointed	Azoic	3	2	4

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
48	Charnockite	CK01	Charnockite - Massive, Poorly Fractured	Azoic	0.3	0.2	0.4
49	Khondalite	KH01	Khondalites, Granulites - Weathered, Jointed	Azoic	1.5	1	2
50	Khondalite	KH01	Khondalites, Granulites - Massive, Poorly Fractured	Azoic	0.3	0.2	0.4
51	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Weathered, Jointed	Azoic	1.5	1	2
52	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Massive, Poorly Fractured	Azoic	0.3	0.2	0.4
53	Gneiss	GN01	Undifferentiated metasedimentaries/ Undifferentiated metamorphic - Weathered, Jointed	Azoic to Proterozoic	1.5	1	2
54	Gneiss	GN01	Undifferentiated metasedimentaries/ Undifferentiated metamorphic - Massive, Poorly Fractured	Azoic to Proterozoic	0.3	0.2	0.4
55	Gneiss	GN02	Gneiss -Weathered, Jointed	Azoic to Proterozoic	3	2	4
56	Gneiss	GN02	Gneiss-Massive, Poorly Fractured	Azoic to Proterozoic	0.3	0.2	0.4
57	Gneiss	GN03	Migmatites' Gneiss - Weathered, Jointed	Azoic	1.5	1	2
58	Gneiss	GN03	Migmatitic Gneiss - Massive, Poorly Fractured	Azoic	0.3	0.2	0.4
59	Intrusive	IN01	Basic Rocks (Dolerite, Anorthosite etc.) - Weathered, Jointed	Proterozoic to Cenozoic	2	1	3
60	Intrusive	IN01	Basic Rocks (Dolerite, Anorthosite etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	0.35	0.2	0.5
61	Intrusive	IN02	Ultrabasics (Epidiorite, Granophyre etc.) - Weathered, Jointed	Proterozoic to Cenozoic	2	1	3
62	Intrusive	IN02	Ultrabasics (Epidiorite, Granophyre etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	0.35	0.2	0.5

2.2.2. 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	Alluvium	AL02	Pebble / Gravel/ Bazada/ Kandi	Quaternary	22	20	24
3	Alluvium	AL03	Older Alluvium (Silt/Sand/Gravel/Lithomargic clay)	Quaternary	22	20	24
4	Alluvium	AL04	Aeolian Alluvium (Silt/ Sand)	Quaternary	22	20	24
5	Alluvium	AL05	Coastal Alluvium (Sand/Silt/Clay) -East Coast	Quaternary	16	14	18
5	Alluvium	AL05	Coastal Alluvium (Sand/Silt/Clay) - West Coast	Quaternary	10	8	12
6	Alluvium	AL06	Valley Fills	Quaternary	22	20	24
7	Alluvium	AL07	Glacial Deposits	Quaternary	22	20	24
8	Laterite	LT01	Laterite / Ferruginous concretions	Quaternary	7	6	8
9	Basalt	BS01	Basic Rocks (Basalt) - Vesicular or Jointed	Mesozoic to Cenozoic	13	12	14
9	Basalt	BS01	Basic Rocks (Basalt) - Weathered	Mesozoic to Cenozoic	7	6	8
10	Basalt	BS01	Basic Rocks (Basalt) - Massive Poorly Jointed	Mesozoic to Cenozoic	2	1	3
11	Basalt	BS02	Ultra Basic - Vesicular or Jointed	Mesozoic to Cenozoic	13	12	14
11	Basalt	BS02	Ultra Basic - Weathered	Mesozoic to Cenozoic	7	6	8

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
12	Basalt	BS02	Ultra Basic - Massive Poorly Jointed	Mesozoic to Cenozoic	2	1	3
13	Sandstone	ST01	Sandstone/Conglomerate	Upper Palaeozoic to Cenozoic	12	10	14
14	Sandstone	ST02	Sandstone with Shale	Upper Palaeozoic to Cenozoic	12	10	14
15	Sandstone	ST03	Sandstone with shale/ coal beds	Upper Palaeozoic to Cenozoic	12	10	14
16	Sandstone	ST04	Sandstone with Clay	Upper Palaeozoic to Cenozoic	12	10	14
17	Sandstone	ST05	Sandstone/Conglomerate	Proterozoic to Cenozoic	6	5	7
18	Sandstone	ST06	Sandstone with Shale	Proterozoic to Cenozoic	6	5	7
19	Shale	SH01	Shale with limestone	Upper Palaeozoic to Cenozoic	4	3	5
20	Shale	SH02	Shale with Sandstone	Upper Palaeozoic to Cenozoic	4	3	5
21	Shale	SH03	Shale, limestone and sandstone	Upper Palaeozoic to Cenozoic	4	3	5
22	Shale	SH04	Shale	Upper Palaeozoic to Cenozoic	4	3	5

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
23	Shale	SH05	Shale/Shale with Sandstone	Proterozoic to Cenozoic	4	3	5
24	Shale	SH06	Shale with Limestone	Proterozoic to Cenozoic	4	3	5
25	Limestone	LS01	Miliolitic Limestone	Quaternary	6	5	7
27	Limestone	LS02	Limestone / Dolomite	Upper Palaeozoic to Cenozoic	6	5	7
29	Limestone	LS03	Limestone/Dolomite	Proterozoic	6	5	7
31	Limestone	LS04	Limestone with Shale	Proterozoic	6	5	7
33	Limestone	LS05	Marble	Azoic to Proterozoic	6	5	7
35	Granite	GR01	Acidic Rocks (Granite, Syenite, Rhyolite etc.) - Weathered , Jointed	Mesozoic to Cenozoic	7	5	9
36	Granite	GR01	Acidic Rocks (Granite, Syenite, Rhyolite etc.)- Massive or Poorly Fractured	Mesozoic to Cenozoic	2	1	3
37	Granite	GR02	Acidic Rocks (Pegmatite, Granite, Syenite, Rhyolite etc.) - Weathered, Jointed	Proterozoic to Cenozoic	11	10	12
38	Granite	GR02	Acidic Rocks (Pegmatite, Granite, Syenite, Rhyolite etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3
39	Schist	SC01	Schist - Weathered, Jointed	Azoic to Proterozoic	7	5	9
40	Schist	SC01	Schist - Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3
41	Schist	SC02	Phyllite	Azoic to Proterozoic	4	3	5

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
42	Schist	SC03	Slate	Azoic to Proterozoic	4	3	5
43	Quartzite	QZ01	Quartzite - Weathered, Jointed	Proterozoic to Cenozoic	6	5	7
44	Quartzite	QZ01	Quartzite - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3
45	Quartzite	QZ02	Quartzite - Weathered, Jointed	Azoic to Proterozoic	6	5	7
46	Quartzite	QZ02	Quartzite- Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3
47	Charnockite	CK01	Charnockite - Weathered, Jointed	Azoic	5	4	6
48	Charnockite	CK01	Charnockite - Massive, Poorly Fractured	Azoic	2	1	3
49	Khondalite	KH01	Khondalites, Granulites - Weathered, Jointed	Azoic	7	5	9
50	Khondalite	KH01	Khondalites, Granulites - Mssive, Poorly Fractured	Azoic	2	1	3
51	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Weathered, Jointed	Azoic	7	5	9
52	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Massive, Poorly Fractured	Azoic	2	1	3
53	Gneiss	GN01	Undifferentiated metasedimentaries/ Undifferentiated metamorphic - Weathered, Jointed	Azoic to Proterozoic	7	5	9
54	Gneiss	GN01	Undifferentiated metasedimentaries/ Undifferentiated metamorphic - Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3
55	Gneiss	GN02	Gneiss -Weathered, Jointed	Azoic to Proterozoic	11	10	12

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
56	Gneiss	GN02	Gneiss-Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3
57	Gneiss	GN03	Migmatitic Gneiss - Weathered, Jointed	Azoic	7	5	9
58	Gneiss	GN03	Migmatitic Gneiss - Massive, Poorly Fractured	Azoic	2	1	3
59	Intrusive	IN01	Basic Rocks (Dolerite, Anorthosite etc.) - Weathered, Jointed	Proterozoic to Cenozoic	7	6	8
60	Intrusive	IN01	Basic Rocks (Dolerite, Anorthosite etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3
61	Intrusive	IN02	Ulrta Basics (Epidiorite, Granophyre etc.) - Weathered, Jointed	Proterozoic to Cenozoic	7	6	8
62	Intrusive	IN02	Ulrta Basics (Epidiorite, Granophyre etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3

2.2.3. 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

2.2.4. 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

2.2.5. 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.

2.2.6. 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.

2.2.7. 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.

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

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

2.3. 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

RAINFALL

RAINFALL OF INDIA

Rainfall is the main source of ground water recharge in the country. However, distribution of rainfall has a wide variation both in space and time. Rain gauge stations are established and maintained by different departments and Undertakings of Central and State governments and also by private parties as per their specific data requirements. Though the period of seasons varies from place to place, 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). Most part of India receives rainfall mainly during SW Monsoon season.

The rainfall has direct impact on ground water regime. Groundwater table is usually deeper during pre-monsoon 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, displaying two distinct phases. The first phase, after the end of the monsoon, there is a rapid decline represented as a relatively steeper slope in the hydrograph and continued to be declined until the preceding monsoon begins in the subsequent year. Based on these dynamics, the ground water assessed in a groundwater year (June to May) comprises both monsoon season, spans from the beginning of the monsoon to one month after its cessation and non-monsoon season, the remaining period of the groundwater year. It is pertinent to mention that, the assessment of ground water resources for monsoon period in a ground water year include both monsoon months plus one subsequent calendar month after monsoon.

The normal rainfall distribution across States and Union territories showcases a broad spectrum, reflecting the country's diverse climatic conditions. The minimum normal rainfall is observed in Ladakh, with just 50.9 mm, while Meghalaya, known for its heavy precipitation, records the highest at 3751.6 mm. On average, the country’s average normal rainfall is 1537.77 mm, though the distribution is uneven. The median normal rainfall stands at 1255.95 mm, meaning that half of the states and UTs experience rainfall below the normal, indicating that a significant portion of the country has received lesser rainfall than the national average. The standard deviation is 854.99 mm, reflects the variability in rainfall, with some regions, particularly in the northeast, receiving abundant rainfall, while others, like the arid areas of Rajasthan and Ladakh, receive far less.

The annual rainfall in 2023 varied significantly across Indian States/UTs. Goa received the highest rainfall (3642.3 mm), followed by Andaman & Nicobar Islands (3510.9 mm) and Meghalaya (3022.6 mm). Ladakh experienced the lowest rainfall (84.1 mm), though this was 65.2% above its normal rainfall. The Comparison of annual rainfall of 2023 to the normal rainfall reveals that, 20 states/UTs experienced below-normal rainfall (Arunachal Pradesh, Assam, Meghalaya, Nagaland, Manipur, Mizoram, Tripura, West Bengal, Jharkhand, Bihar, Uttar Pradesh, Jammu & Kashmir, Odisha, Maharashtra, Chhattisgarh, Andhra Pradesh, Puducherry, Karnataka, Kerala, and

Lakshadweep), 16 with above-normal precipitation (Sikkim, Uttarakhand, Haryana, Chandigarh, Delhi, Punjab, Himachal Pradesh, Ladakh, Rajasthan, Madhya Pradesh, Gujarat, Dadra & Nagar Haveli and Daman & Diu, Goa, Andaman & Nicobar Islands, Telangana, and Tamil Nadu).

The most significant negative deviations were observed in Manipur (-50.8%), Mizoram (-30.5%), and Kerala (-23.8%). However, some States/UTs experienced substantially higher than normal rainfall. Ladakh received the highest positive deviation (65.2%), followed by Chandigarh (52.3%) and Rajasthan (29.8%). The rainfall pattern for the groundwater assessment year 2023-24 also reveals a similar trend to that of the calendar year 2023. Goa received the highest total rainfall (3734.3 mm), followed by the Andaman & Nicobar Islands (3551.2 mm) and Meghalaya (2959.0 mm). Ladakh experienced the lowest total rainfall (94.9 mm). The northeastern states, along with Goa and the Andaman & Nicobar Islands, received significantly higher rainfall compared to most other states. In contrast, northwestern states like Rajasthan, Haryana, and Delhi received considerably less rainfall during the groundwater assessment year 2023-24.

RAINFALL OF MANIPUR

Manipur have sub-tropical to temperate climate depending upon the elevation. The temperature varies from 0° C to 39° C. The state experiences the phenomenon influence of the South West Tropical monsoon. About 60 to 65 % of the annual precipitation is received during south-west monsoon from June to September. The maximum rainfall of monsoon period occurs between June and September. The beginning of winter is marked by a steep fall in temperature during December. January is the coldest month. In February the temperature starts rising gradually. The winter winds are generally weak and variable. The average annual temperature ranges from 18°C-20°C to 23°C-25°C respectively in the higher and lower elevation. The monsoon lasts for five months from May to September with June, July and August being the wettest months. The following agro-climatic zones are the main characteristic zones in the area:

(i) The cold season (December, January, February)
(ii) The hot dry season (March, April)
(iii) The rainy season (May, June, July, August, September)
(iv) The Retreating monsoon season (October, November)

Table 3.1 District Wise Normal Rainfall of Manipur for the Ground Water Assessment year 2023-24

S. No	State/ UT	District	Normal Rainfall (mm)		
			Monsoon	Non-Monsoon	Total
1	Manipur	Bishnupur	1608.3	110.49	1718.79
2	Manipur	Churachandpur	1741.2	392.26	2133.46
3	Manipur	Imphal East	1398.2	318.94	1717.14
4	Manipur	Imphal West	1011.1	373.78	1384.88
5	Manipur	Thoubal	940.3	336.48	1276.78

The Average annual rainfall in the resources worthy/assessment area for the Ground water Assessment Year 2023-24 is 914.864 mm, of which 665.32 mm is monsoon rainfall and 249.544 mm is non-monsoon rainfall.

Table 3.2 District wise Rainfall Statistics of Manipur for the Ground Water Assessment Year 2023-24

	District wise Rainfall Statistics of Manipur for the Ground Water Assessment Year 2023-24																			
S.No		District-wise Monthly Rainfall (mm)- Year 2023												District-wise Monthly Rainfall (mm)- Year 2024			Normal Rainfall (mm)	Rainfall during the Calendar Year 2023 (mm)	Monsoon Rainfall during the GW Assessment Year 2023-24 (mm)	Non-Monsoon Rainfall during the GW Assessment Year 2023-24 (mm)
	Districts	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR				
1	Bishnupur	0	0.02	23.84	57.41	67.41	116.26	99.28	139.37	151.25	33.66	39.52	40.01	0	30.96	0	1718.79	768.03	539.82	259.15
2	Churachandpur	0	0	31.28	47.41	59.72	116.38	87.44	96.99	133.83	36.54	30.81	26.86	0	20.88	0	2133.46	667.26	471.18	216.96
3	Imphal East	0	0.12	30.83	53.63	60.94	172.37	118.89	218.81	126.52	37.32	55.56	42.29	0	50.63	0	1717.14	917.28	673.91	293.88
4	Imphal West	0	0.35	37.88	82.35	83.13	273.17	269.65	267.89	174.87	40.68	46.85	37.71	0	56.37	0	1384.88	1314.53	1026.26	344.29
5	Thoubal	0	0.12	30.83	53.63	60.94	129.13	90.1	153.94	140.07	34.62	41.96	37.04	0	35.97	0	1276.78	772.38	547.86	260.37

Table 3.3 Rainfall and Recharge in Manipur during the Ground Water Assessment Year 2023-24

S.No	DISTRICT	Rainfall (mm)			Recharge Worthy Area (ha)	Ground Water Recharge (ham)		
		Monsoon	Non-Monsoon	Total		Monsoon	Non-Monsoon	Total
1	Bishnupur	539.82	110.49	650.31	255900	9572.66	2341.21	11913.87
2	Churachandpur	471.18	78.55	549.73	255900	6707.1	1579.99	8287.09
3	Imphal East	665.89	422.59	1088.48	255900	11959.41	2988.93	14948.34
4	Imphal West	1015.6	557.54	1573.14	255900	6297.14	2402.24	8699.38
5	Thoubal	634.11	78.55	712.66	255900	5799.79	2137.68	7937.47

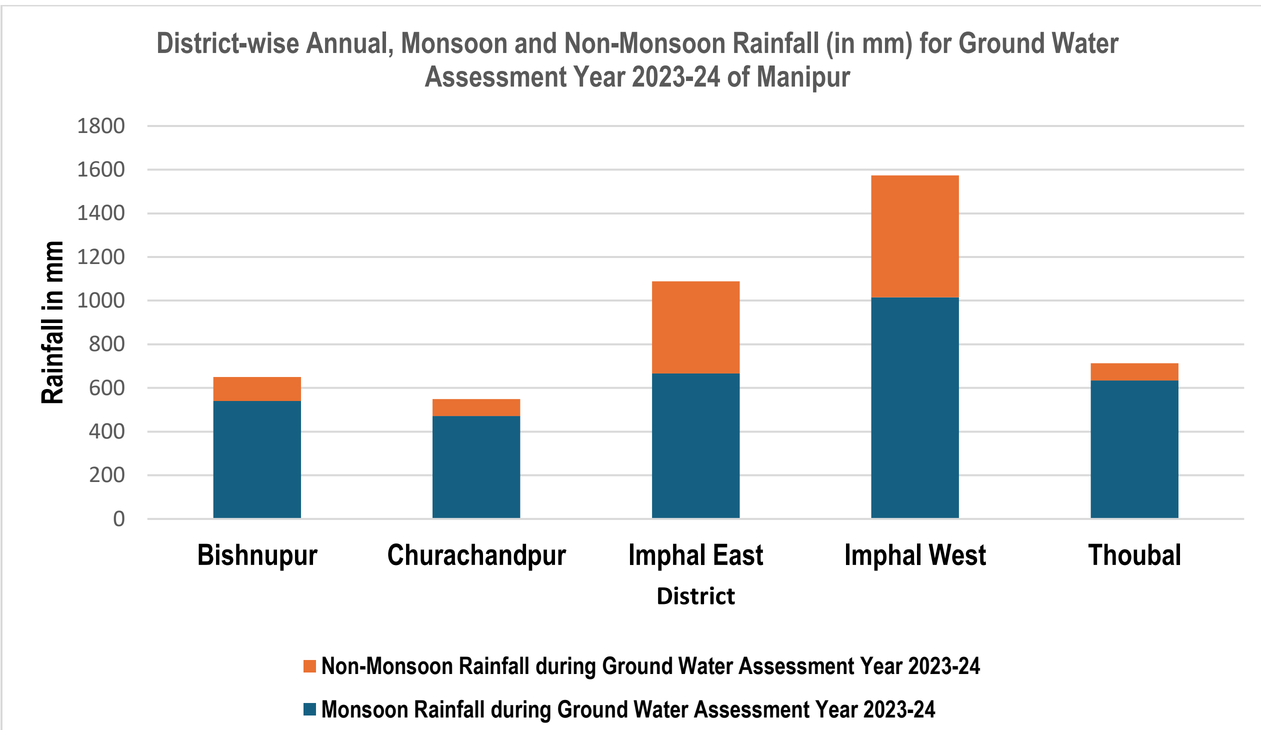


Fig.3.1 District-wise Annual, Monsoon and Non-Monsoon Rainfall (in mm) for Ground Water Assessment Year 2023-24

CHAPTER 4

HYDROGEOLOGICAL SETUP OF State/UT

The State of Manipur is occupied by mostly North South parallel hill ranges made up of consolidated and semi-consolidated rocks ranging in age from pre-Mesozoic to Miocene. The consolidated formations confined to the eastern part of the state along the Myanmar border. The semi-consolidated formations, which cover almost the entire state, comprise shale, siltstone, sandstone, and conglomerate. These formations belong to Disang, Barail, Surma and Tipam group of rocks. Unconsolidated Alluvium of Quaternary age occurs in the valleys and topographical lows in the central Imphal valley and western part of the state. The present resource estimation has been carried out in the districts of central Manipur (i.e., Imphal valley) where Unconsolidated Alluvium is major formation.

Description of aquifer dispositions, its lateral and vertical variations

Basically, the area considered for the estimation of Groundwater Resources is made up of Alluvium of fluvio-lacustrine origin. The principal constituents are clay, silt and sand whereas sand, gravel, pebbles and boulders are found in the foothill regions. The hillocks inside are basically composed of Disang shales but some have sandstone capping. Alluvium covers the widest aerial extent in the area. They are mainly dark grey to black carbonaceous clay, silt and sand of which clay forms the main sediments while silt and sand are subordinate. Major parts of the area belong to Alluvium which is further divided into Older and Younger Alluviums due to change in lithology.

Variation of Groundwater conditions with aquifer characteristics, depth, groundwater quality

Based on lithology and hydrogeological set up, the area is broadly divided into two types of aquifers; i.e. Weathered Rock Aquifer and Alluvium Aquifer. Two types of Aquifers are:

I. Weathered rock Aquifer: Moderately thick weathered shales are responsible for this type of aquifer. The water yielding properties are variable depending upon nature of the weathered material and surface cover.

ii. Alluvium Aquifer: The various geomorphic landforms constitute this type of aquifers. The nature of aquifer material is from Unconsolidated to Semi consolidated (sand, gravel, pebbles, gravel mixed with sand). Large alluvial plain form the potential source of groundwater.

The area covered by the valley that can be investigated for groundwater potential forming roughly 10 % of the total geographical state area. The valleys have superficial alluviums which are underlined by Tertiary rocks of Barail Series in Imphal valley. Granular zones are encountered up to a depth of about 145 m in Imphal valley. Tube wells have been installed at various places of the valley area with the yields ranging from 0.6 to 4 cum/hr. Considering the clayey nature of formation in the top aquifer, development of this resource is considered nascent on a large scale either in irrigation or water supply.

Semi consolidated Formations: Tertiary formations consisting of shale, sandstone, siltstone, and mudstone of Disang and Barail Groups constitute the Semi-consolidated formations in Imphal valley. They occur in the flanking denudational, denude-structural and structure-denudational hills and occur in the piedmont and part of the valley beneath the alluvial deposit. Highly splintery, fragile, jointed shales are predominant. The thickness of weathered rock in this formation varies from place to place. At places fairly good amount of water is yielded in parts of this formation as per CGWB and PHED, Manipur. The recorded average discharge in these places is around 272 lpm.

Unconsolidated Formations: In Imphal valley, unconsolidated formation consists of sand, silt, clay, gravel pebbles etc. with lake deposits. This unit covers the major portions of the Imphal valley. The thickness of unconsolidated alluvial deposits varies from place to place with maximum thickness of more than 145m at Mayang Imphal. The peripheral zone of the valley consists predominantly of sand, gravel whereas the rest is covered dominantly with thick layer of clay. The thickness of clay layer varies from place to place. It goes on increasing from periphery towards the centre of the valley. The thickness of clay layer at places, in the study area goes up to 61 m, and maximum thickness of clay occurs in the south-central parts lying just north of Loktak Lake.

The average thickness of alluvial deposits varies generally from 30 m to 110 m as per the findings of CGWB and PHED, Manipur. Below the depth of 110 m semi-consolidated sedimentary rocks are found.
The unconsolidated formation formed at the foothill, i.e., western peripheral zone of the valley, forming higher piedmont, consists of colluvial materials. These colluvial materials taper away within a short distance.

Aquifer geometry: Average aquifer thickness ranges from 10 to 21m. Piezometric head vary from 2.50 to 4.30 m, bgl. The transmissivity and hydraulic conductivity ranges between 4.30 and 89 m^2/day and 0.67 to 16 m/day. The discharge of tube wells ranges about 10-30 m^3 /hr at 10-15 m drawdown. In fact, there is great variation in both vertical and lateral lithology, even over small distances. Sand and gravel layers have indefinite and largely undefined boundaries.

Occurrence, movement, and distribution of groundwater: Groundwater is found to occur under water table conditions in the shallow dug well horizons with depth to water table varying from 1.64 to 12 mbgl. Deeper depth to water level is observed in the northern foothill parts of the area. The groundwater movement is essentially towards the central lower part from the peripheral higher elevation of the valley and finally results to the north to south hydraulic gradient during pre-monsoon and north to south west south (SWS) region during post-monsoon period in the valley area. The hydraulic gradient in the southwestern fringe area is 12 m/km while it is 3.6 m/km in the eastern fringe. The hydraulic gradient in the southern part is 4.4 m/km (along Iril River).

Ground Water Level Conditions: Investigations carried out by CGWB show that groundwater in the near surface aquifer occurs under water table conditions. CGWB has so far established 25 observation net work stations in the state which are being monitored four times a year prior to 1991, since then regular monitoring programme could not continue due to disturbance. The water level in general lies between 1.64 and 4.25 mbgl. In the foot hill areas water level generally rest up to 12 m bgl.

Ground Water Quality: Groundwater in the state of Manipur is in general found to be suitable for domestic and agricultural purposes. However, recent studies have indicated localized higher concentration of iron (Fe) in some pockets of Manipur.

CHAPTER 5

GROUND WATER RESOURCES OF MANIPUR,2024

The assessment of Dynamic Ground Water Resource of Manipur presented in this report is for the groundwater year 2023-2024 as on March 2024. In the present report, the smallest administrative unit viz. block is considered for resources assessment unit (AU). In case of Churachandpur district, Khuga Catchment area (or Khuga valley) covering an area of 321 sq km was considered as the assessment unit.

Area with more than 20% slope has been excluded for the resource assessment (as per GEC 2015). The total area considered for the resources estimation of Manipur state is 2559 sq.km, which covered Imphal West, Imphal East, Thoubal, Bishnupur and parts of Churachandpur district. The remaining four hill districts of Manipur (i.e., Chandel district, Senapati district, Ukhrul district and Tamenglong district) were excluded from the resource assessment. Nine CD blocks were considered for resources assessment for this Assessment Year, 2023-2024 as on March 2024.

Since the poor-quality groundwater is only a localized phenomenon, the block-wise poor-quality area have been taken as Nil. The sub-unit demarcation into command and non-command is not carried out since the data for the same are not available.

Groundwater extraction for domestic use has been estimated based on the number of different types of groundwater abstraction structures and their unit draft per year. The State Government authorities like Minor Irrigation Department, Water Resource Department, Agriculture Department, Soil & Water Conservation, MAHUD, PHED, IPD Wing-PHED, MASTEC, DGM etc. provided the number of groundwater structures.

Groundwater extractions during monsoon and non-monsoon periods have been estimated separately by taking four months as monsoon and eight months as non-monsoon period. The annual unit groundwater extraction has been taken as 1.0 ham for shallow tube wells, considering the average discharge of wells as 15 m^3/hour with two hours pumpage per day.

Block-wise groundwater extraction for irrigation was estimated based on the number of structures as provided by Minor Irrigation Department, Manipur. The unit annual extraction has been taken as 3 hams as given in GEC 2015 for the states of some of the North Eastern States including Manipur. Groundwater used for domestic and irrigational purposes is higher than groundwater extraction for Industrial uses in the state.

The details of canals have been collected from Water Resource Department, Govt of Manipur. All the canals are unlined and the canal seepage factor has been taken as 15 ham/day/million sq.m of wetted area. For estimating the recharge from surface water irrigation, details regarding various major and medium irrigation projects are collected from Water Resource Department, Govt of Manipur.

The return flow factor for surface water irrigation has been taken as 0.50 for paddy and 0.30 for non-paddy, which works out to be 0.374 for the assessment unit as the weighted average of return flow factor as a whole. Return flow factor for groundwater irrigation has been taken as 0.45 for paddy and 0.25 for non-paddy which works out to be 0.292 for the assessment unit as the weighted average of groundwater return flow factor a whole.

Recharge from tanks and ponds and Recharge from water conservation structure have been taken for non-monsoon. Norms recommended by GEC-2015 for Seepage from Tanks & Ponds is 1.4 mm / day. In the absence of water level data, the recharge from rainfall has been calculated using Rainfall Infiltration Factor (RIF). Following the norms recommended by GEC'97 & GEC 2015, Rainfall Infiltration Factor has been taken as 0.12 for Tertiary Sedimentary Formations. The natural discharge during non-monsoon period is taken as 10% since only RIF method is considered.

The population has been projected to 2025 based on decadal growth rate as given in Census of India, 2011. Categorization of assessment units are done based on stage of groundwater development only, since data on long term water level trend is absent.

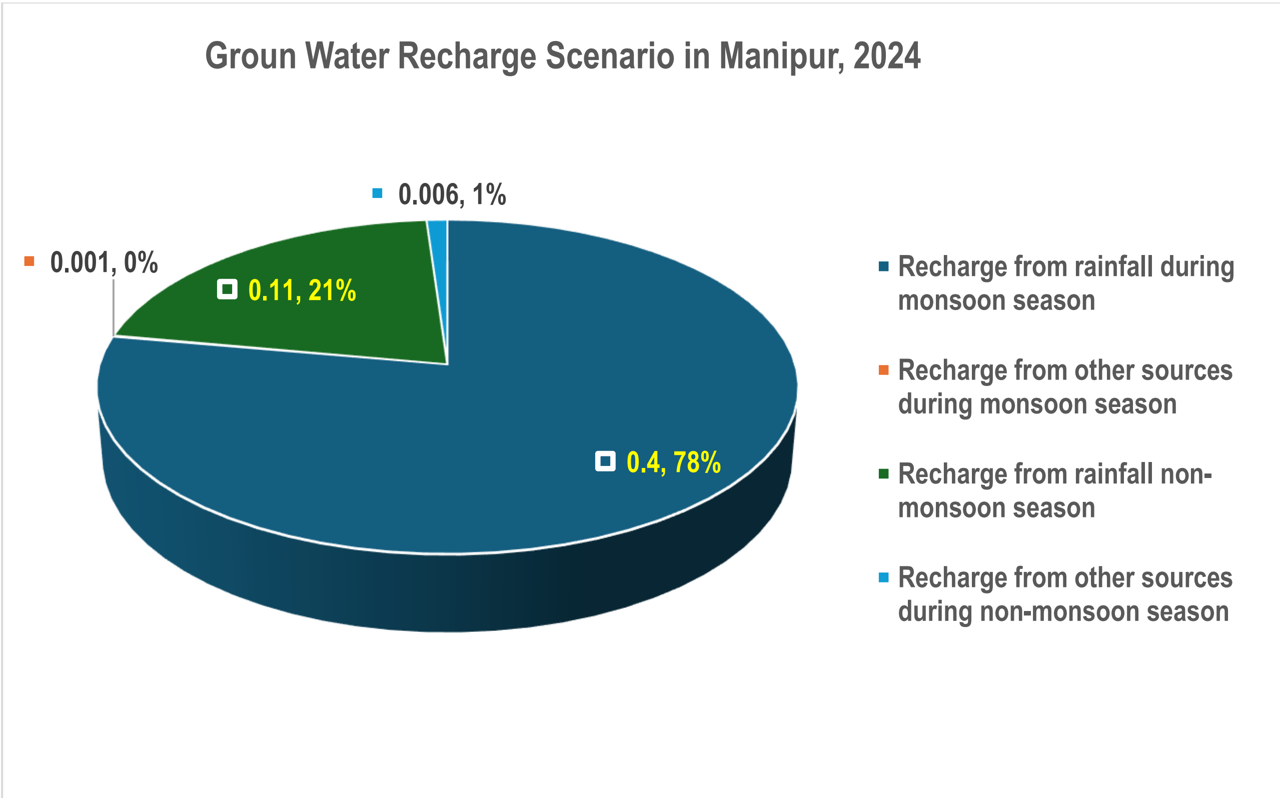
5.1 ANNUAL GROUND WATER RECHARGE

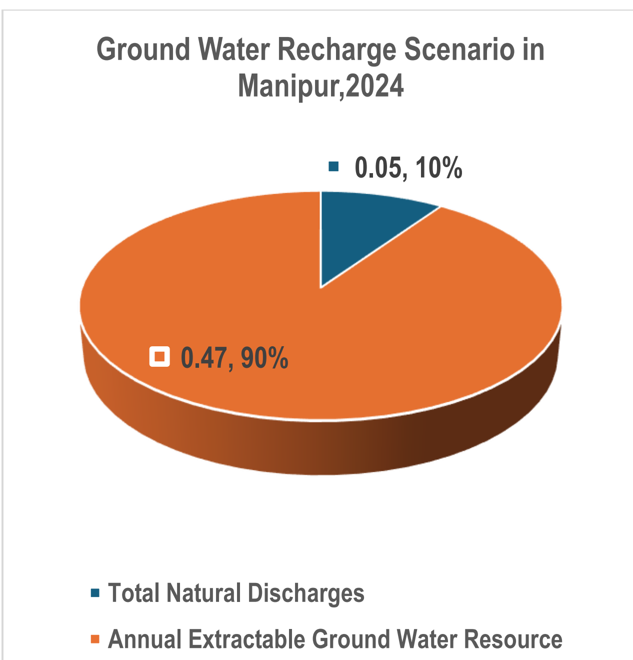
As per the 2024 assessment of Dynamic Ground Water Resources, the Total Annual Ground Water Recharge of Manipur has been assessed as 0.52 billion cubic meter (bcm) and the Annual Extractable Ground Water Resources for the state is 0.47 bcm with total natural discharges at 0.05 bcm.

Rainfall recharge during monsoon and non-monsoon period is the major contributor of total annual groundwater recharge of Manipur, which is 0.51 bcm or 98 % of the total recharge (Monsoon season 78%, non-monsoon season: 22%) and the remaining 2% (Monsoon season: 91%, non-monsoon season:9 %) or 0.011 bcm is from 'Other sources' viz. canal seepage, return flow from irrigation, recharge from tanks, ponds and water conservation structures taken together (***Fig-5.1***). The contribution in annual ground water recharge from rainfall during monsoon season is more than 90% in Manipur (***Fig- 5.2***). The overall contribution of rainfall (both monsoon & non- monsoon) recharge to state's total annual ground water recharge is 98% and the share of recharge from 'Other sources' viz. canal seepage, return flow from irrigation, recharge from tanks, ponds and water conservation structures taken together is 2 %.

Ground Water Resources of Manipur (as in 2024) is given in **Annexure-I** and the district-wise figures are given in **Annexure-II**. The over-all scenario of ground water resource and extraction is given in ***Fig-5.1, 5.2, 5.3, 5.4 & 5.5.***

In order to compare the unit recharge of different assessment units, the volumetric estimates of annual ground water recharge had been converted to depth units (m) by dividing the annual ground water recharge (ha.m) by the area of the respective assessment units (hectare). Spatial variation in annual ground water recharge (m) is shown in **Fig-5.3.** The annual ground water recharge is significantly high in the valley areas, where rainfall is plenty and thick piles of unconsolidated alluvial formations are conducive for recharge. Annual Ground Water Recharge is >0.1 and ≤0.2 m





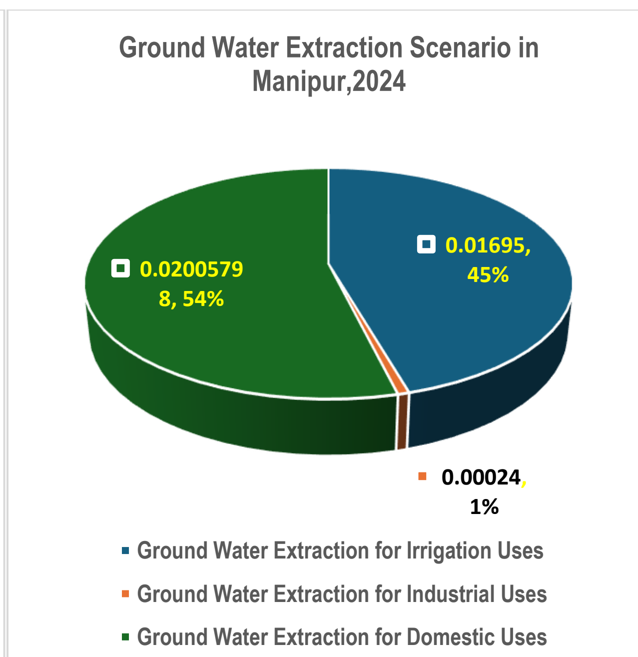


Fig-5.1: Ground Water Resources and Extraction Scenario in Manipur, 2024

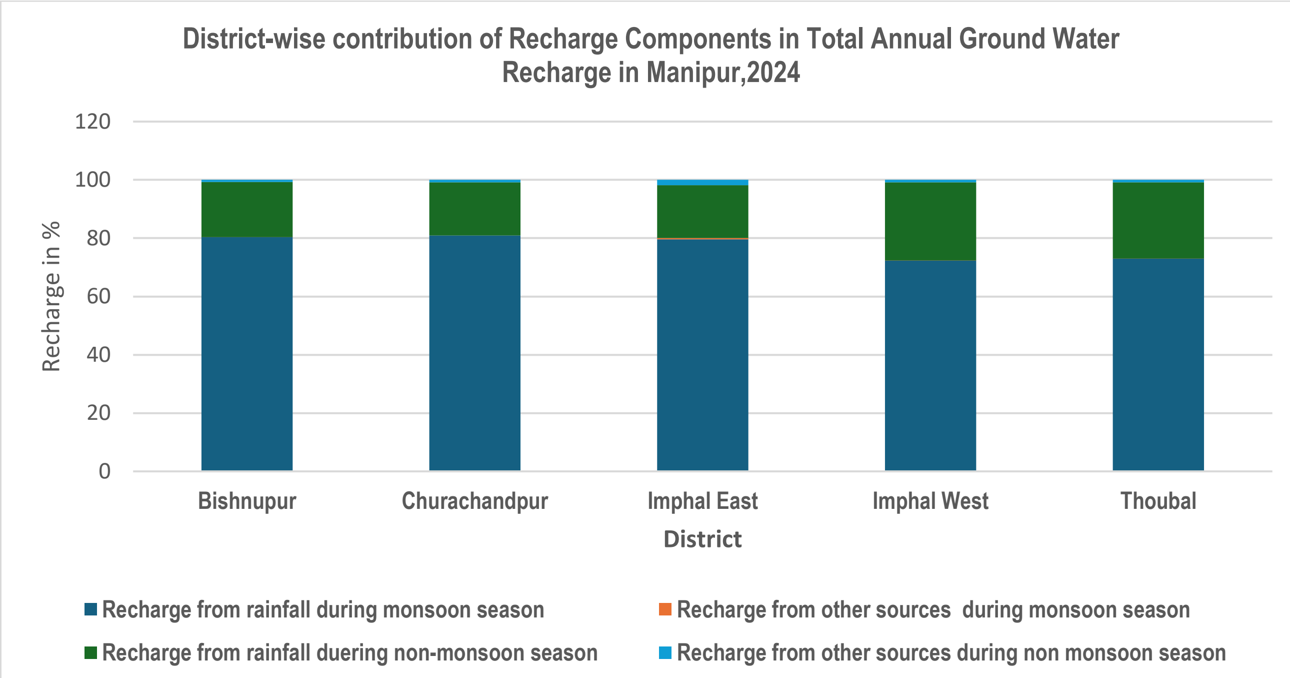


Fig. 5.2 District-wise contribution of Recharge components in Total ground water Recharge in Manipur, 2024

5.2 ANNUAL EXTRACTABLE GROUND WATER RESOURCES

5.2.1 ANNUAL TOTAL GROUND WATER EXTRACTION

The assessment of ground water extraction is carried out considering the Minor Irrigation Census data and sample surveys carried out by the State Ground Water Departments like Minor Irrigation Department, Manipur. The Total Annual Ground Water Extraction of the state for the year 2024 has been estimated as 0.04 bcm. The agriculture sector is one of the largest consumers of groundwater resources, accounting for 50% of the total annual groundwater extraction, which amounts to 0.02 bcm. The domestic use more than 40 % (0.02 bcm), while industrial use is negligible (0.0002 bcm) of total annual groundwater extraction of the State.

5.3 STAGE OF GROUND WATER EXTRACTION

The over-all stage of groundwater extraction of Manipur is 8 %. As such all the assessment units falls under Safe category.

5.4 CATEGORIZATION OF ASSESSMENT UNITS

In the present assessment, the total annual groundwater recharge of Manipur has been assessed as 0.52 bcm. Keeping an allocation for natural discharge, the annual extractable ground water resource has been assessed as 0.47 bcm. The annual groundwater extraction (as in 2024) is 0.04 bcm. The stage of groundwater extraction as a whole works out is 8 %. 100% of the total 9 assessment units (Blocks/ Mandals/ Talukas) in the state are categorized as 'Safe' units, where the stage of Ground water extraction is less than 70 %.

5.5 COMPARIOSN WITH PREVIOUS ASSESSMENT

A comparison is made between the previous assessment as on 2022 and present assessment as on March, 2023 and presented in tabular statement given in table.5.1.

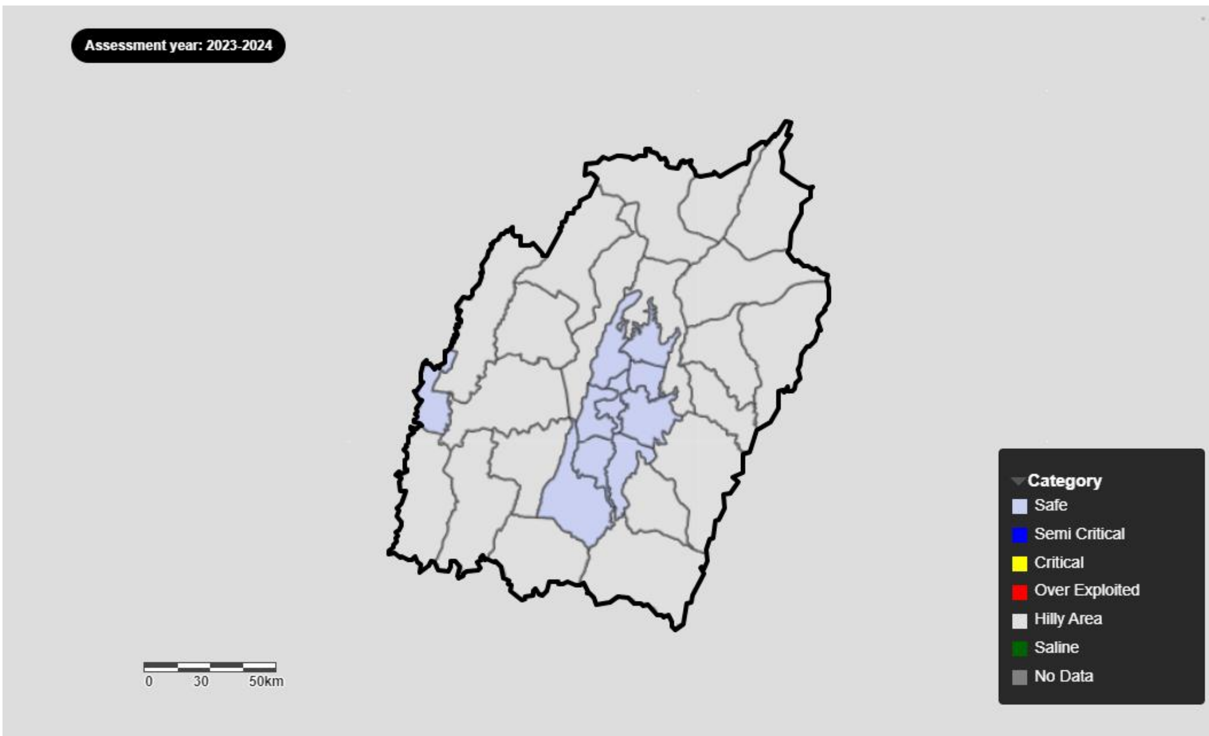
Table 5.1 Comparison between Dynamic Groundwater Resource of Manipur, 2023 and 2024

Sl.No.	Item	Year of Estimation (2023)	Year of Estimation (2024)	Comparison between Dynamic GW Resources estimated in 2023 & 2024
1	2	3	4	5 (4 – 3)
1.	Annual Extractable Ground Water Resource (HAM)	46606.51	46607.54	1.03 (Increase)
2.	Existing Gross Extraction (HAM)	3724.80	3726.96	2.16 (Increase)
A	Irrigation uses (HAM)	1695.00	1695.00	0
B	Domestic uses (HAM)	2005.80	2007.96	2.16 (Increase)
C	Industrial uses (HAM)	24.00	24.00	0
3.	Stage of GW Extraction (%)	7.99	8.00	0.01 (Increase)
4.	Provision for domestic (HAM)	2022.18	2022.18	0
5.	Provision for future use (HAM)	41918.43	42880.57	962.14 (Increase)

INTEGRATION OF GROUND WATER AND SURFACE WATER DATA WITH A VIEW TO FACILITATEPLANNING FOR CONJUNCTIVE USE OF WATER RESOURCES

Assessment of ground water resources is based on the principle of water balance using the equation 'Inflow – Outflow = Change in Storage (of an aquifer)'. Major inflow components include recharge due to rainfall and recharge from other sources. Major outflow component is ground water extraction for domestic, irrigation and industrial uses. Vertical flow across the aquifer system, lateral flow along the aquifer system (through flow), transpiration, evaporation and base flow are other important components.

The area of each assessment unit (block/taluk/mandal/tehsil etc.) is divided into command area and non-command area for the purpose of assessment. If an assessment unit is having more than 100 ha area under major and medium irrigation projects then that much area will be considered as command area. For the command area, along with other data/information pertaining to ground water resource assessment, data/information related to canal flows is collected from the relevant agencies for assessing the recharge from canal seepage. Similarly, data related to irrigation water applied in the assessment area from surface and ground water sources in different seasons are estimated for assessing the return flow from irrigation (return flow factor depends upon depth to water level, paddy/non-paddy crops etc.). Recharge from water bodies/tanks/lakes are assessed in the area based on average water spread area and recharge factor. Recharge from water conservation structures in the area are assessed based on the storage capacity, number fillings and recharge factor. All these data/information are collected/compiled for assessment of ground water resource of the assessment units. Based the ground water resources assessed and surface water sources availability, integrated water resource management plan and planning for conjunctive management of surface and ground water can be devised at block/assessment level by the planners. This data/information collected/compiled for assessment will be very useful for local administrators for managing water resources in a holistic and sustainable manner.



Fi. 5.3 Categorization Map of GWRA 2024 – Manipur

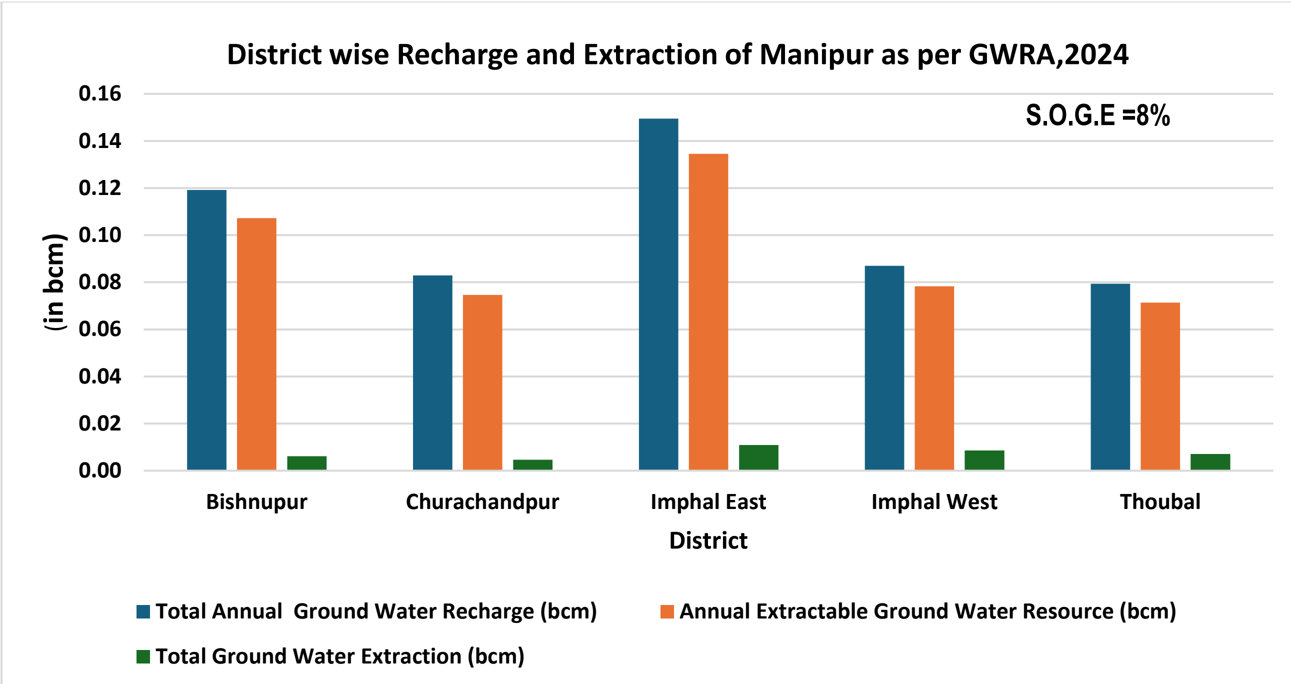


Fig-5.4: State wise % of Groundwater extraction for Irrigation vs. Industrial and Domestic Purposes

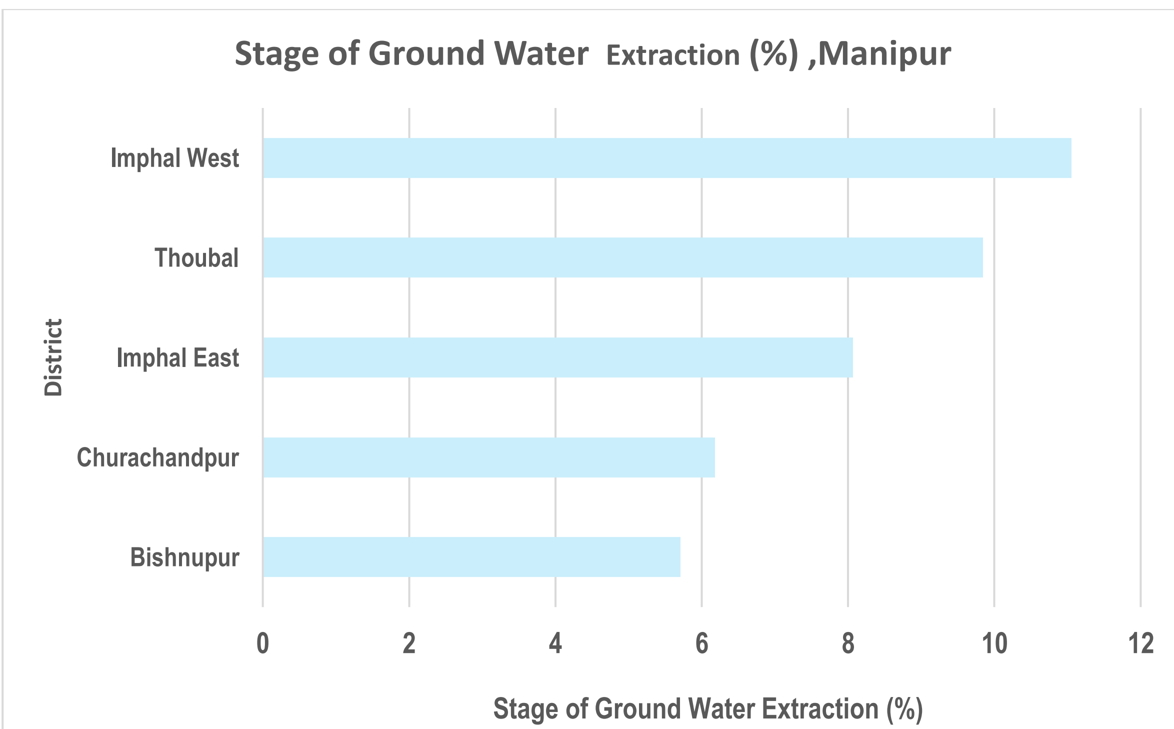


Fig. 5.5 Stage of Extraction of Ground Water of Manipur as per GWRA 2024 for all the districts in Decreasing order

CHAPTER 6

CONCLUSIONS

The Ground Water Resources of Manipur as in 2024 have been assessed block-wise for the recharge worthy area. Total Annual Ground Water Recharge of the State has been assessed as 0.52 bcm and Annual Extractable Ground Water Resources as 0.47 bcm. The Annual Ground Water Extraction is 0.04 bcm and Stage of Ground Water extraction is 8.00 %. All the assessment units have been categorized as 'Safe' and there is no saline area in the state. Out of 9 assessment units 9 units (100 %) as 'Safe' categories of assessment units and there is no saline assessment unit.

Similarly, out of 2559 sq. km recharge worthy area of the State, 2559 sq. km (100 %) under 'Safe' categories of assessment units. Out of total 466.0754 mcm annual extractable ground water resources of the State, 466.0754 mcm (100 %) are under 'Safe' categories of assessment units. The comparison with previous assessment shows there is no major changes in the Ground Water Resources of Manipur.

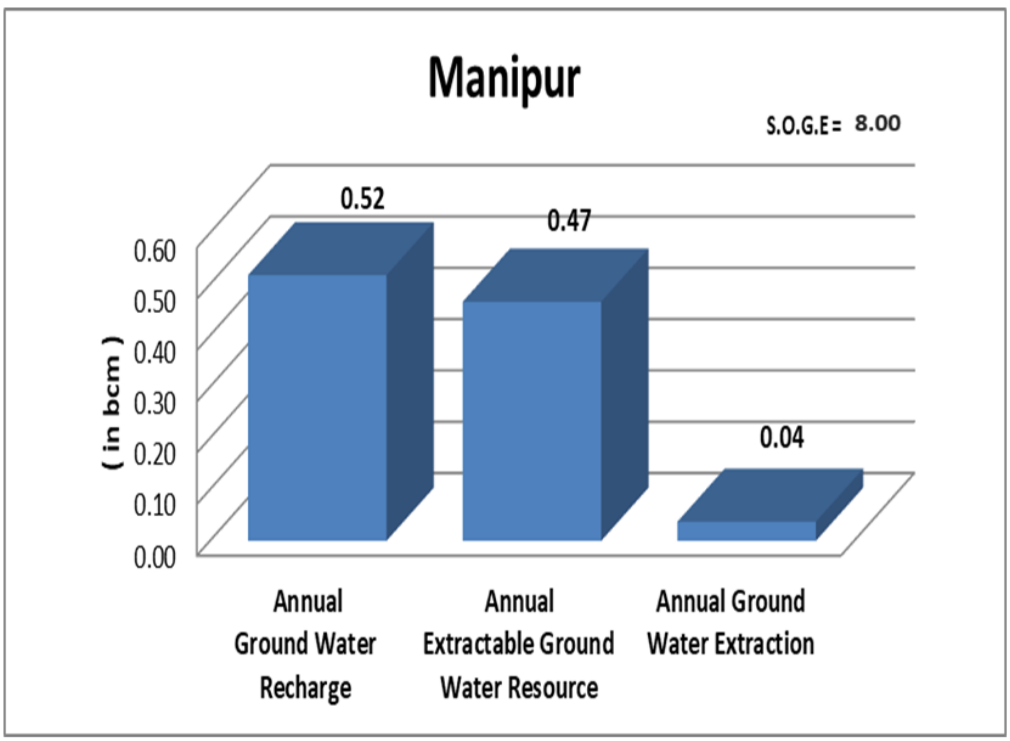


Fig. 6.1 Dynamic Ground Water Recourses Scenario 2024– Manipur

It is also pertinent to add that as it is advisable to restrict 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.

GEC-2015 methodology has been developed for prevalent Indian conditions, on the basis of terrain characteristics and data availability. "INDIA-GROUNDWATER RESOURCE ESTIMATION SYSTEM (INGRES) 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.

An analysis of assessment results leads us to the following inferences as the way forward in the assessment of Ground water resources.

6.1 WATER BALANCE STUDIES

Ground water is one of the several components of the Hydrologic Cycle, other important components being rainfall, surface water, soil moisture and evapotranspiration. Holistic water resources management interventions require proper understanding of the interactions between the different components of the hydrosphere. 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. Initially, the number of such studies can be taken up in areas representing different hydrogeological set up of India (Southern hard rock terrain, Deccan Basaltic terrain, Indo- Gangetic and Brahmaputra alluvial plains, Coastal alluvium, Desert terrain and Himalayan terrain etc.)

6.2 AQUIFER CHARACTERIZATION AND PARAMETER ESTIMATION

One of the key elements that determine the accuracy of ground water resources assessment is the realistic estimation of the recharge and discharge parameters. 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.

6.3 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 analyzed. Such studies would help bring out the efficacy of various management interventions on the ground water regime.

6.4 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).

6.5 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 (in majority of States) 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.

6.6 AQUIFER-WISE ASSESSMENT WITHIN THE PRESENT ADMINISTRATIVE UNITS (ASSESSMENT UNITS) IN AREAS OTHER THAN HARD ROCK TERRAIN

Areas occupied by unconsolidated sediments (alluvial deposits, aeolian deposits, coastal deposits etc.) usually have flat topography and assessment of ground water resources has been carried out taking administrative units (block/mandal/taluk etc.) as assessment units to facilitate the local administration in planning the ground water management programmes (both supply and demand side). However, if more than one hydrogeological/aquifer units (with distinctive characteristics, sustainability and ground water extraction patterns) exist within these administrative units, and then the assessment units could be further divided into smaller units based on hydrogeological/aquifer characteristics. This will lead to more accurate assessment (aquifer wise) of resources and micro-level/area-specific interventions/management measures could be implemented.

6.7 GROUND WATER ASSESSMENT OF DEEPER AQUIFER SYSTEMS IN INDO-GANGETIC, BRAHMAPUTRA AND COASTAL ALLUVIAL TERRAIN

The dynamic ground water resources mainly comprise ground water resources available within the zone of water table fluctuation which are being regularly replenished every year through rainfall and other sources of recharge. This assessment has been carried out and categorization done based on utilization with respect to annual availability of dynamic ground water resources. However, in Indo- Gangetic, Brahmaputra and Coastal Alluvial areas multiple aquifer systems exist (on a regional scale) with sustainable and high yield characteristics. For assessment of deeper aquifers, more studies on individual aquifer potential/sustainable yield along with facilities for monitoring of piezometric heads (by establishing piezometers tapping different aquifer zones) have to be carried out. The resources of deeper aquifer systems could be considered for extraction during exigencies as well as for drinking water purpose for nearby regions.

6.8 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.

6.9 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 in Manipur (as in 2024)

Assessment Unit Name	Recharge from Rainfall-Monsoon Season	Recharge from Other Sources-Monsoon Season	Recharge from Rainfall-Non-Monsoon Season	Recharge from Other Sources-Non-Monsoon Season	Total Annual Ground Water (Ham) Recharge	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Industrial Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Bishnupur	5403.89	0.04	1274.41	56.8	6735.14	673.514	6,061.63	222	0	136.780	358.78	137.42	5,702.85	**5.92**
Moirang	4168.71	0.02	983.12	26.88	5178.73	517.873	4,660.86	105	0	148.10	253.10	153.51	4,407.76	**5.43**
Churachandpur	6707.1	0	1510.99	69	8287.09	828.709	7,458.38	270	0	191.14	461.14	192.05	6,997.24	**6.18**
Imphal East I	3907.69	25.74	891.37	166.56	4991.36	499.136	4,492.22	444	6	362.31	812.31	364.02	3,679.91	**18.08**
Imphal East II	7988.2	37.78	1822.17	108.83	9956.98	995.698	8,961.28	129	6	138.06	273.06	138.73	8,688.22	**3.05**
Imphal West I	3409.43	0	1260.39	33.65	4703.47	470.347	4,233.12	126	6	320.49	452.49	322.01	3,780.63	**10.69**
Imphal West II	2887.7	0.01	1067.52	40.68	3995.91	399.591	3,596.32	159	6	247.88	412.88	249.05	3,183.44	**11.48**
Kakching	2143.88	0.01	767.17	41.42	2952.48	295.248	2,657.23	162	0	148.65	310.65	149.35	2,346.58	**11.69**
Thoubal	3655.89	0.01	1308.23	20.86	4984.99	498.499	4,486.49	78	0	314.55	392.55	316.04	4,093.94	**8.75**
Total in (HAM)	**40272.49**	**63.61**	**10885.37**	**564.68**	**51786.15**	**5178.615**	**46,607.54**	**1695**	**24**	**2007.96**	**3726.96**	**2022.18**	**42,880.57**	**8.00**
Total in BCM	**0.40**	**0.000636**	**0.11**	**0.006**	**0.52**	**0.05**	**0.47**	**0.02**	**0.00024**	**0.02**	**0.04**	**0.02**	**0.43**	

Annexure-II

District-wise Ground Water Resources Availability, Utilization and Stage of Extraction in Manipur (as in 2024)

S. No.	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	Bishnupur	9572.60	0.06	2257.53	83.68	11913.87	1191.387	10,722.48	327	0.00	284.88	611.88	290.93	10,110.60	5.71
2	Churachandpur	6707.10	0.00	1510.99	69.00	8287.09	828.709	7,458.38	270	0.00	191.14	461.14	192.05	6,997.24	6.18
3	Imphal East	11895.89	63.52	2713.54	275.39	14948.34	1494.834	13,453.51	573	12.00	500.371	1085.37	502.75	12,368.14	8.07
4	Imphal West	6297.13	0.01	2327.91	74.33	8699.38	869.938	7,829.44	285	12.00	568.37	865.37	571.06	6,964.07	11.05
5	Thoubal	5799.77	0.02	2075.40	62.28	7937.47	793.747	7,143.72	240	0.00	463.20	703.20	465.39	6,440.52	9.84
	Total (Ham)	**40272.49**	**63.61**	**10885.37**	**564.68**	**51786.15**	**5178.615**	**46,607.54**	**1695**	**24.00**	**2007.96**	**3726.9609**	**2022.18**	**42,880.57**	**8.00**
	Total (BCM)	**0.4027**	**0.0006**	**0.1089**	**0.0056**	**0.5179**	**0.0518**	**0.4661**	**0.0170**	**0.0002**	**0.0201**	**0.0373**	**0.0202**	**0.4288**	

Annexure-III(A)

Categorization of blocks/ mandals/ taluks (as in 2024) for the State of Manipur

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024													
MANIPUR													
S.No.	States/Union Territories	Total No. of Assessed Units	Safe		Semi-Critical		Critical		Over-Exploited		Saline		
			Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%	
1	Manipur	9	9	100%	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
	Grand Total	9	9	100%	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	

Annexure III (B)

District Wise Categorization of blocks/ mandals/ taluks for the State/UT (as in 2024)

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024														
MANIPUR														
S.No	Name of District	Total No. Of Assessed Units	Safe		Semi-Critical		Critical		Over-Exploited		Saline			
			No.	%	No.	%	No.	%	No.	%	No.	%		
1	Bishnupur	2	2	100%										
2	Churachandpur	1	1	100%										
3	Imphal East	2	2	100%										
4	Imphal West	2	2	100%										
5	Thoubal	2	2	100%										
	Total	**9**	**9**	**100%**										

Annexure III (C)

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

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024													
MANIPUR													
S.No	State/Union Territories	Total Annual Extractable/ Replenishable Resource of Assessed Units (in mcm)	Safe		Semi-Critical		Critical		Over-Exploited		Saline		
			Total Annual Extractable/ Replenishable Resource (in mcm)	%	Total Annual Extractable/ Replenishable Resource (in mcm)	%	Total Annual Extractable/ Replenishable Resource (in mcm)	%	Total Annual Extractable/ Replenishable Resource (in mcm)	%	Total Annual Extractable/ Replenishable Resource (in mcm)	%	
1	**Manipur**	466.0754	466.06509	100%									
	Grand Total (in mcm)	466.0754	466.06509	100%									

Annexure- III (D)

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

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024													
MANIPUR													
S.No	Name of District	Total Annual Extractable/ Replenishable Resource of Assessed Units (in mcm)	Safe		Semi-Critical		Critical		Over-Exploited		Saline		
			Annual Extractable/ Replenishable Resource (in mcm)	%	Annual Extractable/ Replenishable Resource (in mcm)	%	Annual Extractable/ Replenishable Resource (in mcm)	%	Annual Extractable/ Replenishable Resource (in mcm)	%	Annual Extractable/ Replenishable Resource (in mcm)	%	
1	Bishnupur	107.2248	107.2248	100%									
2	Churachandpur	74.5838	74.5838	100%									
3	Imphal East	134.5351	134.5351	100%									
4	Imphal West	78.2944	78.2944	100%									
5	Thoubal	71.4372	71.4372	100%									
	Grand Total (in mcm)	**466.0754**	**466.0754**	100%									

Annexure- III (E)

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

AREA OF ASSESSMENT UNITS UNDER DIFFERENT CATEGORIES IN INDIA (2024)													
MANIPUR													
S.No.	States / Union Territories	Total Recharge Worthy Area of Assessed Units (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	Manipur	2559	2559	100%								
	Total (in sq.km)	2559	2559	100%								

Annexure III (F)

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

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024												
MANIPUR												
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	Bishnupur	496	496	100%								
2	Churachandpur	321	321	100%								
3	Imphal East	709	709	100%								
4	Imphal West	519	519	100%								
5	Thoubal	514	514	100%								
	Total (Sq.km)	2559	2559	100%								

Annexure IV (A)

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

CATEGORIZATION of ASSESSMENT UNITS, 2024							
MANIPUR: ALL ARE SAFE							
S. No	Name of District	S. No	Name of Semi-Critical Assessment Unit	S. No	Name of Critical Assessment Unit	S. No	Name of Over-Exploited Assessment Unit
	1	1		1		1	
		2				2	
						3	
						4	
ABSTRACT							
Total No. of Assessed Units		Number of Semi critical Assessment Unit		Number of Critical Assessment Unit		Number of Over Exploited Assessment Unit	

Annexure IV (B)

Quality problems in Assessment units (as in 2024)

QUALITY PROBLEMS IN ASSESSMENT UNITS, 2024							
MANIPUR: NIL FOR ALL DISTRICTS							
S. No	Name of District	S. No	Name of Assessment Unit affected by Fluoride	S. No	Name of Assessment Unit affected by Arsenic	S. No	Name of Assessment Unit affected by Salinity
1		1		1		1	
		2		2			
				3			
ABSTRACT							
Total No. of Assessed Units		Number of Assessment Unit affected by Fluoride		Number of Assessment Unit affected by Arsenic		Number of Assessment Unit affected by Salinity	

Annexure IV (C)

List of Saline Assessment units: NOT APPLICABLE

Annexure V (A)

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

MANIPUR							
S.No	Name of States / Union Territories	Total Number of Assessment Units Improved	Number of Assessment Units Improved	Number of Assessment Units Deteriorated	Number of Assessment Units with No Change	Number of Assessment Units Newly formed or Previous Assessment Units Reorganized	Remarks if any
		1+2+3+4	1	2	3	4	
1	Manipur						No Change

Annexure V (B)

Comparison of categorization of assessment units (2023 to 2024)

COMPARISON OF CATEGORIZATION OF ASSESSMENT UNITS (2023 & 2024)									
MANIPUR									
S.No	Name of District	Name of Assessment Unit	Stage of Ground Water Extraction (%) 2023	Categorization in 2023	Name of District	Name of Assessment Unit	Stage of Ground Water Extraction (%) 2024	Categorization in 2024	Remark
1	Bishnupur	Bishnupur	5.92	Safe	Bishnupur	Bishnupur	5.92	Safe	Improved
2	Bishnupur	Moirang	5.39	Safe	Bishnupur	Moirang	5.43	Safe	Improved
3	Churachanpur	Churachandpur	6.18	Safe	Churachanpur	Churachandpur	6.18	Safe	Improved
4	Imphal East	Imphal East I	18.09	Safe	Imphal East	Imphal East I	18.08	Safe	Improved
5	Imphal East	Imphal East II	3.05	Safe	Imphal East	Imphal East II	3.05	Safe	Improved
6	Imphal West	Imphal West I	10.69	Safe	Imphal West	Imphal West I	10.69	Safe	Improved
7	Imphal West	Imphal West II	11.48	Safe	Imphal West	Imphal West II	11.48	Safe	Improved
8	Thoubal	Kakching	11.69	Safe	Thoubal	Kakching	11.69	Safe	Improved
9	Thoubal	Thoubal	8.75	Safe	Thoubal	Thoubal	8.75	Safe	Improved
10			**7.99**	Safe			**8.00**	Safe	Improved

Annexure VI

Assessment Unit Wise Report (Attribute Table)

Sl.No	State_code	State_District_Code	State_District_Block_Code	State	District	Assessment Unit Name	Assessment Unit Type	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)	Irrigation Use (Ham)	Industrial Use (Ham)	Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (OE/Critical/Semicritical/Safe)	Bo_Aquifer
1	MN	MN03	MN030100	MANIPUR	HURACHANPU	HURACHANDPUI	BLOCK	59000	32100	6707.1	0	1511	69	8287.09	828.71	7458.38	270	0	191.144295	461.14	192.05	6996.33	6.182844	safe	30
2	MN	MN03	MN030400	MANIPUR	CHURACHANP	THANLON	BLOCK	106300	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	0
3	MN	MN03	MN030500	MANIPUR	CHURACHANP	CHURACHANDPU	BLOCK	82500	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	0
4	MN	MN03	MN030600	MANIPUR	CHURACHANP	SINGNGAT	BLOCK	97700	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	0
5	MN	MN03	MN030700	MANIPUR	CHURACHANP	TIPAIMUKH	BLOCK	111500	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	0
6	MN	MN07	MN070100	MANIPUR	TAMENGLONG	NUNGBA	BLOCK	107600	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	0
7	MN	MN07	MN070300	MANIPUR	TAMENGLONG	TAMENGLONG	BLOCK	85800	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	0
8	MN	MN07	MN070500	MANIPUR	TAMENGLONG	TAMENGLONG N	BLOCK	119400	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	0
9	MN	MN07	MN070600	MANIPUR	TAMENGLONG	TAMENGLONG W	BLOCK	126300	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	0
10	MN	MN04	MN040100	MANIPUR	IMPHAL EAST	IMPHAL EAST I	BLOCK	23290	23290	3907.7	25.74	891.37	166.56	4991.36	499.13	4492.23	444	6	362.312505	812.31	364.02	3678.21	18.0825559	safe	23
11	MN	MN04	MN040200	MANIPUR	IMPHAL EAST	IMPHAL EAST II	BLOCK	47610	47610	7988.2	37.78	1822.2	108.83	9956.98	995.7	8961.28	129	6	138.080595	273.08	138.73	8687.55	3.04733252	safe	20
12	MN	MN02	MN020200	MANIPUR	CHANDEL	CHANDEL	BLOCK	68700	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	0
13	MN	MN02	MN020100	MANIPUR	CHANDEL	CHAKPIKARONG	BLOCK	141300	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	0
14	MN	MN02	MN020300	MANIPUR	CHANDEL	TENGNOUPAL	BLOCK	121300	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	0
15	MN	MN01	MN010200	MANIPUR	BISHNUPUR	MOIRANG	BLOCK	21600	21600	4168.7	0.02	983.12	26.88	5178.73	517.87	4660.86	105	0	148.099845	253.1	153.51	4402.35	5.43032831	safe	20
16	MN	MN01	MN010100	MANIPUR	BISHNUPUR	BISHNUPUR	BLOCK	28000	28000	5403.9	0.04	1274.4	56.8	6735.14	673.51	6061.63	222	0	136.775355	358.77	137.42	5702.22	5.91870503	safe	27
17	MN	MN09	MN090200	MANIPUR	UKHRUL	KAMJONG	BLOCK	110400	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	0
18	MN	MN09	MN090400	MANIPUR	UKHRUL	PHUNGYAR PHA	BLOCK	67900	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	0
19	MN	MN09	MN090600	MANIPUR	UKHRUL	UKHRUL CENTR	BLOCK	119800	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	0
20	MN	MN09	MN090700	MANIPUR	UKHRUL	UKHRUL NORTH	BLOCK	100800	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	0
21	MN	MN09	MN090800	MANIPUR	UKHRUL	UKHRUL SOUTH	BLOCK	55500	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	0
22	MN	MN08	MN080200	MANIPUR	THOUBAL	THOUBAL	BLOCK	32400	32400	3655.9	0.01	1308.2	20.85	4984.98	498.5	4486.48	78	0	314.55408	392.55	316.04	4092.44	8.74962108	safe	25
23	MN	MN08	MN080100	MANIPUR	THOUBAL	KAKCHING	BLOCK	19000	19000	2143.9	0.01	767.17	41.42	2952.48	295.25	2657.23	162	0	148.65063	310.65	149.35	2345.88	11.6907456	safe	30
24	MN	MN06	MN060300	MANIPUR	SENAPATI	PAOMATA	BLOCK	53600	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	0
25	MN	MN06	MN060200	MANIPUR	SENAPATI	MAO-MARAM	BLOCK	103700	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	0
26	MN	MN06	MN060500	MANIPUR	SENAPATI	SADAR HILLS W	BLOCK	76500	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	0
27	MN	MN06	MN060600	MANIPUR	SENAPATI	SADAR HILLS E	BLOCK	93300	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	0
28	MN	MN05	MN050200	MANIPUR	IMPHAL WEST	IMPHAL WEST I	BLOCK	23800	23800	2887.7	0.01	1067.5	40.68	3995.91	399.59	3596.32	159	6	247.87515	412.87	249.05	3182.28	11.4803466	safe	20
29	MN	MN05	MN050100	MANIPUR	IMPHAL WEST	IMPHAL WEST I	BLOCK	28100	28100	3409.4	0	1260.4	33.65	4703.47	470.34	4233.13	126	6	320.49336	452.49	322.01	3779.12	10.6892536	safe	25

Annexure VII

MINUTES OF THE MEETING OF THE STATE LEVEL COMMITTEE (SLC) ON DYNAMIC GROUND WATER RESOURCE ASSESSMENT OF MANIPUR AS ON MARCH 2024

(Meeting platform: Online Mode)

Date 27th August 2024 Time: 11.00 Hrs.

A meeting of State Level Committee (SLC) on Dynamic Ground Water Resource Assessment of Manipur as on March 2024 was convened on 27th August 2024 at 11.00 hrs through online mode.

The meeting was chaired by Sri Ningthoujam Geoffrey, IAS, Commissioner, Minor Irrigation, Govt. of Manipur & Chairman of SLC. The Chairman of the SLC welcomed all the members of SLC present in the meeting. List of members attended in the meeting is enclosed as Annexure-I.

Shri Tapan Chakraborty, Regional Director, CGWB, NER & Member Secretary, SLC welcomed all the representative members of the SLC. He highlighted that Ground Water Resources of Manipur has been carried out jointly by Central Ground Water Board, NER and Minor Irrigation Department, Manipur (State Nodal Department) in coordination with other members/departments of SLC.

Dr. S S Singh, Scientist-D(Hg) & OIC-GWRA of CGWB, NER briefed about computation of dynamic ground water resources of Manipur through IN-GRES software. Groundwater Resources Estimation System (IN-GRES)" is a software/web-based application developed by CGWB in collaboration with Vassar Lab, IIT-Hyderabad.

With due permission of the Chair, a PPT presentation on "Dynamic Groundwater Resources of Manipur as on March 2024" was made by Dr. S S Singh, Scientist-D, CGWB, NER, Guwahati.

As desired by the Chair, committee members of SLC discussed in detail on the methodology of resource estimation, various factors utilized / considered as per norm or otherwise, source of various field data utilized for resource calculation etc. SLC has agreed to update assessment of GWRA of Manipur by taking into consideration of all newly created rechargeable districts/blocks in GWRA 2025.

On the request of CGWB, the state nodal department has agreed to provide the shape files, data etc. of the newly created districts/blocks at earliest possible for inclusion in GWRA 2025. Groundwater extraction structures for domestic use to be shared by PHED, Manipur for updating in the resource estimation.

After thorough discussion all the members of the State Level Committee (SLC) has agreed and approved the Dynamic Ground Water Resources of Manipur for the Assessment Year 2023-24 as on March 2024.

The meeting was ended with the vote of thanks by Dr. S S Singh, Scientist-D(Hg) & OIC-GWRA of CGWB, NER, Guwahati.

Sd/-

Sri Ningthoujam Geoffrey, IAS
Commissioner (MI), Govt. of Manipur& Chairman, SLC

(Sri Tapan Chakraborty)
Regional Director, CGWB NER& Member Secretary, SLC

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ABBREVIATIONS

CGWA	Central Ground Water Authority
CGWB	Central Ground Water Board
Bcm	Billion cubic meter
CLEG	Central Level Expert Group for overall reassessment of groundwater resource of the country
GEC-1997	Ground Water Resources Estimation Committee, 1997
GEC-2015	Ground Water Resources Estimation Committee, 2015
GWRA	Ground Water Resources Assessment
ham	Hectare metre
IMD	India Meteorological Department
IN-GRES	India Groundwater Resource Estimation System
lps	Litres per second
m	Meter
m bgl	Meter below ground level
mcm	Million cubic metre
M.I. D	Minor Irrigation Department
DOWR,	Department of Water Resources, River Development & Ganga
RD & GR	Rejuvenation, Ministry of Jal Shakti, Govt. of India
NAQUIM	National Aquifer Mapping & Management Programme
PHED	Public health Engineering Department
SLC(GWRA)	State level Committee on Ground Water resource Assessment
UT	Union Territory
WRD	Water Resource Department

CONTRIBUTORS

The computation of Dynamic Ground water Resources of Manipur for the Assessment Year 2023-24 as in 2024 has been carried out jointly by Central Ground Water Board, North Eastern Region and Minor Irrigation Department, the State Nodal Department of Ground Water (Manipur) as per the Ground Water Estimation Committee-2015 (GEC-2015) methodology under the guidance of the State Level Committees (SLC) and overall supervision of Central Level Expert Group (CLEG). Field data generated by CGWB and statistical information/data generated/compiled by State Departments like, Minor Irrigation Department, Directorate of Economic & Statistics, Water Resource Department, Public Health & Engineering Department, Department of Industries & Commerce Department of Agriculture; Department of Horticulture & Soil Conservation, MAHUD, NABARD, IMD, CWC, Brahmaputra Board, NIH etc. The assessment of and compilation of the report was carried out by Dr. Sorokhaibam Somarendro Singh, Scientist-D, CGWB, NER, Guwahati with the team of R.K Dipankar Slam, Chief Engineer, Minor Irrigation Department under the able guidance of Sri Tapan Chakraborty, Regional Director, CGWB, NER and Ningthoujam Geoffrey, Commissioner, Minor Irrigation Department, Govt. of Manipur

Principal Contributors:

1. Dr. Sorokhaibam Somarendro Singh, Scientist-D, CGWB, NER, Guwahati
2. Himangshu Kachari, Scientist-B, CGWB, NER, Guwahati

Contributors:

1. R.K. Dipankar Salam, Chief Engineer, Minor Irrigation Department, Manipur
2. Biplab Ray, Scientist-D, CGWB, NER, Guwahati
3. Dhrubajyoti Khanikar, Scientist-D, CGWB, NER, Guwahati
4. Dr. D J Khound, Scientist-D, CGWB, NER, Guwahati
5. C K Gogoi, Scientist-C, CGWB, NER, Guwahati
6. All members/departments of SLC on GWRA of Manipur,2024

Team CGWB, CHQ:

1. Shri. S. N. Dwivedi, Scientist-D & Director (Admin), Central Ground Water Board, CHQ, Faridabad.
2. Shri. Sujatro Ray Chowdhuri, Scientist-C, Central Ground Water Board, CHQ, Faridabad.
3. Miss. Subhra Satapathy, Scientist-C, Central Ground Water Board, CHQ, Faridabad.

Team INGRES:

1. Dr KBVN Phanindra, Professor, IIT Hyderabad
2. Sh M. Prem Chand, Research Scholar, IIT Hydreabad

Overall Guidance & Supervision:

1. Dr. Sunil Kumar Ambast, Chairman, Central Ground Water Board, CHQ, Faridabad.
2. Mrs. T. S. Anitha Shyam, Member South, Central Ground Water Board, CHQ, Faridabad.
3. Sri N Varadaraj, Member (East), Central Ground Water Board, CHQ, Faridabad
4. Ningthoujam Geoffrey, IAS, Commissioner, MI to the Govt. of Manipur
5. Sri Tapan Chakraborty, Regional Director, CGWB, NER, Guwahati