DYNAMIC GROUND WATER RESOURCES OF MEGHALAYA, 2024

Central Ground Water Board

Department of Water Resources,

River Development & Ganga Rejuvenation

Ministry of Jal Shakti

Government of India

Meghalaya

January, 2025

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Foreword

Groundwater is a vital resource for providing drinking water, supporting agricultural productivity, sustaining industrial growth, and serving as a crucial component of our ecological system. However, rising water demand has led to excessive groundwater extraction and, at times, unregulated exploitation. To ensure the sustainability of this critical resource, it is essential to plan and implement effective management strategies and regulatory measures. As the saying goes, "We can only manage what we can measure," emphasizing the importance of accurate monitoring and assessment in groundwater management.

The annual dynamic groundwater resources of Meghalaya, 2024 have 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 Meghalaya, 2024 is a collaborative effort of Water Resource Department (State Nodal Department), Government of Meghalaya and the Central Ground Water Board, State Unit Office, Shillong. 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 extend my heartfelt congratulation to the CGWB, SUO, Shillong and Water Resources Department, the State Nodal Department for their pivotal role in compiling this report, and in conducting and completing this assessment. I also commend the State Level Committee on Ground Water Resources (SLCGWRA), Meghalaya, for their invaluable contributions and guidance in ensuring the timely completion and compilation of this assessment. I am confident that this comprehensive report will serve as an important document for planners, decision-makers, and stakeholders, fostering the sustainable use and management of groundwater in Meghalaya.

Shillong
January 2025

Dr. Shakil P. Ahammed, IAS
Addl. Chief Secretary, Govt. of Meghalaya
&
Chairman, State Level Committee
(GWRA),
Meghalaya

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

Message

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 **Meghalaya, 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 **Meghalaya** 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 **Meghalaya** 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 **Meghalaya** 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 (South)

Sri N Varadaraj
Member (East)

भारत सरकार
जल शक्ति मंत्रालय
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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 Meghalaya 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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Faridabad
January, 2025

(N Varadaraj)
Member (East)

तपन चक्रवर्ती
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Regional Director

भारतसरकार
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Dept. of Water Resources, RD & GR
Central Ground Water Board
North Eastern Region

PREFACE

Meghalaya is a land with hilly terrain and fast flowing streams. The state receives abundant rainfall during monsoon season, yet there is acute scarcity of water during summer as the major part of rainfall is lost as surface run-off. Development of ground water in the State is negligible. With rapid growth in population in the state the demand of drinking as well as domestic water requirement is increasing by leaps and bound; particularly, in urban areas.

For sustainable development of ground water resource, precise estimation of ground water resource is essential, so that it reflects the actual ground water scenario. Moreover, distribution of ground water resources in the state is not uniform due to its geological and topographical conditions.

The current Dynamic Ground Water Resource Potential of the state has been done based on the latest methodology as recommended by Ground Water Resource Estimation Committee-2015(GEC-2015) and duly approved by Govt. of India. The assessment was jointly carried out by Water Resources Department, Government of Meghalaya and team of officers of Central Ground Water Board, State Unit Office, Shillong.

The present report is based on the field data generated by Central Ground Water Board and statistical information collected from other State Departments. The annual ground water recharge, net ground water availability and existing gross extraction on irrigation and domestic uses, etc, have been estimated for the state. The report also highlights on the net annual ground water availability for future use.

As per present assessment total annual ground water recharge in the state of Meghalaya is 1.86BCM. The Annual Extractable Ground Water Resources of the state is 1.53 BCM after deducting the natural discharge. Present Ground Water Extraction is 0.07 BCM out of which 0.02446 BCMextraction is on account of irrigation, 0.000252 BCM is on account of Industrial extraction and the annual domestic extraction is 0.04573 BCM. The annual allocation for Domestic use has been made as 0.05 BCM based upon the population data projected upto year 2025. The over-all stage of ground water extraction of the state is 4.60%.

This report, with its comprehensive technical data, offers valuable insights into the current groundwater scenario in Meghalaya State. It will serve as a crucial resource for policymakers, technical experts, professionals, and user agencies, enabling them to manage groundwater development in a planned and sustainable manner.

(Tapan Chakraborty)
Regional Director
CGWB, NER, Guwahati

DYNAMIC GROUND WATER RESOURCES OF MEGHALAYA, 2024

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DYNAMIC GROUND WATER RESOURCES OF MEGHALAYA, 2024

AT A GLANCE

1.	Total Annual Ground Water Recharge	: 1.86 BCM
2.	Annual Extractable Ground Water Resources	: 1.53 BCM
3.	Annual Ground Water Extraction	: 0.07 BCM
4.	Stage of Ground Water Extraction	: 4.60 %

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	40	100	0.0813	100	1.53	100
2	Semi Critical						
3	Critical						
4	Over-Exploited						
5	Saline						
	TOTAL	40	100	0.0813	100	1.53	100

EXECUTIVE SUMMARY

The dynamic ground water resources of Meghalaya state has been re-estimated jointly by Central Ground Water Board and Water Resources Department, Govt. of Meghalaya based on GEC 2015 methodology for the assessment year 2023-24. This assessment is carried out at periodical intervals under the guidance of the State Level Committee on Ground Water Resources Meghalaya and under the overall supervision of the Central Level Expert Group (CLEG). Such joint exercises have been taken up earlier in 1980, 1995, 2004, 2009, 2011, 2013, 2017, 2020, 2022, and 2023. From the year 2022, the exercise is being carried out annually. The assessment involves computation of dynamic ground water resources or Annual Extractable Ground Water Resource, Total Current Annual Ground Water Extraction (utilization) and the percentage of utilization with respect to annual extractable resources (stage of Ground Water Extraction).

The state of Meghalaya covers a total geographical area of 22,429 Sq.km. There are twelve districts in the state. The State capital is Shillong. As per 2011 census, the state has a population of 29,66,889. The state receives heavy rainfall under the influence of SW monsoon and occasionally in winter. Copious rainfall is received in certain parts of the states. However, rainfall varies from place to place and altitude to altitude.

The state is essentially underlain by hard and massive rocks belonging to the Archaean Gneissic complex with acid and basic intrusive, and Precambrian Shillong Group of rocks. The unconsolidated occur mostly along extreme north-western fringe of the state in South West Garo Hills and West Garo Hills district. Major part of state is occupied by hilly terrain (64% approx.).The aquifer system in the state can be divided as two aquifer systems, viz., first aquifer (shallow) and second aquifer (deeper). Shallow or first aquifer consists of weathered residuum where ground water occurs under water table condition and is mainly developed through construction of dug wells. The second aquifer is the deeper aquifer which tapped the fractured zone and is mainly developed through borewells. Based on the study of litholog and analysis of depth of construction of dug wells and bore wells, it is found that the first aquifer occur within depth of 20 to 40 m. Ground water in the second aquifer occurs under semi-confined to confined condition in the fractures upto the maximum explored depth of 280m. The south-western, southern and south-eastern parts of the state is covered by semi- consolidated formations comprising sandstones, shales, conglomerates, limestones etc. belonging to Cretaceous – Tertiary age. The aquifers are formed by rock strata that are *granular/porous, fissured/fractured or cavernous. These aquifers are thick and discontinuous in nature. The unconsolidated sediments comprising sand, gravel, silt, clay, etc. are found to occur as thin veneer along rivulets and as valley-fills.*

In the current assessment year, both pre and post monsoon depth to water level in the state was found within 10 mbgl. No significant decline in ground water level trend had been observed. Chemical Quality of groundwater is generally good and suitable for domestic, irrigation and industrial uses. However, presence of high fluoride content is found in pockets.

Assessment of Dynamic Ground Water Resources of the state has been done for 40 assessment units. The assessment has been carried out block-wise (39 Nos.). Apart from that, Greater Shillong Area has also been taken as one assessment unit. The recharge worthy area of the state is only 8135.45 sq.km.

The total annual ground water recharge in the state has been assessed as 1.86BCM. The Annual Extractable Ground Water Resources of the state is 1.53 BCM after deducting the natural discharge. Present Ground Water Extraction is 0.07 BCM out of which 0.02446 BCM extraction is on account of irrigation, 0.000252 BCM is on account of Industrial extraction and the annual domestic extraction is 0.04573 BCM. The annual allocation for Domestic use has been made as 0.05 BCM based upon the population data projected upto year 2025. The over-all stage of groundwater extraction of the state is 4.60%.

As compared to 2023 assessment, the Annual Ground Water Recharge has increased from 1.83 to 1.86bcm during 2024 assessment, Annual Extractable Ground Water Resources has increase from 1.51 to 1.53 bcm. The reasons can be attributed to increase in recharge from rainfall and other sources. The Ground Water Extraction has increased minutely. Therefore, Stage of ground water extraction has slightly increased from 4.58 % to 4.60 %.

CHAPTER 1

INTRODUCTION

The state of Meghalaya comprising twelve districts covers an area of 22,429 sq. km. The state is basically a hilly terrain with rolling hill ranges, tablelands and narrow ravines. As per 2011 Census, the total population of the State is 29,66,889 as against 23,18,822 in 2001 Census and 17,74,778 in 1991. The population Density is 132 persons per sq. km and decadal growth is 27.95 percent (2001 census).

Agriculture is the main livelihood of the people of the states and 80% (approx.) of the total population depend upon on agriculture.

The state is essentially underlain by hard and massive rocks belonging to the Archaean Gneissic complex with acid and basic intrusive, and Precambrian Shillong Group of rocks. However, the southwestern, southern and southeastern part of the state are covered by sedimentary rocks belonging to the Cretaceous-Tertiary Age, which consist of sandstone, shale, conglomerate, limestone etc. Unconsolidated sediments consisting of sand, gravel, silt, clay etc.are met with a thin veneer of Alluvium along the rivulets and streams traversing the state. Significant thickness of alluvium is found along the northwestern fringe in Garo Hills district, bordering state of Assam and Bangladesh.

The state is characterized by tropical monsoon climate with a rainy summer and dry winter. Heavy rainfall is received during summer under the spell of South-West monsoon and occasionally during winter. Copious rainfall is received in certain parts of the states. Mawsynram, located in the State, has the unique distinction of recording the highest average annual precipitation in the world.

Groundwater occurs under unconfined to semi-confined conditions in general, in all the geological formations. However, autoflow condition occurs in some part of South West Garo Hills district.

The previous assessment of dynamic groundwater resources of Meghalaya was carried out block-wise during 2022-23.The assessment was done for 39 blocks of the state.

The current(2023-24) dynamic ground water resources of the state have been assessed jointly by Central Ground Water Board and Water ResourcesDepartment, Govt. of Meghalaya based on GEC 2015 methodology. The assessment has been done block-wise. Watershed as an assessment unit could not be taken up due to paucity of watershed wise data in Meghalaya. Though there are 39 blocks in the state, Greater Shillong area has also been taken as one assessment unit. Hence, for the current resource assessment the total number of assessment unit is 40.

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)	1.153	1.234	1.78	3.305	1.83	2	1.68	1.69	1.72
2	Annual Extractable Ground Water Resource (bcm)	1.04	1.11	1.6	2.974	1.64	1.82	1.51	1.51	1.53
3	Annual Ground Water Extraction for Irrigation, Domestic & Industrial Uses (bcm)	0.002	0.0022	0.002	0.013	0.04	0.08	0.05	0.07	0.07
4	Stage of Ground Water Extraction (%)	0.18	0.12	0.1	0.42	2.28	4.22	3.55	4.58	4.6

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	7		7		7		11		11		12		12		39		40	
2	Safe	7		7		7		11		11		12		12		39		40	
3	Semi -Critical																		
4	Critical																		
5	Over-Exploited																		
6	Saline																		

For the current assessment, various data provided by Water Resources Department, Community & Rural Development Department, Agriculture Department, Directorate of Economics and Statistics, Directorate of Fisheries, Soil and Water Conservation Department, Public Health Engineering Department of Govt. of Meghalaya and North Eastern Space Application Centre (NESAC), etc. have been used. For population data, projected population based on 2011 census report has been used. Salient details of status of groundwater 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.

Ground water regime:

In Meghalaya, ground water in general, occurs under unconfined to semi-confined conditions. However, in southern part of South West Garo Hills district of Meghalaya, ground water occurs under confined conditions giving rise to auto flow wells.

In unconsolidated formation, the pre and post monsoon water levels generally vary from 2to 10 mbgl and 2 to 5 mbgl respectively. The water levels in consolidated/semi-consolidated formation rest in the range of 2 - 45 mbgl both pre and post monsoon periods.

Water level trends for the period of last 10 years shows that there is no significant decline anywhere in the State. The rise and fall in water level had been observed in the range of 0 to 10 cm/year in most of the stations.

Spring:

Spring is defined as a localized natural discharge of ground water appearing at the ground surface as a current of flowing water through well-defined outlets. Though ground water prospect is low in hilly areas, ground water emanates as springs. Meghalaya endowed with abundant rainfall, numerous springs appears in the state during rainy season. However, most of the spring dries up or its discharge dwindles during the lean period.

The springs are mainly located in the foothills and intermontane valleys. Some perennial springs flow throughout the year but their yield decrease significantly during the dry season (March – April). However, several perennial springs potential with good potential exist in the state. Most of the springs showed drastic increase in discharge during post-monsoon season suggesting the direct influence of rainfall recharge.

Springs found in Meghalaya are mainly depression (topographic) and fractured types. It has also been observed that the discharge of springs increased during monsoon season and gradually decreases with the cessation in rainfall. Spring discharge as observed (during National Aquifer Mapping study) in the state has been presented in **Table.1.3.**

Table.1.3: Springs in Meghalaya

District	No. of Springs studied	Spring discharge (litre per minute)	
		Pre-monsoon	Post monsoon
East Garo Hills	13	1.5 - 30	18.46 -34
East Jaintia Hills	9	0.36-6.6	1.02-27
East Khasi Hills	54	0.6-120	3-180
North Garo Hills	1	144	276
Ri-Bhoi	17	0.57-81	0.6-102
South Garo Hills	7	1.02-6	5.4-25.8
South West Garo Hills	2	0.6-54	0.6-20.4
West Garo Hills	7	0-7.0	10 - 30
West Jaintia Hills	25	0-36.6	0.06 – 40.2
West Khasi Hills	25	0.6 - 60	0.2 ->96

Ground Water Quality

Ground water in the State ranges from acidic to alkaline with pH values ranging from 4.42 to 10.51. The electrical conductivity values for ground water in phreatic aquifer in Meghalaya range from 14.1 to 662 µs/cm at 25ºC indicating the quality of ground water to be of low salinity and the water is potable. Total hardness (Ca+Mg) expressed as $CaCO_3$ in ppm is small indicating that the water is soft in quality. The other chemical constituents of ground water namely HCO_3, Cl, Ca, Mg, Fe etc. all are within permissible limit according to Bureau of Indian Standard (IS: 10500-91**).** The chemical analysis of ground water samples from phreatic aquifer reveals that the ground water of Meghalaya is generally suitable for drinking purposes. Almost all the chemical constituents are within the permissible limits of drinking water standards except for Iron and Flouride which is high in some pockets. Higher concentration of iron above permissible limit in phreatic aquifer and semi confined aquifer were found in some pockets of 7 districts. High fluoride concentration beyond permissible limit were found in some deeper aquifer in 2 districts viz. East Jaintia Hills district at Mynthlu and at four locations (Chasingre, Rongram, Jengjal and Dadenggre) in West Garo Hills district.The ranges of the water quality data from dug well, borewell and springs are presented in Table-1.4.

Table 1.4: Ground water Quality of Meghalaya.

Sl. No.	Chemical constituents (Concentrations in mg/l except pH & EC)	Dug well	Borewell	Spring
		Range (ppm)		
1	pH	4.79 to 8.58	4.42 to 10.51	4.60 to 8.8
2	EC* µS/cm at 25°C	14.1 to 662	20 to 545.2	13.03 to 405
3	Turbidity(NTU)	BDL to 29	BDL to 4.9	BDL to 1.2
4	TDS	BDL to 385	BDL to 283.2	BDL to 236
5	CO_3	BDL to 172.3	BDL to 240.6	BDL to 89.79
6	HCO_3	BDL to 220	BDL to 176	BDL to 195.16
7	TH as $CaCO_3^*$	10.01 to 95.1	10 to 135.13	10 to 195.16
8	Cl*	7.09 to 63.12	7.09 to 165.13	14.18 to 67.35
9	SO_4	BDL to 87.1	BDL to 67.35	BDL to 46.49
10	NO_3	BDl to 29.3	BDL to 79.81	BDL to 9.88
11	F^-	BDL to 0.54	BDL to 3.47	BDL to 1.7
12	Ca*	1.7 to 70	0.22 to 41.6	1.7 to 93.6
13	Mg*	0 to 26.69	1.2 to 32	0.5 to 16.5
14	TH*	15 to 180	1.2 to 136	15 to 276.5
15	Na*	0.6 to 74	BDL to 100	0.13 to 37.1
16	K*	0.12 to 45.1	BDL to 86.26	0.04 to 27.88
17	Fe	BDL to 4.43	BDL to 39.65	BDl to 2.4

CHAPTER 2

GROUND WATER RESOURCE ESTIMATION METHODOLOGY

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

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

2.1. GROUND WATER ASSESSMENT OF UNCONFINED AQUIFER

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

2.1.1. Assessment of Annually Replenishable or Dynamic Ground Water Resources

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

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

Equation (1) can be further elaborated as –

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

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

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

Where,

ΔS - Change is storage

R_{RF} - Rainfall recharge

R_{STR} - Recharge from stream channels

R_{SWI} - Recharge from surface water irrigation

R_{GWI} - Recharge from ground water irrigation

R_{TP} - Recharge from Tanks& Ponds

R_{WCS} - Recharge from water conservation structures

VF - Vertical flow across the aquifer system

LF - Lateral flow along the aquifer system (through flow)

GE - Ground water extraction

T - Transpiration

E - Evaporation

B - Base flow

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

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

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

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

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,

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

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

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

Normalization of Rainfall Recharge

Let R_i be the rainfall recharge and r_i be the associated rainfall. The subscript "i" takes values 1 to N where N is the number of years for which data is available. This should be at least 5. The rainfall recharge, R_i is obtained as per equation (6) & equation (7) depending on the sub-unit for which the normalization is being done.
After the pairs of data on R_i and r_i have been obtained as described above, a normalisation procedure is carried out for obtaining the rainfall recharge corresponding to the normal monsoon season rainfall. Let r(normal) be the normal monsoon season rainfall obtained as the average of recent 30 to 50 years of monsoon season rainfall. Two methods are possible for the normalisation procedure. The first method is based on a linear relationship between recharge and rainfall of the form

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

Where,

R = Rainfall recharge during monsoon season
r = Monsoon season rainfall
a = a constant

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

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

Where,

R_{RF}(normal) - Normalized Rainfall Recharge in the monsoon season
R_i- Rainfall Recharge in the monsoon season for the i^{th}year
r(normal) - Normal monsoon season rainfall
r_i- Rainfall in the monsoon season for the i^{th} year
N - No. of years for which data is available

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

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

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:

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

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

Where,

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

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 –

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

Where,

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

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

2.1.1.1.3. Percent Deviation

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

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

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

Sl. No.	Source	Estimation Formula	Parameters
			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.

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

Where,

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

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

The methods for estimation of ground water extraction are as follows.
Unit Draft Method: **–** In this method, season-wise unit draft of each type of well in an assessment unit is estimated. The unit draft of different types (eg. Dug well, Dug cum bore well, shallow tube well, deep tube well, bore well etc.) is multiplied with the number of wells of that particular type to obtain season-wise ground water extraction by that particular structure.
Crop Water Requirement Method: **–** For each crop, the season-wise net irrigation water requirement is determined. This is then multiplied with the area irrigated by ground water abstraction structures. The database on crop area is obtained from Revenue records in Tehsil office, Agriculture Census and also by using Remote Sensing techniques.
Power Consumption Method: **–**Ground water extraction for unit power consumption (electric) is determined. Extraction per unit power consumption is then multiplied with number of units of power consumed for agricultural pump sets to obtain total ground water extraction for irrigation.

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

There are several methods for estimation of extraction for domestic use(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.

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

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.

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

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,

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

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

2.1.1.10. Validation of Stage of Ground Water Extraction

The assessment based on the stage of ground water extraction has inherent uncertainties. In view of this, it is desirable to validate the 'Stage of Ground Water Extraction' with long term trend of ground water levels.

Long term Water Level trends are prepared for a minimum period of 10 years for both pre-monsoon and post-monsoon period. If the ground water resource assessment and the trend of long term water levels contradict each other, this anomalous situation requires a review of the ground water resource computation, as well as the reliability of water level data. The mismatch conditions are enumerated below.

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

2.1.1.11. Categorisation of Assessment Unit

2.1.1.11.1. Categorisation of Assessment Unit Based on Quantity

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

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

2.1.1.11.2. Categorisation of Assessment Unit Based on Quality

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

2.1.1.12. 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.

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

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 Categorisation. Spring discharge measurement has been carried out by volumetric measurement of discharge of the springs. Spring discharges multiplied with time in days of each season will give the quantum of spring resources available during that season.

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

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:

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

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.

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

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. GROUND WATER ASSESSMENT IN URBAN AREAS

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

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

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

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

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

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

2.3. GROUND WATER ASSESSMENT IN WATER LEVEL DEPLETION ZONES

There are areas where ground water level shows a decline even in the monsoon season. The reasons for this may be any one of the following: (a) There is a genuine depletion in the ground water regime, with ground water extraction and natural ground water discharge in the monsoon season (outflow from the region and base flow) exceeding the recharge. (b) There may be an error in water level data due to inadequacy of observation wells. If it is concluded that the water level data is erroneous, recharge assessment has been made based on rainfall infiltration factor method. If, on the other hand, water level data is assessed as reliable, the ground water level fluctuation method has been applied for recharge estimation. As ΔS in equation 3& 4 is negative, the estimated recharge will be less than the gross ground water extraction in the monsoon season. It must be noted that this recharge is the gross recharge minus the natural discharges in the monsoon season. The immediate conclusion from such an assessment in water depletion zones is that the area falls under the over-exploited category which requires micro level study.

2.4. NORMS HAS BEEN USED IN THE ASSESSMENT

2.4.1. Specific Yield

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

Table-2.1: Norms Recommended for Specific Yield

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
1	Alluvium	AL01	Younger Alluvium (Clay/Silt/Sand/ Calcareous concretions)	Quaternary	10	8	12
2	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	Quarternary	2	1	3
26	Limestone	LS01	KarstifiedMiliolitic Limestone	Quarternary	10	5	15
27	Limestone	LS02	Limestone / Dolomite	Upper Palaeozoic to Cenozoic	2	1	3
28	Limestone	LS02	Karstified Limestone / Dolomite	Upper Palaeozoic to Cenozoic	10	5	15
29	Limestone	LS03	Limestone/Dolomite	Proterozoic	2	1	3

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
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
48	Charnockite	CK01	Charnockite - Massive, Poorly Fractured	Azoic	0.3	0.2	0.4

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
49	Khondalite	KH01	Khondalites, Granulites - Weathered, Jointed	Azoic	1.5	1	2
50	Khondalite	KH01	Khondalites, Granulites - Mssive, 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	Migmatitic 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

2.4.2. Rainfall Infiltration Factor

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

Table-2.2: Norms Recommended for Rainfall Infiltration Factor

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
1	Alluvium	AL01	Younger Alluvium (Clay/Silt/Sand/ Calcareous concretions)	Quaternary	22	20	24
2	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
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

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
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
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	Quarternary	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	Proterozoic to	11	10	12

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
			etc.) - Weathered, Jointed	Cenozoic			
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
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/	Azoic to Proterozoic	2	1	3

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
			Undifferentiated metamorphic - Massive, Poorly Fractured				
55	Gneiss	GN02	Gneiss -Weathered, Jointed	Azoic to Proterozoic	11	10	12
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

2.4.3. Norms for Canal Recharge

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

.Table-2.3: Norms Recommended for Recharge due to Canals

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

2.4.4. Norms for Recharge Due to Irrigation

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

Table-2.4: Norms Recommended for Recharge from Irrigation

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

2.4.5. Norms for Recharge due to Tanks & Ponds

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

2.4.6. Norms for Recharge due to Water Conservation Structures

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

2.4.7. Unit Draft

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

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

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.

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

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

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

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

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

CHAPTER 3

3.0 RAINFALL OF MEGHALAYA

Meghalaya receives high rainfall during the South -West monsoon, which usually starts from the middle of May and declines towards mid-October. The rainy season commences with the onset of southwest monsoon in April and lasts up to October that encourages a lot of wet cultivation in the state.Average rainy days during the season vary from 60 in the west-central part to over 100 days in the southeastern part. Heavy precipitation occurs in areas like Cherrapunjee (Sohra) and Mawsynram. Mawsynram and Cherrapunji in the East Khasi Hills district are geographically considered as the rainiest places in the World. Cherrapunji, which has an average annual precipitation of about 11,430 mm (450 inches) and Mawsynram, a village directly west of Cherrapunji, where rainfall of around 17,800 mm (700 inches) per year has been recorded. The area receives rainfall on an average for 161 days in a year. The normal Rain fall of the state is 3074mm.

Table 3.1:District wise Normal Rainfall, Actual Rain fall during Ground Water Assessment Year 2023-24

District	Year	Monsoon		Non-Monsoon	
		Actual (mm)	Normal (mm)	Actual (mm)	Normal (mm)
WEST KHASI HILLS	2023-2024	2077.8	3000	397.8	1062
EAST GARO HILLS	2023-2024	2425.69	2214	497.81	761
EAST KHASI HILLS	2023-2024	2152	3000	1200	1032
WEST JAINTIA HILLS	2023-2024	2702	1613	376	707
EAST JAINTIA HILLS	2023-2024	2912	1613	609	707
SOUTH WEST KHASI HILLS	2023-2024	3352.6	3000	452.8	918
SOUTH WEST GARO HILLS	2023-2024	1165	1156	317.2	478
SOUTH GARO HILLS	2023-2024	1741	3000	280	1210
NORTH GARO HILLS	2023-2024	1097	2118	421.5	685
WEST GARO HILLS	2023-2024	2142	1960	325	718
RI BHOI	2023-2024	1239.85	1544	329.5	486

Table 3.2 Rainfalland Recharge in Meghalaya during the Ground Water Assessment Year 2023-24

Sl.No	STATE/ UT	DISTRICT	Rainfall (mm)			Recharge Worthy Area (ha)	Ground Water Recharge (ham)		
			Monsoon	Non-Monsoon	Total		Monsoon	Non-Monsoon	Total
1	Meghalaya	EAST GARO HILLS	2425.69	497.81	2923.5	50215	6961.74	2465.56	9427.3
2	Meghalaya	EAST JAINTIA HILLS	2554.6	639.3	3193.9	82735	12572.28	4381.76	16954.04
3	Meghalaya	EAST KHASI HILLS	1162	1292.5	2454.5	86732	17281.57	5412.42	22693.99
4	Meghalaya	NORTH GARO HILLS	1097	421.5	1518.5	37031	8074.46	1893.96	9968.42
5	Meghalaya	RI BHOI	1239.85	329.5	1569.35	68878	5155.55	1424.59	6580.14
6	Meghalaya	SOUTH GARO HILLS	1741	280	2021	65957	16853.75	6675.76	23529.51
7	Meghalaya	SOUTH WEST GARO HILLS	1165	317.2	1482.2	42520	6016.03	2076.27	8092.3
8	Meghalaya	SOUTH WEST KHASI HILLS	3352.6	452.8	3805.4	48537	11671.74	2686.11	14357.85
9	Meghalaya	WEST GARO HILLS	2216.9	347.6	2564.5	127784	24100.12	7206.99	31307.11
10	Meghalaya	WEST JAINTIA HILLS	1827.8	413.2	2241	79186	7988.05	3269.42	11257.47
11	Meghalaya	WEST KHASI HILLS	2077.8	397.8	2475.6	123970	23884.24	7821.62	31705.86

CHAPTER 4

4.0 HYDROGEOLOGICAL SETUP OF MEGHALAYA

The hydrogeological formations occurring in the state iscomplex and heterogeneous in nature and the major part is covered by hard and massive rocks.

The consolidated formation comprises the Archaean Gneissic Complex, acid and basic intrusive, quartzite and phyllite of Shillong Group of rocks. These formations lack primary porosity and the movement and occurrence of ground water is controlled by secondary porosity like joints, faults etc. These formations have rather low ground water potentiality.

Semi-consolidated formations of the state include limestone, sandstone, siltstone and shale, interbedded with the coal seams. The Khasi, Jaintia and Dupitila Group of rock comprise the semi-consolidated formation. The aquifers are thick and discontinuous in nature and are more prospective for groundwater development than crystalline Archaean rocks.

The unconsolidated sediments comprising sand, gravel, silt clay etc are found to occur as thin veneer along rivulets and as valley-fills. Significant thickness of this unconsolidated formation is found to occur only along extreme north-western fringe of the state in South West Garo Hills and West Garo Hills district.

4.1 Aquifer System:

The aquifer system in the state can be divided as a two aquifer systems, viz., first aquifer (shallow) and second aquifer (deeper). Shallow or first aquifer consists of weathered residuum where ground water occurs under water table condition and is mainly developed through construction of dug wells. The second aquifer is the deeper aquifer which tapped the fractured zone and is mainly developed through borewells. Based on the study of litholog and analysis of depth of construction of dug wells and bore wells, it is found that the first aquifer occur within depth of 20 to 40m. Ground water in the second aquifer occurs under semi-confined to confined condition in the fractures upto the maximum explored depth of 280m. Principal aquifer system of the state is presented in **Fig.1.**

Ground water exploration has been carried out in different parts of the state to delineate the potential aquifers and their geometry and to determine the hydrogeological parameters of the aquifer systems.

In general, the yield from the gneissic complex is more than that of granitic plutons. Quartzite formations, in turn, sustain higher yields than both granitic and gneissic formations. Within this hard rock terrain, most fractures occur primarily within a depth of 150 meters. The cavernous limestone of the Jaintia Hills holds greater potential for groundwater occurrence compared to the Cherrapunjee area.

In the western fringes of the Garo hills, Alluvium and Upper Tertiary sediments have formed some of the most productive aquifers of the State. Ground water occurs under unconfined to confined conditions within depth of 300m. In this area , yield of tubewells occur in the range of 4.8 -164.8 m^3/hour, tapping prominent aquifer zones of 30 -60 m thickness within constructed depth of 200m for a maximum drawdown of 13.3 m. Dupitala and Chengapara sandstones make good aquifers. The discharge in these formations was found ranging from 25-150 m^3/hr for wells drilled down to a depth of 250 m and 25 m^3/hr in shallow wells of 50 m depth. Auto flowing wells are reported from Ampati, Bairagipara, Zikzak etc. with artesian head ranging from 0.80 to 9m.

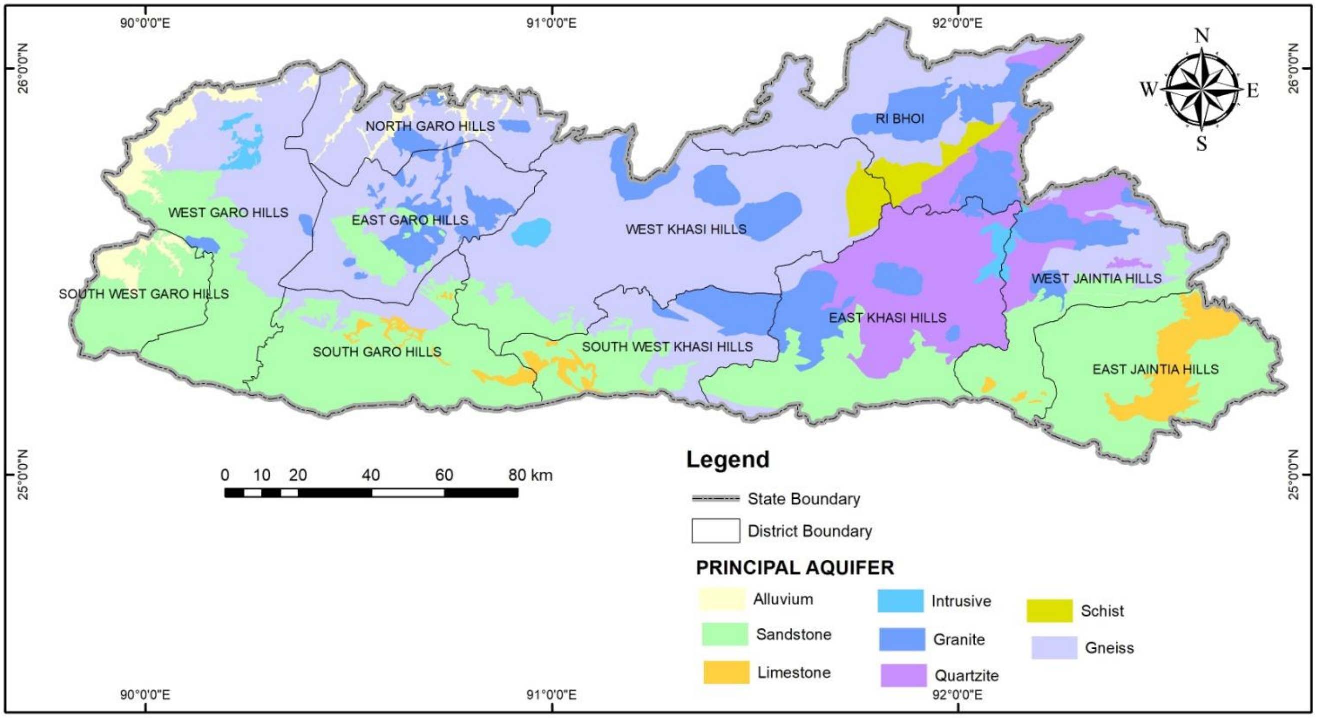

Fig:1. Principal Aquifer System of Meghalaya.

Summarized results of exploration carried out by CGWB in Meghalaya is presented in **Table 4.1** and the hydrogeology of Meghalaya in **Table 4.2**.

Table 4.1: Summarized results of groundwater exploration in Meghalaya.

Area	Rock type	Depth Drilled (m)	Discharge (m^3/hr)	Drawdown (m)	Specific Capacity (lpm /m)	T (m^2/d)	Storativity (S)
Khasi, Jaintia and Garo Hills	Hard rock	37 – 248	0.54 – 50	2.40 – 44	6 – 70	3 – 288	-
Greater Shillong	Hard Rock	80 – 232	5 – 40	2 – 40	-	1 – 87	-
Garo Hills	Soft rock	22 – 300	8 – 222	1.50 – 13.30	75 – 1726	4 – 1595	3.7×10^{-4} to 9.9×10^{-1}

Table 4.2: Hydrogeology of Meghalaya

Age	Group	Formation	Lithology	Hydrogeological Conditions	Yield (m^3/hr)
Pleistocene to Holocene	Newer (Recent) and Older Alluvium		Unconsolidated Sediments Sand, silt and clay	Thick, continuous aquifer in the western, northern and southern fringes of the State. Ground water occurs under unconfined to semi-confined conditions; Depth to water level rests at 3 to 5 m.bgl (metres below ground level)	30 - 100
Mio- Pliocene		Dupitla	Mottled clay, sandstone, shale and conglomerate	Thick, discontinuous aquifer encountered down to 250 m.bgl in the West Garo Hills area. Groundwater occurs under semi-confined to confined conditions; Depth to water level rests at 4 to 9 m.bgl	25 - 150
Oligo-Miocene	Garo group	Chengapara	Coarse sandstone, siltstone, clay and marl		
		Baghmara	Coarse sandstone, conglomerate, silty clay and fossiliferous limestone		
		Simsang	Fine sandstone and alternation of siltstone- mudstone		
Eocene-Oligocene	Barail group	-------	Coarse sandstone, shale, minor coal lenses carbonaceous shale,		
Palaeocene-Eocene	Jaintia group	Kopili	Shale, sandstone, marls and coal	Discontinuous aquifer in the cavernous limestones and sandstones area. Groundwater occurs under unconfined to semi-confined conditions; Depth to water level rests at 2 to 4 m.bgl	5 - 15
		Shella	Alternation of sandstone, limestone		
		Langer	Calcareous shale, sandstone, limestone		
Upper Cretaceous	Khasi Group	Mahadek	Arkosic sandstone (Glauconitic)		
			Conglomerate		
		Jadukata	Conglomerate/sandstone		
Paleo-Meso Proterozoic	Shillong Group		Quarzite, phyllite, quartz-sericite schist, conglomerate	Aquifer formed by weathered and fractured zones extending down to 150 m. bgl. Groundwater occurs under unconfined to semi-confined conditions; Depth to water level rests at 7 to 17 m.bgl	2 - 10

CHAPTER-5

GROUND WATER LEVEL SCENARIO IN MEGHALAYA

5.1 Groundwater Level Scenario (2023)

Groundwater level data of pre-monsoon 2023

During pre-monsoon (March 2023) period, 70 stations had been monitored in the state. Water level in the range of 0-2 mbgl was recorded in 24.3% (17) stations, in the range of 2-5 mbgl in 57.1% (40) and in the range of 5-10 mbgl in 11.5% (8) stations. One station located in North Garo Hills district recorded water level in the range of 10-20mbl. Water level beyond 20mbgl was observed in four stations located in Ri-Bhoi, East Jaintia Hills and West Garo hills district. In dug wells, the minimum and maximum water levels of 0.1 mbgl and 7.90 mbgl had been recorded inEast Khasi Hills and West Garo Hills district respectively.The depth to water level in the state during pre-monsoon period has been presented in Fig.2.

Groundwater level data for post-monsoon 2023

During the month of November 2023, water level in the range of 0-2 mbgl was recorded in 44.1% (34) of the monitored stations in the state. In 45.5% (35) stations, it was recorded in the range of 2-5 mbgl and in 5.2% (4) stations in the range of 5-10mbgl. Water level beyond 20 mbgl was recorded in four stations located in Ri-Bhoi and West Garo Hills district. In dugwells, the minimum water level of 0.5 magl was recorded in South Garo Hills district and the maximum of 6.88 mbgl was recorded in West Garo Hills district.

The depth to water levels in the state during pre-monsoon and post period has been presented in Table 5.1 and depictedin Fig.2 and Fig.3.

Table 5.1: Depth to ground water level during the year, 2023.

Location	Station No.	Station Type (Dug Well/ Borewell/Tube Well)	Depth to Water Level (mbgl)	
			March-2023	Novemner-2023
East Garo Hills				
Dawagittingri	MLEG19	Dug Well	-	0.17
Baiza Rongreng	MLEG15	Dug Well	4.35	2.75
Darugiri New	MLEG18	Dug Well	-	1.62
Dobetkolgiri	MEEG12	Dug Well	2.15	-
Dobu	MLEG13	Dug Well	3.20	2.50
Narringirri	MLEG14	Dug Well	1.95	3.53

Rongjeng	78K2D1	Dug Well	5.20	4.25
Rongmil	78K2D3	Dug Well	3.54	2.85
Samanda Megapagre	MLEG16	Dug Well	4.40	2.66
Songsak New	MLEG20	Dug Well	-	1.78
East Khasi Hills				
Nongrim Hills	MLEK16	Dug Well	6.9	1.5
Cherrapunji	78O3C1	Dug Well	0.10	0.00
Dangar	MLEK14	Dug Well	2.20	1.30
Ichamati	MLEK15	Dug Well	1.05	0.50
Lachuamiere	MLEK09	Dug Well	0.36	0.78
NIT Cherrapunji	MLEKHOW3	Bore Well	4.80	5.49
Nongmynsong	MLEK12	Dug Well	2.93	2.62
Shillong Golf Link	MLEK07	Dug Well	6.45	3.09
North Garo Hills				
Bajengdoba	78K1C2	Dug Well	3.30	2.93
Bajengdoba OW	MLNG 02	Dug Well	5.62	-
Dainadubi	MLEG11	Dug Well	3.40	2.90
Kharkutta	78K1D7	Dug Well	2.50	2.02
Mendal	78K1B1	Dug Well	2.70	1.78
Mendal OW	MLNG 01	Bore Well	10.74	-
Mendipathar OW	MLNG04	Bore Well	6.91	8.01
MendipatharSoksan	MLNG05	Dug Well	-	3.47
WaGeasi	MLNG03	Dug Well	3.80	2.22
Ri-Bhoi				
Byrnihat	MLRB02A	Dug Well	3.15	1.85
Nayabunglow	MLRB04	Dug Well	5.84	3.76
Nongladew	MLRBOW02	Bore Well	2.25	2.09
Nongpoh	78O1D1	Dug Well	3.06	3.05
Pahanmawlier	MLRB06	Dug Well	0.30	0.40
PatharkhammaBarigaon	MLRB9	Dug Well	4.80	3.40
Purduwa OW	MLRBOW4	Bore Well	3.79	3.10
RPBF Kyrdemkulai OW	MLRBOW9	Bore Well	32.38	28.02
Tamanpahlong	MLRB	Dug Well	2.15	1.85
Tdohumshaiw	MLRBOW6	Bore Well	30.45	26.22
South Garo Hills				
Bamongre	MLSG13	Dug Well	-	1.36
Baghmara	MLSG01	Dug Well	2	1.12
Betagre	MLSG07	Dug Well	1.75	1.28
Chiringpara	MLSG08	Dug Well	4.6	3.07
Dopha-Adan	MLSG09	Dug Well	0.85	-0.5
Dumnikura	MLSG02	Dug Well	3.35	3.38

Gasuapara	MLSG04	Dug Well	2.55	2.10
Glmatkolgre	MLSG10	Dug Well	3.95	1.25
Konduk	MLSG11	Dug Well	3.6	1.0
Mandangre	MLSG12	Dug Well	0.4	0.44
South West Garo Hills				
Ampati New	MLSWG01	Dug Well		-0.08
Chimesengre	MLSWG02	Dug Well		1.99
Ampati	78G3D1	Dug Well	2.60	1.44
Betasing II	ASWG25	Dug Well	0.40	1.85
Garobandha	78K2A1	Dug Well	3.90	3.42
Mahendraganj	78G3D2	Dug Well	3.20	1.83
Zikzak	78G3D5	Dug Well	4.65	3.05
West Garo Hills				
Balachanda II	MLWG31	Dug Well	-	3.85
Baljek new	MLWG32	Dug Well	-	1.27
Kherapara Bazar	MLWG33	Dug Well	-	2.90
Asanang	78K2B1	Dug Well	4.50	3.81
Baljek	ASWG17	Dug Well	2.60	1.35
Belguri	ASWG21	Dug Well	7.90	6.88
Chasingre (NEHU)	MLWG28	Bore Well	-	43.41
Dadengre	MLWG27	Bore Well	-	-
Dalu	MLWG25	Dug Well	4.80	3.60
Damjongre	MLWG21	Dug Well	4.00	3.04
Jengjal	MLWG30	Bore Well	-	8.93
Nidanpur	78K1A3	Dug Well	2.20	1.70
Phulbari	78K1A1	Dug Well	3.40	3.37
Phutamamri	ASWG20	Dug Well	3.50	3.02
Purkhasia	78K3A1	Dug Well	4.30	2.97
Rajabala	ASWG26	Dug Well	5.95	4.98
Rongram	ASWG18	Dug Well	3.00	1.15
Rongram OW	MLWG29	Bore Well	26.01	25.59
Salsella	MLWG22	Dug Well	2.55	1.15
Snalgre	MLWG23	Dug Well	1.18	1.36
Tikrikilla	78K1A2	Dug Well	3.35	2.74
West Jaintia Hills				
Dauki	83C4A1	Dug Well	1.12	0.71
Jowai	83C3A1	Dug Well	0.50	0.25
West Khasi Hills				
Mairang N	MLWK02	Dug Well	1.10	0.40
Nongdaju	MLWK01	Dug Well	3.65	1.65

5.1.0 Fluctuation of Groundwater Level:

Comparison of Pre-monsoon 2023 to Pre-monsoon 2022 (Fig.4)

Comparison of water level of Pre-monsoon (March) period of 2023 with that of Pre-monsoon data of 2022, indicate rise during March 2023 in 70.8% (46) of the monitored stations and fall in 29.2% (19) stations.Entire fall was recorded in 0-2m range. Rise in 61.5% (40) stations had been found recorded within 2m and 9.3%(6) stations in the range of 2-4m.

Comparison of November 2023 to November 2022 (Fig.5)

In comparison to November 2022, fall in water level was recorded in 58.7% (37) monitored stations and rise in 41.3% (26) stations during November 2023. Most of the rise and fall were restricted to 2m, Only 2 (3.2%) stations recorded fall and 3 (4.8%) stations recorded rise in the range of 2-4m. One station located in West Garo Hills recorded fall beyond 4m.

Comparison of Pre-Monsoon 2023 with decadal mean of Pre-Monsoon (2013 to 2022) (Fig.6)

The comparison of Pre-monsoon (March)water level data of 2023 to the decadal mean of preceding ten years Pre-monsoon data reveals that 70% (28) monitored stations recorded rise and 12(30%) stations recorded fall. Most of the rise and fall had been recorded within 2 m. Rise in the range of 2-4m was recorded in one station located in South West Garo Hills district. Similarly, fall in the range of 2-4m was recorded in one station of North Garo Hills district. The rise ranged from 0.04m to 3.07m and the fall ranged from 0.01 m to 2.09 m.

Comparison of Post-Monsoon 2023 with decadal mean of Post-Monsoon (2013 to 2022), (Fig.7)

Comparing Post Monsoon **(**November)water level data of 2023with mean of the same period of preceding 10 years it was found that 47.8% (22) stations indicated rise and 52.2% (24) stations indicated fall in water level during November 2023. Entire rise and fall was found within 2m range. The rise and decline in water level had been found in the range of 0 to 1.11 m and 0.05 to 1.53 m respectively. The maximum rise and fall in water level had been observed in West Garo Hills district and East Garo Hills district respectively.

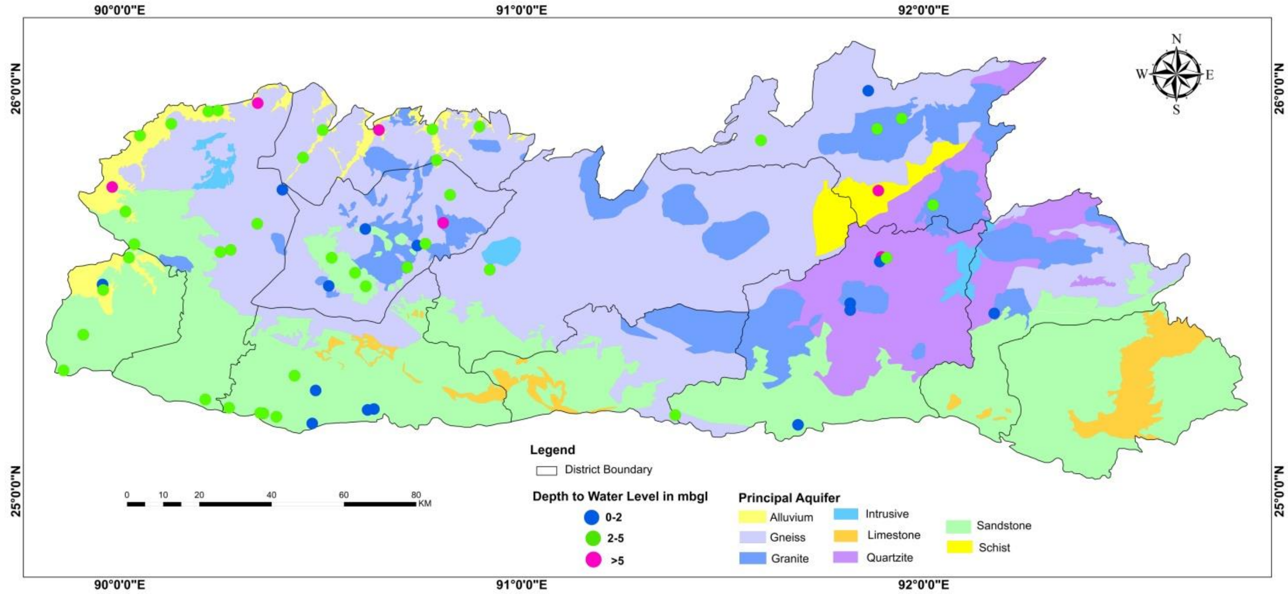

Fig.2: Depth to water level of Meghalaya during Pre-monsoon (March, 2023) period.

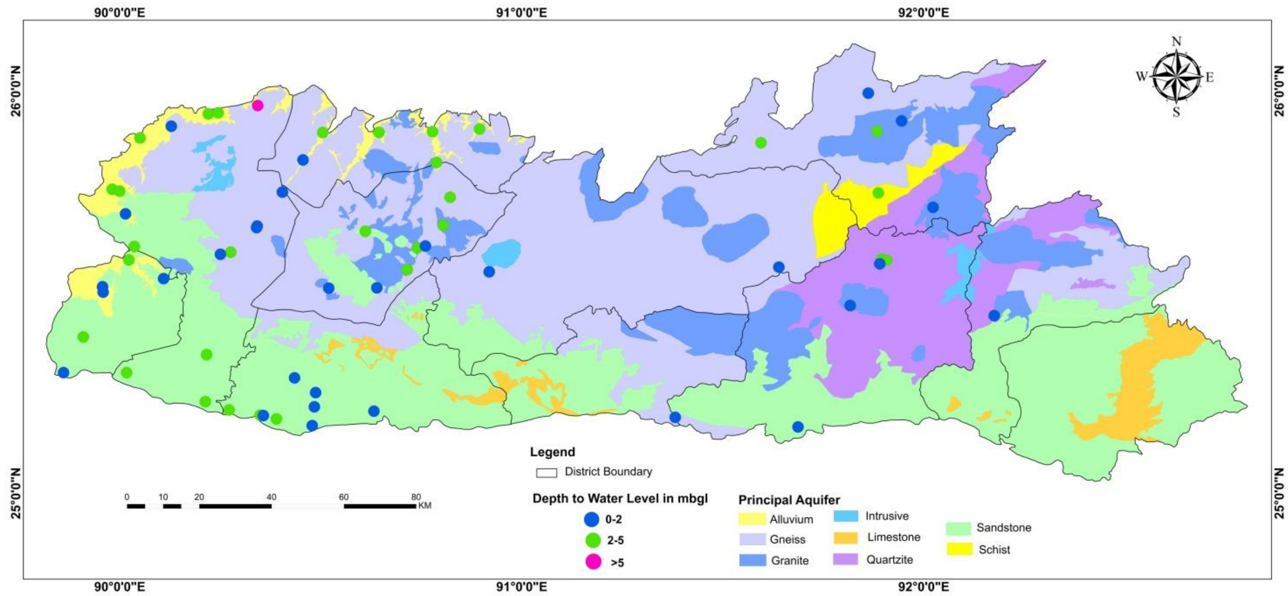

Fig.3: Depth to water level of Meghalaya during Post monsoon (November, 2023) period.

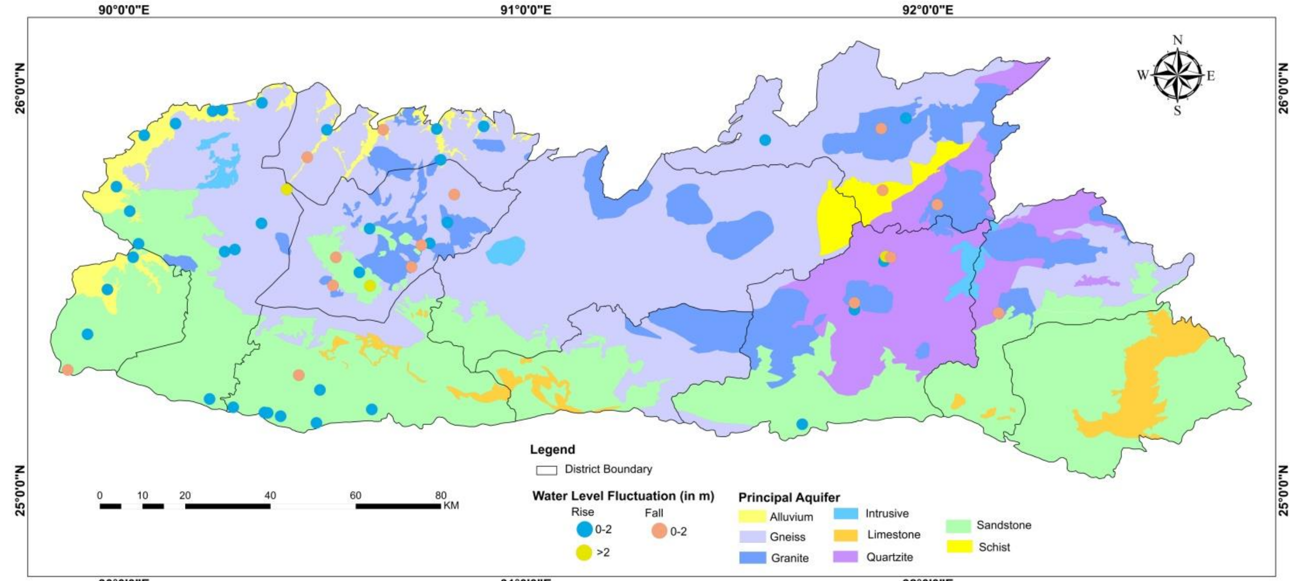

Fig.4: Ground water level fluctuation in Meghalaya during Pre-monsoon, 2023 (March) with pre-monsoon , 2022.

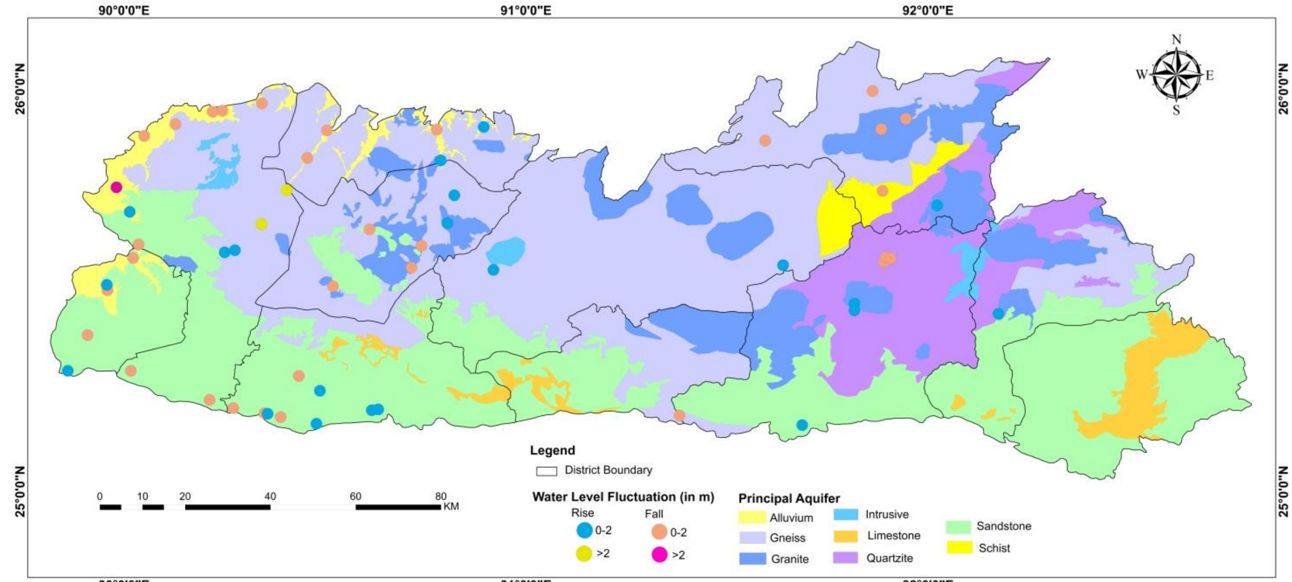

Fig.5: Ground water level fluctuation in Meghalaya during Post monsoon, 2023 (November) with Post monsoon , 2022.

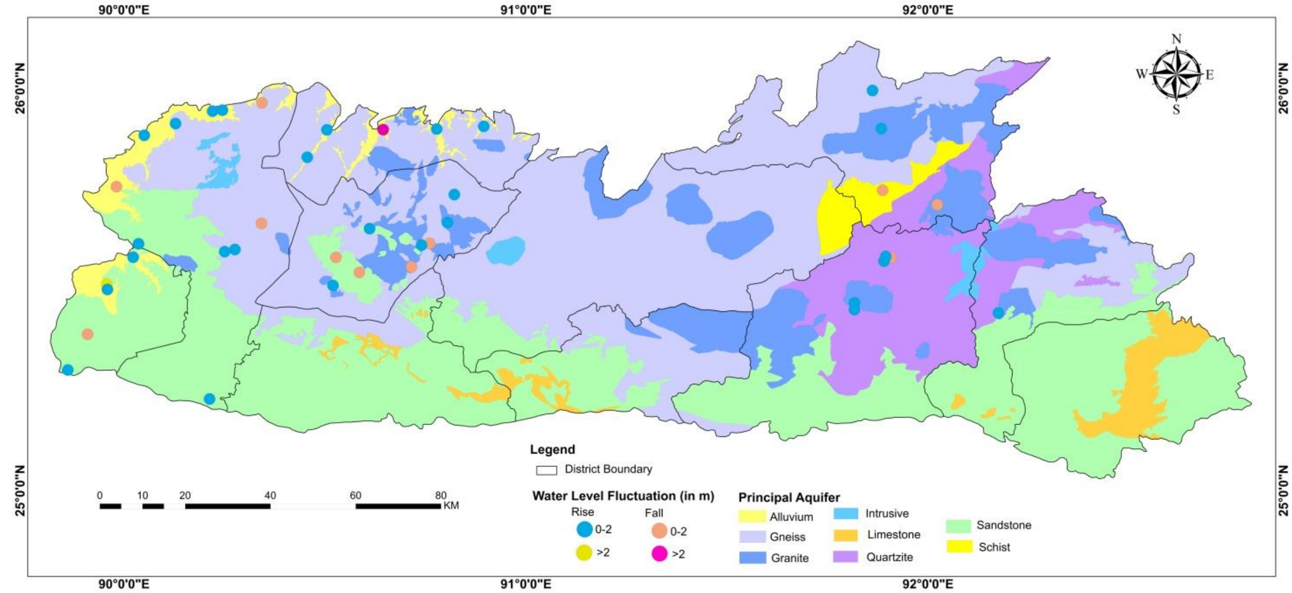

Fig.6: Ground water level fluctuation in Meghalaya during Pre- monsoon, 2023(March) with Decadal Mean (March, 2013-2022)

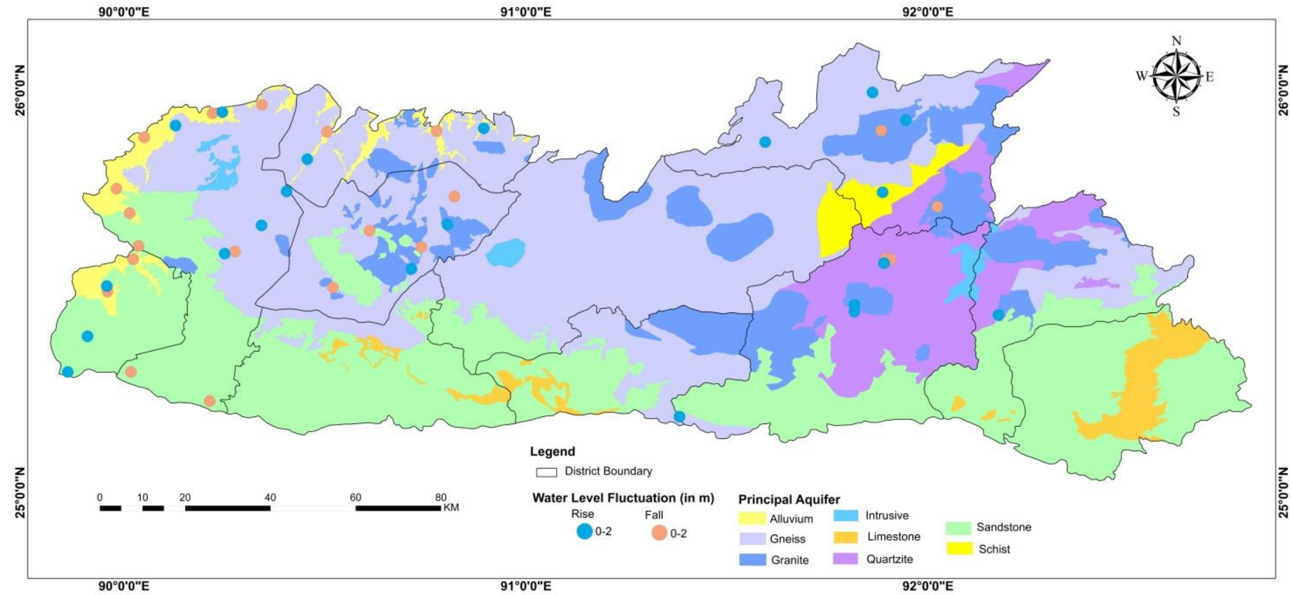

Fig.7: Ground water level fluctuation in Meghalaya during Post monsoon, 2023 (November) with Decadal Mean (November, 2013-2022)

CHAPTER 6

GROUND WATER RESOURCES OF MEGHALAYA

Total ground water recharge is 1.86 BCM and Annual extractable groundwater resources is 1.53 BCM after deducting natural discharge and resultant flow. Ground water extraction for various uses has been estimated for all the assessment units of Meghalaya. Gross annual ground water extraction for all uses is 0.07 BCM and allocation for domestic and industrial supply up to year 2025 is 0.05 BCM. Balance groundwater resources available for future development is 1.48 BCM. The stage of groundwater extraction is 4.60 % and all the 40 assessment units in Meghalaya state falls under **SAFE** category.

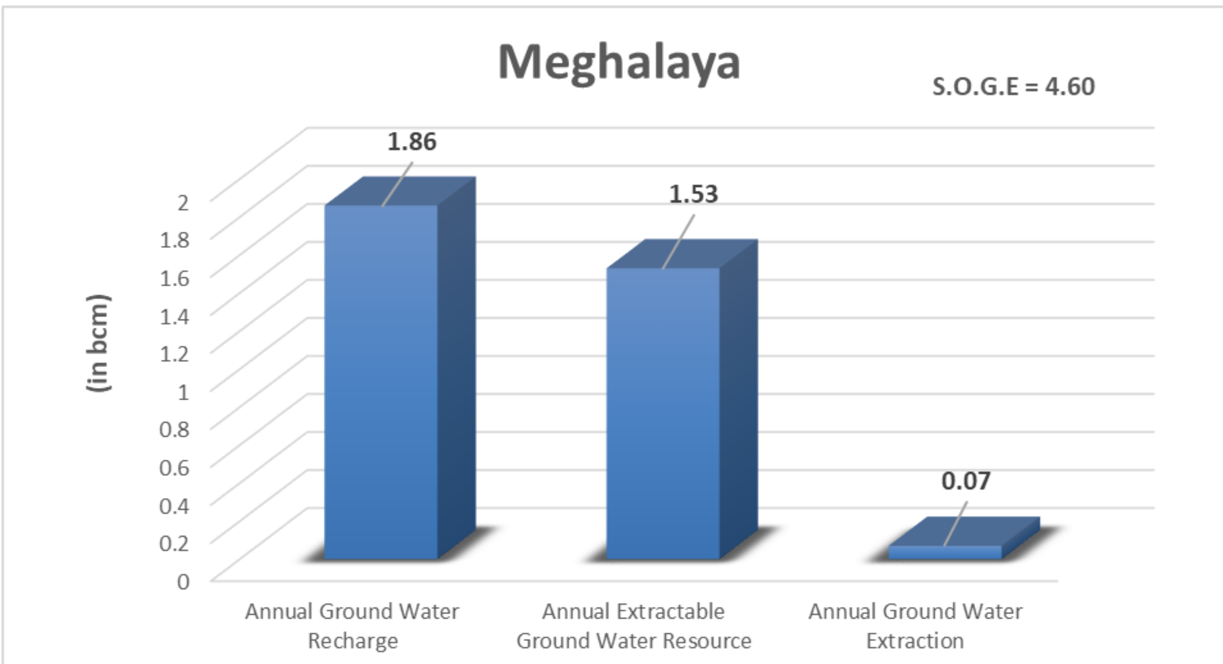

Fig 8: Dynamic Ground water Recourses Scenario 2024– Meghalaya

6.1. COMPARIOSN WITH PREVIOUS ASSESSMENT

Sl. No.	ITEM	Year 2022-23	Year 2023-24	COMPARISON
	Estimation	INGRES	INGRES	
1	Total Annual Ground Water Recharge (BCM)	1.83	1.86	0.03
2	Annual Extractable Ground Water Resources (BCM)	1.51	1.53	0.02
3	Irrigation extraction (BCM)	0.0244	0.0244	0
4	Industrial extraction (BCM)	0.00025	0.00025	0
5	Domestic extraction (BCM)	0.0443	0.0457	0.0014
6	Stage of GW Extraction (%)	4.58%	4.60%	0.02
7	Provision for Domestic use (BCM)	0.05	0.05	0
8	GW availability for future use (BCM)	1.43	1.48	0.04
9	No. of SAFE Units	39	40	1
10	No. of O.E. Units	0	0	0
11	No. of Dark/ Critical units	0	0	0

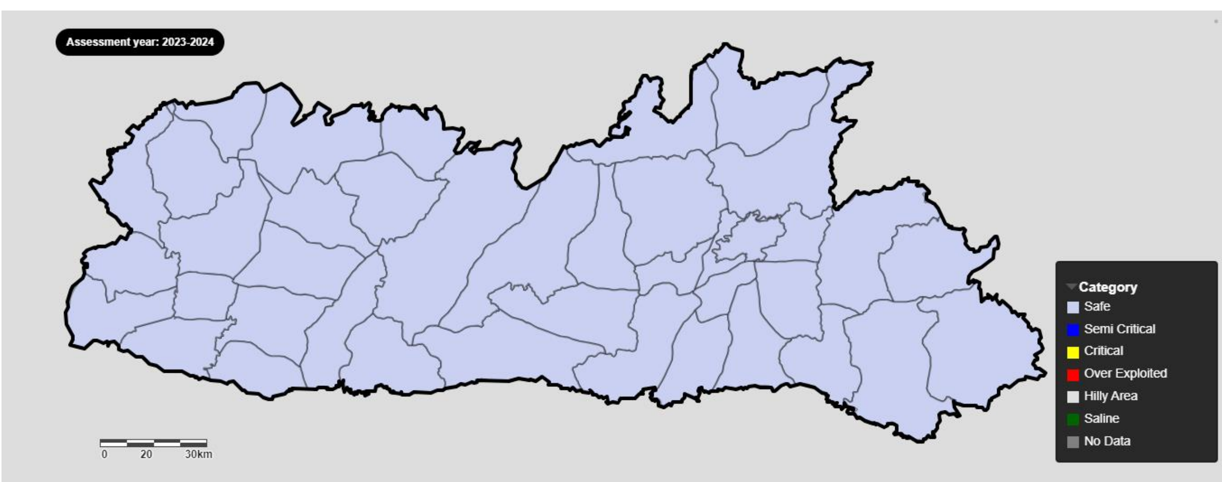

Fig 9: Categorization Map of Meghalaya

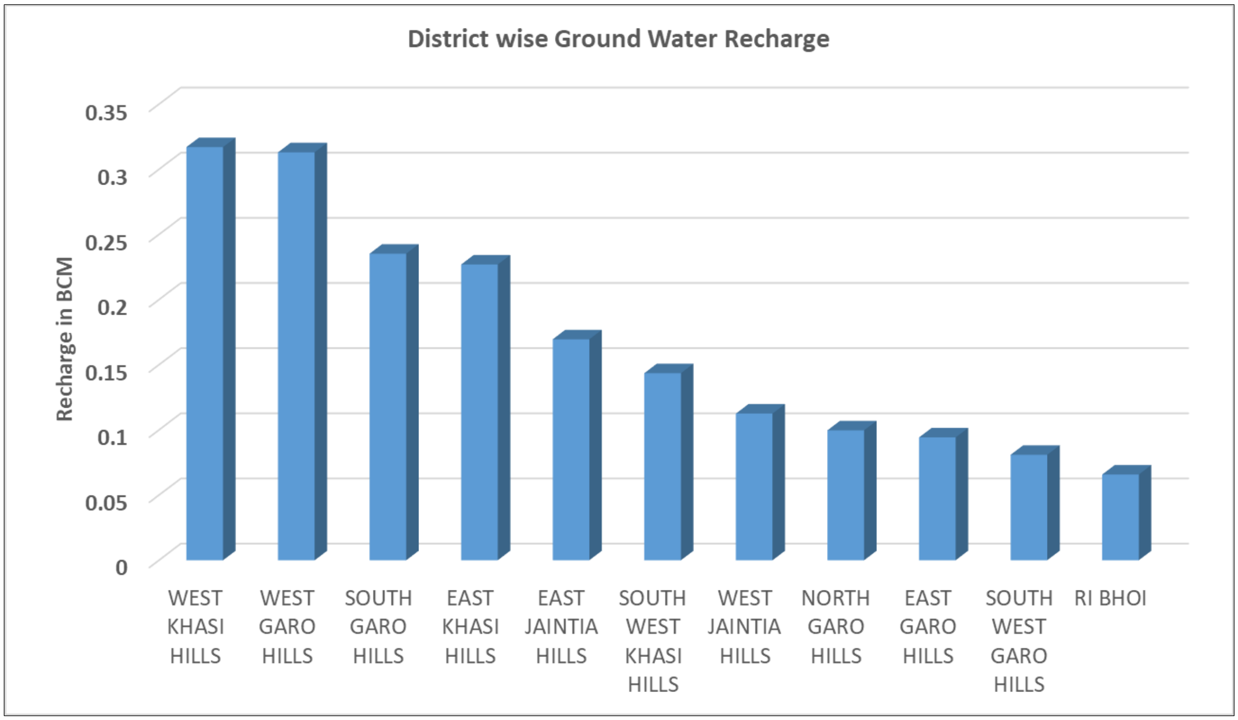

Fig 10: Bar Diagram showing District wise Ground Water Recharge of Meghalaya

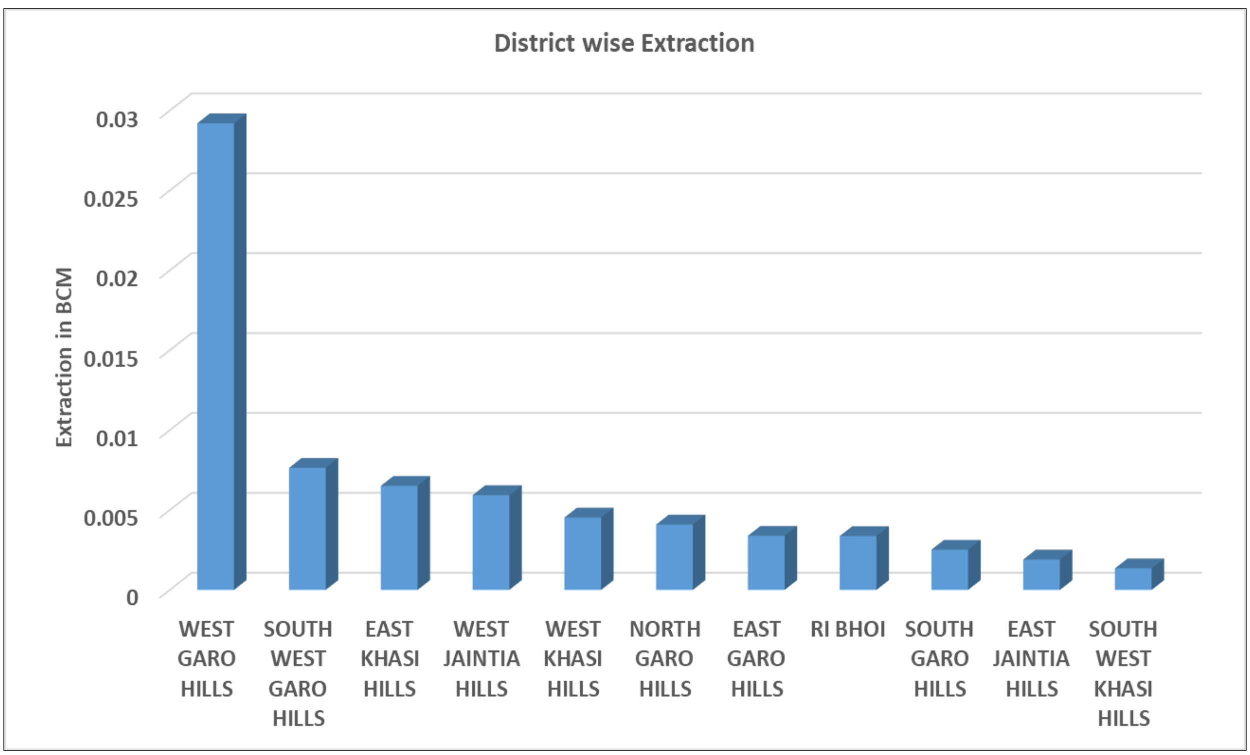

Fig 11: Bar Diagram showing District wise Ground Water Extraction of Meghalaya.

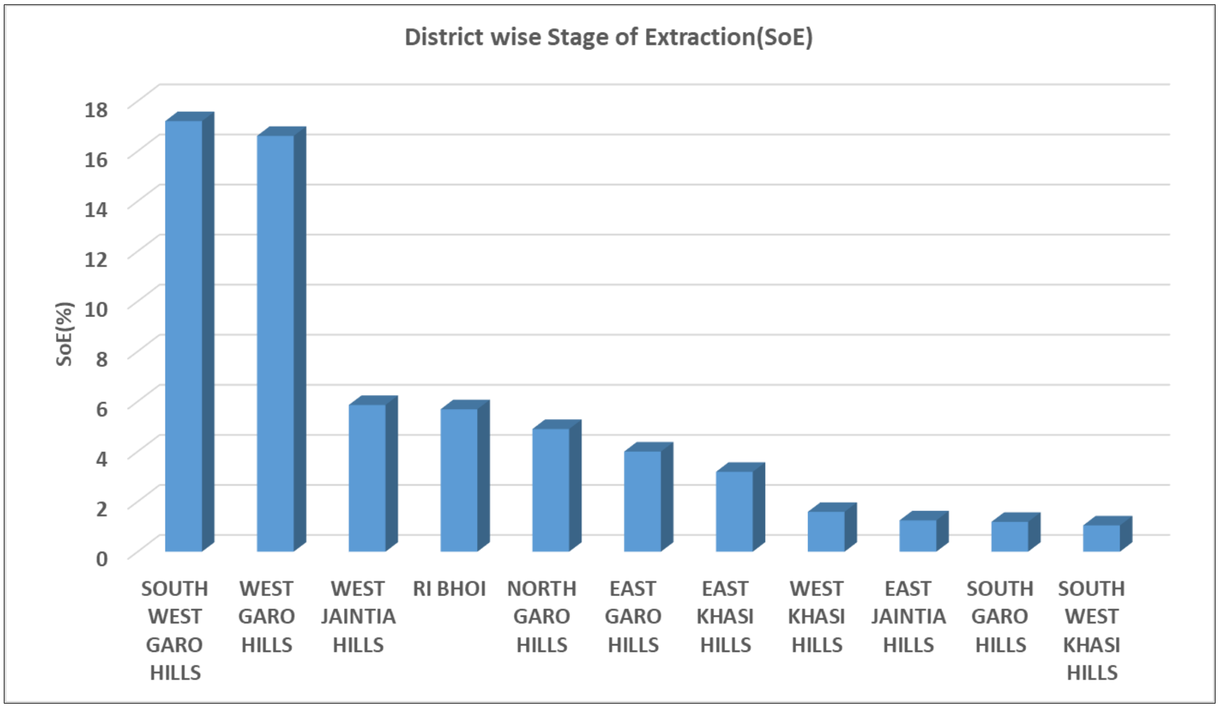

Fig 12:Bar Diagram showing District wise Stage of Extraction of Meghalaya.

CHAPTER 7

CONCLUSIONS

Ground water in the state is primarily controlled by lithology, structure and also by physiography. Ground water mainly occurs under unconfined to semi-confined condition in both consolidated and unconsolidated formation.

In the present assessment, the Ground water resources have been assessed block-wise. The Total Annual Ground Water Recharge of the State has been assessed as 1.86 BCM and Annual Extractable Ground Water Resources as 1.53 BCM. The current Annual Ground Water Extraction is 0.07 BCM and Stage of Ground Water Extraction is 4.60 %. All the 40 assessment units have been categorized as 'Safe'.

Similarly, out of 8135.45 sq km recharge worthy area of the State, 8135.45 sq km (100 %) under 'Safe' categories of assessment units. Out of total 1.53 bcm annual extractable ground water resources of the State, 1.53 bcm(100 %) are under 'Safe' categories of assessment units.

As compared to 2023 assessment, the Annual Ground Water Recharge has increased from 1.83 to 1.86 bcm, Annual Extractable Ground Water Resources has increase from 1.51 to 1.53 BCM. The reasons can be attributed to increase in recharge from rainfall and other sources. The Ground Water Extraction has increased minutely. Therefore, Stage of ground water extraction has slightly increased from 4.58 % to 4.60 %.

Annexure-I

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

STATE-WISE GROUND WATER RESOURCES OF INDIA, 2024															
Meghalaya (in bcm)															
S. No.	States / Union Territories	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	Meghalaya	1.35	0.06	0.42	0.04	1.86	0.33	1.53	0.02	0	0.05	0.07	0.05	1.48	4.6
	Total (Bcm)	1.35	0.06	0.42	0.04	1.86	0.33	1.53	0.02	0	0.05	0.07	0.05	1.48	4.6

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

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024															
MEGHALAYA															
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	EAST GARO HILLS	6386.29	575.45	1795.66	669.9	9427.3	942.72	8484.58	0	0	339.07	339.06	368.38	8116.2	4
2	EAST JAINTIA HILLS	12480.85	91.43	4292.83	88.93	16954.04	1695.41	15258.63	0	0	190.46	190.47	211.46	15047.17	1.25
3	EAST KHASI HILLS	16813.38	468.19	4950.22	462.2	22693.99	2269.39	20424.6	0	2.1	649.31	651.38	694.9	19727.63	3.19
4	NORTH GARO HILLS	6013.23	2061.23	1325	568.96	9968.42	1617.61	8350.81	1.8	0	407.57	409.37	439.32	7909.69	4.9
5	RI BHOI	5042.91	112.64	1330.29	94.3	6580.14	658.01	5922.13	0	22.47	314.69	337.16	349.65	5550.01	5.69
6	SOUTH GARO HILLS	16789.14	64.61	6616	59.76	23529.51	2352.96	21176.55	0	0	251.54	251.54	272.05	20904.5	1.19
7	SOUTH WEST GARO HILLS	5855.53	160.5	1857.49	218.78	8092.3	3650.12	4442.18	511.92	0	252.06	763.99	258.33	3671.92	17.2
8	SOUTH WEST KHASI HILLS	11468.86	202.88	2625.09	61.02	14357.85	1435.78	12922.07	0	0	135.17	135.17	147.29	12774.78	1.05
9	WEST GARO HILLS	23701.2	398.92	6532.95	674.04	31307.11	13724.81	17582.3	1933.2	0.6	986.94	2920.73	1071.79	16886.94	16.61
10	WEST JAINTIA HILLS	7879.86	108.19	3194.72	74.7	11257.47	1125.75	10131.72	0	0	593.44	593.45	667.29	9464.42	5.86
11	WEST KHASI HILLS	22567.36	1316.88	7018.54	803.08	31705.86	3170.59	28535.27	0	0	453.13	453.13	497.18	28038.1	1.59
	Total(Ham)	134998.6	5560.92	41538.79	3775.67	185874	32643.15	153230.8	2446.92	25.17	4573.38	7045.45	4977.64	148091.4	4.6
	Total(Bcm)	1.35	0.06	0.42	0.04	1.86	0.33	1.53	0.02	0	0.05	0.07	0.05	1.48	4.6

Annexure-III(A)
Categorization of blocks/ mandals/ taluks in India (as in 2024) for Meghalaya

CATEGORIZATION OF BLOCKS/ MANDALS/ TALUKAS IN INDIA (2024)													
S.No.	State/Union Territories	Total No. of Assessed Units	Safe		Semi-Critical		Critical		Over-Exploited		Saline	
	States		Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%
1	MEGHALAYA	40	40	100	-	-	-	-	-	-	-	-
	Grand Total	40	40	100	-	-	-	-	-	-	-	-

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

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024													
MEGHALAYA													
S.No	Name of District	Total No. of Assessed Units	Safe		SemiCritical		Critical		OverExploited		Saline	
			No.	%	No.	%	No.	%	No.	%	No.	%
1	SOUTH WEST GARO HILLS	2	2	100	-	-	-	-	-	-	-	-
2	SOUTH WEST KHASI HILLS	2	2	100	-	-	-	-	-	-	-	-
3	EAST GARO HILLS	3	3	100	-	-	-	-	-	-	-	-
4	WEST GARO HILLS	6	6	100	-	-	-	-	-	-	-	-
5	WEST KHASI HILLS	4	4	100	-	-	-	-	-	-	-	-
6	EAST JAINTIA HILLS	2	2	100	-	-	-	-	-	-	-	-
7	RI BHOI	3	3	100	-	-	-	-	-	-	-	-
8	SOUTH GARO HILLS	4	4	100	-	-	-	-	-	-	-	-
9	WEST JAINTIA HILLS	3	3	100	-	-	-	-	-	-	-	-
10	EAST KHASI HILLS	9	9	100	-	-	-	-	-	-	-	-
11	NORTH GARO HILLS	2	2	100	-	-	-	-	-	-	-	-
	Total	40	40	100	-	-	-	-	-	-	-	-

Annexure III (C)

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

ANNUAL EXTRACTABLE RESOURCE OF ASSESSMENT UNITS UNDER DIFFERENT CATEGORIES IN MEGHALAYA(2024)

S.No.	State/Union Territories	Total Annual Extractable Resource of Assessed Units (in mcm)	Safe		Semi-Critical		Critical		Over-Exploited	
			Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%
1	MEGHALAYA	1532.31	1532.31	100	-	-	-	-	-	-
	Total (in mcm)	1532.31	1532.31	100	-	-	-	-	-	-
	Grand Total (in mcm)	1532.31	1532.31	100						

Annexure- III (D)

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

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024

MEGHALAYA

S.No	Name of District	Total Annual Extractable Resource of Assessed Units (in Mcm)	Safe		Semi-Critical		Critical		Over-Exploited	
			Annual Extractable Resource (in Mcm)	%	Annual Extractable Resource (in Mcm)	%	Annual Extractable Resource (in Mcm)	%	Annual Extractable Resource (in Mcm)	%
1	SOUTH WEST GARO HILLS	44.42	44.42	100	-	-	-	-	-	-
2	SOUTH WEST KHASI HILLS	129.22	129.22	100	-	-	-	-	-	-
3	EAST GARO HILLS	84.85	84.85	100	-	-	-	-	-	-
4	WEST GARO HILLS	175.82	175.82	100	-	-	-	-	-	-
5	WEST KHASI HILLS	285.35	285.35	100	-	-	-	-	-	-
6	EAST JAINTIA HILLS	152.59	152.59	100	-	-	-	-	-	-
7	RI BHOI	59.22	59.22	100	-	-	-	-	-	-
8	SOUTH GARO HILLS	211.77	211.77	100	-	-	-	-	-	-
9	WEST JAINTIA HILLS	101.32	101.32	100	-	-	-	-	-	-
10	EAST KHASI HILLS	204.25	204.25	100	-	-	-	-	-	-
11	NORTH GARO HILLS	83.51	83.51	100	-	-	-	-	-	-
	Total (mcm)	1532.31	1532.31	100	-	-	-	-	-	-
	Grand Total (mcm)	1532.31	1532.31	100						

Annexure- III (E)

Recharge Worthy Area of Assessment unit under Different Category for Meghalaya (as in 2024)

AREA OF ASSESSMENT UNITS UNDER DIFFERENT CATEGORIES IN MEGHALAYA (2024)													
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	MEGHALAYA	8135.45	8135.45	100	-	-	-	-	-	-	-	-
	Total	8135.45	8135.45	100	-	-	-	-	-	-	-	-
	Grand Total	8135.45	8135.45	100								

Annexure III (F)

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

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024													
MEGHALAYA													
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	SOUTH WEST GARO HILLS	425.2	425.2	100	-	-	-	-	-	-	-	-
2	SOUTH WEST KHASI HILLS	485.37	485.37	100	-	-	-	-	-	-	-	-
3	EAST GARO HILLS	502.15	502.15	100	-	-	-	-	-	-	-	-
4	WEST GARO HILLS	1277.84	1277.84	100	-	-	-	-	-	-	-	-
5	WEST KHASI HILLS	1239.7	1239.7	100	-	-	-	-	-	-	-	-
6	EAST JAINTIA HILLS	827.35	827.35	100	-	-	-	-	-	-	-	-
7	RI BHOI	688.78	688.78	100	-	-	-	-	-	-	-	-
8	SOUTH GARO HILLS	659.57	659.57	100	-	-	-	-	-	-	-	-
9	WEST JAINTIA HILLS	791.86	791.86	100	-	-	-	-	-	-	-	-
10	EAST KHASI HILLS	867.32	867.32	100	-	-	-	-	-	-	-	-
11	NORTH GARO HILLS	370.31	370.31	100	-	-	-	-	-	-	-	-
	Total (in sq.km)	8135.45	8135.45	100	-	-	-	-	-	-	-	-

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

CATEGORIZATION of ASSESSMENT UNITS, 2024							
MEGHALAYA							
S. No	Name of District	S. No	Name of Semi-Critical Assessment Units	S. No	Name of Critical Assessment Units	S. No	Name of Over-Exploited Assessment Units
1							
ABSTRACT							
Total No. of Assessed Units		Number of Semicritical Assessment Units		Number of Critical Assessment Units		Number of Over Exploited Assessment Units	
40		0		0		0	

Annexure IV (B)
Quality problems in Assessment units (as in 2024)

QUALITY PROBLEMS IN ASSESSMENT UNITS, 2024							
MEGHALAYA							
S. No	Name of District	S. No	Name of Assessment Units affected by Fluoride	S. No	Name of Assessment Units affected by Arsenic	S. No	Name of Assessment Units affected by Salinity
ABSTRACT							
Total Number of Assessed Units		Number of Assessment Units affected by Fluoride		Number of Assessment Units affected by Arsenic		Number of Assessment Units affected by Salinity	
0		0		0		0	

Annexure V (A)
Summary of Assessment units improved or deteriorated from 2023 to 2024 assessment

State-Wise Summary Of Assessmet Units Improved Or Deteriorated From 2024 To 2023 Assessment							
S. No.	Name of States / Union Territories	Total Number of Asssessed Units	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
1	**MEGHALAYA**	40	0	0	39	1	1 new assessment unit was added i.e Greater Shillong during the current assessment

Annexure V (B)
Comparison of categorization of assessment units (2023 to 2024)

COMPARISON OF CATEGORIZATION OF ASSESSMENT UNITS (2024 AND 2023)									
MEGHALAYA									
S. No	Name of District	Name of Assessment Unit	Stage of Ground Water Extraction (%) in 2023	Categorization 2023	Name of District	Name of Assessment Unit	Stage of Ground Water Extraction (%) in 2024	Categorization 2024	Remark
Improved									
NIL									

COMPARISON OF CATEGORIZATION OF ASSESSMENT UNITS (2024 AND 2023)									
MEGHALAYA									
S. No	Name of District	Name of Assessment Unit	Stage of Ground Water Extraction (%) in 2023	Categorization 2023	Name of District	Name of Assessment Unit	Stage of Ground Water Extraction (%) in 2024	Categorization 2024	Remark
Deteriorated									
NIL									

Annexure VI
Assessment Unit Wise Report (Attribute Table)

Sl. No	District	Assessment Unit Name	Total Area of Assessment Unit (Ha)	Recharge Worthy Area(Ha)	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 for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (Over-Exploited/Critical/Semi-Critical/Safe/Saline)	Urban Aus or not
1	SOUTH WEST GARO HILLS	Betasing	41200	22763	3497.73	109.57	1109.55	167.44	4884.29	2220.91	2663.38	477.36	0	126.81	604.18	130.18	2055.83	22.68	safe	No
2	SOUTH WEST GARO HILLS	Zikzak	45400	19757	2357.8	50.93	747.94	51.34	3208.01	1429.21	1778.8	34.56	0	125.25	159.81	128.15	1616.09	8.98	safe	No
3	SOUTH WEST KHASI HILLS	Mawkyrwat	64078	21422	4089.63	175.89	936.07	52.1	5253.69	525.37	4728.32	0	0	99.86	99.86	108.98	4619.34	2.11	safe	No
4	SOUTH WEST KHASI HILLS	Ranikor	70022	27115	7379.23	26.99	1689.02	8.92	9104.16	910.41	8193.75	0	0	35.31	35.31	38.31	8155.44	0.43	safe	No
5	EAST GARO HILLS	Samanda	54700	19085	2443.16	182.84	737.98	214.31	3578.29	357.83	3220.46	0	0	86.31	86.31	93.16	3127.3	2.68	safe	No
6	EAST GARO HILLS	Songsak	43100	15156	2208.02	195.12	533.57	226.56	3163.27	316.32	2846.95	0	0	121.21	121.21	130.59	2716.36	4.26	safe	No
7	EAST GARO HILLS	Dambo Rongjeng	46500	15974	1735.11	197.49	524.11	229.03	2685.74	268.57	2417.17	0	0	131.54	131.54	144.63	2272.54	5.44	safe	No
8	WEST GARO HILLS	Selsella	53500	35211	9409	304.75	2502.39	575	12791.14	4637.38	8153.76	1864.8	0.6	450.31	2315.71	496.03	5792.33	28.40	safe	No
9	WEST GARO HILLS	Tikrikilla	33000	15892	2760.07	24.51	734.06	32.75	3551.39	1046.66	2504.73	68.4	0	140.90	209.3	147.38	2288.95	8.36	safe	No
10	WEST	Dadenggiri	61700	2618	3498	16.4	930.	15.7	4461.	2960	1500.	0	0	91.82	91.82	100.3	1400.	6.12	safe	No

	GARO HILLS			1	.75	9	52	1	47	.67	8					4	46			
11	WEST GARO HILLS	Gambegre	24800	10341	1979	16.96	526.33	16.13	2538.42	1056.18	1482.24	0	0	47.96	47.96	51.77	1430.47	3.24	safe	No
12	WEST GARO HILLS	Dalu	45900	21244	3450.71	18.63	1147.18	17.72	4634.24	2773.65	1860.59	0	0	104.28	104.28	112.56	4058.26	5.60	safe	No
13	WEST GARO HILLS	Rongram	62200	18915	2603.67	17.58	692.47	16.73	3330.45	1250.27	2080.18	0	0	151.66	151.66	163.71	1916.47	7.29	safe	No
14	WEST KHASI HILLS	Mairang	87729	24555	4640.9	290.13	1309.76	174.73	6415.52	641.55	5773.97	0	0	119.17	119.16	128.46	5645.52	2.06	safe	No
15	WEST KHASI HILLS	Mawthadraishan	47948	14489	2738.42	371.02	772.84	225.03	4107.31	410.73	3696.58	0	0	81.46	81.46	89.74	3606.84	2.20	safe	No
16	WEST KHASI HILLS	Mawshynrut	160878	54407	9206.09	259.33	3247.7	159.55	12872.67	1287.27	11585.4	0	0	148.60	148.6	164.21	11421.19	1.28	safe	No
17	WEST KHASI HILLS	Nongstoin	94045	30519	5981.95	396.4	1688.24	243.77	8310.36	831.04	7479.32	0	0	103.91	103.91	114.77	7364.55	1.39	safe	No
18	EAST JAINTIA HILLS	Khliehriat	119400	50445	8158.46	66.74	2806.13	65.65	11096.98	1109.7	9987.28	0	0	129.32	129.32	142.71	9844.57	1.29	safe	No
19	EAST JAINTIA HILLS	Saipung	84600	32290	4322.39	24.69	1486.7	23.28	5857.06	585.71	5271.35	0	0	61.15	61.15	68.75	5202.6	1.16	safe	No
20	RI BHOI	Umsning	118897	40313	2898.54	35.09	764.62	28.76	3727.01	372.7	3354.31	0	4.3025	167.60	171.89	187.13	3162.89	5.12	safe	No
21	RI BHOI	Umling	59963	13744	1031.37	43.72	272.07	37.47	1384.63	138.46	1246.17	0	18.1696	104.15	122.33	114.64	1113.35	9.82	safe	No
22	RI BHOI	Jirang	65940	14821	1113	33.83	293.6	28.07	1468.5	146.85	1321.65	0	0	42.94	42.94	47.88	1273.77	3.25	safe	No
23	SOUTH GARO HILLS	Rongara	58700	17440	5426.19	10.98	1828.83	10.1	7276.1	727.61	6548.49	0	0	47.35	47.35	52.09	6496.4	0.72	safe	No
24	SOUTH GARO HILLS	Baghmara	44200	15465	3359.9	25.38	1415.51	23.38	4824.17	482.42	4341.75	0	0	97.54	97.54	105.06	4236.69	2.25	safe	No
25	SOUTH GARO HILLS	Chokpot	43800	16686	3760.98	15.23	1584.49	14.28	5374.98	537.5	4837.48	0	0	49.03	49.03	52.64	4784.84	1.01	safe	No
26	SOUTH GARO HILLS	Gasuapara	42000	16366	4242.07	13.02	1787.17	12	6054.26	605.43	5448.83	0	0	57.62	57.62	62.26	5386.57	1.06	safe	No
27	WEST JAINTIA	Amlarem	39800	17583	2277.39	23.22	979.15	12.24	3292	329.2	2962.8	0	0	30.70	30.7	32.51	2930.29	1.04	safe	No

	HILLS																			
28	WEST JAINTIA HILLS	Thadlaskein	90460	42486	3356.14	46.21	1442.94	34.78	4880.07	488.01	4392.06	0	0	316.99	317	358.6	4033.45	7.22	safe	No
29	WEST JAINTIA HILLS	Laskein	47640	19117	2246.33	38.76	772.63	27.68	3085.4	308.54	2776.86	0	0	245.75	245.75	276.18	2500.68	8.85	safe	No
30	NORTH GARO HILLS	Resubelpara	72500	23901	3884.37	1272.66	855.91	366.46	6379.4	1170.22	5209.18	1.8	0	269.82	271.62	287.86	4919.52	5.21	safe	No
31	NORTH GARO HILLS	Kharkutta	43500	13130	2128.86	788.57	469.09	202.5	3589.02	447.39	3141.63	0	0	137.75	137.75	151.46	2990.17	4.38	safe	No
32	EAST KHASI HILLS	Mawkynrew	34594	11292	1853.68	276.1	502.55	275.62	2907.95	290.8	2617.15	0	0.9	42.74	43.65	46.87	2569.37	1.67	safe	No
33	EAST KHASI HILLS	Mylliem	7880	3073	508.29	49.45	137.8	48.52	744.06	74.4	669.66	0	0	62.20	62.2	71.4	598.26	9.29	safe	No
34	EAST KHASI HILLS	Greater Shillong	18000	3250	421.26	0.82	142.76	0.76	565.6	56.56	509.04	0	1.2	213.37	214.57	213.37	294.47	42.15	safe	No
35	EAST KHASI HILLS	Pynursla	41411	12059	3052.97	7.84	827.69	7.22	3895.72	389.57	3506.15	0	0	16.78	16.77	17.61	3488.55	0.48	safe	No
36	EAST KHASI HILLS	Shella Bholaganj	35199	10513	2321.86	7.16	786.85	6.24	3122.11	312.21	2809.9	0	0	48.32	48.31	52	2757.91	1.72	safe	No
37	EAST KHASI HILLS	Khatarshnong Laitkroh	32394	12835	2324.81	7.7	630.28	7.26	2970.05	297	2673.05	0	0	58.79	58.79	67.15	2605.9	2.20	safe	No
38	EAST KHASI HILLS	Mawryngkneng	24205	8794	1492.27	43.95	404.57	43.56	1984.35	198.43	1785.92	0	0	91.96	91.96	102.54	1683.38	5.15	safe	No
39	EAST KHASI HILLS	Mawsynram	50964	14733	3039.61	53.56	1030.09	52.78	4176.04	417.61	3758.43	0	0	54.57	54.56	57.31	3701.13	1.45	safe	No
40	EAST KHASI HILLS	Mawphlang	30153	10183	1798.63	21.61	487.63	20.24	2328.11	232.81	2095.3	0	0	60.58	60.57	66.65	2028.66	2.89	safe	No

Annexure VII
Minutes of the Meeting of the SLC Committee

MINUTES OF MEETING OF THE STATE LEVEL COMMITTEE ON GROUND WATER RESOURCE ASSESSMENT (SLCGWRA) FOR THE STATE OF MEGHALAYA

The meeting of State Level Committee on Groundwater Resource Assessment (SLCGWRA) for assessment of Dynamic Ground Water Resources of Meghalaya as on 2024 was held on 20th September 2024 at Committee Room –II, Room No.317, Meghalaya Civil Secretariat (Main), Shillong. The meeting was chaired by Sh. Sibhi. C. Sadhu, IAS, Secretary, Water Resources Department, Govt. of Meghalaya, Shillong. The list of Members present is enclosed.

The Officer In Charge, Central Ground Water Board, SUO Shillong, welcomed the Committee members and delivered a brief note on the agenda of the meeting and salient findings of the current assessment of Ground Water Resources of Meghalaya. She highlighted that the assessment is being carried out jointly by Central Ground Water Board and Water Resource Department (Nodal Department) in co-ordination with other state departments of the state.

With the permission of the Chair, Ms. Anenuo Pienyu, Scientist-C, CGWB, SUO, Shillong delivered a powerpoint presentation on the methodology and software (INGRES) used for resource estimation and the results of for Dynamic Ground water resources of the state as on 2024 after computation. She pointed out about some changes opted for the current assessment , viz., the assessment has been done block-wise, Greater Shillong Area has been taken as one separate unit and data of spring sources were used for computation of additional potential recharge.

A detailed discussion on data used for assessment of Dynamic groundwater resources of Meghalaya was held where various queries were addressed. The population figures used were projected data based on 2011 Census. The Chairman advised to obtain actual population data from the concerned state department. He also advised the Nodal department to obtain block-wise groundwater extraction data on domestic/other uses and from other municipal area apart from Shillong viz. Tura, Jowai etc for better accuracy in the extraction component.

Apart from Resource related issues, esteemed member from Soil & Water Conservation department also opinioned for monitoring of Springshed Project by CGWB taken up by their department. It was informed that the issue will be included in the agenda of Quarterly dialogue of CGWB, CWC and State Govt. of Meghalaya.

After thorough discussion, the Committee unanimously agreed and accepted the figures of Dynamic Ground Water resources of Meghalaya as on March, 2024.

The meeting ended with a vote of thanks from the Chair.

(Sibhi C. Sadhu), IAS
Secretary, Water Resource Department
Government of Meghalaya

1

Meeting of State Level Committee on Ground Water Resource Assessment, Meghalaya as on 2024
Venue: Committee Room no. II, Main Secretariat Building, Shillong
Date: 20th September 2024
Attendance Sheet

Sl. No.	Name & Designation	Organisation	Phone number	e-mail	Signature
1	Shri S C Sadhu, IAS Secretary Water Resources	Govt. of Meghalaya			[signature]
2	Mrs. M.B. Ritshong.	WRD.	9436715941.	mbritshong@gmail.com.	[signature]
3	M. J. A. Jas [illegible], IFC.	Forest + Env. Dept.	9436 998762		[signature]
4	Shri N. Lyngdoh, I/c S.E Agriculture	Dept of Agriculture	7630082770	jda.mechanical@gmail.com	[signature]
5	Smti. B. Lyngdoh	Directorate of Horticulture	9862511123	barbarielyngdoh@gmail.com	[signature]
6	Shasinh Kent, Sc-C(Hq)	CGWB	8732892899	kent.shasinh@gmail.com	[signature]
7	Dakshina Rekha scientist-D & OIC	CGWB, SUO, Shillong	9435733549	cgwbshillong@gmail.com	[signature]
8	Shri Gideon L. L. Mawnai	Directorate of Horticulture	8794347692	lewislyngdoh19@gmail.com	[signature]
9	Smti. H. A. Sangma, ADF	Directorate of Fisheries	8638083113	[illegible]@gmail.com.	[signature]
10	Shri. L. Shabong Joint Director (Hq)	Soil & Water Conservation Dept.	8787567264	shabongls@gmail.com	[signature]

Meeting of State Level Committee on Ground Water Resource Assessment, Meghalaya as on 2024
Venue: Committee Room no. II, Main Secretariat Building, Shillong
Date: 20th September 2024
Attendance Sheet

Sl. No.	Name & Designation	Organisation	Phone number	e-mail	Signature
11	Shri. A. M. Sangma Assistant Engineer	C&RD	9436165002	crrd-meg@nic.in	[signature]
12	Smt D. W. Rymbai Executive Engineer	PHE Dept	9774418292	wabaluti1@gmail.com	[signature]
13	Ms. Anenuo Pienyu Scientist-C (HG)	CGWB	9089447789	cgwbshillong@gmail.com	[signature]
14					
15					
16					
17					
18					
19					
20					

CONTRIBUTORS

Estimation of dynamic ground water resources of Meghalaya is based on the data provided by various state and central government departments like Water Resources Department, North Eastern Space Application Centre (NESAC), Community & Rural Development Department, Agriculture Department, Directorate of Economics and Statistics, Directorate of Fisheries, Soil and Water Conservation Department, Public Health Engineering Department, Govt. of Meghalaya etc. During this assessment, all the block wise data were collected mainly through District Level Committee on Ground Water Resource (DLCGWR). The computation of the resource estimation was done through INGRES software and compilation, uploading of data and preparation of the report was done by Ms. D. Rabha, Scientist-D, Shri Shasinlo Kent, Scientist-C and Ms. Rinku Rani Das, Scientist-B of CGWB, SUO, Shillong and Shri. Carlden E. Wahlang, Superintending Engineer, Water Resources Department under the guidance of Shri Tapan Chakraborty, Regional Director, CGWB, NER, Guwahati and Dr. Shakil P. Ahammed, IAS, Addl. Chief Secretary, Govt. of Meghalaya.

Principal Contributors:

1. Ms. D. Rabha, Scientist-D & Officer-In-Charge, CGWB, SUO, Shillong
2. Mr. Shasinlo Kent, Scientist-C, CGWB, SUO, Shillong
3. Ms. Rinku Rani Das, Scientist-C, CGWB, SUO, Shillong

Contributors:

1. Smti. Agatha Doreen Blah, Chief Engineer, Water Resources Department, Meghalaya
2. Smti. Mary Biple Ritshong, Addl. Chief Engineer, Water Resources Department, Meghalaya
3. Shri. Carlden E. Wahlang, Superintending Engineer, Water Resources Department
4. All members/ department of SLC on GWRA of Meghalaya 2024

Team INGRES:

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

Overall Guidance & Supervision:

1. Shri. 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. Dr. Shakil P. Ahammed, IAS, Addl. Chief Secretary, Govt. of Meghalaya
4. Shri Tapan Chakraborty, Regional Director, CGWB NER, Guwahati