DYNAMIC GROUND WATER RESOURCES OF ARUNACHAL PRADESH, 2024

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

Itanagar
January, 2025

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Foreword

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

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

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

Itanagar
January 2025

Shri. Pige Ligu, IAS
Secretary, WRD & Chairman
State level Committee (GWRA)
Arunachal Pradesh

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Government of India
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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 **Arunachal Pradesh, 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 Arunachal Pradesh 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 **Arunachal Pradesh** 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 **Arunachal Pradesh** 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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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 Arunachal Pradesh 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)
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North Eastern Region

PREFACE

The State of Arunachal Pradesh is characterized by hilly terrain with steep slopes. valley areas, which are found as repository of groundwater in state. The valleys covered with unconsolidated alluvial deposits and semi-consolidated Tertiary sedimentary formations are having fairy good scope, for groundwater development.

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

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

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

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

The Ground Water Resources of Arunachal Pradesh, 2024 have been assessed block-wise for the recharge worthy area. Total Annual Ground Water Recharge of the State has been assessed as 3.88 bcm and Annual Extractable Ground Water Resources as 3.46 bcm. The Annual Ground Water Extraction is 0.013 bcm and Stage of Ground Water extraction is 0.39 %. All the assessment units and districts have been categorized as 'Safe and there is no saline area in the state.

The report will be very helpful for the user agencies.

Guwahati
January, 2025

तचक्रवर्ती
(Tapan Chakraborty) Regional
Director &
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2.	Annual Extractable Ground Water Resources	3.46 bcm
3.	Annual Ground Water Extraction	0.013 bcm
4.	Stage of Ground Water Extraction	0.39 %

CATEGORIZATION OF ASSESSMENT UNITS

(Blocks/ Mandals/ Talukas)

Sl.No	Category	Number of Assessment Units		Recharge worthy Area		Annual Extractable Ground Water Resource	
		Number	%	in lakh sq. km	%	(in bcm)	%
1	Safe	42	100	5721.38	100	3.46	100
2	Semi Critical						
3	Critical						
4	Over-Exploited						
5	Saline						
	TOTAL	42	100	5721.38	100	3.46	100

EXECUTIVE SUMMARY

The state of Arunachal Pradesh is underlain by diverse rock types of different geological ages from Pre-Cambrian to Recent. Major part of the state is covered with consolidated crystalline rocks and meta-sediments of Precambrian and Palaeozoic age, while Tertiary sediments consisting of semi-consolidated argillaceous assemblage, represented by the Disang, Barail, Tipam, Siwalik and Dihing groups of rock, occupy periphery areas bordering Assam and behave as run-off and in select patches functions as infiltration zone. In consolidated formations, ground water potential appears to be limited. Semi-consolidated Tertiary formations are likely to give moderate or poor yield and expected to be controlled by aquifer geometry and structural features. Ground water in both consolidated and semi-consolidated formations also manifests as springs and in all geological formation springs occur as both seasonal and perennial in nature.

Unconsolidated Quaternary sediments comprising the terrace deposits of Pleistocene (Bhabar zone) and also the terrace and alluvial fan deposits of Holocene age prevail in the fringe valley areas and as thin carpet in isolated structural valley sand with considerable thickness in open and wide valleys joining Brahmaputra Alluvial plains. The unconsolidated alluvial sediments in the valley areas act as good repositories for ground water development. Valleys adjoining Assam are most promising where good thickness of granular zones is distributed. Discharge of the deep tube wells, tapping mostly unconsolidated Quaternary sediments & at places Upper Tertiary formations, varies from 1.4m³/hr to 54m³/hr, while transmissivity ranges from 1 to 661m²/day. Storativity ranges from 0.35x10-3 to 6.65x10-3

The ground water resource estimation of the state has been done block-wise by considering 42 nos. of groundwater recharge worthy blocks as assessment unit. The Total Annual Groundwater Recharge of the State has been estimated as 3.88 bcm and Annual Extractable Groundwater Resources is 3.46 bcm. The Current Annual Ground Water Extraction for all uses is 0.013 bcm and Stage of Ground Water Extraction is 0.39 %. The Total Annual Ground Water Recharge has decreased from 4.65 bcm to 3.88 bcm. There is minor change in the current annual ground water extraction. All the 42 assessment units have been categorized as ‘Safe’. There is no saline area in the state.

Similarly, out of 5721.38 sq km recharge worthy area of the State, 5721.38 sq km (100 %) under ‘Safe’ categories of assessment units. Out of total 3455.95 mcm annual extractable ground water resources of the State, 3455.95 mcm (100 %) are under ‘Safe’ categories of assessment units.

As compared to 2023 assessment, the Total Annual Ground Water Recharge for the State has decreased from 4.65 bcm in 2023 to 3.88 bcm in 2024, Annual Extractable Ground Water Resources decreased from 4.16 bcm in 2023 to 3.46 bcm in 2024 and Total Ground Water Extraction decreased from 0.017 bcm in 2023 to 0.013 bcm in 2024. The Stage of Ground Water Extraction decreased from 0.42 % to 0.39 %.

CHAPTER 1

1.0 INTRODUCTION

Water is a fundamental resource essential for life, and groundwater has increasingly become a crucial natural resource meeting the freshwater needs of various sectors in India. However, the sustainable development and efficient management of this limited resource pose significant challenges. Groundwater is the backbone of India's agriculture and drinking water security, contributing nearly 62% to irrigation, 85% to rural water supply, and 50% to urban water supply. Although groundwater is replenished annually, its availability is uneven across different locations and times. The groundwater in the zone of water level fluctuation is primarily recharged annually, with rainfall being the main contributor. The National Water Policy of 2012 emphasizes periodic, scientifically-based assessments of groundwater resources, including evaluating trends in water availability due to factors such as climate change during water resource planning. To meet growing water demands, the policy advocates for direct rainfall use, desalination, and minimizing unnecessary evapotranspiration to augment usable water resources. Additionally, the policy prioritizes safe water for drinking and sanitation, followed by other domestic needs (including animals), food security, subsistence agriculture, and minimum ecosystem needs. Any remaining water should be allocated to promote conservation and efficient use. Therefore, sustainable groundwater utilization requires a realistic and scientifically sound quantitative assessment of its availability.

Arunachal Pradesh occupies the easternmost part of the country and is spread over an area of 83,743 sq. km. The state lies between Latitudes 26°302N - 29°302N latitude and 91°302E – 97°302E longitude. The state is bounded on the north by China, on the east by Myanmar and on the west by Bhutan. In the south it is bounded by the state of Assam and Nagaland. The state has been divided into 16 districts, 51 Sub-divisions, 92 blocks and 190 circles as per 2011 census.

1.1 Previous assessments:

The first assessment of ground water resources of Arunachal Pradesh was carried out in 1992 based on 'Ground Water Estimation Methodology', 1984 (GEC'84). The ground water resource of the state was reassessed for the assessment year 2004 using 'Ground Water Resource Estimation Methodology – 1997' (GEC'97). The ground water resource of the state of Arunachal Pradesh has been re-assessed based on the GEC-97 methodology and modified database for base years 2004, 2009, 2011, and 2013. Comprehensive revisions led to the GEC 2015 methodology, which has been used for assessments since 2017 (2017, 2020, 2022 & 2023). In response to the rapidly changing patterns of groundwater extraction, the formulation of management strategies, and the need for regulatory interventions to address short-term fluctuations in groundwater resources, the Ministry of Jal Shakti has proposed the annual estimation of groundwater resources for the country, starting from the year 2022 onwards.

1.2 Re-assessment of Ground Water Resources, 2024

In the present assessment, the total annual groundwater recharge in the state has been assessed as 3.88 bcm. Keeping an allocation for natural discharge, the annual extractable ground water resource has been assessed as 3.46 bcm. The annual groundwater extraction (as in 2024) is 0.013 bcm. The average stage of groundwater extraction for the state as a whole works out to be about 0.39 %. Out of the total **42** assessment units (Blocks) in the state, all the units **(100%)** have been categorized as **'Safe 'units**, where the stage of Ground water extraction is less than 70 %. There is no saline area in the state.

CHAPTER 2

2.0 GROUND WATER RESOURCE ESTIMATION METHODOLOGY

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

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

2.1. GROUND WATER ASSESSMENT OF UNCONFINED AQUIFER

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

2.1.1. Assessment of Annually Replenishable or Dynamic Ground Water Resources

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

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

Equation (1) can be further elaborated as –

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

Where,

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

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

2.1.1.1. Rainfall Recharge

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

2.1.1.1.1. Ground Water Level Fluctuation Method

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

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

Where,

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

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

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

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

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

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,

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

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

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

$$R = ar \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..\ldots\ldots\ldots.(8)$$

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:

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

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,

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

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:

$$a = \frac{NS_4 - S_1 S_2}{NS_3 - S_1^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(11)$$

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

Where,

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

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 –

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

Where,

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

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

2.1.1.1.3. Percent Deviation

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

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

Where,

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

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

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

2.1.1.2. Recharge from Other Sources

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

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

2.1.1.3. Evaporation and Transpiration

Evaporation is estimated for the aquifer in the assessment unit if water levels in the aquifer are within the capillary zone. For areas with water levels within 1.0mbgl, evaporation is estimated using the evaporation rates available for other adjoining areas. If depth to water level is more than 1.0mbgl, the evaporation losses from the aquifer is taken as zero.
Transpiration through vegetation has been estimated if water levels in the aquifer are within the maximum root zone of the local vegetation. If water levels are within 3.5mbgl, transpiration is estimated using the transpiration rates available for other areas. If it is greater than3.5m bgl, the transpiration has been taken as zero.

2.1.1.4. Recharge During Monsoon Season

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

2.1.1.5. Recharge During Non-Monsoon Season

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

2.1.1.6. Total Annual Ground Water Recharge

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

2.1.1.7. Annual Extractable Ground Water Resource (EGR)

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

2.1.1.8. Estimation of Ground Water Extraction

Ground water draft or extraction is assessed as follows.

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

Where,

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

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

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

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

There are several methods for estimation of extraction for domestic use (GE_{DOM}). Some of the commonly adopted methods are described here.
***Unit Draft Method:* –** In this method, unit draft of each type of well is multiplied by the number of wells used for domestic purpose to obtain the domestic ground water extraction.
***Consumptive Use Method:* –** In this method, population is multiplied with per capita consumption usually expressed in litre per capita per day (lpcd). It can be expressed using following equation.

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

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.

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

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,

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

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. Categorization of Assessment Unit

2.1.1.11.1. Categorization of Assessment Unit Based on Quantity

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

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

2.1.1.11.2. Categorization of Assessment Unit Based on Quality

As it is not possible to categorize the assessment units in terms of the extent of quality hazard, based on the available water quality monitoring mechanism and database on ground water quality, the Committee recommends that each assessment unit, in addition to the Quantity based categorization (safe, semi-critical,

critical and over-exploited) should bear a quality hazard identifier. If any of the three quality hazards in terms of Arsenic, Fluoride and Salinity are encountered in the assessment sub unit in mappable units, the assessment sub unit has been tagged with the particular Quality hazard.

2.1.1.12. Allocation of Ground Water Resource for Utilization

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.

$$Alloc = 22 \times N \times L_g mm\ per\ year \dots\dots\dots\dots\dots\dots\dots.\dots\dots\dots\dots\dots\dots\dots.(19)$$

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.

$$Potential\ ground\ water\ resource\ due\ to\ springs = Q \times No.of days \dots\dots\dots\dots..\dots\dots.(20)$$

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:

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

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.

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

Where,

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

A = Flood Prone Area

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

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
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
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

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
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
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

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
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
49	Khondalite	KH01	Khondalites, Granulites - Weathered, Jointed	Azoic	1.5	1	2
50	Khondalite	KH01	Khondalites, Granulites - Massive, Poorly Fractured	Azoic	0.3	0.2	0.4
51	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Weathered, Jointed	Azoic	1.5	1	2
52	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Massive, Poorly Fractured	Azoic	0.3	0.2	0.4

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
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

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

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

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
50	Khondalite	KH01	Khondalites, Granulites - Mssive, Poorly Fractured	Azoic	2	1	3
51	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Weathered, Jointed	Azoic	7	5	9
52	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Massive, Poorly Fractured	Azoic	2	1	3
53	Gneiss	GN01	Undifferentiated metasedimentaries/ Undifferentiated metamorphic - Weathered, Jointed	Azoic to Proterozoic	7	5	9
54	Gneiss	GN01	Undifferentiated metasedimentaries/ Undifferentiated metamorphic - Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3
55	Gneiss	GN02	Gneiss -Weathered, Jointed	Azoic to Proterozoic	11	10	12
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	Ultra Basics (Epidiorite, Granophyre etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3

2.4.3. Norms for Recharge Due to Irrigation

The Recommended Norms are presented in ***Table-2.3***.

Table-2.3: 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

2.4.4. 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.

2.4.5. 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.

2.4.6. 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:

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

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.

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

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

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

3.1 Rainfall of Arunachal Pradesh

Arunachal Pradesh, situated in the northeastern part of India, experiences significant rainfall due to its unique topography and climatic conditions. The state receives the majority of its annual precipitation during the southwest monsoon season, which spans from June to September. The southwest monsoon is the primary contributor to the state's rainfall, accounting for approximately 70%–80% of the annual precipitation. This period is characterized by heavy and consistent rainfall. 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. The monsoon months (June to September) typically experience the highest frequency of rainy days, often exceeding 20 days per month. In contrast, the winter months (December to February) usually have fewer rainy days, often less than 5 days per month. Historically, districts such as East Siang and Papum Pare have been known to receive higher rainfall amounts due to their geographical location. The area receives rainfall on an average for 161 days in a year. The normal Rain fall of the state is 2807 mm.

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

District	Year	Monsoon		Non-Monsoon	
		Actual (mm)	Normal (mm)	Actual (mm)	Normal (mm)
CHANGLANG	2023-2024	1149.54	1690.4	553.27	909.1
EAST KAMENG	2023-2024	1813.48	1459.8	423.82	676.3
EAST SIANG	2023-2024	2177.89	3397.0	518.4	1021.8
LOHIT	2023-2024	1061.71	1750.1	515.61	1253.4
LOWER DIBANG VALLEY	2023-2024	1520.64	1923.5	453.5	1583.5
LOWER SUBANSIRI	2023-2024	1831.59	1276.3	405.93	860.6
PAPUM PARE	2023-2024	1994.25	2408.0	239.43	928.8
TIRAP	2023-2024	1491.51	2510.4	516.07	949.0
UPPER SUBANSIRI	2023-2024	1209.01	1093.6	527.26	652.9
WEST KAMENG	2023-2024	1567.09	1976.8	277.78	544.6
WEST SIANG	2023-2024	1737.52	2223.2	775.45	689.7

Table 3.2: District wise Rainfall during the Calendar Year 2023 for the Arunachal Pradesh

DISTRICT	Jan 2023		Feb 2023		Mar 2023		Apr 2023		May 2023		Jun 2023		Jul 2023		Aug 2023		Sep 2023		Oct 2023		Nov 2023		Dec 2023	
	Actual (mm)	Normal (mm)	Actual (mm)	Normal (mm)	Actual (mm)	Normal (mm)	Actual (mm)	Normal (mm)	Actual (mm)	Normal (mm)	Actual (mm)	Normal (mm)	Actual (mm)	Normal (mm)	Actual (mm)	Normal (mm)	Actual (mm)	Normal (mm)	Actual (mm)	Normal (mm)	Actual (mm)	Normal (mm)	Actual (mm)	Normal (mm)
PAPUM PARE	4.14	47.8	55.94	83.9	96.03	146.1	135.47	217.4	248.98	239.6	522.43	311.5	647.84	333.7	425.55	243	156.34	268.1	242.09	120	13.66	42.2	12.92	35.8
TIRAP	2.15	44.9	85.05	91	150.74	174.2	209.64	352.7	174.4	428.3	408.57	667.8	350.07	973.1	361.1	550.5	220.53	462.6	151.24	179.1	10.22	39.4	22.43	28
UPPER SUBANSIRI	20.66	47.8	93.34	83.9	103.88	146.1	126.99	217.4	243.69	239.6	343.24	311.5	299.75	333.7	297.1	243	127.82	268.1	141.1	120	9.93	42.2	12.38	35.8
LOWER SUBANSIRI	8.55	47.8	45.44	83.9	64.85	146.1	117.34	217.4	183.23	239.6	455.3	311.5	581.63	333.7	477.13	243	120.43	268.1	197.1	120	11.66	42.2	10.81	35.8
WEST KAMENG	0.14	20.3	36.52	28.8	49.85	34.8	68.21	89.6	163.45	157.3	349.1	390.7	545.33	366	417.38	249.3	114.76	200.6	140.52	90.8	12.12	22.8	3.57	8.1
EAST KAMENG	1.44	20.3	72.37	28.8	109.51	34.8	103.66	89.6	219.71	157.3	464.26	390.7	624.57	366	398.89	249.3	129.21	200.6	196.55	90.8	23.3	22.8	10.46	8.1
EAST SIANG	8.19	53.8	132.19	115	138.84	187.1	111.67	273.9	214.79	361.8	464.91	755.1	821.36	886.4	582.96	601.6	152.9	609.1	155.76	232.2	9.2	49.2	19.8	46.7
CHANGLANG	1.53	44.9	99.07	91	150.02	174.2	165.23	352.7	159.13	428.3	357.4	667.8	290.35	973.1	289.64	550.5	101.26	462.6	110.89	179.1	20.29	39.4	37.87	28
LOHIT	1.99	63.5	124.2	106.3	137.53	211.1	130.29	410.1	148.76	293.8	340.87	452.9	250.54	610.1	298.3	376.6	71.51	298.3	100.49	191.4	21.83	49.4	33.23	44.2
LOWER DIBANG VALLEY	4.02	-	129.04	-	128.46	-	100.6	-	162.49	-	365.21	-	491.46	-	454.12	-	91.29	-	118.56	-	14.65	-	21.19	-
WEST SIANG	19.76	53.8	152.43	115	161.62	187.1	159.54	273.9	349.87	361.8	417.14	755.1	485.14	886.4	407.28	601.6	204.54	609.1	223.42	232.2	9.36	49.2	19.08	46.7

CHAPTER 4

4.0 HYDROGEOLOGICAL SETUP OF ARUNACHAL PRADESH

DESCRIPTION OF ROCK TYPES WITH AREA COVERAGE

Hydrogeologically the state can be categorized into three units, viz-(i) Consolidated representing the crystalline formations and the (ii) Semi-consolidated and (iii) Unconsolidated units representing the Sedimentaries.

The consolidated formations (crystalline) occur along the high and moderate hill ranges of the state. These formations mostly comprise meta-sediments like gneiss and schist and fissured formations (i.e.-Phyllites, Schist, Quartzites etc.) belonging to Archean to Paleozoic age. They act basically as run-off zone. The weathered part as well as the secondary pores developed in the form of joints, fissures etc in the consolidated formations have good ground water potential.

The semi-consolidated formations comprise the Tertiary Group of rocks represented by the Disang, Barail, Tipam, Siwalik and Dihing groups of rock. They are occupying the areas in the south and southwestern part of the state and show gradual decrease in altitude and behave as run-off, infiltration as also discharge zones. They contribute recharge to ground water depending on litho-character.

Ground water in both consolidated and semi-consolidated formations is manifested as springs. Springs in all geological formations are both seasonal and perennial in nature.

The older alluvium comprising the terrace deposits of Pleistocene and also the terrace and alluvial fan deposits of Holocene age form the unconsolidated formation. They are distributed as thin layers in intermontane valleys and with considerable thickness in open and wide valleys joining Brahmaputra Alluvial plains. Deposition shows poor sorting in distribution of grains. High or low rate of infiltration is observed depending on physical geometry and matrix of formation. Terrace types of deposits are found extending in and along the foothill zone. It is commonly referred to Bhabar belt, comprising sand, gravel, pebble and boulder. The zone contains one or more aquifers, which have fair to good ground water potential. The aquifers at places tend to be artesian in nature. Unconsolidated Quaternary and Upper Tertiary formations form the main hydrological units in the state.

4.1. Rock Types

The state constitutes rocks from Archaean to Recent. Major part is covered with consolidated crystalline rocks and meta-sediments of Precambrian and Palaeozoic times, while Tertiary sediments consisting semi-consolidated argillaceous assemblage occupy periphery areas bordering Assam. Unconsolidated Quaternary sediments comprising Alluvium prevail in the fringe valley areas and as thin carpet in isolated structural valleys. More than 90% of the area is covered by hilly terrain.

Unconsolidated Quaternary and Upper Tertiary formations form the main hydrological units for ground water recharge in the state. Other than this, Semi consolidated Lower Tertiary and Upper Paleozoic formations are important from Ground Water development point of view.

4.2 Hydrometeorological Conditions

The climate of the state is mainly influenced by orography. It is sub-tropical, wet and highly humid in nature in the foothill regions and cold in higher elevations. The temperature falls below freezing point during extremely cold period. The maximum temperature ranges from 27°C and minimum winter temperature in the higher altitude goes down below freezing point. Humidity is very high. Heavy rainfall is received during summer and occasional rainfall during winter. January and February are the driest months. The rainfall received during summer is under the spell of South-West monsoon. The onset of South-West monsoon in the region occurs by the end of May or the first week of June and withdraws by late September or early October. But, very often pre-monsoon showers are experienced during March and April. Copious rainfall is received in the southern, eastern and northeastern part of the state during the summer. From March to May, the region comes under the influence of equatorial Westerlies and receives precipitation with occasional thundershowers.

The average annual rainfall in different stations of the state varies from 2000 to 5000 mm with some variation. The isohyets showing the rainfall pattern in the state on the basis of normal annual rainfall, has been depicted in Plate III.

4.3 Description of Hydrogeological Units

The unconsolidated alluvial sediments in the valley areas act as good repositories for ground water development. Valleys adjoining Assam are most promising where good thickness of granular aquifer zones is distributed. However, physical parameters of heterogeneous aquifer sediments with variable matrix play an important role in determining permeability, transmissibility and specific capacity of aquifer zones. Intervening clay layers found with arenaceous sediments indicate leaky aquifer system. Auto-flow conditions seen at places are promoted due to high hydraulic head. In the intermontane valleys thickness of alluvium and weathered residium are important factors. Potential aquifer zones are likely to prevail

Semi-consolidated Tertiary formations are likely to give moderate or poor yield and expected to be controlled by aquifer geometry and structural features.

In consolidated formations ground water potentiality appears to be very much limited. However, highly weathered and fissured formation in pockets may offer some scope for development

Ground water exploration studies were carried out by Central Ground Water Board (CGWB) in the state revealed that water bearing formations are observed in Unconsolidated Alluvium of Quaternary Age, Primary/Secondary porosity of semi-consolidated sandstone of Tertiary Age, Secondary porosity of granite, schist, gneiss, phyllite of Archean to Pre Cambrian-Age. Discharge of the deep tubewells varies from 1.4 m^3/hr to 54 m^3/hr while transmissivity ranges from 1.14 to 661 m^2/day. Storativity ranges from 0.35 x 10-3 to 6.65 x10-3.

Table 4.1: Ground Water Potential in different Hydrogeological formations of Arunachal Pradesh

Formation	Lithology	Groundwater potential
Unconsolidated	sand, clay, silt, gravel, pebble, cobble and boulder	Moderate yield, 30-50m^3/hr. Drawdown within 10 to 15m.

Semi-consolidated	Shale, siltstone, sandstone, interbedded with coal seams and limestone	Low yield, up to 20m^3/hr. Drawdown within 25m.
Consolidated		
Fissured Formation	Phyllites, schist, slates, quartzites	Low yield, 5 to 15m^3/hr.
Metasediment	Gnessic complex with acid and basic intrusives	Yield up to 5m^3/hr.

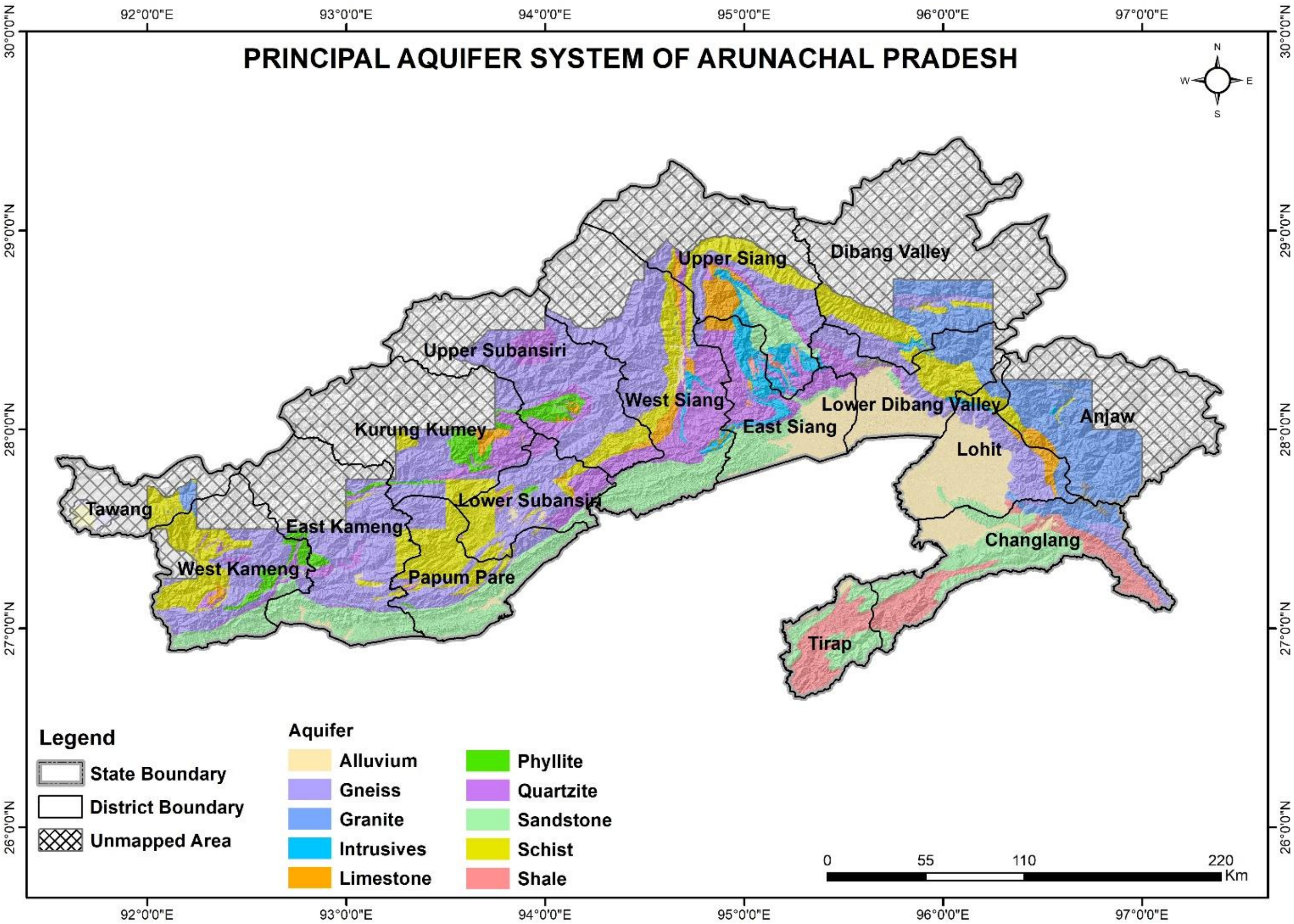

Fig-4.1: Principal Aquifer System of Arunachal Pradesh.

CHAPTER-5

5.0 GROUND WATER LEVEL SCENARIO IN THE ARUNACHAL PRADESH

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

5.1 Groundwater Level Scenario (2023)

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

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

Location	Station Type (Dug Well/ Borewell/Tube Well)	Depth to Water Level (mbgl)	
		March-2023	November-2023
Changlang			
Jairampur	Dug Well	6.12	1.30
Namchik	Dug Well	4.55	3.74
Namphai	Dug Well	4.95	3.60
Newlisan Kharsang	Dug Well	4.78	2.83
East Siang			
Oyan	Dug Well	9.61	7.87
Pasighat New	Dug Well	10.41	8.68
Ruksin	Dug Well	1.94	1.45
Satmile	Dug Well	2.36	1.65
Sika Baman Todee	Dug Well	5.76	3.74
Lohit			
Lathow	Dug Well	5.12	4.0
Medo	Dug Well	-	1.98
Lower Dibang valley			
Kangklong	Dug well	-	9.89
Lower Subansiri			
Bomte	Dug Well	1.85	1.62

Rajgarh	Dug Well	5.86	1.22
Papum Pare			
Banderedewa I	Dug Well	12.08	12.09
Chimpu	Dug Well	3.72	3.22
Doimukh	Dug Well	1.73	0.68
Holangi New	Dug Well	3.61	1.69
Kimin New	Dug Well	1.38	0.74
Naharlagun I	Dug Well	6.66	6.15
Nirjuli Vill IIA	Dug Well	1.21	0.80
Nirjuli Vill IIB	Dug Well	1.32	1.02
Papu Nallah	Dug Well	4.43	3.83
Sonajuli	Dug Well	2.99	2.45
Tirap			
Borduria	Dug Well	4.89	5.71
Deomali	Dug Well	5.36	5.33
Hukanjuri	Dug Well	5.13	6.66

Depth to Water level during March, 2023

A significant part of Arunachal Pradesh is hilly. Hence, most of the monitoring stations are located along the southern boundary bordering the Brahmaputra valley of Assam.

During the month of March 2023, 29 stations were monitored in the state. Water level within 2-5 mbgl had been recorded in majority of the wells i.e. 44.8% (13) of the monitored stations. Depth to water level in the range of 0-2 mbgl had been observed in 20.7% (6) stations and in the 5-10 mbgl range in 27.6% (8) stations. Two stations located in East Siang and Papum pare district recorded water level in the 10-20 mbgl range. Minimum water level of 1.21 mbgl and maximum water level of 12.08 mbgl had been recorded in Papum pare district during the period.

Depth to water level during November 2023

During the month of November 2023, groundwater level in the state was recorded in 43.4% (13) of the monitored stations within 0-2 mbgl, in 30% (9) stations in the range of 2-5 mbgl and in23.3% (7) stations in the range of 5-10 mbgl. Water level in the range of 10-20 mbgl was recorded only in one station. Both the minimum and maximum water levels of 0.68 mbgl and 12.09 mbgl had been recorded in Papum pare district.

5.2 Fluctuation of Groundwater Level:

5.2.1 Comparison of Pre-monsoon 2023 to Pre-monsoon 2022

Comparison of water levels of March 2022 and March 2023 indicated rise in 50% (14) stations in the range 0-2 m and 7.1% (3) station in the range of 2-4 m during March 2023. Fall was observed in 39.3 % 11) stations in the range 0-2 m and in one station (3.6%) in the range of 2-4 m. A total of 28 stations had been analyzed in the state.

5.2.2 Comparison of Post-monsoon 2023 to Post-monsoon 2022

Comparison of water levels of November 2023 and November 2022 indicated fall in water level in 57.1% (16) stations and rise in 42.9% (12) stations. The entire fall had been recorded within 2m and was observed mostly in stations located in Changlang, East Siang, Lohit, Papum pare and Tirap district. All the stations located in Lohit, Lower Dibang Valley and Lower Subansiri district indicated rise. Two stations located in Changlang district recorded rise in the range of 2-4m and above 4m.

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

March 2023 water level had been compared with mean water level data of the same period of preceding 10 years. Fall in water levels had been recorded in 15 (71.4%) stations and rise in 6 (28.6%) stations. Entire fall had been observed within 2m. Decline in water level was observed in 57.1% (12) stations in the range of 0-2 m and 14.3 % (3) stations in the range of 2-4 m. Maximum rise of 1.67 m and maximum fall of 2.94 m had been observed in Tirap and Changlang district respectively.

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

Comparison of November 2023 water level with mean of the same period of preceding 10 years indicate rise in 19.1 % (4) stations. Rise was recorded in 14.3% (3) stations in the range of 0-2 m and 4.8% (1) station in the range of 2-4m. The rise ranged from 0.07 to2.55 m. Total fall was recorded in 80.9% (17) stations. Fall was observed in71.4% (15) stations in the range of 0-2 m and in 9.52% (2) stations in the range of 2-4 m. The fall was found to vary from 0.11 m to 3 m. The maximum rise and the maximum fall in water level had been recorded in Changlang and East Siang district respectively.

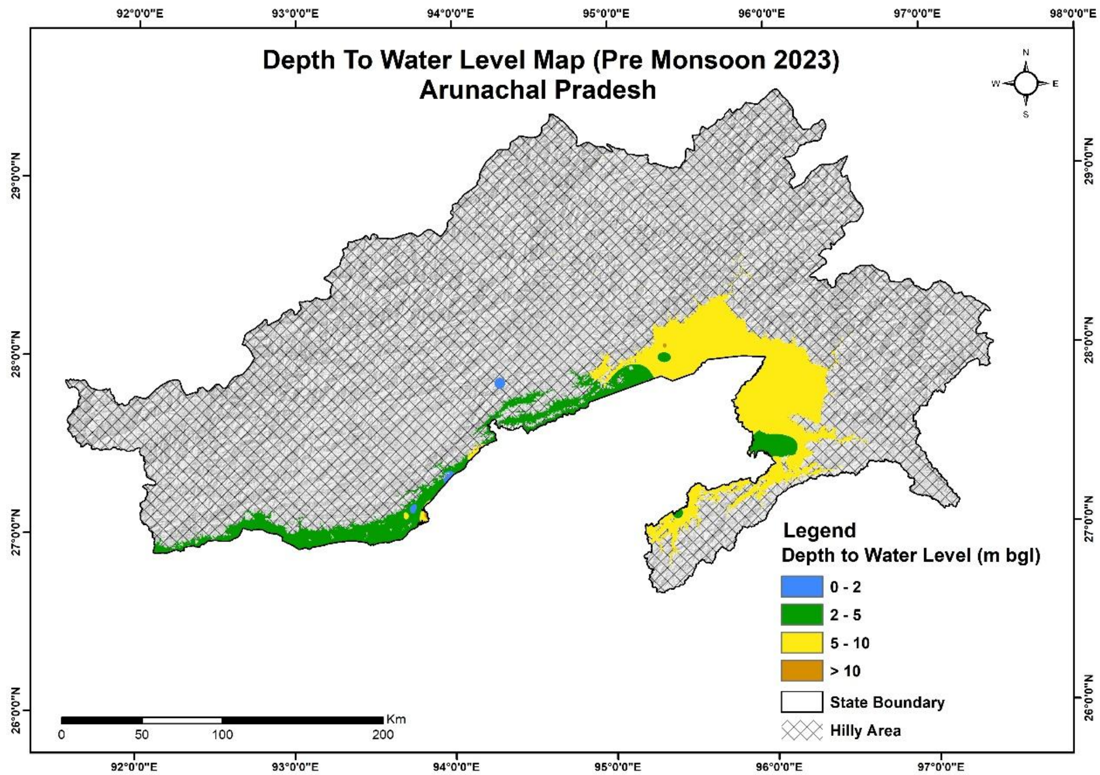

Fig-5.1: Pre-monsoon depth to water level map (2023)

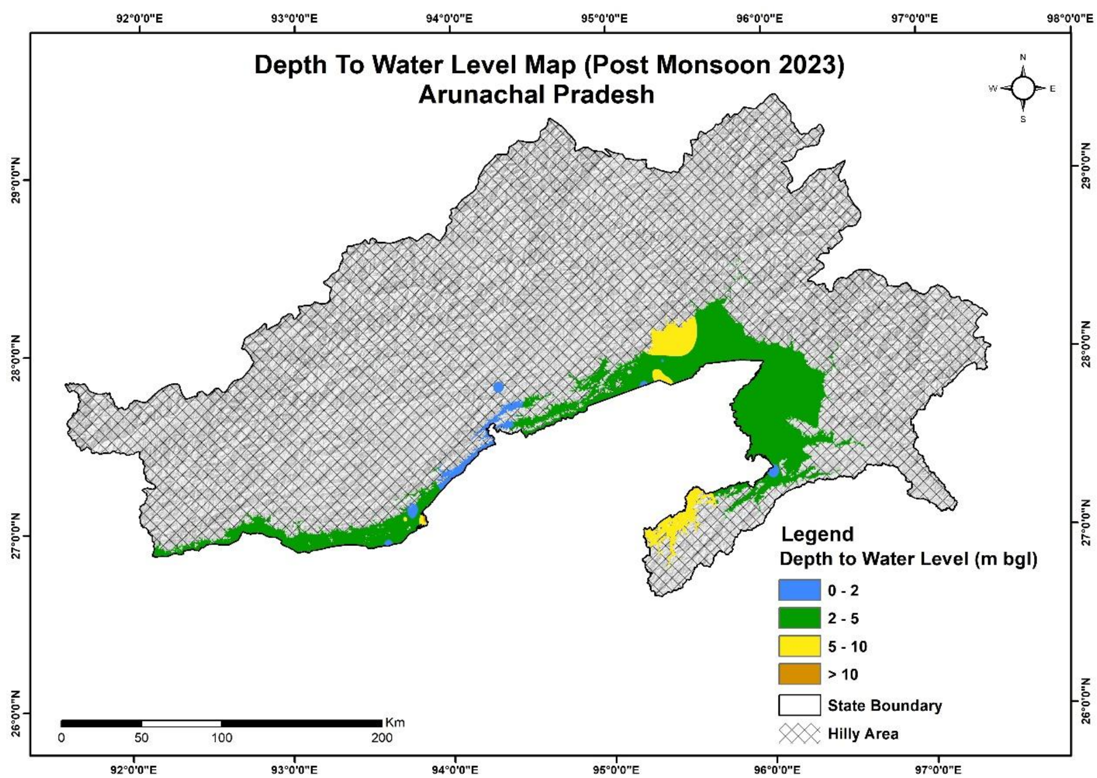

Fig-5.2: Post-monsoon depth to water level map (2023)

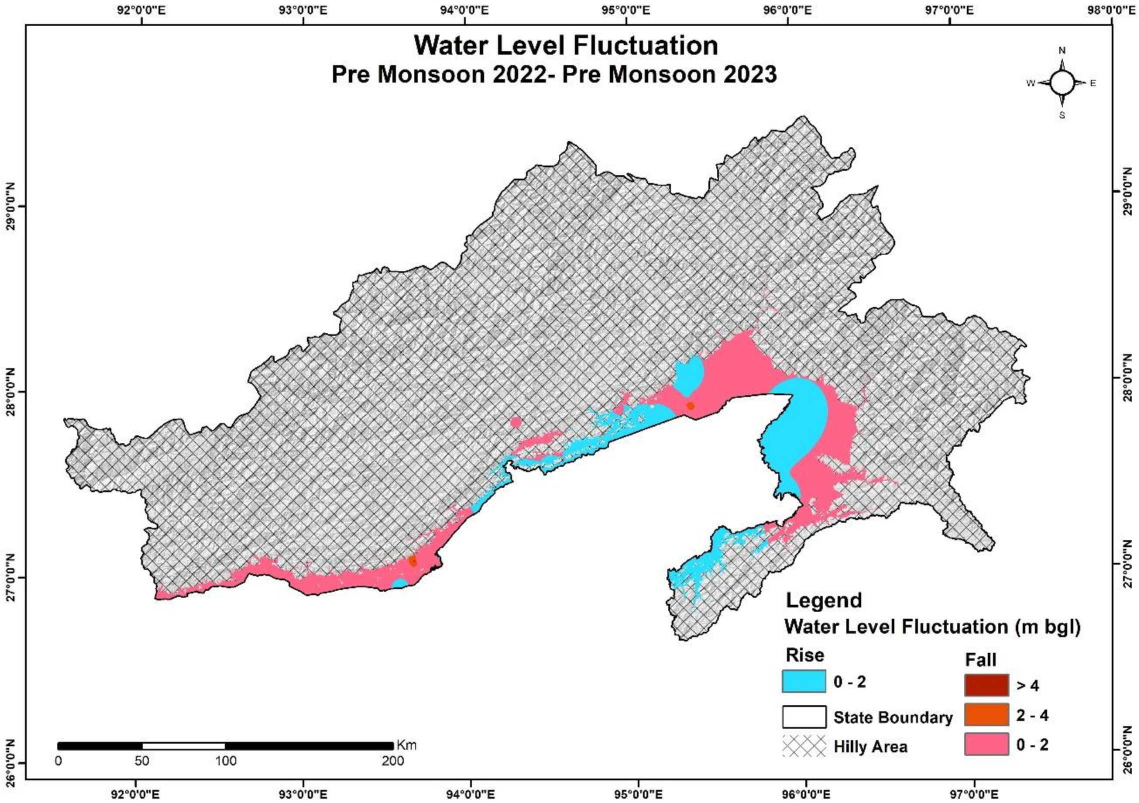

Fig-5.3: Groundwater Level Fluctuation: Pre-monsoon 2022 compared to Pre-monsoon 2023

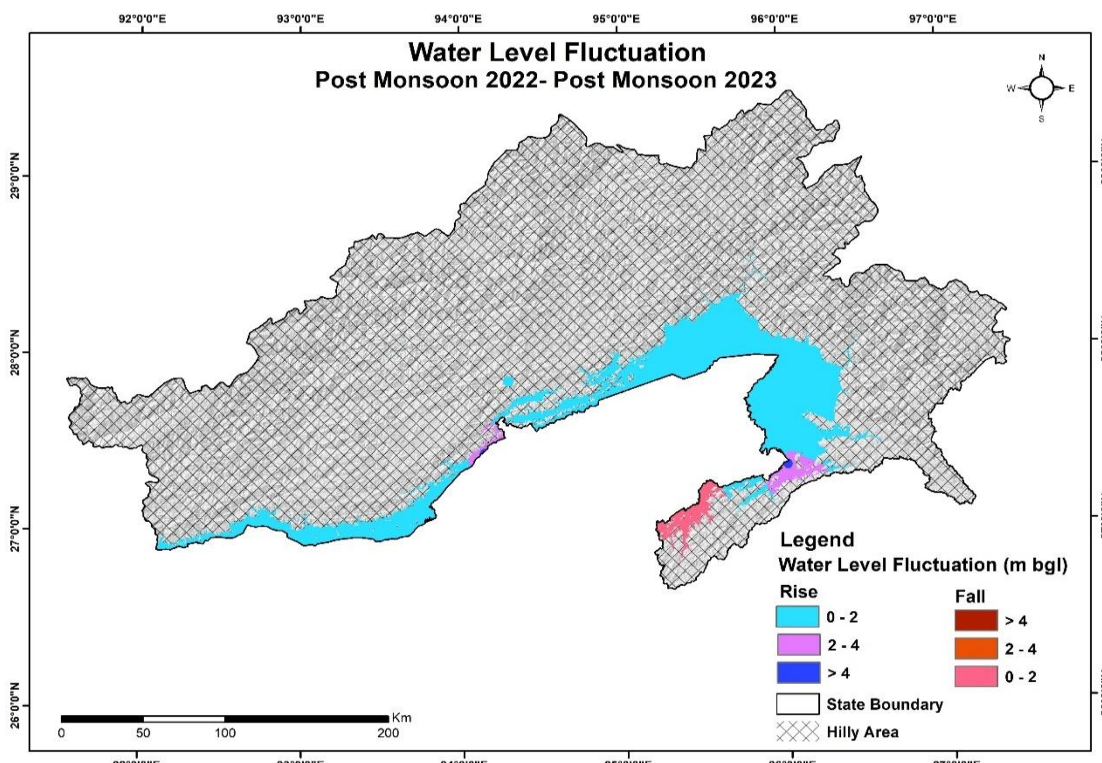

Fig-5.4: Groundwater Level Fluctuation: Post-monsoon 2022 compared to Post-monsoon 2023

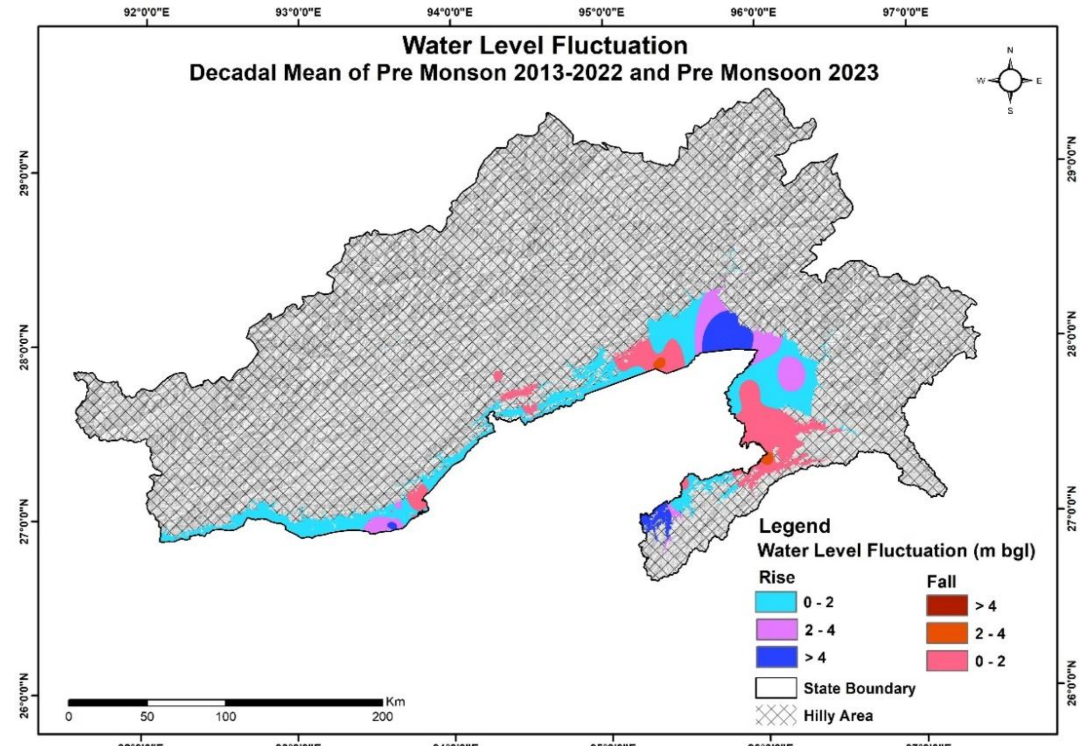

Fig-5.5: Decadal water level fluctuation with mean Pre-Monsoon (2013 to 2022) and Pre-Monsoon 2023

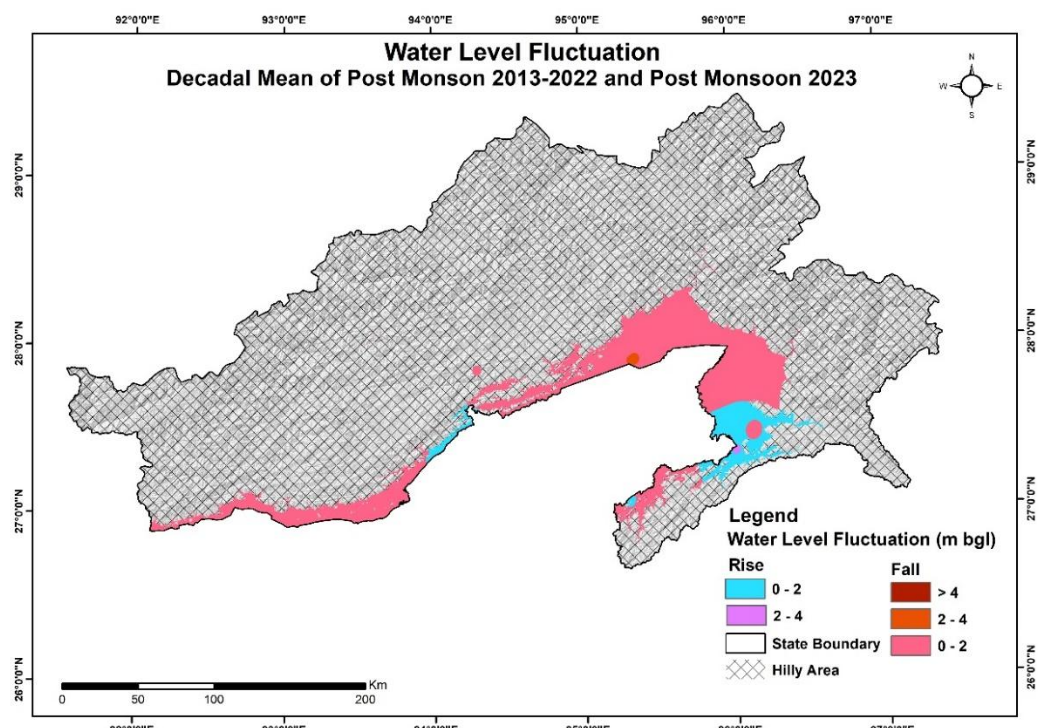

Fig-5.6: Decadal water level fluctuation with mean Post-Monsoon (2013 to 2022) and Post-monsoon 2023

CHAPTER 6

6.0 GROUND WATER RESOURCES OF THE ARUNACHAL PRADESH

6.1. ANNUAL GROUND WATER RECHARGE

Total ground water recharge is 3.88 BCM and Annual extractable groundwater resources is 3.45 BCM after deducting natural discharge and resultant flow. Ground water extraction for various uses has been estimated for all the assessment units of Arunachal Pradesh. Gross annual ground water extraction for all uses is 0.013 BCM. Balance groundwater availability for future use is 3.44 BCM. The stage of groundwater extraction is 0.39 % and all the 42 assessment units in Arunachal Pradesh state falls under **SAFE** category.

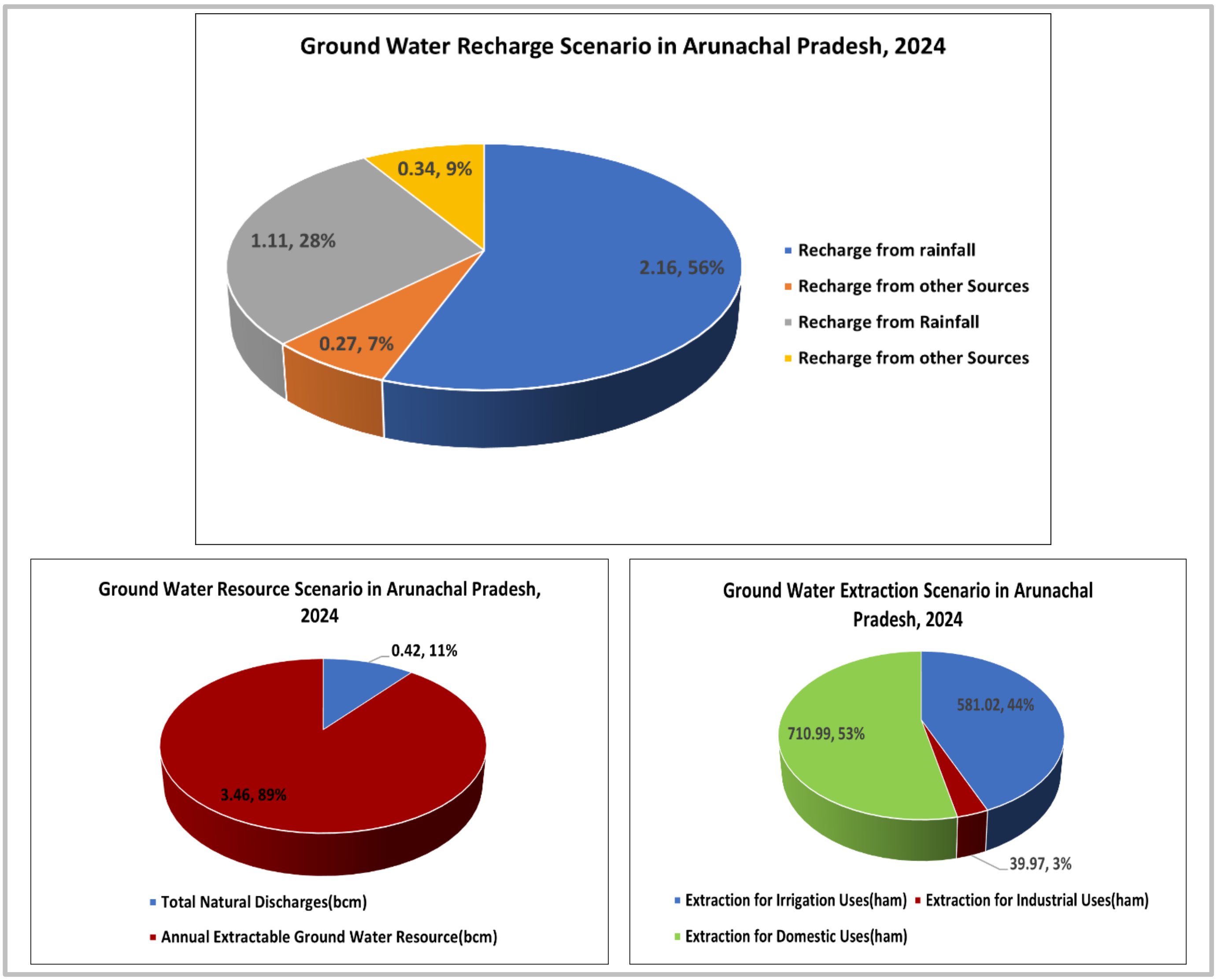

Fig-6.1: Ground Water Resources and Extraction Scenario in Arunachal Pradesh, 2024

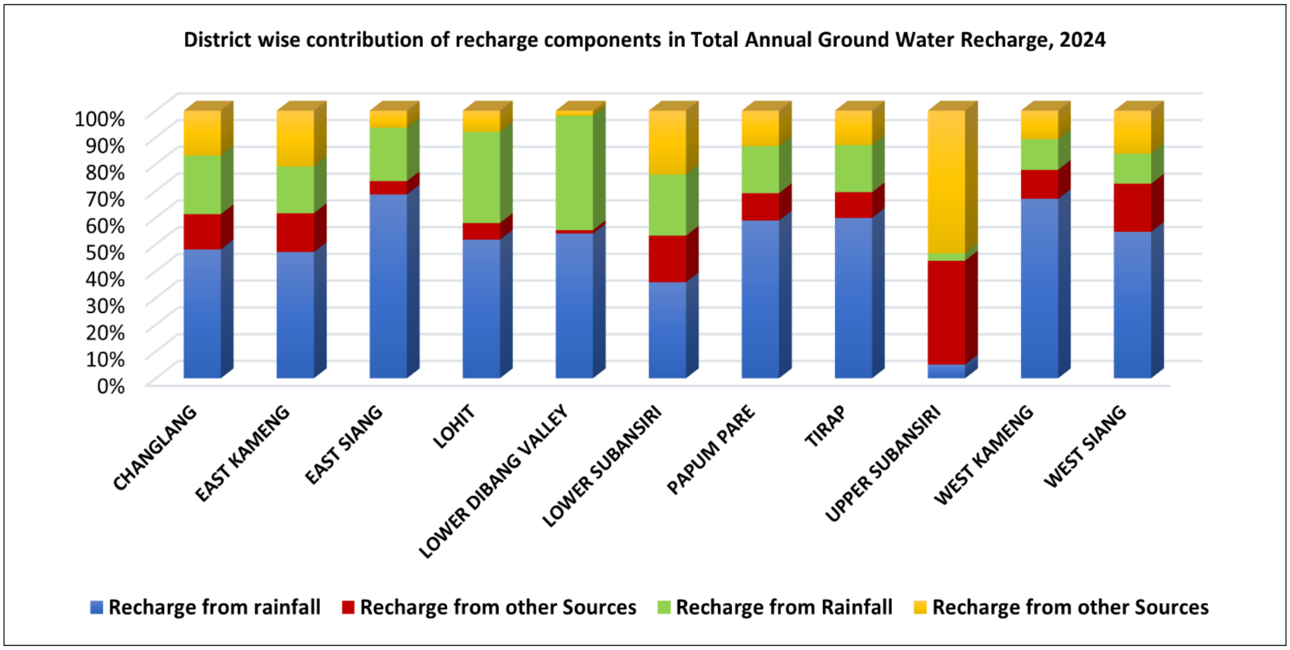

Fig-6.2: District wise contribution of Recharge components in Total Annual ground Water Recharge of Arunachal Pradesh, 2024

6.2. STAGE OF GROUND WATER EXTRACTION

The overall stage of groundwater extraction in the state is 0.39 %. The district wise distribution of Stage of Groundwater Extraction is presented below: -

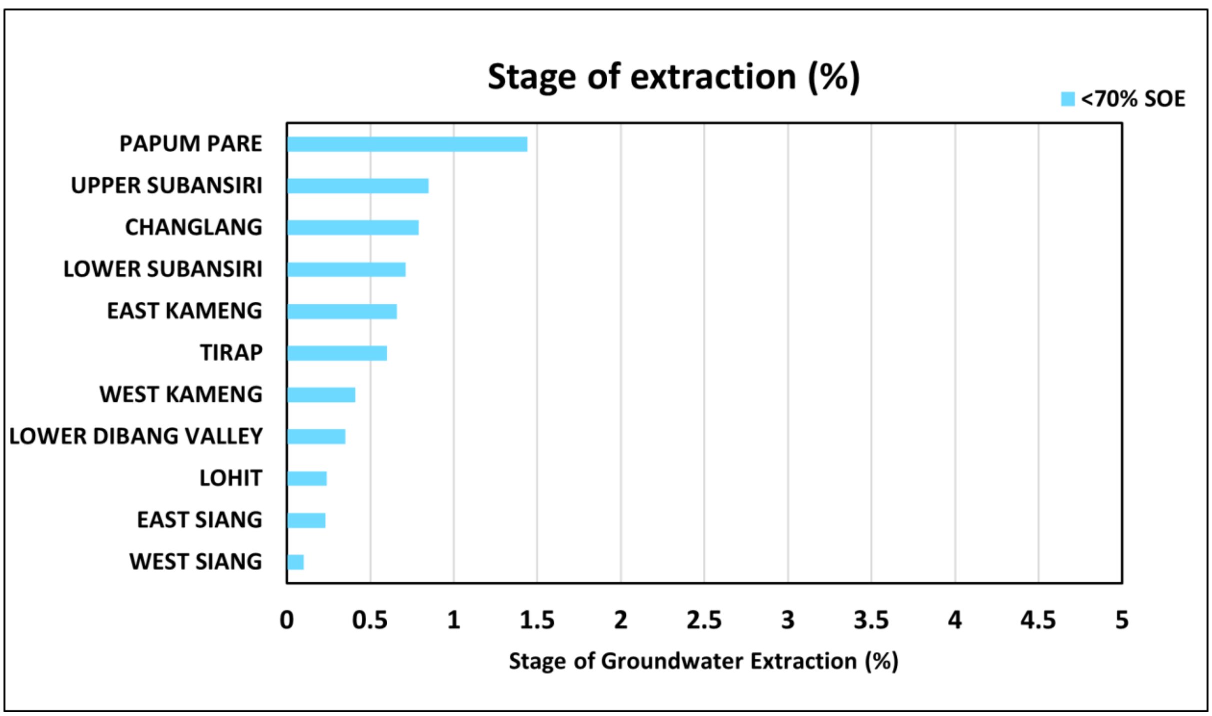

Fig-6.3: District wise Stage of Ground Water Extraction

6.3. CATEGORIZATION OF ASSESSMENT UNITS

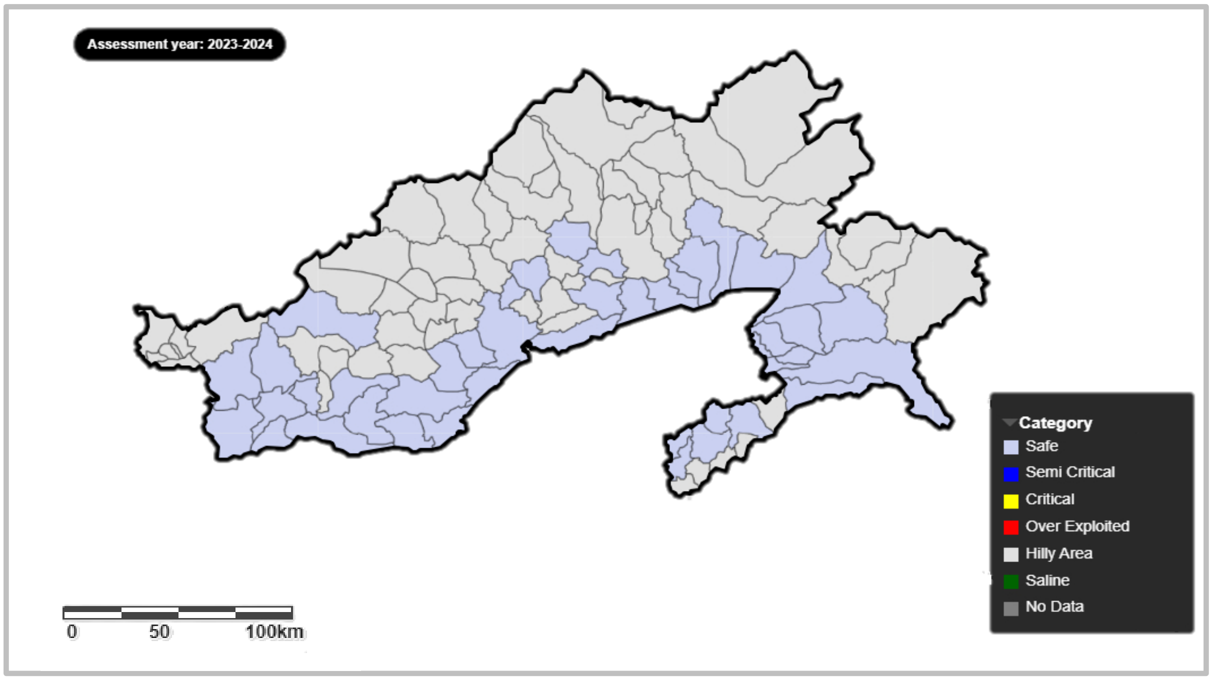

Fig-6.4: Categorization of Assessment Units

6.4. COMPARISON WITH PREVIOUS ASSESSMENT

Table-6.1: Comparison of 2023 & 2024 assessment of Arunachal Pradesh

Sl. No.	ITEM	Year 2022-23	Year 2023-24	COMPARISON
	Estimation	INGRES	INGRES	
1	Total Annual Ground Water Recharge (BCM)	4.65	3.88	Decrease by 0.77
2	Annual Extractable Ground Water Resources (BCM)	4.16	3.46	Decrease by 0.70
3	Irrigation extraction (BCM)	0.01	0.006	Decrease by 0.004
4	Industrial extraction (BCM)	0.00038	0.0004	No major Change
5	Domestic extraction (BCM)	0.0069	0.007	No Major Change
6	Stage of GW Extraction (%)	0.42	0.39	Decrease by 0.03
7	Provision for Domestic use (BCM)	0.0075	0.0075	
8	GW availability for future use (BCM)	4.14	3.44	Decrease by 0.7
9	No. of SAFE Units	42	42	No change
10	No. of O.E. Units	Nil	Nil	
11	No. of Dark/ Critical units	Nil	Nil	

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 3.88 BCM and Annual Extractable Ground Water Resources as 3.46 BCM. The current Annual Ground Water Extraction is 0.013 BCM and Stage of Ground Water Extraction is 0.39 %. All the 42 assessment units have been categorized as ‘Safe’.

Similarly, out of 5721.38 sq km recharge worthy area of the State, 5721.38 sq km (100 %) under ‘Safe’ categories of assessment units. Out of total 3.46 bcm annual extractable ground water resources of the State, 3.46 bcm (100 %) are under ‘Safe’ categories of assessment units.

As compared to 2023 assessment, the Total Annual Ground Water Recharge for the State has decreased from 4.65 bcm in 2023 to 3.88 bcm in 2024, Annual Extractable Ground Water Resources decreased from 4.16 bcm in 2023 to 3.46 bcm in 2024 and Total Ground Water Extraction decreased from 0.017 bcm in 2023 to 0.013 bcm in 2024. The Stage of Ground Water Extraction decreased from 0.42 % to 0.39 %.

Annexure-I

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024															
ARUNACHAL PRADESH (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	**ARUNACHAL PRADESH**	2.16	0.27	1.11	0.34	3.88	0.42	3.46	0.01	0	0.01	0.01	0.01	3.44	0.39
	Total (bcm)	2.16	0.27	1.11	0.34	3.88	0.42	3.46	0.01	0	0.01	0.01	0.01	3.44	0.39

Annexure-II

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024															
ARUNACHAL PRADESH (in Ham)															
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	**CHANGLANG**	16679	4549.9	7569.1	5815.4	34613.49	3461.36	31152	64.8	0	180.17	244.97	188.4	30899	0.79
2	**EAST KAMENG**	8567.6	2632	3181	3784	18165.45	1816.45	16348	94.1	0	14.36	108.46	16.26	16238	0.66
3	**EAST SIANG**	60264	4367	17483	5602.8	86538.88	9147.93	78569	110.42	4.2	63.67	178.27	65.66	78389	0.23
4	**LOHIT**	63804	7648.6	41950	9764.9	122887.79	12597	110571	34.36	8.4	227.86	270.62	237.07	110291	0.24
5	**LOWER DIBANG VALLEY**	42860	963.08	33884	1502.6	79210.46	7921.05	71289	216.5	0	31.41	247.91	31.9	71041	0.35
6	**LOWER SUBANSIRI**	2263.3	1095.1	1442.4	1503.3	6138.44	796.06	5508	16.83	0	22.28	39.11	26.71	5464.5	0.71
7	**PAPUM PARE**	8263.7	1432.2	2465	1856.9	11501.42	3828.84	10099	15.36	25.29	105.06	145.71	123.14	9935.6	1.44
8	**TIRAP**	6078.6	968.18	1784.8	1304.7	10136	1013.63	9122.7	6.25	0	48.8	55.04	50.06	9066.4	0.6
9	**UPPER SUBANSIRI**	141.52	1067.7	73.65	1468.7	2751.6	275.17	2476.4	16.64	0.9	3.62	21.16	4.39	2454.5	0.85
10	**WEST KAMENG**	2343	381.06	397.31	375.13	3496.5	349.63	3146.8	1.64	0	11.4	13.04	11.73	3133.5	0.41
11	**WEST SIANG**	4445.3	1460.5	916.74	1302.2	8124.7	812.46	7312.2	4.12	1.18	2.35	7.65	2.4	7304.5	0.1
	Total (Ham)	215711	26565	111147	34281	383564.27	42019.5	345595	581.02	39.97	710.99	1331.94	757.72	344216	0.39
	Total (Bcm)	2.16	0.27	1.11	0.34	3.88	0.42	3.46	0.01	0	0.01	0.01	0.01	3.44	0.39

Annexure-III(A)

CATEGORIZATION OF BLOCKS/ MANDALS/ TALUKAS IN INDIA (2024)												
S.No	States / Union Territories	Total No. of Assessed Units	Safe		Semi-Critical		Critical		Over-Exploited		Saline	
			Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%
1	ARUNACHAL PRADESH	42	42	100	-	-	-	-	-	-	-	-
	Grand Total	42	42	100	-	-	-	-	-	-	-	-

Annexure III (B)

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024												
ARUNACHAL PRADESH												
			Safe		Semi-Critical		Critical		Over-Exploited		Saline	
S.No	Name of District	Total No. of Assessed Units	No	%	No.	%	No.	%	No.	%	No.	%
1	CHANGLANG	5	5	100.0	-	-	-	-	-	-	-	-
2	EAST KAMENG	4	4	100.0	-	-	-	-	-	-	-	-
3	EAST SIANG	4	4	100.0	-	-	-	-	-	-	-	-
4	LOHIT	5	5	100.0	-	-	-	-	-	-	-	-
5	LOWER DIBANG VALLEY	2	2	100.0	-	-	-	-	-	-	-	-
6	LOWER SUBANSIRI	3	3	100.0	-	-	-	-	-	-	-	-
7	PAPUM PARE	4	4	100.0	-	-	-	-	-	-	-	-
8	TIRAP	4	4	100.0	-	-	-	-	-	-	-	-
9	UPPER SUBANSIRI	2	2	100.0	-	-	-	-	-	-	-	-
10	WEST KAMENG	5	5	100.0	-	-	-	-	-	-	-	-
11	WEST SIANG	4	4	100.0	-	-	-	-	-	-	-	-
	Total	42	42	100.0	-	-	-	-	-	-	-	-

Annexure III (C)

ANNUAL EXTRACTABLE RESOURCE OF ASSESSMENT UNITS UNDER DIFFERENT CATEGORIES, 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	ARUNACHAL PRADESH	3455.95	3455.95	100	-	-	-	-	-	-
	Total	3455.95	3455.95	100	-	-	-	-	-	-
	Grand Total	3455.95	3455.95	100	-	-	-	-	-	-

Annexure- III (D)

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024										
ARUNACHAL PRADESH										
			Safe		Semi-Critical		Critical		Over-Exploited	
S.No	Name of District	Total Annual Extractable Resource of Assessed Units (in mcm)	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%
1	CHANGLANG	311.52	311.52	100	-	-	-	-	-	-
2	EAST KAMENG	163.48	163.48	100	-	-	-	-	-	-
3	EAST SIANG	785.69	785.69	100	-	-	-	-	-	-
4	LOHIT	1105.71	1105.71	100	-	-	-	-	-	-
5	LOWER DIBANG VALLEY	712.89	712.89	100	-	-	-	-	-	-
6	LOWER SUBANSIRI	55.08	55.08	100	-	-	-	-	-	-
7	PAPUM PARE	100.99	100.99	100	-	-	-	-	-	-
8	TIRAP	91.23	91.23	100	-	-	-	-	-	-
9	UPPER SUBANSIRI	24.76	24.76	100	-	-	-	-	-	-
10	WEST KAMENG	31.47	31.47	100	-	-	-	-	-	-
11	WEST SIANG	73.12	73.12	100	-	-	-	-	-	-
	Total (mcm)	3455.95	3455.95	100	-	-	-	-	-	-
	Grand Total (mcm)	3455.95	3455.95	100	-	-	-	-	-	-

Annexure- III (E)

AREA OF ASSESSMENT UNITS UNDER DIFFERENT CATEGORIES IN INDIA (2024)														
S.No	States / Union Territories	Total Recharge Worthy Area of Assessed Units (in sq km)	Recharge Worthy Area (in sq km)	Safe		Semi-Critical		Critical		Over-Exploited		Saline	
				Recharge Worthy Area in sq km	%	Recharge Worthy Area in sq km	%	Recharge Worthy Area in sq km	%	Recharge Worthy Area in sq km	%	Recharge Worthy Area in sq km	%
1	ARUNACHAL PRADESH	5721.38	5721.38	5721.38	100	-	-	-	-	-	-	-	-
	Total	5721.38	5721.38	5721.38	100	-	-	-	-	-	-	-	-
	Grand Total	5721.38	5721.38	5721.38	100	-	-	-	-	-	-	-	-

Annexure III (F)

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024													
ARUNACHAL PRADESH													
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	CHANGLANG	530.0	530.0	100.0	-	-	-	-	-	-	-	-
2	EAST KAMENG	312.5	312.5	100.0	-	-	-	-	-	-	-	-
3	EAST SIANG	1101.0	1101.0	100.0	-	-	-	-	-	-	-	-
4	LOHIT	2000.0	2000.0	100.0	-	-	-	-	-	-	-	-
5	LOWER DIBANG VALLEY	1200.0	1200.0	100.0	-	-	-	-	-	-	-	-
6	LOWER SUBANSIRI	101.35	101.35	100.0	-	-	-	-	-	-	-	-
7	PAPUM PARE	178.19	178.19	100.0	-	-	-	-	-	-	-	-
8	TIRAP	125.0	125.0	100.0	-	-	-	-	-	-	-	-

9	**UPPER SUBANSIRI**	7.0	7.0	100.0	-	-	-	-	-	-	-	-
10	**WEST KAMENG**	61.75	61.75	100.0	-	-	-	-	-	-	-	-
11	**WEST SIANG**	104.59	104.59	100.0	-	-	-	-	-	-	-	-
	Total	5721.38	5721.38	100.0	-	-	-	-	-	-	-	-

Annexure IV (A)

CATEGORISATION OF ASSESSMENT UNIT, 2024							
ARUNACHAL PRADESH							
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**
ABSTRACT							
Total No. of Assessed Units		**Number of Semi critical Assessment Units**		**Number of Critical Assessment Units**		**Number of Over Exploited Assessment Units**	
42		0		0		0	

Annexure IV (B)

QUALITY PROBLEMS IN ASSESSMENT UNITS, 2024							
ARUNACHAL PRADESH							
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 No. of Assessed Units	Number of Assessment Units affected by Fluoride	Number of Assessment Units affected by Arsenic	Number of Assessment Units affected by Salinity
0	0	0	0

Annexure IV (C)

List of Saline Assessment units - Nil

Annexure V (A)

State-Wise Summary of Assessment Units Improved Or Deteriorated From 2023 To 2024 Assessment				
S.No	Name of States / Union Territories	Number of Assessment Units Improved	Number of Assessment Units Deteriorated	Number of Assessment Units with No Change
1	**ARUNACHAL PRADESH**	0	0	42

Annexure V (B)

COMPARISON OF CATEGORIZATION OF ASSESSMENT UNITS (2023 AND 2024)									
ARUNACHAL PRADESH									
S.No	Name of District	Name of Assessment Unit	Stage of Ground Water Extraction (%)2023	Categorization in2023	Name of District	Name of Assessment Unit	Stage of Ground Water Extraction (%)2024	Categorization in2024	Remark
1	CHANGLANG	Changlang	2	safe	CHANGLANG	Changlang	0.05	safe	No change
2		Diyun	3	safe		Diyun	1.26	safe	No change
3		Bordumsa	2.74	safe		Bordumsa	1.45	safe	No change
4		Khagam	0.81	safe		Khagam	0.71	safe	No change

5		Nampong	0.92	safe		Nampong	0.13	safe	No change
6	EAST KAMENG	Chayangtajo	2.31	safe	EAST KAMENG	Chayangtajo	0.1	safe	No change
7		Pakke-Kessang	1.46	safe		Pakke-Kessang	0.28	safe	No change
8		Seijosa	1.07	safe		Seijosa	0.28	safe	No change
9		Seppa	3.3	safe		Seppa	2.36	safe	No change
10	EAST SIANG	Ruksin	0.45	safe	EAST SIANG	Ruksin	0.28	safe	No change
11		Mebo	0.2	safe		Mebo	0.13	safe	No change
12		Pasighat	0.51	safe		Pasighat	0.33	safe	No change
13		Ramle Bango	0.83	safe		Ramle Bango	0.38	safe	No change
14	LOHIT	Lekang_Mahadevpur	1.8	safe	LOHIT	Lekang_Mahadevpur	0.91	safe	No change
15		Chongkham	0.2	safe		Chongkham	0.13	safe	No change
16		Namsai	0.77	safe		Namsai	0.55	safe	No change
17		Tezu	0.16	safe		Tezu	0.08	safe	No change
18		Wakro	0.28	safe		Wakro	0.1	safe	No change
19	LOWER DIBANG VALLEY	Roing-Koronu	0.19	safe	LOWER DIBANG VALLEY	Roing-Koronu	0.53	safe	No change
20		Dambuk	0.26	safe		Dambuk	0.06	safe	No change
21	LOWER SUBANSIRI	Ziro I	3.09	safe	LOWER SUBANSIRI	Ziro I	1.14	safe	No change
22		Tame Raga	2.48	safe		Tame Raga	0.87	safe	No change
23		Yachuli	2.93	safe		Yachuli	0.26	safe	No change
24	PAPUM PARE	Doimukh	4.2	safe	PAPUM PARE	Doimukh	3.19	safe	No change
25		Balijan	3.27	safe		Balijan	0.9	safe	No change
26		Kimin	12.15	safe		Kimin	2.65	safe	No change
27		Sagalee	1.47	safe		Sagalee	0.21	safe	No change
28	TIRAP	Namsang	0.66	safe	TIRAP	Namsang	0.59	safe	No change
29		Kanubari	1.25	safe		Kanubari	0.57	safe	No change
30		Khonsa	0.56	safe		Khonsa	0.27	safe	No change
31		Niausa	1.95	safe		Niausa	1.04	safe	No change
32	UPPER SUBANSIRI	Daporijo	12.74	safe	UPPER SUBANSIRI	Daporijo	1.58	safe	No change
33		Dumporijo	10.16	safe		Dumporijo	0.47	safe	No change
34	WEST KAMENG	Dirang	1.04	safe	WEST KAMENG	Dirang	0.5	safe	No change
35		Kalaktang	0.11	safe		Kalaktang	0.24	safe	No change
36		Nafra	0.59	safe		Nafra	0.29	safe	No change
37		Singchung	1.35	safe		Singchung	1.36	safe	No change
38		Thrizino	0.61	safe		Thrizino	0.24	safe	No change
39	WEST SIANG	Rumgong	0.01	safe	WEST SIANG	Rumgong	0.01	safe	No change

40		Darak	0.02	safe		Darak	0.01	safe	No change
41		Basar	1.12	safe		Basar	0.21	safe	No change
42		Likabali	0.86	safe		Likabali	0.23	safe	No change

Annexure VI: Attribute Table

Sl. No	State	District	Assessment Unit Name	Assessment Unit Type	Total Geographical Area	Recharge Worthy Area	Recharge from Rainfall-MON	Recharge from Other Sources-MON	Recharge from Rainfall-NM	Recharge from Other Sources-NM	Total Annual Ground Water (Ham) Recharge	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)	Irrigation Use (Ham)	Industrial Use (Ham)	Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (OE/ Critical/ Semi critical/ Safe)	Urban Assessment Unit (Yes/No)
1	ARUNACHAL PRADESH	CHANGLANG	Changlang	BLOCK	56799	3136.7	987.11	282	447.96	360	2077.1	207.71	1869.4	0	0	1.0126	1.01	1.06	1868.3	0.054	safe	No
2	ARUNACHAL PRADESH	CHANGLANG	Diyun	BLOCK	14899	7622.6	2398.8	705.79	1088.6	901.58	5094.8	509.48	4585.3	5.28	0	52.431	57.71	54.82	4525.2	1.2586	safe	No
3	ARUNACHAL PRADESH	CHANGLANG	Bordumsa	BLOCK	8692	8549.7	2690.6	847.3	1221	1082.6	5841.5	584.15	5257.3	8.64	0	67.762	76.4	70.86	5177.8	1.4532	safe	No
4	ARUNACHAL PRADESH	CHANGLANG	Khagam	BLOCK	244022	25855	8136.6	1939.2	3692.5	2481	16249	1624.9	14624	49.92	0	53.461	103.38	55.9	14518	0.7069	safe	No
5	ARUNACHAL PRADESH	CHANGLANG	Nampong	BLOCK	81057	7835.8	2465.9	775.64	1119.1	990.29	5350.9	535.1	4815.8	0.96	0	5.504	6.47	5.76	4809.1	0.1343	safe	No
6	ARUNACHAL PRADESH	EAST KAMENG	Chayangtajo	BLOCK	111005	6362	1744.2	1182.8	647.6	1829.3	5404	540.39	4863.6	0	0	5.0189	5.02	5.68	4857.9	0.1032	safe	No
7	ARUNACHAL PRADESH	EAST KAMENG	Pakke-Kessang	BLOCK	55529	6151.3	1686.5	335.91	626.15	306.21	2954.7	295.48	2659.3	6.75	0	0.5882	7.34	0.67	2651.8	0.276	safe	No
8	ARUNACHAL PRADESH	EAST KAMENG	Seijosa	BLOCK	69183	14737	4040.4	227.6	1500.1	233.39	6001.6	600.15	5401.4	12.55	0	2.6396	15.19	2.99	5385.9	0.2812	safe	No
9	ARUNACHAL PRADESH	EAST KAMENG	Seppa	BLOCK	51359	3999.3	1096.5	885.65	407.1	1415.1	3804.3	380.43	3423.9	74.8	0	6.113	80.91	6.92	3342.2	2.3631	safe	No
10	ARUNACHAL PRADESH	EAST SIANG	Ruksin	BLOCK	45589	28885	13726	1707.3	4586.9	2469	22489	3016.8	19473	34.08	3.6	17.579	55.26	18.13	19417	0.2838	safe	No
11	ARUNACHAL PRADESH	EAST SIANG	Mebo	BLOCK	78433	50854	30207	1286.1	8075.5	1977.7	41547	4154.7	37392	28.4	0	19.473	47.87	20.08	37344	0.128	safe	No
12	ARUNACHAL PRADESH	EAST SIANG	Pasighat	BLOCK	29279	21043	10796	770.45	3341.6	1136.5	16044	1013	15031	30.53	0.6	18.878	50	19.47	14981	0.3326	safe	No
13	ARUNACHAL PRADESH	EAST SIANG	Ramle Bango	BLOCK	51640	9317.1	5534.4	603.12	1479.5	19.72	7636.8	963.55	6673.2	17.41	0	7.7365	25.14	7.98	6647.8	0.3767	safe	No
14	ARUNACHAL PRADESH	LOHIT	Lekang_Mahadevpur	BLOCK	10673	10620	3388	1270.3	2227.5	1621.9	8507.8	877.93	7629.8	7.22	0	61.981	69.2	64.49	7558.1	0.907	safe	No

15	ARUNACHAL PRADESH	LOHIT	Chongkham	BLOCK	86457	66920	21349	1834.1	14036	2341.6	39561	3960.3	35601	6.08	0	41.869	47.95	43.56	35551	0.1347	safe	No
16	ARUNACHAL PRADESH	LOHIT	Namsai	BLOCK	41618	35191	11227	1975.2	7381.2	2521.7	23105	2559.4	20545	6.46	8.16	98.223	112.84	102.19	20428	0.5492	safe	No
17	ARUNACHAL PRADESH	LOHIT	Tezu	BLOCK	174097	58688	18723	1721.5	12310	2197.8	34952	3495.2	31457	7	0.24	17.944	25.18	18.67	31431	0.08	safe	No
18	ARUNACHAL PRADESH	LOHIT	Wakro	BLOCK	208355	28581	9117.9	847.41	5994.8	1082	17042	1704.2	15338	7.6	0	7.8427	15.45	8.16	15322	0.1007	safe	No
19	ARUNACHAL PRADESH	LOWER DIBANG VALLEY	Roing-Koronu	BLOCK	122995	74710	26684	547.96	21096	851.86	49180	4918	44262	210.6	0	22.128	232.73	22.47	44029	0.5258	safe	No
20	ARUNACHAL PRADESH	LOWER DIBANG VALLEY	Dambuk	BLOCK	117962	45290	16176	415.12	12789	650.72	30031	3003.1	27027	5.9	0	9.2866	15.18	9.43	27012	0.0562	safe	No
21	ARUNACHAL PRADESH	LOWER SUBANSIRI	Ziro I	BLOCK	62060	3773.1	882.05	326.79	536.99	417.02	2162.9	216.28	1946.6	12.39	0	9.7426	22.13	11.68	1922.5	1.1369	safe	No
22	ARUNACHAL PRADESH	LOWER SUBANSIRI	Tame Raga	BLOCK	195221	2267.6	424.09	326.6	322.73	517.17	1590.6	324.66	1265.9	3.54	0	7.5317	11.07	9.03	1253.3	0.8745	safe	No
23	ARUNACHAL PRADESH	LOWER SUBANSIRI	Yachuli	BLOCK	93519	4094.3	957.14	441.7	582.7	569.12	2550.7	255.06	2295.6	0.9	0	5.0081	5.91	6	2288.7	0.2574	safe	No
24	ARUNACHAL PRADESH	PAPUM PARE	Doimukh	BLOCK	49496	7651.9	3548.7	69.49	1058.5	88.24	4764.9	1560.4	3204.5	5.28	24.48	72.348	102.11	84.8	3090	3.1864	safe	No
25	ARUNACHAL PRADESH	PAPUM PARE	Balijan	BLOCK	60904	3562.7	1652.2	470.4	492.85	630.48	3246	487.99	2758	3.84	0.81	20.175	24.83	23.65	2729.7	0.9003	safe	No
26	ARUNACHAL PRADESH	PAPUM PARE	Kimin	BLOCK	52634	2814.1	1305.1	66.97	389.3	84.66	1846	1427	418.98	0.48	0	10.646	11.12	12.48	406.03	2.6541	safe	No
27	ARUNACHAL PRADESH	PAPUM PARE	Sagalee	BLOCK	116789	3790.2	1757.8	825.3	524.33	1053.5	4160.9	442.94	3718	5.76	0	1.8858	7.65	2.21	3710	0.2058	safe	No
28	ARUNACHAL PRADESH	TIRAP	Namsang	BLOCK	33619	4658.8	2265.5	32.41	665.18	66.23	3029.3	302.93	2726.4	2.25	0	13.774	16.02	14.13	2710	0.5876	safe	No
29	ARUNACHAL PRADESH	TIRAP	Kanubari	BLOCK	23376	2410.8	1172.3	434.44	344.21	554.6	2505.6	250.56	2255	2.8	0	10.063	12.86	10.32	2241.9	0.5703	safe	No
30	ARUNACHAL PRADESH	TIRAP	Khonsa	BLOCK	61555	3498.9	1701.5	78.15	499.57	143.6	2422.8	242.28	2180.5	0	0	5.7983	5.8	5.95	2174.6	0.266	safe	No
31	ARUNACHAL PRADESH	TIRAP	Niausa	BLOCK	33249	1931.6	939.32	423.18	275.8	540.3	2178.6	217.86	1960.7	1.2	0	19.167	20.36	19.66	1939.9	1.0384	safe	No
32	ARUNACHAL PRADESH	UPPER SUBANSIRI	Daporijo	BLOCK	25681	320.33	64.76	354.12	33.7	506.76	959.34	95.94	863.4	11.44	0.9	1.313	13.65	1.59	849.47	1.581	safe	No
33	ARUNACHAL PRADESH	UPPER SUBANSIRI	Dumporijo	BLOCK	53039	379.67	76.76	713.6	39.95	961.91	1792.2	179.23	1613	5.2	0	2.309	7.51	2.8	1605	0.4656	safe	No
34	ARUNACHAL PRADESH	WEST KAMENG	Dirang	BLOCK	191769	1368	519.05	209.09	88.02	211.8	1028	102.79	925.17	0	0	4.6072	4.61	4.74	920.43	0.4983	safe	No
35	ARUNACHAL PRADESH	WEST KAMENG	Kalaktang	BLOCK	175069	1648.5	625.48	34.76	106.07	69.53	835.84	83.58	752.26	0.97	0	0.8061	1.78	0.83	750.46	0.2366	safe	No
36	ARUNACHAL PRADESH	WEST KAMENG	Nafra	BLOCK	165211	1160.5	440.34	76.12	74.67	30	621.13	62.12	559.01	0	0	1.6057	1.6	1.65	557.37	0.2862	safe	No
37	ARUNACHAL PRADESH	WEST KAMENG	Singchung	BLOCK	98916	583.46	221.38	29.25	37.54	0	288.17	28.81	259.36	0.33	0	3.1919	3.52	3.28	255.75	1.3572	safe	No
38	ARUNACHAL PRADESH	WEST KAMENG	Thrizino	BLOCK	111234	1414.5	536.71	31.84	91.01	63.8	723.36	72.33	651.03	0.34	0	1.1931	1.53	1.23	649.46	0.235	safe	No
39	ARUNACHAL PRADESH	WEST SIANG	Rumgong	BLOCK	43265	3235.9	1375.3	0	283.63	0	1659	165.89	1493.1	0	0	0.1583	0.16	0.16	1492.9	0.0107	safe	No

40	ARUNACHAL PRADESH	WEST SIANG	Darak	BLOCK	74531	1566.2	665.68	846	137.28	1080	2729	272.9	2456.1	0	0	0.1622	0.16	0.17	2455.9	0.0065	safe	No
41	ARUNACHAL PRADESH	WEST SIANG	Basar	BLOCK	68943	2676.4	1137.5	110.27	234.59	216.04	1698.4	169.84	1528.6	2.84	0	0.3213	3.16	0.33	1525.4	0.2067	safe	No
42	ARUNACHAL PRADESH	WEST SIANG	Likabali	BLOCK	83027	2980.5	1266.8	504.19	261.24	6.13	2038.3	203.83	1834.5	1.28	1.18	1.7114	4.17	1.74	1830.3	0.2273	safe	No

Annexure VII: Minutes of the meeting of the SLC Committee

Government of India
MINISTRY OF JAL SHAKTI
Department of Water Resources, RD & GR
CENTRAL GROUND WATER BOARD
North Eastern Region
BHUJAL BHAWAN, Betkuchi, Opp. ISBT
Guwahati -781 035

भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग
केन्द्रीय भूमि जल बोर्ड,पूर्वोत्तर क्षेत्र
भूजल भवन, बेतकुची, आई एस बी टी के सामने
गुवाहाटी – 781 035

No. 643/ 18 /CGWB /NER/GWRE/2024
Dated: 5th September 2024

विषय : MINUTES OF THE MEETING OF STATE LEVEL COMMITTEE (SLC) ON DYNAMIC GROUND WATER RESOURCE ASSESSMENT OF ARUNACHAL PRADESH AS ON MARCH 2024

महोदय,

The undersigned is directed to enclose herewith the minutes of the meeting of the State Level Committee (SLC) on Dynamic Ground Water Resource Assessment of Arunachal Pradesh as on March 2024 that was convened on **26th August 2024 at 14.30 Hrs** for information and necessary action please.

भवदीय/yours faithfully,
SOROKHAIBAM SOMARENDRO SINGH
Digitally signed by SOROKHAIBAM SOMARENDRO SINGH Date: 2024.09.05 16:50:20 +05'30'
(डॉ एस एस सिंह/ Dr. S S Singh)
वैज्ञानिक -डी/Scientist-D(HG))
प्रभारी अधिकारी/OIC - GWRA(NER)
For Member Secretary
Encl: As above

सेवा मे,

1. The Commissioner/Secretary (WRD), Govt. of Arunachal Pradesh, Civil Secretariat, Block 3, 3rd floor (Room No 01), Itanagar-791111
2. The Commissioner/Secretary (Planning), Govt. of Arunachal Pradesh, Itanagar-791111
3. The Chief Engineer(P&D), Water Resource Department, Arunachal Pradesh, Chimpu, Itanagar-79 1113
4. The Chief Engineer (West Zone) & Nodal Officer of GWRA-Arunachal Pradesh, Water Resource Department, Arunachal Pradesh, Vivek Vihar, Itanagar-791111
5. The Chief Engineer (East Zone), Water Resource Department, Arunachal Pradesh, Cona, Itanagar-791113
6. The Chief Engineer (P & D), PHE & WS, Arunachal Pradesh, Itanagar-791111
7. The Director of Agriculture, B Sector, Papum Pare, NH52A, Itanagar Road, Naharlagun, Naharlagun, Arunachal Pradesh 791110

प्रति लिपि :

1. The TS to Member (South), Central Ground Water Board, CHQ, Faridabad-121001 for information please
2. TS to Regional Director, CGWB, NER, Guwahati for information please
3. The OIC, Central Ground Water Board, SUO, Itanagar

Tel: 0361-2270063/ 2270064/ 2270065 e-mail: rdner-cgwb@nic.in web: www.cgwb.gov.in

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

Date 26th August 2024 Time: 14.30 Hrs.

The meeting of State Level Committee (SLC) on Ground Water Resources of Arunachal Pradesh as on March 2024 was convened on 26th August 2024 at 14.30 hrs through Hybrid Mode.

The meeting was chaired by Sri Pige Ligu, IAS, Secretary to the Govt. of Arunachal Pradesh, Water Resource Department & Chairman of SLC. The Chairman of the SLC welcomed all the members of SLC present in the meeting. List of members attended in the meeting is enclosed as Annexure-I.

Sri Tapan Chakraborty, Regional Director & Member Secretary, SLC welcomed all the representative members of the SLC, Arunachal Pradesh who have attended in the meeting offline and online. He highlighted that Ground Water Resources of Arunachal Pradesh has been carried out jointly by Central Ground Water Board, NER, Guwahati, and Water Resource Department (State Nodal Department), Arunachal Pradesh in coordination with other members/departments of SLC.

Sri Rajat Gupta, Asst.HG, CGWB, SUO, Itanagar gave a detailed power point presentation of the Dynamic Groundwater Resources of Arunachal Pradesh as on March 2024. He highlighted that assessment was carried out by considering 42 nos of blocks as assessment units in 2024. Block wise growth rate, domestic population data were taken from 2011 census report.

A detailed discussion on Dynamic GWRE was held where various queries by Secretary, WRD and Chief Engineer (P&D), WRD, Arunachal Pradesh were addressed by Central Ground Water Board.

Chairman, SLC assured that state sister departments will try to provide more detail information/data at block and village level for inclusion in the coming GWRA of 2025.

Member Secretary, SLC has requested to all the members of SLC to initiate a water level monitoring mechanism by the state government for the existing departmental wells (dug wells, tube wells, bore wells etc.) in the state of Arunachal Pradesh in order to bring more precision in groundwater assessment.

Chairman, SLC appreciated to the team SLC for successfully completion of GW resource assessment,2024 by taking into consideration of newly created

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the coming GWRA 2025 need to be collected from the concerned state departments. In this regard, she has instructed WRD, Arunachal Pradesh to explore the possibilities to collect latest block boundary map from the State Remote Sensing Application Centre.

Dr. S S Singh, Scientist-D (HG) & OIC of GWRA extend sincere thanks to the Government of Arunachal Pradesh for all valuable and endless support to arrive at this block level assessment during GWRA 2024. He also requested to the Chair for a suitable brainstorming session between CGWB and state agencies with special focus on improving density of dynamic data like GW level, GW Quality at finer scale (up to village level wherever possible) depending upon the need along with aquifer parameters.

In this regard, Chairman, SLC Arunachal Pradesh has welcomed the proposal for a in depth discussion between CGWB and state agencies at the earliest possible.

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

The meeting ended with a vote of thanks by Dr. S S SIngh. Scientist-D (HG) & OIC of GWRA.

Sd/-
Sri Pige Ligu, IAS
Secretary to the Govt. of Arunachal Pradesh
WRD & Chairman, SLC

(Sri Tapan Chakraborty)
Regional Director, CGWB NER
& Member Secretary, SLC
Dated: 26th August 2024

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Annexure-I

STATE LEVEL COMMITTEE (SLC) MEETING ON GROUND WATER RESOURCE ASSESSMENT OF ARUNACHAL PRADESH AS ON MARCH 2024

Dated :26th August 2024

List of members attended in the meeting

1. Sri Pige Ligu, IAS, Secretary to the Govt. of Arunachal Pradesh, Water Resource Department, Itanagar & Chairman, SLC
2. Sri Tapan Chakraborty, Regional Director, CGWB, NER & Member Secretary, SLC
3. Er. Getom Borang, Chief Engineer (P&D), Water Resource Department, Arunachal Pradesh
4. Er. Tokbom Lego, Chief Engineer (East), Water Resource Department, Arunachal Pradesh
5. Representative of Chief Engineer (P & D), PHE & WS, PHED, Arunachal Pradesh
6. Representative of Director, State Planning Department, Arunachal Pradesh
7. Dr. S S Singh, Scientist-D & OIC-GWRA, CGWB, NER, Guwahati
8. Sri Rajat Gupta, AHG, CGWB, SUO, Itanagar
9. Ms Dimpi Barpatra, YP (HG), CGWB, SUO, Itanagar

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CONTRIBUTORS

The computation of Dynamic Ground water Resources of Arunachal Pradesh for the Assessment Year 2023-24 as in 2024 has been carried out jointly by Central Ground Water Board, North Eastern Region and Water Resource Department, the State Nodal Department of Ground Water (Arunachal Pradesh) as per the Ground Water Estimation Committee-2015 (GEC-2015) methodology under the guidance of the State Level Committees (SLC) and overall supervision of Central Level Expert Group (CLEG). Field data generated by CGWB and statistical information/data generated/compiled by State Departments like, Irrigation Department, Directorate of Economic & Statistics, Water Resource Department, Public Health & Engineering, Dte. of Industries & Commerce, Dept. of Agriculture; Dept. of Horticulture & Soil Conservation, NABARD, IMD, CWC, Brahmaputra Board, NIH etc. The assessment of and compilation of the report was carried out by Rajat Gupta, Asst. hydrogeologist, CGWB, SUO Itanagar and Tiamenba Longshir, Asst. Hydrogeologist of CGWB, NER, Guwahati with the team of Sh Getom Borang, Chief Engineer (WZ), WRD under the able guidance of Sri Tapan Chakraborty, Regional Director, CGWB, NER and Sh Pige Ligu, IAS, Secretary, WRD, Arunachal Pradesh

Principal Contributors:

1. Rajat Gupta, Asst. Hydrogeologist, CGWB, SUO, Itanagar
2. Tiamenba Longshir, Asst. Hydrogeologist, CGWB, NER, Guwahati

Contributors:

1. Smt. Sadhana Deori, Retd. IAS, Secretary, WRD, Arunachal Pradesh
2. Getom Borang, Chief Engineer, Water Resource Department, Arunachal Pradesh
3. Biplab Ray, Scientist-D, CGWB, NER, Guwahati
4. Dr. S S Singh, Scientist-D, CGWB, NER, Guwahati
5. Dr. D J Khound, Scientist-D, CGWB, NER, Guwahati
6. Ms. Mophi Mili, Scientist-C, CGWB, NER, Guwahati
7. Tame Hage, JE, WRD(P&D), Govt. of Arunachal Pradesh
8. Ms. Dimpi Barpatra, YP(Hg), CGWB, SUO, Itanagar
9. All members/departments of SLC on GWRA of Arunachal Pradesh,2024

Team INGRES:

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

Overall Guidance & Supervision:

1. Dr. Sunil Kumar Ambast, Chairman, Central Ground Water Board, CHQ, Faridabad.
2. Mrs. T. S. Anitha Shyam, Member South, Central Ground Water Board, CHQ, Faridabad.
3. Pige Ligu, IAS, Commissioner, Secretary, WRD, Arunachal Pradesh
4. Sri Tapan Chakraborty, Regional Director, CGWB, NER, Guwahati
5. Dr. S S Singh, Scientist-D & OIC, GWRA, NER, Guwahati