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REPORT ON THE DYNAMIC GROUND WATER RESOURCES OF SIKKIM, 2024

Central Ground Water Board, Eastern Region, Kolkata

CGWB, ER, Kolkata
November, 2024

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Prepared by

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Eastern Region
Government of India

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

Message

Groundwater is the key resource for India's agricultural and drinking water security. Though groundwater is dynamic and replenishable natural resource, extensive extraction is causing an alarming decline in water levels. Scientific assessment of the availability of groundwater resources provides the basic input for planning sustainable management interventions. Central Ground Water Board (CGWB), in collaboration with State Groundwater Departments, conducts regular assessments of groundwater resources every year. These assessments serve as the basis for guiding the management and regulation of groundwater resources in the state. These assessments also serve as the foundation for planning various groundwater management interventions, which may include initiatives such as artificial recharge etc. Present assessment of groundwater resources 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) for Sikkim is an effort by the Central Ground Water Board, Eastern Region. I should also mention the diligent efforts of officers of CGWB, Eastern Region, Central Ground Water Board, Eastern Region, Kolkata. I extend my congratulations to all of them. I also appreciate the valuable contributions of the State Level Committee (SLC) for their guidance in timely completion of the assessment

It is very much anticipated that this compilation will prove to be of immense value to administrators, planners, and all other stakeholders engaged in formulating strategies and interventions aimed at ensuring the long-term sustainability of groundwater.

N. Vardaraj

(N. Vardaraj)
Member (East)

PREFACE

Sikkim is a small mountainous State characterized by rugged undulating topography with series of ridges and valleys. The various rock types prevalent in the state are pelitic and carbonate rocks and gondwanas over a gneissic basement and occasional colluviums and valley fill deposits, as well as alluvial terraces along higher order streams and river courses. The formations reveal an intense tectonic-structurally complex deformational history. Ground water occurs largely in disconnected localized pockets and in deeper fractures zones. Springs are the main source and conduits of water.

The ground water resource assessment (in 2024) for the State of Sikkim has been carried out as per GEC 2015 guidelines through ‘IN-GRES’, with Blocks as primary assessment units. A total of 40 Blocks has been assessed for Ground Water Resource Assessment 2024. Out of these 40 Blocks, 34 are the Administrative blocks and 6 blocks comes under Rest of the Area which is not part of any BAC (Block Administrative Centre) of each district of Sikkim state. These 6 Blocks still has been taken in for total Resource calculation of Sikkim State.

Total Annual Ground Water Recharge has been estimated at 0.24 bcm and Annual Extractable Ground Water Resource has been estimated at 0.22 bcm. Current Annual Ground Water Extraction for all uses has been estimated at 0.013 bcm, which translates into a Stage of Ground Water Extraction at 5.85 %, and as per the present assessment all the Forty assessment units/ Blocks are in ‘Safe’ category.

As compared to 2023 assessment, Total Annual Ground Water Recharge of the State is same as 0.24 bcm. Annual Extractable Ground Water Resource is also same as 0.22 bcm. The Annual Ground Water Extraction from all sources though marginally increased from 0.012 bcm to 0.013 bcm. Stage of Ground Water Extraction increased from 5.54 % to 5.85 %.

This report is the outcome of the efforts made by Sri. Sandip Bhowal, Scientist- B, and Dr. Indranil Roy, Scientist-D, Central Ground Water Board, Eastern Region towards assessment of dynamic component of ground water resources available in the State of Sikkim. The author is also grateful to Miss. Mahasweta Mukherjee, Young Professional for her efforts regarding preparation of thematic maps for the report preparation.

(Dr. Anadi Gayen)

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DYNAMIC GROUND WATER RESOURCES OF SIKKIM, 2024

AT A GLANCE

1.	Total Annual Ground Water Recharge	24164.56 ham
2.	Annual Extractable Ground Water Resources	21748.11 ham
3.	Annual Ground Water Extraction	1273.07 ham
4.	Stage of Ground Water Extraction	5.85 %

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	40	100	0.01496	21.05	0.217481	100
2	Semi Critical	-	-	-	-	-	-
3	Critical	-	-	-	-	-	-
4	Over-Exploited	-	-	-	-	-	-
5	Saline	-	-	-	-	-	-
	TOTAL	**40**	**100**	**0.01496**	**21.05**	**0.217481**	**100**

Contributors' Page

Central Ground Water Board Eastern Region, Kolkata
Dr. Indranil Roy, Scientist -D Shri. Sandip Bhowal, Scientist -B Miss. Mahasweta Mukherjee, Young Professional

Executive Summary

India is the largest user of groundwater in the world with a fourth of the total global withdrawal. Indian cities cater to about 48% of its water supply from groundwater. Hence, there is dire need to know the updated resource position for proper management of the groundwater resource. Groundwater Resource Assessment refers to the process of evaluating the quantity and quality of groundwater to determine its sustainability and usage. In India, State Ground Water Departments and Central Ground Water Board carry out Ground Water Resource Assessment at periodical intervals as a joint exercise under the guidance of the respective State Level Committee and under the overall supervision of the Central Level Expert Group (CLEG). The assessment process involves computation of dynamic ground water resources or Annual Extractable Ground Water Resource, Total Current Annual Ground Water Extraction (utilization) and the percentage of utilization with respect to annual extractable resources (Stage of Ground Water Extraction). The assessment units (blocks) are categorized based on Stage of Ground Water Extraction, which are then validated with long-term water level trends. The assessment prior to that of year 2017 were carried out following Ground Water Estimation Committee (GEC) 97 Methodology, whereas from 2017 onwards assessment is based on norms and guidelines of the GEC 2015 Methodology. Previous estimates of groundwater resources in Sikkim used the GEC'15 methodologies in 2016-2017, 2019-2020, 2021-2022, 2022-2023 and 2023-2024.

Present estimation of groundwater resources in Sikkim for the current assessment year (2024) started as per instruction of CHQ, CGWB referring Ministry of Jal Shakti notification. The constitution of the Permanent State-Level Committee for Ground Water Resources Estimation of Sikkim was formed on 26.07.2023. The working group finalized the report in consultation of other members of the committee and prepared the report. Under the Chairmanship Secretary, Water Resource Department, Sikkim, SLC, SLGWAC approved the report as an outcome of the meeting dated 28.08.2024.

The ground water resource assessment (in 2024) for the State of Sikkim is carried out as per GEC 2015 guidelines through 'IN-GRES', with blocks as primary assessment units. IN-GRES is a software/web-based application developed by Central Ground Water Board (CGWB) in collaboration with Indian Institute of Technology- Hyderabad for assessment of ground water resources.

Present assessment covered all 40 blocks of Sikkim coming under 6 districts of the state. Earlier only districts were considered as assessment units.

Based on the present assessment categorization scheme:

- All 40 assessment units (AUs) are classified as Safe;
- No block is coming under semi-critical, critical or over-exploited category

The ground water resource assessment (in 2024) for the State of Sikkim has been carried out as per GEC 2015 guidelines through 'IN-GRES', with Blocks as primary assessment units. A total of 40 Blocks has been assessed for Ground Water Resource Assessment 2024. Out of these 40 Blocks, 34 are the Administrative blocks and 6 blocks comes under Rest of the Area which is not part of any BAC (Block Administrative Centre) of each district of Sikkim state. These 6 Blocks still has been taken in for total Resource calculation of Sikkim State.

Total Annual Ground Water Recharge has been estimated at 0.24 bcm and Annual Extractable Ground Water Resource has been estimated at 0.22 bcm. Current Annual Ground Water Extraction for all uses has been estimated at 0.013 bcm, which translates into a Stage of Ground Water Extraction at 5.85 %, and as per the present assessment all the Forty assessment units/ Blocks are in 'Safe' category.

As compared to 2023 assessment, Total Annual Ground Water Recharge of the State is same as 0.24 bcm. Annual Extractable Ground Water Resource is also same as 0.22 bcm. The Annual Ground Water Extraction from all sources though marginally increased from 0.012 bcm to 0.013 bcm. Stage of Ground Water Extraction increased from 5.54 % to 5.85 %.

CHAPTER I

INTRODUCTION

1.1 Background for Re-estimating the Ground Water Resources of the State of Sikkim

Sustainable development and efficient management of ground water resource is a challenge. Proper planning and management of ground water development in a state in a judicious and socio-economically equitable manner, principally depends on proper quantification of ground water resources and also on assessment of status of ground water development.

Estimation of ground water resources on scientific basis for different States of India was made for the first time following the guidelines prescribed by 'Ground Water Over-Exploitation Committee' – 1979, constituted by Agricultural Refinance and Development Corporation (ARDC) headed by the Chairman, CGWB. CGWB and State Ground Water Departments computed the gross water availability by ARDC norms. To make the methodology more realistic, Govt. of India constituted a new committee on ground water estimation (GEC) in 1982 headed by the Chairman, CGWB. The Committee prescribed guidelines for estimation, which was known as GEC 1984 Methodology. CGWB have adopted this methodology and estimated the ground water resources. The estimation of ground water resource based on GEC 1984 methodology was done for the first time in 1985 but all the Four (04) districts in hilly state of Sikkim were not considered for ground water estimation. These Districts were excluded as in hilly terrain availability and development of ground water through abstraction structures is negligible (only spring water is in use) and hence not suitable for application of the methodology. Later following the modified GEC 1997 Methodology estimation of ground water resource has been carried out in 2012-2013. However, for Sikkim no ground water resource estimation was carried out on 2012-2013. Ground water estimation methodology is further modified in 2015 namely, GEC 2015 Methodology. Following the modified GEC 2015 Methodology estimation of ground water resource in Sikkim State was first carried out in 2016-2017 followed by 2019-2020, 2021-2022, 2022-2023 and 2023-2024. Present ground water resource estimation is carried out for 40 assessment units (40 Blocks coming under 6 Districts) following the same.

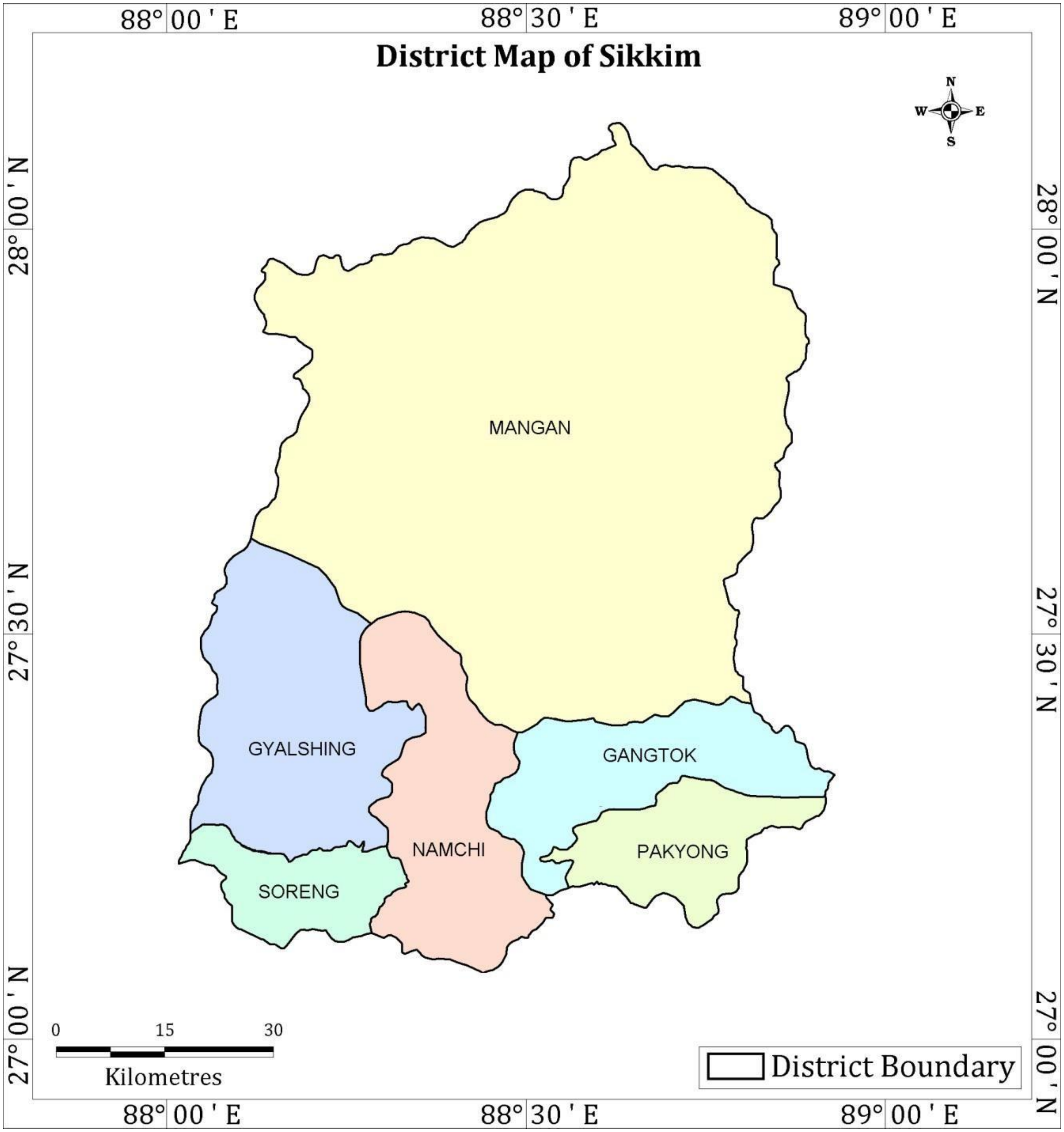

Figure 1: Administrative map showing six districts of Sikkim

1.2 Constitution of State-level committee for Ground Water Resources Estimation

With a view to re-estimate ground water resource in the State of Sikkim for the assessment year 2024, based on the guidelines provided in the GEC 2015 methodology, a permanent State Level Committee has been constituted by Govt. of Sikkim. The constitution of the Permanent State-Level Committee for Ground Water Resources Estimation of Sikkim was formed on 26.07.2023. (**Annexure-I**)

1.3 Brief Outline of the Proceedings of the Resources Estimation

Dynamic ground water resource has been estimated for the state of Sikkim previously in the year 2012-13 as per GEC'97 methodologies and in 2016-2017, 2019-2020, 2021-2022, 2022-2023 and 2023-2024 as per GEC'15 methodologies. As per instruction of CHQ, CGWB referring GOI of Ministry of Jal Shakti, Ground Water Resource Estimation (as on 31st March, 2024) (as per GEC'2015) is initiated. The State Level Committee for Ground Water Assessment formed "Groundwater Resource Assessment Cell" and "Working Group" for Dynamic Groundwater Resources Re-Assessment of Sikkim (as on March 31st, 2024) vide Minutes of the Meeting of 1st State Level Committee for Assessment of Ground Water Resources of Sikkim 2024 (as on 31.03.2024) held on 11.06.2024 (**Annexure-II**) and assigned the work to CGWB, Eastern Region. The working group finalized the report in consultation of other members of the committee and prepared the report.

After submission of the report to SLGWAC, a meeting of the State Level Committee for Ground Water Assessment is convened by the Member Secretary and Convener (Regional Director, CGWB, ER) on 28.08.2024. The meeting was held under the Chairmanship of PCE, Water Resource Department, Govt. of Sikkim. After a detailed discussion among the members the reports on **—Dynamic Ground Water Resources of Sikkim (as on 31st March, 2024)"** have been approved by the Committee. (**Annexure III**).

CHAPTER 2

GROUND WATER RESOURCE ESTIMATION METHODOLOGY

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

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

2.1. GROUND WATER ASSESSMENT OF UNCONFINED AQUIFER

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

2.1.1. Assessment of Annually Replenishable or Dynamic Ground Water Resources

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

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

Equation (1) can be further elaborated as –

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

Where,

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

B - Base flow

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

2.1.1.1. Rainfall Recharge

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

2.1.1.1.1. Ground Water Level Fluctuation Method

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

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

Where,

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

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

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

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

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

Where,

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

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

$$R_{RF} = \Delta h \times A \times S_Y - R_{STR} - R_{SWI} - R_{GWI} - R_{TP} - R_{WCS} \pm VF \pm LF + GE + T + E + B \ldots\ldots\ldots\ldots\ldots (6)$$
$$R_{RF} = \Delta h \times A \times S_Y - R_{STR} - R_C - R_{SWI} - R_{GWI} - R_{TP} - R_{WCS} \pm VF \pm LF + GE + T + E + B \ldots\ldots\ldots (7)$$

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

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

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:

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

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,

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

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:

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

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

Where,

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

2.1.1.1.2. Rainfall Infiltration Factor Method

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

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

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

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

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

Sl. No.	Source	Estimation Formula	Parameters
			RFF = Return Flow Factor
4	Recharge due to Tanks & Ponds	$R_{TP} = AWSA \times N \times RF$	R_{TP} = Recharge due to Tanks & Ponds AWSA = Average Water Spread Area N = Number of days Water is available in the Tank/Pond RF = Recharge Factor
5	Recharge due to Water Conservation Structures	$R_{WCS} = GS \times RF$	RWCS = Recharge due to Water Conservation Structures GS = Gross Storage = Storage Capacity multiplied by number of fillings. RF = Recharge Factor

2.1.1.3. Evaporation and Transpiration

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

2.1.1.4. Recharge During Monsoon Season

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

2.1.1.5. Recharge During Non-Monsoon Season

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

2.1.1.6. Total Annual Ground Water Recharge

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

2.1.1.7. Annual Extractable Ground Water Resource (EGR)

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

2.1.1.8. Estimation of Ground Water Extraction

Ground water draft or extraction is assessed as follows.

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

Where,

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

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

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

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

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

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

Where,

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

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

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

The commonly adopted methods for estimating the extraction for industrial use are as below:
Unit Draft Method: - In this method, unit draft of each type of well is multiplied by the number of wells used for industrial purpose to obtain the industrial ground water extraction.
Consumptive Use Pattern Method: – In this method, water consumption of different industrial units is determined. Numbers of Industrial units which are dependent on ground water are multiplied with unit water consumption to obtain ground water extraction for industrial use.

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

Where,

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

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

2.1.1.9. Stage of Ground Water Extraction

The stage of ground water extraction is defined by,

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

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

2.1.1.10. Validation of Stage of Ground Water Extraction

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

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

2.1.1.11. Categorisation of Assessment Unit

2.1.1.11.1. Categorisation of Assessment Unit Based on Quantity

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

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

2.1.1.11.2. Categorisation of Assessment Unit Based on Quality

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

2.1.1.12. Allocation of Ground Water Resource for Utilisation

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

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

Where,

Alloc = Allocation for domestic water requirement
N = population density in the unit in thousands per sq. km.
L_g= fractional load on ground water for domestic water supply (≤ 1.0)

2.1.1.13. Net Annual Ground Water Availability for Future Use

The water available for future use is obtained by deducting the allocation for domestic use and current extraction for Irrigation and Industrial uses from the Annual Extractable Ground Water Recharge. The resulting ground water potential is termed as the net annual ground water availability for future use. The

Net annual ground water availability for future use is calculated separately for non-command areas and command areas. As per the recommendations of the R&D Advisory committee, the ground water available for future use can never be negative. If it becomes negative, the future allocation of Domestic needs can be reduced to current extraction for domestic use. Even then if it is still negative, then the ground water available for future uses has been projected as zero.

2.1.1.14. Additional Potential Resources under Specific Conditions

2.1.1.14.1. Potential Resource Due to Spring Discharge

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

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

Where,

Q = Spring Discharge

No of days = No of days spring yields.

2.1.1.14.2. Potential Resource in Waterlogged and Shallow Water Table Areas

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

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

Where,

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

A = Area of shallow water table zone.

S_Y = Specific Yield

2.1.1.14.3. Potential Resource in Flood Prone Areas

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

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

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

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

Where,

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

A = Flood Prone Area

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

Where the assessment unit is a watershed, there is a need to convert the ground water assessment in terms of an administrative unit such as block/ taluka/ mandal. This has been done as follows.
A block may comprise of one or more watersheds, in part or full. First, the ground water assessment in the subareas, command, non-command and poor ground water quality areas of the watershed has been converted into depth unit (mm), by dividing the annual recharge by the respective area. The contribution of this subarea of the watershed to the block, is now calculated by multiplying this depth with the area in the block occupied by this sub-area.
The total ground water resource of the block has been presented separately for each type of sub-area, namely for command areas, non-command areas and poor ground water quality areas, as in the case of the individual watersheds.

2.2. GROUND WATER ASSESSMENT IN URBAN AREAS

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

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

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

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

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

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

2.3. GROUND WATER ASSESSMENT IN WATER LEVEL DEPLETION ZONES

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

2.4. NORMS HAS BEEN USED IN THE ASSESSMENT

2.4.1. Specific Yield

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

Table-2.1: Norms Recommended for Specific Yield

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
1	Alluvium	AL01	Younger Alluvium (Clay/Silt/Sand/ Calcareous concretions)	Quaternary	10	8	12
2	Alluvium	AL02	Pebble / Gravel/ Bazada/ Kandi	Quaternary	16	12	20
3	Alluvium	AL03	Older Alluvium (Silt/Sand/Gravel/Lithomargic clay)	Quaternary	6	4	8
4	Alluvium	AL04	Aeolian Alluvium (Silt/ Sand)	Quaternary	16	12	20
5	Alluvium	AL05	Coastal Alluvium (Sand/Silt/Clay)	Quaternary	10	8	12
6	Alluvium	AL06	Valley Fills	Quaternary	16	12	20
7	Alluvium	AL07	Glacial Deposits	Quaternary	16	12	20
8	Laterite	LT01	Laterite / Ferruginous concretions	Quaternary	2.5	2	3

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
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
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	10	5	15

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

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

2.4.2. Rainfall Infiltration Factor

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

Table-2.2: Norms Recommended for Rainfall Infiltration Factor

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
1	Alluvium	AL01	Younger Alluvium (Clay/Silt/Sand/ Calcareous concretions)	Quaternary	22	20	24
2	Alluvium	AL02	Pebble / Gravel/ Bazada/ Kandi	Quaternary	22	20	24
3	Alluvium	AL03	Older Alluvium (Silt/Sand/Gravel/Lithomargic clay)	Quaternary	22	20	24
4	Alluvium	AL04	Aeolian Alluvium (Silt/ Sand)	Quaternary	22	20	24
5	Alluvium	AL05	Coastal Alluvium (Sand/Silt/Clay) -East Coast	Quaternary	16	14	18
5	Alluvium	AL05	Coastal Alluvium (Sand/Silt/Clay) - West Coast	Quaternary	10	8	12
6	Alluvium	AL06	Valley Fills	Quaternary	22	20	24
7	Alluvium	AL07	Glacial Deposits	Quaternary	22	20	24
8	Laterite	LT01	Laterite / Ferruginous concretions	Quaternary	7	6	8
9	Basalt	BS01	Basic Rocks (Basalt) - Vesicular or Jointed	Mesozoic to Cenozoic	13	12	14
9	Basalt	BS01	Basic Rocks (Basalt) - Weathered	Mesozoic to Cenozoic	7	6	8
10	Basalt	BS01	Basic Rocks (Basalt) - Massive Poorly Jointed	Mesozoic to Cenozoic	2	1	3
11	Basalt	BS02	Ultra Basic - Vesicular or Jointed	Mesozoic to Cenozoic	13	12	14
11	Basalt	BS02	Ultra Basic - Weathered	Mesozoic to Cenozoic	7	6	8
12	Basalt	BS02	Ultra Basic - Massive Poorly Jointed	Mesozoic to Cenozoic	2	1	3
13	Sandstone	ST01	Sandstone/Conglomerate	Upper Palaeozoic to Cenozoic	12	10	14
14	Sandstone	ST02	Sandstone with Shale	Upper Palaeozoic to Cenozoic	12	10	14
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	4	3	5

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
				Palaeozoic to Cenozoic			
20	Shale	SH02	Shale with Sandstone	Upper Palaeozoic to Cenozoic	4	3	5
21	Shale	SH03	Shale, limestone and sandstone	Upper Palaeozoic to Cenozoic	4	3	5
22	Shale	SH04	Shale	Upper Palaeozoic to Cenozoic	4	3	5
23	Shale	SH05	Shale/Shale with Sandstone	Proterozoic to Cenozoic	4	3	5
24	Shale	SH06	Shale with Limestone	Proterozoic to Cenozoic	4	3	5
25	Limestone	LS01	Miliolitic Limestone	Quarternary	6	5	7
27	Limestone	LS02	Limestone / Dolomite	Upper Palaeozoic to Cenozoic	6	5	7
29	Limestone	LS03	Limestone/Dolomite	Proterozoic	6	5	7
31	Limestone	LS04	Limestone with Shale	Proterozoic	6	5	7
33	Limestone	LS05	Marble	Azoic to Proterozoic	6	5	7
35	Granite	GR01	Acidic Rocks (Granite,Syenite, Rhyolite etc.) - Weathered , Jointed	Mesozoic to Cenozoic	7	5	9
36	Granite	GR01	Acidic Rocks (Granite,Syenite, Rhyolite etc.)-Massive or Poorly Fractured	Mesozoic to Cenozoic	2	1	3
37	Granite	GR02	Acidic Rocks (Pegmatite, Granite, Syenite, Rhyolite 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	Proterozoic	2	1	3

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
			Fractured	to Cenozoic			
45	Quartzite	QZ02	Quartzite - Weathered, Jointed	Azoic to Proterozoic	6	5	7
46	Quartzite	QZ02	Quartzite- Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3
47	Charnockite	CK01	Charnockite - Weathered, Jointed	Azoic	5	4	6
48	Charnockite	CK01	Charnockite - Massive, Poorly Fractured	Azoic	2	1	3
49	Khondalite	KH01	Khondalites, Granulites - Weathered, Jointed	Azoic	7	5	9
50	Khondalite	KH01	Khondalites, Granulites - Mssive, Poorly Fractured	Azoic	2	1	3
51	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Weathered, Jointed	Azoic	7	5	9
52	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Massive, Poorly Fractured	Azoic	2	1	3
53	Gneiss	GN01	Undifferentiated metasedimentaries/ Undifferentiated metamorphic - Weathered, Jointed	Azoic to Proterozoic	7	5	9
54	Gneiss	GN01	Undifferentiated metasedimentaries/ Undifferentiated metamorphic - Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3
55	Gneiss	GN02	Gneiss -Weathered, Jointed	Azoic to Proterozoic	11	10	12
56	Gneiss	GN02	Gneiss-Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3
57	Gneiss	GN03	Migmatitic Gneiss - Weathered, Jointed	Azoic	7	5	9
58	Gneiss	GN03	Migmatitic Gneiss - Massive, Poorly Fractured	Azoic	2	1	3
59	Intrusive	IN01	Basic Rocks (Dolerite, Anorthosite etc.) - Weathered, Jointed	Proterozoic to Cenozoic	7	6	8
60	Intrusive	IN01	Basic Rocks (Dolerite, Anorthosite etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3
61	Intrusive	IN02	Ulrta Basics (Epidiorite, Granophyre etc.) - Weathered, Jointed	Proterozoic to Cenozoic	7	6	8
62	Intrusive	IN02	Ulrta Basics (Epidiorite, Granophyre etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3

2.4.3. Norms for Canal Recharge

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

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

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

2.4.4. Norms for Recharge Due to Irrigation

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

Table-2.4: Norms Recommended for Recharge from Irrigation

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

2.4.5. Norms for Recharge due to Tanks & Ponds

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

2.4.6. Norms for Recharge due to Water Conservation Structures

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

2.4.7. Unit Draft

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

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

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

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

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

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

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

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

CHAPTER 3

RAINFALL

Sikkim is characterized by a monsoon climate, heavy rainfall, and frequent landslides and floods. The state's hydrometeorology is also influenced by the Sikkim Himalayan terrain, which includes hillsides and valleys.

Sikkim is one of the rainiest regions in India. Most parts of the place experience torrential rains during summers. This happens because of the fact that the proximity of Sikkim to the Bay of Bengal and also the mountains of the State come directly in the path of the monsoon clouds. So much so that evens a small depression over the Bay of Bengal triggers off a downpour in Sikkim. Even during spring and autumn moisture laden clouds formed due to local evaporation. And these eventually continue to batter a greater part of Sikkim. It is only during October to March that there is hardly any rain and the weather remains more or less clear. Rainfall however varies considerably from place to place because of the fill features. The northern border of Sikkim experiences comparatively low rainfall because the monsoon clouds dry out by the time they hit the northern barrier. For the sake of comparison, Gangtok registers an average of 325 cm rainfall per annum whereas Muguthang in the extreme north experiences an average rainfall of only 60 cm per annum. Most of Sikkim does not experience high intensity of winds. However, at many hill tops and passes, winds and blizzards are having considerably high speeds.

Table 3.1. Rainfall during Ground Water Assessment Year 2023-24 for the State/UT and District wise

Sl No	District	Block	Pre-Monsoon Actual Rainfall (mm)	Pre-Monsoon Normal Rainfall (mm)	Post-Monsoon Actual Rainfall (mm)	Post-Monsoon Normal Rainfall (mm)
1	Gangtok	Gangtok_ROA	2171.9	1885.4	1353.2	871.0
2	Gangtok	Khamdong	1177.6	1885.4	758.1	871.0
3	Gangtok	Ranka	2171.9	1885.4	1353.2	871.0
4	Gangtok	Rakdong Tintek	2171.9	1885.4	1353.2	871.0
5	Gangtok	Martam	1177.6	1885.4	758.1	871.0
6	Gangtok	Gangtok / Nandok	2171.9	1885.4	1353.2	871.0
7	Gyalsingh	Yuksom	1605.0	1511.3	489.3	530.4
8	Gyalsingh	Hee Martam	1615.7	1511.3	643.3	530.4
9	Gyalsingh	Arithang Chongrang	1224.0	1511.3	251.8	530.4

Sl No	District	Block	Pre-Monsoon Actual Rainfall (mm)	Pre-Monsoon Normal Rainfall (mm)	Post-Monsoon Actual Rainfall (mm)	Post-Monsoon Normal Rainfall (mm)
10	Gyalsingh	Gyalsingh	1615.7	1511.3	643.3	530.4
11	Gyalsingh	Dentam	1224.0	1511.3	251.8	530.4
12	Gyalsingh	Gyalsingh_ROA	1615.7	1511.3	643.3	530.4
13	Mangan	Chunthang	1537.8	1669.3	1074.6	1069.5
14	Mangan	Mangan_ROA	2236.8	1669.3	1656.7	1069.5
15	Mangan	Mangan	2236.8	1669.3	1656.7	1069.5
16	Mangan	Dzongu / Passingdang	2236.8	1669.3	1656.7	1069.5
17	Mangan	Kabi Tingda	1314.4	1669.3	1126.6	1069.5
18	Namchi	Jorethang	2005.4	1674.2	618.0	529.3
19	Namchi	Melli Sumbuk	2005.4	1674.2	618.0	529.3
20	Namchi	Namchi	2005.4	1674.2	618.0	529.3
21	Namchi	Wok Sikkip	2005.4	1674.2	618.0	529.3
22	Namchi	Yangdang	2005.4	1674.2	618.0	529.3
23	Namchi	Namthang	2005.4	1674.2	618.0	529.3
24	Namchi	Temi Tarku	2005.4	1674.2	618.0	529.3
25	Namchi	Namchi_ROA	2005.4	1674.2	618.0	529.3
26	Namchi	Ravangla	2005.4	1674.2	618.0	529.3
27	Pakyong	Duga	1513.6	1885.4	758.1	871.0
28	Pakyong	Parkha	1513.6	1885.4	758.1	871.0
29	Pakyong	Rhenock	1306.3	1885.4	631.1	871.0
30	Pakyong	Pakyong	1513.6	1885.4	758.1	871.0
31	Pakyong	Namchibong	1177.6	1885.4	450.0	871.0
32	Pakyong	Regu	1306.3	1885.4	631.1	871.0
33	Pakyong	Pakyong_ROA	1513.6	1885.4	758.1	871.0
34	Soreng	Soreng_ROA	2352.9	1511.3	661.0	530.4
35	Soreng	Chumbung-Chakung	2352.9	1511.3	661.0	530.4
36	Soreng	Baiguney	2352.9	1511.3	661.0	530.4
37	Soreng	Soreng	2352.9	1511.3	661.0	530.4
38	Soreng	Mangalbarey	2352.9	1511.3	661.0	530.4
39	Soreng	Daramdin	2352.9	1511.3	661.0	530.4
40	Soreng	Kaluk	2352.9	1511.3	661.0	530.4

**(source: IMD)*

CHAPTER 4

HYDROGEOLOGICAL SETUP OF THE STATE

Sikkim is characterized by rugged topography with series of ridges and valleys, generally aligned in NE – SW direction with altitude varying between 230 and 8598 meter amsl. The state can be categorized into nine physiographic divisions i.e. a) Summit & Ridge, b) Escarpment, c) Very steep slope (>50%), d) Steep slope (30 – 50%), e) Moderately Steep slope (20 - 30 %), f) Valleys, g) Cliff & Precipitous slope (20 - 30 %), h) Glacial drifts/ Moraines/Boulders, i) High mountains with perpetual snow. Perennial Tista and Rangit rivers along with their tributaries mainly control drainage. Drainage is of six orders in nature. Sub-parallel, rectangular, trellis and radial drainage pattern are most conspicuous. Snow and numerous glaciers characterize high mountain ranges in Sikkim Himalaya particularly the North district. These glaciers are the perennial source of water and regulate the run off in all major rivers of Sikkim. The glaciers of Sikkim may be grouped into seven glacier complexes; namely Chhombo, Yumthang, Lamgpo, Zemu, Talung, Rathang and Rel glacier complexes. These complexes cover about 17% of Sikkim.

4.1 Description of rock types:

The state of Sikkim is covered by diverse rock type. General geology of Sikkim in different districts is as follows:

Mangan District

Tso Lhamo Series and Lacchi Series (peletic and carbonate rocks)
Mount Everest limestone (massive arenaceous limestone)
Mount Everest pelitic Group (Phyllite, Quartzite, Schist and granite)

Gangtok, Pakyaong, Jorethang, Soreng and Namchi Districts

Quaternary (Alluvial deposit)
- Unconformity -
Gondwana Supergroup (Sand stone, shale, carbonaceous shale, coal, pebbly slate)
- Thrust contact -
Daling Group (Quartzite, phyllite, dolomite, slate, schist)
- Thrust contact -
Lingtse granite gneiss
- Thrust contact –
Chungthang Group (Biotite gneiss, quartzite, impure marble, graphitic schist)
Darjeeling Group (Migmatitic gneiss with calc-silicate lenses)
Kanchenjungha Group (Augen gneiss, quartzites, amphibolites, migmatitic gneiss)

Geological units have undergone metamorphism due to tectonic disturbances during upheaval of the Himalayas. Chungthang, Darjeeling and Kanchenjungha groups of rocks occur as Nappés on the north of Main Boundary Fault, which is most prominent and comprises of multiple thrust surfaces. Gondwana rocks occur mainly in South Sikkim around Namchi, generally called a 'Window' the frame of which is provided by Dalings and Buxa group rocks. Quaternary deposits are developed sporadically along the streams and rivers. Tectonically the area can be divided in to four units, namely,

Sub-Himalayan Domain

This domain lies in the south and consists of mollase type deposits of the Siwaliks (Mio- Pliocene), and is separated from the lesser Himalayan domain in the north by the Main Boundary Thrust (MBT).

Lesser Himalayan Domain

It consists of a thin strip of Gondwana rocks, carbonate rocks (Buxa Formation) and a thick metasedimentary sequence of dominantly pelites with subordinate psammite and wacke (Daling Group).

Higher Himalayan Domain

It overlies the Lesser Himalayan Domain and is composed of medium to high-grade crystalline rocks, commonly referred to as the Higher Himalayan crystallines. These are dominantly of pelitic composition, with sporadic quartzites, calc-silicate rocks, metabasics and small bodies of granite. The Higher Himalayan crystallines are separated from the Lesser Himalayan Domain by the Main Central Thrust (MCT).

Tethyan Belt

A thick pile of fossiliferous Cambrian to Eocene sedimentary rocks belonging to the Tethyan Belt (Tethyan Sedimentary Sequence) overlie the Higher Himalayan crystallines on the hanging wall side of a series of north-dipping normal faults constituting the South Tibetan Detachment System in the extreme north of Sikkim.

The structural disposition has been brought about by cumulative effect of 3 major movements and subsequent denudation. Due to different set of structural disturbances, numerous fractures, small-scale faults and joints have been developed. Three sets of joints are found in all the rock types of the formations present in Sikkim. Fracture cleavage occurs in the schistose rock. The geological set up of Sikkim according to the above-mentioned physiographic units as mentioned by Geological Survey of India is as follows.

Table 4.1 Generalized Stratigraphic Succession of the rock units of the State of Sikkim

NORTH SIKKIM
(Comprising of Mangan District)

Group	Formation	Rock Type	Age
Tso Lhamo	Tso Lhamo Formation	Dark Limestones and shales, quartzites and sandstones.	Middle Triassic
Lachhi	Lachhi Series	Pebble beds, lime stones and shales, quartzitessilts and shales	Carboniferous-Permain
Mt. Everest Peletic group		Phyllites, Quartzite, Quart-Biotite schist with granite	Late Permain-Lr. Palaeozoic

CENTRAL AND SOUTH SIKKIM
(Comprising of Gangtok,Pakyaong, Jorethang, Soreng and Namchi Districts)

Group	Formation	Rock Type	Age
Quaternary		Alluvium, terrace deposits etc	Recent
~~ ***Unconformity*** ~~~~~~~~~~~~~~~~			
Upper Gondwanas	Danuda	Fine to coarse grained sandstone Carbonaceous Shale	Permian Late Palaezoic
Lower Gondwana Group	Rangit Pebble Slate	Shale and coal pebbly cum boulder Slate	Upper Carboniferous to Permian
^^^^^^^^^^^^^^^^^^ ***Thrust Contact*** ^^^^^^^^^^^^^^^^^^			
Buxa	Buxa	Greyish coloured dolomite with purple coloured quartziteand Phyllites, some black Slates	Early Palaeozoic
Daling Group	Reyang and Garubathan	Purple coloured phyllite and variegated slates massive grey quartzite and sericite schists	Proterozoic
^^^^^^^^^^^^^^^^^^ ***Thrust Contact*** ^^^^^^^^^^^^^^^^^^			
Lingtse Group	Granite Gneiss	Highly sheared porphyroblastic granite Gneiss	Pre Cambrian
^^^^^^^^^^^^^^^^^^ ***Thrust Contact*** ^^^^^^^^^^^^^^^^^^			
Chungthang Group		Biotite Muscovite gneiss, quartzites, marbles, graphitic schist	Early Pre Cambrian
Darjeeling Group		Migmatitic Gneisses with Calc Silicates lenses	Early Pre Cambrian
Kanchenjunga Group		Augen Gneisses, Quartzite, Amphibolites and Migmatitic Gneisses	Early Pre Cambrian

Description of the rock types in briefly given below.

Kanchenjunga

The Kanchenjunga group of rocks is characterized by augen gneisses, quartzites, amphibolites and magmatic gneisses. The gneiss consists essentially of microcline, albite, oligoclase, quartz, muscovite and biotite.

Darjeeling

The Darjeeling group of rocks is characterized by magmatic gneisses with Calc silicate lenses, biotite gneiss, biotite schists, augen gneiss and granite. The Daling-Darjeeling gneiss contact is occasionally marked by mylonitisation.

Chunthang

The Chunthang group of rocks is characterized by quartzites, pure and impure marbles, mica schists, graphite schists, granetiferous amphibolites together with granite gneiss, augen gneisses, migmatites and granites of various types and pegmatites.

Lingtse

The Lingtse granite has been traced from north – eastern Sikkim south wars almost along the boundary of Daling-Chunthang. This has also been recorded from the west and north western part of the Sikkim. This granite is essentially constituted of acid intermediate plagioclase, Potash feldspar and quartz with abundance of biotite over muscovite. At time Porphyritic to angen texture becomes very prominent.

Dalings

Among the Daling group Buxa formation is younger and consists of quartzites variegated slates, black slates and dolomite. Buxa formation, Reyang formation is the Oldest among the rock group present here and is represented mainly by an alternative sequence of metamorphosed politic-semi-pelitic to psammitic rock comprising Chloritic phyllite, sericite phyllite, grey quartzite, massive quartzite and variegated slates.

Gondwanas

The group can be sub-divided into two formations namely the Talchir and Damunda from the lithostratigraphic considerations. The basal portions of the Gondwana are represented by pebbly cum boulder slate formation. The Damunda is represented by well bedded quartzite grey wacke to sub-grey wacke sandstone, locally arkosic and silicified with medium to fine grained micaceous sandstones, slates, carbonaceous slates and sheared semi-anthracitic coal. Sandstones are very hard and compact.

The Gondwanas contain impressions of plant fossils, as also some marine fossil has been recorded from these rocks. The plant fossils are mainly of *Glossopteris indica*, *Verteloraria phyllotheca*, *Schizoneura*, *Gangamopteris* and *Glossopteris*.

Quaternary deposits

These include the discontinuous and small patches of alluvium along river channels, colluviums at the foot of the hills and hill slopes, etc. Terrace development is extensive along the great Rangit River, lower reaches of Rangit and Tista, some of which are annexed and are extensively cultivated.

4.2 Ground Water Condition

In general, Hydrogeologically or in other words ground water occurrences of the State can be divided in two groups as ground water in (1) Non-permafrost area; and (2) Permafrost area

Ground Water condition in non-permafrost area:

Ground water occurs in this area in largely disconnected localized bodies under favourable geological conditions, such as Jointed, fractured zones in the various lithological units, weathered zones in the Phyllite, Schist, Gneisses, Quartzite etc. Due to higher relief of the area and steeper gradient, ground water comes out as seepages and springs whenever the land surface intersects local ground water body. Ground water exploration has been undertaken by Central Ground Water Board to explore the possibility of ground water occurrences & its potentiality in the hilly terrain of Sikkim. In total 29 no of exploratory wells (27 in South Sikkim and 2 in East Sikkim) and 9 nos. observation wells have been constructed at 25 placesdown to depth of 27 and 101 m bgl. Six sets of fractures have been identified in the depth of 10 – 70 m bgl. It is observed that discharge of the wells are at relatively high rate (89 to1608 lpm) in 8 nos. of well, at a medium to low rate (7.5 to 60 lpm) in 8 no of wells and at a very low rate (<7.5 lpm) in 10 no of wells. It is also observed that the fractures below 45 m bgl are regionally persistent and productive in nature. Transmissivity of the fractured aquifers ranges from 5.32 m^2/day to 316.43 m^2/day in Gondwana Formation and 16.14 m^2/day to 199.90 m^2/day in Daling Formation. General geological map of Sikkim is given in Plate-3.

Ground water condition in Permafrost area:

In general Glaciers are restricted in West and North Sikkim. They are grouped under seven glacier complexes; namely Chhombo, Yumthang, Lamgpo, Zemu, Talung, Rathang and Rel glacier complexes Water in these area (both ground water & surface water) is under frozen condition throughout the year.

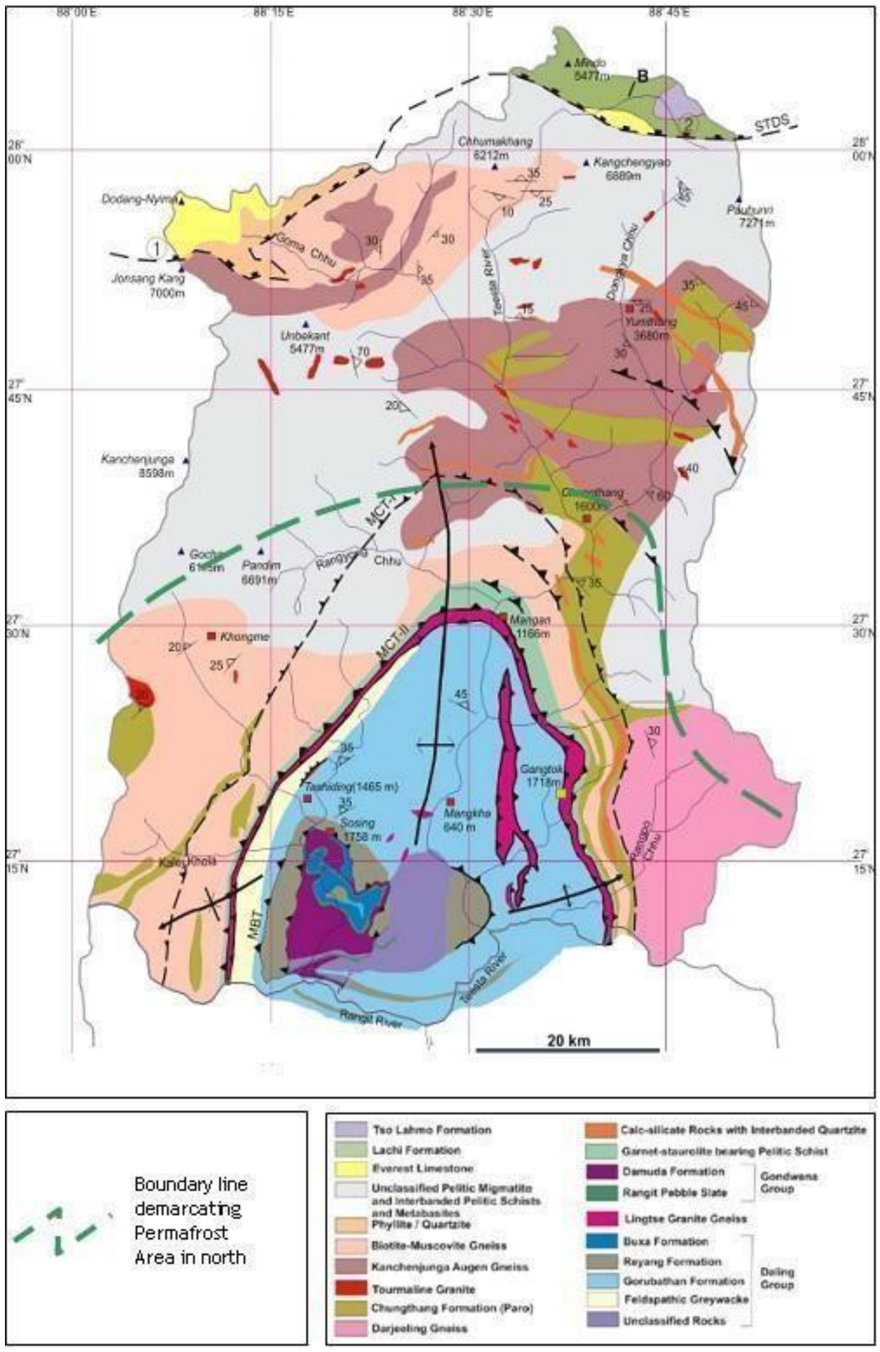


Figure 2: Geology of Sikkim

4.3 Ground Water quality:

Ground water in Sikkim used for drinking and other domestic purposes from springs and some kholas. As such chemical constituents have so far been determined for spring water mainly. In the entire study area ground water occurs mainly in the form of springs and it was found that the ground water is of extremely good quality. The spring water is fresh, potent and suitable for domestic, irrigation and industrial uses. The Chemical quality of spring water in the state shows that it is fresh and fit for both drinking and irrigation purpose. The concentrations of different chemical constituents present in the ground water are well within the desirable limit as stipulated for drinking water by the Bureau of Indian Standard (BIS). However, it is observed that spring water is very much vulnerable to surface pollution which necessitates effective and proper measures to prevent any contamination. In such situation Chlorination is desirable before spring water is used for drinking purposes. Bacterial contamination is very common in spring water especially in the hilly terrain and appropriate safeguards and remedial measures have to take to avoid any type of infections. The ranges of chemical constituents of the spring water samples collected from the various springs of Sikkim District are given below:

Table 4.2.: Chemical Quality of Spring Water of Sikkim

Sl No.	Chemical Constituents/Parameters	Units	Range	BIS Drinking Water Standards IS- 10500-2012	
				Desirable Limits	Maximum Permissible Limits
1	Electronic Conductivity (µs/cm at 25°)	(µs/cm at 25°)	21-410		
2	pH	mg/l	6.79-8.10 mg/l	6.5	8.5
3	Total Dissolved Solid (TDS)	mg/l	8-361 mg/l	500	2000
4	Total Hardness as $CaCO_3$	mg/l	7-300 mg/l	200	600
5	Calcium	mg/l	1.6-62 mg/l	75	200
6	Magnesium	mg/l	0.24-24 mg/l	30	100
7	Sodium	mg/l	0.23-10 mg/l	-	-
8	Potassium	mg/l	0.1-16.0 mg/l	-	-
9	Iron	mg/l	<0.01-0.56 mg/l	0.30	No Relaxation
10	Silicon	mg/l	<0.01-16.0	-	-
11	Bicarbonate	mg/l	6.10-332 mg/l	-	-
12	Chloride	mg/l	1.40-16 mg/l	250	1000
13	Fluoride	mg/l	0.12-0.29 mg/l	1.0	1.5
14	Sulphate	mg/l	0.43-14 mg/l	200	400

Sl No.	Chemical Constituents/Parameters	Units	Range	BIS Drinking Water Standards IS- 10500-2012	
				Desirable Limits	Maximum Permissible Limits
15	Nitrate	mg/l	0.37-2.03 mg/l	45	No Relaxation

From a perusal of the above table, it is apparent that the quality of ground water from this hard rock terrain is excellent in nature except in higher concentration of iron in some spring water and it reflects that the water is of Ca-Mg-bicarbonate type. The spring and Khola water are of superficial origin with ground water escaping as springs by shortest available trajectory without getting stagnated. Hence the spring water shows almost the characteristics of rain water. However, there are some higher ranges of chemical constituents e.g., 410 µS/Cm of EC, 361 mg/l of TDS, total hardness of 300 mg/l of $CaCO_3$ and inter-filtrating rain water underground allowing longer with the different litho units in the area is indicated in such cases.

It is also seen that ground water occurring in the springs is not only excellent in quality, but the range of variations in Chemical constituents is also lesser. Regarding suitability of irrigation from spring and khola water, it is observed that they fall within permissible limit ranging from 0.018 to 2.8 (SAR values)

The chemical quality of ground water in Sikkim is very good both for drinking and irrigation purposes-except for higher concentrations of iron which should be removed before being put to drinking and other domestic uses.

The local population, in absence of other sources mainly depends on spring sources which are vulnerable to surface pollution. Effective measurement should be taken to prevent any contamination and chlorination should be done when used for drinking purposes.

CHAPTER-5

GROUND WATER LEVEL SCENARIO IN THE STATE

5.1 Groundwater Level Scenario (2023)

Presently there are only a very limited number of monitoring stations exists in Sikkim which started only in 2024. Hence, long-term water level data are not available.

CHAPTER 6

GROUND WATER RESOURCES OF THE STATE

6.1. ANNUAL GROUND WATER RECHARGE

The detailed Summary and Analysis of the Annual Ground Water Recharge are discussed below.

District-Wise Summary

6.1.1. Gangtok

- Total Recharge from Rainfall (Monsoon Season): 4,331.75 Ham
- Total Recharge from Other Sources (Monsoon Season): 93.05 Ham
- Total Recharge from Rainfall (Non-Monsoon Season): 1,872.07 Ham
- Total Recharge from Other Sources (Non-Monsoon Season): 25.46 Ham
- Total Annual Groundwater Recharge: 6,230.21 Ham

6.1.2. Mangan

- Total Recharge from Rainfall (Monsoon Season): 3,869.62 Ham
- Total Recharge from Other Sources (Monsoon Season): 48.53 Ham
- Total Recharge from Rainfall (Non-Monsoon Season): 1,833.39 Ham
- Total Recharge from Other Sources (Non-Monsoon Season): 6.67 Ham
- Total Annual Groundwater Recharge: 5,758.21 Ham

6.1.3. Gyalsingh

- Total Recharge from Rainfall (Monsoon Season): 3,450.58 Ham
- Total Recharge from Other Sources (Monsoon Season): 105.44 Ham
- Total Recharge from Rainfall (Non-Monsoon Season): 1,005.42 Ham
- Total Recharge from Other Sources (Non-Monsoon Season): 4.08 Ham
- Total Annual Groundwater Recharge: 4,565.52 Ham

6.1.4. Soreng

- Total Recharge from Rainfall (Monsoon Season): 1,027.47 Ham
- Total Recharge from Other Sources (Monsoon Season): 28.77 Ham
- Total Recharge from Rainfall (Non-Monsoon Season): 349.58 Ham
- Total Recharge from Other Sources (Non-Monsoon Season): 3.98 Ham
- Total Annual Groundwater Recharge: 1,409.80 Ham

6.1.5. Pakyong

- Total Recharge from Rainfall (Monsoon Season): 4,673.06 Ham
- Total Recharge from Other Sources (Monsoon Season): 40.21 Ham
- Total Recharge from Rainfall (Non-Monsoon Season): 1,670.76 Ham
- Total Recharge from Other Sources (Non-Monsoon Season): 8.94 Ham

- Total Annual Groundwater Recharge: 6,393.96 Ham

6.1.6. Namchi

- Total Recharge from Rainfall (Monsoon Season): 4,070.51 Ham
- Total Recharge from Other Sources (Monsoon Season): 50.68 Ham
- Total Recharge from Rainfall (Non-Monsoon Season): 1,058.67 Ham
- Total Recharge from Other Sources (Non-Monsoon Season): 6.72 Ham
- Total Annual Groundwater Recharge: 5,186.58 Ham

Block-Wise Summary

The following analysis is based on the recharge data for blocks in each district:

1. Gangtok District (6 blocks)

- Blocks such as **Rakdong Tintek** (632.65 Ham) and **Khamdong** (1,056.61 Ham) also contribute substantially to the recharge.

2. Mangan District (5 blocks)

- The **Dzongu / Passingdang** block has the highest recharge (1,921.57 Ham), followed by **Chunthang** (707.71 Ham) and **Kabi Tingda** (646.37 Ham).

3. Gyalsingh District (6 blocks)

- **Dentam** (1,124.41 Ham) is the highest contributor to recharge, followed by **Gyalsingh** (703.10 Ham).

4. Soreng District (7 blocks)

- **Soreng** block (179.80 Ham) and **Baiguney** (151.23 Ham) contribute less to the total recharge compared to the other blocks in the district.
- **Chumbung-Chakung** has the least recharge (130.08 Ham).

5. Pakyong District (7 blocks)

- **Regu** (982.32 Ham) are the highest contributors, while blocks like **Namchibong** (220.94 Ham) contribute significantly less.

6. Namchi District (9 blocks)

- **Ravangla** (509.84 Ham) and **Namchi** (540.35 Ham) are the top contributors in Namchi, followed by **Temi Tarku** (377.18 Ham).

State Summary

- Total Recharge from Rainfall (Monsoon Season): 17,644.38 Ham
- Total Recharge from Other Sources (Monsoon Season): 398.83 Ham
- Total Recharge from Rainfall (Non-Monsoon Season): 6,068.00 Ham
- Total Recharge from Other Sources (Non-Monsoon Season): 53.35 Ham
- Total Annual Groundwater Recharge: 24,164.56 Ham

Analysis

- **High Recharge Areas:** Unpopulated areas of the state shows a substantial recharge.
- **Low Recharge Areas:** Blocks like **Soreng**, **Mangalbarey**, and **Kaluk** show comparatively lower recharge rates.
- **Non-Monsoon Season Recharge:** Most recharge from rainfall occurs during the monsoon season, while non-monsoon season recharge is significantly lower across all districts.
- **Recharge Variability:** Recharge varies significantly from district to district, with Gangtok and Mangan having the highest totals.

Table 6.1: The details of the Annual Ground water recharge (Block-Wise)

Sl. No	District	Assessment Unit Name	Recharge from Rainfall-Monsoon Season	Recharge from Other Sources-Monsoon Season	Recharge from Rainfall-Non Monsoon Season	Recharge from Other Sources-Non Monsoon Season	Total Annual Ground Water (Ham) Recharge
1	Gangtok	Rakdong Tintek	441.83	22.83	163.41	4.58	632.65
2	Gangtok	Khamdong	751.26	22.89	277.85	4.61	1056.61
3	Gangtok	Martam	412.98	22.81	152.74	4.56	593.09
4	Gangtok	Gangtok / Nandok	301.43	24.84	111.48	5.86	443.61
5	Gangtok	Gangtok_ROA	2571.80	0.00	951.17	0.00	3522.97
6	Gangtok	Ranka	394.39	22.88	145.86	4.60	567.73
7	Mangan	Dzongu / Passingdang	1216.95	9.72	693.86	1.04	1921.57
8	Mangan	Kabi Tingda	404.88	9.65	230.85	0.99	646.37
9	Mangan	Chunthang	439.26	14.21	250.45	3.79	707.71
10	Mangan	Mangan	274.28	9.42	156.39	0.85	440.94
11	Mangan	Mangan_ROA	0.00	0.00	0.00	0.00	0.00
12	Gyalsingh	Arithang Chongrang	534.23	19.87	133.33	0.59	688.02
13	Gyalsingh	Gyalsingh	546.02	20.08	136.28	0.72	703.10
14	Gyalsingh	Hee Martam	446.84	19.87	111.52	0.59	578.82
15	Gyalsingh	Dentam	883.20	20.07	220.43	0.71	1124.41
16	Gyalsingh	Gyalsingh_ROA	185.66	0.00	46.34	0.00	232.00
17	Gyalsingh	Yuksom	354.60	20.90	88.50	1.22	465.22
18	Soreng	Soreng	139.54	4.87	34.83	0.56	179.80
19	Soreng	Mangalbarey	136.33	4.76	34.03	0.50	175.62
20	Soreng	Chumbung-Chakung	100.01	4.67	24.96	0.44	130.08
21	Soreng	Daramdin	237.07	4.78	59.17	0.51	301.53
22	Soreng	Soreng_ROA	0.00	0.00	0.00	0.00	0.00
23	Soreng	Baiguney	116.94	4.67	29.18	0.44	151.23
24	Soreng	Kaluk	262.12	4.71	65.42	0.46	332.71
25	Pakyong	Pakyong	701.92	8.09	259.60	1.66	971.27
26	Pakyong	Parkha	653.24	8.03	241.60	1.62	904.49
27	Pakyong	Pakyong_ROA	660.89	0.00	244.43	0.00	905.32
28	Pakyong	Regu	710.02	8.06	262.60	1.64	982.32
29	Pakyong	Duga	397.58	8.04	147.04	1.62	554.28
30	Pakyong	Rhenock	346.36	8.08	128.10	1.65	484.19
31	Pakyong	Namchibong	154.04	8.20	56.97	1.73	220.94

Sl. No	District	Assessment Unit Name	Recharge from Rainfall-Monsoon Season	Recharge from Other Sources-Monsoon Season	Recharge from Rainfall-Non Monsoon Season	Recharge from Other Sources-Non Monsoon Season	Total Annual Ground Water (Ham) Recharge
32	Namchi	Ravangla	413.50	7.74	87.87	0.73	509.84
33	Namchi	Yangdang	396.90	7.83	84.34	0.79	489.86
34	Namchi	Melli Sumbuk	308.83	7.67	65.63	0.69	382.82
35	Namchi	Wok Sikkip	227.94	7.67	48.44	0.69	284.74
36	Namchi	Jorethang	234.63	7.67	49.86	0.69	292.85
37	Namchi	Namthang	510.08	7.67	108.39	0.69	626.83
38	Namchi	Temi Tarku	304.16	7.68	64.64	0.70	377.18
39	Namchi	Namchi	438.45	7.90	93.17	0.83	540.35
40	Namchi	Namchi_ROA	34.22	0.00	7.27	0.00	41.49
		Total	**17644.38**	**398.83**	**6068.00**	**53.35**	**24164.56**

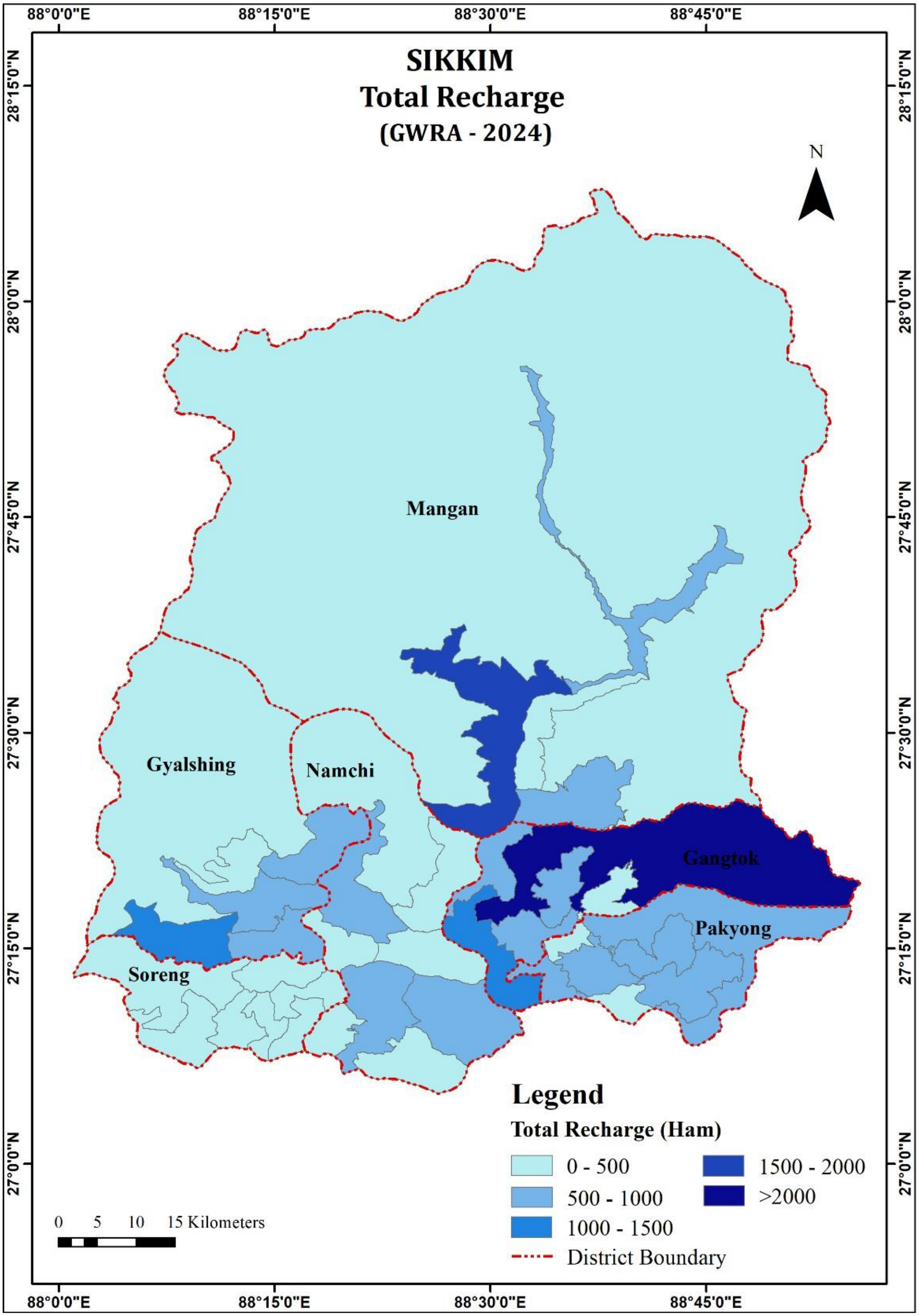


Figure: 6.1. Annual Ground Water Recharge

6.2. ANNUAL EXTRACTABLE GROUND WATER RESOURCES

There detailed District-wise Summarization of the Annual Extractable Ground Water Resources Is discussed below.

6.2.1 Gangtok District:

- **Total Annual Extractable Groundwater Resource:** 7,582.90 Ham
- **Key Assessment Units:**
  - **Rakdong Tintek:** 569.38 Ham
  - **Khamdong:** 950.94 Ham
  - **Martam:** 533.78 Ham
  - **Gangtok / Nandok:** 399.25 Ham
  - **Gangtok (Rest of the Area):** 3,170.67 Ham (significantly high compared to other units)
  - **Ranka:** 510.95 Ham
- **Summary:** Gangtok, the capital district, shows the largest total groundwater resource among the districts. The **Gangtok (Rest of the Area)** unit, with over 3,170 Ham, plays a major role in the groundwater availability here.

6.2.2. Mangan District:

- **Total Annual Extractable Groundwater Resource:** 5,377.49 Ham
- **Key Assessment Units:**
  - **Dzongu / Passingdang:** 1,729.41 Ham
  - **Kabi Tingda:** 581.74 Ham
  - **Chunthang:** 636.94 Ham
  - **Mangan:** 396.85 Ham
  - **Mangan (Rest of the Area):** 0.00 Ham
- **Summary:** Mangan's major groundwater resource comes from **Dzongu / Passingdang**, contributing a substantial 1,729.41 Ham. However, the **Mangan (Rest of the Area)** unit reports zero groundwater resource.

6.2.3. Gyalsingh District:

- **Total Annual Extractable Groundwater Resource:** 5,441.21 Ham
- **Key Assessment Units:**
  - **Arithang Chongrang:** 619.22 Ham
  - **Gyalsingh:** 632.79 Ham
  - **Hee Martam:** 520.94 Ham
  - **Dentam:** 1,011.97 Ham
  - **Gyalsingh (Rest of the Area):** 208.80 Ham
  - **Yuksom:** 418.70 Ham

- **Summary:** Gyalsingh has a fairly balanced distribution of groundwater resources across its assessment units. The largest contributor is **Dentam** with 1,011.97 Ham, while **Gyalsingh (Rest of the Area)** has the least with only 208.80 Ham.

6.2.4. Soreng District:

- **Total Annual Extractable Groundwater Resource:** 2,155.89 Ham
- **Key Assessment Units:**

  - **Soreng:** 161.82 Ham
  - **Mangalbarey:** 158.06 Ham
  - **Chumbung-Chakung:** 117.07 Ham
  - **Daramdin:** 271.37 Ham
  - **Soreng (Rest of the Area):** 0.00 Ham
  - **Baiguney:** 136.11 Ham
  - **Kaluk:** 299.44 Ham

- **Summary:** Soreng district has a total resource of 2,155.89 Ham, with **Kaluk** contributing the most (299.44 Ham). The **Soreng (Rest of the Area)** unit, like others, reports zero groundwater resource.

6.2.5. Pakyong District:

- **Total Annual Extractable Groundwater Resource:** 5,297.19 Ham
- **Key Assessment Units:**

  - **Pakyong:** 874.14 Ham
  - **Parkha:** 814.04 Ham
  - **Pakyong (Rest of the Area):** 814.79 Ham
  - **Regu:** 884.09 Ham
  - **Duga:** 498.85 Ham
  - **Rhenock:** 435.77 Ham
  - **Namchibong:** 198.85 Ham

- **Summary:** Pakyong's groundwater resources are spread relatively evenly, with **Regu** contributing the highest amount (884.09 Ham), followed closely by **Pakyong** (874.14 Ham).

6.2.6. Namchi District:

- **Total Annual Extractable Groundwater Resource:** 5,539.96 Ham
- **Key Assessment Units:**

  - **Ravangla:** 458.86 Ham
  - **Yangdang:** 440.88 Ham
  - **Melli Sumbuk:** 344.54 Ham
  - **Wok Sikkip:** 256.27 Ham
  - **Jorethang:** 263.57 Ham

- **Namthang:** 564.14 Ham
- **Temi Tarku:** 339.47 Ham
- **Namchi:** 486.31 Ham
- **Namchi (Rest of the Area):** 37.34 Ham (lowest resource)

- **Summary:** Namchi district has a relatively balanced distribution, with **Namthang** (564.14 Ham) being the highest contributor. The **Namchi (Rest of the Area)** unit has the least groundwater resource (37.34 Ham).

State of Sikkim:

- **Total Annual Extractable Groundwater Resource (State):** 21,748.11 Ham
- **Summary:** Sikkim as a whole has a total groundwater resource of 21,748.11 Ham. The largest contributors are from **Gangtok** (7,582.90 Ham), **Mangan** (5,377.49 Ham), **Gyalsingh** (5,441.21 Ham), and **Pakyong** (5,297.19 Ham). These four districts collectively account for a significant portion of the state's groundwater resources.

Key Insights:

1. **Gangtok district** is the largest contributor.
2. **Mangan** and **Gyalsingh** districts are also significant contributors, with notable resources in **Dzongu** and **Dentam**.
3. **Soreng** has smaller resource numbers but still has several viable units like **Kaluk**.
4. **Pakyong** has a well-distributed groundwater resource across several units.
5. **Namchi** has a balanced distribution, with **Namthang** as a major contributor.
6. The **ROA (Rest of Area)** units consistently report zero groundwater resources in most districts, indicating areas with no significant groundwater availability.

Table 6.2: The details of the Annual Extractable Ground Water Resources (Block-Wise)

Sl. No	District	Assessment Unit Name	Annual Extractable Ground Water Resource (Ham)
1	Gangtok	Rakdong Tintek	569.38
2	Gangtok	Khamdong	950.94
3	Gangtok	Martam	533.78
4	Gangtok	Gangtok / Nandok	399.25
5	Gangtok	Gangtok_ROA	3170.67
6	Gangtok	Ranka	510.95
7	Mangan	Dzongu / Passingdang	1729.41
8	Mangan	Kabi Tingda	581.74

Sl. No	District	Assessment Unit Name	Annual Extractable Ground Water Resource (Ham)
9	Mangan	Chunthang	636.94
10	Mangan	Mangan	396.85
11	Mangan	Mangan_ROA	0.00
12	Gyalsingh	Arithang Chongrang	619.22
13	Gyalsingh	Gyalsingh	632.79
14	Gyalsingh	Hee Martam	520.94
15	Gyalsingh	Dentam	1011.97
16	Gyalsingh	Gyalsingh_ROA	208.80
17	Gyalsingh	Yuksom	418.70
18	Soreng	Soreng	161.82
19	Soreng	Mangalbarey	158.06
20	Soreng	Chumbung-Chakung	117.07
21	Soreng	Daramdin	271.37
22	Soreng	Soreng_ROA	0.00
23	Soreng	Baiguney	136.11
24	Soreng	Kaluk	299.44
25	Pakyong	Pakyong	874.14
26	Pakyong	Parkha	814.04
27	Pakyong	Pakyong_ROA	814.79
28	Pakyong	Regu	884.09
29	Pakyong	Duga	498.85
30	Pakyong	Rhenock	435.77
31	Pakyong	Namchibong	198.85
32	Namchi	Ravangla	458.86
33	Namchi	Yangdang	440.88
34	Namchi	Melli Sumbuk	344.54
35	Namchi	Wok Sikkip	256.27
36	Namchi	Jorethang	263.57
37	Namchi	Namthang	564.14
38	Namchi	Temi Tarku	339.47
39	Namchi	Namchi	486.31
40	Namchi	Namchi_ROA	37.34
		Total	21748.11

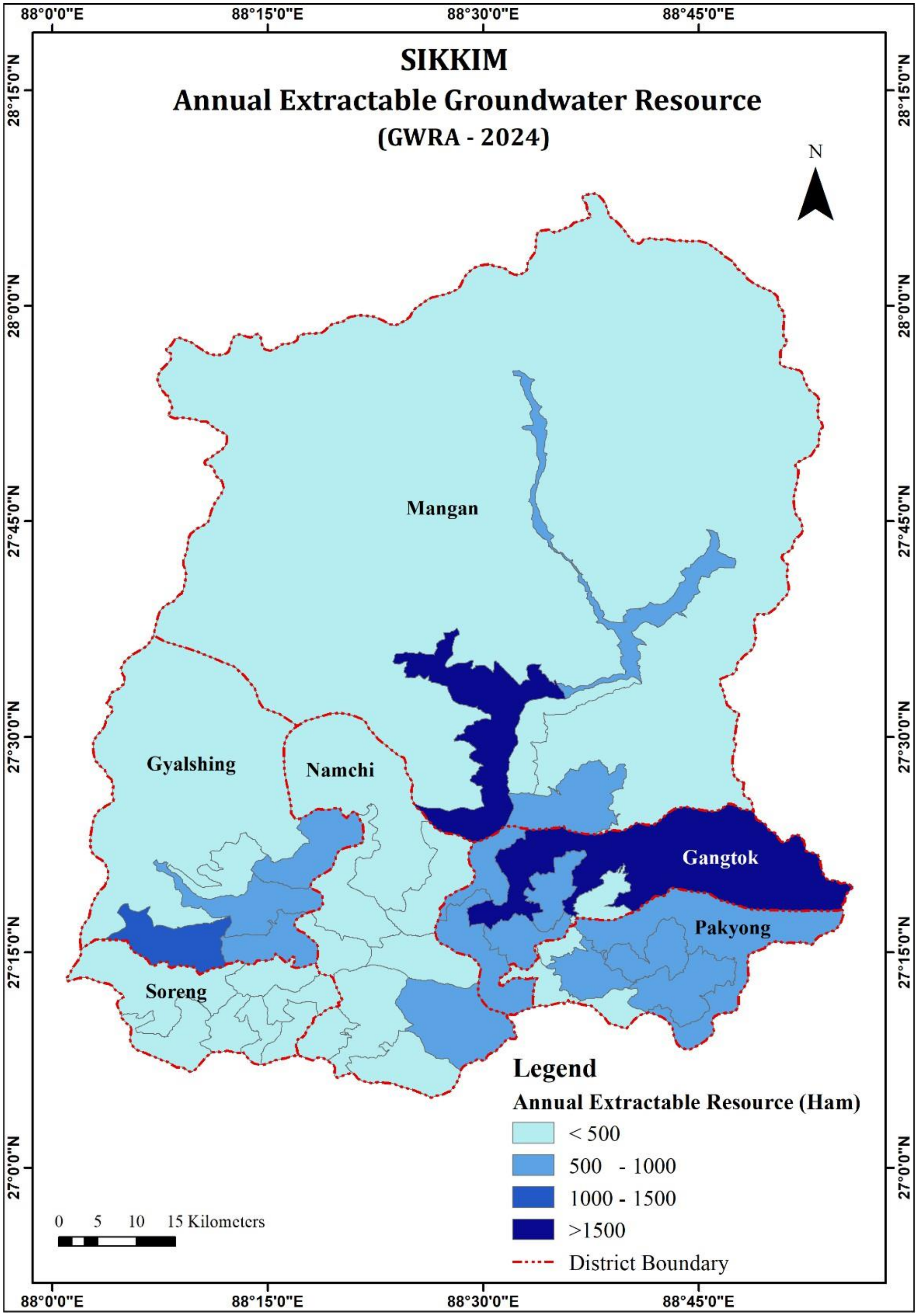


Figure: 6.2. Annual Extractable Ground Water Resource

6.3. ANNUAL TOTAL GROUND WATER EXTRACTION

The detailed Summary and Analysis of the Annual Total Ground Water Extraction district-wise are discussed below.

6.3.1. District-Wise Groundwater Extraction Summary:

6.3.1.1 Gangtok District:

- **Total Extraction (Ham)**: 570.32
  - **Irrigation Use**: 456.14
  - **Industrial Use**: 6.08
  - **Domestic Use**: 108.35
  - **Key Highlights**:
  - Gangtok district has the highest total extraction (570.32 Ham) in the state, driven largely by irrigation.
  - The most significant block in Gangtok is **Gangtok / Nandok**, contributing significantly to domestic use (90.61 Ham).

6.3.1.2 Mangan District:

- **Total Extraction (Ham)**: 131.33
  - **Irrigation Use**: 103.60
  - **Industrial Use**: 0.00
  - **Domestic Use**: 27.73
    Key Highlights:
  - Mangan has relatively lower total extraction than Gangtok, but irrigation use still plays a major role.
  - Blocks like **Dzongu / Passingdang** and **Kabi Tingda** each have 20.90 Ham of irrigation use, which is consistent across the district.

6.3.1.3 Gyalsingh District:

- **Total Extraction (Ham)**: 290.49
  - **Irrigation Use**: 246.90
  - **Industrial Use**: 0.00
  - **Domestic Use**: 43.59
    Key Highlights:
  - This district also shows a heavy reliance on irrigation use, especially with blocks like **Arithang Chongrang** and **Gyalsingh**, contributing over 40 Ham each.
  - There is no industrial extraction recorded here.

6.3.1.4 Soreng District:

- **Total Extraction (Ham)**: 101.95

  - **Irrigation Use**: 83.65
  - **Industrial Use**: 0.00
  - **Domestic Use**: 18.30
  Key Highlights:
  - Irrigation use is the main contributor, with **Soreng** and **Mangalbarey** leading in extraction.
  - There are no industrial extractions in this district.

6.3.1.5 Pakyong District:

- **Total Extraction (Ham)**: 283.94

  - **Irrigation Use**: 139.60
  - **Industrial Use**: 62.94
  - **Domestic Use**: 81.40
  Key Highlights:
  - Pakyong stands out with notable industrial use, especially in blocks like **Duga** (29.99 Ham) and **Pakyong** (26.65 Ham).
  - Irrigation still dominates, but industrial extraction is relatively significant here.

6.3.1.6 Namchi District:

- **Total Extraction (Ham)**: 238.91

  - **Irrigation Use**: 136.48
  - **Industrial Use**: 17.19
  - **Domestic Use**: 85.24
  Key Highlights:
  - A balanced mix of irrigation and domestic use, with blocks like **Jorethang** contributing high extraction (9.41 Ham for industrial use).
  - **Namchi** block has a significant domestic use of 16.28 Ham.

6.3.2. Block-Wise Groundwater Extraction Summary:

- **Highest Extraction Block**:
  Gangtok / Nandok (Gangtok District) – 147.62 Ham
  This block leads with both a high total extraction and a notable domestic use (90.61 Ham).
- **Blocks with High Irrigation Use**:

  - **Gangtok**: Various blocks, like **Rakdong Tintek** (57.02 Ham) and **Martam** (57.02 Ham), contribute majorly to irrigation extraction.
  - **Mangan**: Blocks like **Dzongu / Passingdang** and **Kabi Tingda** each contribute around 20.90 Ham of irrigation use.

    - **Gyalsingh**: Blocks like **Arithang Chongrang** and **Gyalsingh** show heavy reliance on irrigation with 41.22 Ham each.

- **Blocks with Industrial Use**:

    - **Pakyong District** stands out with several blocks showing industrial extraction, such as **Pakyong** (26.65 Ham) and **Duga** (29.99 Ham).
    - **Namchi District** also shows industrial use, with **Jorethang** contributing 9.41 Ham.

6.3.3 Key Highlights:

1. **High Dependency on Irrigation**:

   Across all districts, irrigation remains the dominant use of groundwater, with substantial contributions from every district, especially Gangtok and Gyalsingh.

2. **Limited Industrial Extraction**:

   Except for **Pakyong** and **Namchi**, industrial use is minimal across most districts. Pakyong stands out with its significant industrial extraction (62.94 Ham).

3. **Domestic Use**:

   Domestic use is spread out, but the **Gangtok / Nandok** block leads with a notable domestic demand of 90.61 Ham.

4. **Variation Between Districts**:

    - **Gangtok** and **Gyalsingh** show high total extractions, while **Mangan**, **Soreng**, and **Namchi** have more moderate extractions.
    - **Pakyong** stands out for industrial use, while **Mangan** and **Gyalsingh** districts are more focused on irrigation.

6.3.4 Conclusion:

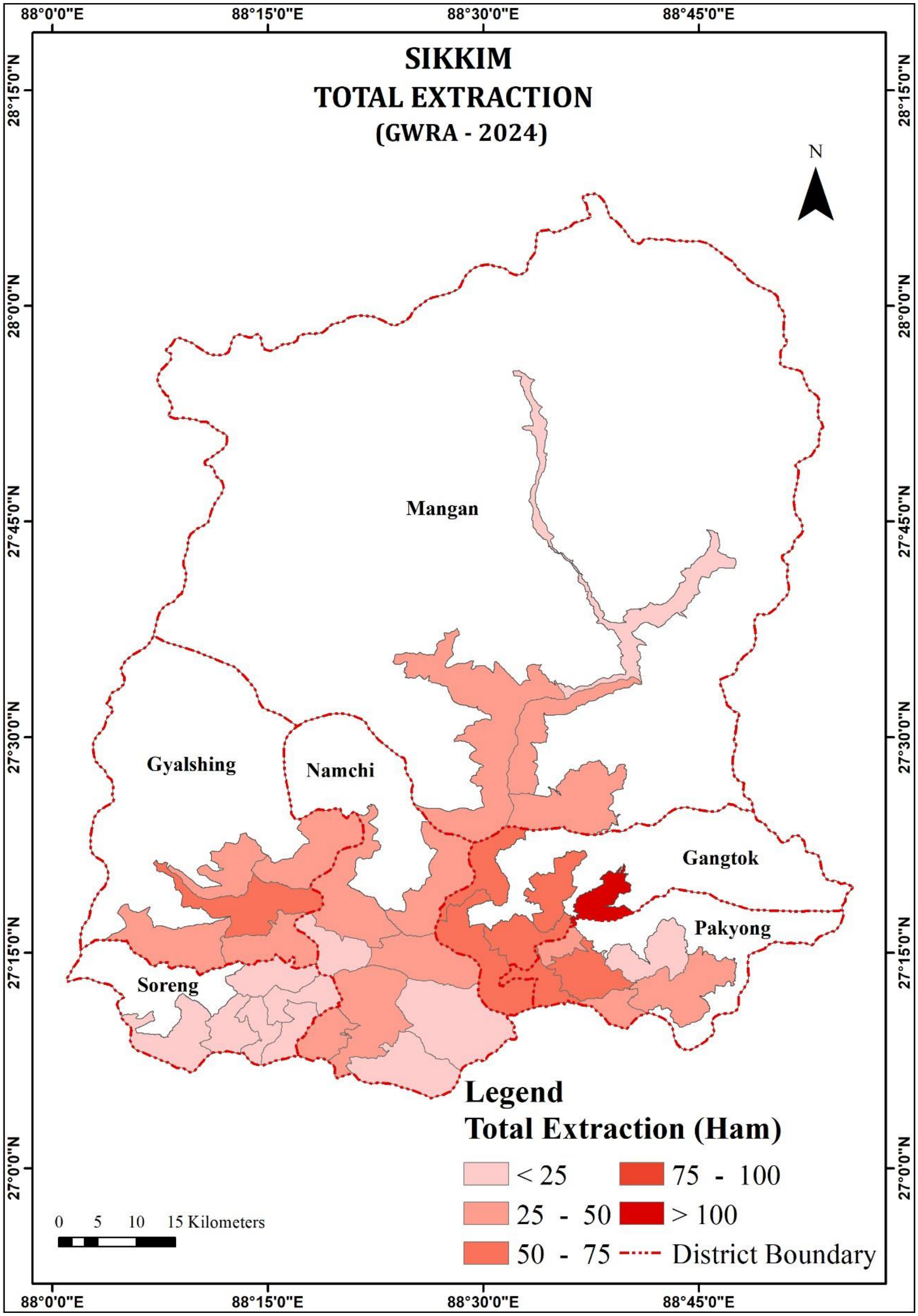
- **Gangtok District** is the largest consumer of groundwater, driven mostly by irrigation and domestic use, while **Pakyong** has the most diverse use with a significant amount of industrial extraction.

- Groundwater management strategies could focus on reducing domestic use in districts like **Gangtok** (especially the Gangtok / Nandok block) and improving irrigation efficiency across the board, as irrigation is the largest use category.

Table 6.3: The details of the Annual Total Ground Water Extraction (Block-Wise)

Sl. No	District	Assessment Unit Name	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Industrial Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)
1	Gangtok	Rakdong Tintek	57.02	0.31	7.15	64.47
2	Gangtok	Khamdong	57.02	0.00	6.69	63.71
3	Gangtok	Martam	57.02	5.77	6.16	68.96
4	Gangtok	Gangtok / Nandok	57.02	0.00	90.61	147.62
5	Gangtok	Gangtok_ROA	0.00	0.00	0.00	0.00
6	Gangtok	Ranka	57.02	0.00	6.38	63.41
7	Mangan	Dzongu / Passingdang	20.90	0.00	4.12	25.02
8	Mangan	Kabi Tingda	20.90	0.00	4.76	25.66
9	Mangan	Chunthang	20.90	0.00	3.88	24.78
10	Mangan	Mangan	20.90	0.00	8.50	29.40
11	Mangan	Mangan_ROA	0.00	0.00	0.00	-
12	Gyalsingh	Arithang Chongrang	41.22	0.00	4.70	45.92
13	Gyalsingh	Gyalsingh	41.22	0.00	11.13	52.35
14	Gyalsingh	Hee Martam	41.22	0.00	3.91	45.13
15	Gyalsingh	Dentam	41.22	0.00	8.24	49.47
16	Gyalsingh	Gyalsingh_ROA	0.00	0.00	0.00	0.00
17	Gyalsingh	Yuksom	41.22	0.00	3.22	44.44
18	Soreng	Soreng	10.45	0.00	6.57	17.02
19	Soreng	Mangalbarey	10.45	0.00	3.33	13.78
20	Soreng	Chumbung-Chakung	10.45	0.00	2.20	12.64
21	Soreng	Daramdin	10.45	0.00	7.69	18.14
22	Soreng	Soreng_ROA	0.00	0.00	0.00	-
23	Soreng	Baiguney	10.45	0.00	2.87	13.33
24	Soreng	Kaluk	10.45	0.00	4.43	14.89
25	Pakyong	Pakyong	20.10	26.65	7.90	54.65
26	Pakyong	Parkha	20.10	0.00	2.33	22.43
27	Pakyong	Pakyong_ROA	0.00	0.00	0.00	0.00
28	Pakyong	Regu	20.10	0.00	6.60	26.70
29	Pakyong	Duga	20.10	29.99	7.14	57.23
30	Pakyong	Rhenock	20.10	4.56	6.88	31.55
31	Pakyong	Namchibong	20.10	0.00	6.99	27.09
32	Namchi	Ravangla	17.06	0.00	9.22	26.28
33	Namchi	Yangdang	17.06	0.00	7.94	25.01
34	Namchi	Melli Sumbuk	17.06	1.28	6.60	24.94
35	Namchi	Wok Sikkip	17.06	0.00	2.16	19.22

Sl. No	District	Assessment Unit Name	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Industrial Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)
36	Namchi	Jorethang	17.06	9.41	3.31	29.78
37	Namchi	Namthang	17.06	0.00	7.53	24.59
38	Namchi	Temi Tarku	17.06	2.74	7.56	27.36
39	Namchi	Namchi	17.06	2.76	16.28	36.10
40	Namchi	Namchi_ROA	0.00	0.00	0.00	0.00
		Total	**894.55**	**83.47**	**294.98**	**1273.07**


SIKKIM
TOTAL EXTRACTION
(GWRA - 2024)
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88°30'0"E
88°45'0"E
28°15'0"N
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27°30'0"N
27°15'0"N
27°0'0"N
Mangan
Gyalshing
Namchi
Gangtok
Pakyong
Soreng
Legend
Total Extraction (Ham)
< 25
25 - 50
50 - 75
75 - 100
> 100
District Boundary
0 5 10 15 Kilometers

Figure: 6.3. Annual Total Groundwater Extraction

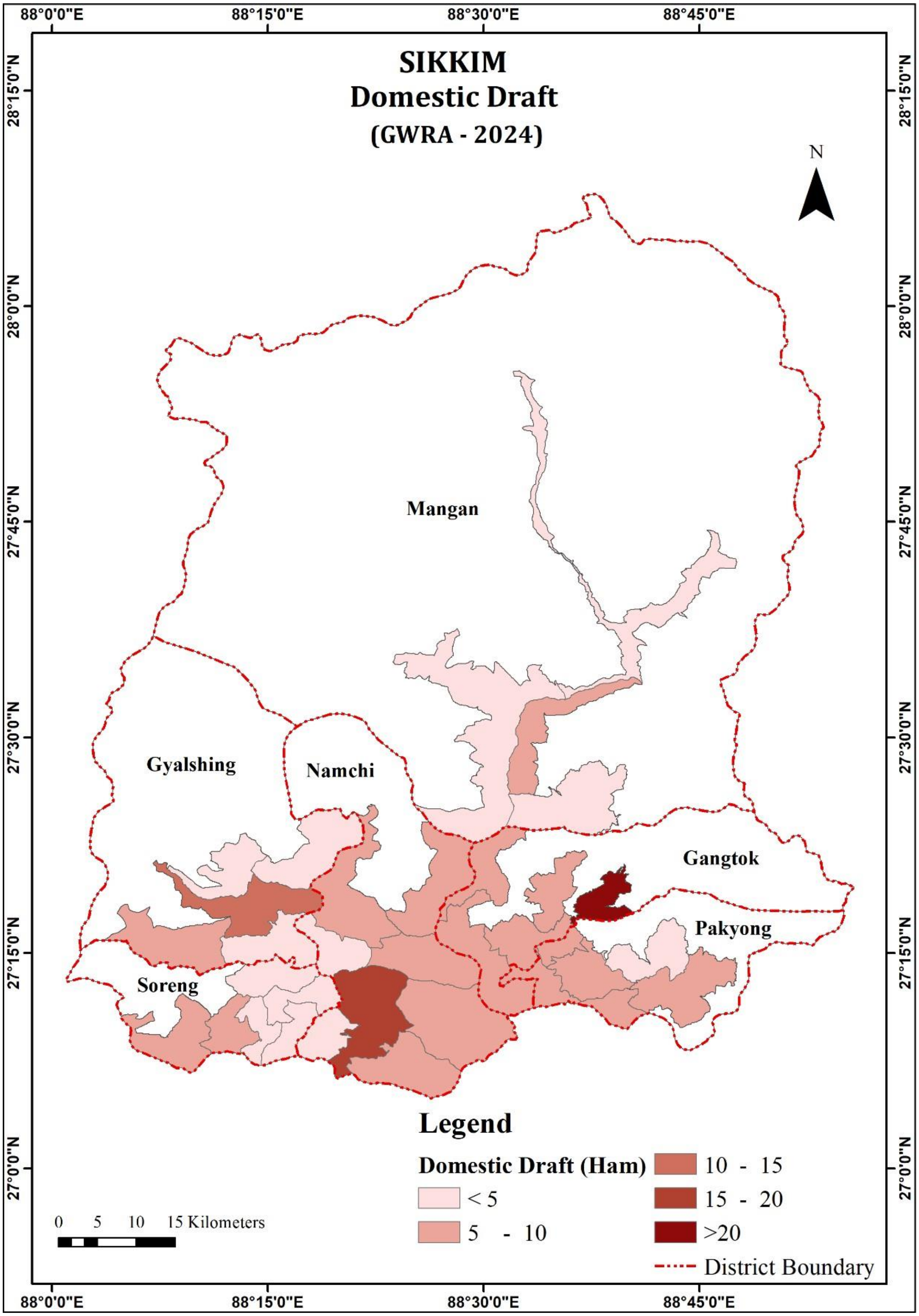

Figure: 6.3.1. Annual Total Domestic Extraction

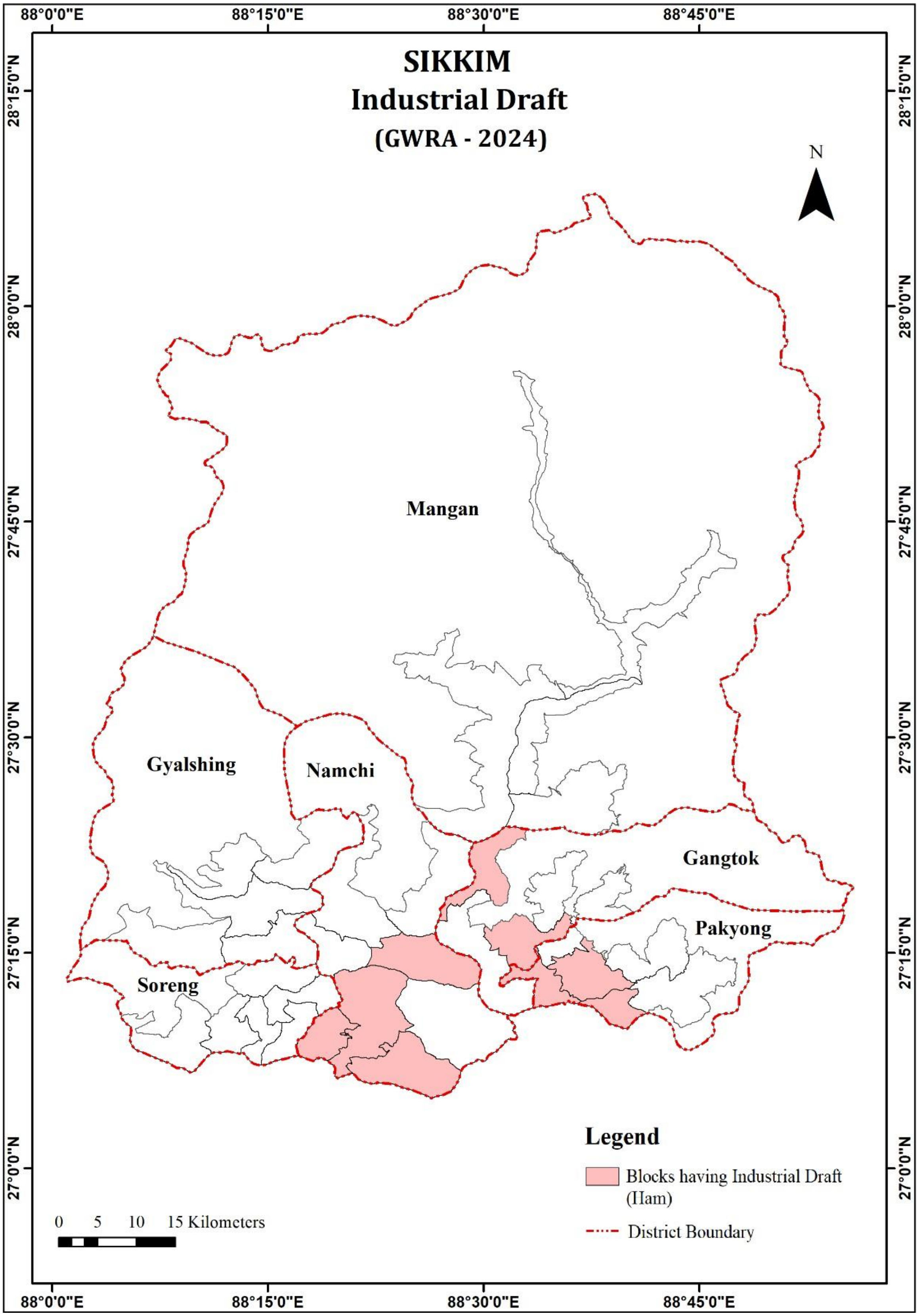

Figure: 6.3.2. Annual Total Industrial Draft

6.4. STAGE OF GROUND WATER EXTRACTION

The detailed Summary and Analysis of the Stage of Ground Water Extraction district-wise are discussed below.

6.4.1. Gangtok District

- **Key Highlights:**
    - **Highest Extraction**: Gangtok / Nandok (36.97% extraction).
    - **Lowest Extraction**: Gangtok (Rest of the Area) (0% extraction).
    - The extraction rate varies widely, with some areas having very low or no extraction at all, while Gangtok and nearby areas show moderate to high extraction.
- **Block-wise Analysis:**
    - **Rakdong Tintek**: 11.32%
    - **Khamdong**: 6.70%
    - **Martam**: 12.92%
    - **Gangtok / Nandok**: 36.97% (Highest extraction in Gangtok).
    - **Gangtok (Rest of the Area)**: 0% (No extraction).
    - **Ranka**: 12.41%

6.4.2. Mangan District

- **Key Highlights:**
    - **Lowest Extraction**: Dzongu / Passingdang (1.45% extraction).
    - **Moderate Extraction**: Mangan (7.41% extraction).
    - There is a general trend of very low groundwater extraction, with Dzongu / Passingdang having the lowest rate and most areas under 10%.
- **Block-wise Analysis:**
    - **Dzongu / Passingdang**: 1.45% (Lowest extraction in Mangan).
    - **Kabi Tingda**: 4.41%
    - **Chunthang**: 3.89%
    - **Mangan**: 7.41%
    - **Mangan (Rest of the Area)**: No data available.

6.4.3. Gyalsingh District

- **Key Highlights:**
    - The extraction rates here are moderate, with no ROA data and relatively low figures across all assessment units.
    - **Highest Extraction**: Hee Martam (8.66% extraction).
    - **Lowest Extraction**: Gyalsingh (Rest of the Area) (0% extraction).

- **Block-wise Analysis:**
  - **Arithang Chongrang**: 7.42%
  - **Gyalsingh**: 8.27%
  - **Hee Martam**: 8.66% (Highest extraction in Gyalsingh).
  - **Dentam**: 4.89%
  - **Gyalsingh (Rest of the Area)**: 0% (No extraction).
  - **Yuksom**: 10.61%

6.44. Soreng District

- **Key Highlights:**
  - **Highest Extraction**: Chumbung-Chakung (10.80% extraction).
  - **Lowest Extraction**: Soreng (Rest of the Area) (No extraction).
  - Generally moderate extraction rates, with some areas showing higher extraction levels like Chumbung-Chakung.

- **Block-wise Analysis:**
  - **Soreng**: 10.52%
  - **Mangalbarey**: 8.72%
  - **Chumbung-Chakung**: 10.80% (Highest extraction in Soreng).
  - **Daramdin**: 6.68%
  - **Soreng (Rest of the Area)**: No extraction.
  - **Baiguney**: 9.79%
  - **Kaluk**: 4.97%

6.4.5. Pakyong District

- **Key Highlights:**
  - **Highest Extraction**: Namchibong (13.62% extraction).
  - **Lowest Extraction**: Pakyong (Rest of the Area).
  - Extraction rates are somewhat balanced, with a few areas having relatively high extraction, especially Namchibong.

- **Block-wise Analysis:**
  - **Pakyong**: 6.25%
  - **Parkha**: 2.76%
  - **Pakyong (Rest of the Area)**: No extraction.
  - **Regu**: 3.02%
  - **Duga**: 11.47%
  - **Rhenock**: 7.24%
  - **Namchibong**: 13.62% (Highest extraction in Pakyong).

6.4.6. Namchi District

- **Key Highlights:**
  - **Highest Extraction**: Jorethang (11.30% extraction).
  - **Lowest Extraction**: Namthang (4.36% extraction).
  - A relatively steady extraction rate, with most blocks showing around 5-10% extraction.
- **Block-wise Analysis:**
  - **Ravangla**: 5.73%
  - **Yangdang**: 5.67%
  - **Melli Sumbuk**: 7.24%
  - **Wok Sikkip**: 7.50%
  - **Jorethang**: 11.30% (Highest extraction in Namchi).
  - **Namthang**: 4.36%
  - **Temi Tarku**: 8.06%
  - **Namchi**: 7.42%
  - **Namchi (Rest of the Area)**: No extraction.

6.4.7. Key Highlights across Sikkim:

- The **highest extraction rate** is found in **Gangtok / Nandok** (36.97%), indicating a higher reliance on groundwater in urban or developed areas.
- **Lowest extraction rates** are seen in remote areas like **Dzongu / Passingdang** (1.45%) and some blocks with 0% extraction (marked as ROA or no data available).
- **Moderate Extraction**: Most districts show a moderate extraction percentage, with many areas hovering between 4-12% extraction.
- **No Extraction**: Areas marked as **ROA** have no groundwater extraction recorded, indicating either no extraction activity or no data.

6.4.8. Overall State Analysis:

- The SOD for Sikkim is **5.85%**, indicating that groundwater extraction is relatively low overall compared to other states of India.
- Urban centers like Gangtok have higher extraction rates, while remote or rural areas tend to have very low or no groundwater extraction. This suggests a possible disparity in groundwater utilization between urban and rural zones.

Table 6.4: The details of the Stage of Groundwater Extraction (Block-Wise)

Sl. No	District	Assessment Unit Name	SGWE (%)
1	Gangtok	Rakdong Tintek	11.32
2	Gangtok	Khamdong	6.70
3	Gangtok	Martam	12.92
4	Gangtok	Gangtok / Nandok	36.97
5	Gangtok	Gangtok_ROA	0.00
6	Gangtok	Ranka	12.41

Sl. No	District	Assessment Unit Name	SGWE (%)
7	Mangan	Dzongu / Passingdang	1.45
8	Mangan	Kabi Tingda	4.41
9	Mangan	Chunthang	3.89
10	Mangan	Mangan	7.41
11	Mangan	Mangan_ROA	-
12	Gyalsingh	Arithang Chongrang	7.42
13	Gyalsingh	Gyalsingh	8.27
14	Gyalsingh	Hee Martam	8.66
15	Gyalsingh	Dentam	4.89
16	Gyalsingh	Gyalsingh_ROA	0.00
17	Gyalsingh	Yuksom	10.61
18	Soreng	Soreng	10.52
19	Soreng	Mangalbarey	8.72
20	Soreng	Chumbung-Chakung	10.80
21	Soreng	Daramdin	6.68
22	Soreng	Soreng_ROA	-
23	Soreng	Baiguney	9.79
24	Soreng	Kaluk	4.97
25	Pakyong	Pakyong	6.25
26	Pakyong	Parkha	2.76
27	Pakyong	Pakyong_ROA	0.00
28	Pakyong	Regu	3.02
29	Pakyong	Duga	11.47
30	Pakyong	Rhenock	7.24
31	Pakyong	Namchibong	13.62
32	Namchi	Ravangla	5.73
33	Namchi	Yangdang	5.67
34	Namchi	Melli Sumbuk	7.24
35	Namchi	Wok Sikkip	7.50
36	Namchi	Jorethang	11.30
37	Namchi	Namthang	4.36
38	Namchi	Temi Tarku	8.06
39	Namchi	Namchi	7.42
40	Namchi	Namchi_ROA	0.00
		Total	**5.85**

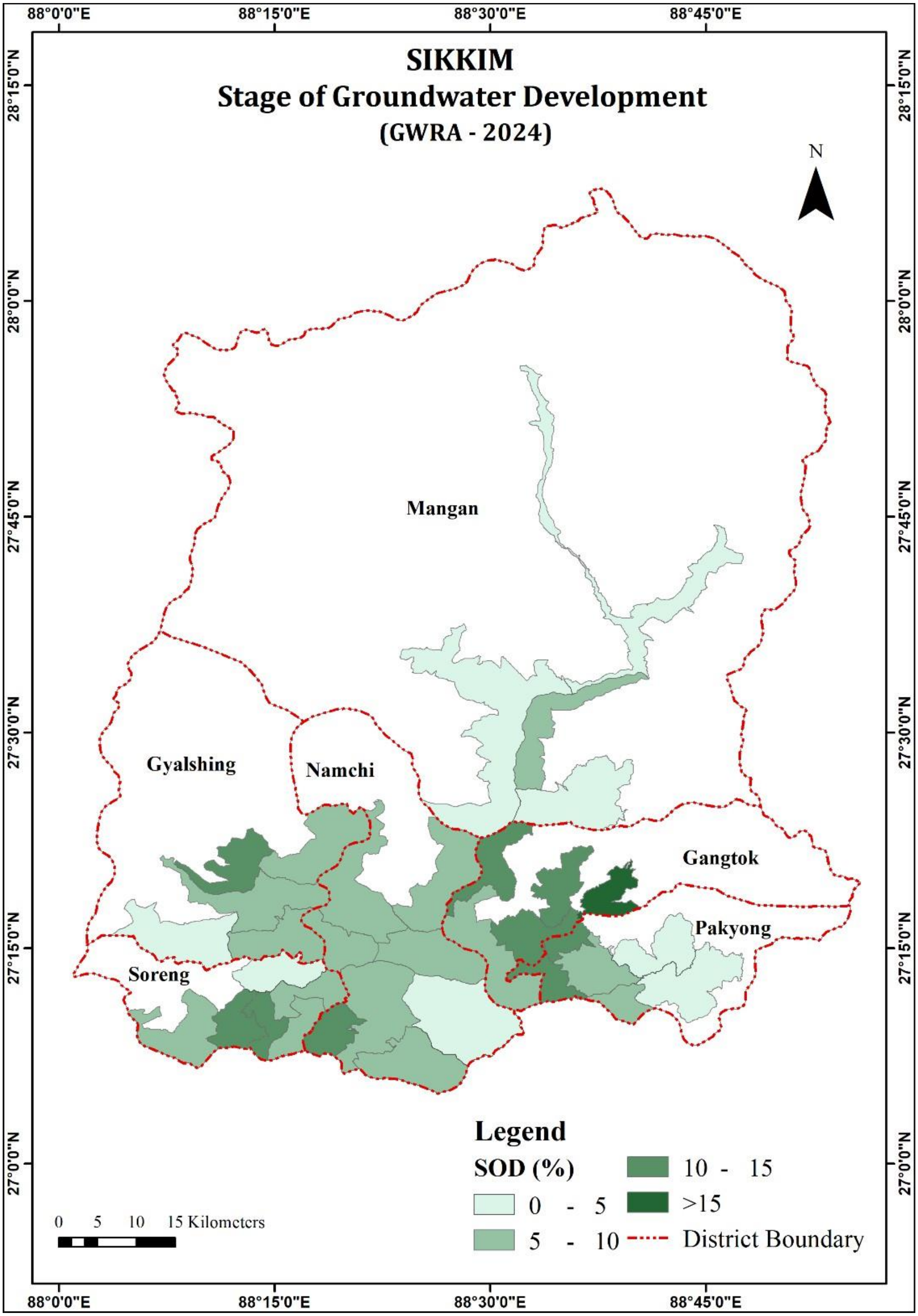
SIKKIM
Stage of Groundwater Development
(GWRA - 2024)
88°0'0"E
88°15'0"E
88°30'0"E
88°45'0"E
28°15'0"N
28°0'0"N
27°45'0"N
27°30'0"N
27°15'0"N
27°0'0"N
N
Mangan
Gyalshing
Namchi
Gangtok
Pakyong
Soreng
Legend
SOD (%)
0 - 5
5 - 10
10 - 15
>15
District Boundary
0 5 10 15 Kilometers

Figure: 6.4. Stage of Groundwater Development

6.5. CATEGORIZATION OF ASSESSMENT UNITS

The detailed Summary and Analysis of Groundwater Categorization Data for Sikkim is discussed below. The 40 assessment units across various districts in Sikkim are categorized as "safe" for groundwater usage. Some units are further classified as "Hilly Area" or "ROA" (Remote/Area of Reference), but the overall classification indicates that groundwater is not over-exploited or critical across these regions.

6.5.1 Gangtok District:

- **Total Assessment Units**: 6
- **Groundwater Categorization**: All units are categorized as "safe."
- **Block Names**: Gangtok, Nandok, Ranka, Martam, Khamdong, Gangtok (Rest of the Area)

6.5.2 Mangan District:

- **Total Assessment Units**: 5
- **Groundwater Categorization**: All units are categorized as "safe."
- **Block Names**: Dzongu, Passingdang, Kabi Tingda, Chunthang, Mangan (Rest of the Area)

6.5.3 Gyalsingh District:

- **Total Assessment Units**: 6
- **Groundwater Categorization**: All units are categorized as "safe."
- **Block Names**: Arithang Chongrang, Hee Martam, Yuksom, Gyalsingh, Gyalsingh (Rest of the Area)

6.5.4 Soreng District:

- **Total Assessment Units**: 7
- **Groundwater Categorization**: All units are categorized as "safe."
- **Block Names**: Soreng, Kaluk, Mangalbarey, Daramdin, Chumbung-Chakung, Soreng (Rest of the Area)

6.5.5 Pakyong District:

- **Total Assessment Units**: 7
- **Groundwater Categorization**: All units are categorized as "safe."
- **Block Names**: Pakyong, Parkha, Regu, Rhenock, Namchibong, Duga, Pakyong (Rest of the Area)

6.5.6 Namchi District:

- **Total Assessment Units**: 9

- **Groundwater Categorization**: All units are categorized as "safe."
- **Block Names**: Ravangla, Yangdang, Melli Sumbuk, Wok Sikkip, Jorethang, Namthang, Namchi (Rest of the Area)

6.5.7 Key Highlights:

1. **Groundwater Status**:

    - All areas listed in the Sikkim state are categorized as “safe,” indicating no immediate concerns for groundwater over-exploitation in these districts and blocks.

2. **ROA and Hilly Areas**:

    - Some areas are marked as "ROA" or "Hilly Area" (e.g., *Mangan (Rest of the Area)* and *Soreng (Rest of the Area)*), which likely indicates remote or more challenging terrain but does not seem to affect the overall groundwater safety.

3. **Safe Groundwater Status**:

    - The consistency of the "safe" categorization across all districts suggests robust groundwater management or favourable climatic conditions contributing to sustainable groundwater levels in the state.

6.5.8. Conclusion:

The groundwater in Sikkim is currently in a stable condition across all the districts and assessment units reviewed. This indicates effective groundwater management and a relatively stable water table, offering a good foundation for water resources planning. The data highlights that no immediate concerns for over-exploitation or critical groundwater levels are present in Sikkim, making it a relatively safe zone for further development and conservation efforts.

Table 6.5. The details of the Categorization of Assessment Units (Block-Wise)

Sl. No	District	Assessment Unit Name	Categorization (Over-Exploited/Critical/Semi-Critical/Safe/Saline)
1	Gangtok	Rakdong Tintek	safe
2	Gangtok	Khamdong	safe
3	Gangtok	Martam	safe
4	Gangtok	Gangtok / Nandok	safe
5	Gangtok	Gangtok_ROA	safe
6	Gangtok	Ranka	safe
7	Mangan	Dzongu / Passingdang	safe
8	Mangan	Kabi Tingda	safe
9	Mangan	Chunthang	safe
10	Mangan	Mangan	safe
11	Mangan	Mangan_ROA	Hilly Area
12	Gyalsingh	Arithang Chongrang	safe
13	Gyalsingh	Gyalsingh	safe
14	Gyalsingh	Hee Martam	safe
15	Gyalsingh	Dentam	safe
16	Gyalsingh	Gyalsingh_ROA	safe
17	Gyalsingh	Yuksom	safe
18	Soreng	Soreng	safe
19	Soreng	Mangalbarey	safe
20	Soreng	Chumbung-Chakung	safe
21	Soreng	Daramdin	safe
22	Soreng	Soreng_ROA	Hilly Area
23	Soreng	Baiguney	safe
24	Soreng	Kaluk	safe
25	Pakyong	Pakyong	safe
26	Pakyong	Parkha	safe
27	Pakyong	Pakyong_ROA	safe
28	Pakyong	Regu	safe
29	Pakyong	Duga	safe
30	Pakyong	Rhenock	safe
31	Pakyong	Namchibong	safe
32	Namchi	Ravangla	safe
33	Namchi	Yangdang	safe
34	Namchi	Melli Sumbuk	safe
35	Namchi	Wok Sikkip	safe
36	Namchi	Jorethang	safe
37	Namchi	Namthang	safe
38	Namchi	Temi Tarku	safe
39	Namchi	Namchi	safe
40	Namchi	Namchi_ROA	safe
		Total	safe

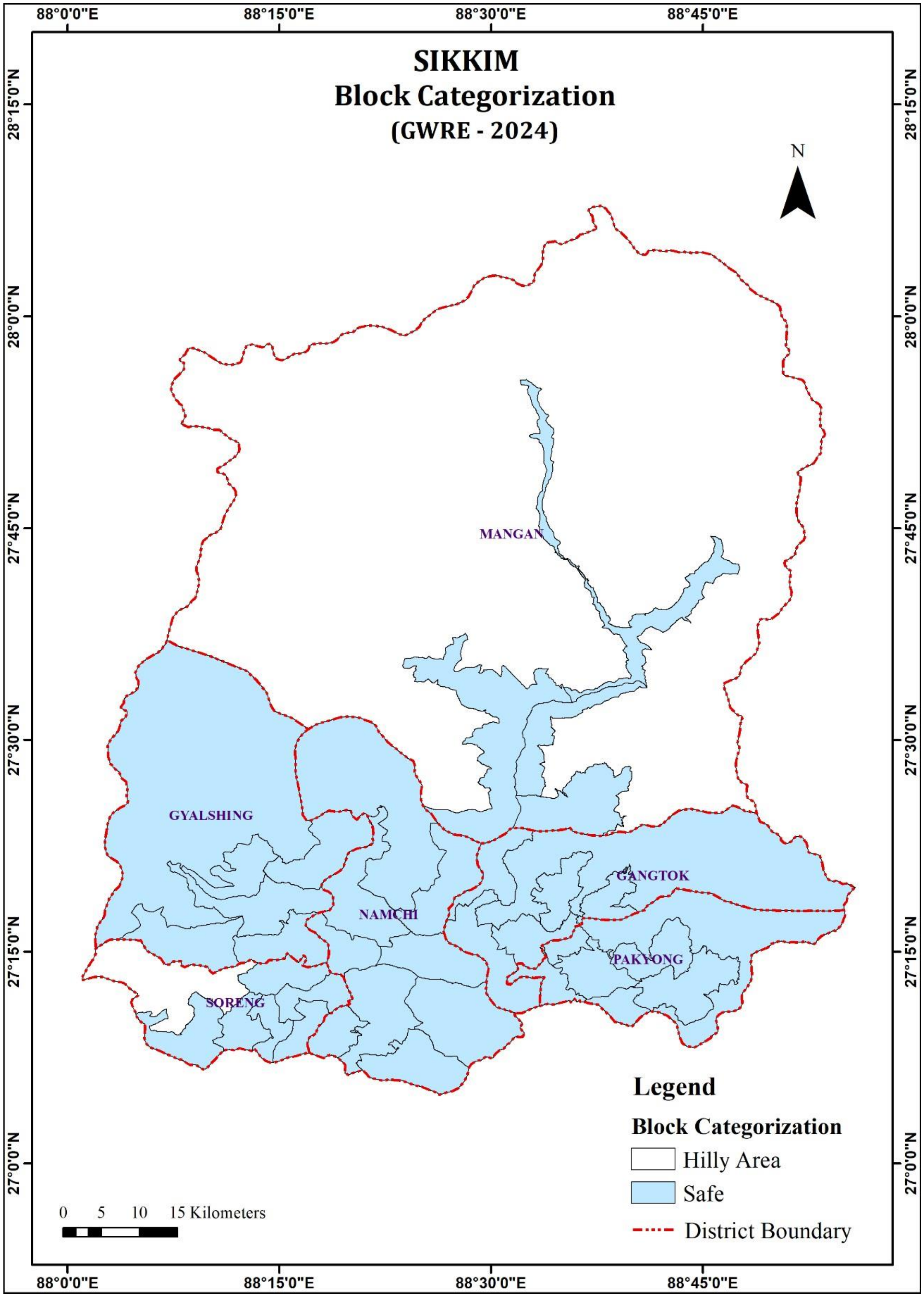

Figure: 6.5. Block-wise Categorization Map of Sikkim

6.6 COMPARISON WITH PREVIOUS ASSESSMENT

Comparison with the earlier ground water resource estimate and reasons for significant departure from earlier estimates.

The ground water resource assessment (in 2024) for the State of Sikkim has been carried out as per GEC 2015 guidelines through ‘IN-GRES’, with Blocks as primary assessment units. The Total Annual Ground Water Recharge has been estimated at 24164.56 ham and the Annual Extractable Ground Water Resource has been estimated at 21748.11 ham. The Current Annual Ground Water Extraction for all uses have been estimated at 1273.07 ham, which translates into a Stage of Ground Water Extraction at 5.85%, and as per the present assessment all the 40 assessment units (Blocks) are in ‘SAFE’ category.

Compared to 2023 assessment, in the State of Sikkim, the Annual Extractable Ground Water Resource reduced from 21867.97 Ham to 21748.11 Ham. The Annual Ground Water Extraction from all sources though increased from 1211.27 to 1273.07 Ham. As a result, the Stage of Ground Water Extraction increased from 5.54 % to 5.85 %. Decrease in annual rainfall resulted in decrease in recharge, which is reflected in decrease in Annual Extractable Resource.

Table – 6.6.1: Comparison of the Resource Estimation 2020, 2022, 2023 & 2024

Comparative Criteria	*Resource Assessment 2020 (ham)*	*Resource Assessment 2022 (ham)*	*Resource Assessment 2023 (ham)*	*Resource Assessment 2024 (ham)*
Total annual ground water recharge	96050	27117.59	24297.75	24164.56
Net annual ground water availability	86445	24405.84	21867.97	21748.11
Total Draft of ground water for all uses	743.12	1473.29	1211.27	1273.07
Annual allocation of ground water for future domestic and industrial water supply	1443.26	382.61	223.17	304.06
Available ground water for future use	84827.70	22912.00	20647.39	20466.00
Stage of Ground Water development (%)	0.86%	6.04%	5.54%	5.85%
Categorization for future ground water development	Safe	Safe	Safe	safe

6.7 UNIT RECHARGE

Unit recharge in groundwater refers to the amount of water that is added to an aquifer per unit area, typically expressed as millimeters or inches per year, to replenish the groundwater supply. It's a way to quantify the rate at which groundwater is being replenished through processes like rainfall, surface water infiltration, or other forms of precipitation that percolate into the ground. This concept is important for understanding how much groundwater can be sustainably withdrawn from an aquifer without depleting its reserves.

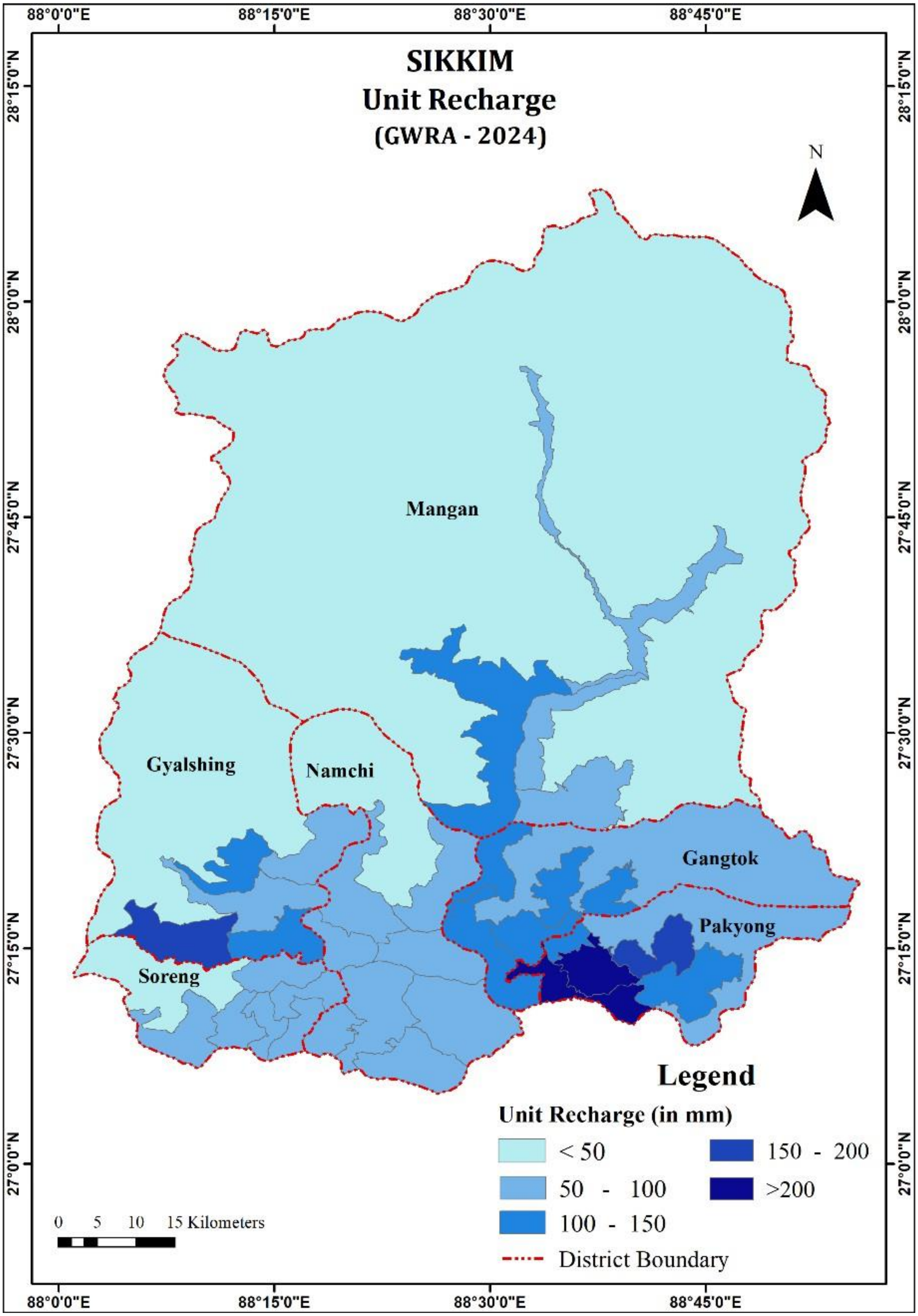

Figure: 6.7. Map of Unit Recharge

6.8 GROUND WATER RESOURCES SCENARIO IN SIKKIM

The ground water resource assessment (in 2024) for the State of Sikkim has been carried out as per GEC 2015 guidelines through ‘IN-GRES’, with blocks as primary assessment units. IN-GRES is a software/web-based application developed by Central Ground Water Board (CGWB) in collaboration with Indian Institute of Technology-Hyderabad for assessment of ground water resources.

Objectives of INGRESS Tool

- To provide common and standardized platform for Ground Water Resource Assessment for the entire country based on Ground Water Resource Estimation Committee-2015 (GEC-2015) methodology.
- Pan-India operationalization for Joint assessment by CGWB and State Ground Water Departments.
- Visibility dashboards allowing user to view the data/map and download reports.
- Provide GIS based Thematic map of assessment units.

Summary of Assessment Units

a)	Assessment Unit	Individual Block
b)	Assessment Sub Unit	Command, Non-Command and Poor-quality area in Block
c)	Total number of Assessment Units in Sikkim	40
d)	Total Number of sub- units	Nil
e)	Base Year of Collection of Data	2023-2024
f)	Year of Projection of data	2024

All 40 blocks of the State of Sikkim under 6 Districts are assessed. Total Annual Ground Water Recharge has been estimated at 0.2416 bcm and Annual Extractable Ground Water Resource has been estimated at 0.2175 bcm. Current Annual Ground Water Extraction for all uses has been estimated at 0.0127 bcm, which translates into a Stage of Ground Water Extraction at 5.85%. As per present assessment categorization scheme, out of 40 assessed units, all are Safe. There is no Over-Exploited Block in the State.

As a whole for the State, in present assessment (2024) compared to earlier assessment (2023) regarding Dynamic Groundwater Resources, Stage of Ground Water Extraction (SGWE) has a very minor increase from 5.54% to 5.85% due to Block-wise assessment in GWRA 2024.

Table 7.1 State Summary Dynamic Groundwater Resource Assessment (2024)

Components	Dynamic GW Resource		
	(MCM)	(BCM)	(ham)
Total Ground Water Recharge	241.64	0.2416	24164.56
Provision for Natural Ground Water Discharge	24.16	0.0242	232778.91
Net Ground Water Availability/ Annual Extractable Groundwater Resource	217.48	0.2175	21748.11
Gross Ground Water Draft for All Uses	12.73	0.0127	1273.07
Current Annual GW Draft for Irrigation	8.95	0.0089	894.55
Current Annual GW Draft for Domestic	2.95	0.0029	83.47
Current Annual GW Draft for Industrial uses	0.83	0.0008	294.98
Stage of G.W. Development (%)	**5.85 %**		
Annual Allocation of GW for Domestic & Industrial Water Supply for 2025	3.04	0.0030	304.06
Net GW Availability for ‘Future Use’	204.66	0.2047	20466.00

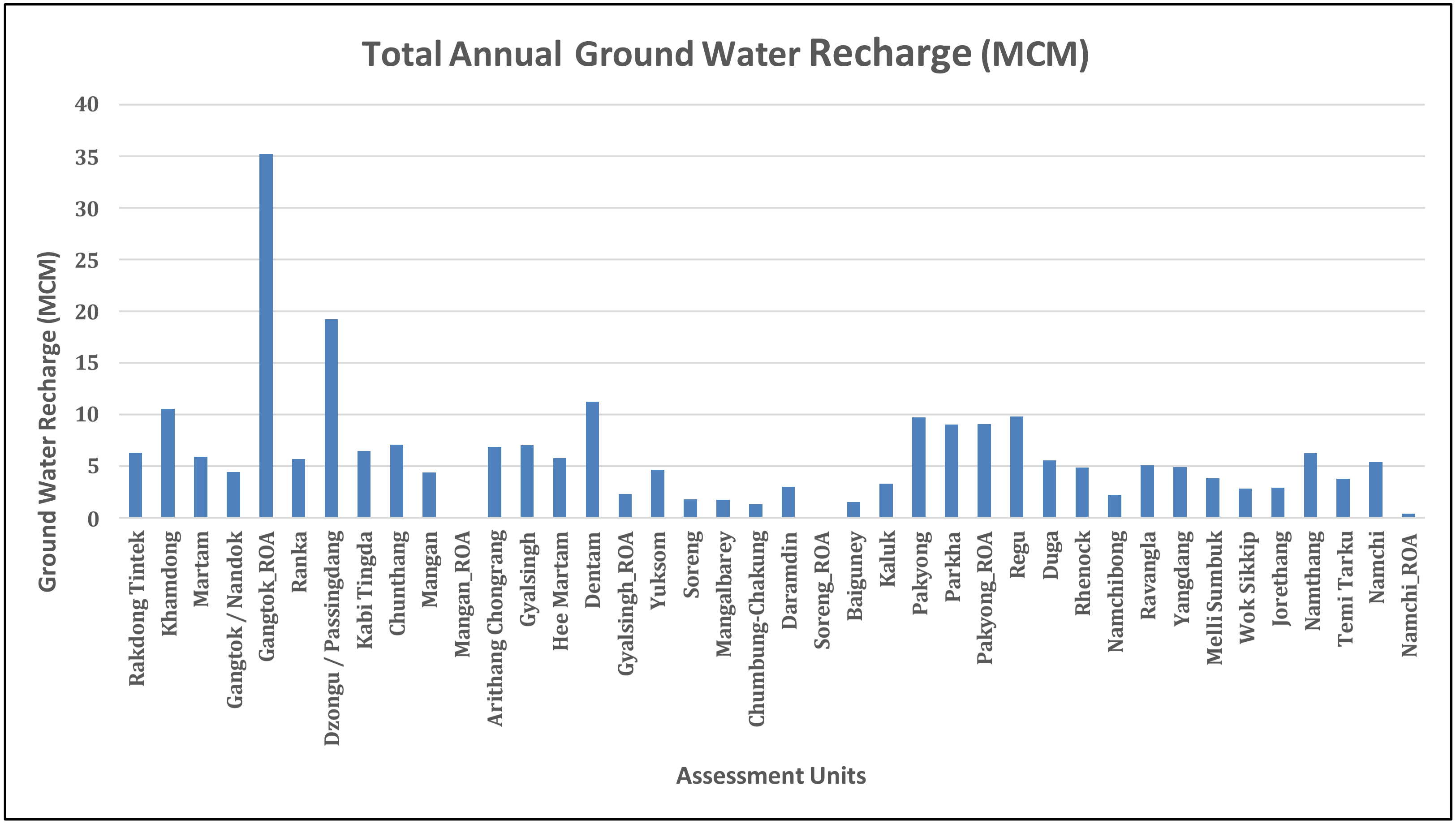

Figure 6.8: Bar Diagram showing Block-wise Ground Water Recharge

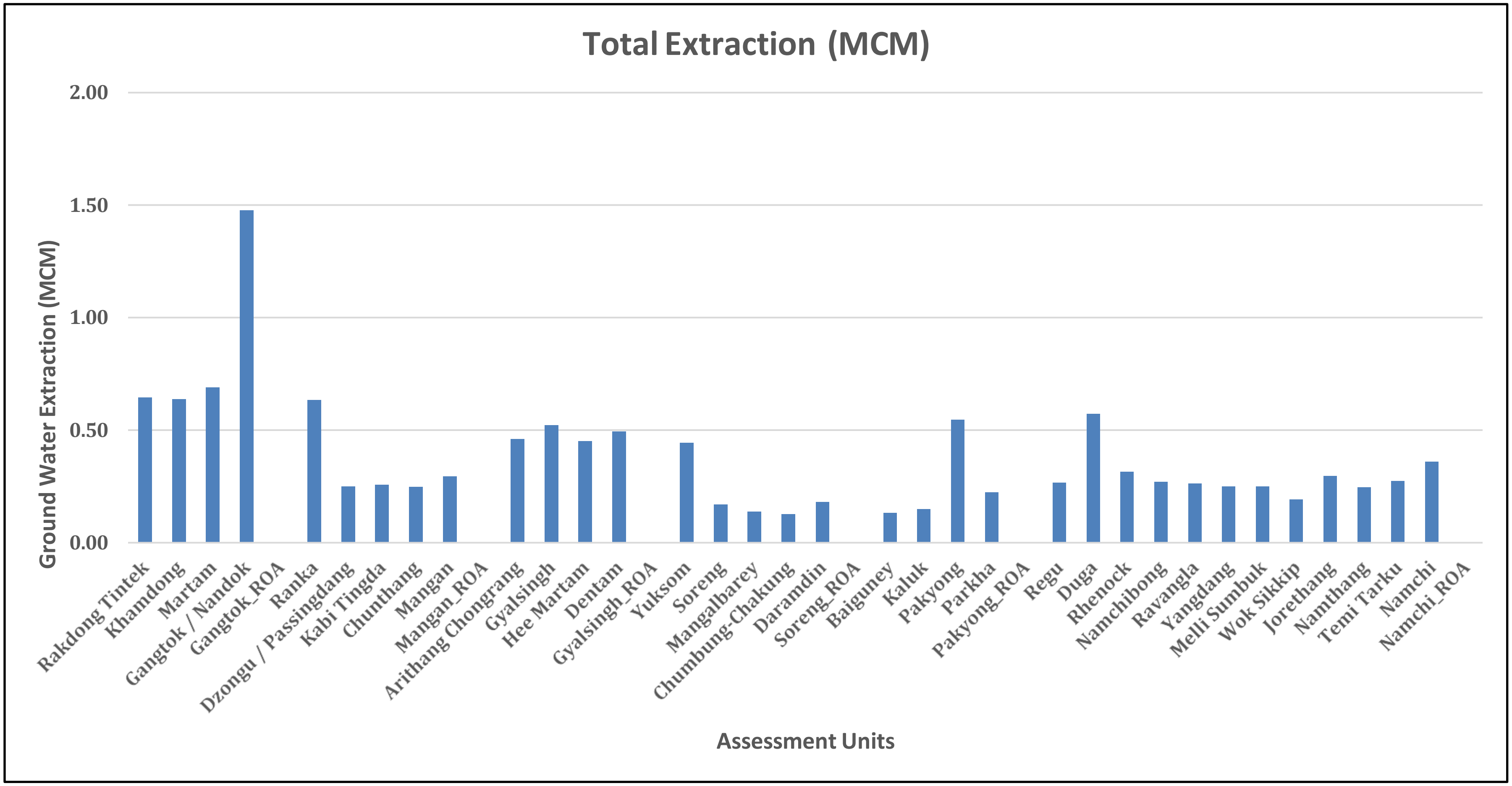

Figure 6.9: Bar Diagram showing Block-wise Extraction

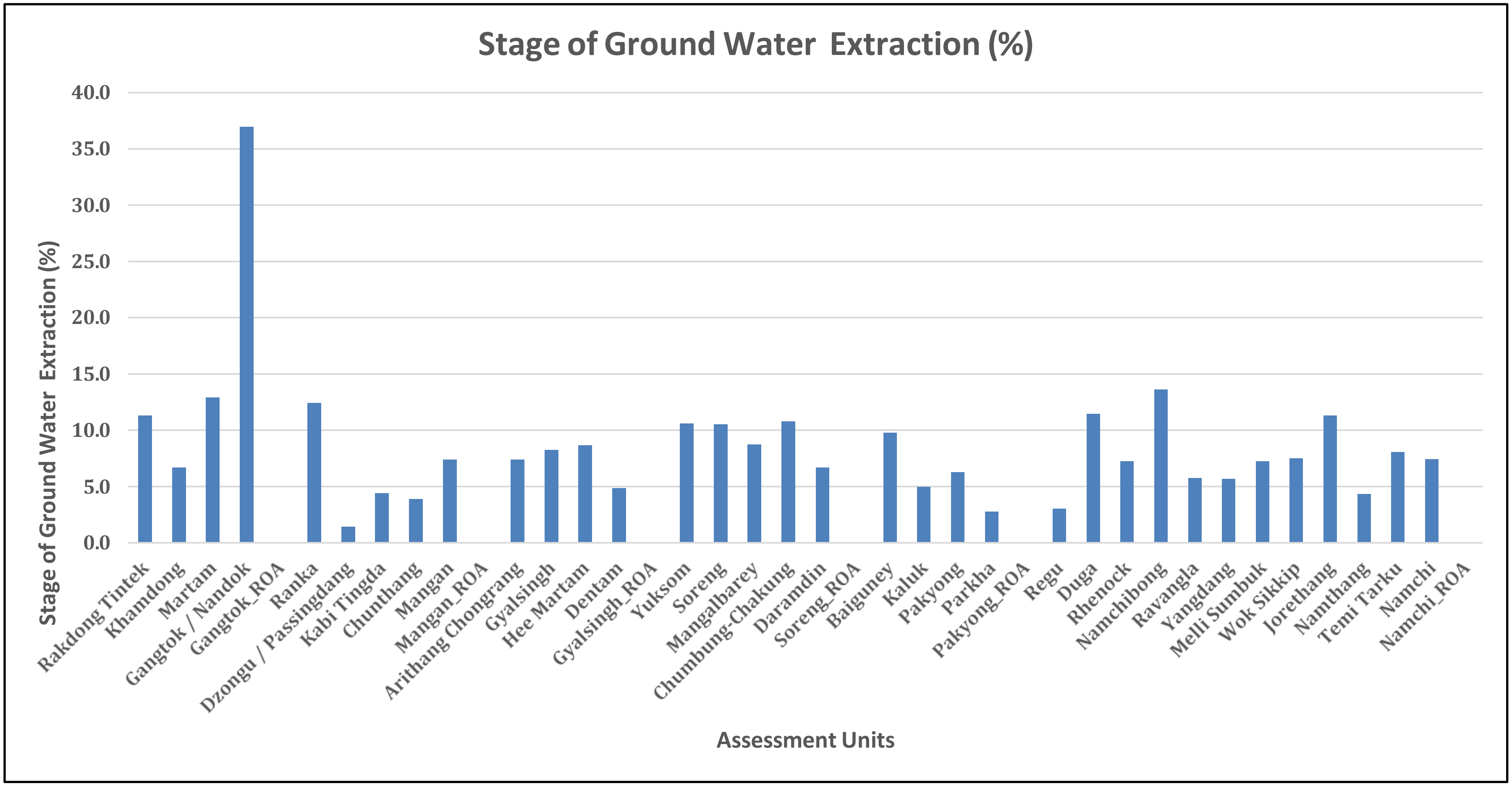

Figure 6.10: Bar Diagram showing Block-wise Stage of Ground Water Extraction (SOE %)

CHAPTER 7

CONCLUSIONS

Sikkim is a small mountainous State characterized by rugged undulating topography with series of ridges and valleys. The various rock types prevalent in the state are pelitic and carbonate rocks and gondwanas over a gneissic basement and occasional colluviums and valley fill deposits, as well as alluvial terraces along higher order streams and river courses. The formations reveal an intense tectonic-structurally complex deformational history. Ground water occurs largely in disconnected localized pockets and in deeper fractures zones. Springs are the main source and conduits of water.

The ground water resource assessment (in 2024) for the State of Sikkim has been carried out as per GEC 2015 guidelines through 'IN-GRES', with Blocks as primary assessment units. A total of 40 Blocks has been assessed for Ground Water Resource Assessment 2024. Out of these 40 Blocks, 34 are the Administrative blocks and 6 blocks comes under Rest of the Area which is not part of any BAC (Block Administrative Centre) of each district of Sikkim state. These 6 Blocks still has been taken in for total Resource calculation of Sikkim State.

Total Annual Ground Water Recharge has been estimated at 0.24 bcm and Annual Extractable Ground Water Resource has been estimated at 0.22 bcm. Current Annual Ground Water Extraction for all uses has been estimated at 0.013 bcm, which translates into a Stage of Ground Water Extraction at 5.85 %, and as per the present assessment all the Forty assessment units/ Blocks are in 'Safe' category.

As compared to 2023 assessment, Total Annual Ground Water Recharge of the State is same as 0.24 bcm. Annual Extractable Ground Water Resource is also same as 0.22 bcm. The Annual Ground Water Extraction from all sources though marginally increased from 0.012 bcm to 0.013 bcm. Stage of Ground Water Extraction increased from 5.54 % to 5.85 %.

The groundwater in Sikkim is currently in a stable condition across all the districts and assessment units reviewed. This indicates effective groundwater management and a relatively stable water table, offering a good foundation for water resources planning. The data highlights that no immediate concerns for over-exploitation or critical groundwater levels are present in Sikkim, making it a relatively safe zone for further development and conservation efforts

Annexure I

Composition of Permanent State-Level Committee for Ground Water Resources Estimation

State Level Committee has been formed and the members are as follows:

i) Secretary, Water Resource Department, Chairman, SLC, GWRA (2023)-Chairperson

ii) Chief Engineer, Water Resource Department, Govt of Sikkim – Member

iii) Chief Engineer, Rural Development and Management Department, Government of Sikkim - Member

iv) Chief Engineer, Water Security and Public Health Engineering Department, Govt of Sikkim- Member

v) The Director, Department of Science and Technology, Govt of Sikkim-Member

vi) The Director, Agriculture/Horticulture Department, Govt of Sikkim-Member

vii) Dr. Anadi Gayen, Regional Director, Central Ground Water Board, Eastern Region, Ministry of Water Resources, River Development & Ganga Rejuvenation, Govt. of India – Member Secretary

viii) The Director, Environment & Soil Conservation Forest Department, Govt of Sikkim - Member

ix) The Director, State Pollution Control Board, Govt of Sikkim - Member

x) The Joint Director, Mines, Minerals and Geology Department, Govt of Sikkim - Member

Annexure II

Minutes of the Meeting of 1st State Level Committee Meeting for Assessment of Ground Water Resources of Sikkim 2024(as on 31.03.2024), held online on 11.06.2024

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The meeting of the 1st State Level Committee for assessment of Ground Water Resources of Sikkim (as on 31.03.2024) was held online on 11.06.2024 at 3.00 pm on Google Meet Platform, under the Chairmanship of the PCE-cum-Secretary, Water Resource Department, Govt. of Sikkim.

The list of attendees is provided as Annexure – 1. The agenda of the meeting was as follows:

1. Welcome and Introduction of all the members and distinguished invitees.
2. Background of the meeting and brief introduction of GWRA 2024 of Sikkim
3. Presentation of the results of the Ground Water Resource Assessment of Sikkim (As on 31.03.2023)
4. Finalization and firming up of the assessment units for GWRA 2024
5. Roadmap for GWRA 2024 for the State of Sikkim
6. Any other items with the permission of the Chair.

At the very outset, with the kind permission of the Chair, Dr Anadi Gayen, Regional Director, Central Ground Water Board (CGWB), Eastern Region (ER), Kolkata, welcomed all the Members of SLC, and other distinguished invitees of the meeting, narrated the agenda in details, and appraised the Chair about the background of the meeting.

Shri Sandip Bhowal, Assistant Hydrogeologist, CGWB, ER, Kolkata presented the GEC 2015 methodology and brief summary of GWRA 2023 for the State of Sikkim and also the broad outlines of the upcoming Ground Water Resource Estimation, 2024 of the State of Sikkim (as on 31.03.2024).

Er. Deepak Singh, Chief Engineer, Water Resource Department, Govt. of Sikkim, shared his observation on the computations methodologies in the INGRES platform and enquired about the rationale thereof, which was explained in detail by Sri. Dr Anadi Gayen, Regional Director, CGWB, ER.

It was also explained, that for the State of Sikkim, this time, the Blocks are to be taken as primary assessment units. Previously six districts were only assessed. Based on directives of the Ministry of Jal Shakti this time block-wise resource assessment will be carried out for the state of Sikkim.

Smt. Urmila Thapa, Assistant Director, Forest & Environment Department, Govt. of Sikkim, enquired about the procedure being followed for computation in the IN-GRES portal, which was explained by Shri A. Choudhury, Scientist- 'D' (HG). She requested for a copy of the current presentation of GWRA being presented before the SLC.

Dr. Indranil Roy, Scientist-'D'(HG) requested that in order to make this exercise a fruitful one, as per the guidelines of CGWB, CHQ, at least one member may be nominated from each of the Constituent Departments of SLC of Sikkim as part of the working group.

Chief Engineer
Water Resources D...
Govt of S...

Minutes of the Meeting of 1st State Level Committee Meeting for Assessment of Ground Water Resources of Sikkim 2024(as on 31.03.2024), held online on 11.06.2024

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The major decisions taken in the meeting are :

1. CGWB, ER will once again share the GWRA 2023 report and the current Power Point Presentation (presented before the SLC on 11.06.2024) with the SLC members for recapitulation.

2. CGWB, ER to share the shape files of the assessment units to be used for computation of GWRA 2024 for Sikkim on 12.06.2024 to the concerned SLC members, present in the meeting and the finalized shape files to be returned by the members to CGWB, along with comments / suggestion on or before 21.06.2024. If no comment/suggestion is received within that time, it will be assumed that GWRA 2024 will be carried out by the existing shape files only.

3. Upon receipt of email from CGWB, ER, each of the constituent members of SLC will consider nominating at least one member to be a part of the working group for GWRA 2024 in respect of Sikkim.

4. Data requirement, as mandated in GEC 2015 guidelines will be made readily available by the concerned Departments of Govt. of Sikkim, for timely completion of GWRA 2024

The meeting ended with a vote of thanks to the chair.

(Er. Gozin Lachenpa)
PCE
Water Resource Department, Govt. of Sikkim
Chairman, SLC, GWRA 2024 (Sikkim)

Chief Engineer
Water Resources Department
Govt of Sikkim Gangtok

Minutes of the Meeting of 1st State Level Committee Meeting for Assessment of Ground Water Resources of Sikkim (as on 31.03.2024), held online on 11.06.2024

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ANNEXURE – I

Participant List of the First Meeting of State Level Committee for Assessment of Ground Water Resources of Sikkim (as on 31.03.2024), held online on 11.06.2024

Sl No	Name	Designation
1	Er. Gozin Lachenpa	**PCE, Water Resource Department & Chairman, SLC, GWRA 2024 (Sikkim)**
2	Er. B. S. Nirola	Chief Engineer, Water Resource Department, Govt. of Sikkim
3	Er. Deepak Singh	Chief Engineer, Water Resource Department, Govt. of Sikkim
4	Dr. Anadi Gayen	Regional Director, CGWB, ER, Kolkata
5	Ms Urmila Thapa,	Assistant Director, Forest Department, Govt. of Sikkim
6	Mr. T. N. Bhutia	Additional Director, Agriculture Department, Govt. of Sikkim
7	Mr. R. Tamang	Assistant Engineer, JJM, Govt. of Sikkim
8	Smt. Sandhya Yadav	Scientist- 'D'(HG), CGWB, ER, Kolkata
9	Dr. Indranil Roy	Scientist- 'D'(HG), CGWB, ER, Kolkata
10	Sri. A. Choudhury	Scientist- 'D'(HG), CGWB, ER, Kolkata
11	Dr. Shaista Khan	Scientist- 'C'(HG), CGWB, ER, Kolkata
12	Sri. Arpan Benaerjee	Scientist- 'C'(HG), CGWB, ER, Kolkata
13	Dr. Nilamoni Barman	Scientist- 'C'(HM), CGWB, ER, Kolkata
14	Sri. Sandip Bhowal	Assistant Hydrogeologist, ER, Kolkata
15	Sri. Rajesh K Sahoo	Assistant Hydrogeologist, ER, Kolkata
16	Sri. Tapash K Sahoo	Assistant Hydrogeologist, ER, Kolkata
17	Sri. Awadesh Kumar	Assistant Hydrogeologist, ER, Kolkata

Chief Engineer
Water Resources Department
Govt of Sikkim, Gangtok

Annexure III

Minutes of the Meeting of 2nd State Level Committee Meeting for Assessment of Ground Water Resources of Sikkim 2024 (as on 31.03.2024) held online on 28.08.2024

The meeting of the 2nd State Level Committee for assessment of Ground Water Resources of Sikkim (as on 31.03.2024) was held online on 28.08.2024 at 2.30 pm on Google Meet Platform. In absence of PCE-cum-Secretary, the meeting was presided by Er. B. S. Nirola, Chief Engineer, Water Resource Department, Govt. of Sikkim, Water Resource Department, Govt. of Sikkim.

The list of attendees is provided as Annexure – 1. The agenda of the meeting was as follows:

1. Welcome and Introduction of all the members and distinguished invitees.
2. Background of the meeting and brief introduction of GWRA 2024 of Sikkim
3. Presentation of the results of the Ground Water Resource Assessment of Sikkim (as on 31.03.2024)
4. Approval of GWRA 2024 for Sikkim state
5. Any other items with the permission of the Chair.

At the very outset, with the kind permission of the Chair, Dr Anadi Gayen, Regional Director, Central Ground Water Board (CGWB), Eastern Region (ER), Kolkata and Member Secretary, SLC, welcomed all the Members of SLC and narrated the agenda in details and appraised about the background of the meeting.

Dr. Indranil Roy, Scientist-'D' (HG), gave a synopsis of GWRA 2024 methodology. Shri Sandip Bhowal, Assistant Hydrogeologist, CGWB, ER, Kolkata presented the results and computational outcomes of Ground Water Resource Estimation of the State of Sikkim (as on 31.03.2024).

It was also explained, that for the State of Sikkim, this time, the Blocks wise GW assessment is considered. Previously six districts were only assessed. As per directives of the Ministry of Jal Shakti this time block-wise resource assessment has been carried out for the state of Sikkim. Based on the changed of assessment units, the collated data have been organized, casted and rationally utilized for computational inputs in the IN-GRES portal.

Er. B. S. Nirola, Chief Engineer, Water Resource Department, Govt. of Sikkim, enquired about the SGWD (7.85%) of Soreng district and mentioned that the district lacked industries, but the SGWD is highest among the districts. Dr Anadi Gayen, Regional Director, CGWB, ER and Dr. Indranil Roy, Scientist-'D' (HG) has explained that the lack of rainfall and decrease in recharge has led to an increase in SGWD of the district.

Er. B. S. Nirola, Chief Engineer, enquired concerning the change in SGWD between GWRA-2023 and GWRA-2024 to which Dr. Indranil Roy, Scientist-'D'(HG) has explained that during GWRA-2024 the assessment unit has been changed from district level to block wise. Owing to this bottom up approach, the slight change in SWRA value has occurred. In addition, Dr Anadi Gayen, Regional Director has mentioned about the impact of climate change and its consequences on water resource and GWRA.

Minutes of the Meeting of 2nd State Level Committee Meeting for Assessment of Ground Water Resources of Sikkim 2024 (as on 31.03.2024) held online on 28.08.2024

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At the end the Ground Water Resources of Sikkim (as on 31.03.2024) was accepted unanimously and was accorded due approval by the members of the State Level Committee (SLC) for the State of Sikkim.

The meeting ended with a vote of thanks to the chair.

(Dr. Anadi Gayen)
Regional Director, CGWB, ER, Kolkata
& Member Secretary, SLC, GWRA 2024 (Sikkim)

Annexure 4

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024 SIKKIM

Sl. No.	Name of District	Name of Block	Ground Water Recharge						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	Total Natural Discharges		Irrigation	Industrial	Domestic	Total			
			Recharge from rainfall	Recharge from other Sources	Recharge from Rainfall	Recharge from other Sources										
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Gangtok	Rakdong Tintek	441.83	22.83	163.41	4.58	632.65	63.27	569.38	57.02	0.31	7.15	64.47	7.42	504.64	11.32
2	Gangtok	Khamdong	751.26	22.89	277.85	4.61	1056.61	105.67	950.94	57.02	0.00	6.69	63.71	6.94	886.98	6.70
3	Gangtok	Martam	412.98	22.81	152.74	4.56	593.09	59.31	533.78	57.02	5.77	6.16	68.96	6.39	464.59	12.92
4	Gangtok	Gangtok / Nandok	301.43	24.84	111.48	5.86	443.61	44.36	399.25	57.02	0.00	90.61	147.62	94.01	248.23	36.97
5	Gangtok	Gangtok_ROA	2571.8	0	951.17	0	3522.97	352.30	3170.67	0.00	0.00	0.00	0.00	0.00	3170.67	0.00
6	Gangtok	Ranka	394.39	22.88	145.86	4.6	567.73	56.78	510.95	57.02	0.00	6.38	63.41	6.62	447.30	12.41
7	Mangan	Dzongu / Passingdang	1216.95	9.72	693.86	1.04	1921.57	192.16	1729.41	20.90	0.00	4.12	25.02	4.18	1704.33	1.45
8	Mangan	Kabi Tingda	404.88	9.65	230.85	0.99	646.37	64.63	581.74	20.90	0.00	4.76	25.66	4.83	556.01	4.41
9	Mangan	Chunthang	439.26	14.21	250.45	3.79	707.71	70.77	636.94	20.90	0.00	3.88	24.78	3.94	612.10	3.89
10	Mangan	Mangan	274.28	9.42	156.39	0.85	440.94	44.09	396.85	20.90	0.00	8.50	29.40	8.62	367.33	7.41
11	Mangan	Mangan_ROA	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	-
12	Gyalsingh	Arithang Chongrang	534.23	19.87	133.33	0.59	688.02	68.80	619.22	41.22	0.00	4.70	45.92	4.81	573.19	7.42
13	Gyalsingh	Gyalsingh	546.02	20.08	136.28	0.72	703.10	70.31	632.79	41.22	0.00	11.13	52.35	11.39	580.18	8.27
14	Gyalsingh	Hee Martam	446.84	19.87	111.52	0.59	578.82	57.88	520.94	41.22	0.00	3.91	45.13	4.00	475.72	8.66
15	Gyalsingh	Dentam	883.2	20.07	220.43	0.71	1124.41	112.44	1011.97	41.22	0.00	8.24	49.47	8.44	962.30	4.89
16	Gyalsingh	Gyalsingh_ROA	185.66	0	46.34	0	232.00	23.20	208.80	0.00	0.00	0.00	0.00	0.00	208.80	0.00
17	Gyalsingh	Yuksom	354.6	20.9	88.5	1.22	465.22	46.52	418.70	41.22	0.00	3.22	44.44	3.29	374.19	10.61
18	Soreng	Soreng	139.54	4.87	34.83	0.56	179.80	17.98	161.82	10.45	0.00	6.57	17.02	6.72	144.65	10.52
19	Soreng	Mangalbarey	136.33	4.76	34.03	0.5	175.62	17.56	158.06	10.45	0.00	3.33	13.78	3.40	144.21	8.72
20	Soreng	Chumbung-Chakung	100.01	4.67	24.96	0.44	130.08	13.01	117.07	10.45	0.00	2.20	12.64	2.25	104.38	10.80
21	Soreng	Daramdin	237.07	4.78	59.17	0.51	301.53	30.16	271.37	10.45	0.00	7.69	18.14	7.87	253.05	6.68
22	Soreng	Soreng_ROA	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	-

Sl. No.	Name of District	Name of Block	Ground Water Recharge						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	Total Natural Discharges		Irrigation	Industrial	Domestic	Total			
			Recharge from rainfall	Recharge from other Sources	Recharge from Rainfall	Recharge from other Sources										
23	Soreng	Baiguney	116.94	4.67	29.18	0.44	151.23	15.12	136.11	10.45	0.00	2.87	13.33	2.94	122.71	9.79
24	Soreng	Kaluk	262.12	4.71	65.42	0.46	332.71	33.27	299.44	10.45	0.00	4.43	14.89	4.54	284.44	4.97
25	Pakyong	Pakyong	701.92	8.09	259.6	1.66	971.27	97.13	874.14	20.10	26.65	7.90	54.65	8.19	819.20	6.25
26	Pakyong	Parkha	653.24	8.03	241.6	1.62	904.49	90.45	814.04	20.10	0.00	2.33	22.43	2.42	791.52	2.76
27	Pakyong	Pakyong_ROA	660.89	0	244.43	0	905.32	90.53	814.79	0.00	0.00	0.00	0.00	0.00	814.79	0.00
28	Pakyong	Regu	710.02	8.06	262.6	1.64	982.32	98.23	884.09	20.10	0.00	6.60	26.70	6.85	857.14	3.02
29	Pakyong	Duga	397.58	8.04	147.04	1.62	554.28	55.43	498.85	20.10	29.99	7.14	57.23	7.41	441.35	11.47
30	Pakyong	Rhenock	346.36	8.08	128.1	1.65	484.19	48.42	435.77	20.10	4.56	6.88	31.55	7.14	403.96	7.24
31	Pakyong	Namchibong	154.04	8.2	56.97	1.73	220.94	22.09	198.85	20.10	0.00	6.99	27.09	7.26	171.49	13.62
32	Namchi	Ravangla	413.5	7.74	87.87	0.73	509.84	50.98	458.86	17.06	0.00	9.22	26.28	9.46	432.34	5.73
33	Namchi	Yangdang	396.9	7.83	84.34	0.79	489.86	48.98	440.88	17.06	0.00	7.94	25.01	8.15	415.66	5.67
34	Namchi	Melli Sumbuk	308.83	7.67	65.63	0.69	382.82	38.28	344.54	17.06	1.28	6.60	24.94	6.77	319.43	7.24
35	Namchi	Wok Sikkip	227.94	7.67	48.44	0.69	284.74	28.47	256.27	17.06	0.00	2.16	19.22	2.22	236.99	7.50
36	Namchi	Jorethang	234.63	7.67	49.86	0.69	292.85	29.28	263.57	17.06	9.41	3.31	29.78	3.40	233.70	11.30
37	Namchi	Namthang	510.08	7.67	108.39	0.69	626.83	62.69	564.14	17.06	0.00	7.53	24.59	7.73	539.35	4.36
38	Namchi	Temi Tarku	304.16	7.68	64.64	0.7	377.18	37.71	339.47	17.06	2.74	7.56	27.36	7.76	311.91	8.06
39	Namchi	Namchi	438.45	7.9	93.17	0.83	540.35	54.04	486.31	17.06	2.76	16.28	36.10	16.70	449.79	7.42
40	Namchi	Namchi_ROA	34.22	0	7.27	0	41.49	4.15	37.34	0.00	0.00	0.00	0.00	0.00	37.34	0.00
		Total (Ham)	**17644.38**	**398.83**	**6068**	**53.35**	**24164.56**	**2416.45**	**21748.11**	**894.55**	**83.4743**	**294.98169**	**1273.07**	**304.06**	**20465.96**	**5.85**
		Total (Bcm)	**0.1764438**	**0.0039883**	**0.06068**	**0.0005335**	**0.2416456**	**0.0241645**	**0.2174811**	**0.0089455**	**0.0008347**	**0.0029498**	**0.0127307**	**0.0030406**	**0.2046596**	**5.85**

Annexure - 5				
CATEGORIZATION OF ASSESSMENT UNITS (2024) SIKKIM				
Sl. No.	District	Assessment Unit Name	Stage of Ground Water Extraction (%)	Categorization (OE/Critical/Semic ritical/Safe)
1	Gangtok	Rakdong Tintek	11.32	safe
2	Gangtok	Khamdong	6.70	safe
3	Gangtok	Martam	12.92	safe
4	Gangtok	Gangtok / Nandok	36.97	safe
5	Gangtok	Gangtok_ROA	0.00	safe
6	Gangtok	Ranka	12.41	safe
7	Mangan	Dzongu / Passingdang	1.45	safe
8	Mangan	Kabi Tingda	4.41	safe
9	Mangan	Chunthang	3.89	safe
10	Mangan	Mangan	7.41	safe
11	Mangan	Mangan_ROA	-	Hilly Area
12	Gyalsingh	Arithang Chongrang	7.42	safe
13	Gyalsingh	Gyalsingh	8.27	safe
14	Gyalsingh	Hee Martam	8.66	safe
15	Gyalsingh	Dentam	4.89	safe
16	Gyalsingh	Gyalsingh_ROA	0.00	safe
17	Gyalsingh	Yuksom	10.61	safe
18	Soreng	Soreng	10.52	safe
19	Soreng	Mangalbarey	8.72	safe
20	Soreng	Chumbung-Chakung	10.80	safe
21	Soreng	Daramdin	6.68	safe
22	Soreng	Soreng_ROA	-	Hilly Area
23	Soreng	Baiguney	9.79	safe
24	Soreng	Kaluk	4.97	safe
25	Pakyong	Pakyong	6.25	safe
26	Pakyong	Parkha	2.76	safe
27	Pakyong	Pakyong_ROA	0.00	safe
28	Pakyong	Regu	3.02	safe
29	Pakyong	Duga	11.47	safe
30	Pakyong	Rhenock	7.24	safe
31	Pakyong	Namchibong	13.62	safe
32	Namchi	Ravangla	5.73	safe
33	Namchi	Yangdang	5.67	safe
34	Namchi	Melli Sumbuk	7.24	safe
35	Namchi	Wok Sikkip	7.50	safe
36	Namchi	Jorethang	11.30	safe
37	Namchi	Namthang	4.36	safe
38	Namchi	Temi Tarku	8.06	safe
39	Namchi	Namchi	7.42	safe
40	Namchi	Namchi_ROA	0.00	safe

Annexure 6

ASSESSMENT UNIT BOCK-WISE RESOURCE POSITION, 2024 SIKKIM

Sl. No	District	Assessment Unit Name	Total Area of Assessment Unit (Ha)	Recharge Worthy Area(Ha)	Recharge from Rainfall-Monsoon Season	Recharge from Other Sources- Monsoon Season	Recharge from Rainfall-Non Monsoon Season	Recharge from Other Sources- Non Monsoon	Total Annual Ground Water (Ham) Recharge	Total Natural Disharges (Ham)	Annual Extractable Ground Water Resource (Ham)	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Industrial Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (Over-Exploited/Critical/Semi-Critical/Safe/Saline)	Urban Aus or not
1	Gangtok	Rakdong Tintek	3921	3921	441.83	22.83	163.41	4.58	632.65	63.27	569.38	57.02	0.31025	7.147065	64.47	7.42	504.64	11.32284	safe	No
2	Gangtok	Khamdong	6667	6667	751.26	22.89	277.85	4.61	1056.61	105.67	950.94	57.02	0	6.687895	63.71	6.94	886.98	6.699687	safe	No
3	Gangtok	Martam	3665	3665	412.98	22.81	152.74	4.56	593.09	59.31	533.78	57.02	5.772	6.15828	68.96	6.39	464.59	12.91918	safe	No
4	Gangtok	Gangtok / Nandok	2675	2675	301.43	24.84	111.48	5.86	443.61	44.36	399.25	57.02	0	90.60778	147.62	94.01	248.23	36.97433	safe	No
5	Gangtok	Gangtok_ROA	46769	15072	2571.8	0	951.17	0	3522.97	352.3	3170.67	0	0	0	0	0	3170.67	0	safe	No
6	Gangtok	Ranka	3500	3500	394.39	22.88	145.86	4.6	567.73	56.78	510.95	57.02	0	6.38312	63.41	6.62	447.3	12.41022	safe	No
7	Mangan	Dzongu / Passingdang	16512	8550	1216.95	9.72	693.86	1.04	1921.57	192.16	1729.41	20.9	0	4.11866	25.02	4.18	1704.33	1.446736	safe	No
8	Mangan	Kabi Tingda	7880	4145	404.88	9.65	230.85	0.99	646.37	64.63	581.74	20.9	0	4.762885	25.66	4.83	556.01	4.410905	safe	No
9	Mangan	Chunthang	8548	4497	439.26	14.21	250.45	3.79	707.71	70.77	636.94	20.9	0	3.879585	24.78	3.94	612.1	3.890476	safe	No
10	Mangan	Mangan	5339	2808	274.28	9.42	156.39	0.85	440.94	44.09	396.85	20.9	0	8.497565	29.4	8.62	367.33	7.408341	safe	No
11	Mangan	Mangan_ROA	385363	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	No
12	Gyalsingh	Arithang Chongrang	6386	6386	534.23	19.87	133.33	0.59	688.02	68.8	619.22	41.22	0	4.700835	45.92	4.81	573.19	7.415781	safe	No
13	Gyalsingh	Gyalsingh	6527	6527	546.02	20.08	136.28	0.72	703.1	70.31	632.79	41.22	0	11.12867	52.35	11.39	580.18	8.272887	safe	No
14	Gyalsingh	Hee Martam	4558	4558	446.84	19.87	111.52	0.59	578.82	57.88	520.94	41.22	0	3.90842	45.13	4	475.72	8.663186	safe	No
15	Gyalsingh	Dentam	6560	6560	883.2	20.07	220.43	0.71	1124.41	112.44	1011.97	41.22	0	8.24462	49.47	8.44	962.3	4.888485	safe	No
16	Gyalsingh	Gyalsingh_ROA	61115	2120	185.66	0	46.34	0	232	23.2	208.8	0	0	0	0	0	208.8	0	safe	No
17	Gyalsingh	Yuksom	4049	4049	354.6	20.9	88.5	1.22	465.22	46.52	418.7	41.22	0	3.21857	44.44	3.29	374.19	10.6138	safe	No
18	Soreng	Soreng	2867	1525	139.54	4.87	34.83	0.56	179.8	17.98	161.82	10.45	0	6.566168	17.02	6.72	144.65	10.51786	safe	No
19	Soreng	Mangalbarey	2807	1490	136.33	4.76	34.03	0.5	175.62	17.56	158.06	10.45	0	3.32588	13.78	3.4	144.21	8.718208	safe	No
20	Soreng	Chumbung-Chakung	2128	1093	100.01	4.67	24.96	0.44	130.08	13.01	117.07	10.45	0	2.19876	12.64	2.25	104.38	10.79696	safe	No
21	Soreng	Daramdin	5075	2591	237.07	4.78	59.17	0.51	301.53	30.16	271.37	10.45	0	7.691645	18.14	7.87	253.05	6.6846	safe	No

Sl. No	District	Assessment Unit Name	Total Area of Assessment Unit (Ha)	Recharge Worthy Area(Ha)	Recharge from Rainfall-Monsoon Season	Recharge from Other Sources- Monsoon Season	Recharge from Rainfall-Non Monsoon Season	Recharge from Other Sources- Non Monsoon	Total Annual Ground Water (Ham) Recharge	Total Natural Disharges (Ham)	Annual Extractable Ground Water Resource (Ham)	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Industrial Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (Over-Exploited/Critical/Semi-Critical/Safe/Saline)	Urban Aus or not
22	Soreng	Soreng_ROA	10204	0	0	0	0	0	0	0	0	0	0	0	-	0	0	-	Hilly Area	No
23	Soreng	Baiguney	2444	1278	116.94	4.67	29.18	0.44	151.23	15.12	136.11	10.45	0	2.87182	13.33	2.94	122.71	9.793549	safe	No
24	Soreng	Kaluk	3463	1823	262.12	4.71	65.42	0.46	332.71	33.27	299.44	10.45	0	4.43183	14.89	4.54	284.44	4.972616	safe	No
25	Pakyong	Pakyong	3964	3964	701.92	8.09	259.6	1.66	971.27	97.13	874.14	20.1	26.65	7.89787	54.65	8.19	819.2	6.251859	safe	No
26	Pakyong	Parkha	4317	4317	653.24	8.03	241.6	1.62	904.49	90.45	814.04	20.1	0	2.328335	22.43	2.42	791.52	2.755393	safe	No
27	Pakyong	Pakyong_ROA	8221	5865	660.89	0	244.43	0	905.32	90.53	814.79	0	0	0	0	0	814.79	0	safe	No
28	Pakyong	Regu	6301	6301	710.02	8.06	262.6	1.64	982.32	98.23	884.09	20.1	0	6.59993	26.7	6.85	857.14	3.020055	safe	No
29	Pakyong	Duga	2330	2330	397.58	8.04	147.04	1.62	554.28	55.43	498.85	20.1	29.99205	7.14451	57.23	7.41	441.35	11.47239	safe	No
30	Pakyong	Rhenock	1956	1956	346.36	8.08	128.1	1.65	484.19	48.42	435.77	20.1	4.56	6.884995	31.55	7.14	403.96	7.240058	safe	No
31	Pakyong	Namchibong	1367	1367	154.04	8.2	56.97	1.73	220.94	22.09	198.85	20.1	0	6.99413	27.09	7.26	171.49	13.62333	safe	No
32	Namchi	Ravangla	7418	4122	413.5	7.74	87.87	0.73	509.84	50.98	458.86	17.05625	0	9.218805	26.28	9.46	432.34	5.727237	safe	No
33	Namchi	Yangdang	6551	3640	396.9	7.83	84.34	0.79	489.86	48.98	440.88	17.05625	0	7.944225	25.01	8.15	415.66	5.672745	safe	No
34	Namchi	Melli Sumbuk	5882	3268	308.83	7.67	65.63	0.69	382.82	38.28	344.54	17.05625	1.28	6.600295	24.94	6.77	319.43	7.238637	safe	No
35	Namchi	Wok Sikkip	3399	1889	227.94	7.67	48.44	0.69	284.74	28.47	256.27	17.05625	0	2.159705	19.22	2.22	236.99	7.499902	safe	No
36	Namchi	Jorethang	2861	1590	234.63	7.67	49.86	0.69	292.85	29.28	263.57	17.05625	9.41	3.31201	29.78	3.4	233.7	11.29871	safe	No
37	Namchi	Namthang	9869	5482	510.08	7.67	108.39	0.69	626.83	62.69	564.14	17.05625	0	7.52849	24.59	7.73	539.35	4.358847	safe	No
38	Namchi	Temi Tarku	5662	3146	304.16	7.68	64.64	0.7	377.18	37.71	339.47	17.05625	2.74	7.56134	27.36	7.76	311.91	8.059622	safe	No
39	Namchi	Namchi	7982	4435	438.45	7.9	93.17	0.83	540.35	54.04	486.31	17.05625	2.76	16.27699	36.1	16.7	449.79	7.423249	safe	No
40	Namchi	Namchi_ROA	23506	428	34.22	0	7.27	0	41.49	4.15	37.34	0	0	0	0	0	37.34	0	safe	No