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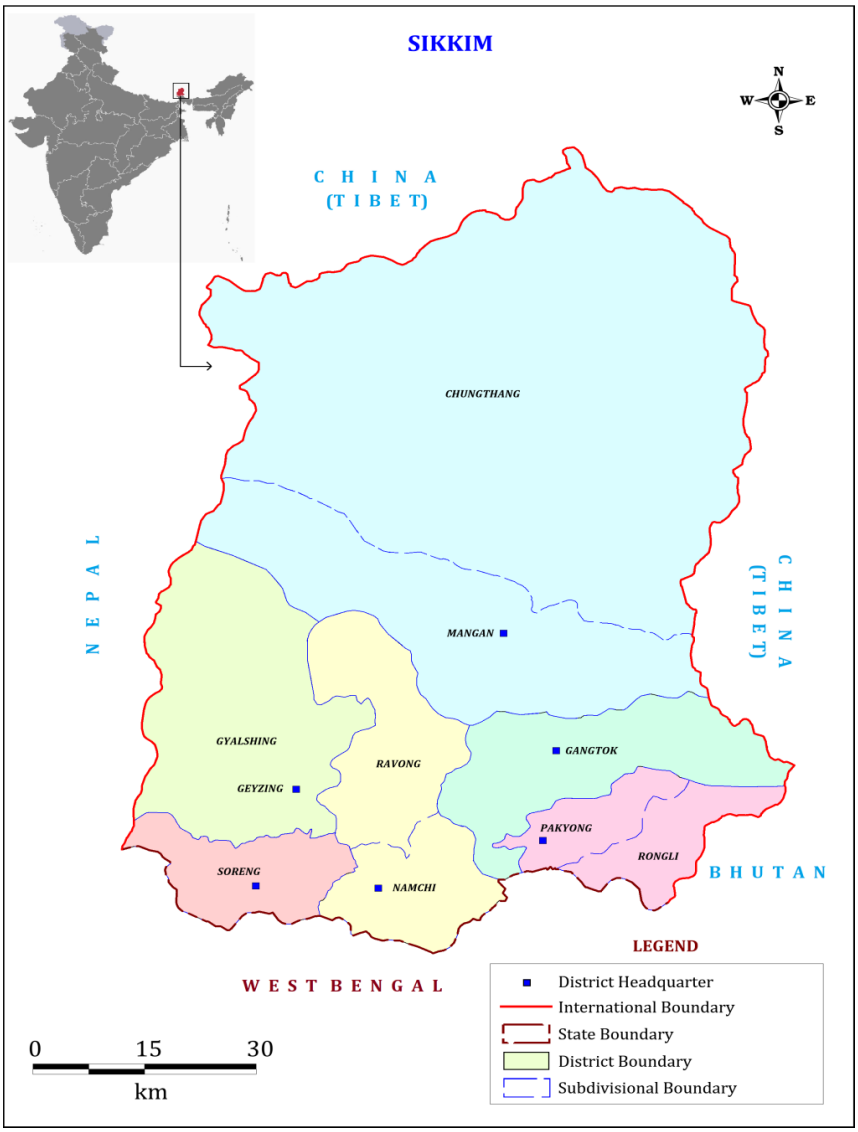
Government of India
Ministry of Jal Shakti
Department of Water Resources, River Development & Ganga Rejuvenation

DYNAMIC GROUND WATER RESOURCES ASSESSMENT OF SIKKIM

(As on 31st March, 2023)



CENTRAL GROUND WATER BOARD
EASTERN REGION, Kolkata
December, 2023

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 Carbonate rocks and Gondwanas over a gneissic basement and occasional Colluvials and valley fill deposits, as well as alluvial terrains 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 2023) for the State of Sikkim has been carried out as per GEC 2015 guidelines through 'IN-GRES', with Districts as primary assessment units. Later assessment results are proportionated block-wise. The Total Annual Ground Water Recharge has been estimated at 0.243 bcm and the Annual Extractable Ground Water Resource has beenestimated at 0.219 bcm. The Current Annual Ground Water Extraction for all uses has been estimatedat 0.012 bcm, which translates into a Stage of Ground Water Extraction at 5.54%, and as per the present assessment all the six assessment units i.e. Six Districts – Gangtok and Pakyong (East Districts), Gyalshing and Soreng (West Districts), Mangan (North District), Namchi, (South District) are in 'SAFE' category. As compared to 2022 assessment, Annual Extractable Ground Water Resource reduced from 0.244 bcm to 0.219 bcm. The Annual Ground Water Extraction from all sources though marginally decreased from 0.015 bcm to 0.012 bcm. As a result, the Stage of Ground Water Extraction marginally decreased from 6.04 % to 5.54 %.

This report is the outcome of the efforts made by Sri. Sandip Bhowal, Assistant Hydrogeologist, and Dr. Indranil Roy, Sc-D, Central Ground Water Board, Eastern Region towards assessment of dynamic component of ground water resources available in the State of Sikkim. The authors are grateful to Shri Anirvan Choudhury, Sc-D for his help during preparation of this report.

Regional Director
Central Ground Water Board
Eastern Region, Kolkata

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CHAPTER I

Introduction

a. Background for estimating the total ground water resources of the State of Sikkim

The state of Sikkim is located in the North Eastern part of the Country and lies between 27° 04' - 28° 08' N latitude 88° 00' to 88° 54' E longitudes covering an area of 7096 sq. Km. The state has international borders with China in the North, Nepal in the West and Bhutan in the East and to the south lays the state of West Bengal. The state has been divided into 06 districts namely, Gangtok and Pakyong (East Districts), Gyalshing and Soreng(West Districts) Mangan (North District), Namchi, (South District).

Sikkim with a vertical strip of rugged mountainous terrain of roughly 65 to 100 kms broad and 170 kms deep has the second highest peak of the world, the mountain Kanchendzonga. The attitude varies from 300 meters in low areas to 8500 metres in highland. The plain area is very small, limited to the intermontane valley. Two-third of the state consist largely snow clad high hills with deep ravines/gorges. About 30% of the state is forest covered.

Sikkim falls within high rainfall zone and especially in Monsoon the state receives a high precipitation and its annual rainfall exceeds 4000 mm. Sikkim has got two important rivers i.e., Teesta and Rangit. Other major Rivers are Rongnichu, Rorochu, Rolepchu in East, Bakachu, Rateychhu, Rangrangchu, Rimbichu, Kalejkhola and Ramamchhu in west.

These are numerous perennial springs with different magnitudes. Ground Water Exploration in parts of Namchi District and Gangtok District is done by Central Ground Water Board and about 40% well has yielded good discharge. Proper utilization of spring water, natural nala and khola water will help to increase the agricultural production and to mitigate the drinking water problems particularly in the rural areas where there is scarcity of water during lean periods.

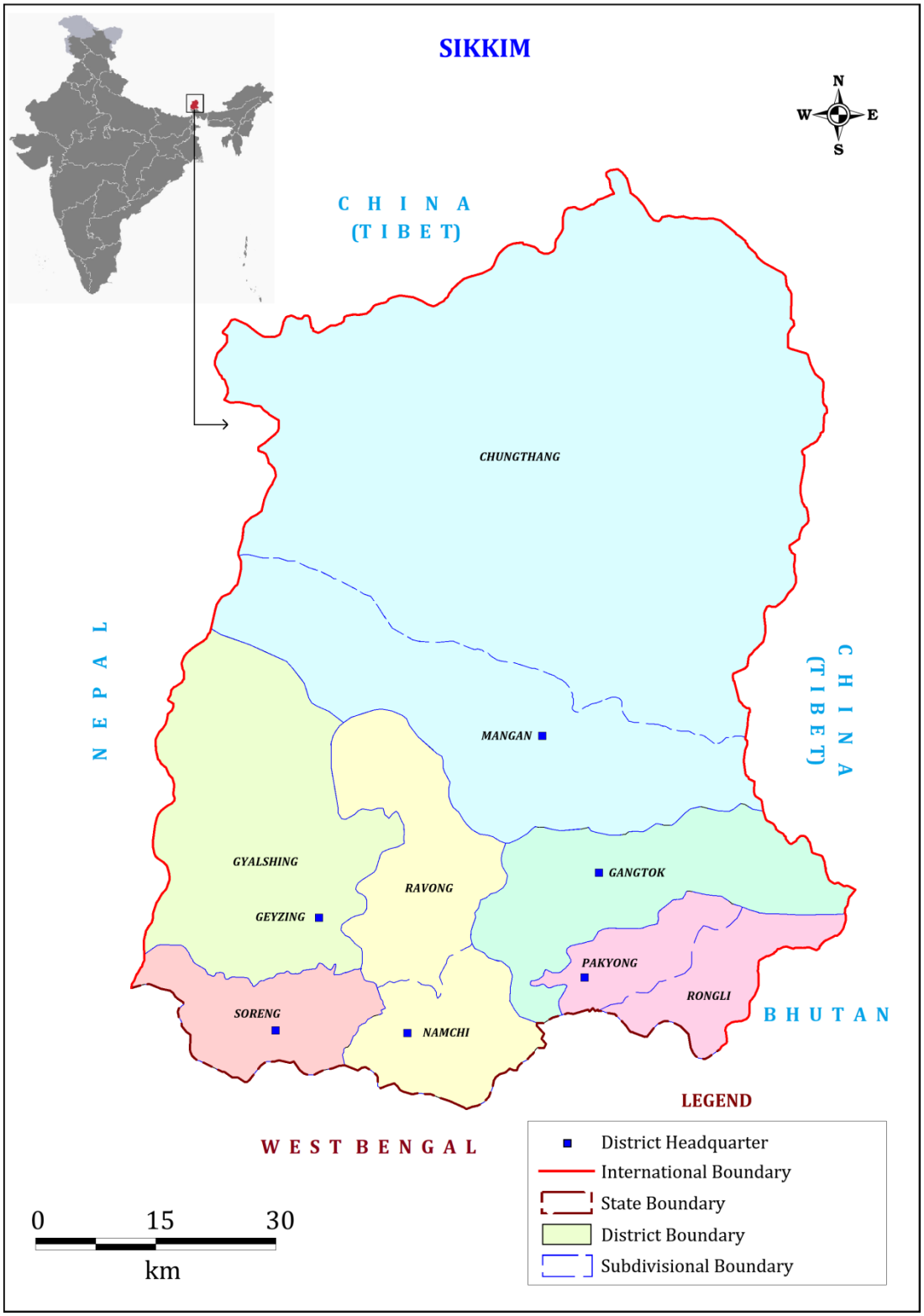

Plate-1: Geographic location of Sikkim

Administrative Base map showing 6 districts of Sikkim state along with their capitals **Plate-2.**

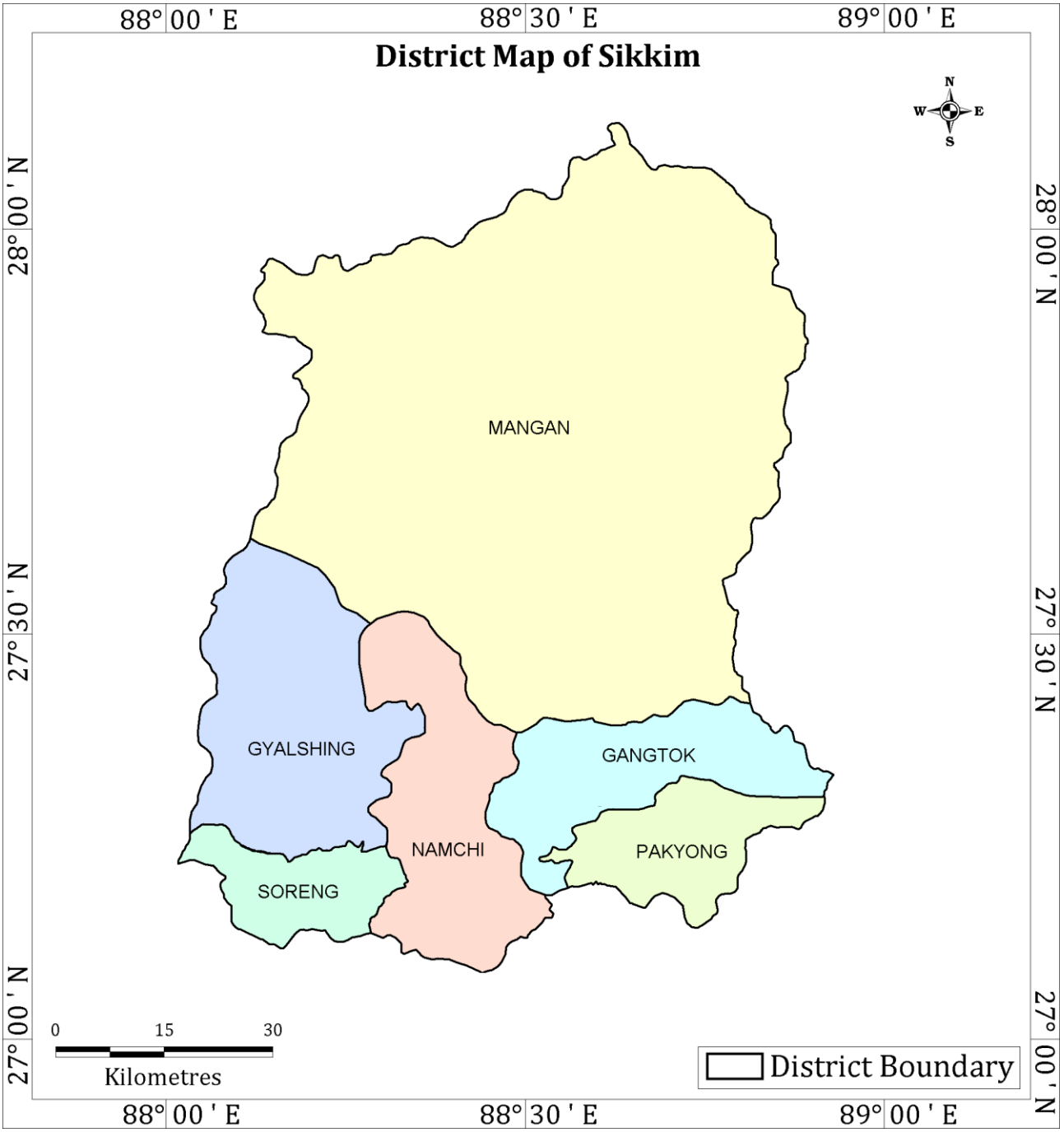

Plate-2: Administrative map showing 6 districts of Sikkim

Table 1: Administrative set-up of Sikkim

Sl	District	Assessment Unit	Total Geographical Area (ham)
1	Gangtok	**Gangtok Outside Block Area**	46769
2		Gangtok	2675
3		Khamdong	6667
4		Martam	3665
5		Rakdong	3921
6		Ranka	3500
	Gangtok	**District Total**	**67197**
7	Gyalsingh	Chongrang	6386
8		Dentam	6560
9		Gyalsingh	6527
10		**Gyalsingh Outside Block Area**	61115
11		Hee Martam	4558
12		Yuksom	4049
	Gyalsingh	**District Total**	**89195**
13	Mangan	Chunthang	8548
14		Dzongu	16512
15		Kabi Tingda	7880
16		Mangan	5339
17		**Mangan Outside Block Area**	385363
	Mangan	**District Total**	**423642**
18	Namchi	Jorethang	2861
19		Melli Sumbuk	5882
20		Namchi	7982
21		**Namchi Outside Block Area**	23506
22		Namthang	9869
23		Ravangla	7418
24		Temi Tarku	5662
25		Wok Sikkip	3399
26		Yangdang	6551
	Namchi	**District Total**	**73130**
27	Pakyong	Duga	2330
28		Pakyong	3964
29		**Pakyong Outside Block Area**	9588
30		Parkha	4317
31		Regu	6301
32		Rhenock	1956
	Pakyong	**District Total**	**28456**
33	Soreng	Baiguney	2444
34		Chumbung-Chakung	2128
35		Daramdin	5075
36		Kaluk	3463

Sl	District	Assessment Unit	Total Geographical Area (ham)
37		Mangalbarey	2807
38		Soreng	2867
39		**Soreng Outside Block Area**	10204
	Soreng	**District Total**	**28988**
	Sikkim	**State Total (ham)**	**710608**

b. Constitution of Permanent State-Level Committee for Ground Water Resources Estimation as on31st March 2023 held online on 26.07.2023

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

c. Minutes of the meeting of Permanent State Level Committee for Assessment of Ground WaterResources of Sikkim (As on 31.03.2023) held online on 13.09.2023 (Minutes of the meeting is annexed).

The meeting of the State Level Committee for assessment of Ground Water Resources of Sikkim (as on 31.03.2023) was held online on 13.09.2023 at 2.00 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 2023 of Sikkim
3. Presentation of the results of the Ground Water Resource Assessment of Sikkim (As on 31.03.2023)
4. 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 Convenor, SLC, welcomed all the Members of SLC, and other distinguished invitees of the meeting and narrated the agenda, in details and also appraised the Chair about the background of the meeting. 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 31.03.2023).

Shri Gozin Lachenpa, Chief Engineer, Water Resource Department, Govt. of Sikkim, shared his observation on the draft computations and enquired about the rationale thereof, which was explained in details by Dr. Indranil Roy, Scientist- 'D' (HG), CGWB, ER. The reasons for changes in computational results from the previous years were also explained.

It was also explained, for the State of Sikkim, as in practice, the Districts have been taken as primary assessment units. Previously there were only four districts. After district reorganization, during late phase of 2021, the numbers of districts have increased to six from four and the names of the resultant districts too have been modified. Based on the changed administrative units, the collated data have been re-organized, re-casted and rationally utilized for computational inputs in the IN-GRES portal. After the estimation the resource is recasted Block-wise based on their geographical area. Shri Deepak Singh, Additional Chief Engineer, Water Resource 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).

Finally, the draft Ground Water Resources of Sikkim (As on 31.03.2023) was accepted unanimously and was accorded due approval by the members of the Permanent State Level Committee (SLC) for the State of Sikkim. The meeting ended with a vote of thanks to the chair.

Participant List of the First Meeting of State Level Committee for Assessment of Ground Water Resources of Sikkim (as on 31.03.2023), held online on 13.09.2023

Sl No	Name	Designation
1	**Sri. T. P. Shangdarpa**	**PCE-cum-Secretary, Water Resource Department & Chairman, Permanent SLC, GWRA 2023 (Sikkim)**
2	Sri. G. Lachenpa	Principal Chief Engineer, Water Resource Department, Govt. of Sikkim & Member, SLC
3	Sri. Subhrangshu Biswas	Chief Engineer, Central Water Commission, Teesta & Bhagirathi Damodar Basin Organization, Kolkata
4	Dr. Anadi Gayen	Regional Director CGWB, ER, Kolkata & Member, SLC
5	Sri. Siddhartha Mitra	Director, Central Water Commission, Teesta & Bhagirathi Damodar Basin Organization, Kolkata
6	Sri. J. D. Basnett	Chief Engineer, Public Health Engineering Department, Govt. of Sikkim & Member, SLC
7	Sri. Deepak Singh	Additional Chief Engineer, Water Resource Department, Govt. of Sikkim
8	Dr. Indranil Roy	Scientist-'D'(HG), CGWB, ER, Kolkata
9	Sri. Anirvan Choudhury	Scientist-'D'(HG), CGWB, ER, Kolkata
10	Sri. Debashish Bagchi	Scientist-'D'(HG), CGWB, ER, Kolkata
11	Sri. Saswat Rai	Executive Engineer, Central Water Commission, Teesta & Bhagirathi Damodar Basin Organization, Gangtok
12	Sri. Sandip Bhowal	Assistant Hydrogeologist, ER, Kolkata

CHAPTER-II

HYDROGEOLOGICAL CONDITIONS OF SIKKIM

a. Geology

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.

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 stratigraphic sequence of the rock of the area is as follows (after G.S.I.)

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.

b. Rainfall:

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.

c. Climate:

The climatologically characteristics like monthly mean values of the maximum and minimum temperature, mean monthly relative humidity, monthly sunshine hours and monthly mean wind speed are available at Gangtok station (East Sikkim), Mangan station (North Station), Namchi Station (South Sikkim) & Gyalshing (West Sikkim). These climatological figures arebeing taken as representative of the Teesta Basin in Sikkim. The temperature distribution like the mean daily maximum temperature in the sub basin varies from about 26.8°C in September to 20.7°C in the month of January. Mean daily minimum temperature is around 7. 5°C in January, 10.7°C in April, 14. 5°C in July and 13.3°C in October. The mean daily Relative Humidity varies from 63.8 % to 88.7 % over the basin. The mean daily Relative Humidity is 68.3 % in October. The mean monthly wind speed varies from as low as 43.2 km/day from July to September to high of 98.4 km/day in the month of April.

b. Hydrogeology:

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

1. <u>Ground Water condition in non-permafrost area:</u>

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.

2. 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.

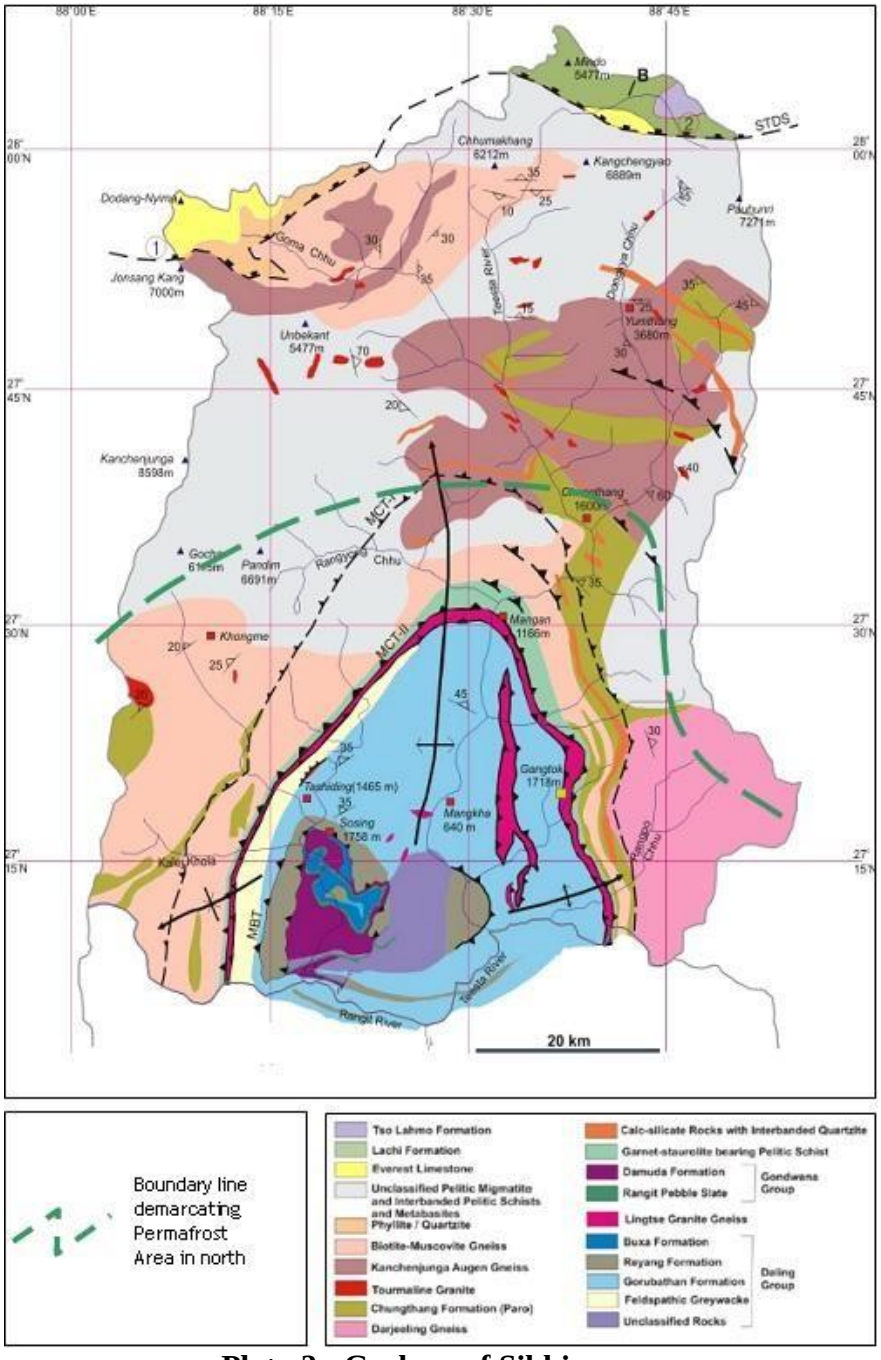

Plate-3: Geology of Sikkim

e. 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 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**
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 trajectorywithout 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 arevulnerable to surface pollution. Effective measurement should be taken to prevent any contamination and chlorination should be done when used for drinking purposes.

f. Ground water pollution:

Periodic quality assessment of drinking water sources is necessary to guarantee the quality and security of water supply to people. From the general literature it was revealed that all chemical parameters in the groundwater of West Sikkim show values within permissible limit.

g. Ground Water Suitability for irrigation:

Sikkim, being a hilly state with varying degree of slopes, constructing big irrigation canals running across the length & breadth of the State is also not feasible and entails a very high capital cost & maintenance cost, and since the majority of farmers are marginal farmers, they are not able to provide irrigation to the crops through costly means.

The Ground water is available in highly dynamic state and unavailable for useful purpose in the highly sloping topography. Hence extraction of groundwater for irrigation purpose is practically zero. Springs, both seasonal and perennial are the main source of available

water. Availability of abundant stream water during the summer allows for growing of paddy which the farmers carry to their field through temporary channels. Otherwise almost all the crops are grown on rain conditions. The topography again is a big constraint in developing a suitable water application method. Design/ layout of drip irrigation, sprinklers etc., are difficult and entail high cost due to difference in pressure head in every terrace/ field.

Hence, a more pragmatic approach is to go for micro irrigation and better methods of water application, like small water harvesting structures, roof water harvesting and water saving application methods like sprinklers, drips, porous pipes etc.

CHAPTER-III

Ground Water Resources Estimation Methodology – GEC'2015 – Brief description

Though the entire country has been assessed for its ground water resource through GEC '15 methodology, the same cannot be applied to Sikkim as it excludes its application in hilly areas with more than 20% slope. The entire state of Sikkim exhibits more than 20% slope. Moreover, as discussed earlier, Sikkim mostly lacks groundwater abstraction structures. The rural population is entirely dependent on spring sources; whereas the urban and rural marketing centres are dependent on water supply schemes tapping major rivers, lakes or springs. This situation poses a major problem towards ground water resource estimation process initiated in the country.

However, it was observed from field studies that several springs are located at slopes more than 20%. Hence, an alternative approach of resource estimation through spring discharge quantification in areas having upto 50% slope was attempted. Recharge areas have been demarcated in each district which excluded the areas under permafrost and areas having >50% slope. Further, recharge has been computed using Rainfall Recharge method anddischarge has been calculated from the values of both natural discharge as well as groundwater draft data. This was followed by calculations as per GEC'15 methodology.

The ground water resource assessment (in 2023) for the State of Sikkim has been carried out as per GEC 2015 guidelines through 'IN-GRES', with Districts as primary assessment units. The Total Annual Ground Water Recharge for Sikkim has been estimated at 24297.75 Ham and the Annual Extractable Ground Water Resource has been estimated at 21867.97 Ham. The Current Annual Ground Water Extraction for all uses has been estimated at 1211.27 Ham, which translates into a Stage of Ground Water Extraction at 5.54% and as per the present assessment, all the six assessment units of the Sikkim state falls under 'SAFE' category.

As compared to 2022 assessment, in the State of Sikkim, the Annual Extractable Ground Water Resource reduced from 24405.84 Ham to 21867.97 Ham. The Annual Ground Water Extraction from all sources though decreased from 1473.29 Ham to 1211.27 Ham. As a result, the Stage of Ground Water Extraction marginally decreased from 6.04 % to 5.54 %.

Decrease in annual rainfall resulted in decrease in recharge, which is reflected in decrease in Annual Extractable Resource. On the other hand, rationalization of groundwater dependency factor resulted in reduction of groundwater draft.

The district has been considered as ground water resource assessment unit. The dynamic groundwater resources of the Sikkim district have been appended below in Table 6.

Salient Points of GEC. 2015

- **Assessment Unit**

  Hard Rock – Watershed, as inflow/outflow across watershed boundaries is negligible.

  Alluvial Areas – Administrative Block
- **Hilly areas** having slope ≥ 20% are not considered
- Where the assessment unit is watershed, ground water assessment is converted in terms of an administrative unit by converting the volumetric resource into depth unit & then multiplying this depth with the corresponding area of the block.
- Each unit is to be delineated into command & non-command areas. Ground Water assessment in command & non-command areas are done separately for monsoon and non-monsoon season.
- Mainly two approaches at present

  A) Ground Water fluctuation method, which is based on is based on ground water balance equation i.e. (Input-Output = Storage). For assessing this equation, various components are assessed separately for monsoon and non-monsoon seasons as well as separately for command and non-command areas using norms recommended by GEC 2015.

  B) Rainfall infiltration method, recharge assessment is done only when data of sufficient duration is available. Overall components are computed separately for monsoon and non-monsoon seasons and for command and non-command areas.

Basic Steps of Groundwater Resources Assessment

- Demarcation of assessment units/ sub-units: units - block (predominantly alluvial states), watershed (pre-dominantly hard rock states)/ sub-units within assessment units – command, non-command, poor quality area;

- Computations of season-wise (monsoon & non-monsoon) gross ground water draft;

- Computations of season-wise (monsoon & non-monsoon) recharge from other sources – recharge from canal seepage, surface water and ground water irrigation, recharge from tanks & ponds, recharge from water conservation structures. Recharge from other sources is estimated using norms recommended;

- Computation of season-wise (monsoon & non-monsoon) rainfall recharge

  - Monsoon rainfall recharge: using two methods namely Water level fluctuationmethod and Rainfall Infiltration Method

  - Non-monsoon rainfall recharge: using Rainfall Infiltration Method.

- Annual Replenishable Ground Water Resources: sum-total of Monsoon and non- Monsoon ground water recharge

- Allocation for Natural Ground Water Discharge during Non-Monsoon season: 5%to 10% of Annual Replenishable Ground Water Resources

- Net Annual Ground Water Availability: Annual Replenishable Ground Water Resources – Allocation for Natural Ground Water Discharge.

- Stage of Ground Water Development = $\frac{\text{Gross Annual Ground Water Draft}}{\text{Net Annual Ground Water Availability}}$

- Categorization of Assessment units based on - Stage of Ground Water Development and long term Water Level Trend as enumerated below

Sl. No.	Stage of Ground Water Development (%)	Significant Long term Decline		Categorization
		Pre-monsoon	Post-monsoon	
1	≤ 70%	No	No	SAFE
		Yes/No	No/Yes	To be re-assessed
		Yes	Yes	To be re-assessed
2	> 70% and ≤ 90%	No	No	SAFE
		Yes/No	No/Yes	SEMI- CRITICAL
		Yes	Yes	To be re-assessed
3	> 90% and ≤ 100%	No	No	To be re-assessed
		Yes/No	No/Yes	SEMI-CRITICAL
		Yes	Yes	CRITICAL
4	> 100%	No	No	To be Re-assessed
		Yes/No	No/Yes	OVER- EXPLOITED
		Yes	Yes	OVER- EXPLOITED

Note:

1. To be re-assessed' means that data is to be checked for the purpose of categorization.
2. **The long term ground water level data should preferably be for the period of 10 years.**
3. The significant rate of water level decline may be taken between 10 and 20 cm per year depending upon the local hydrogeological conditions.
4. However, for all practical purpose, in contrast to GEC-1997 methodology, under GEC' 2015 Methodology, only the stage of ground water development will be taken into consideration for assigning categorization of assessment unit.

CHAPTER IV

Procedure followed in the Present Assessment, Assumptions and Computation of Ground Water Resources Estimation in Sikkim

Though the entire country has been assessed for its ground water resource through GEC '2015 methodology, the same cannot be applied to Sikkim as it excludes its application in hilly areas with more than 20% slope. The entire state of Sikkim exhibits more than 20% slope. Moreover, as discussed earlier, Sikkim mostly lacks groundwater abstraction structures. The rural population is entirely dependent on spring sources; whereas the urban and rural marketing centers are dependent on water supply schemes tapping major rivers, lakes or springs. This situation poses a major problem towards ground water resource estimation process initiated in the country. In case of Sikkim state Rainfall Infiltration Method (RIF method) is utilized to assess the Ground Water Resource Estimation for the year 2023 in INGRES software.

For stochastic validation, an alternative approach of resource estimation through spring discharge quantification was utilized, though the procedure is more prone to estimation error. The basic assumption for the methodology is that sustained spring discharge represents the localized resource of perched aquifer systems in hilly region, considering low residence time as indicated by water chemistry data.

District has been considered as ground water resource assessment unit. Details of ground water resource assessment units with sub-units within assessment units namely, command, non-command, poor quality area has been given in Annexes.

After subtracting the 10% of Total Rainfall Recharge (Considered as Natural Discharges) from Total Rainfall Recharge Net Annual Ground Water Availability has been calculated following the GEC'2015 methodology.

Census (2011) reports population of Sikkim to be 607688. Considering present population growth rate, district-wise population has been projected for year 2025. Reported per capita water consumption is 40 lpcd (RM&DD, 2010). District-wise demographic details of Sikkim along with present water demand and future water demand has beencomputed.

Existing gross ground water draft for domestic and industrial water supply, existing gross ground water draft for irrigation, existing gross ground water draft for all uses, provision for domestic and industrial requirement supply to 2025, net ground water availability for future irrigation development, stage of ground water development (%) has been estimated as per GEC'2015 norm. Stage of ground water development for entire Sikkim has been worked out to be **5.54 %**. And all the assessment units have been categorized as SAFE.

Annual replenishable ground water resources (in meter) have been computed as total annual ground water recharge (ha-m) divided by the area of assessment (ha). For computation of area of assessment, the area being hilly, spring-shed has been considered. Area of individual spring catchment has been considered as 30 ha (0.3 sq. km). In Mangan District (North Sikkim district), average area under spring-shed is more, however major part of the district is permafrost area. Hence the same average spring catchment area has been considered for the district.

Table 4: Important figures of GW Assessment of Sikkim state as on 31st March 2023

Ground water Assessment year	2022-2023
Total annual ground water recharge	24297.75 ham
Net annual ground water availability	21867.97 ham
Total Draft of ground water for all uses	1211.27 ham
Annual allocation of ground water for domestic and industrial water supply up to 2025	223.17 ham
Available ground water for future use	20647.39 ham
Stage of Ground Water development	5.54 %
Categorization for future ground water development	Safe

The available calculation and record suggested that the net annual ground water availability is 21867.97 ham and 223.17 ham is allocated for domestic and industrial use for the next 25 years. The available ground water for future use is 20647.39 ham and the stage of development is 5.54%.

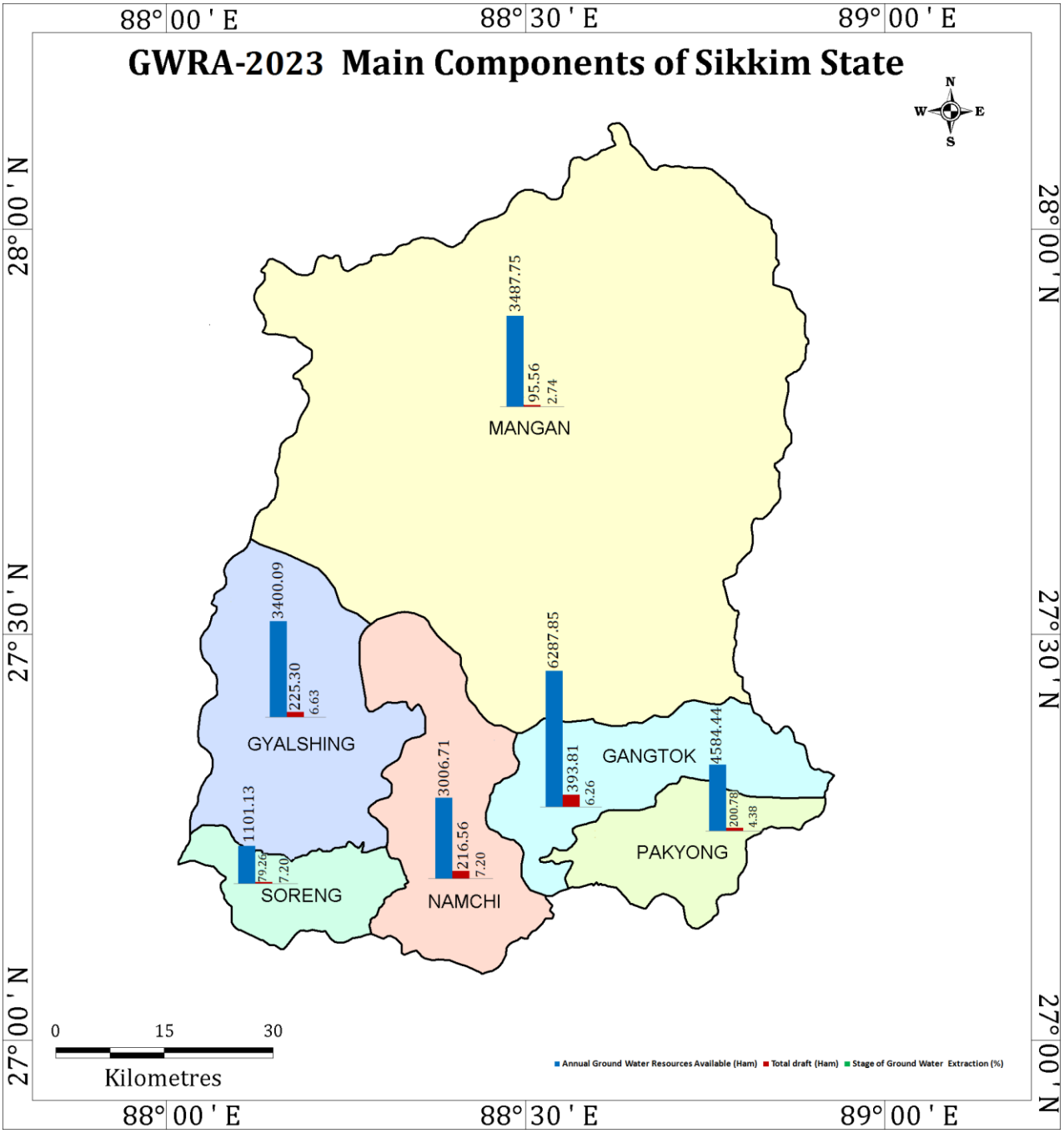

Plate-4: GWRA 2023 of Sikkim State-Main Components

CHAPTER V

COMPUTATION OF GROUND WATER RESOURCES IN SIKKIM

a. Salient features of the dynamic ground water resources assessments including the type assessment units, total number of assessment units in the state, base-year of collection of data, year of projection of data

i)	Assessment Unit	: Districts Gangtok and Pakyong (East Districts), Gyalshing and Soreng (West Districts), Mangan (North District) and Namchi, (South District)
ii)	Assessment Sub Unit	: Entirely Non-Command area
iii)	Total number of Assessment Units in Sikkim State	: 06 districts of Sikkim State.
iv)	Total Number of sub units	: 06 districts of Sikkim State and proportionate to 39 Blocks.
v)	Base Year of Collection of Data	: 2022-2023

b. Assessment sub-unit-wise method adopted for computing rainfall recharge during monsoon season (WLF/RIF)

Rainfall infiltration (RIF) method has been adopted for computing rainfall recharge during monsoon.

c. The total resources of the state, existing development, balance available for future development, stage of development, categorization of assessment units and other relevant salient features of the resources assessment in the state

Total 6 districts namely – Gangtok and Pakyong (East Districts), Gyalshing and Soreng (West Districts), Mangan (North District) & Namchi, (South District) have been taken into account for resource calculation. For six districts stage of ground water development ranges from – Gangtok (6.26%) and Pakyong (4.38%) (East Districts), Gyalshing (6.63%) and Soreng (7.20%) (West Districts), Mangan(2.74%) (North District), Namchi (7.20%) (South District) The total stage of development for the Sikkim state is 5.54**%.** Thus all the districts are coming under safe category.

d. Spatial variation of the Ground water recharge and development scenario in the State/ district-wise:

District wise variations of recharge from rainfall during monsoon have been assessed. Total annual recharge in the Sikkim state is estimated as 24297.75 ham and total natural discharge is calculated as 2429.78 ham. Net ground water availability of the state is estimated as 21867.97 ham**.**

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

The ground water resource assessment (in 2023) for the State of Sikkim has been carried out as per GEC 2015 guidelines through 'IN-GRES', with Districts as primary assessment units. The Total Annual Ground Water Recharge has been estimated at 24297.75 Ham and the Annual Extractable Ground Water Resource has been estimated at 21867.97 Ham. The Current Annual Ground Water Extraction for all uses have been estimated at 1211.27 Ham, which translates into a Stage of Ground Water Extraction at 5.54%, and as per the present assessment all the six assessment units (District) – Gangtok and Pakyong (erstwhile East District), Gyalshing and Soreng (erstwhile West District), Mangan (North District) and Namchi, (South District) are in 'SAFE' category.

Compared to 2022 assessment, in the State of Sikkim, the Annual Extractable Ground Water Resource reduced from 24405.84 Ham to 21867.97 Ham. The Annual Ground Water Extraction from all sources though decreased from 1473.29 to 1211.27 Ham. As a result, the Stage of Ground Water Extraction increased from 6.04 % to 5.54 %. Decrease in annual rainfall resulted in decrease in recharge, which is reflected in decrease in Annual Extractable Resource. On the other hand, rationalization of groundwater dependency factor resulted in reduction of groundwater draft.

Table - 5: Comparison of the Resource Estimation 2020, 2022 & 2023

Comparative Criteria	*Resource Assessment 2020 (ham)*	*Resource Assessment2022 (ham)*	*Resource Assessment2023 (ham)*
Total annual ground water recharge	96050	27117.59	24297.75
Net annual ground water availability	86445	24405.84	21867.97
Total Draft of ground water for all uses	743.12	1473.29	1211.27
Annual allocation of ground water for domestic and industrial water supply upto next 25 years	1443.26	382.61	223.17
Available ground water for future use	84827.70	22912.00	20647.39
Stage of Ground Water development (%)	0.86%	6.04%	5.54%
Categorization for future ground water development	Safe	Safe	Safe

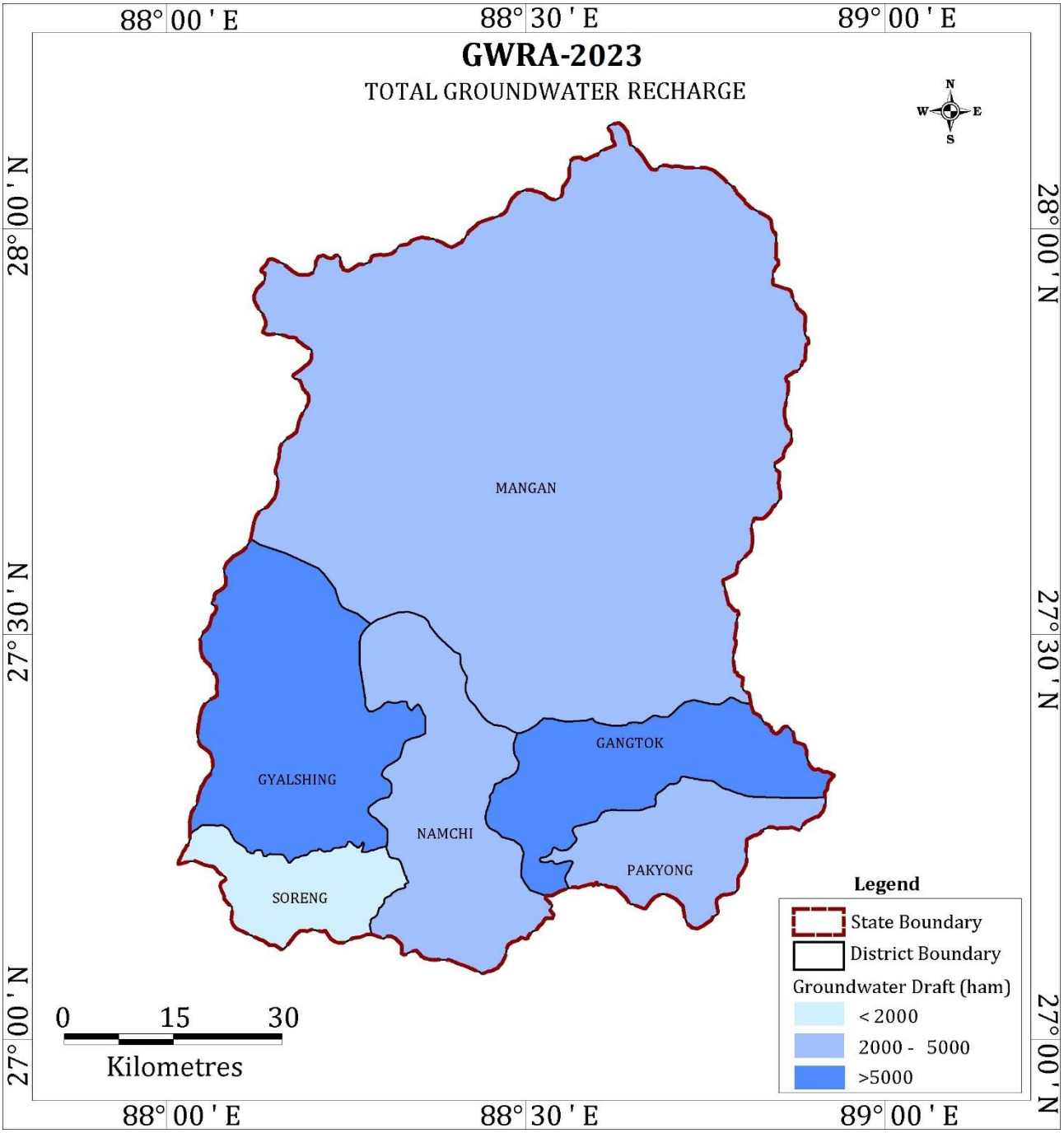

Plate-5: GWRA 2023 Sikkim: Total Ground Water Recharge

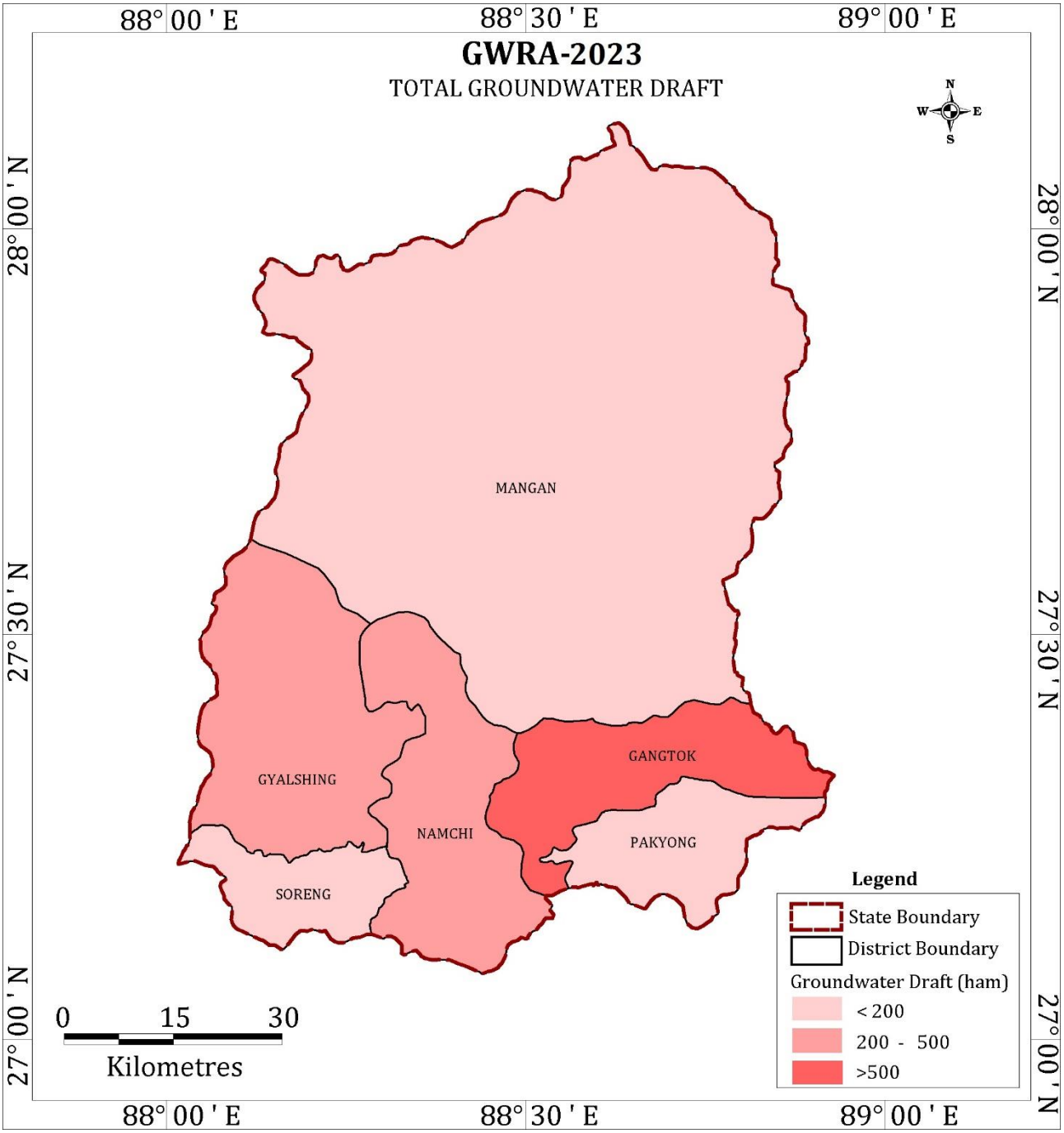

Plate-6: GWRA 2023 Sikkim: Total Ground Water Draft

Annexure III A

GENERAL DESCRIPTION OF THE GROUND WATER ASSESSMENT UNITS OF SIKKIM (2022-2023)

Type of Ground Water Assessment Unit (~~Watershed~~/ District/ ~~Taluka/ Mandal~~):

Sl. No.	***Name of Ground water Assessment Unit / District***	***Type of rock formation***	***Arial extent*** *(in hectares)*							
			Total Geographical Area (Ha)	***Recharge Worthy Area(Ha)***	***Hilly Area***	***Ground Water Recharge worthy Area***			***Shallow Water Table Area***	***Flood Prone Area***
						Command area (Both Surface & Groundwater)	***Non-command area***	***Poor ground water quality area***		
1.	***Mangan (North Sikkim)***	*Tso Lhamo Series, Lacchi Series, Mount Everest Limestone &Pelitic group, Metabasites*	423642	20000	403642		20000	*-Nil-*	*-Nil-*	*Negligible*
2.	***Namchi (South Sikkim)***	*Daling Group, Gondwana Group*	73130	28000	45130		28000	*-Nil-*	*-Nil-*	*Negligible*
3.	***Gangtok (East Sikkim)***	*Daling Group, Lingtse Granite Gneiss, Darjeeling Gneiss,*	67197	35500	31697		35500	*-Nil-*	*-Nil-*	*Negligible*
4	***Pakyong(East Sikkim)***	*Daling Group, Lingtse Granite Gneiss, Darjeeling Gneiss,*	28456	26100	2356		26100	*-Nil-*	*-Nil-*	*Negligible*
5	***Gyalshing (West Sikkim)***	*Phyllite& Quartzite*	89195	30200	58995		30200	*-Nil-*	*-Nil-*	*Negligible*
6	***Soreng (West Sikkim)***	*Phyllite& Quartzite*	28988	9800	19188		9800	*-Nil-*	*-Nil-*	*Negligible*
	Total		**710608**	**149600**	**561008**		**149600**	***-Nil-***	***-Nil-***	***Negligible***

Annexure III B

DETAILS OF GROUND WATER ABSTRACTION STRUCTURES OF SIKKIM USED IN DYNAMIC GROUND WATER RESOURCES ESTIMATION (2022-2023)

Sl. No.	Assessment Unit	Type of GW Abstraction Structure	Irrigation	Domestic	Industrial
1.	**Sikkim**	DW	-DNA-	-DNA-	-DNA-
		DW with pump	-DNA-	-DNA-	-DNA-
		STW	-DNA-	-DNA-	-DNA-
		DTW	-DNA-	-DNA-	-DNA-
		BW (Namchi District/ South Sikkim)	-DNA-	-DNA-	18
		BW (Gangtok District/ East Sikkim)	-DNA-	-DNA-	5
		BW (Pakyong District/ East Sikkim)	-DNA-	-DNA-	11
		Others	-DNA-	-DNA-	-DNA-

NB : *DW = Dug Well*
STW = Shallow Tube Well
DTW = Deep Tube Well BW
= Bore Well
DNA = Data Not Available

Annexure III C

DETAILS OF SPRINGS OF SIKKIM

Ground water Assessment Unit/District	No. of Springs Discharge measured	Average lean period discharge(lpm)	Total No. of Springs
Mangan (North Sikkim)	81	17.32	259
Namchi (South Sikkim)	435	18.37	1384
Gangtok & Pakyong (East Sikkim)	444	18.88	788
Gyalshing & Soreng (West Sikkim)	653	18.96	2069
TOTAL	**1613**	**18.38**	**4500**

lpm = Litres Per Minute

Annexure III D

DETAILS OF DEMOGRAPHIC PARTICULARS OF SIKKIM

District	Population (2011)		Growth Rate (%)		Dependency on GW		Population Dependent on GW (2011)		Per capita consumption for domestic purposes (lpcd)		Present Consumption (ham/yr)	Projected Population at 2025	
	Rural	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**		**Rural**	**Urban**
Mangan (North Sikkim)	125651	21199	1.17	1.17	15%	25%	123138	20775	40	60	95.56	147012	24803
Namchi (South Sikkim)	39065	4644	0.65	0.65	15%	25%	37893	4505	40	60	216.56	25392	3019
Gangtok (East Sikkim)	102846	116604	1.57	1.57	15%	25%	99761	113106	40	60	393.81	161468	183068
Pakyong (East Sikkim)	58250	5883	1.57	1.57	15%	25%	56503	5707	40	60	200.78	91453	9236
Gyalshing (West Sikkim)	67662	4013	1.07	1.07	15%	25%	64279	3812	40	60	225.30	72398	4294
Soreng (West Sikkim)	63525	1235	1.07	1.07	15%	25%	60349	1173	40	60	79.26	67972	1321
TOTAL	**125651**	**21199**	**1.18**	**1.18**	**15%**	**25%**	**121881**	**20563**	**40**	**60**	**1211.27**	**565695**	**225741**

Annexure III E

ASSESSMENT OF DYNAMIC GROUND WATER RESOURCES OF SIKKIM (2022-2023)

(In ham)

Sl. No.	Assessment Unit/ District	Net Annual Ground Water Availability (Ham)	Existing Gross Ground Water Draft for Irrigation (Ham)	Existing Gross Ground Water Draft for Industrial water supply (Ham)	Existing Gross Ground Water Draft for Domestic water supply (Ham)	Existing Gross Ground Water Draft for All uses (Ham) (5+6+7)	Provision for domestic and Industrial requirement supply to 2025 (Ham)	Net Ground Water Availability for future Irrigation development (Ham) (4-5-9)	Stage of Ground Water Development (%) {(7/4) * 100}
1	**2**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	**Mangan (North Sikkim)**	3487.75	83.60	0	11.96	95.56	12.21	3391.94	2.74
2	**Namchi (South Sikkim)**	3006.71	136.45	35.50	44.62	216.56	46.25	2824.01	7.20
3	**Gangtok (East Sikkim)**	6287.85	285.10	6.08	102.63	393.81	107.9	5894.85	6.26
4	**Pakyong (East Sikkim)**	4584.44	120.60	61.20	18.99	200.78	19.96	4443.88	4.38
5	**Gyalshing (West Sikkim)**	3400.09	206.10	0	19.20	225.30	19.84	3174.15	6.63
6	**Soreng (West Sikkim)**	1101.13	62.80	0	16.46	79.26	17.01	1021.32	7.20
7	**TOTAL**	**21867.97**	**894.65**	**102.78**	**213.86**	**1211.27**	**223.17**	**20750.15**	**5.54**

Annexure III F

ASSESSMENT OF DYNAMIC GROUND WATER RESOURCES OF SIKKIM
ADMINISTRATIVE UNIT-WISE CATEGORIZATION (2022-2023)

Sl. No.	AdministrativeUnit	Stage of GroundWater Development (%)	Category (Safe/ Semi-critical/ Critical/ Over-exploited)
1	**2**	**3**	4
1.	**Mangan (North Sikkim)**	2.74	**Safe**
2.	**Namchi (South Sikkim)**	7.20	**Safe**
3.	**Gangtok (East Sikkim)**	6.26	**Safe**
4.	**Pakyong (East Sikkim)**	4.38	**Safe**
5	**Gyalshing (West Sikkim)**	6.63	**Safe**
6	**Soreng (West Sikkim)**	7.20	**Safe**
7.	**TOTAL**	**5.54**	**Safe**

Annexure III G

The computational figures for Dynamic Ground Water Resources of Sikkim, (As on 31.03.2023), as approved and adopted by the SLC are as follows:

District / AU	ANNUAL GW RECHARGE (HaM)					ANNUAL GW EXTRACTION (HaM)				Allocation For Domestic Use (Upto 2025) (HaM)	Net GW Availability For Future Use (HaM)	Stage of GWE (%)	Category
	RF	Other Sources	Total	Natural Discharge	Annual Extractable GWR	Irrigation Use	Industrial Use	Domestic Use	Gross				
Soreng	1192.73	30.75	1223.48	122.35	1101.13	62.8	0	16.46	79.26	17.01	1021.32	7.2	Safe
Pakyong	5035.95	57.87	5093.82	509.38	4584.44	120.6	61.2	18.99	200.78	19.96	4382.69	4.38	Safe
Gangtok	6849.65	136.85	6986.5	698.65	6287.85	285.1	6.08	102.63	393.81	107.9	5888.77	6.26	Safe
Gyalshing	3675.57	102.31	3777.88	377.79	3400.09	206.1	0	19.2	225.3	19.84	3174.15	6.63	Safe
Namchi	3273.94	66.85	3340.79	334.08	3006.71	136.45	35.5	44.62	216.56	46.25	2788.52	7.2	Safe
Mangan	3834.32	40.96	3875.28	387.53	3487.75	83.6	0	11.96	95.56	12.21	3391.94	2.74	Safe
STATE(HaM)	**23862.2**	**435.59**	**24297.8**	**2429.78**	**21868**	**894.65**	**102.78**	**213.86**	**1211.27**	**223.17**	**20647.4**	**5.54**	**Safe**
STATE(BCM)	**0.23862**	**0.00436**	**0.24298**	**0.0243**	**0.21868**	**0.00895**	**0.00103**	**0.00214**	**0.01211**	**0.00223**	**0.20647**	**5.54**	**Safe**

Source: www.ingres.iith.ac.in

Annexure III H

GWRA Sikkim (2023) Block-wise (Proportionated area wise) including outside block areas

Sl	District	Assessment Unit	Total Geographical Area (ham)	Hilly Area (ha)	Total Recharge Worthy Area (ha)	Recharge from Rainfall-MON	Recharge from Other Sources-MON	Recharge from Rainfall-NM	Recharge from Other Sources-NM	Total Annual Ground Water Recharge (Ham)	Total Natural Discharge (Ham)	Annual Extractable Ground Water Resource (Ham)	Irrigation Use (Ham)	Industrial Use (Ham)	Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (OE/ Critical/ Semicritical/ Safe)
1	Gangtok	Gangtok Outside Block Area	46769	31697	15072	1989.17	48.42	918.94	9.68	2966.22	296.62	2669.60	0.00	0.00	0.00	0.00	0.00	2669.60	0.00	-
2	Gangtok	Gangtok	2675	0	2675	353.04	8.59	163.09	1.72	526.45	52.65	473.81	37.33	0.31	13.43	51.07	14.13	422.04	10.78	Safe
3	Gangtok	Khamdong	6667	0	6667	879.90	21.42	406.49	4.28	1312.08	131.21	1180.87	93.04	0.00	33.50	126.54	35.21	1052.62	10.72	Safe
4	Gangtok	Martam	3665	0	3665	483.70	11.77	223.45	2.35	721.28	72.13	649.15	51.15	5.77	18.42	75.34	19.36	572.87	11.61	Safe
5	Gangtok	Rakdong	3921	0	3921	517.49	12.60	239.06	2.52	771.66	77.17	694.49	54.73	0.00	19.70	74.43	20.71	619.05	10.72	Safe
6	Gangtok	Ranka	3500	0	3500	461.92	11.24	213.39	2.25	688.81	68.88	619.93	48.85	0.00	17.58	66.43	18.49	552.59	10.72	Safe
	Gangtok	**District Total**	**67197**	**31697**	**35500**	**4685.22**	**114.04**	**2164.42**	**22.80**	**6986.50**	**698.65**	**6287.85**	**285.10**	**6.08**	**102.63**	**393.81**	**107.90**	**5888.77**	**6.26**	**Safe**
7	Gyalsingh	Chongrang	6386	0	6386	575.32	21.01	201.91	0.63	798.86	79.89	718.97	46.87	0.00	4.37	51.24	4.52	667.58	7.13	Safe
8	Gyalsingh	Dentam	6560	0	6560	590.99	21.58	207.41	0.64	820.63	82.06	738.57	48.15	0.00	4.49	52.64	4.63	685.79	7.13	Safe
9	Gyalsingh	Gyalsingh	6527	0	6527	588.02	21.47	206.37	0.64	816.50	81.65	734.85	47.91	0.00	4.46	52.37	4.61	682.33	7.13	Safe
10	Gyalsingh	Gyalsingh Outside Block Area	61115	58995	2120	190.99	6.97	67.03	0.21	265.20	26.52	238.68	0.00	0.00	0.00	0.00	0.00	238.68	0.00	-
11	Gyalsingh	Hee Martam	4558	0	4558	410.63	14.99	144.11	0.45	570.18	57.02	513.16	33.45	0.00	3.12	36.57	3.22	476.49	7.13	Safe
12	Gyalsingh	Yuksom	4049	0	4049	364.77	13.32	128.02	0.40	506.51	50.65	455.86	29.72	0.00	2.76	32.48	2.86	423.28	7.13	Safe
	Gyalsingh	**District Total**	**89195**	**58995**	**30200**	**2720.72**	**99.34**	**954.85**	**2.97**	**3777.88**	**377.79**	**3400.09**	**206.10**	**0.00**	**19.20**	**225.30**	**19.84**	**3174.15**	**6.63**	**Safe**
13	Mangan	Chunthang	8548	4051	4497	525.48	8.45	336.67	0.76	871.36	87.14	784.22	18.80	0.00	2.69	21.49	2.75	762.67	2.74	Safe
14	Mangan	Dzongu	16512	7962	8550	999.08	16.07	640.10	1.44	1656.68	165.67	1491.01	35.73	0.00	5.11	40.84	5.22	1450.06	2.74	Safe
15	Mangan	Kabi Tingda	7880	3735	4145	484.35	7.79	310.32	0.70	803.15	80.32	722.84	17.33	0.00	2.48	19.81	2.53	702.98	2.74	Safe
16	Mangan	Mangan	5339	2531	2808	328.12	5.28	210.22	0.47	544.09	54.41	489.68	11.74	0.00	1.68	13.42	1.71	476.23	2.74	Safe
17	Mangan	Mangan Outside Block Area	385363	385363	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
	Mangan	**District Total**	**423642**	**403642**	**20000**	**2337.03**	**37.59**	**1497.31**	**3.37**	**3875.28**	**387.53**	**3487.75**	**83.60**	**0.00**	**11.96**	**95.56**	**12.21**	**3391.94**	**2.74**	**Safe**
18	Namchi	Jorethang	2861	1271	1590	141.26	3.48	44.66	0.31	189.71	18.97	170.74	7.87	9.41	2.57	19.85	2.67	150.79	11.63	Safe
19	Namchi	Melli Sumbuk	5882	2614	3268	290.33	7.16	91.79	0.64	389.92	38.99	350.93	16.18	1.28	5.29	22.75	5.48	327.99	6.48	Safe
20	Namchi	Namchi	7982	3547	4435	394.00	9.72	124.56	0.87	529.16	52.92	476.24	21.94	2.76	7.18	31.88	7.44	444.10	6.69	Safe
21	Namchi	Namchi Outside Block Area	23506	23078	428	38.02	0.94	12.02	0.08	51.07	5.11	45.96	0.00	0.00	0.00	0.00	0.00	45.96	0.00	-
22	Namchi	Namthang	9869	4387	5482	487.02	12.01	153.97	1.08	654.08	65.41	588.67	27.12	19.31	8.87	55.30	9.20	533.04	9.39	Safe
23	Namchi	Ravangla	7418	3296	4122	366.20	9.03	115.77	0.81	491.81	49.18	442.63	20.41	0.00	6.67	27.08	6.91	415.31	6.12	Safe
24	Namchi	Temi Tarku	5662	2516	3146	279.49	6.89	88.36	0.62	375.36	37.54	337.82	15.57	2.74	5.09	23.40	5.28	314.23	6.93	Safe
25	Namchi	Wok Sikkip	3399	1510	1889	167.82	4.14	53.06	0.37	225.38	22.54	202.84	9.35	0.00	3.06	12.41	3.17	190.32	6.12	Safe
26	Namchi	Yangdang	6551	2911	3640	323.38	7.98	102.24	0.72	434.30	43.43	390.87	18.01	0.00	5.89	23.90	6.10	366.76	6.11	Safe
	Namchi	**District Total**	**73130**	**45130**	**28000.00**	**2487.52**	**61.35**	**786.43**	**5.50**	**3340.79**	**334.08**	**3006.71**	**136.45**	**35.50**	**44.62**	**216.57**	**46.25**	**2788.51**	**7.20**	**Safe**
27	Pakyong	Duga	2330	0	2330	307.51	4.30	142.06	0.87	454.74	45.47	409.27	14.91	29.99	2.35	47.25	2.46	361.91	11.55	Safe
28	Pakyong	Pakyong	3964	0	3964	523.16	7.31	241.69	1.48	773.64	77.36	696.28	25.34	26.65	3.99	55.98	4.19	640.10	8.04	Safe
29	Pakyong	Pakyong Outside Block Area	9588	2356	7232	954.47	13.34	440.94	2.69	1411.43	141.14	1270.29	0.00	0.00	0.00	0.00	0.00	1270.29	0.00	-
30	Pakyong	Parkha	4317	0	4317	569.75	7.96	263.21	1.61	842.53	84.25	758.28	27.59	0.00	4.35	31.94	4.57	726.12	4.21	Safe
31	Pakyong	Regu	6301	0	6301	831.59	11.62	384.17	2.35	1229.74	122.97	1106.77	40.26	0.00	6.33	46.59	6.67	1059.84	4.21	Safe
32	Pakyong	Rhenock	1956	0	1956	258.15	3.61	119.26	0.73	381.74	38.17	343.57	12.50	4.56	1.97	19.03	2.07	324.44	5.54	Safe
	Pakyong	**District Total**	**28456**	**2356**	**26100**	**3444.63**	**48.14**	**1591.33**	**9.73**	**5093.82**	**509.38**	**4584.44**	**120.60**	**61.20**	**18.99**	**200.79**	**19.96**	**4382.68**	**4.38**	**Safe**
33	Soreng	Baiguney	2444	1166	1278	115.13	3.67	40.41	0.34	159.55	15.96	143.60	8.19	0.00	2.15	10.34	2.21	133.20	7.20	Safe
34	Soreng	Chumbung-Chakung	2128	1035	1093	98.47	3.14	34.56	0.29	136.46	13.65	122.81	7.01	0.00	1.84	8.85	1.90	113.90	7.21	Safe
35	Soreng	Daramdin	5075	2484	2591	233.42	7.44	81.92	0.69	323.47	32.35	291.12	16.60	0.00	4.35	20.95	4.50	270.02	7.20	Safe
36	Soreng	Kaluk	3463	1640	1823	164.23	5.24	57.64	0.48	227.59	22.76	204.83	11.68	0.00	3.06	14.74	3.16	189.99	7.20	Safe
37	Soreng	Mangalbarey	2807	1317	1490	134.23	4.28	47.11	0.40	186.02	18.60	167.42	9.55	0.00	2.50	12.05	2.59	155.28	7.20	Safe
38	Soreng	Soreng	2867	1342	1525	137.39	4.38	48.22	0.40	190.39	19.04	171.35	9.77	0.00	2.56	12.33	2.65	158.93	7.20	Safe
39	Soreng	Soreng Outside Block Area	10204	10204	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
	Soreng	**District Total**	**28988**	**19188**	**9800**	**882.87**	**28.15**	**309.86**	**2.60**	**1223.48**	**122.35**	**1101.13**	**62.80**	**0.00**	**16.46**	**79.26**	**17.01**	**1021.32**	**7.20**	**Safe**
	Sikkim	**State Total (ham)**	**710608**	**561008**	**149600**	**16557.99**	**388.61**	**7304.20**	**46.97**	**24297.75**	**2429.78**	**21867.98**	**894.65**	**102.78**	**213.86**	**1211.29**	**223.17**	**20647.38**	**5.54**	**Safe**
	Sikkim	**State Total (mcm)**				**165.58**	**3.89**	**73.04**	**0.47**	**242.98**	**24.30**	**218.68**	**8.95**	**1.03**	**2.14**	**12.11**	**2.23**	**206.47**	**5.54**	**Safe**
	Sikkim	**State Total (bcm)**				**0.17**	**0.004**	**0.07**	**0.0005**	**0.24**	**0.02**	**0.22**	**0.01**	**0.001**	**0.002**	**0.01**	**0.002**	**0.21**	**5.54**	**Safe**

Annexure III IA

Constitution of Permanent state-level committee for ground water resources estimation as on31st March 2023 held online on 26.07.2023

GOVERNMENT OF SIKKIM
WATER RESOURCES DEPARTMENT
GANGTOK

Memo No:.....60...../WRD Dated:.....26.7.....2023

NOTIFICATION

The State Government is hereby pleased to constitute Permanent State Level Committee for Ground Water Resources Assessment in the State.

Composition

1. The Secretary, Water Resources Department, Government of Sikkim- Chairperson.
2. The Chief Engineer, Water Resources, Government of Sikkim- Member.
3. The Chief Engineer, Rural Development and Management Department, Government of Sikkim- Member.
4. The Chief Engineer, Water Security & Public Health Engineering Department, Government of Sikkim- Member.
5. The Director, Department of Science & Technology, Government of Sikkim- Member.
6. The Director, Agriculture/Horticulture Department, Government of Sikkim- Member.
7. Regional Director, (I/C), CGWB, ER , Kolkata- Member.
8. The Director, Environment & Soil Conservation Forest Department, Government of Sikkim- Member.
9. The Director, State Pollution Control Board, Government of Sikkim- Member.
10. The Joint Director, Mines, Minerals & Geology Department, Government of Sikkim- Member Secretary.

By Order

Sd/-
(T.P Shangdarpa)
PCE-cum-Secretary
Water Resources Department
Government of Sikkim

Copy to:-

1. Regional Director, (I/C), CGWB, ER , Kolkata.
2. The Chief Engineer, Water Resources, Government of Sikkim
3. The Chief Engineer, Rural Development and Management Department, Government of Sikkim
4. The Chief Engineer, Water Security & Public Health Engineering Department, Government of Sikkim
5. The Director, Department of Science & Technology, Government of Sikkim
6. The Director, Agriculture/Horticuture Department, Government of Sikkim
7. The Director, Environment & Soil Conservation Forest Department, Government of Sikkim
8. The Director, State Pollution Control Board, Government of Sikkim
9. The Joint Director, Mines, Minerals & Geology Department, Government of Sikkim
10. File

Additional Chief Engineer(N/E)
Water Resources Department
Government of Sikkim

Annexure III IB

Minutes of the meeting of State Level Committee for Assessment of Ground Water Resources of Sikkim (As on 31.03.2023) held online on 13.09.2023

Minutes of the Meeting of State Level Committee for Assessment of Ground Water Resources of Sikkim (as on 31.03.2023), held online on 13.09.2023

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The meeting of the State Level Committee for assessment of Ground Water Resources of Sikkim (as on 31.03.2023) was held online on 13.09.2023 at 2 PM via 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 2023 of Sikkim
3. Presentation of the results of the Ground Water Resource Assessment of Sikkim (As on 31.03.2023)
4. 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, SLC, welcomed all the Members of SLC, and other distinguished invitees of the meeting and narrated the agenda, in details and also appraised the Chair about the background of the meeting.

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 31.03.2023).

Shri Gozin Lachenpa, Principal Chief Engineer, Water Resource Department, Govt. of Sikkim, shared his observation on the draft computations and enquired about the rationale thereof, which was explained in details by Dr. Indranil Roy, Scientist-'D'(HG), CGWB, ER.

The reasons for changes in computational results from the previous years too were explained in detail before the august gathering along with the source data, utilized in the computational process, including the reason for choosing District as primary assessment Unit.

It was also explained, for the State of Sikkim, as in practice, the Districts have been taken as primary assessment units. Previously there were only four districts. After district reorganization, during late phase of 2021, the number of districts has increased to six from four and the names of the resultant districts too have been modified.

Based on the changed administrative units, the collated data have been re-organized, re-casted and rationally appropriated for computational inputs in the IN-GRES portal.

Shri Deepak Singh, Additional Chief Engineer, Water Resource 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).

At the end the draft Ground Water Resources of Sikkim(As on 31.03.2023) was accepted unanimously and was accorded due approval by the attendee members of the Permanent State Level Committee(SLC) for the State of Sikkim.

Minutes of the Meeting of State Level Committee for Assessment of Ground Water Resources of Sikkim (as on 31.03.2023), held online on 13.09.2023

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The draft computational figures for Dynamic Ground Water Resources of Sikkim, Ground (As on 31.03.2023), as approved and adopted by the SLC are as follows:

District / AU	ANNUAL GW RECHARGE - (HaM)					ANNUAL GW EXTRACTION (HaM)				Allocation For Domestic Use (Upto 2025) (HaM)	Net GW Availability For Future Use (HaM)	Stage of GWE (%)	Category
	RF	Other Sources	Total	Natural Discharge	Annual Extractable GWR	Irrigation	Industrial Use	Domestic Use	Gross				
Gangtok	6849.65	136.85	6986.5	698.65	6287.85	285.1	6.08	102.63	393.81	107.9	5888.77	6.26	Safe
Gyalshing	3675.57	102.31	3777.88	377.79	3400.09	206.1	0	19.20	225.3	19.84	3174.15	6.63	Safe
Mangan	3834.32	40.96	3875.28	387.53	3487.75	83.6	0	11.96	95.56	12.21	3391.94	2.74	Safe
Namchi	3273.94	66.85	3340.79	334.08	3006.71	136.45	35.5	44.62	216.56	46.25	2788.52	7.20	Safe
Pakyong	5035.95	57.87	5093.82	509.38	4584.44	120.6	61.2	18.99	200.78	19.96	4382.69	4.38	Safe
Soreng	1192.73	30.75	1223.48	122.35	1101.13	62.8	0	16.46	79.26	17.01	1021.32	7.20	Safe
STATE(HaM)	**23862.16**	**435.59**	**24297.75**	**2429.78**	**21867.97**	**894.65**	**102.78**	**213.86**	**1211.27**	**223.17**	**20647.39**	**5.54**	**Safe**
STATE(BCM)	**0.2386216**	**0.0043559**	**0.2429775**	**0.0242978**	**0.2186797**	**0.0089465**	**0.0010278**	**0.002138638**	**0.0121127**	**0.0022317**	**0.2064739**	**5.54**	**Safe**

S. No	Name of District	Annual Ground Water Resources Available (Ham)		Total draft (Ham)		Stage of Ground Water Extraction (%)		Categorization	
		2022	2023	2022	2023	2022	2023	2022	2023
1	GANGTOK	5898.25	6287.85	547.93	393.81	9.29	6.26	SAFE	SAFE
2	PAKYONG	4298	4584.44	154.71	200.78	3.60	4.38	SAFE	SAFE
3	GYALSHING	5105.87	3400.09	236.16	225.30	4.63	6.63	SAFE	SAFE
4	SORENG	1654.67	1101.13	89.47	79.26	5.41	7.20	SAFE	SAFE
5	NAMCHI	3513.11	3006.71	343.42	216.56	9.78	7.20	SAFE	SAFE
6	MANGAN	3935.94	3487.75	101.6	95.56	2.58	2.74	SAFE	SAFE
	TOTAL	**24405.84**	**21867.97**	**1473.29**	**1211.27**	**6.04**	**5.54**	**SAFE**	**SAFE**

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

(Shri Gozin Lachenpa)
Principal Chief Engineer
Water Resource Department, Govt. of Sikkim
Chairman, Permanent SLC, GWRA 2023 (Sikkim)

Principal Chief Engineer
Water Resource & River Dev. Deptt.
Govt. of Sikkim

Minutes of the Meeting of State Level Committee for Assessment of Ground Water Resources of Sikkim (as on 31.03.2023), held online on 13.09.2023

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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 31.03.2023), held online on 13.09.2023

Sl No	Name	Designation
1	**Sri. T. P. Shangdarpa**	**PCE-cum-Secretary, Water Resource Department & Chairman, Permanent SLC, GWRA 2023 (Sikkim)**
2	Sri. G. Lachenpa	Principal Chief Engineer, Water Resource Department, Govt. of Sikkim & Member, SLC
3	Sri. Subhrangshu Biswas	Chief Engineer, Central Water Commission, Teesta & Bhagirathi Damodar Basin Organization, Kolkata
4	Dr. Anadi Gayen	Regional Director CGWB, ER, Kolkata & Member, SLC
5	Sri. Siddhartha Mitra	Director, Central Water Commission, Teesta & Bhagirathi Damodar Basin Organization, Kolkata
6	Sri. J. D. Basnett	Chief Engineer, Public Health Engineering Department, Govt. of Sikkim & Member, SLC
7	Sri. Deepak Singh	Additional Chief Engineer, Water Resource Department, Govt. of Sikkim
8	Dr. Indranil Roy	Scientist-'D'(HG), CGWB, ER, Kolkata
9	Sri. Anirvan Choudhury	Scientist-'D'(HG), CGWB, ER, Kolkata
10	Sri. Debashish Bagchi	Scientist-'D'(HG), CGWB, ER, Kolkata
11	Sri. Saswat Rai	Executive Engineer, Central Water Commission, Teesta & Bhagirathi Damodar Basin Organization, Gangtok
12	Sri. Sandip Bhowal	Assistant Hydrogeologist, ER, Kolkata