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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, 2020)

CENTRAL GROUND WATER BOARD
EASTERN REGION, Kolkata
July, 2021

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. Dynamic Ground Water Resources Assessment of India - 2020 70 The ground water resource assessment (in 2020) 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 0.96 bcm and the Annual Extractable Ground Water Resource has been estimated at 0.86 bcm. The Current Annual Ground Water Extraction for all uses has been estimated at 0.007 bcm, which translates into a Stage of Ground Water Extraction at 0.86 %, and as per the present assessment all the four assessment units (Four Districts – East, North, South& West) are in 'SAFE' category. As compared to 2017 assessment, Annual Extractable Ground Water Resource reduced from 1.52 bcm to 0.8645 bcm. The Annual Ground Water Extraction from all sources though marginally increased from 0.000874 bcm to 0.007431 bcm. As a result, the Stage of Ground Water Extraction marginally increased from 0.057 % to 0.86 %. Decrease in annual rainfall resulted in minor decrease in recharge, which is reflected in marginal decrease in Annual Extractable Resource. The marginal increase in Annual Ground Water Extraction is attributed to the growth of industries in the districts, utilizing ground water for industrial use, resulting in marginal increase in the Stage of Ground Water Extraction.

This report is the outcome of the efforts made by Sri. Sandip Bhowal, Assistant Hydrogeologist and Sri. Anirvan Choudhury, Scientist-'B'(Hydrogeology), Central Ground Water Board, Eastern Region towards assessment of dynamic component of ground water resources available in the State of Sikkim.

Place : Kolkata
Date : 30.07.2021

Regional Director
Central Ground Water Board
Eastern Region, Kolkata

CONTENTS

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 04 districts namely, North, East, West and South Districts.

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 South Sikkim and East Sikkim 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 are scarcity of water during lean periods.

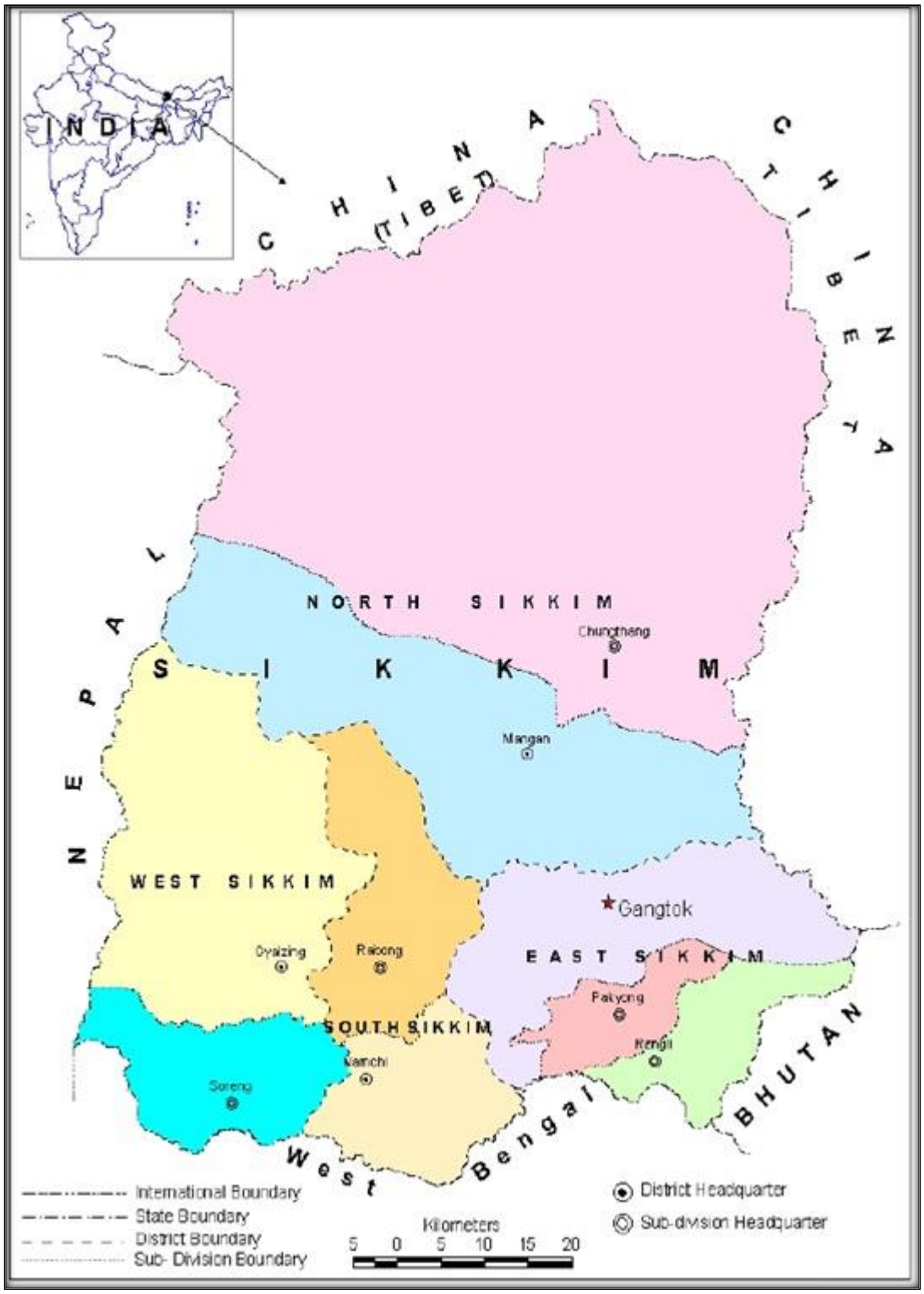

Plate-1: Geographic location of Sikkim

Administrative Base map showing 4 districts of Sikkim state along with their capitalsin **Plate-2.**

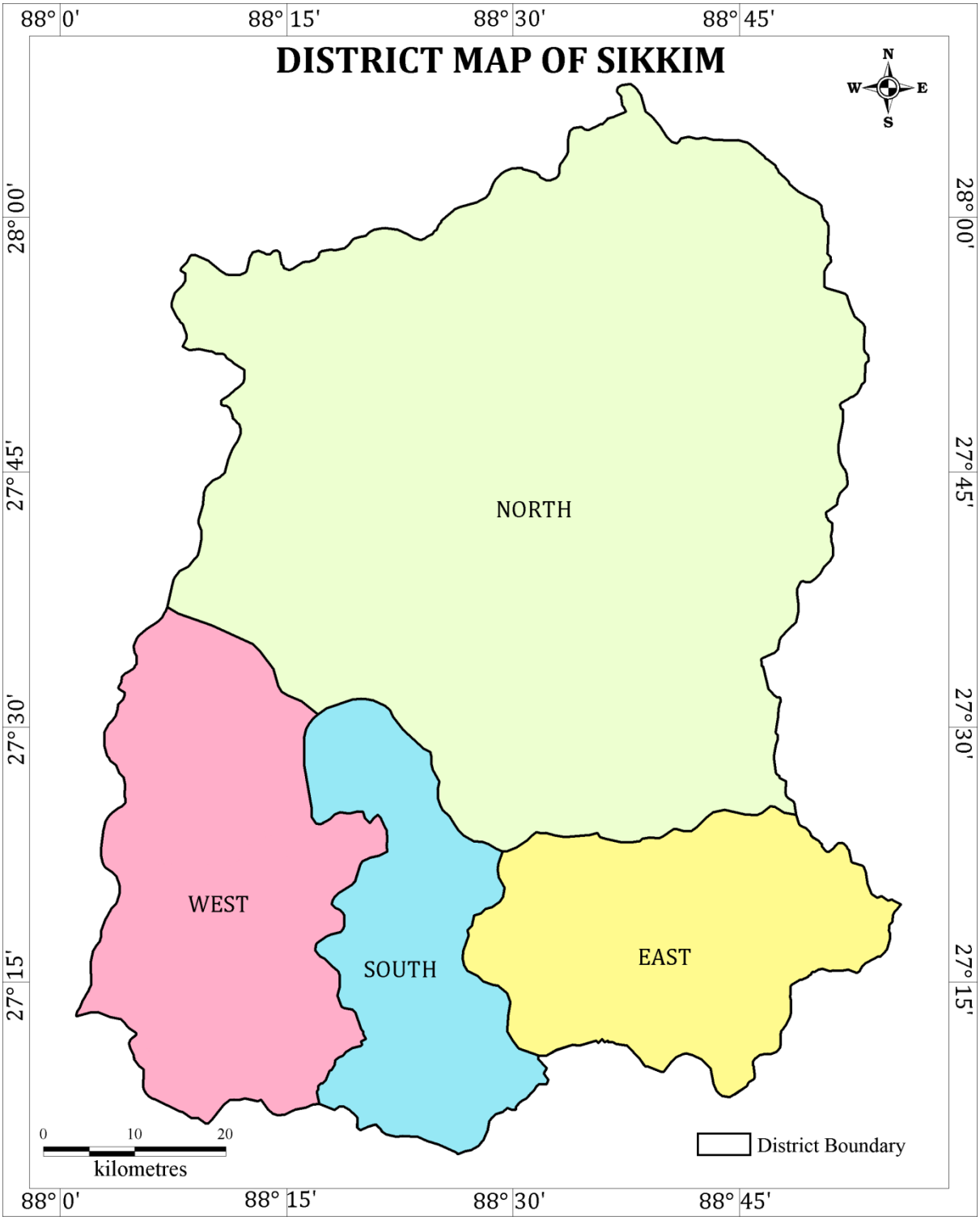

Plate-2: Administrative map showing 4 districts of Sikkim state

Table 1: Administrative set-up of Sikkim

Name of District	Sub-Division Block
North District	Mangan
	Chungthang
	Dzongu
	Kabi
South District	Namchi
	Sikkip
	Jorethang
	Ravangla
	Temi
	Namthang
	SumbukYangang
East District	Duga
	Nandok
	Martam
	Ranka
	Khamdong
	Rakdongtintek
	Pakyong
	Parakha
	Rhenock
	Regu
West District	Gyalshing
	Yuksam
	Chongrang
	Dentam
	HeeMartam
	Kaluk
	Soreng
	Chumbung
	Daramdin
	Mangalbarey

b. Constitution of state-level committee for ground water resources estimation as on 31st March 2020 held online on 22.01.2021

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

i) Sri. Suren Karkidholi, PCE-Cum-Secretary, Water Resource Department, Chairman, SLC,GWRA (2020)

ii) Sri. G. Lachenpa, Chief Engineer, Water Resource Department, Govt of Sikkim

iii) Sri. B. S. Nirola, Additional Chief Engineer, Water Resource Department, Govt of Sikkim

iv) Sri. S. S. Timsina, S E**,** Water Resource Department, Govt of Sikkim

v) Sri. Jagdish Pradhan, Additional Director, Agriculture PMKSY, Govt of Sikkim

vi) Sri. Keshap Kumar Luitel, Joint Director, Mines & Geology, Govt of Sikkim

vii) Sri. Chit Raj Mishra, Chief Engineer, PHED, Govt of Sikkim

viii) Sri. Sanjeeb Rai, Chief Engineer Rural Management Department, Govt of Sikkim

ix) Dr. S. K. Samanta, Regional Director, Central Ground Water Board, Eastern Region (ER), Ministry of Water Resources, River Development & Ganga Rejuvenation, Govt. of India

x) Smt. Sandhya Yadav, Scientist-D (HG), CGWB, ER, Kolkata

xi) Smt. Rose Anita Kujur, Scientist-D (HG), CGWB, ER, Kolkata

xii) Sri. B. B. Sahu, Scientist-B (HG), CGWB, ER, Kolkata

xiii) Sri. A. Choudhury, Scientist-B (HG), CGWB, ER, Kolkata

xiv) Sri. A. N. Chowdhury, Assistant Chemist, CGWB, ER, Kolkata

xv) Shi. Sandip.Bhowal, Assistant Hydrogeologist, CGWB, ER, Kolkata

c. Minutes of the meeting of State Level Committee for Assessment of Ground water Resources of Sikkim (As on 31.03.2020) held online on 25.03.2021 (Minutes of the meeting to be annexed).

As per initiative of Regional Director, Central Ground Water Board, ER, Kolkata and the PCE-Cum-Secretary, Water Resource Department, Chairman, SLC, GWRA (2020), the State Level Committee has been formed. Accordingly, an online meeting was arranged between representatives of Water Resource Department, Govt of Sikkim& CGWB 25.03.2021, and discussion has been carried out on Methodologies & Results of the G W Resource Estimation 2020 of Sikkim State.

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:

North 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)

East, West and South 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

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, quartzites silts and shales	Carboniferous-Permain
Mt. Everest Peletic group		Phyllites, Quartzite, Quart-Biotite schist with granite	Late Permain-Lr. Palaeozoic

CENTRAL AND SOUTH SIKKIM

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 quartzite and 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 cal 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 have 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.

DISTRICT RAINFALL (mm) FOR 2009- 2020

District: EAST Sikkim

Note: (1) The district rainfall in millimetres (R/F) shown below are the arithmetic averages of Rainfall of Stations under the District.
(2) % Dep. Are the Departures of rainfall from the long period averages of rainfall for the district.
(3) Blank spaces show non- availability of Data.

YEAR	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.
2009	5.7	-87	4.2	-95	87.3	-36	251.7	24	335.4	-1	355.4	-37	408.6	-29	454.1	-12	180.1	-51	201.6	5	1.7	-96	5.4	-81
2010	5.7	-87	18.0	-78	186.7	80	359.4	98	272.7	-17	504.6	-15	601.0	-10	493.8	-13	375.8	-12	95.6	-42	23.6	-20	0.1	-100
2011	21.6	-36	40.5	-28	68.5	11	14.7	-17	278.8	-4	515.9	11	587.3	15	459.1	4	376.7	6	44.9	-71	60.8	230	2.3	-88
2012	17.8	-47	21.5	-62	28.4	-54	312.2	78	201.6	-31	614.4	32	481.3	-5	442.2	0	410.9	15	72.4	-53	0.1	-99	1.0	-95
2013	4.3	-87	32.1	-43	127.7	107	256.1	46	409.0	40	382.6	-18	412.1	-19	325.1	-26	195.5	-45	191.8	24	40.7	121	7.9	-59
2014	0	-100	5.4	-90	68.2	11	96.7	-45	441.4	51	472.7	2	478.7	-6	522.3	18	273	-23	16.7	-89	2.4	-87	4.2	-78
2015	7.4	-78	17.4	-69	73.3	19	270.3	54	387.8	33	603.1	30	561.0	10	284.7	-35	316.1	-11	99.6	-36	55.8	203	1.0	-95
2016	15.2	-55	7.4	-87	125.3	103	220.4	26	338.7	16	391.1	-16	569.1	12	213.3	-52	348.2	-2	98.2	-37	0.1	-99	0.4	-98
2017	7.7	-77	9.0	-84	112.3	82	266.1	52	315.7	8	318.3	-31	485.7	-5	400.6	-9	274.5	-23	83.3	-46	6.5	-65	0.0	-100
2018	0.6	-98	24.9	-56	113.0	83	268.5	53	302.7	4	456.0	-2	408.9	-20	442.6	0	279.5	-22	44.5	-71	11.4	-38	23.7	22
2019	2.1	-92	49.2	2	102.1	27	203.0	-9	429.4	29	384.7	-19	657.7	33	363.9	-18	337	-4	70.1	-52	3.2	-87	11.5	-29
2020	39.9	60	29.5	-39	121.7	52	164.9	-26	205.7	-38	476.5	0	683.2	38	515.9	16	538.5	54	55.3	-62	0.1	-99	19.1	17

Source: **HYDROMET DIVISION, INDIA METEOROLOGICAL DEPARTMENT, NEW DELHI**

Data Hosted in ENVIS SIKKIM Website www.sikenvis.nic.in

DISTRICT RAINFALL (mm) FOR 2009- 2020

District: NORTH Sikkim

Note: (1)The district rainfall in millimetres(R/F)shown below are the arithmetic averages of Rainfall of Stations under the District.

(2) %Dep. Are the Departures of rainfall from the long period averages of rainfall for the district.

(3) Blank spaces show non- availability of Data.

YEAR	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.
2009																								
2010									424.9	21	582.8	8	531.6	10	599.1	30	329.1	6	106.7	-52	111.8	131	11.2	-65
2011	31.8	-48	72.4	-26	79.7	-60	150.3	-37	190.8	-46	393.8	-22	442.8	-10	397.2	-7	261.5	-33	126.8	-52	68.8	58	12.4	-45
2012	96.4	56	39.5	-60	208.3	4	365.3	53	139.7	-61	599.2	19	595.9	22	316.2	-26	785.4	102	302.4	14	0.0	-100	17.5	-22
2013	9.6	-84	62.8	-36	120.8	-39	200.5	-16	615.5	73	313.6	-38	530.2	8	301.8	-30	310.3	-20	226.7	-14	82.4	89	10.4	-54
2014	0	-100	29.8	-70	163	-18	194.4	-18	417	17	651.6	30	605.1	24	629.8	47	297.5	-24	36.7	-86	25.2	-42	13.6	-39
2015	22.0	-64	34.0	-65	180.6	-9	239.4	0	498.4	40	796.4	58	393.6	-20	664.7	55	320.2	-18	102.8	-61	59.0	36	37.5	67
2016	81.8	33	34.9	-65	306.8	54	226.7	-5	383.7	8	548	9	487.3	0	301.6	-30	638.1	64	139.8	-47	0.0	-100	0.0	-100
2017	7.7	-77	9.0	-84	112.3	82	266.1	52	315.7	8	318.3	-31	485.7	-5	400.6	-9	274.5	-26	83.3	-46	6.5	-6.5	0.0	-100
2018	15.2	-75	66.4	-33	216.2	8	221.0	-7	397.3	12	584.2	16	688.2	41	510.8	19	751.9	93	203.5	-23	68.9	58	15.1	-33
2019	25.7	-37	92.7	3	236.2	39	155.3	-25	443.7	52	531.4	29	588.0	41	351.4	-5	559.8	91	88.7	-51	8.5	-75	26.3	21
2020	83.1	104	25.2	-72	155.0	-9	343.7	67	375.0	28	993.7	140	818.9	97	467.2	26	409.7	40	220.9	21	23.5	-32	17.2	-21

Source: **HYDROMET DIVISION, INDIA METEOROLOGICAL DEPARTMENT, NEW DELHI**

Data Hosted in ENVIS SIKKIM Websitewww.sikenvis.nic.in

DISTRICTRAINFALL(mm)FOR2009- 2020

District:SOUTH Sikkim

Note: (1) The district rainfall in millimetres(R/F) shown below are the arithmetic averages of Rainfall of Stations under the District.

(2) %Dep. Are the Departures of rainfall from the long period averages of rainfall for the district.

(3) Blank spaces show non-availability of Data.

YEAR	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.
2009																								
2010									130.0	-60	346.7	-41	547.4	-18	378.8	-33	528.7	24	93.1	-44	0.2	-99	0.0	-100
2011	11.5	-66	5.4	-90	90.4	47	117	-33	152.7	-48	308.5	-34	663.3	30	513.4	16	318.2	-11	13.9	-91	28.6	55	1.0	-95
2012	10.1	-70	3.6	-94	9.1	-85	122	-31	187.5	-36	367.2	-21	372.1	-27	359.7	-18	385.1	8	16.9	-89	0.0	-100	0.0	-100
2013	4.0	-88	25.7	-54	66.2	7	111	-37	263.8	-10	288.4	-38	297.8	-41	339.6	-23	189.2	-47	141.5	-9	2.2	-88	13.5	-30
2014	0	-100	5.6	-90	54.6	-12	10	-94	164.7	-44	279.3	-40	391.1	-23	651.4	48	353.5	-1	44.1	-71	0	-100	1.6	-92
2015	2.4	-93	9.2	-84	74.4	21	155.0	12	269.9	-7	394.8	-15	625.8	23	377.3	-14	448.5	26	84.0	-46	30.0	63	3.8	-80
2016	15.2	-55	2.1	-96	30.5	-51	30.4	-83	234.8	-19	384.2	-17	629.2	24	175.1	-60	359.9	1	127.6	-18	0.0	-100	1.8	-91
2017	5.6	-83	0.0	-100	69.0	12	147.9	-16	229.0	-21	156.7	-66	497.5	-2	373.0	-15	425.2	19	75.2	-51	7.0	-62	0.0	-100
2018	2.9	-91	14.5	-74	78.5	27	153.4	-13	224.7	-23	372.6	-20	400.3	-21	416.2	-6	363.5	-2	34.1	-78	0.0	-100	26.2	35
2019	5.6	-85	58.3	-24	73.1	-39	202.7	-3	241.8	-22	221.7	-58	503.4	-16	164.8	-70	453.0	16	109.3	-36	5.3	-79	14.1	-22
2020	21.9	-40	31.6	-59	70.4	-42	135.0	-35	200.4	-36	556	5	929.6	55	679.7	23	766.2	97	47.2	-72	0.0	-100	10.2	-43

Source: HYDROMET DIVISION, INDIA METEOROLOGICAL DEPARTMENT, NEW DELHI

Data Hosted in ENVIS SIKKIM Websitewww.sikenvis.nic.in

DISTRICTRAINFALL(mm)FOR2009- 2020

District: WEST Sikkim

Note: (1)The district rainfallin millimeters(R/F)shown beloware the arithmeticaveragesof Rainfallof Stationsunder the District.

(2) %Dep. Are theDepartures of rainfall fromthe long periodaveragesofrainfall for thedistrict.

(3) Blankspacesshownon- availabilityof Data.

YEAR	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.	R/F	%DEP.
2009																								
2010																								
2011													85.5	-83	449.0	5	241.0	-38	57.0	-78	38.0	-13	6.0	-73
2012	16.0	-74	5.0	-95	21.0	-89	126.0	-47	240.0	-32	486.0	-3	376.0	-23	520.0	21	548.0	41	81.0	-69	0.0	-100	10.0	-55
2013	8.0	-87	43.0	-56	79.0	-60	155.0	-35	354.0	0	241.0	-52	583.0	19	459.2	7	374.5	-4	153.0	-42	3.2	-93	8.7	-61
2014	0	-100	1.3	-99	41.3	-79	59.8	-75	204	-43	543.3	8	204.7	-58	439	3	109	-72	66.5	-75	6	-86	1.7	-92
2015	7.0	-89	23.5	-76	38.5	-81	121.0	-49	240.5	-32	446.6	-11	351.0	-28	273.0	-36	466.5	20	56.0	-79	1.0	-98	4.0	-82
2016	11.2	-82	4.5	-95	70.0	-65	84.5	-65	234.5	-34	401.7	-20	501.5	2	176.7	-59	585.1	50	110.5	-58	0.0	-100	0.0	-100
2017							77.1	-68	181.7	-49	278.0	-45	642.4	31	602.6	41	602.1	55	69.2	-74	6.2	-86	0.0	-100
2018	2.9	-95	18.5	-81	39.5	-80	105.8	-56	194.8	-45	335.2	-33	548.8	12	555.7	30	200.1	-49	45.5	-83	0.0	-100	14.3	-36
2019	4.0	-79	33.2	23	40.0	-28	176.5	63	172.1	-12	147.3	-59	640.8	30	315.0	-24	354.3	9	49.1	-61	2.5	-89	18.0	36
2020	20.9	7	21.3	-21	36.4	-35	58.3	-46	116.0	-40	299.6	-17	438.2	-11	245.2	-41	277.0	-15	63.7	-50	0.0	-100	6.7	-49

Source: **HYDROMET DIVISION, INDIA METEOROLOGICAL DEPARTMENT, NEW DELHI**

Data Hosted in ENVIS SIKKIM Websitewww.sikenvis.nic.in

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 are being 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 places down 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.

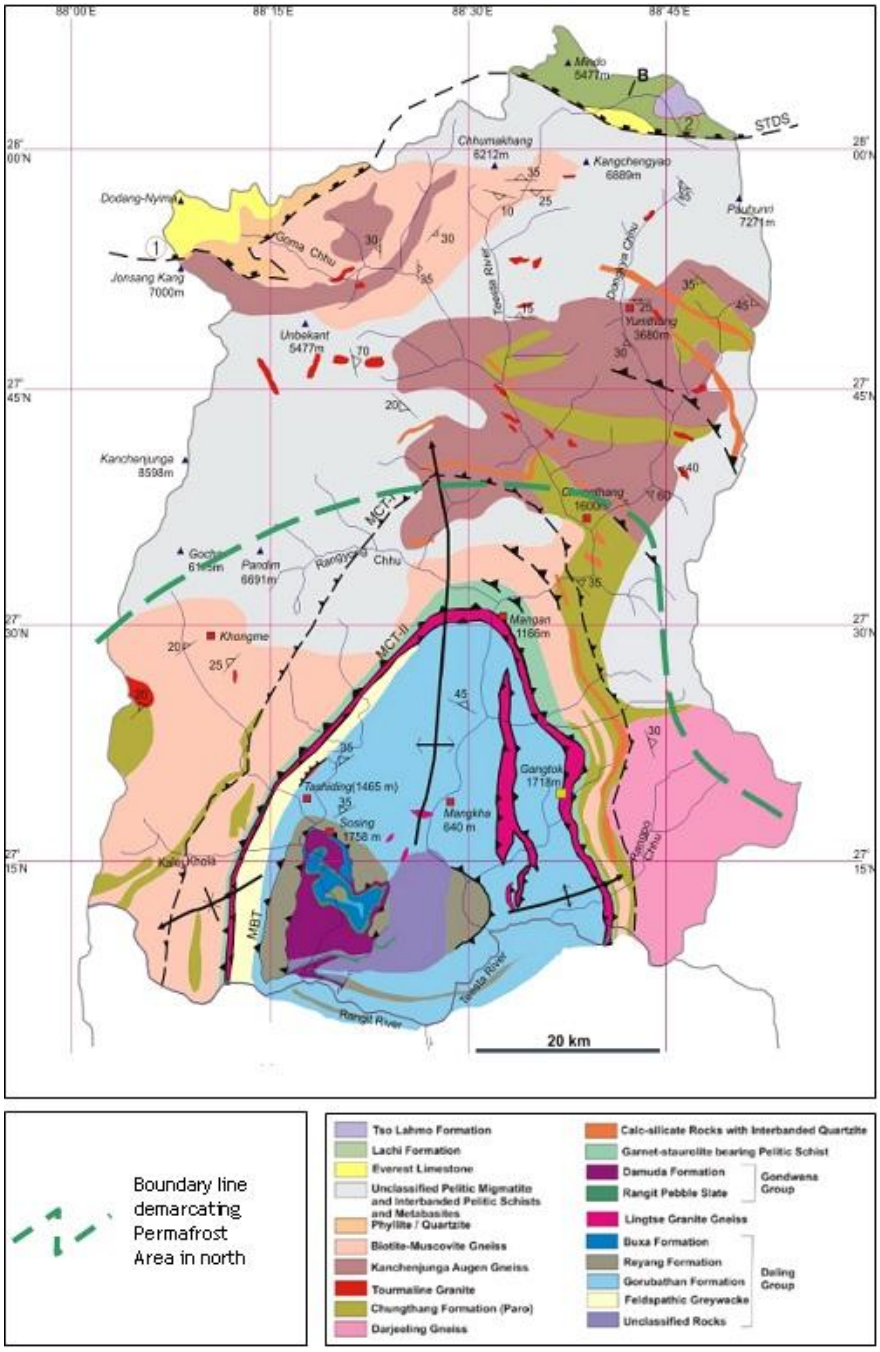

Plate-3: Geology of Sikkim

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 taken 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 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.

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'15 – 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 and discharge 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 2020) 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 West District has been estimated at 11897 Ham and the Annual Extractable Ground Water Resource has been estimated at 10707.30 Ham. The Current Annual Ground Water Extraction for all uses has been estimated at 316.20 Ham, which translates into a Stage of Ground Water Extraction at 1.16% and as per the present assessment, the assessment unit of the West district falls under 'SAFE' category.

As compared to 2017 assessment, in West district, the Annual Extractable Ground Water Resource reduced from 20854.41 Ham to 10707.30 Ham. The Annual Ground Water Extraction from all sources though increased from 0 to 316.20 Ham. As a result, the Stage of Ground Water Extraction marginally increased from 0.00 % to 1.16 %.

Decrease in annual rainfall resulted in decrease in recharge, which is reflected in decrease in Annual Extractable Resource. The increase in Annual Ground Water Extraction is attributed to the domestic use in the districts, utilizing ground water, resulting in marginal increase in the Stage of Ground Water Extraction.

The district has been considered as ground water resource assessment unit. The dynamic groundwater resources of the Sikkim district has 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 fluctuation method 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 and 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 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. In case of Sikkim state Rainfall Infiltration Method (RFIM) has been taken to assess the Ground Water Resource Estimation for the year 2020 in INGRES software.

For stochastic validation, an alternative approach of resource estimation through spring discharge quantification was utilised, though the procedure is more prone to estimation error. The basic assumption for the methodology is that sustained spring discharge represents the localised 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, *Pers. Comm.*). District-wise demographic details of Sikkim along with present water demand and future water demand has been computed.

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 **0.86 %**. 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 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 G. W. Assessment of Sikkim state as on 31st March 2020

Ground water Assessment year & Unit	2019-2020 &District
Total annual ground water recharge	96050 ham
Net annual ground water availability	86445 ham
Total Draft of ground water for all uses	743.12 ham
Annual allocation of ground water for domestic and industrial water supply up to 2025	1443.30ham
Available ground water for future use	84827.70 ham
Stage of Ground Water development	0.86 **%**
Categorization for future ground water development	Safe

The available calculation and record suggested that the net annual ground water availability is 86445 ham and 1443.30 ham is allocated for domestic and industrial use for the next 25 years. The available ground water for future use is84827.70 ham and the stage of development is 0.86%.

CHAPTER V

COMPUTATION OF GROUND WATER RESOURCES IN SIKKIM STATE

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 (East, West, North & South)
ii)	Assessment Sub Unit	: Entirely Non-Command area
iii)	Total number of Assessment Units in Sikkim State	: 4 districts of Sikkim State.
iv)	Total Number of sub units	: 4 districts of Sikkim State.
v)	Base Year of Collection of Data	: 2019-2020

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

For estimation of dynamic ground water resources of Sikim, Rainfall infiltration Factor (RIF) has been adopted for computation. Total 4 districtsnamely East, West, North & South have been taken into account for resource calculation. For four districts stage of ground water development ranges from North (0.06%), West (1.16%), East (2.93%) & South (3.68%)**.** The total stage of development for the Sikkim state is 0.86**%.** 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 as67235 hamand total natural discharge is calculated as 9605ham.Net ground water availability of the state is estimated as 86445 ham**.**

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

The ground water resource assessment (in 2020) 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 96050 Ham and the Annual Extractable Ground Water Resource has been estimated at 86445 Ham. The Current Annual Ground Water Extraction for all uses have been estimated at 743.12 Ham, which translates into a Stage of Ground Water Extraction at 0.86%, and as per the present assessment all the four assessment units (Four Districts – East, North, South & West) are in 'SAFE' category.

As compared to 2017 assessment, Annual Extractable Ground Water Resource reduced from 152227.14 Ham to 86445 Ham. The Annual Ground Water Extraction from all sources though marginally increased from 87.4 Ham to 743.12 Ham. As a result, the Stage of Ground Water Extraction marginally increased from 0.057% to 0.86%.

Decrease in annual rainfall resulted in minor decrease in recharge, which is reflected in marginal decrease in Annual Extractable Resource. The marginal increase in Annual Ground Water Extraction is attributed to the growth of industries in the districts, utilizing ground water for industrial use, resulting in marginal increase in the Stage of Ground Water Extraction.

Table - 5: Comparison of the Resource Estimation 2017& 2020

Comparative Criteria	***Resource Assessment 2017 (ham)***	***Resource Assessment 2020 (ham)***
Total annual ground water recharge	563216.75	96050
Net annual ground water availability	152227.14	86445
Annual allocation of ground water for domestic and industrial water supply up to next 25 years	1411.46	1443.26
Available ground water for future use	150728.28	84827.70
Stage of Ground Water development (%)	0.06%	0.86%
Categorization for future ground water development	Safe	Safe

Annexure III A

GENERAL DESCRIPTION OF THE GROUND WATER ASSESSMENT UNITS OF SIKKIM (2019-2020)

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.	*North Sikkim*	*Tso Lhamo Series, Lacchi Series, Mount Everest Limestone &Pelitic group, Metabasites*	423642.05	392767.1209	30874.93		392767.1209	*-Nil-*	*-Nil-*	*Negligible*
2.	*South Sikkim*	*Daling Group, Gondwana Group*	73129.5	71095.50	2034		71095.50	*-Nil-*	*-Nil-*	*Negligible*
3.	*East Sikkim*	*Daling Group, Lingtse Granite Gneiss, Darjeeling Gneiss,*	95653.22	1339.92	94313.3		1339.92	*-Nil-*	*-Nil-*	*Negligible*
4.	*West Sikkim*	*Phyllite& Quartzite*	118183.69	114076.18	4107.50		114076.18	*-Nil-*	*-Nil-*	*Negligible*
	Total		**710608.46**	**672252.10**	**38356.36**		**672252.10**	***-Nil-***	***-Nil-***	***Negligible***

Annexure III B

DETAILS OF GROUND WATER ABSTRACTION STRUCTURES OF SIKKIM USED IN DYNAMIC GROUND WATER RESOURCES ESTIMATION (2019-2020)

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 (East & South)	-DNA-	-DNA-	50
		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
North Sikkim	81	17.32	259
South Sikkim	435	18.37	1384
East Sikkim	444	18.88	788
West Sikkim	653	18.96	2069
TOTAL	**1613**	**18.38**	**4500**

NB : lpm = Litres Per Minute

Annexure III D

DETAILS OF DEMOGRAPHIC PARTICULARS OF SIKKIM

District	Population (2011)	% Population Dependent on GW	Population Dependent on GW (2011)	Per capita consumption for domestic purposes	Present Consumption (ham/yr)	Projected Population at 2025	Population Dependent on GW (2025)	Future Requirement (ham/yr)
North Sikkim	43354	97%	42171	40 lpcd	62	47041	45757	**67**
South Sikkim	146742	98%	143880	40 lpcd	210	172209	168850	**247**
East Sikkim	281293	97%	274155	40 lpcd	400	343740	335017	**489**
West Sikkim	136299	95%	129171	40 lpcd	189	157950	149690	**219**
TOTAL	**607688**	**97%**	**589376**	**40 lpcd**	**860**	**720940**	**699314**	**1021**

Annexure III E

ASSESSMENT OF DYNAMIC GROUND WATER RESOURCES OF SIKKIM (2019-2020)

(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.	North Sikkim	57392.78	0	0	37.08875	37.088745	94.17	57298.61	0.06
2.	South Sikkim	5952.62	0	83.16	135.776	218.935985	344.75	5524.71	3.68
3.	East Sikkim	12392.44	0	91.54	271.01	362.55	688.14	11612.77	2.93
4.	West Sikkim	10707.26	0	0	124.5336	124.53362	316.2	10391.06	1.16
5.	**TOTAL**	**86445.10**	**0.00**	**174.70**	**568.41**	**743.11**	**1443.26**	**84827.15**	**0.86**

Annexure III F

ASSESSMENT OF DYNAMIC GROUND WATER RESOURCES OF SIKKIM
ADMINISTRATIVE UNIT-WISE CATEGORIZATION (2019-2020)

Sl. No.	Administrative Unit	Stage of Ground Water Development (%)	Category (Safe/ Semi-critical/ Critical/ Over-exploited)
1	**2**	**3**	4
1.	North Sikkim	0.06	**Safe**
2.	South Sikkim	3.68	**Safe**
3.	East Sikkim	2.93	**Safe**
4.	West Sikkim	1.16	**Safe**
5.	**TOTAL**	**0.86**	**Safe**

Annexure III G

ASSESSMENT OF ANNUAL REPLENISHABLE GROUND WATER RESOURCES OF SIKKIM - ADMINISTRATIVE UNIT-WISE CATEGORIZATION (2019-2020)

Sl. No.	District	Geographical area (ha)	No. of Springs	Estimated Average Individual Spring Catchment area (ha)	Estimated Total Spring Catchment area (ha)	Other Recharge Worthy Area (ha)	Total Recharge Area (ha)	Net Annual GW Availability (ha-m)	Annual Replenishable Ground Water Resources (m)
1	2	3	4	5	6 (= 4 x 5)	7	8(= 6 + 7)	9	10 (=9/8)
1.	North Sikkim	422600	259	30	7770	5590	13360	236	0.018
2.	South Sikkim	75000	1384	30	41520	8970	50490	1336	0.026
3.	East Sikkim	95700	788	30	23640	7850	31490	782	0.025
4.	West Sikkim	116600	2069	30	62070	12230	74300	2062	0.028
	TOTAL	**709900**	**4500**		**135000**	**34640**	**169640**	**4416**	**0.026**