DYNAMIC GROUND WATER RESOURCES
UNION TERITORY OF LADAKH, 2024

Central Ground Water Board

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

Government of India

NORTH WESTERN HIMAAYAN REGION
Jammu
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प्रमोद कुमार त्रिपाठी
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जल शक्ति मंत्रालय
जल संसाधन,
नदी विकास और गंगा संरक्षण विभाग
केन्द्रीय भूमि जल बोर्ड
Government of India
Ministry of Jal Shakti
Department of Water Resources,
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Central Ground Water Board

MESSAGE

Ladakh lies on the rain shadow side of the Himalayas, where dry monsoon winds reaches Leh after being robbed of its moisture in plains and the mountainous region. The UT of Ladakh has a combination of the conditions of arctic and desert climate. Hence, it is often called "COLD DESERT".

The UT lies in the Greater Himalayas towards the eastern side of Jammu and Kashmir. It has the mighty Karakoram Range in the North and, bounded by the Zanskar ranges in the south. Several rivers flow through Ladakh out of which the Indus is the most important one.

Ground water has always played a vital role in sustainability of livelihood in the UT which is a cold desert and having scanty rainfall. The major precipitation of the region is in the form of snowfall. In this scenario, estimation of ground water resource in the UT of Ladakh becomes essential to meet present and future groundwater requirements. The Groundwater resource estimation, 2024 based on Groundwater Estimation Committee (GEC-2015) methodology has been carried out for UT of Ladakh, considering the blocks of Leh and Kargil district as assessment units. The overall stage of groundwater development in Kargil district is 34.15% whereas in Leh district it is 29.96%. All accessible blocks except Leh block of UT of Ladakh are under safe category.

I extend my sincere appreciation to the officers of the Central Ground Water Board, North Western Himalayan Region (NWHR), Jammu and the Public Health Engineering/Irrigation & Flood Control (PHE/I&FC) Department of Jal Shakti, Government of Ladakh (UT), for their dedicated efforts for ground water resource estimation and the preparation of this report. This report will be immensely valuable to administrators, planners, and other user agencies.

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Government of India
Ministry Of Jal Shakti
Department Of WR, RD & GR
Central Ground Water Board
North Western Himalayan Region
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Foreword

For efficient management and development of Groundwater Resources, it is imperative to have a reliable estimation of Groundwater Resources. Estimation of groundwater resources for all watersheds or administrative units as recommended in Groundwater Estimation Committee (GEC-2015) has also been attempted in Union Territory of Ladakh as well. Union Territory of Ladakh being hilly terrain has high peaks, steep slopes, hence whole area is not accessed. Ground water resources estimation 2024 has been carried out for 18 out of 31 blocks spread in isolated plains and valleys in Union Territory of Ladakh where the surface slope is less than 20% and are worthy of ground water recharge. These 18 blocks (Assessment Units) constitute 9 blocks in Kargil district and 9 blocks in Leh district.

As per Ground Water Resources Estimation 2024, the overall stage of groundwater development in Union Territory is 30.93%. The stage of groundwater development in Kargil district is 34.15% and in Leh district it is 29.96%. In Kargil district stage of groundwater development ranges between 17.46% (Shargole) and 66.64% (Pashkum block), whereas In Leh district it ranges between 12.95% (Diskit) and 81.98% (Leh Block). One blocks in Leh District i.e. Leh (81.98%) has stage of ground water extraction between 70% & 90% and categorized as 'Semi Critical' and need to be regulated efficiently.

The efforts made by Sh. Kush Kumar, STA (Hg) and Sh. Mohd Abid Khan (AHG) under the supervision of Sh. Rayeesh Ahmed Pir, Scientist-B and officers from Department of Jal Shakti, UT of Ladakh, helped to complete the groundwater resource estimation assignment well in time, are worth mentioning.

The report is repository of useful information for all planners and user agencies engaged in the development and management of groundwater resources in Union Territory of Ladakh, with hope that Report would be utilized fully for real-time management of groundwater resources.

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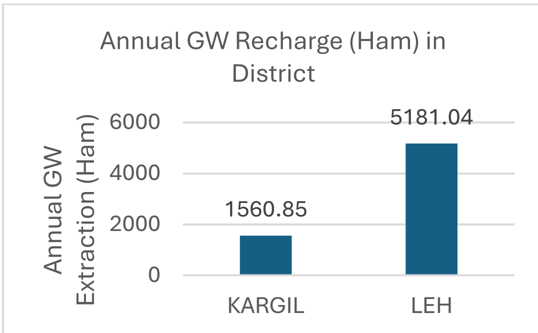
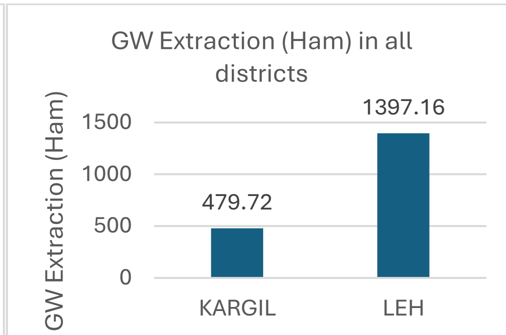
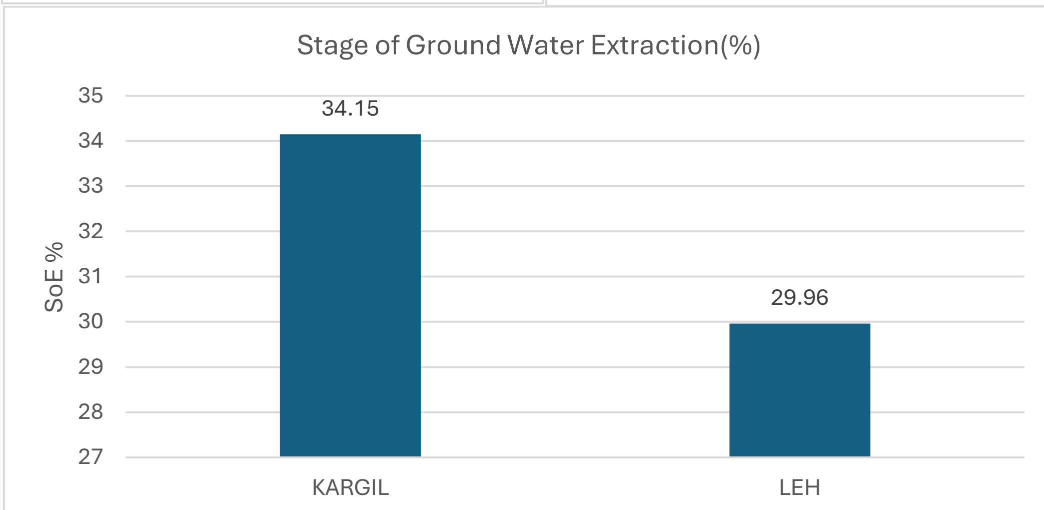
DYNAMIC GROUND WATER RESOURCES OF UT OF LADAKH, 2024







Contributors

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DYNAMIC GROUND WATER RESOURCES OF UT OF LADAKH, 2024

AT A GLANCE

1.	Total Annual Ground Water Recharge	6741.89 ham
2.	Annual Extractable Ground Water Resources	6067.7 ham
3.	Annual Ground Water Extraction	1876.88 ham
4.	Stage of Ground Water Extraction	30.93%

CATEGORIZATION OF ASSESSMENT UNITS

(Blocks/ Mandals/ Taluks)

Sl.No	**Category**	**Number of Assessment Units**		**Recharge worthy Area**		**Annual Extractable Ground Water Resource**	
		Number	**%**	**in lakh sq. km**	%	**(in BCM)**	%
1	Safe	17	94.44	0.00873	90.66	0.0548458	90.39
2	Semi Critical	1	5.56	0.0009	9.34	0.0058312	9.61
3	Critical	0	0	0	0	0	0
4	Over-Exploited	0	0	0	0	0	0
5	Saline	0	0	0	0	0	0
	TOTAL	**18**	**100**	0.00963	**100**	**0.060677**	**100**

EXECUTIVE SUMMARY

For the efficient management and development of ground water resources, it is imperative to have reliable estimation of groundwater Resources. Estimation of groundwater resources for all watersheds or administrative units as recommended in Groundwater Estimation Committee (GEC 2015) has also been attempted in Union Territory of Ladakh as well. Union Territory of Ladakh being hilly terrain, the whole of the area has not been accessed. Hence, ground water resources estimation as on 31st March 2024 has been attempted for all blocks of the Leh and Kargil district in Union Territory of Ladakh where the surface slope is less than 20%. Unlike the groundwater resources estimation 2022 in Kargil district 5 assessment unit (valleys) bifurcated into 9 assessment unit (blocks). Similarly, in Leh district 3 assessment units (valleys) bifurcated into 9 assessment unit (blocks).

As per the groundwater resources estimation 2024, the overall stage of groundwater development in union territory is 30.93%, the stage of groundwater development is 34.15 % in Kargil district and 29.96 % in Leh district. In Kargil district stage of groundwater development ranges between 17.46 % in Shargole and 48.80 % in GM Pora where it is in Leh district changes between 12.95 % in Diskit to 81.98 % in Leh. Leh block of Leh district having higher stage of groundwater extraction which is 81.98 % falls in semi-critical category needs to be regulated in efficiently.

The efforts made by the groundwater assessment cell comprising of officers from Central Groundwater Board North Western Himalayan region, Jammu and the PHE/I&FC department of UT of Ladakh in bringing out this report is highly appreciated. The efforts made by Kush Kumar STA(HG), Mohd. Abid Khan (AHG) and Gulshan Kumar STA (GP) on data analysis interpretation in Ingres platform and GWRE 2024 report writing helped to complete the assignment well in time, are worth mentioning.

The report is repository of useful information for all planners and user agencies engaged in the development and management of groundwater resources in union territory of Ladakh with hope that report would be utilize fully for real time management of groundwater resources.

CHAPTER-1

1.0 INTRODUCTION

1.1 BACKGROUND

Groundwater is an important source to meet the water requirements of various sectors like irrigation, domestic, and industries. Groundwater usage, if left unregulated, may lead to serious inter-sectoral conflicts. Hence the growth in both agriculture and industry is impingent on how India can manage its groundwater resources, particularly the aquifers in different parts of the country. The sustainable development of groundwater resources requires a precise quantitative assessment based on reasonably valid scientific principles. The fundamental basis for good groundwater management is a clear understanding of aquifers and the status of groundwater accumulation and movement in these aquifers.

To assess the irrigation potential from the groundwater, an estimate of groundwater resources was made in the year 1973 by the Ministry of Agriculture in consultation with Union Territory groundwater and minor irrigation organization. Subsequently, in the early eighties, the groundwater resource was re-estimated based on the Methodology proposed by the Groundwater Over Exploitation Committee-1977. In 1982, the Government of India had constituted a Groundwater Estimation Committee to improve the quantitative assessment of groundwater and to suggest a methodology after considering all aspects of groundwater estimation. This Committee recommended a methodology, namely: Groundwater Estimation Committee Methodology–1984 (GEC-84). Since then, the Central Groundwater Board and State Groundwater Organization have adopted this GEC–1984 methodology and estimated the groundwater resource in the Jammu and Kashmir Union Territory.

However, some limitations were encountered in the estimation, and this necessitated revision of methodology for more accurate assessment. Therefore, to review GEC– 84 and to look into all the related issues, a Committee on Groundwater Estimation was constituted vide GOI, MOWR Notification No. 3/9/93-GWII/2333 dated 13.11.1995, which had recommended a revised methodology, namely: Groundwater Resource Estimation Methodology–1997 (GEC-97) for estimating the groundwater resource for all the States in future. The Government of India also desired that a Working Group on the Estimation of Groundwater Resource and Irrigation potential from Groundwater should be constituted in each State for furnishing the relevant information to the Planning

Commission and to review the GEC-97 and to suggest suitable modification if any. However, the R&D Advisory Committee on Groundwater Estimation, Government of India, thought of refining the existing Methodology, i.e., GEC-1997, and strengthening the norms for various parameters for resource estimation like specific yield, canal seepage factor, rainfall recharge factor, irrigation return flow factor, etc. Therefore, it was decided in the 11th Meeting of the R and D Advisory Committee on Groundwater Estimation, held on 13.11.2009, to carry out the Groundwater Estimation in the alluvial areas as per the norms mentioned in the Methodology GEC-1997 with the refinement of data.

The Groundwater Estimation Committee- 1997 has been the basis of groundwater assessment in the country for the last two decades. The groundwater development program implemented in the country was also guided by groundwater resource availability worked out using this methodology. The experience gained in the last more than one decade of employing this methodology supplemented by several research and pilot project studies has brought to focus the need to update this methodology of groundwater resource assessment. The National Water Policy also enunciates periodic assessment of groundwater potential on a scientific basis.

In 2010, the Ministry of Water Resources constituted a Central Level Expert Group (CLEG) for overall supervision of the reassessment of groundwater resources in the entire country. The group finalized its report, and the draft report was circulated to all the members of the Committee for their views. During the fourth meeting of the committee, held on 03-12-2015, the draft report of "Groundwater Resource Estimation Committee - 2015 (GEC 2015) was discussed in detail. The views expressed by the members for revised methodology were considered, and necessary modifications were made and the report of the Committee was finalized. As decided in the meeting held on 09.02.2016 at New Delhi on Revision of Groundwater estimation Methodology-97, a workshop on "Groundwater Resource Estimation Methodology - 2015" was held on 24th January 2017 at CWPRS, Khadakwasla, Pune involving stakeholders and experts. The major changes proposed in the workshop were (i) to change the criteria for categorization of assessment units and (ii) to remove the potentiality tag.

The revised methodology, as recommended, has incorporated several changes compared to the recommendations of the Groundwater Estimation Committee - 1997. The revised methodology GEC 2015 recommends aquifer-wise groundwater resource assessment to which demarcation of lateral as well as vertical extent and disposition of different aquifers is pre-requisite. However, it is recommended that groundwater resources may be assessed to a depth of 100m in hard rock areas and

300m in soft rock areas till the aquifer geometry is completely established throughout the country through aquifer mapping.

It also recommends the estimation of Replenishable and in-storage groundwater resources for both unconfined and confined aquifers. Keeping in view of the rapid change in groundwater extraction, GEC-2015 recommends resource estimation once every three years. This methodology recommends that after the assessment is done, a quality flag may be added to the assessment unit for parameters salinity, fluoride, and arsenic. In inhabited hilly areas, where surface and sub-surface runoff are high and generally water level data is missing, it is difficult to compute the various components of the water balance equation. Hence, it is recommended that wherever spring discharge data is available, the same may be assessed as a proxy for 'groundwater resources' in hilly areas.

The Ministry of Jal Shakti Department of Water Resources RD&GR requested all the State/UT Governments to constitute State/UT Level Committees for overall supervision of assessment of groundwater resources at the state level. As per guidelines of Central Groundwater Board, Ladakh Government, vide Government Order No. 220-LA(GAD) of 20230 Dated: 06-07-2023 (Appendix–VII), has notified a committee, namely: "Union Territory Level Committee on Groundwater Resource Estimation" as of March 2024 for proper monitoring and Finalization of the Report.

Accordingly, steps were taken to carry out the groundwater resource assessment with data for the period 2023-2024 for the present study. The recommendations of GEC-2015 have been suitably incorporated in the present report.

1.2 HISTORICAL BACKGROUND OF LADAKH

Ladakh "land of high passes" is a region in northern India. It is located between the Kunlun Mountain range in the north and the main Himalayas to the south. Ladakh is well-known for its remote mountain scenery. It is inhabited by a mix of Indo-Aryan and Tibetan people. Their language is an archaic dialect of the Tibetan language. Historically, the region of Ladakh included Baltistan, the Indus and Zanskar Valleys, Lahaul and Spiti, Aksai Chin, and the Nubra Valley. The modern region borders Tibet to the east, Lahaul and Spiti to the south, the Kashmir and Baltistan to the west. In the past, Ladakh was important for trade. It was where several important trade routes met. Tourism is an exception, and it has been very important for Ladakh's economy since 1974.

The largest town in Ladakh is Leh, followed by Kargil as the second largest town in Ladakh. Under Jammu and Kashmir Reorganization Act, 2019, Ladakh was declared as a separate Union Territory. In August 2019, a reorganization act was passed by the Parliament of India, which contained provisions to reconstitute Ladakh as a union territory, separate from the rest of Jammu and Kashmir, on 31 October 2019. Ladakh is the highest plateau in the Indian states; much of it is over 3,000 m above sea level.

It spans the Himalayan and Karakoram mountain ranges and the upper Indus River valley. The Indus is the most important part of Ladakh for its people. Most major historical and current towns (Shey, Leh, Basgo, and Tingmosgang) are located close to the Indus River. The stretch of the Indus flowing through Ladakh is the only part of this river in India. The river is sacred in Hindu religion and culture. Ladakh Range, which is a southeastern extension of the Karakoram Range, and the upper Indus River valley is one of the highest regions of the world. Its natural features consist mainly of high plains and deep valleys. The high plain predominates in the east, diminishing gradually toward the west. In southeastern Ladakh lies Rupshu, an area of large, brackish lakes with a uniform elevation of about 4,100 meters. To the northwest of Rupshu lies the Zanskar Range, an inaccessible region where the people and the cattle remain indoors for much of the year because of the cold. Zanskar is drained by the Zanskar River, which, flowing northward, joins the Indus River below Leh. In the heart of Ladakh, farther to the north, cultivation through manuring and irrigation is practiced by farmers living in valley villages at elevations between about (2,750 and 4,550 meters). Kargil, a portion of the western Ladakh union territory, northwestern India. Centered on the town of Kargil lies in the Zanskar Range of the Himalayas and abuts the line of control between India and Pakistan. Kargil town, located roughly equidistant between Srinagar (southwest) and Leh (southeast), is considered the gateway to Ladakh.

Kargil’s landscape is mountainous, rugged, and high, the minimum elevation being some 8,000 feet (2,440 meters). The climate is cold and dry, with scanty precipitation that falls mainly as snow in winter. One locality, Drass, is reputed to be one of the world’s coldest permanently inhabited places, with winter temperatures dropping to as low as −40 °C or colder. Vegetation is extremely sparse in Ladakh except along streambeds and wetlands on high slopes. The plant *Ladakiella klimesii*, growing up to 6,150 meters above sea level, was first described here and named after this region. The first European to study the wildlife of this region was William Moorcroft in 1820, followed by Ferdinand Stoliczka, an Austrian-Czech paleontologist, who carried out a massive expedition there in the 1870s.

1.3 ASSESSMENT AREA

The Union Territory of Ladakh is the northern most Union territory of India. It lies between the latitudes 32º17’ to 36º58’ N and longitudes 73º26’ to 80º30’ E. The UT has a total geographical area of 59,146 Sq. Km. The Union Territory has an international border with Pakistan in the west. The States of Himachal Pradesh forms its southern border, and the UT of Jammu & Kashmir form the Western and southwestern border. Major parts of the UT represent high and rugged mountainous terrain.

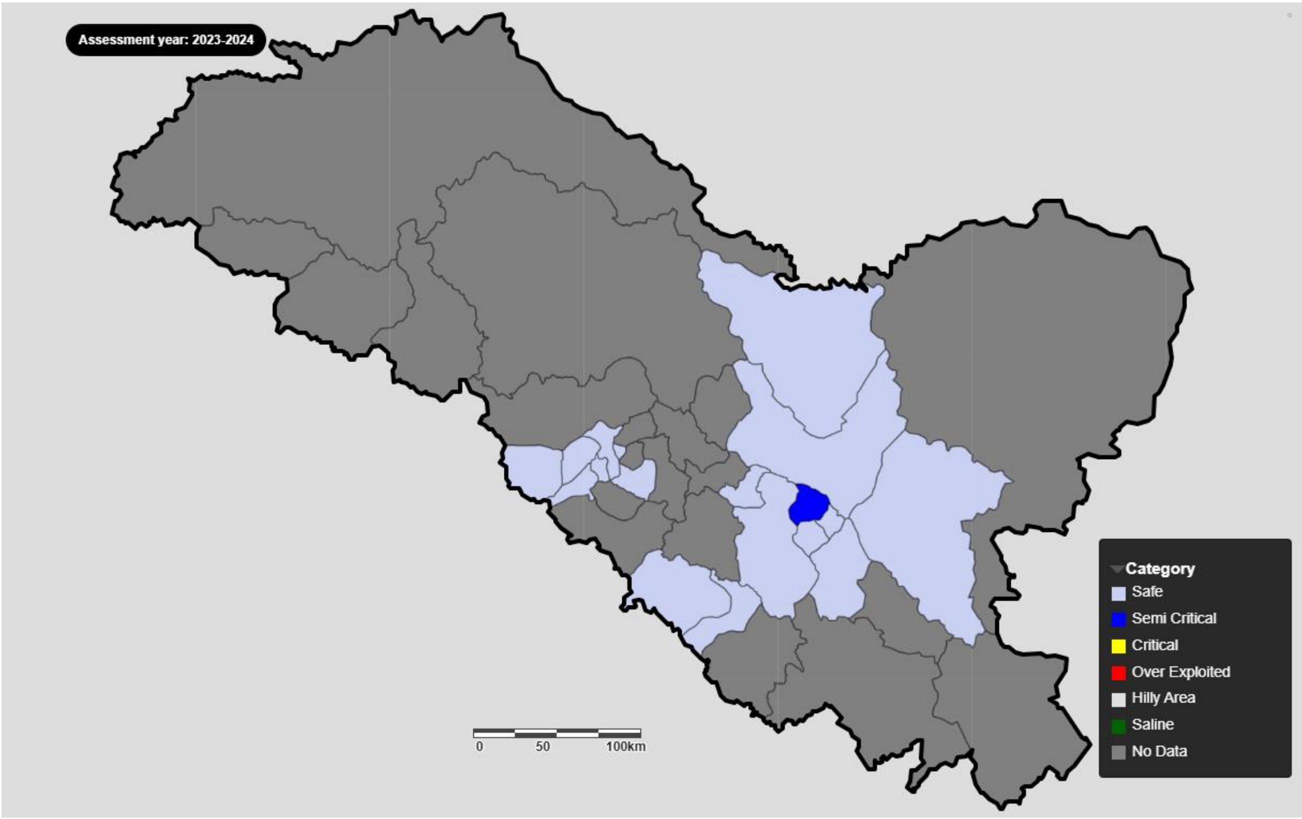


Figure 1 Location map of UT of Ladakh

The UT of Ladakh is located in the northernmost part of India, connected with the rest of the parts of the country by road through NH – 44 and Himachal Pradesh via Manali. Administratively the UT of Ladakh is divided into 06 districts viz- Leh, Kargil, Chilas, Gilgit, Gilgit Wazarat and Tribal Teritary districts. The map of category of assessment unit of the pan India is presented in Figure 1. The remaining four administrative units (except Leh and Kargil districts) are inaccessible and under illegal occupation of Pakistan (Pok).

The UT of Ladakh has great diversity in its temperature and precipitation. The climate over the greater parts of the state resembles the mountainous and continental parts of the temperate latitudes. Unlike other States, groundwater resources estimation cannot be done block-wise since the entire Union Territory is hilly and mountainous. Therefore, instead of a block as a unit for the estimation of the groundwater resources is taken as valleys and plain areas in both the districts. Total 08 no. of assessment units (05 no. in Kargil district & 03 no. in Leh district) have been taken.

1.4 PHYSIOGRAPHY

The Topography of the region is extremely rugged, mountainous, and highly inaccessible. The highest passes like Khardungla (The highest motorable road in the world) and the largest glaciers like Siachen (the world's highest battlefield) are located in this UT. The altitude of the area varies from 3000-8000 m amsl. Indus and Shyok are the main valleys. Indus River is the lifeline of the entire Leh district. The important plains are the Leh plain, More plain, Hanle Plain, Depsang plain, and soda plain. Some of the highest peaks of the Western Himalayas are also located in this region.

GREAT HIMALAYA / HIGHER HIMALAYA

The Great Himalayas, with mighty snowy peaks, average height exceeding 6000 m, is higher, steeper, and more rugged than Lesser Himalayan Zone. Nanga Parbat attaining an elevation of 8126 m is located in this part of the Himalayas. The twin peak of Nun (7135 m) and Kun (7077 m) is also located in this part of the Great Himalaya. Rising steeply like a wall from Lesser Himalaya, the whole of this zone with the exception of the deep ravines lies above the perpetual snow line. The mountain ranges in this zone too have steep southern slopes and gentler northern slopes. Further, the mountain ranges are intersected by high glaciated valleys in the upper part and dissected by streams into transverse gorges in the lower part. About 140 km long and 40 km wide, the Kashmir Valley is enclosed from the west and south by Pir Panjal, whereas to the northeast by Great Himalaya. It abounds in many beautiful and picturesque flower valleys, meadows, lakes, rivers, and man-made gardens. Jhelum River, along with its tributaries, form the principal drainage of the Valley. It is a structural Basin covering an area of about 4865 sq km representing an old lacustrine bed. The Valley shows temperate summers and severe winters in which the night temperature falls below freezing point.

TRANS-HIMALAYAN ZONE

The Ladakh region to the north and east of Kashmir Valley is known for its high-altitude terrain and extremely rigorous climate. This zone is also characterized by WNW-ESE to NW-SE trending mountain ranges. Zanskar, Ladakh, and Karakoram ranges are located in this zone. Ladakh Range, situated between Indus and Shyok rivers, attains height, up to 6529 m in the central part. The glaciers and streams draining its flanks have incised deep valleys filled with moraines.

Indus Valley, located between Zanskar Range in the south and Ladakh Range in the north, is a broad, flat Valley with its Valley floor elevation varying from 3195 m at Leh to 3395 m at Upshi. Bajada (Piedmont fan surface), erosional and depositional terraces, recent flood plains with associated bars of Indus River, palaeolake, and aeolian surfaces are the main geomorphic features of Indus Valley. Shyok Valley occupies the terrain between Ladakh and Karakoram ranges. It is also a broad open Valley characterized by relatively dense vegetation. Karakoram Range, with K2 (8610 m), the world's second-highest peak occurring north of Ladakh Range, has its entire crest-line covered with perpetual snow with several giant glaciers crawling slowly down its prominent slope, glaciers like Siachen occur along the southern face of the range. To the immediate north of the Great Himalaya in the Zanskar Range bounded by Indus and Tsarap Chu-Doda rivers to the north and south, respectively

1.4.1 DRAINAGE

As already stated, the main river in this region is the Indus River, which originates from Mt. Kailash in Tibet and flows towards the NW direction. Indus basin has two sub-basins, namely Shyok and Gilgit Qara–Qash river basin. Two main rivers falling in this are Nubra and Shyok rivers. Nubra is a perennial river and is originated from Siachen Glacier and flows in Northwest to southeast direction. Syok River is also a perennial river and is originated from South Rimo Glacier and Central Rimo Glacier.

The important major rivers draining the Kargil area are Dras, Suru and Zanskar.

1.4.2 SOILS

The soil of this region is sandy to loamy and deficient in organic matter, and the availability of phosphorus and potashes low and mixed with stones and gravels. It is shallow in formation, weakly friable, and being sandy, it is vulnerable to all types of erosion. As a result, soils developed on river terraces highly porous and coarse-grained. The fertility of the soil varies from place to place, and the growing season is very short.

1.4.3 CLIMATE

Ladakh experiences a cold continental arid climate, typical of the Tibetan plateau in the northeast comprising the Ladakh region. The entire Ladakh region lies in the rain shadow region of the Himalayas. The climate is classified as cold continental climate, the temperature being as low as –35ºC to –45ºc during the night in winter and remains sub-zero during the day.

The area falls in the rain shadow region of the Himalayas, and as such, precipitation is significantly less and scanty. The annual precipitation in the form of rainfall is 80-120 mm per year, whereas snowfall is about 140 mm/year.

1.5 GEOLOGY

Geologically the area is the collision ground of two continental masses, the Indian plate in the south and the Tibetan plate in the north bringing in the juxtaposition of dissimilar rock assembly; ages with volcanic ultrabasic rocks. The geological formations right from Pre-Cambrian to Recent are present in the Area.

***Table 1 Geology of Ladakh UT*.**

Formation	**Age**
Alluvial Lacustrine deposits, fluvioglacial outwash material, Lamayuru deposits, and Laminated Clays	Recent to Sub-Recent
Siwalik Clays/Teritiaries, liyan formation, Shegol formations (with Ophiolites)	Miocene to Pleistocene
Ninden/kalche formation	Eocene
Khalsa formation/shyok volcanic/Karakoram formation	Cretaceous
Qazilanker Conglomerate/zangla formation/Kiota limestones	Jurassic
Murgo formation	Triassic
Panjal Traps	Permian
Pengong Granitoids, Kuling formation, Phe volcanic/sasar Brangsa formation, Lipak formation	Permo-Carboniferous
Muth Qurtzites/tacke/Kelung formation	Silurian-Devonian
Thankung Schists/Phe formation, Pengong metasedimentary group	Cambro-Silurian
Karakoram Crystalline Complex/Lukung Schist, salkhalas, unclassified granites and gneisses	Pre-Cambrian

CHAPTER 2

GROUND WATER RESOURCE ESTIMATION METHODOLOGY

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

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

2.1. GROUND WATER ASSESSMENT OF UNCONFINED AQUIFER

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

2.1.1. Assessment of Annually Replenishable or Dynamic Ground Water Resources

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

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

Equation (1) can be further elaborated as –

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

Where,

ΔS - Change is storage

R_{RF} - Rainfall recharge

R_{STR} - Recharge from stream channels

R_C - Recharge from canals

R_{SWI} - Recharge from surface water irrigation

R_{GWI} - Recharge from ground water irrigation

R_{TP} - Recharge from Tanks & Ponds

R_{WCS} - Recharge from water conservation structures

VF - Vertical flow across the aquifer system

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

GE - Ground Water Extraction

T - Transpiration

E - Evaporation

B - Base flow

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

2.1.1.1. Rainfall Recharge

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

2.1.1.1.1.Ground Water Level Fluctuation Method

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

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

Where,

ΔS - Change is storage

R_{RF} - Rainfall recharge

R_{STR} - Recharge from stream channels

R_{SWI} - Recharge from surface water irrigation

R_{GWI} - Recharge from ground water irrigation

R_{TP} - Recharge from Tanks& Ponds

R_{WCS} - Recharge from water conservation structures

VF - Vertical flow across the aquifer system

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

GE - Ground water extraction

T - Transpiration

E - Evaporation

B - Base flow

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

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

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

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

Where,

ΔS - Change is storage

Δh - rise in water level in the monsoon season

A - Area for computation of recharge

S_Y - Specific Yield

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

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

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

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

Normalization of Rainfall Recharge

Let R_i be the rainfall recharge and r_i be the associated rainfall. The subscript "i" takes values 1 to N where N is the number of years for which data is available. This should be at least 5. The rainfall recharge, R_i is obtained as per equation (6) & equation (7) depending on the sub-unit for which the normalization is being done.

After the pairs of data on R_i and r_i have been obtained as described above, a normalisation procedure is carried out for obtaining the rainfall recharge corresponding to the normal monsoon season rainfall. Let r(normal) be the normal monsoon season rainfall obtained as the average of recent 30 to 50 years of monsoon season rainfall. Two methods are possible for the normalisation procedure. The first method is based on a linear relationship between recharge and rainfall of the form

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

Where,

R = Rainfall recharge during monsoon season

r = Monsoon season rainfall

a = a constant

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

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

Where,

R_{RF}(normal) - Normalized Rainfall Recharge in the monsoon season

R_i- Rainfall Recharge in the monsoon season for the i^{th}year

r(normal) - Normal monsoon season rainfall

r_i- Rainfall in the monsoon season for the i^{th} year

N - No. of years for which data is available

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

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

Where,

R_{RF}(normal) - Normalized Rainfall Recharge in the monsoon season

r(normal) - Normal monsoon season rainfall

a and b - Constants.

The two constants 'a' and 'b' in the above equation are obtained through a linear regression analysis. The computational procedure has been followed in the second method is as given below:

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

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

Where,

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

2.1.1.1.2.Rainfall Infiltration Factor Method

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

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

Where,

R_{RF} - Rainfall recharge in ham

A - Area in hectares

RFIF - Rainfall Infiltration Factor

R- Rainfall in mm

a - Minimum threshold value above which rainfall induces ground water recharge in mm

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

2.1.1.1.3.Percent Deviation

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

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

Where,

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

R_{RF} (normal, rifm) =

Rainfall recharge for normal monsoon season rainfall estimated by t

he rainfall infiltration factor method

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

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

2.1.1.2. Recharge from Other Sources

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

Sl. No.	Source	Estimation Formula	Parameters
1	Recharge from Canals	$R_C = WA \times SF \times Days$	R_C = Recharge from Canals WA = Wetted Area SF = Seepage Factor Days = Number of Canal Running Days
2	Recharge from Surface Water Irrigation	$R_{SWI} = AD \times Days \times RFF$	R_{SWI} = Recharge due to applied surface water irrigation AD = Average Discharge Days = Number of days water is discharged to the Fields RFF = Return Flow Factor
3	Recharge from Ground Water Irrigation	$R_{GWI} = GE_{IRR} \times RFF$	R_{GWI} = Recharge due to applied ground water irrigation GE_{IRR} = Ground Water Extraction for Irrigation

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

2.1.1.3. Evaporation and Transpiration

Evaporation is estimated for the aquifer in the assessment unit if water levels in the aquifer are within the capillary zone. For areas with water levels within 1.0mbgl, evaporation is estimated using the evaporation rates available for other adjoining areas. If depth to water level is more than 1.0mbgl, the evaporation losses from the aquifer is taken as zero.

Transpiration through vegetation has been estimated if water levels in the aquifer are within the maximum root zone of the local vegetation. If water levels are within 3.5mbgl, transpiration is estimated using the transpiration rates available for other areas. If it is greater than3.5m bgl, the transpiration has been taken as zero.

2.1.1.4. Recharge During Monsoon Season

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

2.1.1.5. Recharge During Non-Monsoon Season

The rainfall recharge during non-monsoon season is estimated using rainfall infiltration factor Method only when the non-monsoon season rainfall is more than 10% of normal annual rainfall. The sum of non-monsoon rainfall recharge and the recharge from other sources and lateral and vertical flows into

& out of the sub unit and stream inflows & outflows during non-monsoon season is the total recharge/ accumulation during non-monsoon season for the sub unit. Similarly, this is to be computed for all the sub units available in the assessment unit.

2.1.1.6. Total Annual Ground Water Recharge

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

2.1.1.7. Annual Extractable Ground Water Resource (EGR)

The Annual Extractable Ground Water Resource (EGR) is computed by deducting the Total Annual Natural Discharge from Total Annual Ground Water Recharge.

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

2.1.1.8. Estimation of Ground Water Extraction

Ground water draft or extraction is assessed as follows.

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

Where,

GE_{ALL} = Ground water extraction for all uses

GE_{IRR} = Ground water extraction for irrigation

GE_{DOM} = Ground water extraction for domestic uses

GE_{IND} = Ground water extraction for industrial uses

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

The methods for estimation of ground water extraction are as follows.

***Unit Draft Method:* –** In this method, season-wise unit draft of each type of well in an assessment unit is estimated. The unit draft of different types (eg. Dug well, Dug cum bore well, shallow tube well, deep tube well, bore well etc.) is multiplied with the number of wells of that particular type to obtain season-wise ground water extraction by that particular structure.

***Crop Water Requirement Method:* –** For each crop, the season-wise net irrigation water requirement is determined. This is then multiplied with the area irrigated by ground water abstraction structures. The database on crop area is obtained from Revenue records in Tehsil office, Agriculture Census and also by using Remote Sensing techniques.

***Power Consumption Method:* –**Ground water extraction for unit power consumption (electric) is determined. Extraction per unit power consumption is then multiplied with number of units of power consumed for agricultural pump sets to obtain total ground water extraction for irrigation.

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

There are several methods for estimation of extraction for domestic use(GEDOM). Some of the commonly adopted methods are described here.

***Unit Draft Method:* –** In this method, unit draft of each type of well is multiplied by the number of wells used for domestic purpose to obtain the domestic ground water extraction.

***Consumptive Use Method:* –** In this method, population is multiplied with per capita consumption usually expressed in litre per capita per day (lpcd). It can be expressed using following equation.

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

Where,

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

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

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

The commonly adopted methods for estimating the extraction for industrial use are as below:

Unit Draft Method: - In this method, unit draft of each type of well is multiplied by the number of wells used for industrial purpose to obtain the industrial ground water extraction.

Consumptive Use Pattern Method: – In this method, water consumption of different industrial units is determined. Numbers of Industrial units which are dependent on ground water are multiplied with unit water consumption to obtain ground water extraction for industrial use.

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

Where,

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

The load on ground water for industrial water supply can be obtained from water supply agencies in the Industrial belt.

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

2.1.1.9. Stage of Ground Water Extraction

The stage of ground water extraction is defined by,

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

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

2.1.1.10. Validation of Stage of Ground Water Extraction

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

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

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

2.1.1.11.Categorisation of Assessment Unit

2.1.1.11.1.Categorisation of Assessment Unit Based on Quantity

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

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

2.1.1.11.2.Categorisation of Assessment Unit Based on Quality

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

2.1.1.12.Allocation of Ground Water Resource for Utilisation

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

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

Where,

Alloc = Allocation for domestic water requirement

N = population density in the unit in thousands per sq. km.

L_g= fractional load on ground water for domestic water supply (≤ 1.0)

2.1.1.13.Net Annual Ground Water Availability for Future Use

The water available for future use is obtained by deducting the allocation for domestic use and current extraction for Irrigation and Industrial uses from the Annual Extractable Ground Water Recharge. The resulting ground water potential is termed as the net annual ground water availability for future use. The Net annual ground water availability for future use is calculated separately for non-command areas and command areas. As per the recommendations of the R&D Advisory committee, the ground water available for future use can never be negative. If it becomes negative, the future allocation of Domestic needs can be reduced to current extraction for domestic use. Even then if it is still negative, then the ground water available for future uses has been projected as zero.

2.1.1.14.Additional Potential Resources under Specific Conditions

2.1.1.14.1.Potential Resource Due to Spring Discharge

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

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

Where,

Q = Spring Discharge

No of days = No of days spring yields.

2.1.1.14.2.Potential Resource in Waterlogged and Shallow Water Table Areas

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

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

Where,

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

A = Area of shallow water table zone.

S_Y = Specific Yield

2.1.1.14.3.Potential Resource in Flood Prone Areas

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

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

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

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

Where,

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

A = Flood Prone Area

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

Where the assessment unit is a watershed, there is a need to convert the ground water assessment in terms of an administrative unit such as block/ taluka/ mandal. This has been done as follows.

A block may comprise of one or more watersheds, in part or full. First, the ground water assessment in the subareas, command, non-command and poor ground water quality areas of the watershed has been converted into depth unit (mm), by dividing the annual recharge by the respective area. The contribution of this subarea of the watershed to the block, is now calculated by multiplying this depth with the area in the block occupied by this sub-area.

The total ground water resource of the block has been presented separately for each type of sub-area, namely for command areas, non-command areas and poor ground water quality areas, as in the case of the individual watersheds.

2.2. GROUND WATER ASSESSMENT IN URBAN AREAS

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

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

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

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

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

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

2.3. GROUND WATER ASSESSMENT IN WATER LEVEL DEPLETION ZONES

There are areas where ground water level shows a decline even in the monsoon season. The reasons for this may be any one of the following: (a) There is a genuine depletion in the ground water regime, with ground water extraction and natural ground water discharge in the monsoon season (outflow from the region and base flow) exceeding the recharge. (b) There may be an error in water level data due to inadequacy of observation wells.

If it is concluded that the water level data is erroneous, recharge assessment has been made based on rainfall infiltration factor method. If, on the other hand, water level data is assessed as reliable, the ground water level fluctuation method has been applied for recharge estimation. As ΔS in equation 3& 4 is negative, the estimated recharge will be less than the gross ground water extraction in the monsoon season. It must be noted that this recharge is the gross recharge minus the natural discharges in the monsoon season. The immediate conclusion from such an assessment in water depletion zones is that the area falls under the over-exploited category which requires micro level study.

2.4. NORMS HAS BEEN USED IN THE ASSESSMENT

2.4.1. Specific Yield

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

Table-2.1: Norms Recommended for Specific Yield

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
1	Alluvium	AL01	Younger Alluvium (Clay/Silt/Sand/ Calcareous concretions)	Quaternary	10	8	12
2	Alluvium	AL02	Pebble / Gravel/ Bazada/ Kandi	Quaternary	16	12	20
3	Alluvium	AL03	Older Alluvium (Silt/Sand/Gravel/Lithomargic clay)	Quaternary	6	4	8
4	Alluvium	AL04	Aeolian Alluvium (Silt/ Sand)	Quaternary	16	12	20
5	Alluvium	AL05	Coastal Alluvium (Sand/Silt/Clay)	Quaternary	10	8	12
6	Alluvium	AL06	Valley Fills	Quaternary	16	12	20
7	Alluvium	AL07	Glacial Deposits	Quaternary	16	12	20
8	Laterite	LT01	Laterite / Ferruginous concretions	Quaternary	2.5	2	3
9	Basalt	BS01	Basic Rocks (Basalt) - Weathered, Vesicular or Jointed	Mesozoic to Cenozoic	2	1	3
10	Basalt	BS01	Basic Rocks (Basalt) - Massive Poorly Jointed	Mesozoic to Cenozoic	0.35	0.2	0.5
11	Basalt	BS02	Ultra Basic - Weathered, Vesicular or Jointed	Mesozoic to Cenozoic	2	1	3
12	Basalt	BS02	Ultra Basic - Massive Poorly Jointed	Mesozoic to Cenozoic	0.35	0.2	0.5
13	Sandstone	ST01	Sandstone/Conglomerate	Upper Palaeozoic to Cenozoic	3	1	5
14	Sandstone	ST02	Sandstone with Shale	Upper Palaeozoic to Cenozoic	3	1	5
15	Sandstone	ST03	Sandstone with shale/ coal beds	Upper Palaeozoic to Cenozoic	3	1	5
16	Sandstone	ST04	Sandstone with Clay	Upper Palaeozoic to Cenozoic	3	1	5
17	Sandstone	ST05	Sandstone/Conglomerate	Proterozoic to Cenozoic	3	1	5

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
18	Sandstone	ST06	Sandstone with Shale	Proterozoic to Cenozoic	3	1	5
19	Shale	SH01	Shale with limestone	Upper Palaeozoic to Cenozoic	1.5	1	2
20	Shale	SH02	Shale with Sandstone	Upper Palaeozoic to Cenozoic	1.5	1	2
21	Shale	SH03	Shale, limestone and sandstone	Upper Palaeozoic to Cenozoic	1.5	1	2
22	Shale	SH04	Shale	Upper Palaeozoic to Cenozoic	1.5	1	2
23	Shale	SH05	Shale/Shale with Sandstone	Proterozoic to Cenozoic	1.5	1	2
24	Shale	SH06	Shale with Limestone	Proterozoic to Cenozoic	1.5	1	2
25	Limestone	LS01	Miliolitic Limestone	Quarternary	2	1	3
26	Limestone	LS01	KarstifiedMiliolitic Limestone	Quarternary	10	5	15
27	Limestone	LS02	Limestone / Dolomite	Upper Palaeozoic to Cenozoic	2	1	3
28	Limestone	LS02	Karstified Limestone / Dolomite	Upper Palaeozoic to Cenozoic	10	5	15
29	Limestone	LS03	Limestone/Dolomite	Proterozoic	2	1	3
30	Limestone	LS03	Karstified Limestone/Dolomite	Proterozoic	10	5	15
31	Limestone	LS04	Limestone with Shale	Proterozoic	2	1	3
32	Limestone	LS04	Karstified Limestone with Shale	Proterozoic	10	5	15
33	Limestone	LS05	Marble	Azoic to Proterozoic	2	1	3
34	Limestone	LS05	Karstified Marble	Azoic to Proterozoic	10	5	15
35	Granite	GR01	Acidic Rocks (Granite,Syenite, Rhyolite etc.) - Weathered , Jointed	Mesozoic to Cenozoic	1.5	1	2
36	Granite	GR01	Acidic Rocks (Granite,Syenite, Rhyolite etc.)-Massive or Poorly Fractured	Mesozoic to Cenozoic	0.35	0.2	0.5
37	Granite	GR02	Acidic Rocks (Pegmatite, Granite, Syenite, Rhyolite etc.) - Weathered, Jointed	Proterozoic to Cenozoic	3	2	4
38	Granite	GR02	Acidic Rocks (Pegmatite, Granite, Syenite, Rhyolite etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	0.35	0.2	0.5

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
39	Schist	SC01	Schist - Weathered, Jointed	Azoic to Proterozoic	1.5	1	2
40	Schist	SC01	Schist - Massive, Poorly Fractured	Azoic to Proterozoic	0.35	0.2	0.5
41	Schist	SC02	Phyllite	Azoic to Proterozoic	1.5	1	2
42	Schist	SC03	Slate	Azoic to Proterozoic	1.5	1	2
43	Quartzite	QZ01	Quartzite - Weathered, Jointed	Proterozoic to Cenozoic	1.5	1	2
44	Quartzite	QZ01	Quartzite - Massive, Poorly Fractured	Proterozoic to Cenozoic	0.3	0.2	0.4
45	Quartzite	QZ02	Quartzite - Weathered, Jointed	Azoic to Proterozoic	1.5	1	2
46	Quartzite	QZ02	Quartzite- Massive, Poorly Fractured	Azoic to Proterozoic	0.3	0.2	0.4
47	Charnockite	CK01	Charnockite - Weathered, Jointed	Azoic	3	2	4
48	Charnockite	CK01	Charnockite - Massive, Poorly Fractured	Azoic	0.3	0.2	0.4
49	Khondalite	KH01	Khondalites, Granulites - Weathered, Jointed	Azoic	1.5	1	2
50	Khondalite	KH01	Khondalites, Granulites - Mssive, Poorly Fractured	Azoic	0.3	0.2	0.4
51	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Weathered, Jointed	Azoic	1.5	1	2
52	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Massive, Poorly Fractured	Azoic	0.3	0.2	0.4
53	Gneiss	GN01	Undifferentiated metasedimentaries/ Undifferentiated metamorphic - Weathered, Jointed	Azoic to Proterozoic	1.5	1	2
54	Gneiss	GN01	Undifferentiated metasedimentaries/ Undifferentiated metamorphic - Massive, Poorly Fractured	Azoic to Proterozoic	0.3	0.2	0.4
55	Gneiss	GN02	Gneiss -Weathered, Jointed	Azoic to Proterozoic	3	2	4
56	Gneiss	GN02	Gneiss-Massive, Poorly Fractured	Azoic to Proterozoic	0.3	0.2	0.4
57	Gneiss	GN03	Migmatitic Gneiss - Weathered, Jointed	Azoic	1.5	1	2
58	Gneiss	GN03	Migmatitic Gneiss - Massive, Poorly Fractured	Azoic	0.3	0.2	0.4
59	Intrusive	IN01	Basic Rocks (Dolerite, Anorthosite etc.) - Weathered, Jointed	Proterozoic to Cenozoic	2	1	3

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
60	Intrusive	IN01	Basic Rocks (Dolerite, Anorthosite etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	0.35	0.2	0.5
61	Intrusive	IN02	Ultrabasics (Epidiorite, Granophyre etc.) - Weathered, Jointed	Proterozoic to Cenozoic	2	1	3
62	Intrusive	IN02	Ultrabasics (Epidiorite, Granophyre etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	0.35	0.2	0.5

2.4.2. Rainfall Infiltration Factor

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

Table-2.2: Norms Recommended for Rainfall Infiltration Factor

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

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
11	Basalt	BS02	Ultra Basic - Weathered	Mesozoic to Cenozoic	7	6	8
12	Basalt	BS02	Ultra Basic - Massive Poorly Jointed	Mesozoic to Cenozoic	2	1	3
13	Sandstone	ST01	Sandstone/Conglomerate	Upper Palaeozoic to Cenozoic	12	10	14
14	Sandstone	ST02	Sandstone with Shale	Upper Palaeozoic to Cenozoic	12	10	14
15	Sandstone	ST03	Sandstone with shale/ coal beds	Upper Palaeozoic to Cenozoic	12	10	14
16	Sandstone	ST04	Sandstone with Clay	Upper Palaeozoic to Cenozoic	12	10	14
17	Sandstone	ST05	Sandstone/Conglomerate	Proterozoic to Cenozoic	6	5	7
18	Sandstone	ST06	Sandstone with Shale	Proterozoic to Cenozoic	6	5	7
19	Shale	SH01	Shale with limestone	Upper Palaeozoic to Cenozoic	4	3	5
20	Shale	SH02	Shale with Sandstone	Upper Palaeozoic to Cenozoic	4	3	5
21	Shale	SH03	Shale, limestone and sandstone	Upper Palaeozoic to Cenozoic	4	3	5
22	Shale	SH04	Shale	Upper Palaeozoic to Cenozoic	4	3	5
23	Shale	SH05	Shale/Shale with Sandstone	Proterozoic to Cenozoic	4	3	5
24	Shale	SH06	Shale with Limestone	Proterozoic to Cenozoic	4	3	5
25	Limestone	LS01	Miliolitic Limestone	Quarternary	6	5	7
27	Limestone	LS02	Limestone / Dolomite	Upper Palaeozoic to Cenozoic	6	5	7
29	Limestone	LS03	Limestone/Dolomite	Proterozoic	6	5	7
31	Limestone	LS04	Limestone with Shale	Proterozoic	6	5	7
33	Limestone	LS05	Marble	Azoic to Proterozoic	6	5	7
35	Granite	GR01	Acidic Rocks (Granite,Syenite, Rhyolite etc.) - Weathered , Jointed	Mesozoic to Cenozoic	7	5	9
36	Granite	GR01	Acidic Rocks (Granite,Syenite, Rhyolite etc.)-Massive or Poorly Fractured	Mesozoic to Cenozoic	2	1	3

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
37	Granite	GR02	Acidic Rocks (Pegmatite, Granite, Syenite, Rhyolite etc.) - Weathered, Jointed	Proterozoic to Cenozoic	11	10	12
38	Granite	GR02	Acidic Rocks (Pegmatite, Granite, Syenite, Rhyolite etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3
39	Schist	SC01	Schist - Weathered, Jointed	Azoic to Proterozoic	7	5	9
40	Schist	SC01	Schist - Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3
41	Schist	SC02	Phyllite	Azoic to Proterozoic	4	3	5
42	Schist	SC03	Slate	Azoic to Proterozoic	4	3	5
43	Quartzite	QZ01	Quartzite - Weathered, Jointed	Proterozoic to Cenozoic	6	5	7
44	Quartzite	QZ01	Quartzite - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3
45	Quartzite	QZ02	Quartzite - Weathered, Jointed	Azoic to Proterozoic	6	5	7
46	Quartzite	QZ02	Quartzite- Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3
47	Charnockite	CK01	Charnockite - Weathered, Jointed	Azoic	5	4	6
48	Charnockite	CK01	Charnockite - Massive, Poorly Fractured	Azoic	2	1	3
49	Khondalite	KH01	Khondalites, Granulites - Weathered, Jointed	Azoic	7	5	9
50	Khondalite	KH01	Khondalites, Granulites - Mssive, Poorly Fractured	Azoic	2	1	3
51	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Weathered, Jointed	Azoic	7	5	9
52	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Massive, Poorly Fractured	Azoic	2	1	3
53	Gneiss	GN01	Undifferentiated metasedimentaries/ Undifferentiated metamorphic - Weathered, Jointed	Azoic to Proterozoic	7	5	9
54	Gneiss	GN01	Undifferentiated metasedimentaries/ Undifferentiated metamorphic - Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3
55	Gneiss	GN02	Gneiss -Weathered, Jointed	Azoic to Proterozoic	11	10	12
56	Gneiss	GN02	Gneiss-Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3
57	Gneiss	GN03	Migmatitic Gneiss - Weathered, Jointed	Azoic	7	5	9

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
58	Gneiss	GN03	Migmatitic Gneiss - Massive, Poorly Fractured	Azoic	2	1	3
59	Intrusive	IN01	Basic Rocks (Dolerite, Anorthosite etc.) - Weathered, Jointed	Proterozoic to Cenozoic	7	6	8
60	Intrusive	IN01	Basic Rocks (Dolerite, Anorthosite etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3
61	Intrusive	IN02	Ulrta Basics (Epidiorite, Granophyre etc.) - Weathered, Jointed	Proterozoic to Cenozoic	7	6	8
62	Intrusive	IN02	Ulrta Basics (Epidiorite, Granophyre etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3

2.4.3. Norms for Canal Recharge

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

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

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

2.4.4. Norms for Recharge Due to Irrigation

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

Table-2.4: Norms Recommended for Recharge from Irrigation

DTW m bgl	Ground Water		Surface Water	
	Paddy	Non-paddy	Paddy	Non-paddy
≤ 10	45.0	25.0	50.0	30.0
11	43.3	23.7	48.3	28.7
12	40.4	22.1	45.1	26.8
13	37.7	20.6	42.1	25.0
14	35.2	19.2	39.3	23.3

DTW m bgl	Ground Water		Surface Water	
	Paddy	Non-paddy	Paddy	Non-paddy
15	32.9	17.9	36.7	21.7
16	30.7	16.7	34.3	20.3
17	28.7	15.6	32.0	18.9
18	26.8	14.6	29.9	17.6
19	25.0	13.6	27.9	16.4
20	23.3	12.7	26.0	15.3
21	21.7	11.9	24.3	14.3
22	20.3	11.1	22.7	13.3
23	18.9	10.4	21.2	12.4
24	17.6	9.7	19.8	11.6
≥ 25	20.0	5.0	25.0	10.0

2.4.5. Norms for Recharge due to Tanks & Ponds

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

2.4.6. Norms for Recharge due to Water Conservation Structures

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

2.4.7. Unit Draft

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

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

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

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

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

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

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

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

CHAPTER 3

RAINFALL

Ladakh is characterized by a cold desert and fragile ecosystem that is geographically connected to the Western Himalaya and highly susceptible to changing climate.

he general climate of Ladakh is classified as a cold desert climate. Throughout the year, the region experiences extremely low humidity and significant temperature variations between day and night. The climate is harsh, with long, bitterly cold winters and short, mild summers. Precipitation is scarce, occurring mostly in the form of snow during the winter months, contributing to the region's stark and arid landscape. Despite these conditions, Ladakh receives a good amount of sunshine throughout the year, which, combined with its thin air, can lead to surprisingly warm feelings in direct sunlight, even when temperatures are low.

1. **Normal Rainfall of the State/ UT**

S.No.	Districts	Normal Rainfall (mm)		
		Monsoon	Non-Monsoon	Total
1	**Kargil**	10.4	78.9	89.3
2	**Leh**	26	36.4	62.4
	Total	**36.4**	**115.3**	**151.7**

2. **District Wise Normal Rainfall of the State/UT**

S.No.	Districts	Normal Rainfall (mm)		
		Monsoon	Non-Monsoon	Total
1	**Kargil**	10.4	78.9	89.3
2	**Leh**	26	36.4	62.4
	Total	**36.4**	**115.3**	**151.7**

3. **Rainfall during the Calendar Year 2023 for the State/UT and District Wise**

S.No.	Districts	Normal Rainfall (mm)		
		Monsoon	Non-Monsoon	Total
1	**Kargil**	10.4	78.9	89.3
2	**Leh**	26	36.4	62.4
	Total	**36.4**	**115.3**	**151.7**

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

S.No.	Districts	Normal Rainfall (mm)		
		Monsoon	Non-Monsoon	Total
1	**Kargil**	10.4	78.9	89.3
2	**Leh**	26	36.4	62.4
	Total	**36.4**	**115.3**	**151.7**

CHAPTER 4

HYDROGEOLOGICAL SETUP LADAKH

4. HYDROGEOLOGY

Based on geology and aquifer characteristics, the area of the Ladakh region can be divided into two broad hydrogeological units. These units are

I. Porous formations

II. Fissured formations.

***I. Porous formations:* -**This includes moraines and Fluvioglacial Deposits of Ladakh. The area is situated on the northern bank of the Indus River and covers an area of about 100 sq. km between Phyang Nala in the west to Sabu Nala in the east. The sediments consist of morainic material, overlain by varved clays and silts of lacustrine origin, again overlain by morainic boulders and cobbles in mechanically disintegrated loose sandy matrix deposited by rivers.

II. *Fissured formations:* - These include hard igneous, sedimentary& metamorphic rocks.

4.1 LEH DISTRICT

This district has the distinction of having its border with three countries viz China in the north and east, Afganistan in the northwest corner, and Pakistan in the west. It is further bounded by Kargil district in the west and state of Himachal Pradesh towards South East. The total geographical area of the district is 45110 Sq.km. The altitude of the area varies from 3000-8000 m amsl. Indus and Shyok are the main valleys lndus river is the lifeline of the entire Leh district. The important plains are the Leh plain, More plain, Hanle Plain, Depsang plain, and soda plain. Some of the highest peaks of the Western Himalayas are also located in this district. The valley parts viz., Phyang, Nubra and Chusul are taken as assessment units in Leh District for the evaluation of the groundwater resources.

4.1.1 HYDROGEOLOGY AND SUB SURFACE CORRELATION

Leh valley is a broad U-shaped valley bounded by the Ladakh range in the North and Zanskar range in the south. The plain is underlain by morainic deposits consisting of boulders, cobbles, pebbles embedded in an arenaceous matrix, and the lake deposits comprising predominantly of clays, sandy clays, and silt. The sediments are overlain by varved clays and silts of lacustrine origin again succeeded by morainic boulders and cobbles in a disintegrated loose sandy matrix and alluvial deposits.

Groundwater Exploration by CGWB is confined to Leh Plains and Nubra Valley. A percussion rig was flown to this area in the year 1973, heralded a new chapter in Groundwater Exploration in India in view of the district's unique location. Seventeen exploratory wells, beginning from the year 1973, have been drilled in the district up to 2019.

Based on data collected from these boreholes as shown in table No. It is concluded that the depth to the water level in the constructed wells ranges from 1.30 m bgl at Zorawar fort to 43.36 m bgl at the ITBP II site. The yield obtained from these wells ranged from as low as 197 lpm for 16.57 m drawdown at Skalzangling to as high as 1600 lpm for a drawdown of 3.0 m at Pituk site.

Groundwater exploration activities again resumed in the Leh district during the AAP 2005-2006. Eight exploratory tube wells and 01 Observation Well were constructed in Leh plains and Nubra Valley. The Depth of tube wells ranges from 43 mts at Siachen to 84 mts at Patter Sahib and the yield varies from 1000 lpm at pather Sahib to 1200 lpm at Siachen Base-III.

Almost in all the boreholes, coarser Clastic sediments in the form of Sand, Cobbles, Pebbles, and boulders with very thin bands of finer Clastic sediments were encountered between 25 and 62.0 m. bgl. The Transmissivity values range between 204 to 28465 m^2/day.

No attempt has been made to draw Hydrogeological cross-sections in the absence of any major finer Clastic bands within the limited drilling depth of 65 to 70 m bgl. The electrical conductivity of groundwater remains within 360 micro-mhos-cm. Proving its suitability for every purpose.

4.2 KARGIL DISTRICT

Kargil district with headquarters at Kargil town lies between the northern latitude $75^0$45’ to $76^0$30’and longitude $34^0$15’ to $34^0$47’30”. Leh bounds this district on the northeastern side, **L**ine Of **C**ontrol in the north, and Anantnag, Baramula, Srinagar, and Kishtwar districts on the South Western side. Suru, Zanskar, Drass Shamker Chikara, Wakna, Laws, and Indus were some of the valleys of this district. District Headquarters, Kargil, is approachable by National Highway NH-44, from Srinagar, at a distance of 204 km. As the area is accessible by road from May to October and remains under snow cover during the rest of the period.

Kargil district has a total geographical area of 14,036 sq km, comprising 129 villages, 02 tehsils (Kargil and Zanskar), 09 CD blocks (Kargil, Shaker, Drass, Sankoo, Zanskar, Shargole, Taisuru, G.M. Pur, and Cha development blocks), and 65 Village Panchayats. The valley parts of Kargil Town Shankoo, Drass, Chanigound Olding, Khachay Shargole and Zansakr are taken as assessment units in Kargil District for the evaluation of the groundwater resources.

4.2.1 HYDROGEOLOGY

Groundwater occurs mainly in the morainic deposits comprising of Talus and Scree formations. Groundwater levels in these deposits are very deep & range between 60 m to 75 m bgl

The chemical quality in the Kargil district is by and large fit for drinking and irrigation purposes. From the chemical quality point of view, groundwater in the area is fresh and potable with electrical conductivity (EC) generally less than 700 µS/cm at 25°C. But in Sankoo village, Fluoride content more than the permissible limits of 1.5 mg/lt is observed.

Central Groundwater Board has explored valley-fill deposits of Kumathang Cantt area by constructing one exploratory tubewell. The total depth of this tubewell is 86.00 m bgl. The zones encountered are 63.00 to 71.00 m and 78.00 to 84.00 m bgl.

CHAPTER-5

GROUND WATER LEVEL SCENARIO IN THE UT

5.1 Groundwater Level Scenario (2023)

Groundwater level data of pre-monsoon 2023
Groundwater level data for post-monsoon 2023

5.1.0 Fluctuation of Groundwater Level:

Comparison of Pre-monsoon 2023 to Pre-monsoon 2022
Comparison of November 2023 to November 2022
Comparison of Pre-Monsoon 2023 with decadal mean of Pre-Monsoon (2013 to 2022)
Comparison of post-monsoon 2023 with decadal mean of post-monsoon (2013 to 2022)

Maps
Depth to Water Level Map of the State/UT (Pre Monsoon 2023 and Post Monsoon 2023)
Groundwater Level Fluctuation: Pre-monsoon 2022 compared to Pre-monsoon 2023
Groundwater Level Fluctuation: November 2022 compared to November 2023
Decadal water level fluctuation with mean Pre-Monsoon (2013 to 2022) and Pre-Monsoon 2023
Decadal water level fluctuation with mean Post-Monsoon (2013 to 2022) and Post-Monsoon 2023

NOT APPLICABLE IN THE UT OF LADAKH AS NO WATER LEVEL DATA MONITORING IS BEING DONE BY THE CGWB NWHR JAMMU.

CHAPTER 6

GROUND WATER RESOURCES OF THE UT

6.1. ANNUAL GROUND WATER RECHARGE

The annual groundwater recharge of Leh is calculated as 5181.04 ham and for Kargil it is about 1560.85 ham. The Valleys and Plain areas of UT of Ladakh have been taken as assessment units and for computing the rainfall recharge during monsoon season. The rainfall Infiltration Factor (RIF) Method has been mostly applied as the difference of computing this with Water Level Fluctuations (WLF) Method. WLF Method was not considered as data is not available.

6.2. ANNUAL EXTRACTABLE GROUND WATER RESOURCES

The annual extractable Groundwater resources as calculated through Ingres in Kargil district is 4662.92 ham and in Leh district is 1404.78 ham.

6.3. ANNUAL TOTAL GROUND WATER EXTRACTION

The annual total ground water extraction in Kargil and Leh is 479.72 ham and 1397.16 ham respectively. The most of extraction is done for the domestic use. The extraction for domestic, industrial and irrigation for Kargil district is 454.57 ham,17.90 ham and 7.24 ham respectively**.** The extraction for domestic, industrial and irrigation for Leh district is 1281.61 ham,49.86 ham and 65.67 ham respectively

6.4. STAGE OF GROUND WATER EXTRACTION

The stage of groundwater extraction of Ladakh is calculated as 30.93 %. The stage of extraction in Kargil district is 34.15 % and Leh district is 29.16 %.

6.5. CATEGORIZATION OF ASSESSMENT UNITS

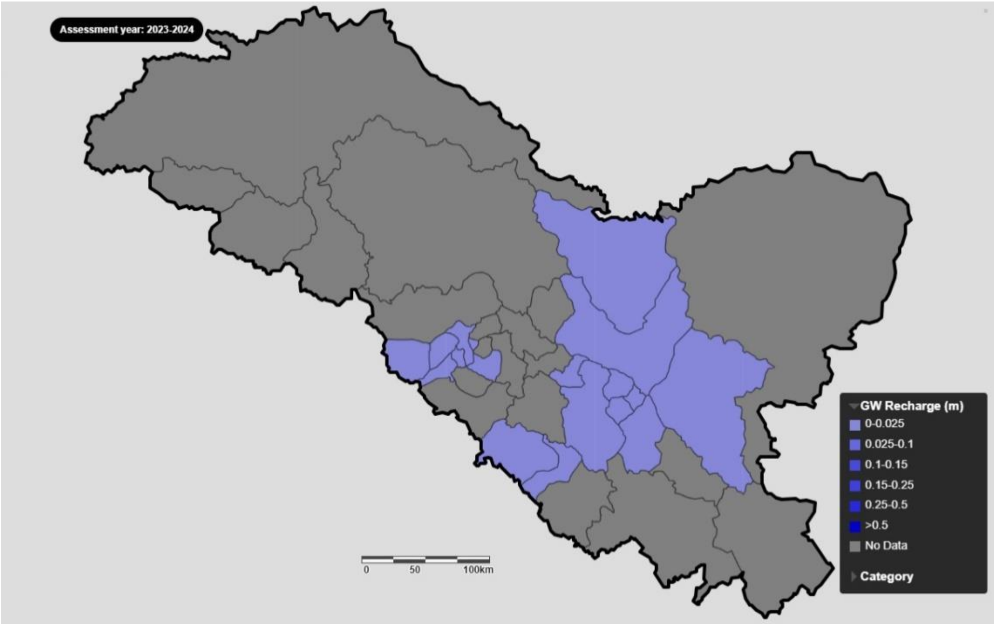
The stage of assessment and their respective characterization is mentioned in the following table:

Table 1: Stage of Groundwater development and respective characterization of all assessment units

Sr. No	Assessment Unit (Block)/ District	Stage of Groundwater Development (%)	Pre-monsoon	Post-monsoon	Categorization for future groundwater development (Safe/semi-critical /critcal/over-exploited
			Water level Trend Is there a significant decline (Yes/No)	Water level Trend Is there a significant decline (Yes/No)	
1	Kharu	61.42	Not Available	Not Available	Safe
2	Chuchot	38.76	Not Available	Not Available	Safe
3	Diskit	12.95	Not Available	Not Available	Safe
4	Durbuk	18.05	Not Available	Not Available	Safe
5	Panamic	15.61	Not Available	Not Available	Safe
6	Saspol	26.7	Not Available	Not Available	Safe
7	Thiksay	61.6	Not Available	Not Available	Safe
8	Leh	81.98	Not Available	Not Available	Semi Critical
9	Nimoo	18.94	Not Available	Not Available	Safe
10	Gm pora	48.8	Not Available	Not Available	Safe
11	Pashkum	66.64	Not Available	Not Available	Safe
12	Zanskar	22.55	Not Available	Not Available	Safe
13	Bimbat	32.18	Not Available	Not Available	Safe
14	Drass	36.02	Not Available	Not Available	Safe
15	Kargil	45.06	Not Available	Not Available	Safe
16	Karsha	31.68	Not Available	Not Available	Safe
17	Sankoo	43.73	Not Available	Not Available	Safe
18	Shargole	17.46	Not Available	Not Available	Safe

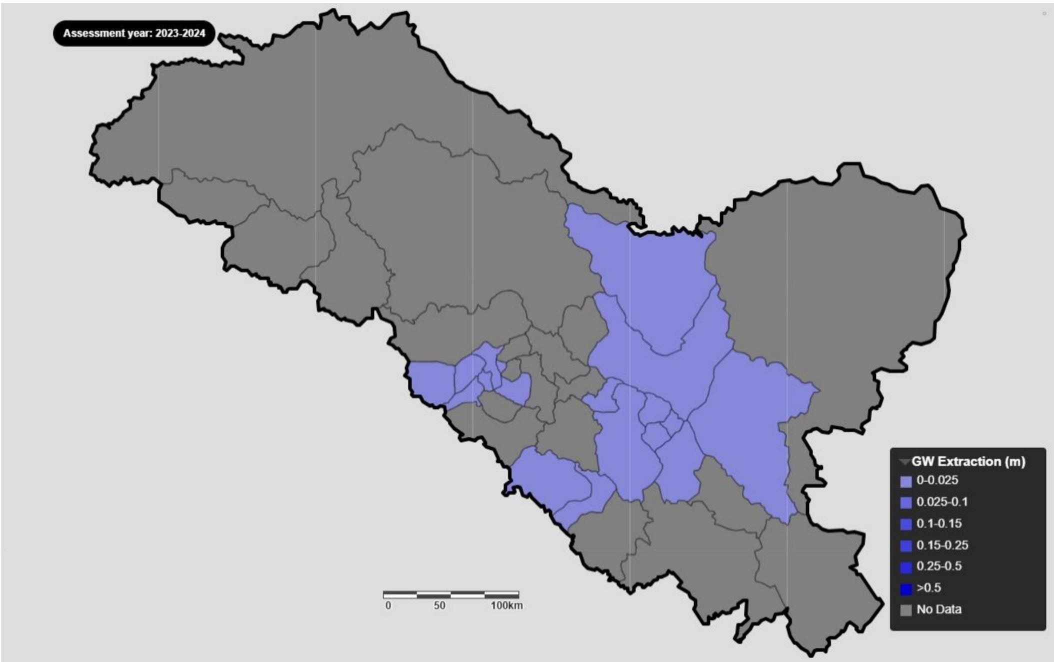
6.6. COMPARISION WITH PREVIOUS ASSESSMENT

Unit Recharge Map of UT of Ladakh



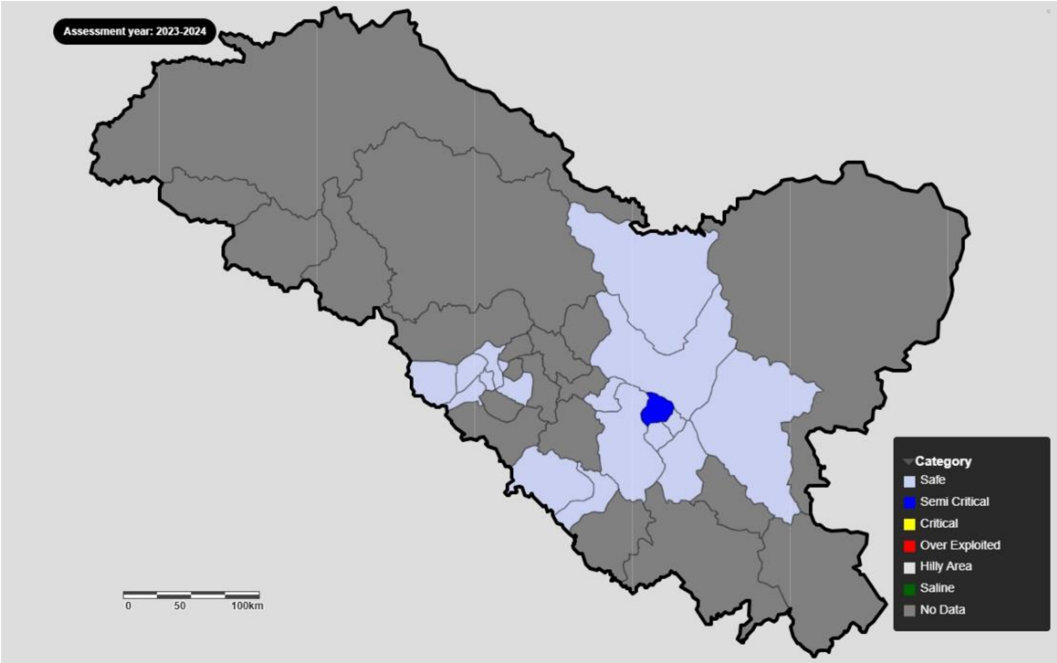
MAP 1. Unit Recharge Map of UT of Ladakh

Extraction Map of the UT of Ladakh



MAP 2. Extraction Map of the UT of Ladakh

Categorization Map of the UT of Ladakh



MAP 3. Categorization Map of the UT of Ladakh

Diagrams

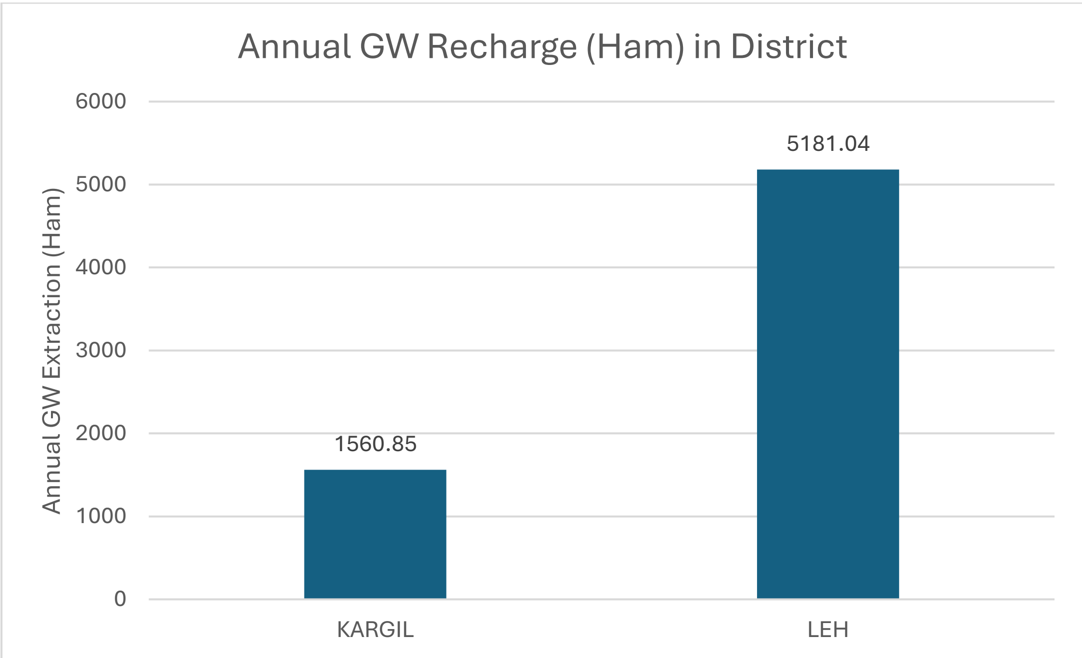


Figure 2. Bar Diagram with District wise Recharge

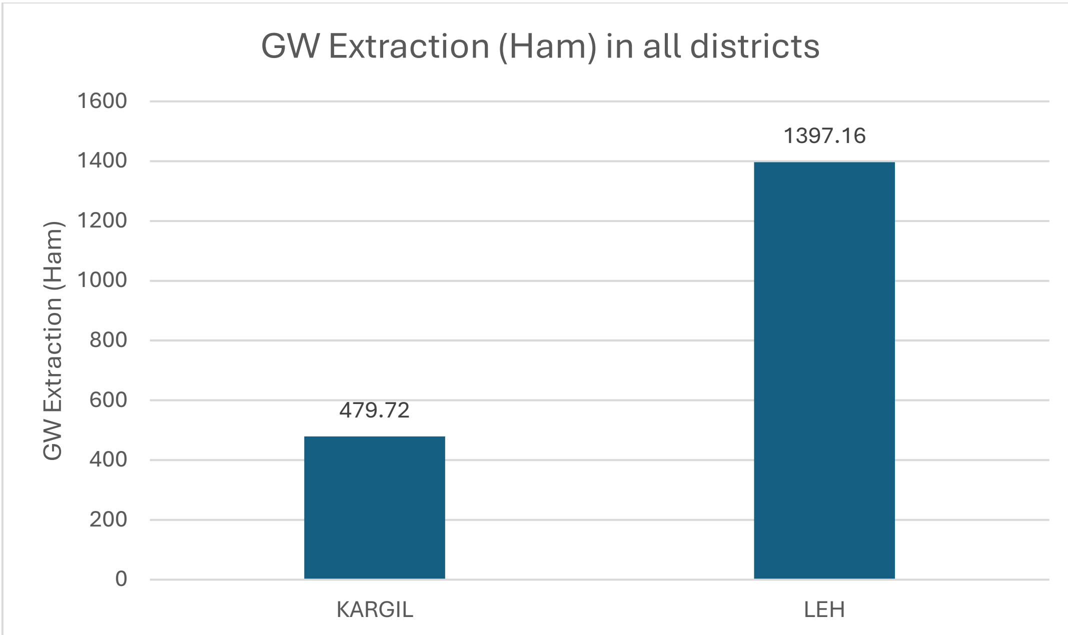


Figure 3.Bar Diagram with District wise Extraction figures

Bar Diagram with District wise Rech, Extraction figures

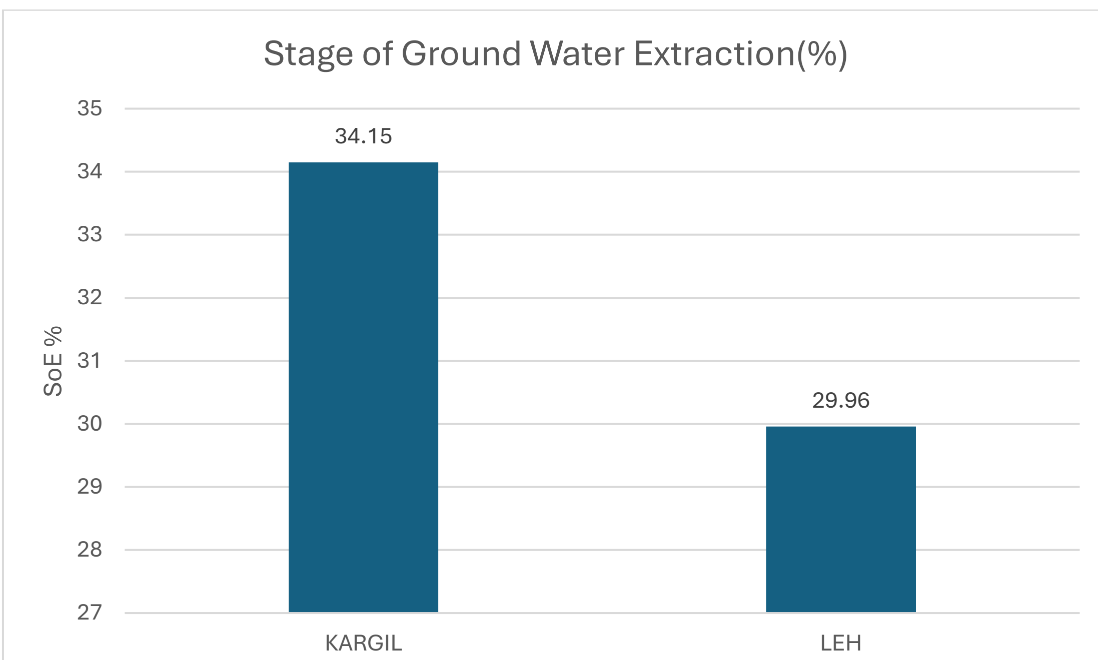


Figure 4.Bar Diagram of SoE of all the Districts in Decreasing order

CHAPTER 7

CONCLUSIONS

The conclusions that can be drawn from the exercise of Groundwater Resource Estimation 2024, are as follows:

1. The overall stage of Groundwater extraction for UT of Ladakh is 30.93 % and stage of groundwater extraction for Leh and Kargil is 34.15 % and 29.96 % respectively.

2. The recharge worthy area in Leh and Kargil district is 71400 hectare and 24900 hectare respectively. All the calculations have been carried out using the mentioned recharge worthy area.

3. All the assessment units in Leh districts are in safe category except Leh block which is in semi critical category.

4. All the assessment unit in Kargil district are in safe category. The status of all the assessment units have maintained the same status.

5. The blocks of Leh district like Kharu, Chuchot, Saspol, Thiksay, and Nimoo have improved from Semi critical to safe category.

6. The net Annual Groundwater availability for future use for the UT of Ladakh is 4190.82 ham and bifurcation for the Annual Groundwater available for future use for Leh and Kargil district is 3265.76 ham and 925.06 ham respectively.

7. There is no chemical issues as such observed in the UT of Ladakh. The groundwater Quality is considerably suitable for drinking and agriculture purpose.

Annexure-I

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

S. No.	Assessment Unit (Block)/District	Net Annual Groundwater Availability (ham)	Utilization (ham)	Stage of extraction (%)
	1	2	3	4
1	KHARU	183.12	112.47	61.42
2	CHUCHOT	476.19	184.59	38.76
3	DISKIT	1264.31	163.78	12.95
4	DURBUK	606.36	109.43	18.05
5	PANAMIC	661.43	103.24	15.61
6	SASPOL	284.05	75.84	26.7
7	THIKSAY	129.57	79.81	61.6
8	LEH	583.12	478.06	81.98
9	NIMOO	474.77	89.94	18.94
10	GM PORA	91.83	44.81	48.8
11	PASHKUM	62.98	41.97	66.64
12	ZANSKAR	273.58	61.70	22.55
13	BIMBAT	139.89	45.01	32.18
14	DRASS	182.91	65.88	36.02
15	KARGIL	199.83	90.04	45.06
16	KARSHA	126.57	40.10	31.68
17	SANKOO	125.94	55.07	43.73
18	SHARGOLE	201.25	35.14	17.46

Annexure-II

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

S. No.	Assessment Unit (Block)/District	Net Annual Groundwater Availability (ham)	Utilization (ham)	Stage of extraction (%)
	1	2	3	4
1	Leh	4662.92	1397.16	29.96
2	Kargil	1404.78	479.72	34.15

Annexure-III(A)

Categorization of blocks/ mandals/ taluks in India (as in 2024) for the State/UT

Sr. No	Assessment Unit (Block)/ District	Stage of Groundwater Development (%)	Categorization for future groundwater development (Safe/semi-critical /critcal/over-exploited
1	Leh	29.96	Safe
2	Kargil	34.15	Safe

Annexure III (B)

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

Sr. No	Assessment Unit (Block)/ District	Stage of Groundwater Development (%)	Categorization for future groundwater development (Safe/semi-critical /critcal/over-exploited
1	Kharu	61.42	Safe
2	Chuchot	38.76	Safe
3	Diskit	12.95	Safe
4	Durbuk	18.05	Safe
5	Panamic	15.61	Safe
6	Saspol	26.7	Safe
7	Thiksay	61.6	Safe
8	Leh	81.98	Semi Critical
9	Nimoo	18.94	Safe
10	Gm pora	48.8	Safe
11	Pashkum	66.64	Safe
12	Zanskar	22.55	Safe
13	Bimbat	32.18	Safe
14	Drass	36.02	Safe
15	Kargil	45.06	Safe
16	Karsha	31.68	Safe
17	Sankoo	43.73	Safe
18	Shargole	17.46	Safe

Annexure III (C)

Annual Extractable Ground Water Resource of Assessment Units under Different Category for the State/UT (as in 2024)

ANNUAL EXTRACTABLE RESOURCE OF ASSESSMENT UNITS UNDER DIFFERENT CATEGORIES, 2024													
S.No	State/Union Territories	Total Annual Extractable Resource of Assessed Units (in mcm)	Safe		Semi-Critical		Critical		Over-Exploited		Saline		
			Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	
1	LADAKH	60.68	54.85	90.39	5.83	9.61	-	-	-	-	-	-	
	Total	60.68	54.85	90.39	5.83	9.61	-	-	-	-	-	-	
	Grand Total	60.68	54.85	90.39	5.83	9.61	-	-	-	-	-	-	

Annexure- III (D)

District Wise Annual Extractable Ground Water Resource of Assessment Units under Different Category for the State/UT (as in 2024)

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024												
LADAKH												
S.No	Name of District	Total Annual Extractable Resource of Assessed Units (in mcm)	Safe		Semi-Critical		Critical		Over-Exploited		Saline	
			Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%
1	LEH	46.63	40.8	87.49	5.83	12.51	-	-	-	-	-	-
2	KARGIL	14.05	14.05	100	-	-	-	-	-	-	-	-
	Total	60.68	54.85	90.39	5.83	9.61	-	-	-	-		
	Grand Total	60.68	54.85	90.39	5.83	9.61	-	-	-	-		

Annexure- III (E)

Recharge Worthy Area of Assessment unit under Different Category for the State/UT (as in 2024)

GENERAL DESCRIPTION OF THE ADMINISTRATIVE UNIT OF THE LADAKH UNION TERRITORY as on 31.3.2024										
S. No.	Name of Assessment Unit (Part of district)	Type of rock formation	Areal Extent (in Hectares)							
					Groundwater Recharge Worthy Area		Shallow Water Table Area	Flood Prone Area	Bottom of the unconfined aquifer in soft rock areas and depth of weathered zone and/or maximum depth of fractures under unconfined zone(m)
			Total Geographical Area	Hilly Area	Command Area/Non-Command Area	Poor Groundwater Quality Area			
1	Kharu	Alluvium	175500	172700	2800	Nil	Nil	Nil	Nil
2	Chuchot	Alluvium	35800	28400	7400	Nil	Nil	Nil	Nil
3	Diskit	Alluvium	616400	597100	19300	Nil	Nil	Nil	Nil
4	Durbuk	Alluvium	830800	821500	9300	Nil	Nil	Nil	Nil
5	Panamic	Alluvium	804800	795100	9700	Nil	Nil	Nil	Nil
6	Saspol	Alluvium	52400	47800	4600	Nil	Nil	Nil	Nil
7	Thiksay	Alluvium	22600	20600	2000	Nil	Nil	Nil	Nil
8	Leh	Alluvium	48000	39000	9000	Nil	Nil	Nil	Nil
9	Nimoo	Alluvium	284300	277000	7300	NIL	NIL	NIL	NIL
10	Gm pora	Alluvium	15700	13800	1900	NIL	NIL	NIL	NIL
11	Pashkum	Alluvium	5900	4600	1300	NIL	NIL	NIL	NIL
12	Zanskar	Alluvium	128600	121100	7500	NIL	NIL	NIL	NIL
13	Bimbat	Alluvium	52100	50900	1200	NIL	NIL	NIL	NIL
14	Drass	Alluvium	123200	121600	1600	NIL	NIL	NIL	NIL
15	Kargil	Alluvium	42400	38300	4100	NIL	NIL	NIL	NIL
16	Karsha	Alluvium	232200	228700	3500	NIL	NIL	NIL	NIL
17	Sankoo	Alluvium	41300	38700	2600	NIL	NIL	NIL	NIL
18	Shargole	Alluvium	51600	50400	1200	NIL	NIL	NIL	NIL

Annexure III (F)

District Wise Recharge Worthy Area of Assessment unit under Different Category for the State/UT (as in 2024)

GENERAL DESCRIPTION OF THE ADMINISTRATIVE UNIT OF THE LADAKH UNION TERRITORY as on 31.3.2024										
S. No.	Name of Assessment Unit (Part of district)	Type of rock formation	Areal Extent (in Hectares)							
					Groundwater Recharge Worthy Area		Shallow Water Table Area	Flood Prone Area	Bottom of the unconfined aquifer in soft rock areas and depth of weathered zone and/or maximum depth of fractures under unconfined zone(m)
			Total Geographical Area	Hilly Area	Command Area/Non-Command Area	Poor Groundwater Quality Area			
1	Leh	Alluvium	2870600	2799200	71400	Nil	Nil	Nil	Nil
2	Kargil	Alluvium	693000	668100	24900	Nil	Nil	Nil	Nil

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

S.No.	District	Assessment Unit	Groundwater Recharge (Ham)	Natural Discharge (Ham)	Annual Extractable Ground Water Resources (Ham)	Ground Water Extraction (Ham)	Stage of GW Extraction (%)	Category
1.	Leh	Leh	647.91	64.79	583.12	478.06	81.98	Semi-Critical

Annexure IV (B)
Quality problems in Assessment units (as in 2024)
There are no quality problems in any of the assessment units of UT of Ladakh.

Annexure IV (C)
List of Saline Assessment units
There are no saline water problems in any of the assessment units of UT of Ladakh.

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

Comparison of Stage of Ground Water Extraction & Categorization of Previous and Present Assessment Units														
S. No.	AU (Districts)	Stage of Ground Water Extraction (%) & Categories				as on March 2022			as on March 2023			As on March 2024		
		2011	2013	2017	2020	AU (Valleys)	SOE	Category	AU (Blocks)	SOE	Category	AU (Blocks	SOE	Category
	Kargil	9.26 (Safe)	3.79 (Safe)	13.8 (Safe)	3.4 (Safe)	Kargil town	47.5	Safe	Pashkum	31.58	Safe	Pashkum	66.64	Safe
									Sankoo	32.00	Safe	Sankoo	43.73	Safe
									Gm Pora	31.88	Safe	Gm Pora	48.8	Safe
									Kargil	32.85	Safe	Kargil	45.06	Safe
						Chanigod Olding	5.46	Safe	Kargil	32.85	Safe	Kargil	45.06	Safe
						Khachay Shargole	46.4	Safe	Shargole	41.19	Safe	Shargole	17.46	Safe
						Zanskar	25.5	Safe	Karsha	19.19	Safe	Karsha	31.68	Safe
									Zanskar	19.15	Safe	Zanskar	22.55	Safe
						Drass	18.3	Safe	Bimbat	13.17	Safe	Bimbat	32.18	Safe
									Drass	12.93	Safe	Drass	36.02	Safe

Comparison of Stage of Ground Water Extraction & Categorization of Previous and Present Assessment Units														
S. No.	Stage of Ground Water Extraction (SOE %) & Category					as on March 2022			as on March 2023			As on March 2024		
	AU (District)	2011	2013	2017	2020	AU (Valleys)	SOE (%)	Category	AU (Blocks)	SOE (%)	Category	AU (Blocks)	SOE (%)	SOE (%)
1	Leh	1.4 (Safe)	4.26 (Safe)	18.7 (Safe)	36.1 Safe)	Chusul	2.9	Safe	Durbuk	2.75	Safe	Durbuk	18.05	Safe
2						Nubra	18.6	Safe	Panamic	16.44	Safe	Panamic	15.61	Safe
3									Diskit	17.06	Safe	Diskit	12.95	Safe

4						**Phyang**	**84.1**	**Semi-Critical**	**Kharu**	**77.94**	**Semi-Critical**	**Kharu**	**61.42**	**Safe**
5									**Chuchot**	**79.08**	**Semi-Critical**	**Chuchot**	**38.76**	**Safe**
6									**Saspol**	**82.07**	**Semi-Critical**	**Saspol**	**26.7**	**Safe**
7									**Thiksay**	**77.93**	**Semi-Critical**	**Thiksay**	**61.6**	**Safe**
8									**Leh**	**80.33**	**Semi-Critical**	**Leh**	**81.98**	**Semi-Critical**
9									**Nimoo**	**78.30**	**Semi-Critical**	**Nimoo**	**18.94**	**Safe**

Annexure V (B)

Comparison of categorization of assessment units (2023 to 2024)

Assessment Units	**Categorization as per 2023**	**Categorization as per 2024**
Kharu	Semi Critical	Safe
Chuchot	Semi Critical	Safe
Diskit	Safe	Safe
Durbuk	Safe	Safe
Panamic	Safe	Safe
Saspol	Semi Critical	Safe
Thiksay	Semi Critical	Safe
Leh	Semi Critical	Semi Critical
Nimoo	Semi Critical	Safe
Gm pora	Safe	Safe
Pashkum	Safe	Safe
Zanskar	Safe	Safe
Bimbat	Safe	Safe
Drass	Safe	Safe
Kargil	Safe	Safe
Karsha	Safe	Safe
Sankoo	Safe	Safe
Shargole	Safe	Safe

Annexure VI

Sl.No	State	District	Assessment Unit Name	Total Geographical Area	Recharge Worthy Area	Recharge from Rainfall-MON	Recharge from Other Sources-MON	Recharge from Rainfall-NM	Recharge from Other Sources-NM	Total Annual Ground Water (Ham) Recharge
1	LADAKH	LEH	KHARU	175500	2800	16.02	165.03	22.42	0	203.47
2	LADAKH	LEH	CHUCHOT	35800	7400	42.33	427.52	59.26	0	529.11
3	LADAKH	LEH	DISKIT	616400	19300	110.4	1139.84	154.55	0	1404.79
4	LADAKH	LEH	DURBUK	830800	9300	53.2	546.07	74.47	0	673.74
5	LADAKH	LEH	PANAMIC	804800	9700	55.48	601.76	77.68	0	734.92
6	LADAKH	LEH	SASPOL	52400	4600	26.31	252.46	36.84	0	315.61
7	LADAKH	LEH	THIKSAY	22600	2000	11.44	116.5	16.02	0	143.96
8	LADAKH	LEH	LEH	48000	9000	51.48	524.36	72.07	0	647.91
9	LADAKH	LEH	NIMOO	284300	7300	41.76	427.31	58.46	0	527.53
10	LADAKH	KARGIL	GM PORA	15700	1900	4.39	64.7	32.94	0	102.03
11	LADAKH	KARGIL	PASHKUM	5900	1300	3	44.43	22.54	0	69.97
12	LADAKH	KARGIL	ZANSKAR	128600	7500	17.32	156.63	130.02	0	303.97
13	LADAKH	KARGIL	BIMBAT	52100	1200	2.77	131.86	20.8	0	155.43
14	LADAKH	KARGIL	DRASS	123200	1600	3.7	171.79	27.74	0	203.23
15	LADAKH	KARGIL	KARGIL	42400	4100	9.47	141.48	71.08	0	222.03
16	LADAKH	KARGIL	KARSHA	232200	3500	8.09	71.87	60.68	0	140.64
17	LADAKH	KARGIL	SANKOO	41300	2600	6.01	88.86	45.07	0	139.94
18	LADAKH	KARGIL	SHARGOLE	51600	1200	2.77	200.04	20.8	0	223.61

Annexure VII

I/11923

सत्यमेव जयते

भारत 2023 INDIA

वसुधैव कुटुम्बकम्

ONE EARTH · ONE FAMILY · ONE FUTURE

संघ राज्य प्रशासन, लद्दाख

सामान्य प्रशासन विभाग

THE ADMINISTRATION OF UNION TERRITORY OF LADAKH

GENERAL ADMINISTRATION DEPARTMENT

F. No. M/29/2022-GAD SEC

ई-मेल/email:pstocomsecutl@gmail.com
gad.utladakh@ladakh.gov.in

यूटी सचिवालय, लेह /UT Secretariat, Leh
Dated: -06.07.2023

Subject: - Constitution UT level Committee for estimation of Ground Water Resources in the Union territory.

Order No. 220-LA(GAD) of 2023,
Dated: -06.07.2023.

Sanction is hereby accorded to the constitution of "UT Level Ground Water Resources Committee", comprising the following for estimation of Ground Water Resources and coordinating the activities of Ground Water Resource Assessment in the Union territory of Ladakh:

1.	Administrative Secretary, PHE/I&FC Department.	Chairperson
2.	Director, Industries & Commerce.	Member
3.	Director, Rural Development & Panchayati Raj.	Member
4.	Director Housing and Urban Development.	Member
5.	Director, Horticulture/Agriculture.	Member
6.	Chief Engineer, PHE/I&C.	Member
7.	Chief Engineer, NHPC, Ladakh	Member
8.	Regional Director, Central Ground Water Board.	Member/Convener
9.	Any other Officer to be co-opted by the Chairperson of the Committee, if required, as a special invitee.	Member

The terms of reference of the UT level Committee shall be as under:

i. To coordinate with Central Ground Water Board in carrying out the annual Ground Water Resource Assessment activities in the Union territory.

ii. To assess annual water recharge of the UT in accordance with the Ground Water Resources Estimation methodology.

ZAKIR HUSSAIN Digitally signed by ZAKIR HUSSAIN Date: 2023.07.06 12:22:37 +05'30'

I/11923

iii. To estimate the status of utilization of the annual ex-tractable Ground Water Resources.

The Committee shall be serviced by the PHE/I&FC Department.

By order of the Administration of UT, Ladakh.

Sd-

अजीत कुमार साहू, आईएएस/Ajeet Kumar Sahu, IAS

आयुक्त /सचिव/Commissioner/ Secretary.

General Administration Department.

Copy to the: -

1. Chairman, Central Ground Water Board, Ministry of Jal Shakti, Government of India.
2. Joint Secretary (Jammu, Kashmir & Ladakh), Ministry of Home Affairs, Government of India.
3. Sh. Satish Kumar, Member Central Ground Water Board, Ministry of Jal Shakti, Government of India.
4. Regional Director, Central Ground Water Board (CGWB), Regional Unit, Jammu.

Copy also to the: -

1. All Administrative Secretaries.
2. Commissioner/Secretary, PHE/I&FC Department.
3. Secretary to Hon'ble Lieutenant Governor.
4. Deputy Commissioners/CEOs, LAHDC, Leh/Kargil.
5. All Heads of the Department.
6. Director, Industries & Commerce.
7. Director, Rural Development & Panchayati Raj.
8. Director Housing and Urban Development.
9. Director, Horticulture/Agriculture.
10. Chief Engineer, PHE/I&FC.
11. Chief Engineer, NHPC
12. Technical Director, NIC, Leh.
13. Pvt. Secretary to Advisor, Ladakh for information of the Advisor.
14. Superintendent Archive, Archaeology & Museums.
15. Pvt. Secretary to Commissioner/Secretary, General Administration Department for information of the Commissioner/Secretary.
16. Order/Stock file (w.2.s.c)/e-file No.4451.

ZAKIR HUSSAIN

Digitally signed by ZAKIR HUSSAIN
Date: 2023.07.06
12:22:54 +05'30'

(जाकिर हुसैन/Zakir Hussain) JKAS,

प्रशासन के उप सचिव/Deputy Secretary to the Administration.

G20

The Administration of Union Territory of Ladakh
Office of the Chief Engineer PHE/I&FC Department Ladakh
cepheifcladakh@gmail.com

The Commissioner/ Secretary,
PHE/I&FC Department,
UT Ladakh

No - CE/PHE-I&FC/2-23-24/ 1200-04

Dated - 23.08.2023

Subject - Constitution of Working group and data for ground water Resources estimation for UT of Ladakh upto March 2024-reg

Reference - Department of water resources Central Water Board Letter No - TC-22/NWHR/GWRE/2023/136 dated - 10.8.2023

Sir,

As desired, a working group for ground water resources estimation has to be constituted to work as assessment cell for ground water resources estimation upto March 2024 consisting of the following member /officials if approved.

Part A Officials from UT Ladakh

1.	Chief Engineer PHE/I&FC Department UT Ladakh	Chairperson
2.	Executive Engineer, PHE Division Leh	Member
3.	Executive Engineer, I&FC Division Leh	Member
4.	Sh. Shahid Salim Banday AEE PHE Division Leh	Member
5.	Smt Kousar Jabeen AEE I&FC Division kargil	Member

Part B Officials from Central Ground Water Board:-

01.	Mr. M.L. Angurala	SCI-D	Nodal Officer
02.	Mr. Kush Kumar	STA(HG)	Member

Submitted for approval Please

Yours Faithfully,

(Er. Sonam Wangchuk)
Chief Engineer
PHE/I&FC Department
UT Ladakh, Kargil.

Copy to the:-

1. Superintending Engineer, PHE/I&FC Circle Kargil/Leh for information and n/action
2. Executive Engineer I&FC Division Leh for information
3. Executive Engineer PHE Division Leh for Information

Minutes of the Meeting of the SLC Committee.

Draft Minutes of Meeting of UT Level Committee for Ground Water Resource Estimation for UT of Ladakh, as on 31st March, 2024 held on 06.06.2024

UT Level Committee for Ground Water Resource Estimation for UT of Ladakh, as on 31st March, 2024 held on 06.06.2024 at 11.30 AM through virtual mode under the chairmanship of Sh. Sh. Michael M. D'Souza IAS, Administrative Secretary, PHE/I&FC Department, UT of Ladakh & Chairman of UT Level Ground Water Resources Estimation Committee (UTLEC).

The list of participants is given in Annexure-I.

At the outset of the meeting, Sh. M.L. Angurala, Sc-D, Central Ground Water Board, Jammu welcomed the Chairman of SLEC, UT of Ladakh. The meeting was started with introduction of committee members and the agendas to be discussed during meeting proceedings started by way of presentation of the Ground Water Resource Estimation as on March, 2024. Procedures and methodology to be adopted for ground water resource estimation of UT of Ladakh was explained in detail. The committee has in principle accepted the of GWRE as on March, 2024.

After elaborate discussion with the committee members, the Chairman (SLEC) advised

- Block Boundaries will be utilized for carrying out assessment at the block level.
- Ground Water Extraction (Domestics/ Irrigation and Industrial etc) data wil be provided by State GW /Nodal Department.
- Ground water recharge from other sources (Surface water, ground water, canal, pond etc.) should be incorporated in detail in this year assessment.
- Monsoon and non-monsoon component should be replaced by pre-precipitation and post- precipitation period.
- New tube-wells constructed by PHE/I & FC will be included for the assessment.
- The Chairman (SLEC) emphasized that GWRE in Ladakh may be done accordance with the agro-climatic conditions in Ladakh region as the region has negligible rainfall during

monsoon season and sufficient snow fall in winter season, so the term precipitation may be term in place of rainfall in case of Ladakh.

- Detailed aquifer mapping of Leh town (Urban study) may be carryout by Central Ground Water Board.
- Area having slope more than 20% , where sufficient snow fall taken place also be considered as Groundwater recharge worthy area.
- Methodology and approach to restore Semi-critical/critical category of Stage of Ground Water Extraction to safer category was discussed by CGWB, HOO.
- A cumulative training for data collection and entry in INGRESS portal for GWRE 2023 of UT of Ladakh need to be demonstrated to State GW /Nodal Department GWRE concerned committee members.
- Compiling of basic data/map/information available for each assessment units jointly by officers of by CGWB and State GW /Nodal Department.

CGWB, NWHR, Jammu assured the all advisory will be discussed with the higher authority and will be taken into consideration during GWRE 2024.

Agenda II: Identification of sites for construction of Piezometers & installation of digital Water Level Recorders Telemetry System

Out of 61 proposed Piezometer sites i.e. 35 in Leh and 26 in Kargil district, 25 Pz sites in Leh and 5 Pz sites in Kargil are selected whereas 10 and 21 sites are pending respectively. The Chairman emphasized the NOC for site selection of proposed Piezometers will be provided from the concerned authority.

Meeting ended with the vote of thanks to the Chair.

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GOVERNMENT OF INDIA
(Ministry of Jal Shakti)
Department of Water Resources, River Development & Ganga Rejuvenation
CENTRAL GROUND WATER BOARD
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TC-22/NWHR/GWRE/2024-25 -376 Dated: 04.11.2024

Minutes of Meeting held on 04.10.2024 for approval of GWRE as on March 2024

2nd meeting of UT Level Committee for Ground Water Resource Estimation as on 31st March, 2024 for UT of Ladakh was held on 04.10.2024 at 04.00-PM in Hybrid mode under the Chairmanship of Sh. Michael M. D'Souza IAS, Administrative Secretary, PHE/IFC, UT of Ladakh & Chairperson UTLEC Ladakh.

The approved Minutes of Meeting are enclosed for kind information.

(M.L. Angurala)
Head of Office &
(Member Secretary)
UTLEC

Distribution
1. Director Rural Development Department & Panchayati Raj
2. Director, Industries/ Commerce Department, Ladakh
3. Director. Housing & Urban Development Department, Ladakh
4. Director, Horticulture Department, Ladakh.
5. Chief Engineer, PW(R&B)/ PMGSY/ Mechnical, Ladakh
6. Chief Engineer, PHE/ I&FC, Leh, Ladakh.
7. Deputy Secretary, PHE/I&FC Ladakh.
8. Assistant Director (Planning),PHE/I&FC, Ladakh.

Minutes of Second Meeting of
"UT Level Ground Water Resource Estimation Committee"
Held in Civil Secretariat in Leh on 04-10-2024 at 1600 hrs
Union Territory of Ladakh

The Second meeting of UT Level Ground Water Resource Estimation Committee as on March 2024 was held on 04-10-2024 at 04.00 PM in hybrid mode under the Chairmanship of Sh. Michael M. D'Souza IAS, Administrative Secretary, PHE/IFC, UT of Ladakh & Chairperson UTLEC Laddakh. The list of participants is given in Annexure-I.

Chairman welcomed the members of UTLEC Ladakh and other officers from Central Ground water Board and administration of Ladakh and Sh. M.L. Angurala briefed about the importance of GWRE 2024 and the agenda points for discussion during meeting.

(A) Ground Water Resource Estimation (GWRE) as on March 2024

- First presentation was made by Sh. Kush Kumar, STA-Hg on the Procedures/methodology (GEC 2015) adopted for ground water resource estimation of UT of Ladakh. It was informed that Ground Water Resource Estimation as on March 2024 has been completed considering development block as Assessment unit.
- Out of 31 blocks, only 18 blocks found worthy of ground recharge and considered for Ground Water assessed.
- Leh block in Leh district has the highest stage of ground water extraction (81.98%) between 70% & 90% and categorized as Semi critical. Remaining Assessment unit/ blocks fall in safe category (SOGE <70%).

After elaborate discussions, the UTLEC Ladakh, in principle, accepted the results of Ground Water Resource Estimation Committee 2024.

- Further, Chairman advised the Chief Engineer PHE/I&FC, UT of Ladakh to ensure that
    - During ensuing assessment (GWRE 2025) all requisite data pertaining to ground water recharge and extraction are used in estimation of Ground Water Resources.
    - Further refinement of ground water worthy area for inclusion of more blocks of UT of Ladakh for succeeding year of 2025, may be considered.
    - Geotagging of tube well/ bore well in ground worthy area of UT of Ladakh by PHE/ I&FC department for higher precision and accuracy of data to be ensured.

- Conjunctive use of surface and sub-surface water suggested to reduce the stress on ground water so as to improve ground Stage of Water Ground Extraction (SOGE), in Leh and surrounding area for Ground Water Resource Estimation during 2025 may be ensured.

(B) NAQUIM 2.0 Springshed Development studies in Parts of Kargil District

- Second presentation on the outcome of NAQUIM 2.0 Springshed Development studies in Parts of Kargil District in 2023-2024 was made by Sh. Naresh Singh Barti (AHG). Presentation highlighted the spring type, occurrence, distribution in various geological and hydrogeological environments.
- Occurrence of Arsenic in higher concentration (more than permissible limits) was discussed in details.
- The outcome of spring shed development was highly appreciated by the chairmen and all other members of committee.
- The Chairman of UTLEC advised Chief Engineer PHE/I&FC to take appropriate measures to stop the use of water from Arsenic and Nickel contaminated springs.

The meeting ended with note of thanks to The Chair.

Annexure-I

The list of the officers who attended the "UT Level Ground Water Resource Estimation Committee" held in Civil Secretariat in Leh on 04-10-2024 at 1600 hrs for Union Territory of Ladakh

Sh. Michael M. D'Souza, IAS, Administrative Secretary, PHE/IFC Department, UT of Ladakh (in Chair)

A. **List of Officers from UT of Ladakh :**

1. *Sh. Sajad Qadri, JKAS, Director, Rural Development & Panchayati Raj, UT of Ladakh.*
2. *Sh. Mohammad Nazir Sheikh, JKAS, Director, Industries& Commerce, UT of Ladakh.*
3. *Sh. Moses Kunzang, JKAS, Director, Housing & Urban Development UT of Ladakh.*
4. *Sh. Tsewang, I/c Director, Horticulture Department, Ladakh.*
5. *Sh. Abdul Mutalib, Chief Engineer, PW(R&B)/PMGSY/Mechanical, UT of Ladakh.*
6. *Sh. Maqbool Hussain, Chief Engineer, PHE/ I&FC, UT of Ladakh.*
7. *Sh. Zakir Hussain, JKAS, Deputy Secretary, PHE/I&F Department, UT of Ladakh.*
8. *Sh. Tsewang Norboo, Assistant Director (Planning), PHE/I&FC Department, UT of Ladakh.*

B. **List of Officers from Central Ground Water Board:**

1. M.L. Angurala, Head of Office, CGWB, NWHR, Jammu, J&K.
2. Naresh Singh Barti Assistant Hydrogeologist CGWB, NWHR, Jammu, J&K.
3. Kush Kumar, STA (Hg), CGWB, NWHR, Jammu, J&K.