Restricted/for official Use Only

GOVERNMENT OF INDIA

Ministry of Jal Shakti

Department of Water Resources RD&GR

GROUND WATER MONITORING BULLETIN

MAY–2024

JAMMU & KASHMIR

CENTRAL GROUND WATER BOARD

North Western Himalayan Region

Jammu

GOVERNMENT OF INDIA

Ministry of Jal Shakti

Department of Water Resources

River Development and Ganga Rejuvenation

GROUND WATER MONITORING BULLETIN

MAY–2024

JAMMU & KASHMIR

Principal Contributor: **Rayees Ahmad Pir (Scientist–B)**

CENTRAL GROUND WATER BOARD

NORTH WESTERN HIMALAYAN REGION

3rd Floor, Jal Ayog Bhawan, Rajinder Nagar, Phase 1,

Ban Talab Jammu – 181 123

Jammu

GROUNDWATER MONITORING BULLETIN JAMMU & KASHMIR MAY 2024

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

Jammu and Kashmir is the northern most UT of India after Ladakh. It lies within latitudes of 32°17’ and 36°08’ N and longitudes of 73°23’ and 76°47' E. The UT has a total geographical area of 42,241 Sq. Km. The Union Territory has an international border with Pakistan in the west. The States of Punjab and Himachal Pradesh forms its southern border and the UT of Ladakh form the northern and north eastern border. Major parts of the J&K State represent high and rugged mountainous terrain. Jammu & Kashmir is divided into two administrative divisions’ viz. Kashmir Division and Jammu division. NHS monitoring is being carried out for valley parts (Alluvium area) of 6 districts in the Jammu region (Jammu, Samba, Kathua, Rajouri, Reasi, and Udhampur) and 5 districts of the Kashmir Region (Kupwara, Baramulla, Pulwama, Anantnag, and Srinagar). There is a total of 20 districts in J&K UT. The administrative map of the state is shown in figure 1.

The Central Ground Water Board started monitoring of groundwater regime through the All-India network of hydrograph stations from 1969 onwards. The density of observation wells increased year after year. Earlier groundwater monitoring was carried out through a network of open wells, generally dug wells for drinking purposes tapping shallow aquifers. Keeping in view the importance of future groundwater development, the network was subsequently strengthened by the construction of purpose-built piezometers. Presently in Jammu and Kashmir, a total of 336 dug wells and 89 Piezometers are being monitored for this purpose. The Central Groundwater Board, North Western Himalayan Region is monitoring water levels in observation wells in Jammu and Kashmir State four times a year viz. May (between 20th and 31st), August (between 20th and 31st), November (1st and 10th), and January (1st and 10th). Water samples from observation wells are collected once a year during May for quality testing. The water level and chemical analysis data thus collected is analysed and interpreted by GEMS and Map Info software and Groundwater Regime Monitoring Bulletin is prepared and issued seasonally with interpreted data and thematic maps depicting the groundwater scenario of J&K UT.

The total number of active groundwater monitoring wells is 425 (Dug Wells 336 and Piezometers 89) as on January 2024 which are located in alluvial areas of Jammu, Kathua, Samba, Rajouri, Reasi, Udhampur, Srinagar, Baramulla, Anantnag, Kupwara and Pulwama Districts. Most monitoring stations fall in valley areas of these districts. The present report discusses the regional behaviour of water levels in phreatic aquifers for the period May 2024 which will enable user agencies to plan development strategies.

The main objectives of groundwater regime monitoring in Jammu and Kashmir may be summarised as follows:

1. To study the fluctuation of water levels both spatially and temporally in response to groundwater recharge and/or discharge.
2. To evaluate changes in groundwater level with respect to the preceding year for the same period.
3. To evaluate changes in groundwater levels with respect to a long-term average water level such as the decadal mean.
4. To study the fluctuation of water level during different seasons.

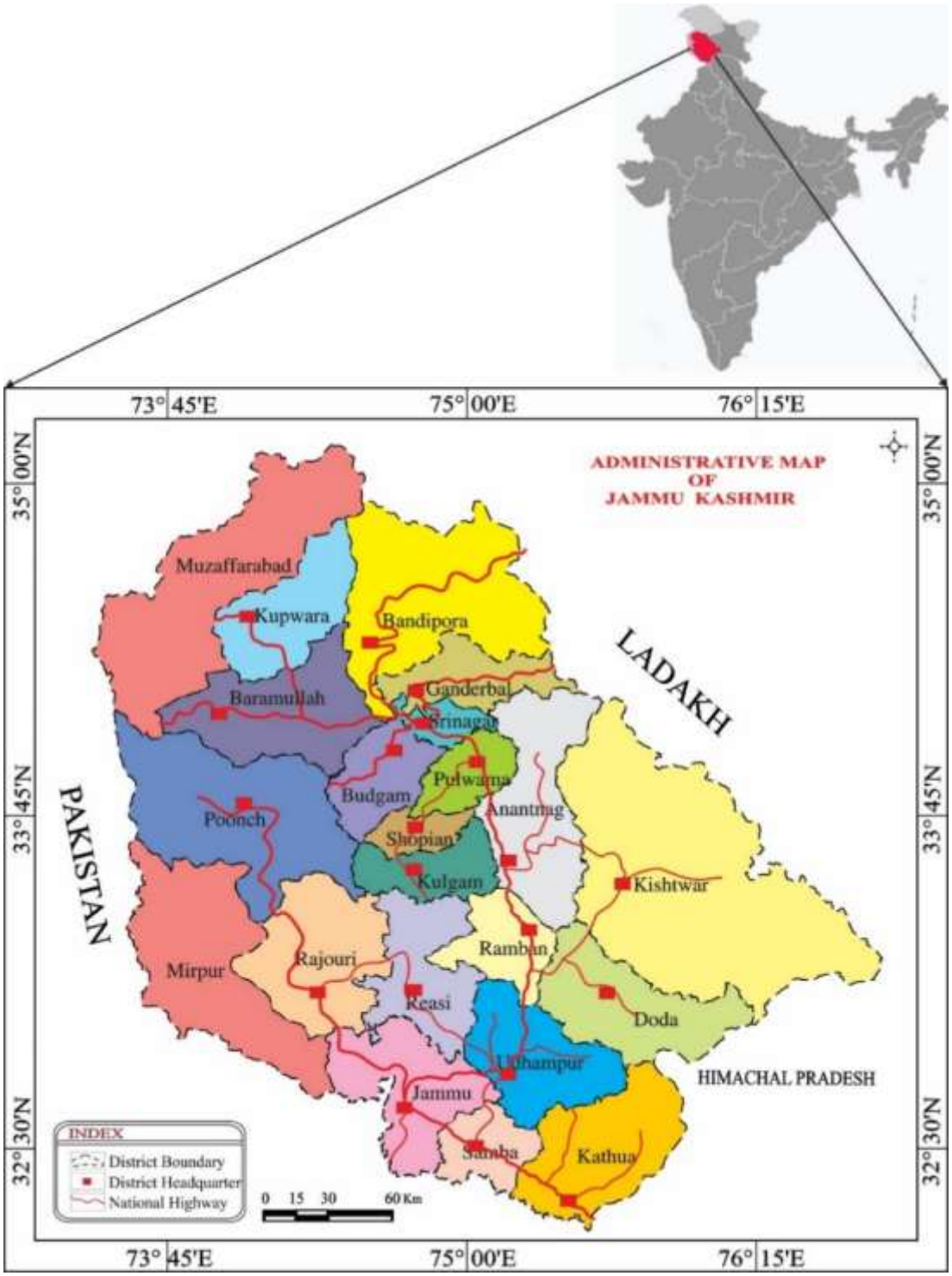

Figure. 1 Administrative Map of J&K

Status of Hydrograph Network Stations

In Jammu & Kashmir, at present, 425 Hydrograph Network Stations are being monitored during pre-monsoon and post-monsoon periods. 241 NHS exist in Jammu Region and 95 stations in Kashmir Region. To date, no monitoring stations have been established in Ladakh Region. District-wise number of hydrograph network stations as of 31.03.2024 and their locations are shown in Figure 2.

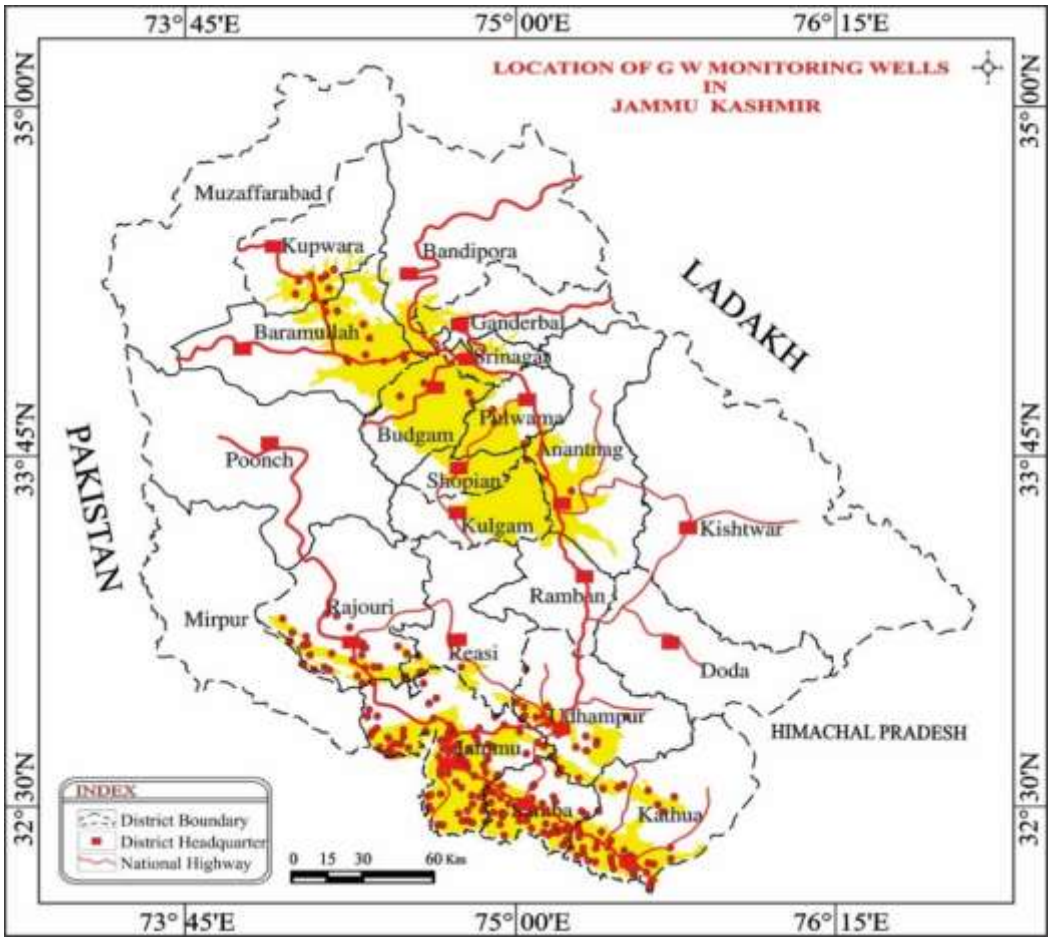

Figure 2. Location Map of Groundwater monitoring wells in Alluvial Aquifers in J&K

1.1 PHYSIOGRAPHY

Physiography of the Jammu & Kashmir State is highly varied with the highest mountain ranges in the world, extensive plateau, enormous valleys, deep gorges, and large canyons in the Middle and Trans-Himalayan Regions. The individual ranges have characteristic steep slopes towards the south and a much gentle slope towards the north. The northern slopes are covered with a thick and dense growth of vegetation. While the southern slopes are mostly bare, with thin sparse forest cover. The Zanskar range separates Ladakh Region from Kashmir Valley while the Pir Panjal range divides Jammu Region and Kashmir Valley (Figure 3). The state can be divided into six distinct physiographic units as discussed below.

Sirowal Belt: The Sirowal belt covers an area of about 1000 km^2 and has an average topographic gradient of 1:250 to 1:300 in the southwest direction. The land elevation of the Sirowal belt above the mean sea level is normally within 320 m. Southern parts of Jammu and Kathua Districts fall in this belt.

Kandi Belt: The elevation of the Kandi belt ranges between 320 m and 400 m above mean sea level (m AMSL). The average topographic gradient varies between 1:60 and 1:100. Kandi belt covers an area of about 1500 km^2 and occupies parts of Jammu and Kathua Districts imperceptibly north of the Sirowal belt. Kandi belt in Jammu & Kashmir state runs in a northwest-southeast direction as a narrow strip between rivers Munawar Tawi in the west and Ravi in the east. The belt is occupied by reworked Siwalik debris, which has a master slope towards the southwest.

Siwalik Region: The land elevation of the Siwalik region ranges between 400 m and 750 m above mean sea level. Ridges and small independent valleys are the prominent features of the Siwalik region which covers parts of Kathua, Jammu, Udhampur, and Rajouri Districts.

Kashmir Valley: The elevation of the valley floor above the mean sea level ranges between 1500 m and 2000 m. Kashmir valley covers an area of 5600 km and comprises parts of Budgam, Pulwama, Srinagar, Anantnag, Baramulla, and Kupwara Districts.

Hilly Mountains: The high mountain ranges have an elevation between 2000 m and 5000 m above MSL and form parts of Udhampur, Anantnag, Baramulla, Srinagar, and Kupwara Districts.

Trans-Himalayan Zone: The trans-Himalayan zone constitutes the inaccessible mountainous terrain of the Kargil and Leh districts in the Ladakh Region. The elevation of this zone varies between 5000 m and 8000 m above mean sea level. However, along the lower reaches of the Indus and Shyok rivers, the elevation is less than 5000 m.

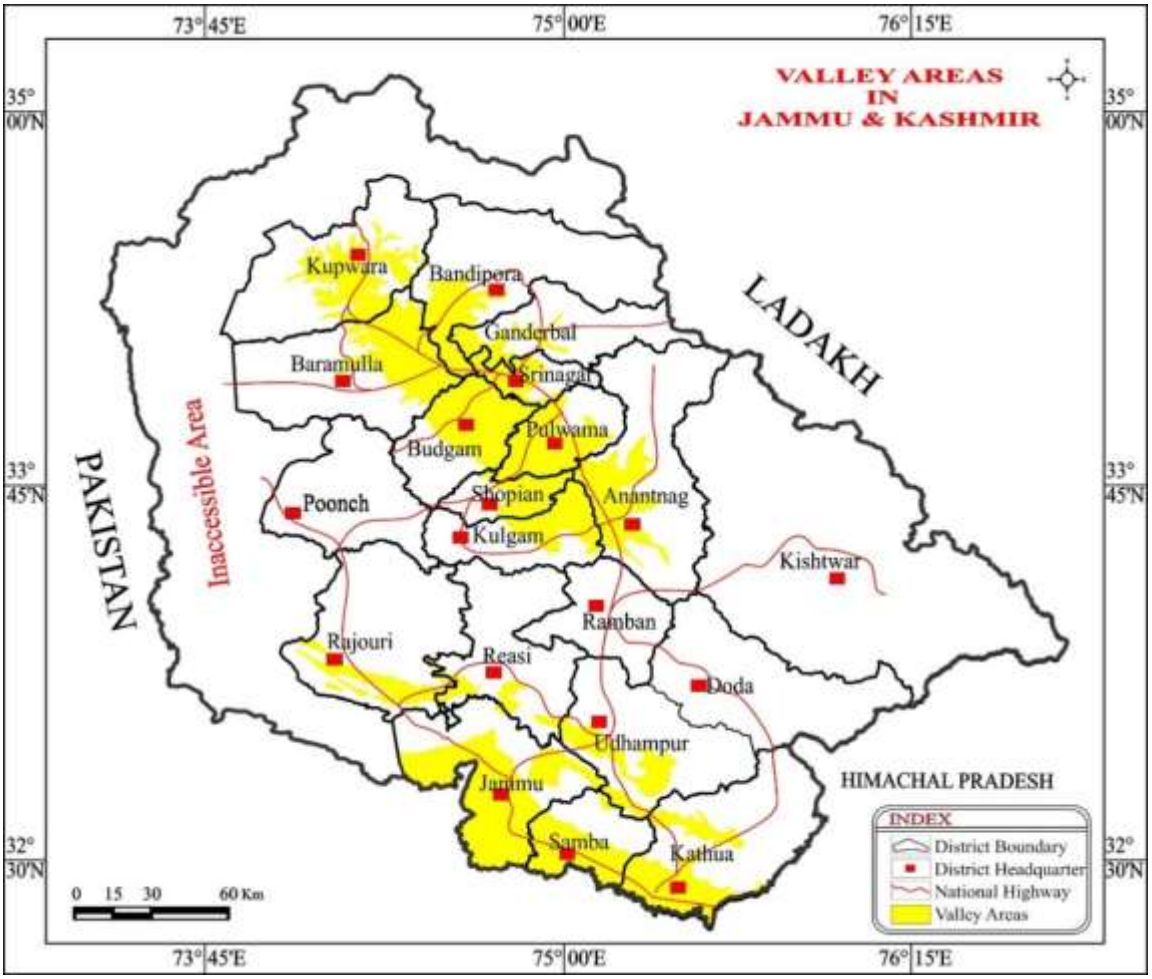

Figure 3. Map showing Valley areas in J&K

1.2. GEOLOGY

Geological formations ranging in age from Pre-Cambrian to Recent are found in the State. These formations can broadly be classified into three categories. Hard or consolidated- rocks comprising granites, slates, quartzite, Panjal traps, limestone, etc. Semi-consolidated rocks comprising claystone, siltstone, sandstone, etc. Unconsolidated formations from Quaternary to Recent age are comprised of Clay, Silt, Sand, Gravel, pebbles, boulders, etc. The brief geological setting of the state is given in Table 2.

Table 1 Geological Setting in J&K State

Age	**Formation**
Recent to Sub-recent	Alluvium
Pleistocene	Karewas
Middle Pliocene to Pleistocene	Siwaliks
Miocene	Murees
Unconformity	
Eocene	Subathu Formation
Cretaceous/ Eocene	Volcanics/ Basic Intrusives
Cretaceous	Flysch Beds
Jurassic	Punch-Mandi Formations
Triassic	Mandi& Infra-Triassic Formations
Paleozoic	Panjal Traps/ Tanwal
Carboniferous / Permian	Agglomeratic Slates Fenestella Shales Gondwana Formations Zewan Beds
Silurian-Devonian	MuthQuartzites
Upper Pre-Cambrian to Lower Cambrian	Dogra Slates
Lower Pre-Cambrian	Salkhala Series
Pre-Cambrian	Granite & Basic Intrusives

The Salkhala outcrops have been traced in the form of hairpin bend around the northwestern end of the Kashmir Valley. The salkhala group comprises a succession of Carbonaceous Shales, Schists, graphitic phyllites, carbonaceous limestones, dolomites, marbles, and quartzites. The Salkhala group is stratigraphically overlain by Dogra Salates, which conformably grades into the lower paleozoic succession. In the southern part of Kashmir, the Dogra Slates are conformably overlain by a succession of phyllites, sandstones, massive quartzites, grits, and conglomerates known as Tanawals and suggesting that the succession bridges the gap between Dogra Slate and upper Paleozoic rocks in the south and southwestern Kashmir.

The Paleozoic formations of Kashmir exposed along the pir-panjal range and great Himalayan ranges rest either over Dogra slates or pre-Cambrian crystalline rocks of the Salkhal group. A succession of white quartzites, Shales, siltstones, and dolomitic limestones exposed around Kashmir synclinorium has been referred to as Muth formation. In the Northern part of Kashmir, the Muth Quartzites are conformably overlain by Syringothris limestone, a succession of Grey and dark

blue limestone with a few interbedded shales, quartzites, and traps. The formation is exposed along the southern slopes of Pirpanjal near Banihal.

Agglomeratic slate series is well exposed in the Pir Panjal range Baramulla district, Liddar valley, Anantnag District, and Kistwar in Doda district. The polymioctites consists of rock fragments derived from glacial erosion as well as from volcanic outburst. It is a succession of slates, sandstone, quartzite, and a few bands of conglomerates. The Agglomeratic slate series is overlain and often intermixed with a thick succession of Andesitic and basaltic traps known as Panjal volcanic. The volcanic occupy the steep slopes and high peaks of the pir panjal ranges and higher reaches of liddar valley. The volcanic activity seems to have persisted in Kashmir from the late carboniferous to late Triassic epochs.

Permian rocks of Kashmir are conformably overlain by a thick succession of limestones and shales known as zeewan formation.

The outcrops of Jurassic rock have restricted distribution in Kashmir. A major part of the rock is buried beneath the quarternary sediments and reported in the northern slopes of Pir Panjal range Baltal and Joji-la areas. The cretaceous rocks have not been reported from the Kashmir Himalayas.

The Murres extensively exposed on the Jammu-Srinagar highway around batote consists of basal conglomerate bed overlain by intercalations of bright red-purple clay and green sandstones and is overlain by Siwalik group rock formations.

Most of the Kashmir valley is occupied by this gravel-sand and mud succession known in Indian Stratigraphy as the ‘Karewa formation’. There are different opinions about the deposition of Karewa formations. But based on detailed geological mapping Bhatt (1978, 1982) proposed that sedimentation of karewa deposits took place in a lake basin but suggested that during deposition of Lower Karewa lake occupied the whole Kashmir valley floor, but during Upper Karewa time the lake was localized only in the north-eastern flank of the basin.

Karewas cover an area of about 5600 sq.Km in Kashmir Valley. Karewa group is defined to include the more or less unconsolidated layered sedimentary succession deposited in fluvio-lacustrine environments in the Kashmir valley, overlying the Precambrian-Mesozoic basement and overlain by Holocene alluvium of modern rivers, etc. Karewa group is divided into two formations viz., Lower Karewa and Upper Karewa. The Lower Karewa formation is characterized by plastic grey to bluish grey clay, light grey sandy clay, lignite, and lignitic-clay, coarse to medium-grained sand, and conglomerates. It is about 1200-mt thick formations.

The Upper Karewa formation is characterized by brown, grey sandy clay, medium to coarse-grained sand, cream-colored marl, conglomerate, and loam (loess) sediments. In this upper Karewas lignitic shale and grey bluish shale are absent. The thickness of this formation is about 50 to 200 mt. The loamy sediments are present throughout the valley making the top of the Karewa Plateau. The Upper Karewa formation sediments are exposed extensively on the Pir Panjal flank due to the uplift of the Pir Panjal range along with its Karewa sediments.

The top of Karewa terraces is capped by a fine-grained mostly silty succession without any bedding structures. These are mainly loam or loess formations. The formation is in some places extremely muddy, silty, or rather sandy. In some cases, sand layers are intercalated.

1.3. DRAINAGE

The entire state of Jammu and Kashmir falls in the Indus River Basin and the only exception is the small area in the extreme northeast which is part of the Quraqush River Basin.

1.3.1. Indus Basin

The total drainage area of the Indus Basin is 11,78,440 km^2 out of which an area of 453,250 km^2 falls in the high Himalayan mountains and the remaining 725,190 km^2 falls in the plains drainage area in plains. A total of 321,290 km^2 area of the Indus basin falls in India whereas only 131,960 km^2 area falls in Pakistan.

The Indus River (Sanskrit-Sindhu, Greek-Sinthos, Latin-Sindhus) originates from lofty mountains near Mansarovar Lake at an elevation of 5182 m and traverses for several hundred km through Tibet and India before reaching Suleiman mountains in Pakistan. A part of the Indus Basin is above the permanent snow line, which varies in altitude from 4268 m in the eastern part to 5792 m in the western part. In Ladakh Region, the snow line is at 5488 m above mean sea level, which recedes during summer.

The hydrographic system of the Indus Basin is very extensive. The river initially runs along the strike of the mountains and then suddenly makes an acute bend to the south and flows directly across the mountain. The Gilgit River joins the Indus at its great bend to the south. The Indus flows initially under the name of Singee Khabab until it is joined by the Ghar River at about 257 km from its source. After a short distance downstream it enters The State of Jammu &Kashmir at an elevation of 4206 m. It skirts Leh at 3200 m and is joined by the Zanskar River while still flowing north but more westerly. The Indus passes near Skardu and reaches Haramosh Mountain (7407 m). Here it takes a turn southwards at an acute angle and passing near Hattu Pir, enters Kohistan. After flowing through the wilds of Kohistan and at about 1450 km from its source, the Indus is joined by Kabul and Swat Rivers from Afghanistan. At this point, the elevation of the Indus falls to about 610 m. After leaving Attock in Pakistan the river flows southwards, parallel to the Suleiman Range. At about 805 km. from the Arabian Sea and at an elevation of 79 mamsl, the Indus receives waters from all of its five major tributaries viz. Jhelum, Chenab, Ravi, Beas, and Satluj, and here, it is known as Panjnad (five rivers). The river finally joins the Arabian Sea through its mouth, which forms a big delta covering 7770 km^2 and a vast coastline of about 201 km.

Major sub-basins of the Indus System in Jammu & Kashmir State are the Jhelum Sub-basin, the Chenab Sub-basin, and the Ravi Sub-basin. A brief account of these three sub-basins is given as: -

Jhelum Sub-Basin

The Jhelum is known in Kashmir as the Veth River. Most parts of Kashmir valley are drained by the Jhelum River, which flows in a northwesterly direction. The Jhelum River (Sanskrit-Vitasta, Greek-Hydaspes, Latin-Bipaspes) originates from Verinag Spring. The River has various tributaries in the valley, several of which come from the everlasting snows of the Liddar valley. Near Srinagar, it is received by the Sind River, and then forms the Wular Lake in Baramulla District which is a delta of the Jhelum River. Below Baramulla, the river leaves the fertile banks of the valley and rushes headlong down a deep gorge at Khadnayar, and joins the Chenab River at Trimmu in Pakistan.

Chenab Sub-Basin

The Chenab River or Asikin, as it was known in Vedic times, is formed by two important tributaries, the Chandra and the Bhaga, which join near Keylong in Himachal Pradesh to form Chandra-Bhaga or the Chenab River in Himachal Pradesh.

The River then flows through the Kashmir Himalayas to emerge into the plains at Akhnoor in Jammu District, about 250 km from its source. Ranbir canal takes off from its left bank in Akhnoor tehsil.

Ravi Sub-Basin

Very small parts of the state, mainly the extreme south-eastern parts, fall in the RaviSub-basin. The Ravi River rises from the northern face of Rohtang Pass in Himachal Pradesh at an elevation of 4116 m. After passing through the Dhaula Dhar hill ranges, the river emerges from the foothills near Madhopur where the head works of the Upper Bari Doab Canal exist. It has the smallest catchment area among the rivers of the Indus System. An important tributary of the Ravi River, the Ujh River Which originates from the Basohli hills of Kathua District joins the mainstream to its right at Lassian.

1.4. HYDROMETEOROLOGY

The State of Jammu and Kashmir has great diversity in its temperature and precipitation. Excepting the plain, south of the Siwaliks of the Jammu Division, the climate over the greater parts of the state resembles that of the mountainous and continental parts of the temperate latitudes. The average rainfall and Annual rainfall in all districts of Jammu & Kashmir is shown in Bar and Pie Chart (Graph 2-5)

1.4.1. The climate of the Jammu Division

The climate of the Jammu division is sub-humid to sub-tropical. It is divisible into two parts namely (i) the plain region, lying to the south of the Siwaliks, and (ii) the mountainous region, stretching over the Middle and the Greater Himalayas in the districts of Doda, Rajouri, Poonch, and Udhampur. The climate of the plain region and Middle Himalayas including the Pir Panjal is characterized by a rhythm of seasons which is caused by the reversal of winds in the form of southwest and north-east monsoons. The reversal of pressure takes place regularly twice a year. This region has a sub-tropical climate with a hot and dry climate in summer and a cold climate in winter. It lies in the northern hemisphere above the tropic of Cancer. The Minimum and Maximum temperature of the district varies between 4°C to 47°C and the monsoon starts from the beginning of July to the first week of September. From October to June the precipitation and temperature patterns resemble closely the valley temperature zones. However, the summer rainfall and temperature resemble the precipitation pattern in the sub-tropical zone. The region receives an average annual precipitation of 1070 mm mainly in the form of rainfall. Snowfall occurs in high mountainous parts of the Jammu region due to the southwest monsoon from July to September and contributes about 80% of the total rainfall. The temperature in plain areas of the Jammu region goes up to 45ºC during summer and drops to as low as 3º C during the winter season. The average number of Annual rainy days in the Jammu region is 59.

1.4.2. The climate of the Kashmir Division

The weather and climate of the Kashmir Division are intrinsically linked with the weather mechanism of the subcontinent in general. The location of the Kashmir Valley at a high altitude (about 1600m AMSL) in the north-western corner of the subcontinent, surrounded by high mountains on all sides, gives it a unique geographical character with distinctive climatic characteristics. It experiences Temperate-cum-Mediterranean type of climate. The average annual precipitation is 660 mm. In winter, rainfall occurs from the western disturbances (temperate cyclones). These disturbances have their origin in the Mediterranean Sea. The rainfall generated by these cyclones is fairly widespread locally known as *Alamgir*. About 65% of the precipitation occurs in the form of snow during the winter season, i.e. December to February. March and April are the months of rainfall. May to September is relatively dry months. The mercury drops between -8ºC and 12ºC during winter and attains a moderate temperature of around 35ºC during summer.

1.5. SOILS

The soils of J&K UT have been classified into the undermentioned 8 groups:

1. **Brown Earth/Brown Forest Soils:** These soils have been spotted in parts of Kathua, Udhampur, Doda, Poonch, Rajouri, Anantnag, and Baramulla District. Their water holding capacity exceeds 40%. They belong to groups Haplustalfs, Ochraualfs, Eustrochrepts, Hapludolls, Udorthrents, Cryothrents, and Udifluvents.

2. Degraded or Grey Brown Podzolic Soils: These soils occur in parts of Baderwah, Ramnagar, Poonch, Gulmarg, and Pahalgam and are of loam to clay texture at their surface and clay loam to clay texture at their sub-surface and of fine granular well developed angular block structure. They belong to great groups Hapludalfs, Hapludolls, Eutrochrepts, and Haplumbrepts.

3. Red and Yellow Podzolic Soils: These soils occur in parts of Udhampur, Kathua, Rajouri, and Poonch. They are of coarse texture, Water holding capacity is 40%. They belong to a great group hapludalfs, haplustalfs.

4. Hill or Mountain Forest Soils: These are sandy loam to loamy, fine to weakly granular soils. They occur at lower elevations and have 32-41% water holding capacity. They belong to a great group cryoboralfs and hapludolls.

5. Mountain Meadow Soils: Sandy loam to clay loam fine to coarse granular mountain meadow soils occur in Gulmarg, Pahalgam, Sonamarg, Lolab, Gurez, and Changthang. Water holding capacity of (51-61%) They belong to great groups Cryoboralfs and Argiudolls.

6. Lithosols: Gravelly loam to gravelly silty loam, coarse to weak granular soils. Lithosols occur on steep slopes in the forest hills of 400 to 600 meters above sea level in Jammu, Udhampur, Kathua, Rajouri, and Poonch Districts. They contain 33 to 38% water holding capacity. They belong to a great group Ustorthrents.

7. Saline Alkali Soils: These soils occur in alluvial belt of Jammu (RS Pura/Bishna), Kathua (Ramkol/Challain). They belong to Ustifluvents, Hapluaquents, and Ustorthents great groups.

8. Alluvial Soils: These soils cover the plains of Kathua, Jammu Rajouri, Poonch, Udhampur in Jammu, and the Valleys in Kashmir. They are situated in the flood plains of Ravi, Chenab, and Jhelum and their tributaries. They are old and new alluvial soils. They belong to a great group Ustifluvents and Udifluvents

Based on the Kashmiri Nomenclature

Nambal (Peaty Soils): Near the banks of the Jhelum River and in the vicinity of the Wular, Manasbal, and Anchar lakes is found the rich peaty soil, locally known as Nambal.

Tand (Mountainous Soils): The land on the slopes of mountains, reclaimed from the forests is called Tand soil. After reclamation, the land gives good productivity, but declines by accelerated soil erosion as land loses its natural strength and after many years the land acquires the shape of a pasture and culturable waste.

Zabelzamin (Alkaline Soils): Patches of irrigated land if excessively irrigated lose their fertility and develop alkaline formations. Such adversely affected patches of saline and alkaline formations are known as zabelzamin. These soils are unproductive from the agricultural point of view unless specially treated with gypsum, water, and manures. There are numerous other types of soils recognized by the Kashmiri farmers, such soils are Kharzamin, Tresh, Limb, Ront, Shath, and Tats.

Karewa Soil (Wudur): Karewas are fresh-water (fluviatile and lacustrine) deposits found as low flat mounds or elevated plateaus in the Valley of Kashmir and the Kishtwar and Bhadarwah tracts of the Jammu Division. The important Karewas are found in Kulgam, Shopian, Budgam, Qazigund, Tangmarg, Gulmarg, Baramulla, Laithpora, Chandhara, Pampore, Bijbehara, Awantipora, Islamabad (Anantnag), Mattan, Tral and Ganderbal. The Karewa soils are composed of fine, silty clays with sand boulder gravel, the coarse detritus being, as a rule, restricted to the peripheral parts of the valley, while the finer variety prevails towards the central parts.

Clayey Soil (Gurti): This soil is found in the flood plains of Jhelum in the southern parts of Srinagar city and is subjected to annual fresh silt deposition. Gurti soil contains a large proportion of clay. Its water retaining capacity is high.

Loamy Soil (Bahil): This soil is found above the level of the flood plain, on the right bank of Jhelum, and is highly fertile and suitable for paddy cultivation. The humus content is high which enriches the soil fertility.

Sandy Loam (Sekil): It has usually been found in the Sind valley in the northwest of the city. In the Sekil soil, if the field is artificially irrigated, good crops of rice are harvested in the summer season.

Sandy Silt (Dazanlad): This soil is a mixture of sand and clay. A peculiar characteristic of Dazanlad is that the field turns red when irrigation water stands in the fields. This soil is generally found in the low-lying areas in the west of the city and also occurs in the hilly areas in the north (Husain, 2000).

2. HYDROGEOLOGY

The hydrogeological setup in the state is very complicated owing to varied geological settings and groundwater conditions. All three regions of Jammu & Kashmir state represent entirely different groundwater regimes. Based on geology and aquifer characteristics, the area of the state can be divided into two broad hydrogeological units. These are Porous and Fissured formations.

Porous Formation

Porous formations are best suitable for exploration and development. Potential zones are encountered in these formations. Region-wise porous formations are described hereunder: -

Jammu Region

In the Outer Plains of the Jammu Region, extending between River Ravi in the east to Munawar Tawi in the west, the groundwater occurs in piedmont deposits belonging to the upper Pleistocene to the Recent age. The deposits comprise unconsolidated sediments in the form of terraces and coalescent alluvial fans developed by the streams debauching out of Siwalik Hills. The sediments consist of coarse clastic ranging in size from boulder to gravel in the loose clay matrix and occasionally alternating bands of clay of varying thickness. Kankar is also intercalated with these sediments at different intervals and in variable quantities.

These deposits are graded into finer sediments from north to south in that order. Down south it comprises alternate bands of sands of all grades and clay with subordinate pecks of gravel and pebbles.

- ***Kandi Formation***

Kandi formation comprises very coarse material with little clay but in the Outer Plain of Jammu & Kashmir State, the typical Kandi formations are not seen. Instead, they comprise boulders, gravels, pebbles, and coarse sand with a substantial amount of clay sometimes hard and sticky of varying thickness. The clay proportion increases towards the southwest. The occurrence of perched water bodies is a common phenomenon in the Kandi belt of Jammu & Kashmir state. Groundwater generally occurs under unconfined conditions in the Kandi formation.

- ***Sirowal Formation***

The Kandi formation coalesces into Sirowal formation in the south, finer outwash of Siwalik debris, brought by streams. Groundwater occurs under both confined as well as unconfined conditions in Sirowal formation. A spring line demarcates the contact between Kandi and Sirowal formations because the groundwater oozes out along this line causing marshy conditions. The spring line has undergone deformation due to the decline of water level resulting from the development of

groundwater in the Sirowal area. However, the base flow could be seen in streams south of this line, which also in the Sirowal formation is the existence of auto-flow conditions in the deeper aquifer system.

The Dun Belt separates the Siwalik hills from the middle Himalayas and runs as a series of river terraces between Basohli (32°30', 76°49'30") in the east to Riasi (33°05', 74°50') and beyond in the west. The sediments are in the form of isolated Sub-Recent to Recent valley fill deposits ranging in thickness between a few metres to a few tens of metres. These deposits are often dissected as a result of the present-day drainage pattern. The deposits comprise coarse clastics such as boulders, cobbles, pebbles, etc. inter-bedded with lenticular clays.

- ***Isolated Valley Fills in Middle Himalayas***

There exist several isolated valleys in the middle Himalayas where groundwater occurs in valley fill deposits comprising lacustrine to fluvioglacial sediments. A few meter-thick layers of loess overlie these deposits, which is windblown.

Groundwater in such valleys generally occurs under confined conditions. One of the prominent isolated valleys in the middle Himalayas is Kishtwar valley in the Kishtwar district of the Jammu Region.

Kashmir Region

Kashmir valley covers an area of 5600 km and is occupied by Karewas which consist of a huge pile of alternating bands of sand, silt, and clay interspersed by glacial boulder beds. The sands are mostly fine to very fine-grained and they are rarely medium to coarse-grained. There is considerable lateral facies variation like sediments. The aggregate thickness of these sediments is of the order of 2500-3000 m. Groundwater in the Karewas of Kashmir valley occurs under both confined as well as unconfined conditions.

Fissured Formation

About 15000 sq. km. area in Jammu Region is occupied by hilly terrain. It comprises rocks ranging in age from Precambrian (Salkhala series) to Miocene or even Pliocene (Murees and upper-middle Siwaliks). The rock types range from soft or friable sandstones, Clays, Shales, and Conglomerates to hard traps and metamorphics such as quartzite and crystalline limestone. In the Siwalik terrain, where groundwater is tapped, it comes mainly either from the weathered mantle or from the joints or cracks of these rocks. Friable Siwalik sandstones do possess primary porosity but are not very potential.

2.1. BEHAVIOUR OF WATER LEVELS IN SHALLOW AQUIFERS

2.1.1. DEPTH TO WATER LEVEL

The water levels in Groundwater Monitoring Wells of Jammu and Kashmir State is measured in May 2024 The water levels observed are shown in Annexures – I. The groundwater levels in different seasons were analysed to evaluate the temporal behaviour of water levels. The behaviour of water levels during May 2024 has been compared with the previous water levels as well as with the average water level for the last decade (decadal behaviour) to ascertain the changes in the groundwater regime. All the data has been put in the GIS format and the data has been analysed. After analysis, the contours of water levels below the ground surface have been created by joining the areas with the same water levels and the areas have been demarcated with uniform contour intervals. The contouring has been done by IDW Interpolation method.

Depth to Water Level -May 2024

Jammu Region: The water level data in respect of 214 wells for May 2024 were analysed. The depth to water level varied from 0.41 m bgl (Khanpur Nagrota in Jammu District) to 36.56 m bgl (Taryai in Jammu district). The categorization of depth to the water level in May 2024 is given in table 3.

20 wells (9.3%) have recorded a water level of less than 2.0 m bgl. About 110 (51.4%) of the total wells analysed have shown depth to water level in the range 2-5 m bgl. Whereas 58 wells (27.1%) have shown water levels in the range of 5-10 m bgl. 16 (7.5%) wells have registered deeper water levels, in the range of 10-20 m bgl. Another 10 wells (4.7%) of the total wells analysed have shown water levels in the range of >20 m bgl.

Valley areas of Jammu, Samba and Kathua districts below the contact of Kandi Sirowal show water level between 2-5 m bgl except few patches that show water levels between 0-2m bgl. In Sirowal area of Outer Plains, most of the water levels have been recorded between 2 - 10 m bgl except a few small patches that show water levels from 0 to 2 m & above 10 m bgl. In Kandi Belt, the water levels are deeper ranging between 5-20 m bgl and a few patches northern and north western Jammu, central parts of Kathua) having water levels more than 20 m bgl. In Udhampur Dun belt Rajouri areas have shown water levels within 10m bgl except Reasi area where > 20 mbgl is observed (Figure 4).

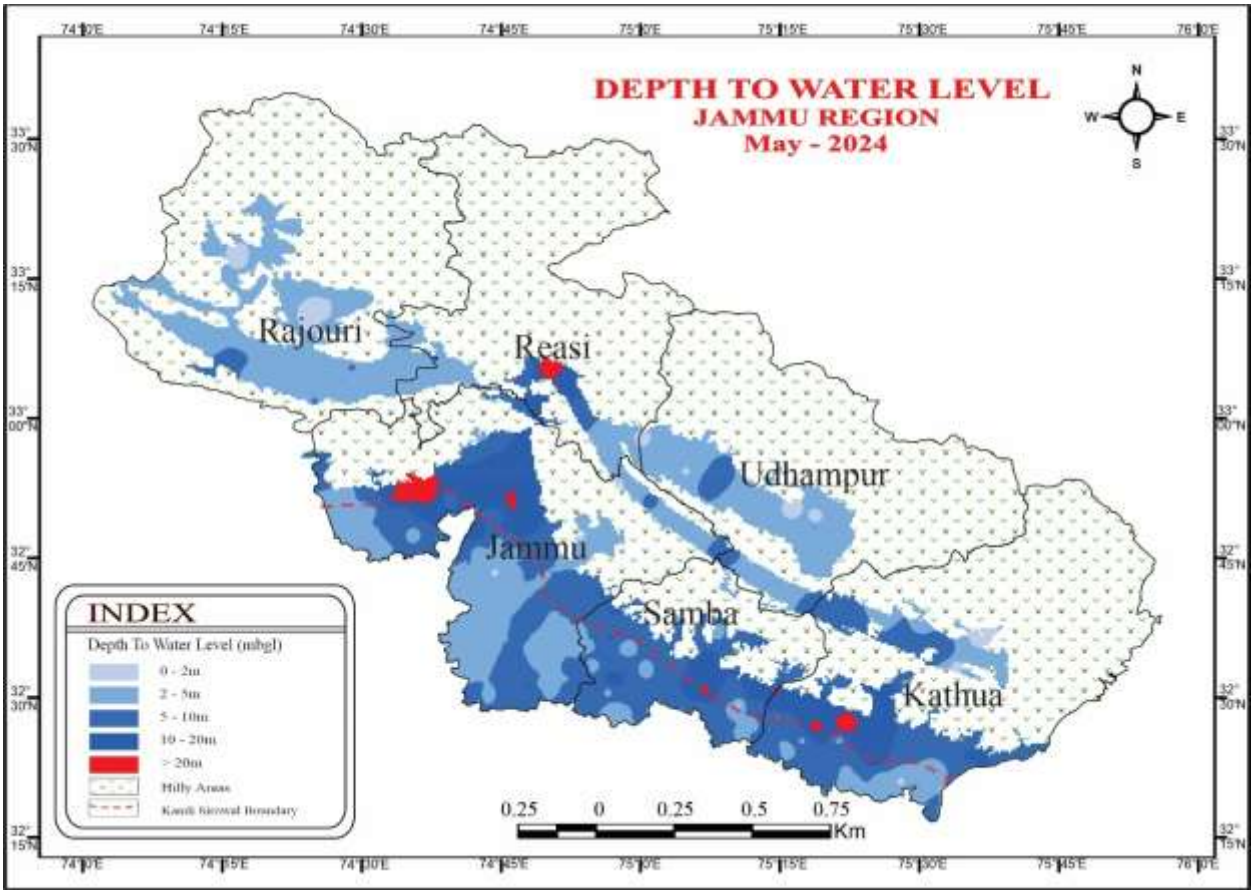

Figure 4. DTWL May 2024 Jammu Region

Table 2. CATEGORIZATION OF DEPTH TO WATER LEVEL- MAY 2024

REGION	District	No. Of wells Analyzed	Depth to Water Level (mbgl)		Number of Wells Showing Depth to Water Level (mbgl) in the Range of					Percentage of Wells Showing Depth to Water Level (mbgl) in the Range of				
			Min	Max	0–2	2–5	5–10	10–20	> 20	0–2	2–5	5–10	10–20	> 20
JAMMU REGION	Jammu	78	0.41	36.56	5	41	20	8	4	6.4	52.6	25.6	10.3	5.1
	Kathua	34	0.65	30.20	3	12	12	4	3	8.8	35.3	35.3	11.8	8.8
	Rajauri	37	1.01	6.54	5	23	9	0	0	13.5	62.2	24.3	0.0	0.0
	Reasi	8	1.93	24.96	1	6	0	0	1	12.5	75.0	0.0	0.0	12.5
	Samba	35	1.25	22.84	1	15	13	4	2	2.9	42.9	37.1	11.4	5.7
	Udhampur	22	0.70	8.70	5	13	4	0	0	22.7	59.1	18.2	0.0	0.0
	Total	**214**	**0.41**	**36.56**	**20**	**110**	**58**	**16**	**10**	**9.3**	**51.4**	**27.1**	**7.5**	**4.7**

2.2. ANNUAL FLUCTUATION OF WATER LEVEL

May 2024 with respect to May 2023

Jammu Region: The water level data in respect of 208 National Hydrograph Stations for the month of May 2024 was analysed. It was compared with May 2023. Majority of the wells have shown fall in water levels. A total of 98 wells have shown rise and 110 wells have shown fall in water levels in the range of 0-2 m, 2-4 m and >4 m. The minimum rise 0.04 m to maximum rise of 13.75 m is

shown. Whereas minimum decline of 0.01 m is recorded to a maximum of 9.45 m. Categorization of fluctuations in water levels is given in table 4. Rise is shown by 91 wells in the range of 0-2 m. 5 wells have registered rise from 2-4 m bgl and 2 wells are showing rise of >4 m. Among 110 wells showing fall, 100 wells have shown fall in water level in the range of 0-2 m, 6 wells have shown fall between 2-4 m, and 4 well have shown fall of >4 m.

All the districts have shown rise in water levels except Kathua district where a significant portion have shown decline in water level. All the districts have registered rise in water levels at few locations, but decline in water levels in the range of 0-2 m is observed in sufficient portions in all the districts except Reasi. Major parts of Jammu, Samba, and entire Kathua districts shown decline. Central and western Udhampur and Reasi shows >2 m decline in water levels (Figure 5).

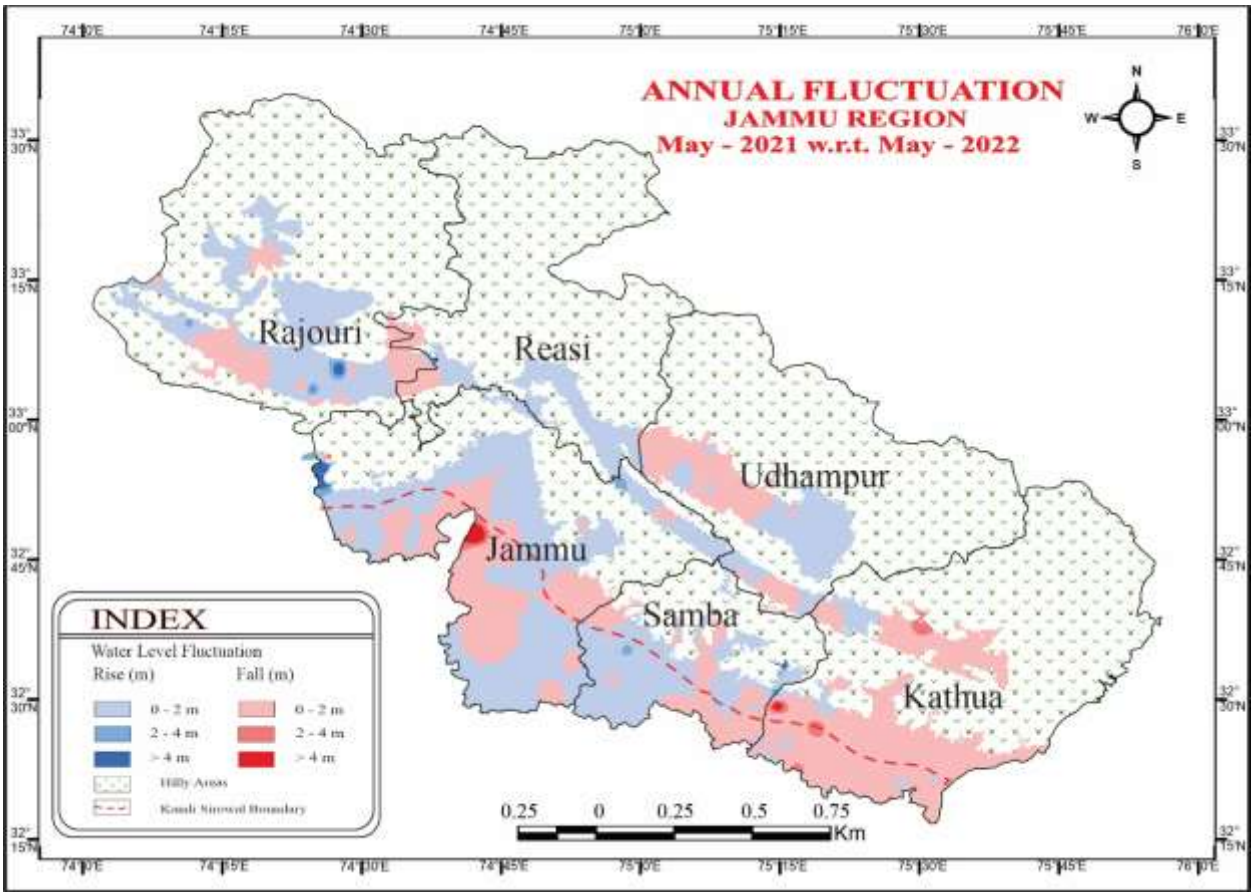

Figure 4. Annual Fluctuation May 2024 Jammu Region

Table 3. CATEGORIZATION OF CHANGES IN WATER LEVEL BETWEEN MAY 2023 AND MAY 24

District	No. Of wells Analyzed	Range of Fluctuation (m)				No. of Wells Showing Fluctuation (m)						Percentage of wells Showing Fluctuation						Total No. Of Wells	
		Rise		Fall		Rise			Fall			Rise			Fall				
		Min	Max	Min	Max	0 – 2	2 – 4	> 4	0 – 2	2 – 4	> 4	0 – 2	2 – 4	> 4	0 – 2	2 – 4	> 4	Rise	Fall
Jammu	74	0.07	13.75	0.02	9.45	29	1	1	40	2	1	39.2	1.4	1.4	54.1	2.7	1.4	31	43
Kathua	33	0.04	2.82	0.01	6.10	14	4	1	13	1	0	42.4	12.1	3.0	39.4	3.0	0.0	19	14
Rajouri	36	0.08	6.68	0.05	1.67	16	0	0	17	1	2	44.4	0.0	0.0	47.2	2.8	5.6	16	20
Reasi	8	0.10	0.90	0.10	0.90	3	0	0	5	0	0	37.5	0.0	0.0	62.5	0.0	0.0	3	5
Samba	35	0.05	7.33	0.02	1.53	16	0	0	16	2	1	45.7	0.0	0.0	45.7	5.7	2.9	16	19
Udhampur	22	0.10	1.85	0.05	1.90	13	0	0	9	0	0	59.1	0.0	0.0	40.9	0.0	0.0	13	9
Total	**208**	**0.04**	**13.75**	**0.01**	**9.45**	**91**	**5**	**2**	**100**	**6**	**4**	**43.8**	**2.4**	**1.0**	**48.1**	**2.9**	**1.9**	98	110

2.3. DECADAL FLUCTUATION OF WATER LEVEL

May 2024 with respect to mean of May 2014 – May 2023

The water level fluctuation for the month of May 2024 Vs. (Mean of May 2014 – May 2023 has been worked out in respect of 207 observation wells. It is observed that a total of 127 wells have shown rise and 80 wells have shown decline in water level (especially in Kandi areas of Outer plains). The minimum rise 0.01 m to a maximum rise of 5.80 m. Whereas minimum decline of 0.02 m to a maximum of 6.43 m. Categorisation of fluctuations in water level is given in table 5.

Out of 127 number of wells showing rise, 112 wells have shown rise less than 2 m, 11 wells have shown rise from 2-4 m and 4 wells have shown rise of > 4 m. Out of 80 wells showing fall, 75 wells have shown fall in the range of 0-2 m, 3 wells have shown fall between 2-4 m and 2 wells have shown fall of >4 m.

Majority of the area shows a decline in water levels in all ranges in Jammu Region. In Jammu district, the decline in range of 0-5m was found in entire area except south western patches. In Samba and Kathua almost all the area have shown decline except few portions, and in Kathua district major area is in declining trend and in central parts decline above 4m is also recorded. (Figure 6).

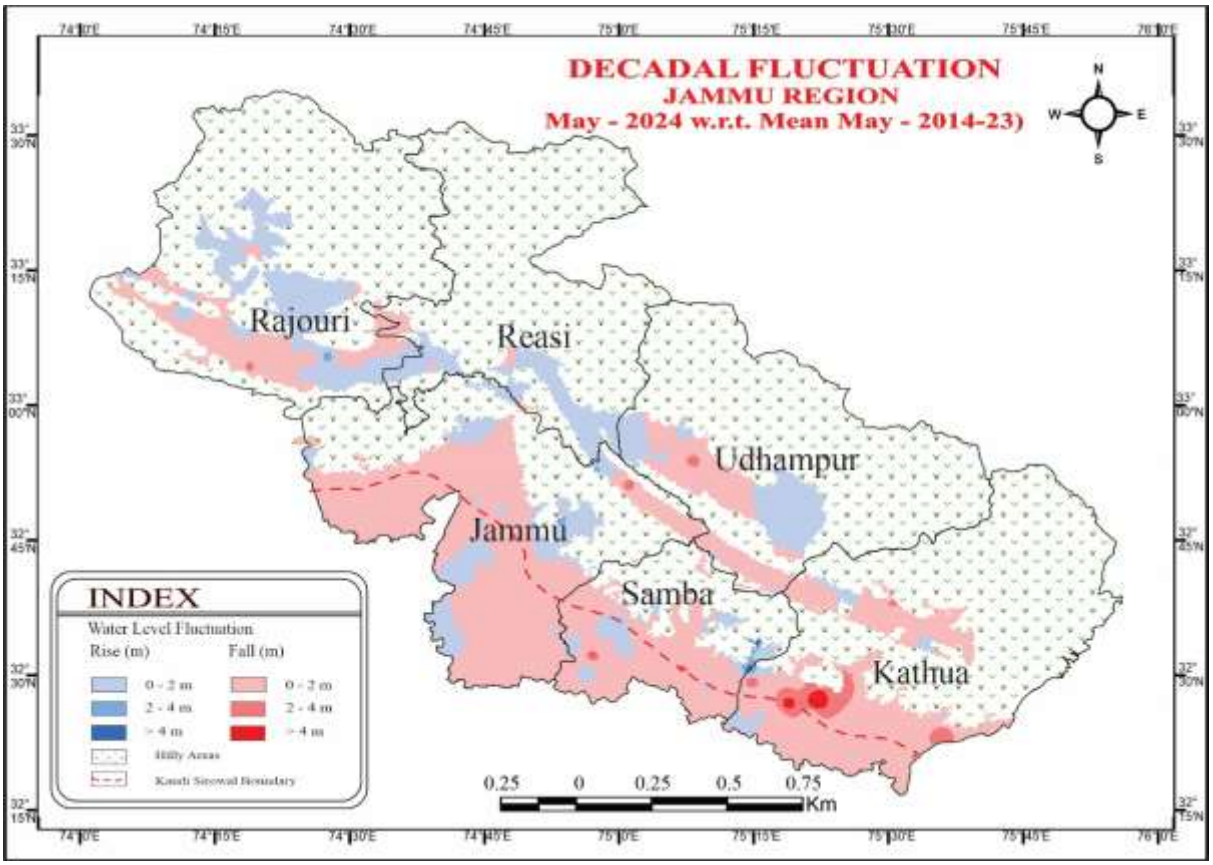

Figure 4. Decadal Fluctuation May 2024 Jammu Region

Table 4 CATEGORISATION OF CHANGES IN WATER LEVEL BETWEEN MAY 2024 TO DECADAL MEAN (MAY 2014-MAY 2023)

District	No. Of wells Analyzed	Range of Fluctuation (m)				No. of Wells Showing Fluctuation (m)						Percentage of wells Showing Fluctuation						Total No. of Wells	
		Rise		Fall		Rise			Fall			Rise			Fall				
		Min	Max	Min	Max	0 – 2	2 – 4	> 4	0 – 2	2 – 4	> 4	0 – 2	2 – 4	> 4	0 – 2	2 – 4	> 4	Rise	Fall
Jammu	77	0.01	3.75	0.02	3.32	48	3	0	24	2	0	62.3	3.9	0.0	31.2	2.6	0.0	51	26
Kathua	30	0.01	4.86	0.08	6.43	12	3	3	11	0	1	40.0	10.0	10.0	36.7	0.0	3.3	18	12
Rajouri	37	0.08	3.36	0.04	2.76	17	3	0	16	1	0	45.9	8.1	0.0	43.2	2.7	0.0	20	17
Reasi	7	0.36	0.77	0.16	0.73	3	0	0	4	0	0	42.9	0.0	0.0	57.1	0.0	0.0	3	4
Samba	34	0.11	5.80	0.05	4.72	22	1	1	9	0	1	64.7	2.9	2.9	26.5	0.0	2.9	24	10
Udhampur	22	0.08	0.79	0.02	3.23	10	1	0	11	0	0	45.5	4.5	0.0	50.0	0.0	0.0	11	11
TOTAL	**207**	**0.01**	**5.80**	**0.02**	**6.43**	**112**	**11**	**4**	**75**	**3**	**2**	**54.1**	**5.3**	**1.9**	**36.2**	**1.4**	**1.0**	**127**	**80**