केंद्रीय भूमि जल बोर्ड

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भारत सरकार

Central Ground Water Board

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

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

Zanskar Valley, Kargil District, Ladakh-UT

उत्तर पश्चिमी हिमालयी क्षेत्र, जम्मू और कशमीर

North Western Himalayan Region, Jammu & Kashmir

REPORT ON

AQUIFER MAPPING IN ZANSKAR VALLEY, KARGIL DISTRICT, LADAHK-UT

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Aquifer Mapping in Parts of Zanskar Valley, Kargil District, Ladahk-UT

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1.0 INTRODUCTION

Aquifer mapping can be defined as a scientific process, wherein a combination of geologic, geophysical, hydrologic, chemical field and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers. The National Project on Aquifer Management (NAQUIM) is an initiative of the Ministry of Jal Shakti, Department of Water Resources RD & GR, Government of India, for mapping and managing the entire aquifer systems in the country. The study integrates multiple disciplines and scientific approaches, including remote sensing, hydrogeology, geophysics, hydrochemistry, drilling, groundwater modelling, and management approaches.

Total targeted area of Aquifer Mapping Implementation Plan for XII Plan period is 8.89 lakh sq km out of 23.25 lakh sq km Mappable area of the country. As far as maps depicting aquifers are concerned, the first map on Hydrogeology was published by Geological Survey of India in 1969 under the title "Geohydrological Map of India" on 1: 20,00,000 scale. Subsequently, CGWB published "Hydrogeological Map of India" on 1:50,00,000 scale with the data updated from the work of CGWB. On the basis of surveys, exploration and special studies undertaken, Central Ground Water Board published its first edition of Hydrogeological Map of India 1:2 Million scale in 1985 and its second edition in 2001. Based on stratigraphy, with the data available at that time, 9 major aquifers (hydrogeological units) were depicted in the map. Aquifer Atlas of Jammu & Kashmir was prepared on 1: 250,000 scale.

Systematic aquifer mapping is expected to improve our understanding of the geologic framework of aquifers, their hydrologic characteristics, water levels in the aquifers and how they change over time, and the occurrence of natural and anthropogenic contaminants that affect the potability of ground water.

1.1. Objectives

The major objectives of Aquifer Mapping are :

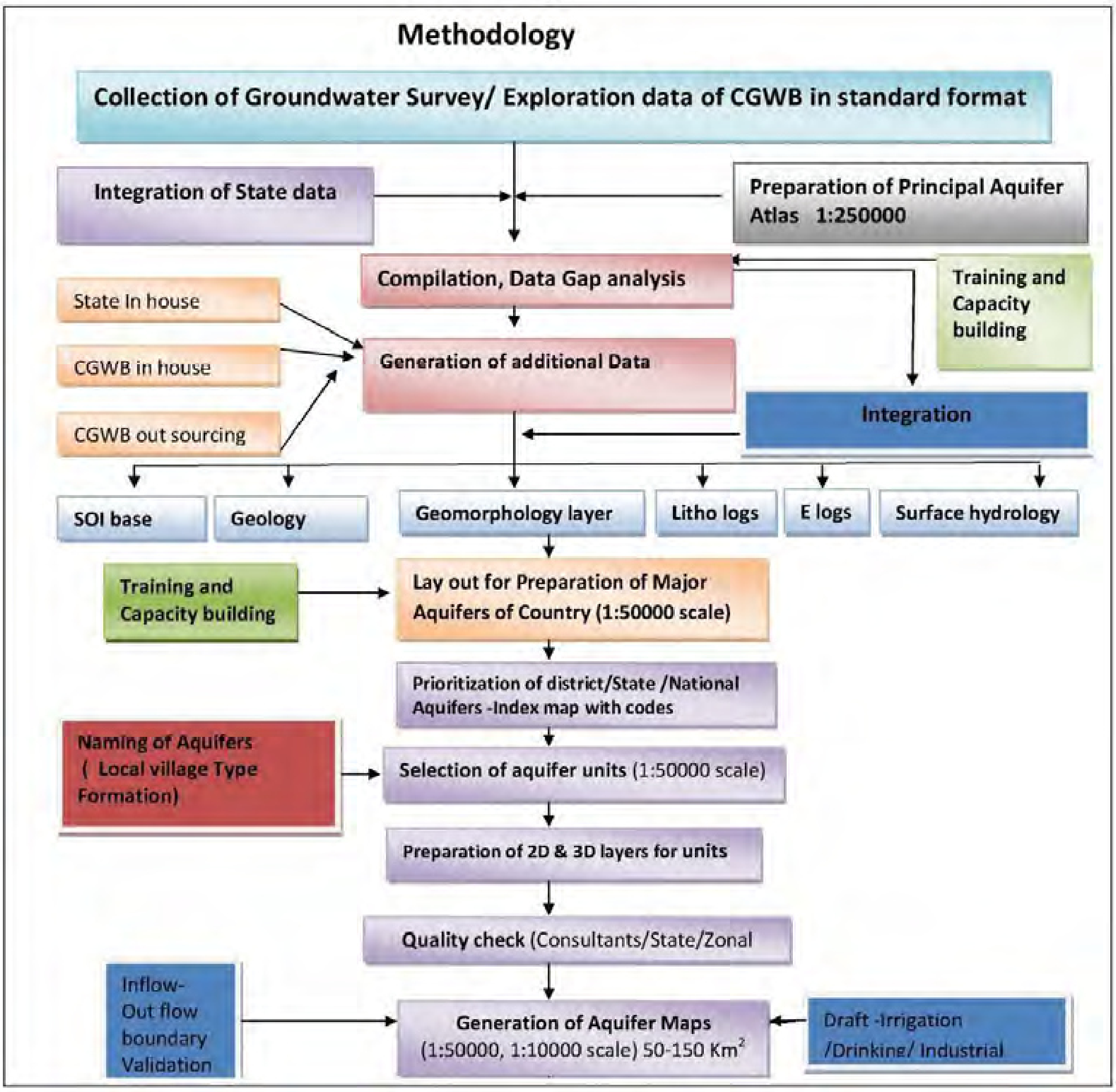
- To identify and map subsurface aquifer geometry at the micro level,
- To evaluate aquifer parameters,
- To quantify the available groundwater resources and to propose plans appropriate to the scale of demand and aquifer characteristics and institutional arrangements for participatory management.

1.2. Scope of the Study

Systematic mapping of an aquifer encompasses a host of activities such as collection and compilation of available information on aquifer systems, demarcation of their extents and their characterization, analysis of data gaps, generation of additional data for filling the identified data gaps and finally preparation of aquifer maps at the desired scale. Results of these studies will contribute significantly to resource management tools such as long-term aquifer monitoring networks and conceptual and quantitative regional ground-water-flow models used planners, policy makers and other stakeholders. Aquifer mapping at the appropriate scale can help prepare, implement and monitor the efficacy of various management interventions aimed at long-term sustainability of our precious ground water resources, which in turn, will help achieve drinking water security, improved irrigation facilities and sustainability in water resources development in the country as a whole.

1.3. Approach and Methodology

The major activities involved in this process include i) collection of data from various sources like CGWB records, State Government agencies and available literature on internet; ii) compilation of existing data; iii) identification of data gaps; iv) generation of data for filling data gaps and finally v) preparation of aquifer maps and Management Plan. The overall methodology for aquifer mapping is shown in the flow chart given below:



1.4. Location and approachability of the study area

Zanskar or Zahar (locally) or Zangskar is a subdistrict or tehsil of the Kargil district, which lies in the Indian union territory of Ladakh. The administrative centre is Padum. The topographical features explain why access to Zanskar is difficult from all sides. Communication with the neighbouring Himalayan areas is maintained across mountain passes or along the Zanskar River when frozen. The easiest approach leads from Kargil through the Suru Valley and over the Pensi La. It is along this track that in 1979 the first and only road in Zanskar was built to connect Padum with the main road from Srinagar into Ladakh.

The Report deals with Aquifer Mapping carried out in Parts of Zanskar Valley, Kargil District, Ladahk –UT which covers an area of 249 sq. km. It falls in the Survey of India Topo Sheet No's 52C/15, 52C/14 and 52G/2 (1:50,000 scale). The area lies between North Latitude 33.40° and 33.65° and East Longitude 76.69° and 77.008° (Figure 1).

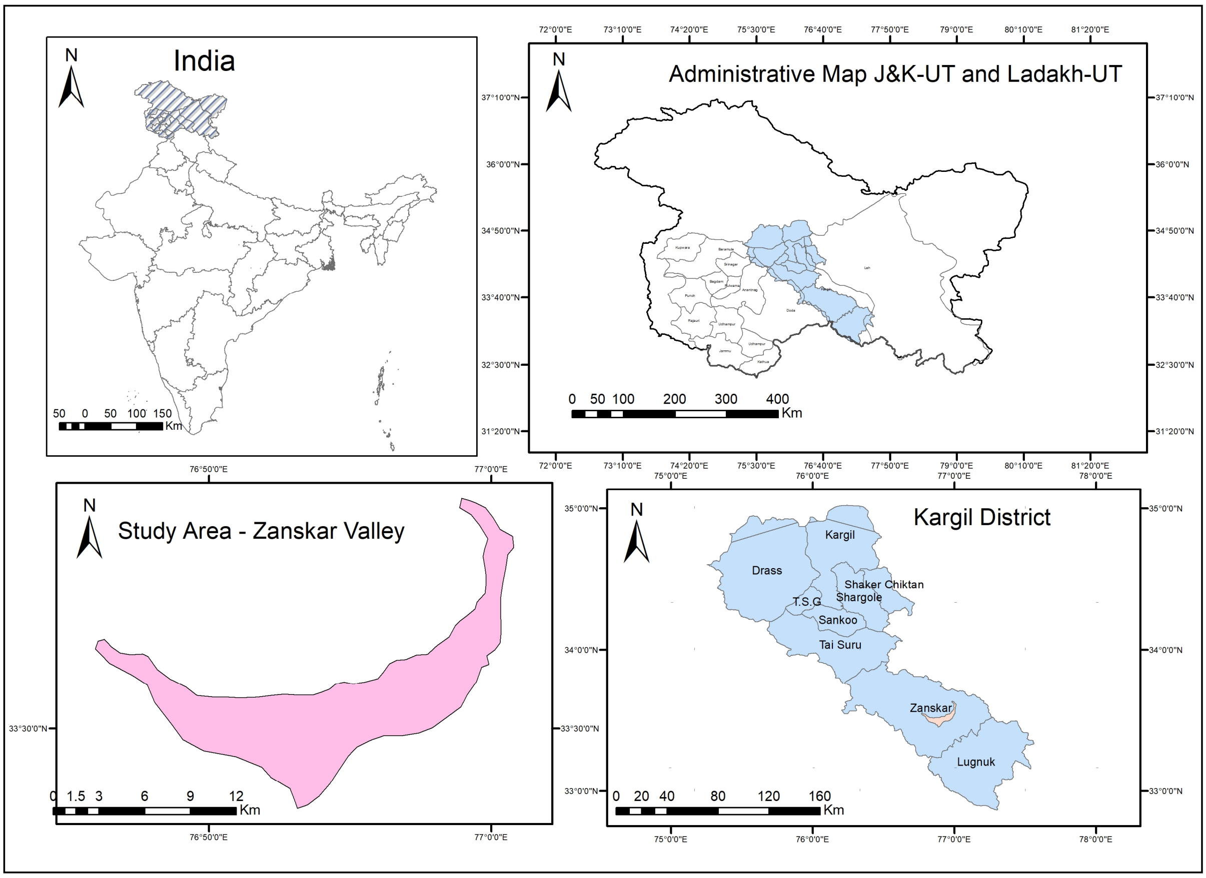


Figure 1: Base Map of the Area

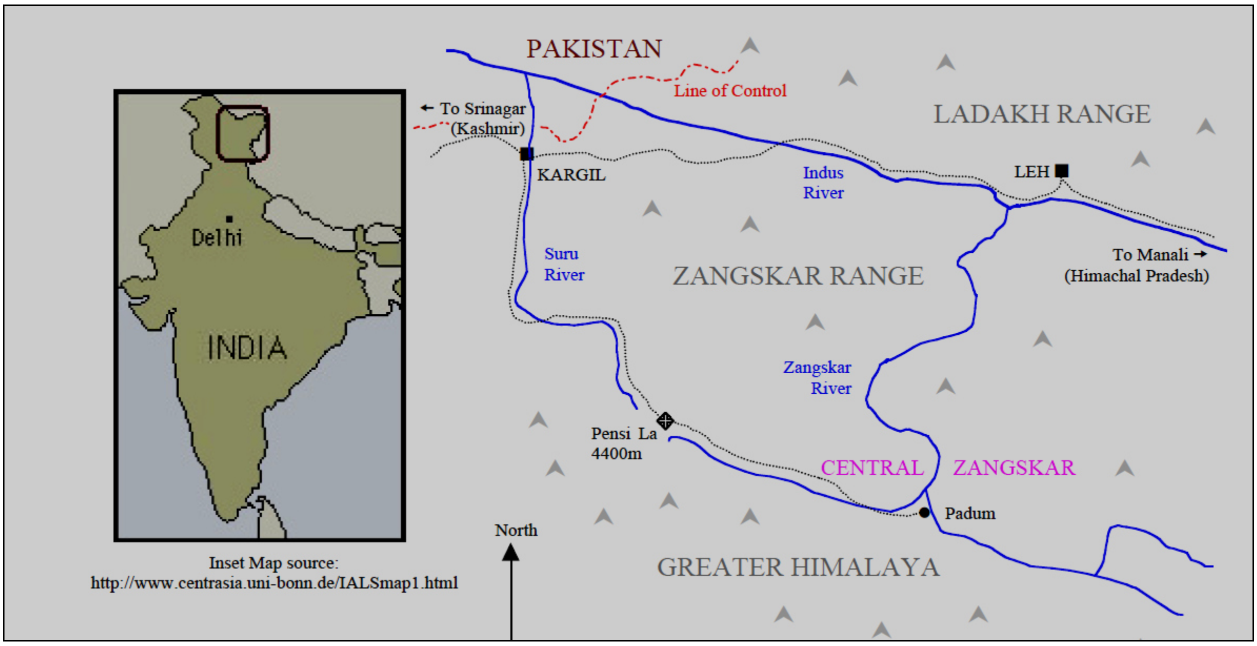


Figure 2: Zanskar Location Map

1.5. Climate

Zanskar is a high altitude semi-desert lying on the Northern flank of the Great Himalayan Range. This mountain range acts as a climatic barrier protecting Ladakh and Zanskar from most of the monsoon, resulting in a pleasantly warm and dry climate in the summer. Rain and snowfall during this period are scarce, although recent decades have shown a trend towards increasing precipitation. Several water-driven mills were built during ancient periods of drought at a great distance from the villages, but have been abandoned because running water is now available nearer to the settlements. Most of the precipitation occurs as snowfall during the harsh and extremely long winter period. These winter snowfalls are of vital importance, since they feed the glaciers which melt in the summer and provide most of the irrigation water. Parts of Zanskar valley are considered some of the coldest continually inhabited places in the world.

1.6. Physiography

Zanskar covers an area of some 7000km^2 at an elevation between 3500 and 7000 meters. High mountain ridges lie on both sides of the NW-SE trending Doda and Lingti/Kurgiakh valleys. To the southwest is the Great Himalayan Range that separates Zanskar from the Kisthwar and Chamba basins. To the northeast lies the Zanskar Range separating Zanskar from Ladakh. Thus, the only outlet for the whole Zanskar hydrographic system is the Zanskar River which cuts a deep and narrow gorge through the Zanskar range. The easiest approach leads from Kargil through the Suru Valley and over the Pensi La. It is along this track that in 1979 the first and only road in Zanskar was built to connect Padum with the main road from Srinagar into Ladakh.

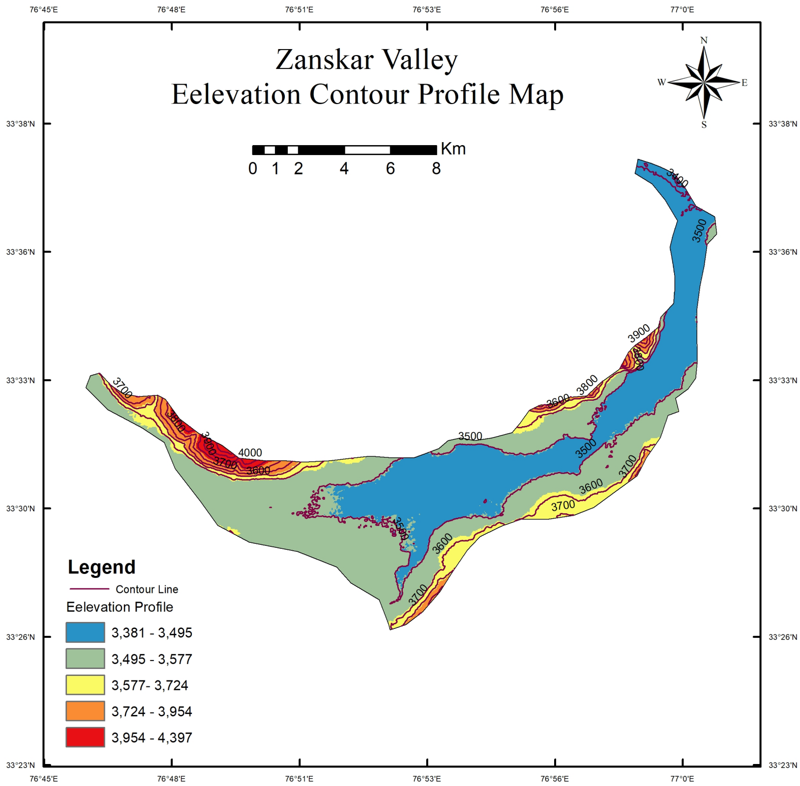


Figure 3: Elevation Contour Profile Map.

1.7. Slope

The Zanskar Range contains maximum slope ranging between 5 degree to above 20 degree. The eastern part of this range has steeper slope compared to the western part. The Zanskar Range nearly separates Kargil district from Leh district. The Ladakh Range runs parallel to the Zanskar range and is located to its north. Slope zones have been shown on map. Analysis of slope is very important. Slopes influence the availability of cultivated land for other human activities. The eastern part of Zanskar lies between the slopes of 15 to 25 degree. Slope of lower parts of the Great Himalayan Range is between 10 to 15 degree.

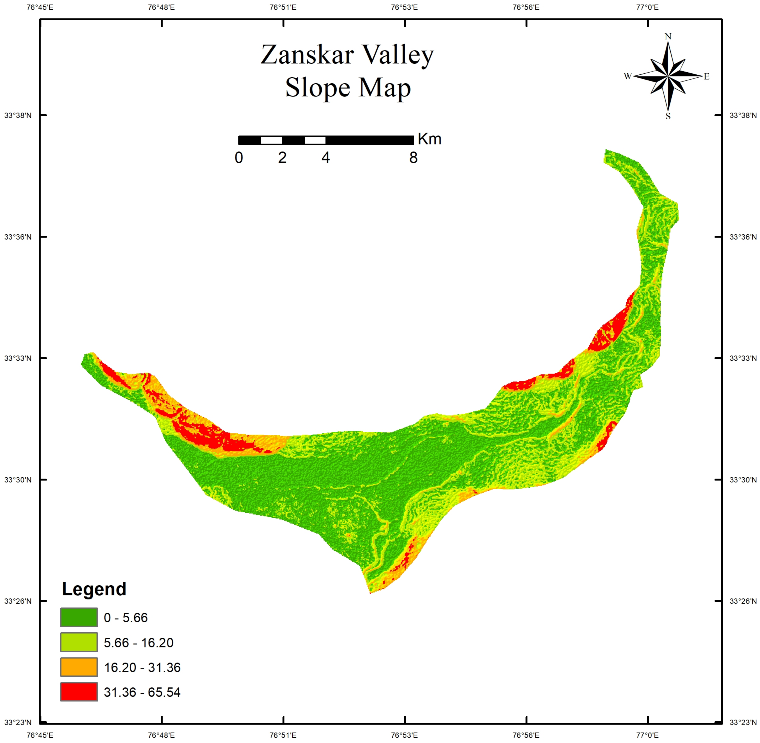


Figure 4: Slope Map of Zanskar Valley

1.8. Geomorphology

A variety of conspicuous geomorphic features are present in the area. It is seen that tectonics played major role in the development of these geomorphic features. In the Padum Valley moraines, alluvium fan, flood plain and scree material are dominated geomorphic features. The four generations of moraines representing four glaciations are preserved. The moraines emanate from the western tributary and the oldest moraine is highly degraded, indurated and comprises of isolated tillite pinnacles that overlie the rocky slopes particularly around Stongde village. This seems to be the oldest moraine observed so far in the Southern Zanskar Range. The Older lateral moraines abut the valley flanks, and extend up to 15 km downstream in the Zanskar Valley, where these terminate as latero-frontal moraines. In the upstream (around Karsha village), the moraines are differentiated into five discontinuous lateral moraine ridges, suggesting pulsating recession of older moraines glaciation. The recessional moraines are draped by fluvial gravels and also obliterated by the large alluvial fans, which are associated with relict or active cirques glaciers. The younger moraines preserved near the exit of the Seni Valley are dissected by the melt water streams and are draped with fluvial gravels giving rise to hummocky mounds. The youngest latero-frontal moraines are confined within the Seni Valley. The two generations of outwash gravel terraces are also identified in the Padum Valley. The older outwash terrace gravel is 15 m thick and has sub-rounded, clast supported deposit. It is overlain by laterally persistent relict lake sediments, which are preserved along the eastern flank of the Padum village. The younger outwash terrace is 10 m thick and abuts the older terrace. Scree fans are present all along the valley slopes and at places drape the moraines and gravel terraces, thus suggesting them to be the youngest geomorphic feature in the study area.

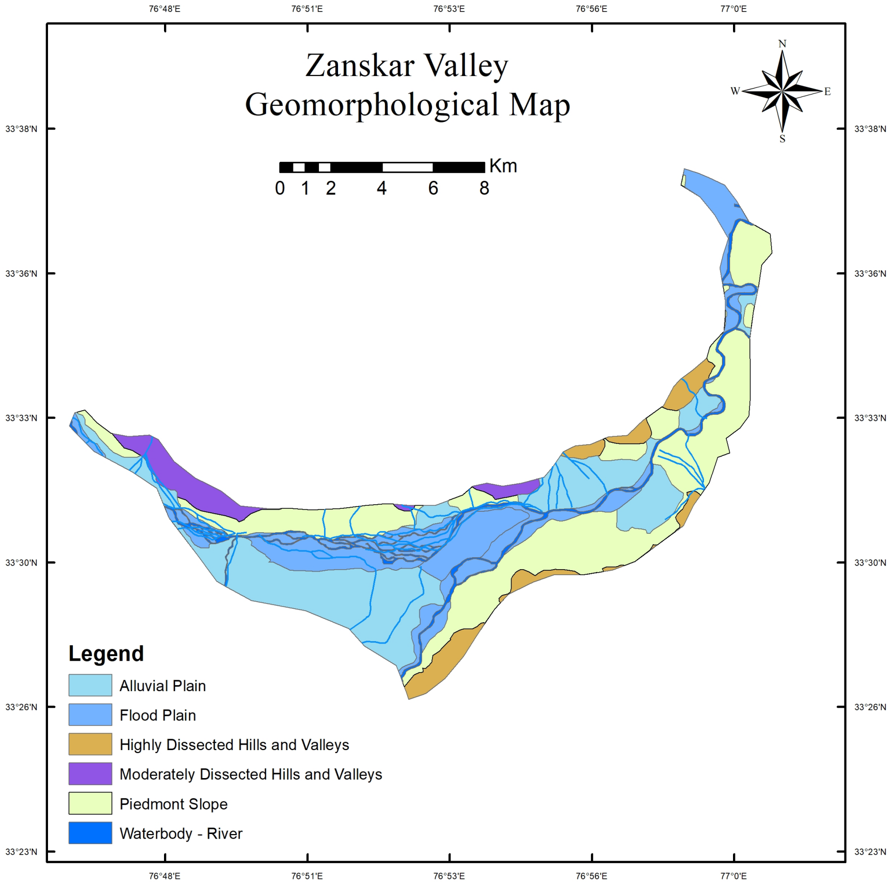


Figure 5: Geomorphological Map of Zanskar Valley.

1.9. Drainage

Zanskar covers an area of some 7000 km^2 at an elevation between 3500 and 7000 meters. It comprises the country lying along the two main tributaries of the Zanskar River. The first one, the Doda has its source near the Pensi-La (4400m.) mountain-pass and then flows south-eastwards along the main valley leading towards Padum, the capital of Zanskar. The second branch is formed by two main tributaries known as Kurgiakh-chu with its source near the Shingo-La and Tsarap-chu with its source near the Baralacha-La. These two rivers unite below the village of Purne to form the Lungnak River (also named Lingti or Tsarap). The Lungnak-Chu then flows northwestwards along a narrow and precipitous gorge towards the Padum Valley where it unites with the Doda River to form the Zanskar River. The Zanskar River then takes globally a north eastern course until it joins the Indus River in Ladakh.

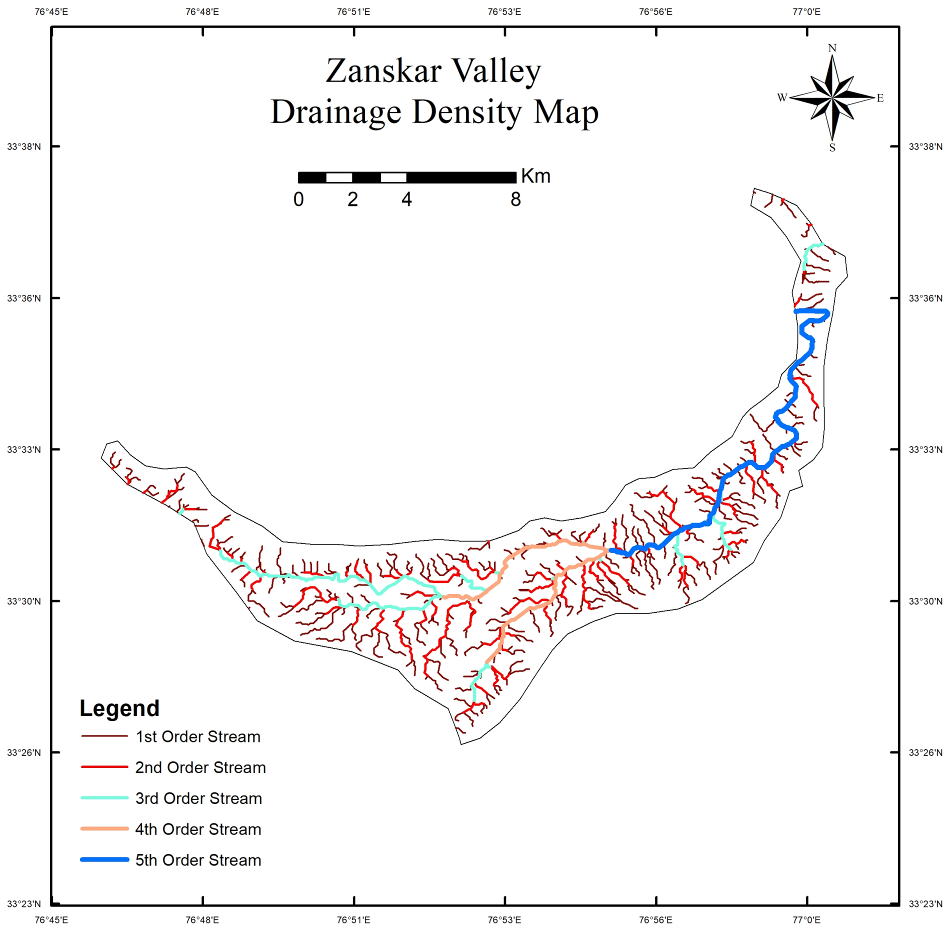


Figure 6: Drainage Density Map of Zanskar Valley.

1.10. Geology

The lithology of Zanskar Valley is represented by the rocks belonging to pre- and post-collision history. The sedimentary sequences span from Proterozoic to Eocene, while the Higher Himalayan Crystalline (HHC) dominated by migmatitic ortho/para-gneisses is extensively intruded by the leucogranitic dikes. The sedimentary formations belonging to the Tethyan Sedimentary Sequence (TSS) contain rocks ranging from Late Carboniferous till the India–Asia continental collision around Eocene. The Zanskar shear zone is one of the major structures that is represented by the normal sense of faulting and is equivalent to the South Tibetan Detachment System (STDS) (Searle 2013). The Suru and Doda rivers broadly follow the trace of the Zanskar shear zone. The modern glaciers are preferentially located on the northern fringes of the HHC (southern part of the Zanskar hill ranges) and flow towards the north into the northeast–southwest trending river defined boundary scarcely exists. In nearly all sections, it has been hitherto examined that the schists seem to pass gradually into the overlying slates, phyllites and quartzites of the overlying Haimantas (Phe Fm.).

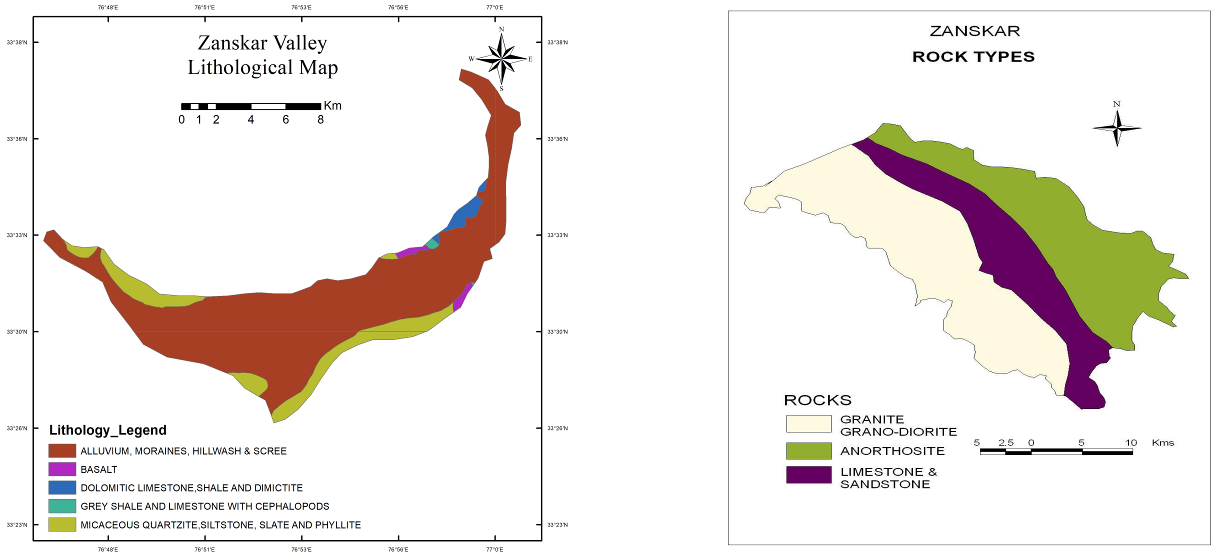


Figure 7: Geological Map of Zanskar Valley.

1.11. Soil

Soil map of Zanskar (figure 7.) shows two types of soil in Zanskar. These are entisols and mollisols. It can be seen from this map that the mollisols are mainly found in the river valleys and entisols cover maximum area of Zanskar region. Most of the western part of Zanskar is covered by snowfields. Rugged, arid, cold, mountainous conditions of Zanskar influence the depth, texture, and compositions of soils in Zanskar. Soil becomes a prime determinant of land suitable for agricultural use, especially since steep slopes and ruggedness greatly limit the availability of the total land area. The soils of Zanskar are characterized by glacial moraines which determine the soil texture. The texture is important in soils because it determines the ability of the soil to retain moisture and transmit water to the layers below. Soils range from gravelly and sandy loams on the alluvial fans to sandy and silty loams on the flood plains in Zanskar. By and large, the soil texture in Zanskar is sandy loam. Sand particles are usually coarse. Soils are characterized by low organic matter and poor water retention capacity.

Table I. Percentage Analysis of Soil in Zanskar

Place	Coarse	Fine Sand	Salt	Clay	Texture
Zanskar	3.77	34.83	15.00	25.50	Silt Loam

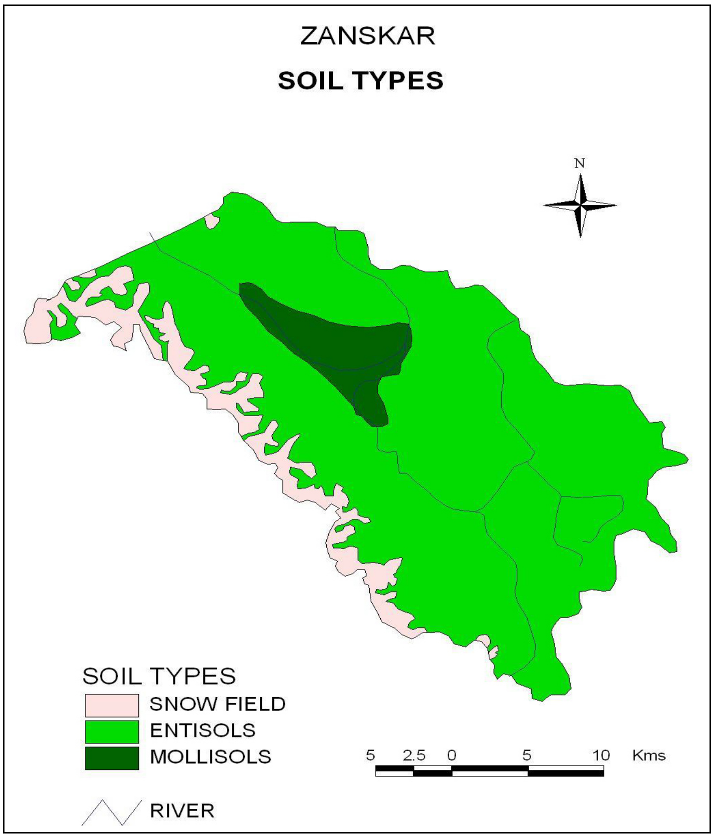


Figure 8: Soil Types Map of Zanskar Valley

1.12 Land use & Land cover

The district-wise land use & land cover map prepared by the National Natural Resource Centre and National Remote Sensing Centre of ISRO, Hyderabad was downloaded from bhuvan-noeda.nrsc.gov.in/theme (figure 8). It has been observed that major parts of the area are covered by agricultural land followed by forest and settlement.

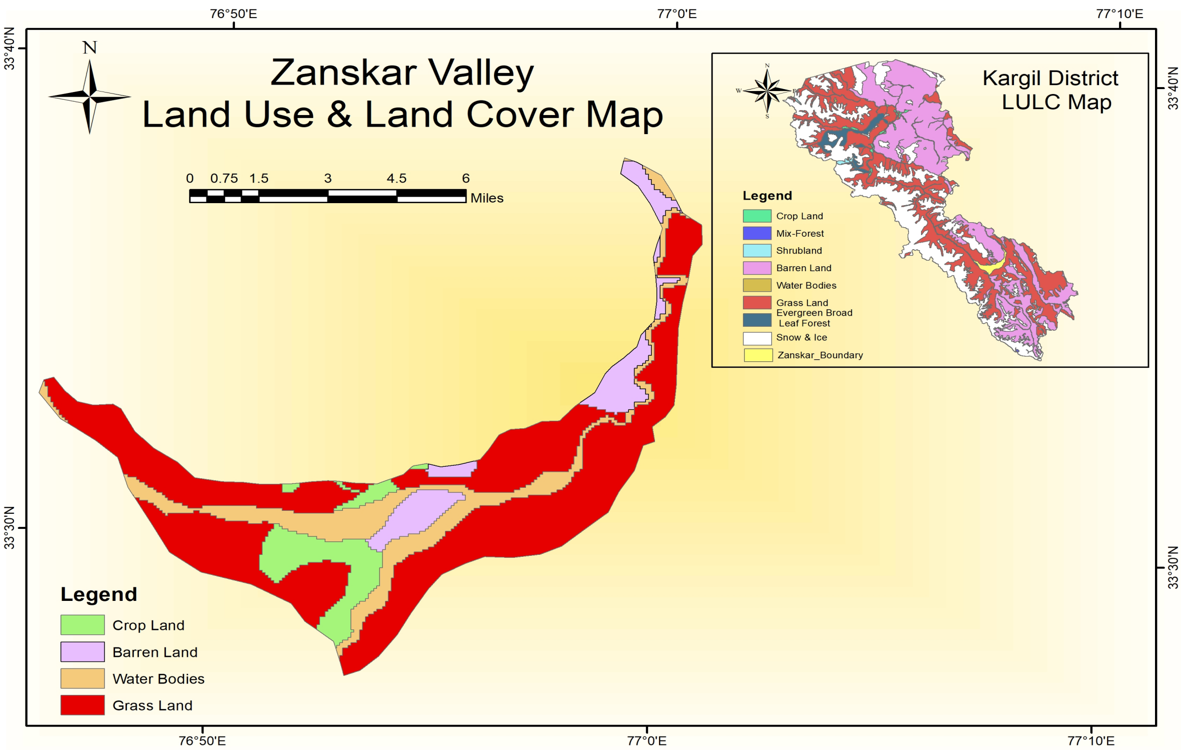


Figure 9: Land Use & Land Cover map of Zanskar Valley

1.13. Agriculture

Agriculture in India has witnessed a gradual transformation from subsistence farming of early fifties to the present intensive agriculture, especially in better-endowed regions where basic infrastructure essential for realising potential of improved technologies in farmer's field were created along with favourable government policies. In the mountainous region like Zanskar, agriculture is the mainstay of the people. 95% of the population are engaged in this activity through sedentary cultivation and pastoral animal rearing. Agricultural implements used by farmers are crude and primitive. Zho, a hybrid between yak and cow is deployed in drawing the small plough. The subsistent farming is still practised because of unfavourable climatic condition and highly fragile mountain ecosystem. The agriculture season sometimes gets delayed due to accumulation of snow in fields in great depths, particularly in lower altitudes (basin region) due to avalanching in spring season results in late sowing of seeds. To clear the snow from fields and to melt the snow, the farmers spread stored soil that enhances albedo by absorbing warmth from the sun. The region supports the cultivation of selected crops like wheat, Grim (barley) Pea, fodder and Vegetable that grow in a short period. The per hectare output of these crops have increased recently due to the development of hybrid variety of seeds that grow in a short period under harsh climatic conditions with assured water supply. The agricultural productivity of a region depends on the fertility and water holding capacity of the soil, intensity of rainfall, depth of water table, and method of cultivation and irrigation facilities. Of all the important factors playing crucial role in productivity, lack of irrigation is the significant factor and among physical factors affecting crop production, amount of rainfall is the most important one.

1.14. Irrigation

Irrigation is a crucial input for the development of agriculture in the UT. UT does not receive rain throughout the year and sometimes it is quite insufficient and it is neither uniform nor certain. Water for irrigation comes essentially from the melt-water of glaciers and snowfields located at higher altitudes. Each village is located where those streams meet the valley and is captured by a main irrigation channel and latter distributed via smaller channels. Those channels, many of them being very old, are governed by some sort of common property regime based on self-management by the village community. When the snow melts, people can finally go outside and start to cultivate the land, which is the activity of most inhabitants (the main crops being wheat and barley). At this altitude, cultivable land is scarce and restricted to alluvial fans and terraces. Due to these difficult conditions, Zanskar's peolpe have developed a system of intensive arable agriculture and complex irrigation to produce enough food for the whole year in just five months.

1.15. Cropping Pattern

Agriculture is the main source of livelihood in the area. Topography, climate and soil are the main factors affecting agriculture. The crop calendar for the area is shown in table 2.

Table:2 Crop Calendar of the area

S. No.	Crop	Period of Sowing	Period of Harvesting
1	Wheat	June to September	October
2	Barley	June to September	October

1.16. Water Table Contour

The area has a mountainous topography and the aquifer systems are discontinuous hence water level and water table contour maps could not be generated.

1.17. Data Availability

The summarized table presenting the data availability, data requirement, data adequacy, data gap analysis & data generation is shown in table 1 and 2 given below :

Table: 3 Data Availability in Aquifer Mapping Area

S. No.	Type of structure	Agency	Quantity	Remarks
1	Tube Wells	CGWB	00	No Tube Well Established till date.
2	Tube Wells	State Govt.	4	
3	Hand Pumps		13	
4	Dug Wells		00	No Dug Well Established till date.
5	Key Wells		00	No Dug Well Established till date.

Table: 4 Data Requirement, Data Adequacy, Data Gap Analysis & Data Generation

S. No.	Parameters	Data Requirement	Data Availability	Data Gap	Data Generation
1	Rainfall data	Meteorological stations spread over the project area	District – wise rainfall data	No data	Data to be collected from IMD
2	Soil	Soil Map and soil infiltration rate	Available on any scale but insufficient.	Data Gap in whole area	Soil infiltration rate across study area
3	Land Use/Land cover	Land Use/Land cover pattern	Land Use data latest	Data Gap in whole area	Latest data required in GIS platform
4	Geomorphology	Digitized geomorphological map	Downloaded from NRSC, ISRO Hyderabad	Data Gap in whole area	Latest geomorphological maps in GIS compatible software
5	Geophysics	Geophysical data in each quadrant	Not available as required	Data Gap in whole area	Data to be generated
6	Exploration Data	EW in each quadrant	Not available	Data Gap in whole area	Data to be generated
7	Aquifer Parameters	Aquifer parameters in all the quadrants	Not available	Data Gap in whole area	Data to be generated
8	Recharge parameters	Recharge parameters for different types of soil and aquifer based on field studies	Available in Resources Estimation but insufficient	Nil	More Data required for accurate results
9	Discharge Parameters (Draft data)	Discharge Parameters of different Ground Water abstraction structures	Available in Resources Estimation but insufficient	Nil	More Data required for accurate results

1.18. Water Conservation and Recharge Practices

Ground water extraction through wells, hand pumps, tube-wells, Bowlies & springs are the major sources of water supply to both rural and urban areas but availability of water during summer is limited in hilly uplands particularly in drought years and requires immediate attention to augment these resources. Roof top rainwater harvesting need to be adopted in urban areas and hilly water deficit areas and proper scientific intervention for spring development and revival is required in water scarce areas.

The area being hilly and mountainous, traditional sources of ground water mainly springs have played a major role since past in providing assured irrigation and water supply. These include the nallas, springs, chashamas. In some areas, at present too, these are the only sources of water for settlements, but the availability of the water during summer is limited. Based on the climatic conditions, topography, hydrogeology of the area, suitable structure for rain water harvesting and artificial recharge to ground water is required.

All the old tanks/ ponds are required to be revived. These practices will help to conserve surface water with resources otherwise being lost and revive depleting/drying of springs.

In the hilly areas, Check dams, Gabion structures and Nalla bunding, Roof top rainwater harvesting structures like storage tanks are recommended while in low hill ranges, low height check dam and roof top rainwater harvesting structures can be adopted. The traditional water sources like springs and bowlies needs to be protected.

2.0 DATA COLLECTION AND GENERATION

2.1. Hydrogeology

Ground water in the major part of the study area occurs in localized, disconnected bodies under favorable geological conditions. Major part of the study area is occupied by rocks belonging to Late Carboniferous to Eocene. The shallow depth Hand pump located in the valley fill deposits yield low to moderate discharge of groundwater. There is no homogenous aquifer system having wide areal extent. However, zones of secondary porosity in them form suitable areas for ground water and occur in fissures, weathered, jointed and fractured parts. Further it also occurs in solution cavities, channels etc. in the carbonate rocks. In alluvial formation it occurs in the valley fill deposits, terraces and river terraces, thin veins of soil cover over hard rock. Ground water occurrence in the area occupied by alluvium deposit is restricted to small isolated patches in hilly areas. The hard rocks are totally devoid of primary porosity. However, the Ground water emerges in the form of springs at contact of pervious and impervious beds and other structural features. Most of the springs are originating from higher reaches, two-three springs jointly makes a high discharge also originating and meeting at higher reaches of mountains under gravity. The Alluvial deposits are highly heterogeneous comprising of varying grades from gravels, sand, silt & clay. These deposits possess a good degree of primary porosity & permeability controlling the occurrence and movement of ground water. Ground water in the area occurs under water table condition in alluvium and confined condition in the underlying rocks of the older age. The ground water occurrence is mainly controlled by topography, drainage, structure and lithology. Springs, in the areas are main source of groundwater. Springs are formed where the water table is intercepted by the topography. In the study area, the springs are widely distributed, occurring in the different formations at varying altitudes. Occurrence of spring is controlled by lithological and structural character of rock formation. Majority of the springs occur along fracture zones.

2.2. Hydrochemistry

The concentration of ions/elements in natural water is governed by general factors, like nature of formation through which water circulates, soil characteristics, concentration due to activities of men etc. Hence the content of natural water may vary from place to place. Water for different purpose should comply with the given specifications. Different parameters for drinking water are as:

a. ***General Parameters (mg/l):*** Iron (as Fe), Aluminium (as Al), Copper (as Cu), Zinc (as Zn), Magnessium (as Mg), Barium (as Ba), Calcium (as Ca), Silver (as Ag), Selenium (as Se), Molybdenum (as Mo), Boron (as B), Nitrate (as NO_3), Sulphate (as SO_4), Sulphide (as H_2S), Fluoride (as F), Chlorides (as Cl), Ammonia (as total ammonia – N), Chloramines (as Cl_2), Residual, Free chlorine, Total Alkilinity as calcium carbonate, etc.

b. ***Physical Parameters:*** Colour (Hazen units), Odour, Taste, Turbidity (NTU), Dissolved solids (mg/l), pH value, Total Hardness (as $CaCO_3$) mg/l.

c. ***Parameters concerning toxic substances (mg/l):*** Total Arsenic (as As), Lead (as Pb), Mercury (as Hg), Total chromium (as Cr^{6+}), Nickel (as Ni), Cadmium (as Cd), Cyanide (as CN), etc.

A total of 39 samples were collected from different Tubewells, Hand pumps and Springs falling in the study area. These samples were sent for chemical laboratory of CGWB NWHR Jammu for chemical analysis. All the collected samples are going to analysed by adopting standard methods of analysis (APHA). The results of the all samples are awaited till date.

2.3 Geophysical

Geophysical studies should be carried out in the Aquifer Mapping area comprises of VES with Schlumberger array, Resistivity Profiling with Wenner configuration and need based Borehole Electrical Loggings. As per the Data Gap Analysis carried out upto March-2020, the geophysical survey not carried out till date in this study area.

2.4 Exploration

Ground Water exploration work is not carried out by CGWB in the area. Besides, state government also drilled mini tube wells and hand pumps in the area. Total 04 numbers of tube wells and 13 hand pumps have been drilled by State agency . Maps have to be prepared with Exploration drilled data. As there is no Ground Water Department in Jammu and Kashmir and no other department is working in this field except for making ground water abstraction structures and extracting huge amount of water, hence the data of Central Ground Water Board was the only reliable source data.

3.0 GROUND WATER RESOURCES

Exploration and Geophysical data required for ground water resource estimation.

4.0 GROUND WATER RELATED ISSUES & PROBLEMS

The area being hilly and mountainous, scarce rain fall. This has resulted in varying degree of recharge to ground water. In such hard rock terrain, since aquifers are discontinuous and having different geological/hydrogeological setup, the ground water scenarios are different in various parts of the area.

- Most of the ground water issues and problems so far noted in the area are localized and need to be treated independently by taking micro level studies in a particular area.
- Slope is rugged, undulating and steep
- Soil run off, gully erosion and degradation of land
- Aquifer thickness is very small.
- Springs, hand pumps and tube wells in few areas are frozen up during winter season.
- Natural sources of water like rivers, streams and ground water have frozen up in the area because of low atmospheric temperature and high altitude.
- The water sources in the area are spring, river dependent and mostly frozen up during winter season.

5.0 MANAGEMENT STRATEGIES

5.1 Ground Water Conditions:

Most of the areas is concentrated in valley portion drained by major river Zansakr and its tributaries. In the past development of ground water was mainly through tube wells and hand pumps along the riverbeds, nallas and also some springs has played a major role for sustainable domestic and irrigational purposes. In some of the areas, at present too these are the only sources of water. However, in recent year modern means of ground water development have been employed. Public Health Engineering has been constructing number of hand pumps and shallow-moderate depth tube wells for large-scale water supplies.

5.2 Management Plan for Ground Water Development

The Ground Water Resources of the 249 Sq km of NAQUIM (Zanskar Valley, Kargil District, Ladakh-UT) have to be calculated by Geophysical Survey. The study area falls in the late Carboniferous to Quaternary deposits and alluvium/moraine formation of recent period with gentle slope having good groundwater potential. The surface run off of melt glacier water is slow due to gentle slope. Hence it is recommended to construct number of water retaining structures (Subsurface Dyke, Check Dam, Nalla Bunds, Gully Plugs) across the rivers and nallas that will enhance the retention period of the ground and surface water, in order to achieve maximum ground water development by constructing ground water abstraction structures.

5.3 Springs

Springs occur wherever groundwater flows out from the earth's surface. Springs typically occur along hillsides, low-lying areas, or at the base of slopes. A spring is formed when natural pressure forces groundwater above the land surface. When water flows out slowly on the surface without distinct outlets, the term seepage is used. Springs are formed where the water springs are formed where the water table is intercepted by the topography. In the study area, the springs are widely distributed, occurring in the different formations at varying altitudes. These springs play important role to fulfil the requirement of the local people for drinking, irrigation and domestic purposes especially in the study area because of scarcity of other fresh water sources or water supply facilities. These springs are also tapped by the PHE Department to supply drinking water.

5.4 Spring Development and Rejuvenation

A spring can be developed into a drinking water supply by collecting the discharged water using pipe and running the water into some type of sanitary storage tank. Protecting the spring from surface contamination is essential during all phases of spring development. Springs can be developed in two different ways and the method you choose will depend on whether it is a concentrated spring or a seepage spring.

Spring Development Procedures: Concentrated Springs

A concentrated spring typically occurs when groundwater emerges from one defined discharge in the earth's surface. Concentrated springs are visible and are often found along hillsides where groundwater is forced through openings in fractured bedrock. This type of spring is relatively easy to develop and is usually less contaminated than other types of springs.

Steps for Developing a Concentrated Spring

- Excavate the land upslope from the spring discharge until three feet of water is flowing.
- Install a rock bed to form an interception reservoir.
- Build a collecting wall of concrete or plastic down slope from the spring discharge.
- Install a pipe low in the collecting wall to direct the water from the interception reservoir to a concrete or plastic spring box.
- Remove potential sources of contamination and divert surface water away from the spring box or collection area.
- Alternative types of interception reservoirs and collecting walls can be constructed.

Spring Development Procedures: Seepage Springs

Seepage springs occur when shallow groundwater oozes or "seeps" from the ground over a large area and has no defined discharge point. This type of spring usually occurs when a layer of impervious soil redirects groundwater to the surface. Seepage springs can be difficult to develop (see Figure 3). They are also highly susceptible to contamination from surface sources and they need to be monitored before development to ensure that they will provide a dependable source of water during the entire year. Flow is often lower from seepage springs, making them less dependable.

Steps for Developing a Seepage Spring.

- Dig test holes upslope from the seep until you locate the point where the impervious layer is 3 feet underground.

- Create a trench approximately 18 to 24 inches wide across the slope. Trench should be extended 6 inches into the impervious layer (below the water-bearing layer) and should extend 4 to 6 feet beyond the seepage area. Install 4 inches of collection tile and surround the tile with gravel.
- Installation of a collecting wall will help prevent water from escaping the collection tile. This collecting wall should be constructed of 4 to 6 inches of concrete.
- Collection tile should be connected to 4-inch pipe that leads to the spring box. Box inlet must be below the elevation of the collector tile.
- Remove potential sources of contamination and divert surface water away from spring box or collection area.

5.5. Proper Management of springs.

Remove Sources of Contamination. No matter what type of spring you have developed, it is critical that you remove potential sources of contamination from the spring's drainage area (the area upslope of the spring discharge point). Surface water draining into that area should be redirected and all activities should be limited within the drainage area. If livestock are present, fences should be used to keep animals from contaminating the drinking water supply.

Water Testing and Disinfection. Once the spring is developed and nearby sources of contamination are eliminated, it is important to submit a water sample to a water testing chemical laboratory for water quality analysis. If a water test indicates any contamination, check the water supply location and construction of the system for potential pollution pathways. Any roadside spring that is being used as a drinking water supply should be tested and these springs should only be used as a source of drinking water if they have been tested and found of desired drinking water specifications.

However, if springs are to be protected and restored, the solutions occur on the land where recharge water first starts the path to the aquifer. Three general approaches are available – avoiding activity that damages or threatens the aquifer, the springs themselves, and the springs runs and other features of the spring system; minimizing the impact of development and use of springs and related features; and, where necessary, mitigating the effects of the impact to the springs. The springs are located in different hydrogeologic settings, with a variety of land uses within their basins. The spring can be developed and rejuvenated as follows:

- ➢ Identify and enforce existing regulations that can be used and should be amended to protect groundwater that flows to springs. Identify pertinent existing groundwater standards that could be amended to increase protection of the surface water quality in springs.
- ➢ The suitable engineering measures (artificial recharge structures) may be constructed in the recharge areas of springs such as check dams, gully plugs, gabions and bushwood check dams and contour trenches may be designed for suitably selected sites to increase its discharge and to reduce the surface run off and protect non-consumptive uses, such as recreation, through the establishment of minimum flows for threatened springs.
- ➢ Vegetation measures as the permanent solution of the spring rejuvenation/ sustainability be sought out

- Establish minimum flows for springs or minimum levels for aquifers threatened by groundwater withdrawals. Once the minimum flow for a spring has been established; implement a recovery or revention strategy if needed to achieve the established flow or level.
- Conduct hydrogeologic investigations to determine the relationships between groundwater levels and spring flows so that groundwater withdrawals can be managed to avoid impacts to spring flows.
- Review existing conservation requirements used in consumptive use permitting. Develop and implement improvements that will result in increased water-use efficiency.

5.6 Construction of Canal Network system

The area can be developed and managed by constructing of canals in the feasible areas. The construction of canal should not be made concrete so that the canal irrigates the area as well as some amount of water percolates and adds to the ground water. Hilly areas do not have well developed irrigation network.

Annexure I

S. No.	Location	Longitude	Latitude	Elevation (m amsl)	Date of collection	Type of Source	Parameter to be analysed
1	Padun	76º52'40.2"	33º28'7.4"	3555	28.07.2019	BW	Basic
2	Padun	76º52'47.4"	33º27'46.5"	3602	28.07.2019	Spring	Basic
3	Padun	76º52'27.3"	33º27'16.0"	3674	28.07.2019	HP	Basic
4	Padun	76º52'09.9"	33º27'26.8"	3710	28.07.2019	Spring	Basic
5	Padun	76º52'49.9"	33º27'28.9"	3631	28.07.2019	Spring	Basic
6	Padun(Lungnuk)	76º52'55.3"	33º27'42.5"	3608	28.07.2019	HP	Basic
7	Padun	76º52'57.6"	33º27'43.7"	3604	28.07.2019	Spring	Basic
8	Padun	76º52'54.4"	33º27'36.2"	3614	28.07.2019	Spring	Basic
9	Padun	76º53'01.2"	33º27'48.5"	3581	28.07.2019	HP	Basic & HM
10	Padun	76º52'46.7"	33º27'44.9"	3588	28.07.2019	BW	Basic
11	Padun	76º52'44.0"	33º27'52.9"	3594	28.07.2019	HP	Basic
12	Padun	76º52'40.2"	33º28'03.4"	3585	28.07.2019	HP	Basic
13	Padun	76º52'36.2"	33º28'12.2"	3556	28.07.2019	BW	Basic
14	Padun	76º52'40.7"	33º28'09.9"	3584	28.07.2019	BW	Basic
15	Cha Gongma	76º53'05.8"	33º28'06.2"	3583	28.07.2019	Spring	Basic
16	Cha Gongma	76º53'4.2"	33º28'15.6"	3572	28.07.2019	Spring	Basic
17	Ufti Chumik	76º53'51.2"	33º29'18.8"	3539	28.07.2019	Spring	Basic
18	Ufti	76º53'36.3"	33º29'37.3"	3535	28.07.2019	HP	Basic
19	Lower Kumik	76º55'33.9"	33º29'49.6"	3532	29.07.2019	Spring	Basic
20	Lower Kumik	76º55'29.6"	33º30'9.8"	3576	29.07.2019	Spring	Basic
21	Lower Kumik	76º55'36.4"	33º30'15.7"	3529	29.07.2019	Spring	Basic
22	Upper Kumik	76º57'11.1"	33º29'44.7"	3760	29.07.2019	Spring	Basic
23	Stongday	76º58'12.8"	33º31'01.0"	3560	29.07.2019	Spring	Basic
24	Gompa	76º58'40.2"	33º31'42.5"	3590	29.07.2019	Spring	Basic
25	Sheling Skiet	77º0'25.7"	33º33'32.2"	3550	29.07.2019	Spring	Basic
26	Chazar Village	77º0'25.1"	33º35'17.6"	3557	29.07.2019	HP	Basic
27	Zanskar River	77º0'16.4"	33º37'22.1"	3452	29.07.2019	River	Basic
28	Zangla	76º59'26.8"	33º39'31.3"	3556	29.07.2019	Glacier Nalla	Basic
29	Sani	76º48'45.7"	33º30'18.6"	3566	30.07.2019	Spring	Basic
30	Sani	76º48'35.3"	33º30'24.1"	3565	30.07.2019	HP	Basic
31	Sani	76º47'52.3"	33º30'53.2"	3580	30.07.2019	Stod River	Basic
32	Tungri	76º47'23.6"	33º32'09.2"	3608	30.07.2019	Tungri Nalla	Basic
33	Satara	76º50'41.5"	33º29'07.4"	3559	30.07.2019	HP	Basic
34	Salapi	76º50'35.1"	33º29'35.2"	3553	30.07.2019	HP	Basic & HM
35	Salapi	76º50'45.0"	33º29'48.5"	3538	30.07.2019	Spring	Basic
36	Gyapak	76º51'3.5"	33º29'36.0"	3553	30.07.2019	HP	Basic
37	Nerok	76º51'42.4"	33º29'30.9"	3587	30.07.2019	HP	Basic
38	Rukruk	76º52'21.7"	33º29'29.9"	3514	30.07.2019	HP	Basic
39	RantakSha	76º45'25.7"	33º33'54.1"	3659	30.07.2019	Spring	Basic

Note - *HP = Hand Pump, *HM= Heavy Metal, *BW= Bore Well

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