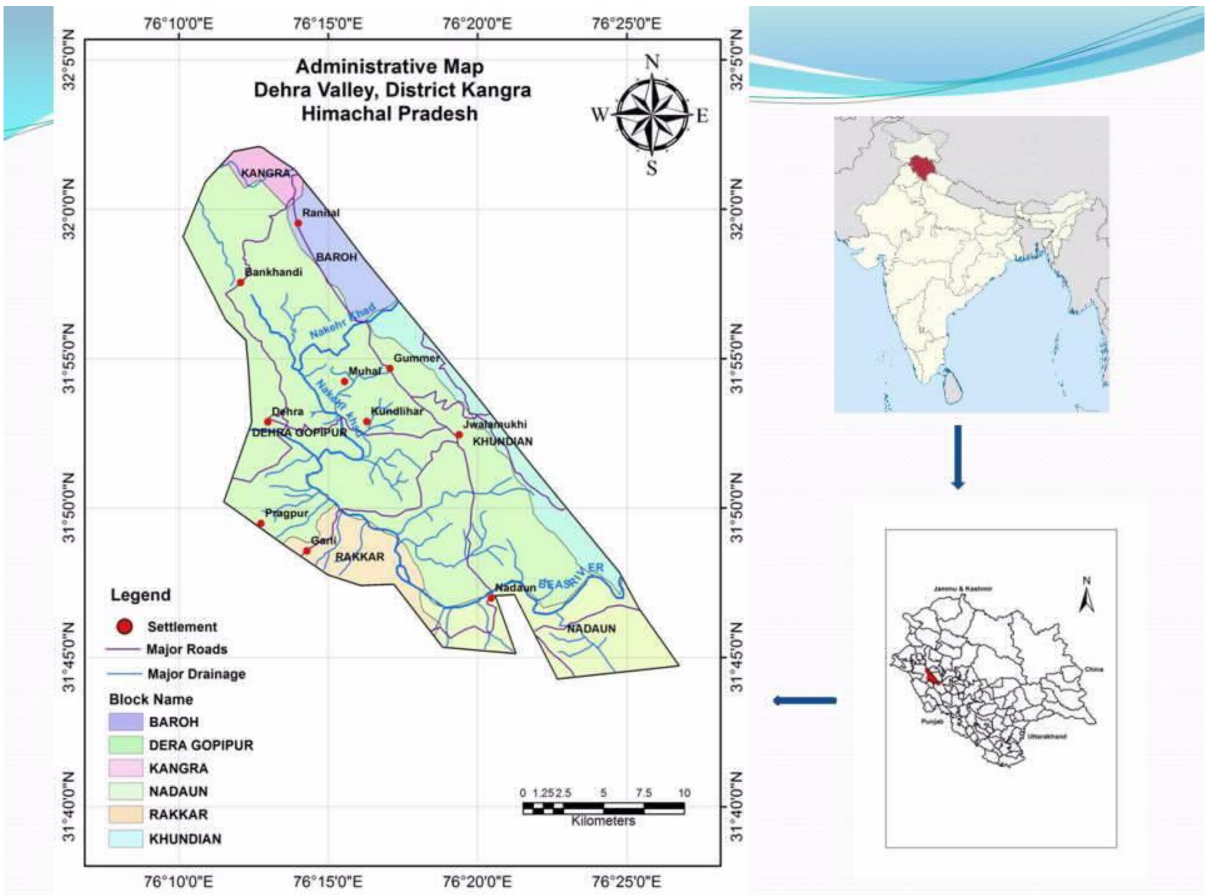
केंद्रीय भू मि जल बोर्ड,
जल संसाधन नदी विकास और गंगा संरक्षण विभाग,
जल शक्ति मंत्रालय,भारत सरकार
Central Ground Water Board,
Department of Water Resources, River Development and Ganga Rejuvenation,
Ministry of Jal Shakti, Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES OF DEHRA VALLEY, DISTRICT KANGRA, HIMACHAL PRADESH

उत्तरी हिमालयन क्षेत्र, धर्मशाला
Northern Himalayan Region, Dharamshala

GOVERNMENT OF INDIA
MINISTRY OF JAL SHAKTI
DEPARTMENT OF WATER RESOURCES, RD & GR
CENTRAL GROUND WATER BOARD,

AQUIFER MAPPING AND MANAGEMENT PLAN IN DEHRA VALLEY, DISTRICT KANGRA, HIMACHAL PRADESH. (2020-2021)



NORTHERN HIMALAYAN REGION DHARAMSHALA

March 2021

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AQUIFER MAPPING AND MANAGEMENT PLAN OF Dehra Valley, Kangra Districts, Himachal Pradesh

1. INTRODUCTION

Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical field and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers. There has been a paradigm shift from "groundwater development" to "groundwater management". An accurate and comprehensive micro-level picture of groundwater in India through aquifer mapping in different hydrogeological settings will enable robust groundwater management plans at the appropriate scale to be devised and implemented for this common-pool resource. This will help achieving drinking water security, improved irrigation facility and sustainability in water resources development in large parts of rural India, and many parts of urban India as well. The aquifer mapping program is important for planning suitable adaptation strategies to meet climate change also. Thus the crux of NAQUIM is not merely mapping, but reaching the goal – that of ground water management through community participation.

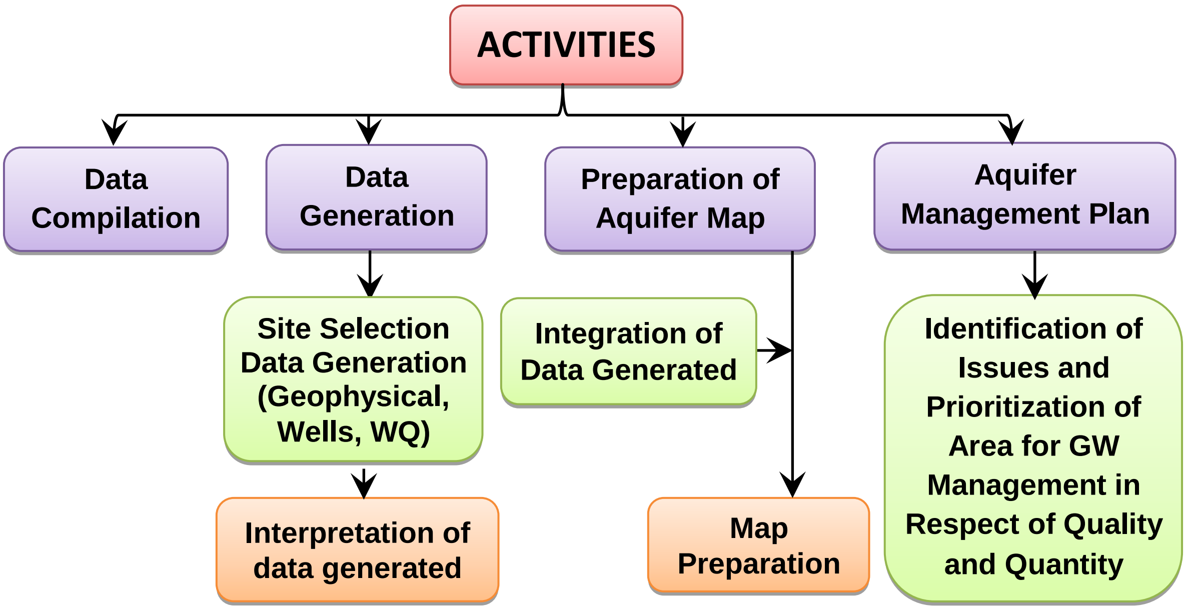
1.1 Objectives

The primary objective of the Aquifer Mapping Exercise can be summed up as "Know your Aquifer, Manage your Aquifer". Demystification of Science and thereby involvement of stake holders is the essence of the entire project. The involvement and participation of the community will infuse a sense of ownership amongst the stakeholders. This is an activity where the Government and the Community work in tandem. Greater the harmony between the two, greater will be the chances of successful implementation and achievement of the goals of the Project. As per the Report of the Working Group on Sustainable Ground Water Management,"It is imperative to design an aquifer mapping programme with a clear-cut groundwater management purpose" This will ensure that aquifer mapping does not remain an academic exercise and that it will seamlessly flow into a participatory groundwater management programme. The aquifer mapping approach can help integrate ground water availability with ground water accessibility and quality aspects.

With these aims, Aquifer Mapping Study is carried out in parts of Kangra and Hamirpur Districts of Himachal Pradesh under the Annual Action Programme 2020-21. These surveys are carried out to integrate the information on the scenario of groundwater occurrence, availability and utilization in terms of quality and quantity along with exploratory drilling, monitoring of water levels with quality, spring monitoring (discharge and quality), pumping tests, infiltration tests, geophysical surveys etc. Development of aquifer mapping at the appropriate scale and formulation of sustainable management plan will help in achieving drinking water security, improving the sustainability of water resources development through springs. It will also result in better management of vulnerable areas. During this study, 24 key observation points, Dugwells were established. Subsequently, all the available data on ground water from the earlier studies are compiled and integrated with these studies to bring out the ground water scenario, lateral and vertical characteristics of the aquifers and better management plan of ground water in a scientific manner.

1.2 Methodology

Various activities of NAQUIM are as follows:



1.3Location, Extent and Accessibility

The study area forms an elongated shape and cover Kangra districts and small parts of Hamirpur Districts. The total area covered under study is 360Sqkm. and covers Southern part of the Kangra district extending from SE to NW direction. The study area comprises 0.055% geographical area of Kangra district (316/5739 Sq. Km), around 0.039% area of Hamirpur districts (44/1118 sq.km) and. The areal extent of the areas is between Northern latitudes of 32°2’0” to 31°44’20” and eastern longitudes of 76°9’20” to 76°26’15” which falls in the Survey of India Toposheet no. 52D/4, 53A/1, 53A/5 AND 53A/6. The area is delimited between Dehra Gopipur in the west, Nadaun block in south west, Ranital in north direction. All the area encompasses the Siwalik formation throughout the area. The area is well connected by tar roads and is traversed by NH 303 and NH503.Kangra district headquater is Dharamshala located in Northern part of district. Administrative map and other important places and features are given in Base map. (Fig 1)

1.4 Administrative Divisions and Demgraphic Particulars

Administratively, area comprises of three districts in parts viz. Kangra & Hamirpur. The study area comprises of 6 Blocks viz. Kangra, Baroh, Dehra, Rakkar, Khundian & Nadaun. Administrative divisions are shown in the Fig.1. The study encompasses the catchment areas of Beas River and its tributaries.

Socio-Economic Conditions: The study area is moderately populated. The total population in 6 blocks is 85357 as per Census 2011. The average density of the study area is 61 persons per sq. km which is significantly lower than the state average of 123 persons per sq. km. The area shows a population growth of 11.32 % per year. (Decadal growth: 6.7% approx.). Around 23% of the population in area belongs to scheduled cast community and around 1% belongs to the scheduled tribe community. Majority of the population lives in villages. The work force constitutes about 54% of the total population. Agriculture is the backbone of the area's economy.

Table 1: Demographical details of the area

Sr. No	District	Block	Area Sq. Km	Total Population	Male	Female	SC	ST	Density (psqkm)	Total Worker
1	Kangra	Kangra	9	4878	2460	2419	446	65	28.36	2054
2		Baroh	20	3868	1860	2008	586	37	28.86	2030
3		Dehra	237	45897	22250	23648	10917	434	73.67	25197
4		Rakkar	23	5901	2890	3010	1520	24	52.22	4383
5		Khundian	27	5352	2605	2747	1059	90	28.02	3394
6	Hamirpur	Nadaun	44	19461	9467	9995	4962	218	106.92	9048
Total			**360**	**85357**	**41532**	**43827**	**19490**	**868**	**60.32**	**46106**

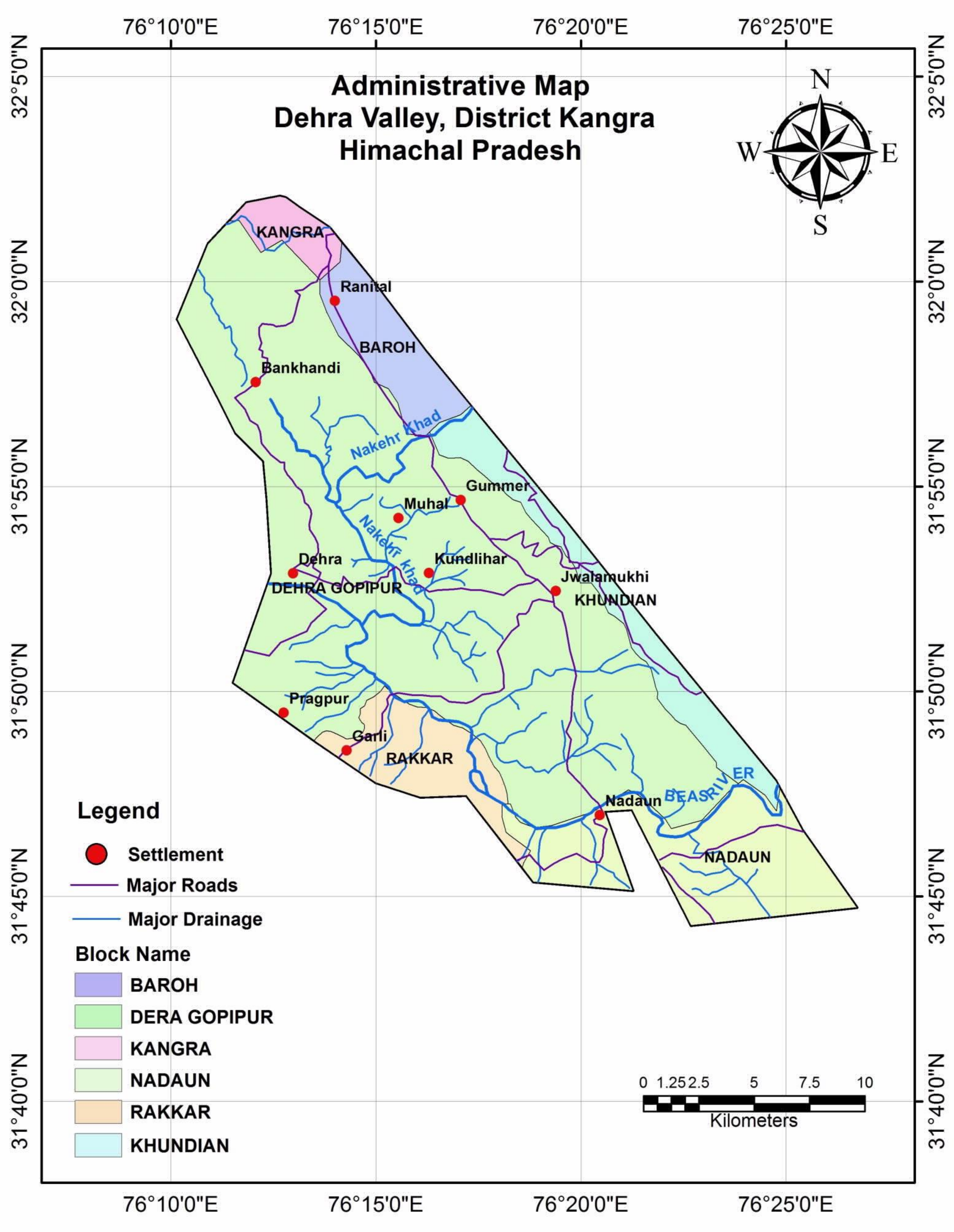


Fig. 1: Administrative Map of the study area.

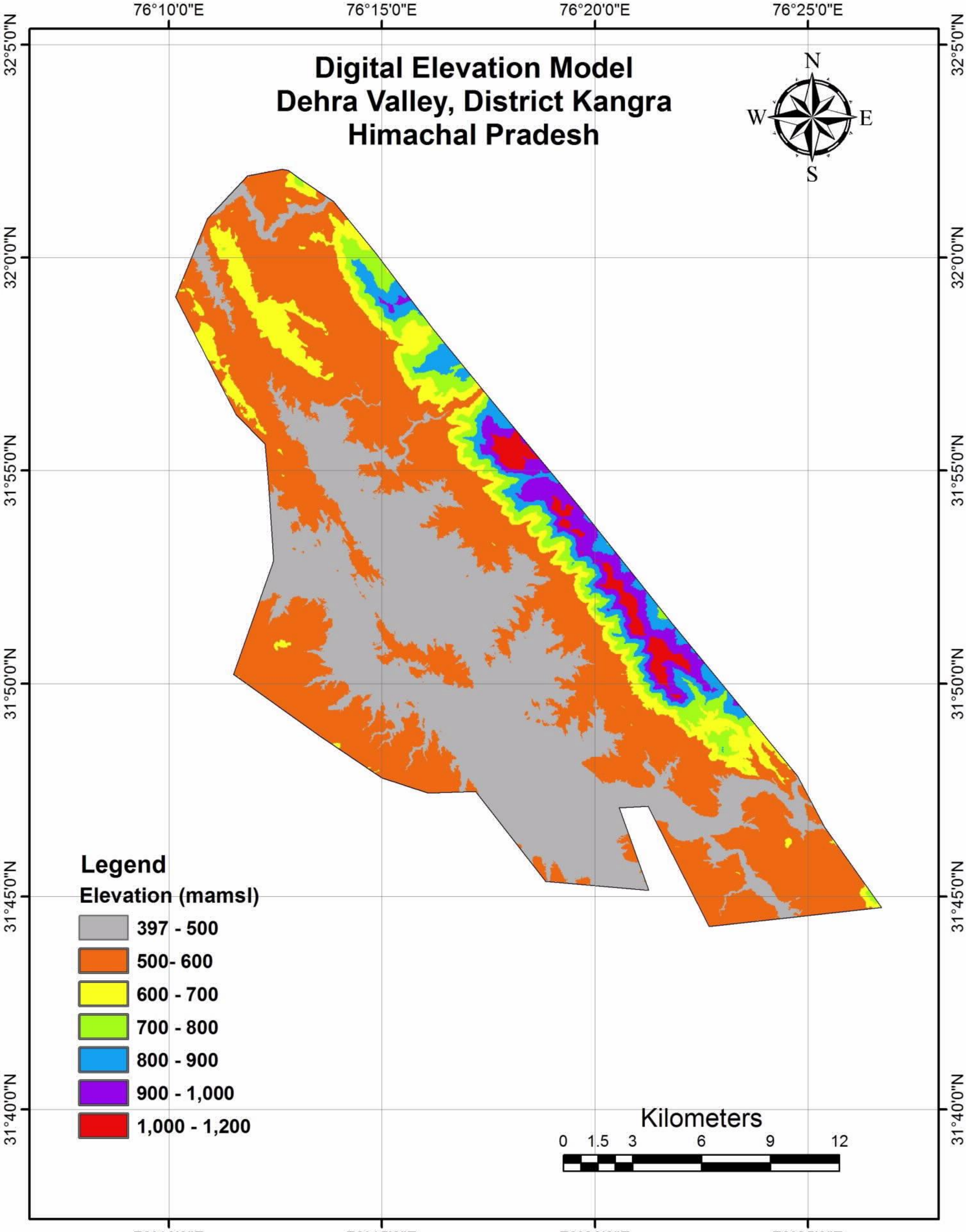


Fig 2: Digital Elevation Map of the study area

1.5 Land Use: The topography of the study area having hilly and valley portion both having slopes ranging from less than 5%in some areas to more than 40%. Large portion of the population occupies the north western to south western part of the area. The land use / land cover map was prepared using Survey of India topographic sheets and IRS P6 LISS – III satellite imagery. The Land use and land cover features in the study area Dense Forest, and River. Similarly Forest Area map was prepared with the help of processed satellite imagery; the same has been shown in **Fig. 3**. The breakup of land use is give in table 2 & 2.1 below

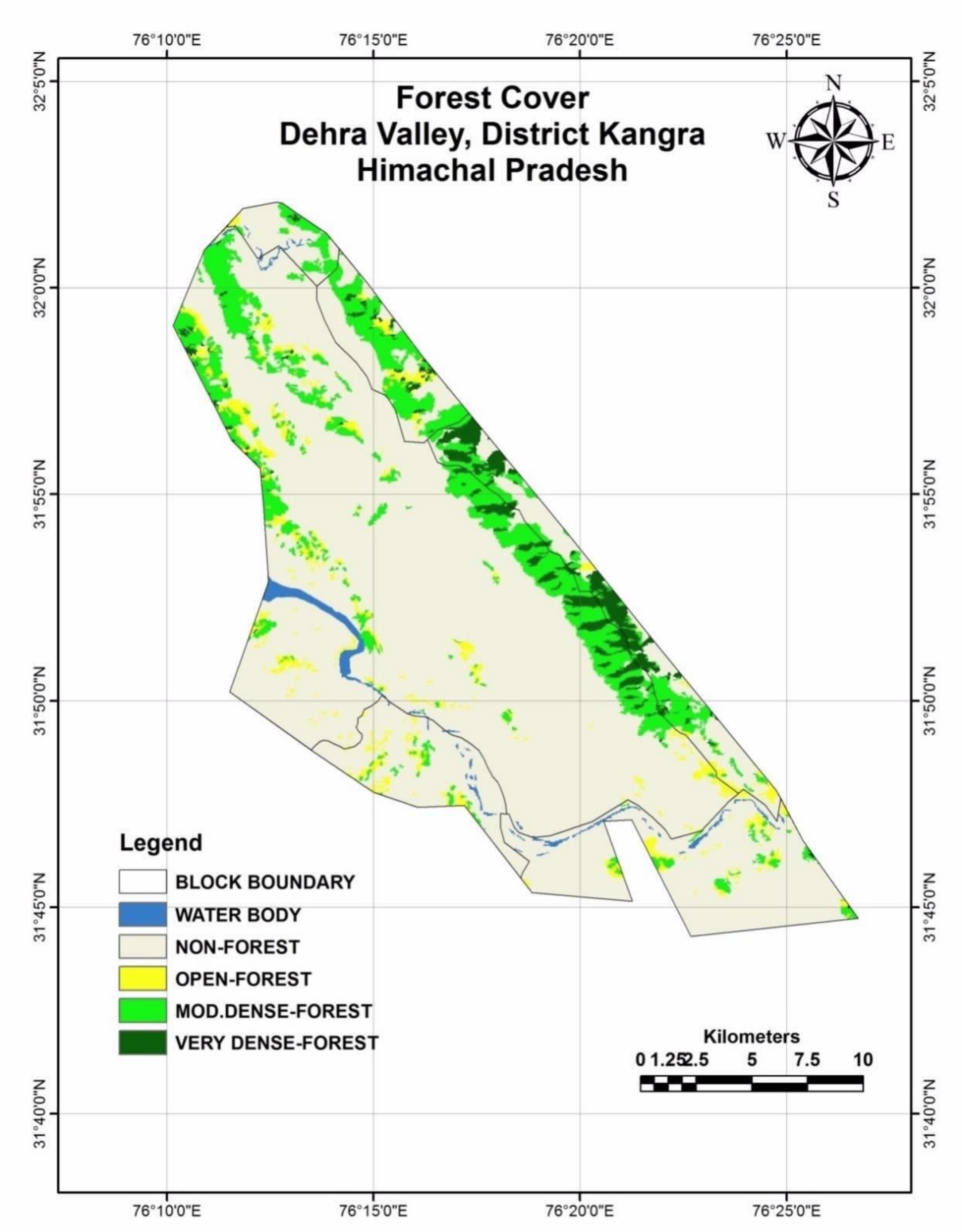


Fig-3: Forest cover map of the study area.

Table 2: Category wise Land use/Land Cover in the study area (contd...)							
Sr. No.	**District**	**Block**	**Forest**	**Land Put to Non-Agri Use**	**Barren Land**	**Permanent Pastures**	**Misc. Tree & Grooves**
1	Kangra	Kangra	157	93	178	11	56
2		Baroh	579	126	320	79	94
3		Dehra	364	6517	1020	13	60
4		Rakker	261	219	673	4	10
5		Khundian	552	146	743	40	69
6	Hamirpur	Nadaun	636	497	806	173	-
		Total	**2340**	**7598**	**3740**	**320**	**289**
Source: District Revenue Officer of respective districts & District Statistical Abstracts of respective districts for the Year-2017-18. (Figures in Hectares)							

Table 2.1: Category wise Land use/Land Cover in the study area									
Sr. No.	**District**	**Block**	**Cultivable Wasteland**	**Other Fallow**	**Current Fallow**	**Net Sown Area**	**Area sown more than once**	**Gross Sown**	**Net Sown/ Total Sown**
1	Kangra	Kangra	33	-	-	135	200	336	40.2
2		Baroh	68	-	-	383	354	737	52.0
3		Dehra	285	-	180	875	588	1465	59.7
4		Rakker	220	-	-	498	-	498	100.0
5		Khundian	267	-	-	336	23	359	93.6
6	Hamirpur	Nadaun	48	5	28	1335	1341	2040	65.4
		Total	**921**	**5**	**208**	**3562**	**2506**	**5435**	**65.5**
Source: District Revenue Officer of respective districts & District Statistical Abstracts of respective districts for the Year-2017-18. (Figures in Hectares)									

1.6 Cropping patterns: The net area sown is around 3562 hectares in 6 CD Blocks with 2506 hectares area sown more than once. The principal crops of area are Wheat and Maize. In Khariff season in addition to Maize, Paddy, Fruits, Vegetables, Pulses/Barley are also cultivated over small area. During Rabi season Wheat is principal crop along with potato, fruits and fodders etc.

Table 3: Block-wise breakup of area cropped under each crop type in study area

			Rabi		**Khariff**		**Others**		
Sr. No	**District**	**Block**	**Wheat**	**Vegetables**	**Maize**	**Paddy**	**Fruits**	**Fodder**	**Pulses/Barley**
1	Kangra	Kangra	206	7	119	88	4	1	10
2		Baroh	306	1	227	80	3	1	31
3		Dehra	1534	33	968	37	25	29	18
4		Rakker	4414	11	402	5	4	7	11
5		Khundian	511	7	270	100	56	0.84	9
6	Hamirpur	Nadaun	1007	11	994	2	8	7	4
		Total	**7978**	**70**	**2861**	**312**	**100**	**45.84**	**71**

Source: District Revenue Officer of respective districts & District Statistical Abstracts of respective districts for the Year: 2017-18. (Figures in Hectares)

1.7 Irrigation

The area is blessed with sufficient Monsoon Rainfall and Non Monsoon rainfall. The irrigation sources in area are Mainly *Kuhl/* Channels, Tube wells, Dug well and lift Irrigation Schemes and one Naker Khad Scheme.

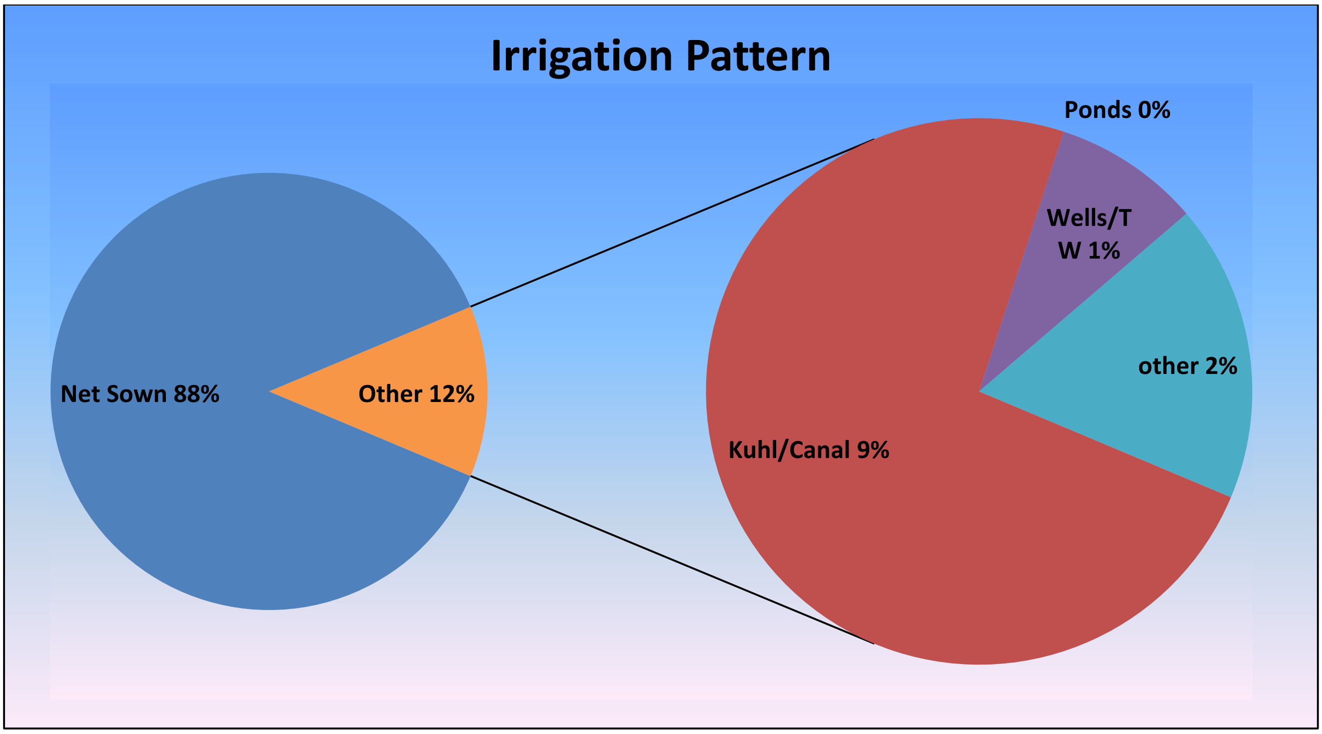


Fig. 4 : Source wise irrigation pattern in study area.

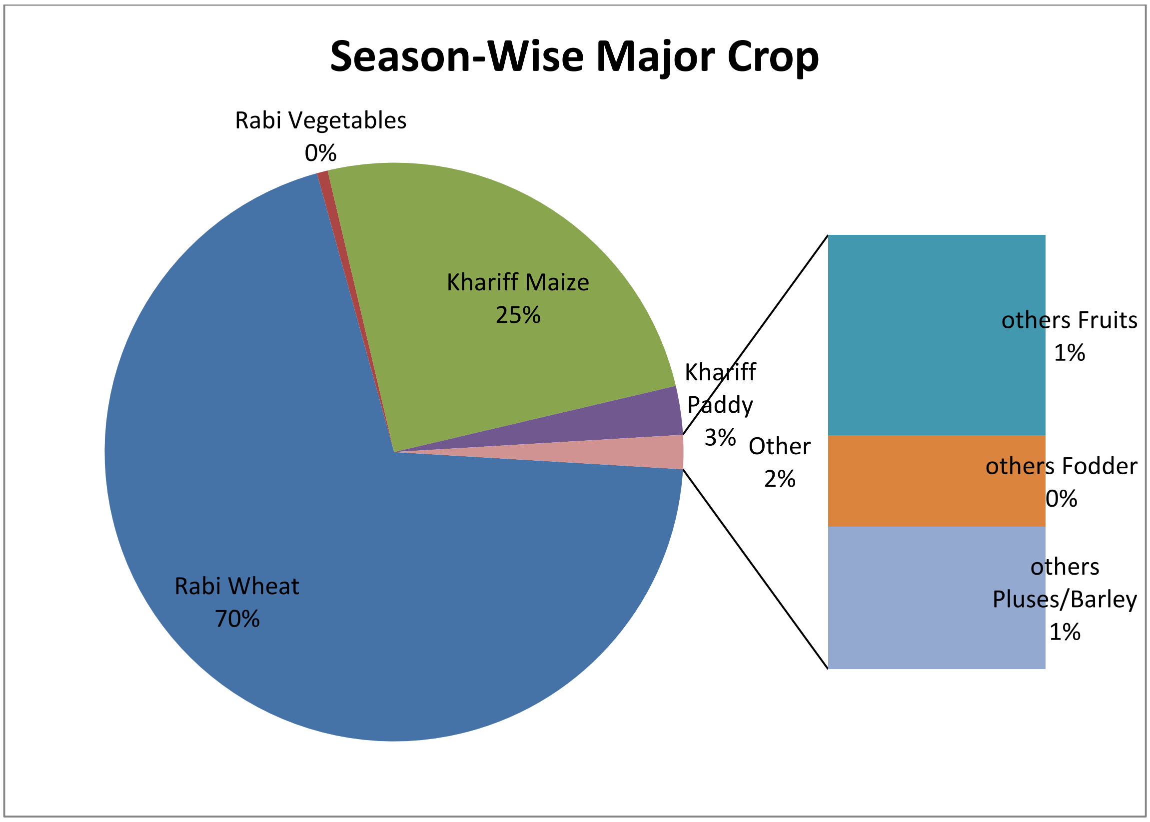


Fig 5 : Season wise major crop in the study area

1.8 Climate: The climate of the district varies from sub-tropical to sub-humid. Winter extends from December to February and summer extends from March to June while July to September are the rainy months. The minimum temperature in the area ranges between 2.5° to 23.5° Celsius in winters, whereas the maximum temperature ranges between 22.6° to 36.5° in summer season. The year may be divided into four seasons. The summers are from March to end June. July to September constitute the premonsoon. October and November constitute the post monsoon season and the period from December to February is the cold season. The area receives more than 72% of annual rainfall during Monsoon season only. The monthly Rainfall of the area for the five years is given in Table 4.

Table:4. Monthly Rainfall at Weather Station Ranital (Lat.- 32°0'54" Long.-76°13'33")

S.N.	**Year**	**Jan**	**Feb**	**Mar**	**Apri**	**May**	**Jun**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Mean**
1	**2015**	41.2	76.2	144	46	24.2	179.	478.	461.	128.8	20.4	2.6	17.	135.0
2	**2016**	5.4	22.2		-	-	75.2	301	460	177.2	10.4	0	0	150.2
3	**2017**	75.4	20	29.8	40.8	24	193.	350	501	127	0	0	53.	141.4
4	**2018**	7.6	27.8	26.6	38.4	23.8	204.	248.	796.	252.2	4.6	14.8	2.6	137.3
5	**2019**	73.6	145	37.6	37.6	32	15.4	454	501.	209.2	3	20.8	81.	134.2

Source: IPH, Data centre, Mandi

All figures in millimeters.

Temporal distribution of rainfall in the study areas: The month wise rainfall in study area can be summarized as:

- **72% of total rainfall occur during Monsoon Season (July to September).**
- **955 mm rainfall (59% of annual rainfall) occurs over 60 days.**

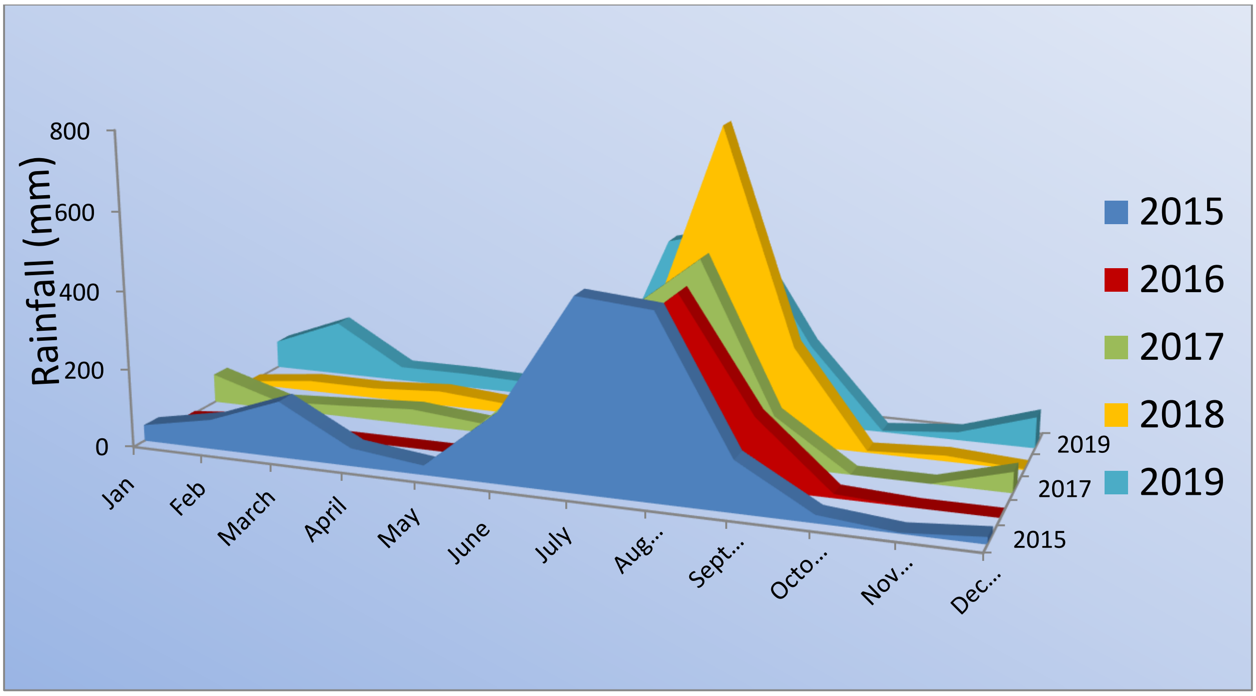


Fig 6: Temporal Distribution of Rainfall in Study Area

1.9 Physiography

The study area is having valley and hills both located at an altitude ranging between 397 metres above the mean sea level to 1200 mamsl. The Beas is the main river which enters the study area from the south east near Nadaun in Hamirpur district. Naker Khad is the main tributaries of Beas river in this area.

Geomorphology : The geomorphological map was interpreted from survey of India topographic sheets and IRS P6 LISS - IV satellite imagery. The topography is generally formed on the middle and lower Siwalik formations and upper siwalik. Jawalamukhi thrust demarcates its southern boundary. In this zone channels are generally deep when they cut across the strike, while along the strike they form wide and open valleys. The valley slopes are generally steep and at many places channels have carved deep gorges. The geomorphic units represented in the study area are Structural hills& valley and river alluvium shown in fig 7.

Hills: The hilly portion located at an altitude ranging between 500 metres and 1200 metres above the mean sea level.

Valleys: The valley portion of the study area is aligned SW to NW. Valley area is more populated, fertile, more cultivated. Dehra Gopipur block is in valley portion of the study area.

1.10 Drainage:

The main river in the area is the Beas, which is perennial. The most of the tributary streams in the area are seasonal. Drainage pattern is mainly dendritic. There are number of 2^{nd} and few 3^{rd} order streams in the area. In the study area Naker Khad is the main tributary of the river Beas. In kundli Har area the Naker Khad is about 300 to 400m in width. The entire channel is filled with channel fill (valley fill) Material. These are mainly sand, pebble, cobble and boulders. The valley area will be flooded during monsoon and will be dry during the summers. During lean periods water pools have been appearing at places. These are due to oozing out of ground water within the channel bed. From November to March the stream flow is sustained by the base flow. The channel will be almost dry from April to till the time monsoon starts.

1.11 Soil Types

For the preparation of the soil map, the soil atlas of the Himachal Pradesh, prepared by C.G.W.B. Northern Himalayan Region is used as the primary source and then updated with satellite imagery (fig 8).

The description of soil types is available at

https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051232.pdf

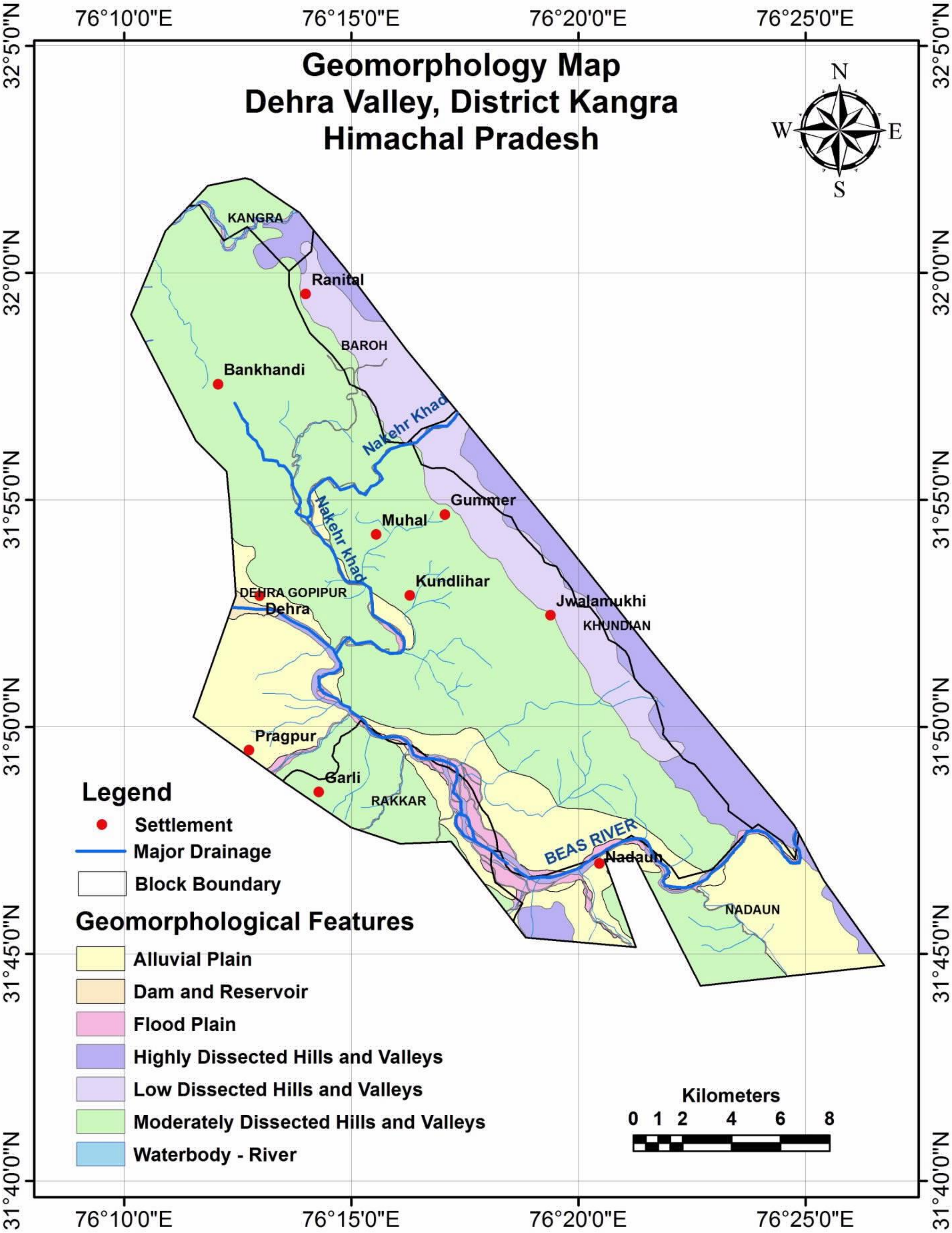


Fig 7: Geomorphological map of the study area

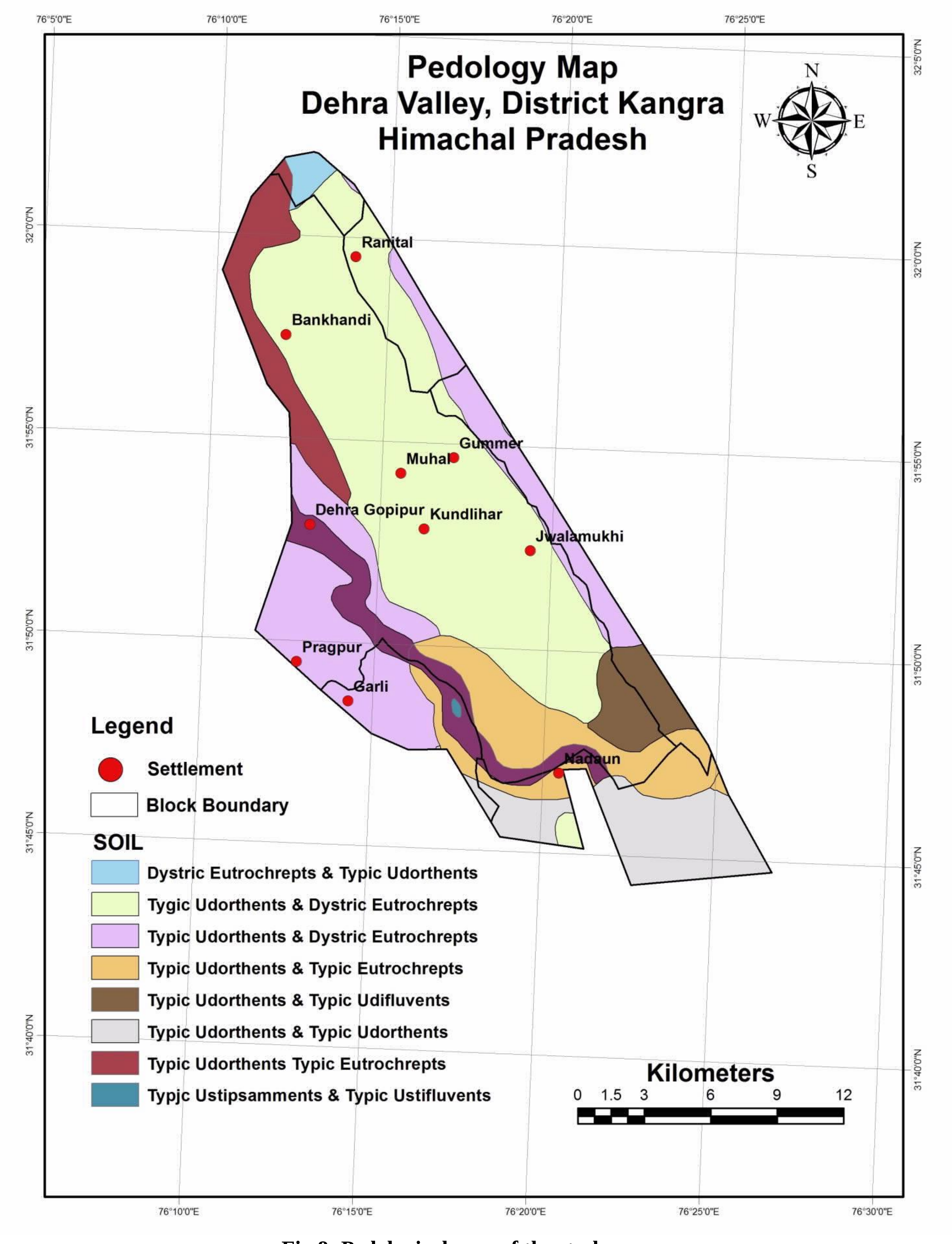


Fig 8: Pedological map of the study area

1.12 Data Adequacy & data gap analysis

The Data gap analysis was done on the basis of NAQUIM & EFC guidelines in Aquifer Mapping Study area of 360sq.kms in Kangra and Hamirpur Districts of Himachal Pradesh. The study area falls in Survey of India Toposheets No.53 A/01, A/05, A/06, and 52 D/04 covering full or partial area of 12 quadrants (Figure -9 - Toposheet Index Map). The Data Gap analysis of all the attributes is given in Table 6.

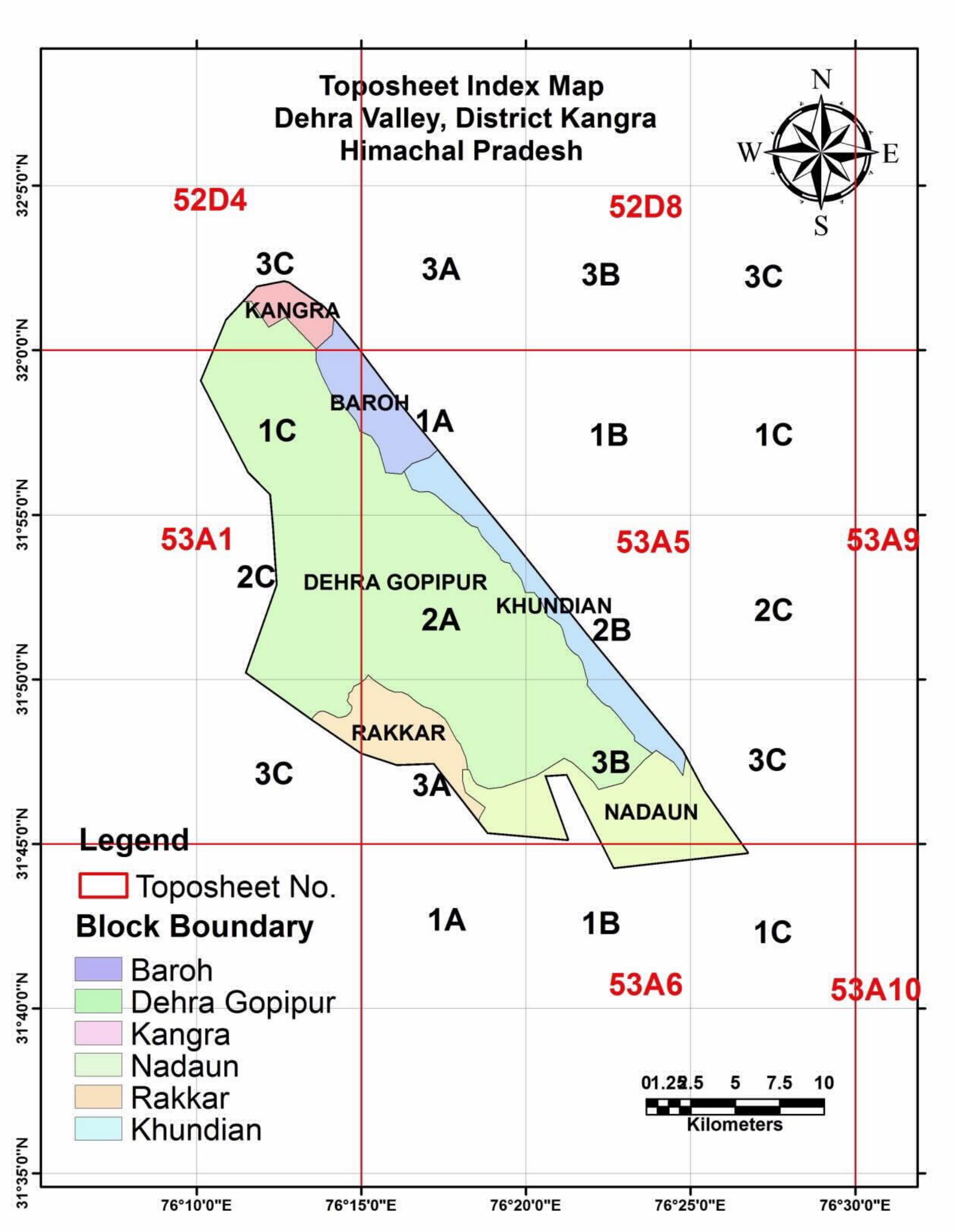


Fig.9: Toposheet Index Map–Study Area

1.12.1 Exploratory Data

The Data gap Analysis indicates the required Ground Water Exploration sites, sets of exploratory and observation wells to ascertain the aquifer parameters, in the area as per the EFC and the existing number of sites in the area and the Gap is indicated where ever the required number of sites is higher than the existing number of sites. On the basis of data gap analysis, quadrant-wise existing and recommended sites is presented and shown as square diagram in the figure-10 and Table No.6

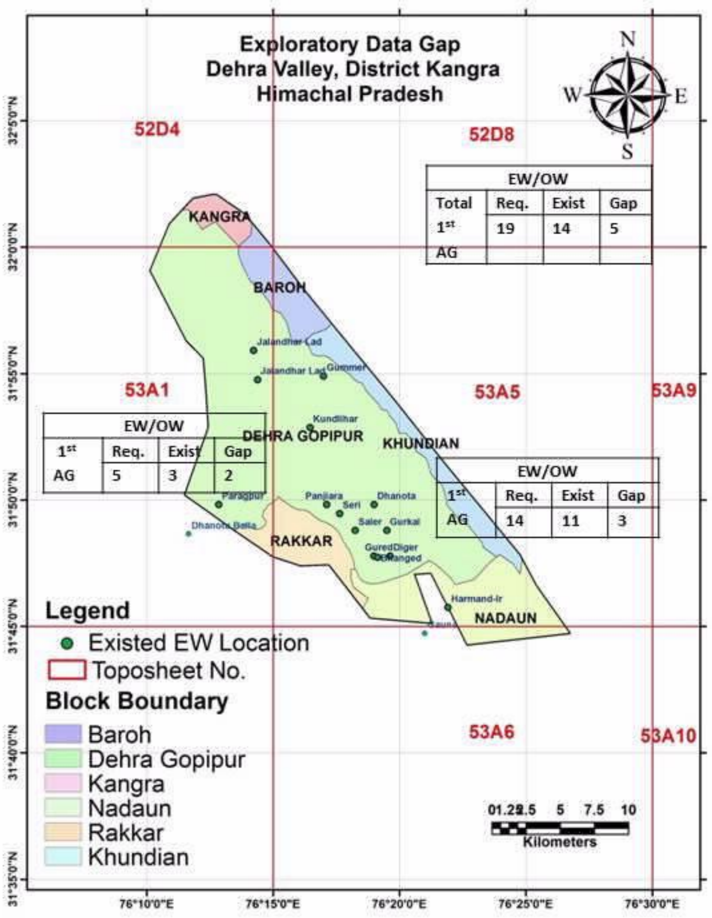


Fig.10: Exploratory Data Gap in the study area, Dehra Valley.

1.12.3 Ground Water Monitoring Stations (GWMS)

The ground water monitoring NHS and Key well observation stations in the area tap the unconfined aquifer. On the basis of data gap analysis, quadrant-wise and aquifer-wise existing and recommended ground water monitoring stations is presented and shown as square diagram in the figure -11.

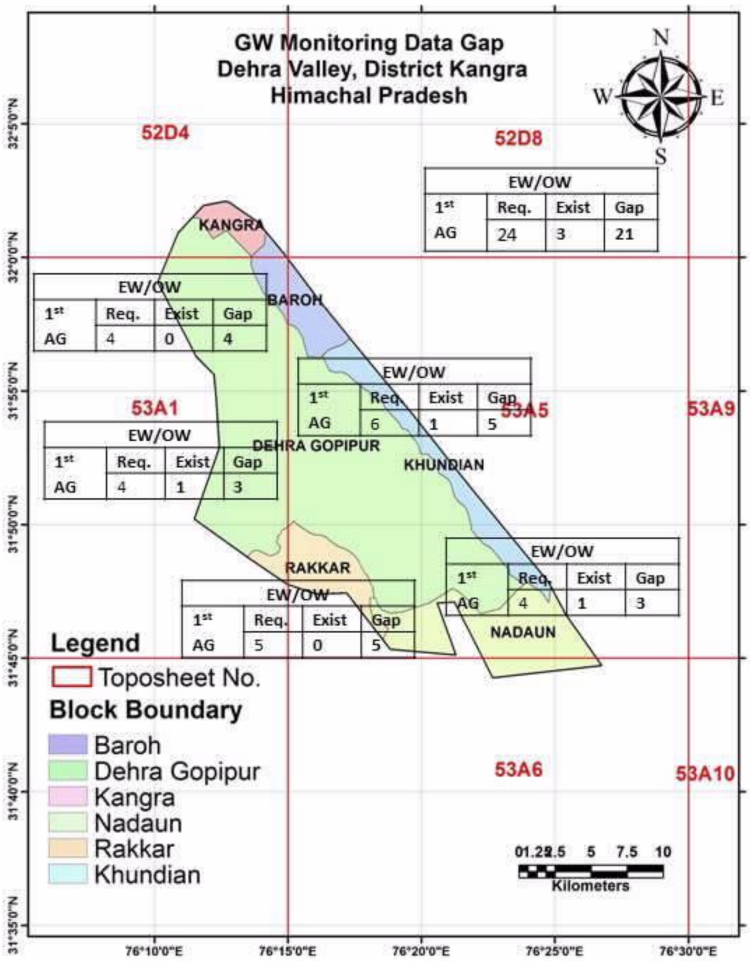


Fig.11: Data Gap Analysis for Ground Water Monitoring

1.12.4 Ground Water Quality Monitoring Stations (GWQMS)

Most of the ground water quality monitoring NHS and Key well observation stations in the area taps the unconfined aquifer. Wells constructed by CGWB and hand pumps by the state agencies tapping the deeper and shallow aquifers are utilised to monitor the quality of ground water in the deeper and shallow aquifers. The quadrant-wise and aquifer-wise existing and recommended ground water quality monitoring stations are shown as square diagram in the fig 12.

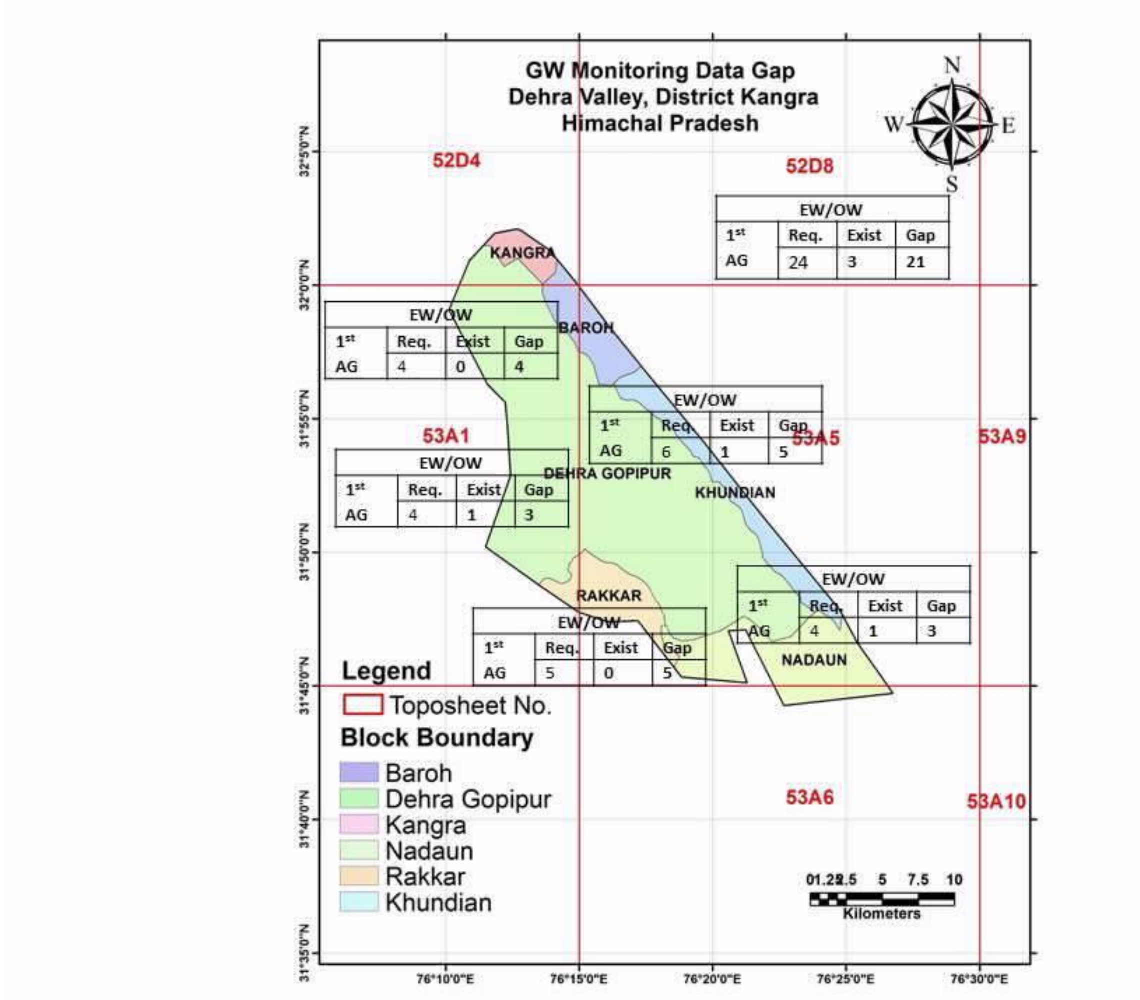


Fig.12: Existing Ground Water Quality Locations in study area.

1.12.5 Rate of Infiltration

The amount of recharge to ground water depends on the infiltration rates of the soils. No infiltration tests have been conducted in previous surveys by CGWB and even this data is not available with state agencies. To know the infiltration characteristics of the soil in the study area, 12 nos. of infiltration tests are required. On the basis of data gap analysis, quadrant-wise existing and recommended infiltration tests are presented and shown as square diagram in the figure -13.

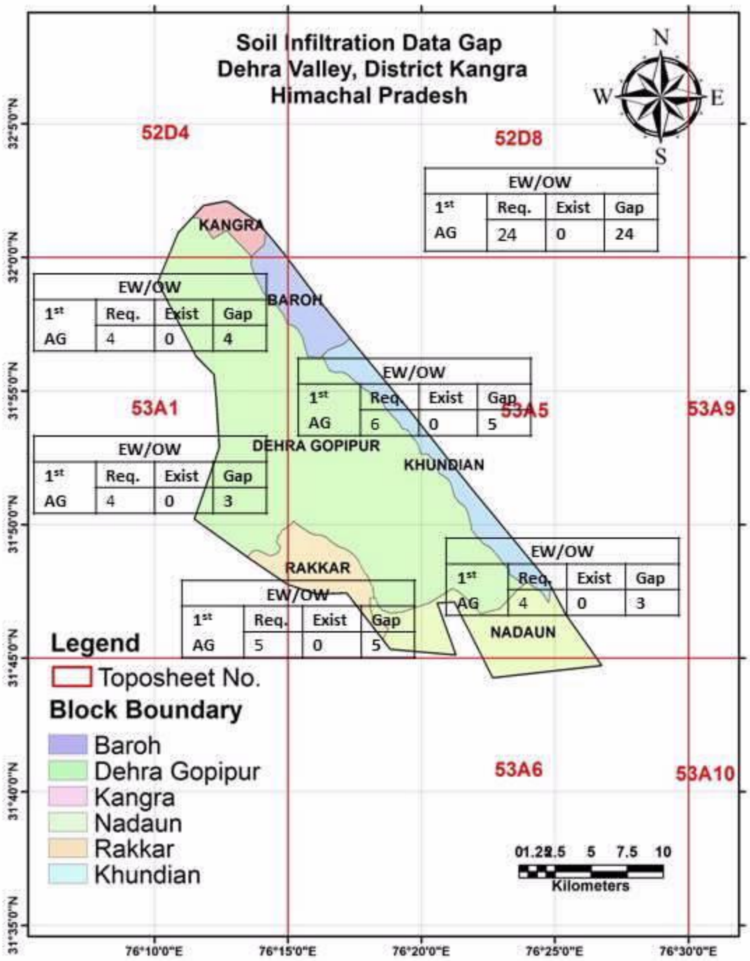


Fig.13: Data Gap Analysis for Soil Infiltration Studies

1.13 Previous Work and Present Status of Data

Central Ground Water Board, NHR, Dharamshala has brought out district reports, ground water management studies reports, ground water exploration reports periodically on all districts of Himachal Pradesh. The systematic surveys and reappraisal hydro geological surveys were carried out by CGWB in area during various field seasons. Central Ground Water Board, NHR, Dharamshala has also carried out ground water exploration studies in the area.

CGWB NHR, Dharamshala is monitoring ground water levels from National Hydrograph Network observations and aquifer mapping wells (Table 5) since 1977 in all valleys of Himachal Pradesh four times a year in the months of, May, August, November and January. The ground water quality is being studied by CGWB once in a year from the samples collected from those observation wells during the month of May.

Table 5: National Hydrograph Network observations falling in the study area are tabulated below:

Sl.No	Name of Village/site	Latitude	Longitude	Estt. Date	RL (mamsl)	Total Depth of DW (mbgl)	Type (DW /TW)	Measuring Point (magl)
1	Dehra Gopipur	31.882028	76.215305	1978	445.20	09.30	DW	0.60
2	Bharoli	31.792056	76.334222	1978	508.81	08.20	DW	0.70
3	Jwalamukhi	31.877417	76.316222	1978	476.08	17.20	DW	0.40

Table 6: Data Gap Analysis Table for all parameters Dehra Valley (2020-2021)									
Quadrant no.	**No. of additional EW's Required**		**No. of additional OW's Required**		**No. of additional VES/TEM Required**	**No. of additional water level monitoring Stations (DW/Spring) Required**	**No. of Soil Infiltration test Required**	**Remarks**
	Aq- I	**Aq- II**	**Aq- I**	**Aq- II**	**Aq- II**	**Aq- I**		
52D04/3C								
53A01/1C	2		2		4	4	4	
53A01/2C					4	4	4	
53A01/3C								
53A05/1A								
53A05/2A					6	6	6	
53A05/3A					5	5	5	
53A05/2B	2		2		1	1	1	
53A05/3B	1		1		3	3	3	
53A05/3C					1	1	1	
53A06/1B								
53A06/1C								
Total	**5**		**5**		**24**	**24**	**24**	

Chapter II

2.1 Geology

Geologically, the rock formations occupying the study area range in age from Pliocene to Middle Miocene of Tertiary. The detailed geological succession encountered in the area is given below in table8:

Table 7: Geological Succession in study area.

Era	Period	Group	Formation	Description of Lithology
Post Tertiary	Recent		Alluvium	Grey to dark grey iron stained fine to coarse sand with pebble and clay
	Pleistocene		Older Alluvium	Multiple fill cyclic sequence of medium to coarse grained grey sand and grit with pebble of sandstone and lenses of clay
Tertiary	Pliocene – Middle Miocene	Siwalik system	Upper Siwalik	Sand stone, boulder conglomerate, clay and grit stone
			Middle Siwalik	Grey sandstone, gravel beds, shale, clay
			Lower Siwalik	Micaceous sandstone, purple clay, mudstone
	Lower Miocene-Oligocene	Subathu group	Kasauli	Grey sandstone, shale, clay;
			Dagshai	Grey/green sandstone, red nodular clay
			Subathu	Grey/green splintery shale, sandstone and limestone bands
Pre Tertiary	Upper Proterozoic-III	Krols	Krol	Sand stone, red shale, dolomite;
			Infra Krol	Carbonaceous shale, slate, greywacke;
			Blaini	Tillitoids, shale, slate, quartzite, dolomitic limestone.

Source: Geological Survey of India

Stratigraphically, majority of the study area is underlain by the Siwalik formations. Structurally these formations are highly disturbed.

Tectonically, the area is highly disturbed, major thrust trending NW-SE, Jwalamukhi Thrust. Jawalmukhi Thrusts separates Lower Siwalik to middle Siwalik. The Geology/ lithology map of the study area was prepared with the help of Himachal Pradesh Geological map on 1:50000 scale. Figure 14.

Lithology: Lithology wise, the area has varied lithology. Rocks in area varies from Recent alluviums to crystalline formation of Proterozoic, through Siwaliks of tertiary. Major lithology of the area is Sandstone, Conglomerate, Boulder, Clay. Lithology map of the area is given in Fig 15.

Lineament: Due to tectonic activity in the area, the lineament development is very prominent in the areas. All these lineament provide necessary weak zones for infiltration as well as movement of groundwater. The lineament map of the area has been prepared from National Geological Lineament Map on 1:50000.(Source: Geological Survey of India) Fig 16.

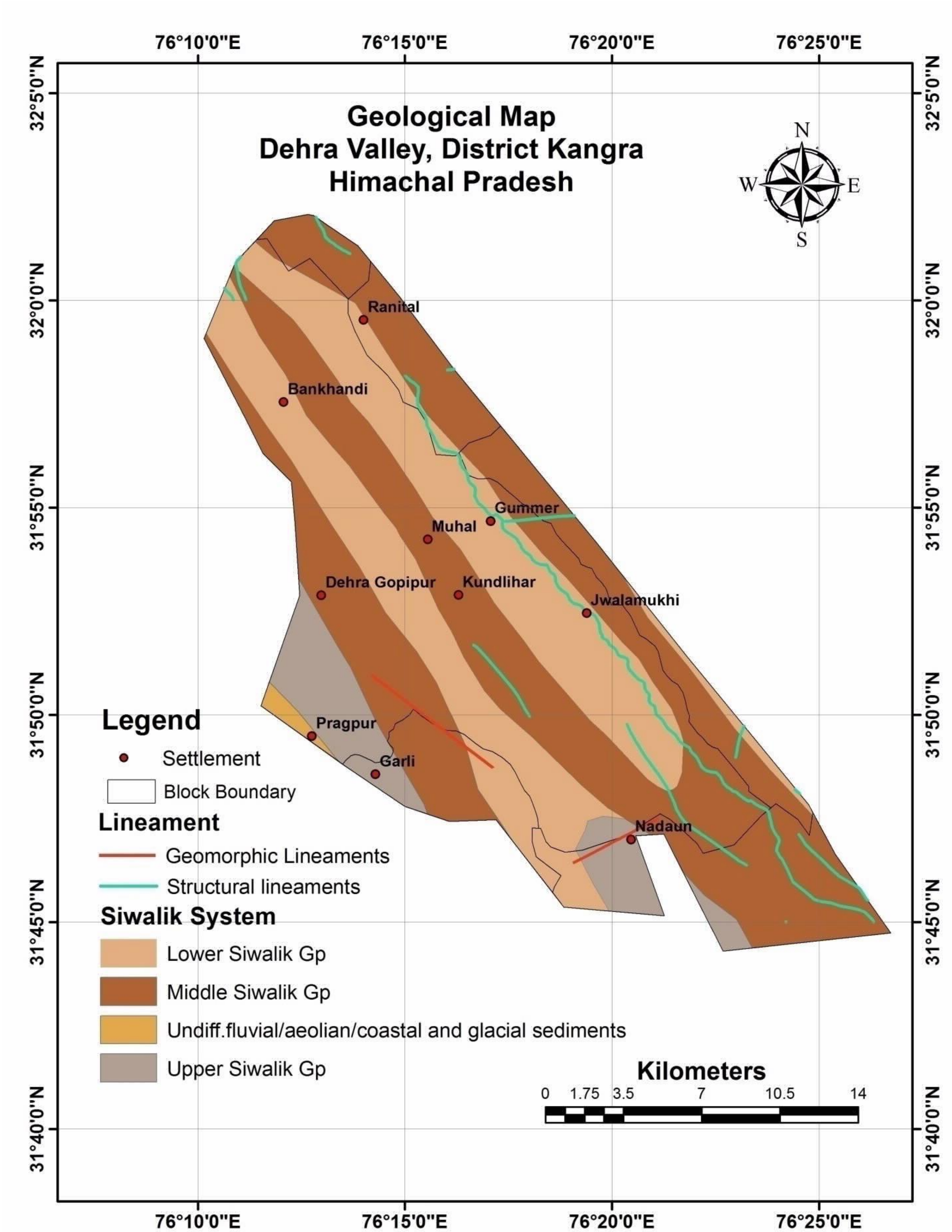


Fig.14: Geological map of the study area

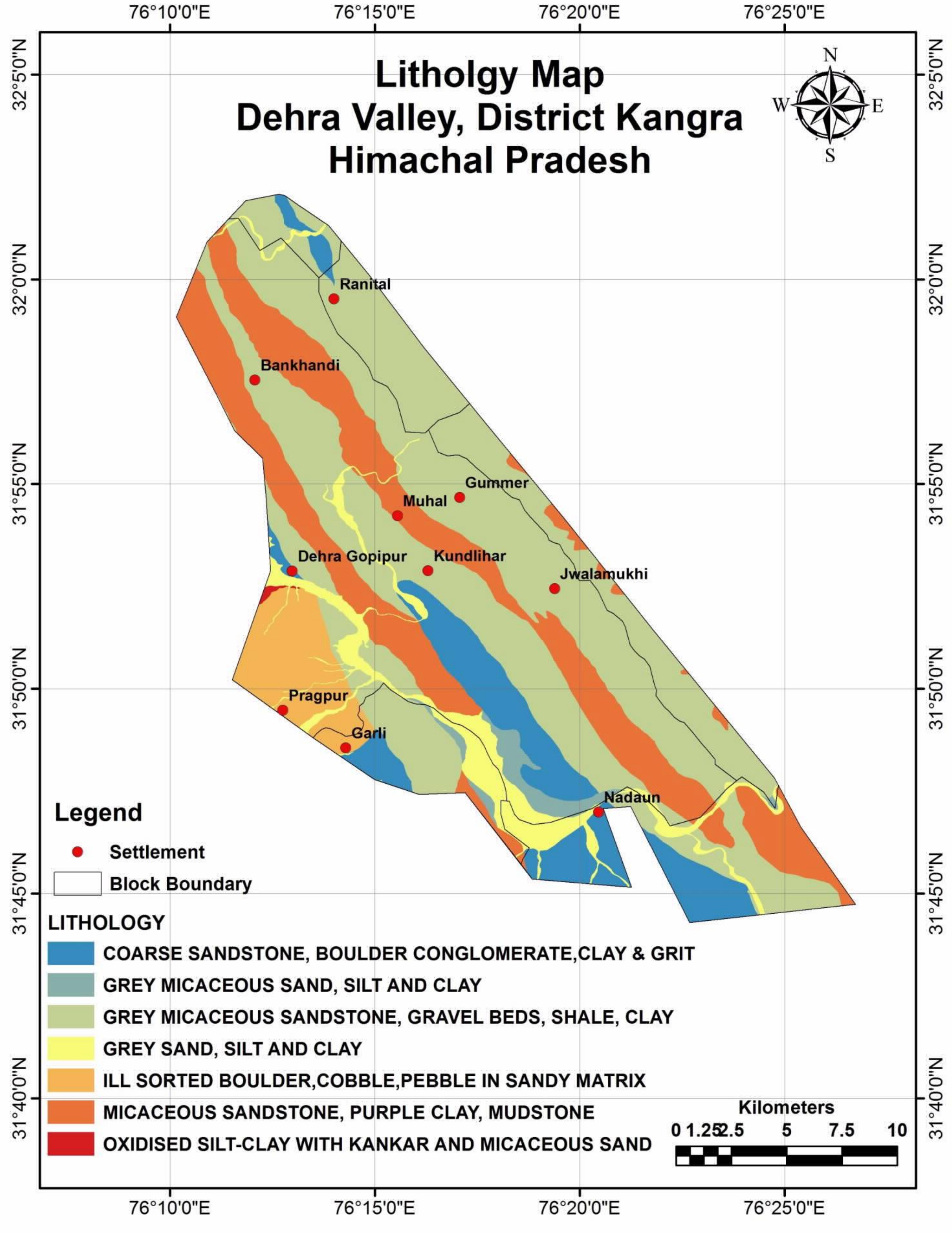


Fig.15: Lithological map of the study area

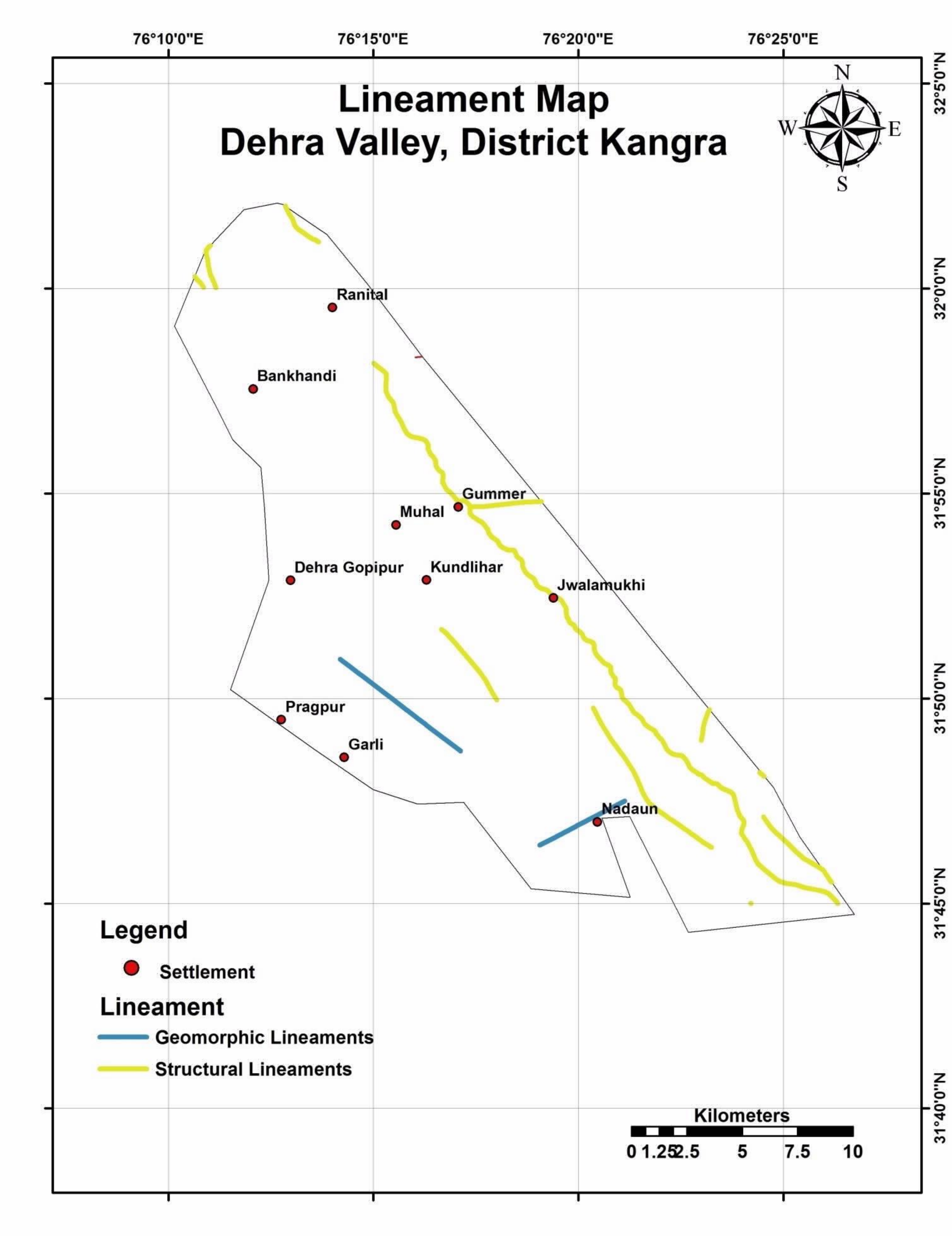


Fig.16: Lineament map of the study area

2.1Hydrogeology

The Hydrogeological frame work of the study area is essentially controlled by the geological setting, distribution of rainfall, snow fall, which facilitates circulation and movement of water through inter-connected primary and secondary porosity of the rocks constituting the aquifers. Based on the geological diversities and relative ground water potentialities the study area is maily comprises of fissured formation. Fissured formations comprise hard rocks belonging to Jutogh, Shali-limestones, Chails, Chandpurs, Kangra-Darla volcanic, Subathus, Dharamsala and Siwaliks.

The study area covers Siwalik formations. In Siwalik formations, the contact zones of various formations and fault zones form potential ground water horizons, especially between Nadaun in the east and Nurpur in the west. Important springs at Trilokpur (30 lps) and Nagni (25 lps) are located at the intersection of Jawalamukhi thrust and north-south trending faults. Compact conglomeratic formations are generally devoid of water, but hand pumps have been successfully installed in low topography area and along fractured zones. The boreholes drilled for installing handpumps have yielded from less than 1 lps to about 20 lps. Discharge is generally higher in Jawalamukhi area along the thrust zone.

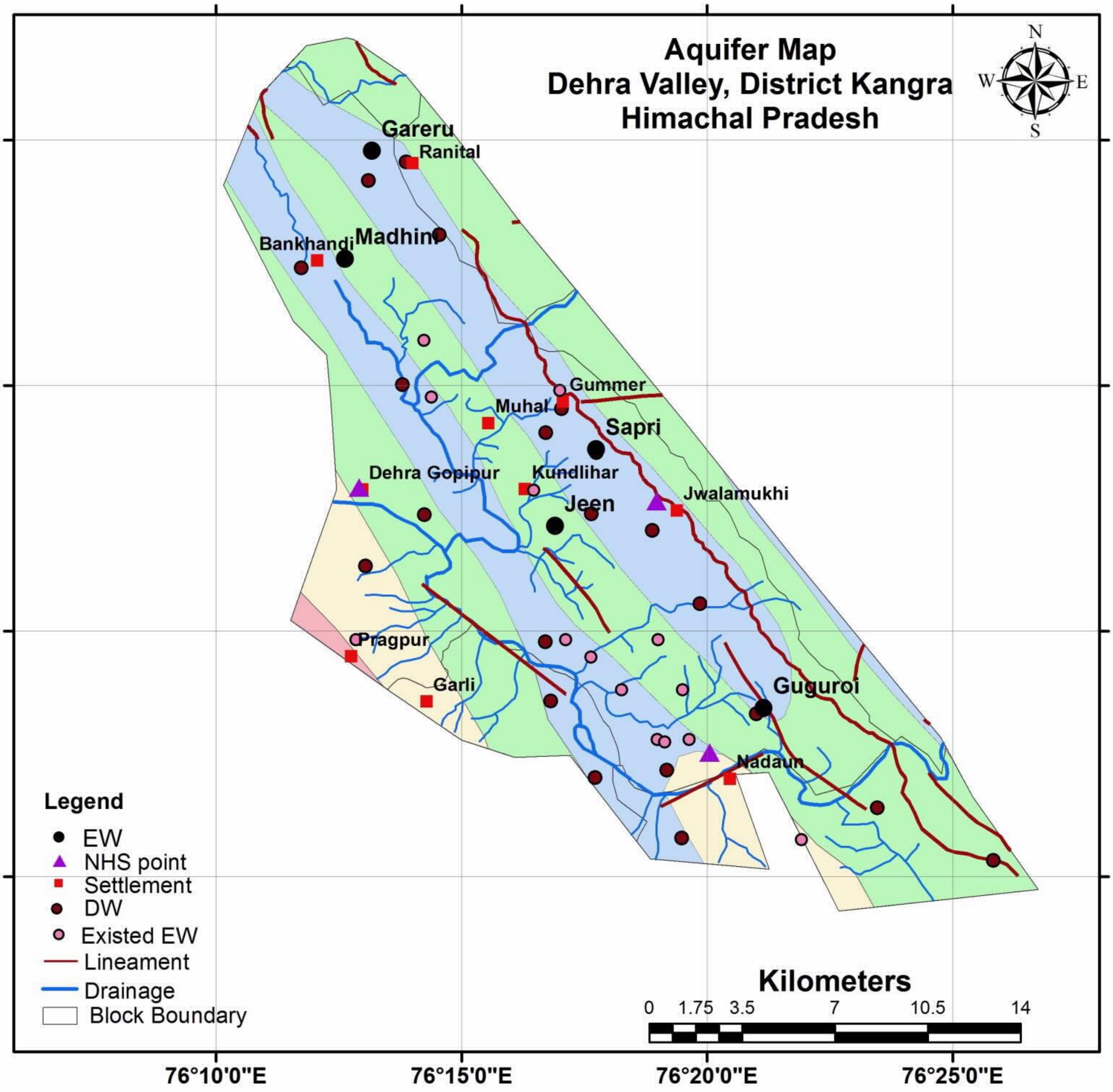
a) Fissured formations: Fissured formations are represented by hard fractured and weathered sandstone with bands of shale. Ground water occurs under phreatic to semi-confined condition. Ground water is developed through bore wells drilled for fitting hand pumps and springs.

b) Porous Formation: Porous formations are constituted by deposits occurring as minor valley fills along the streams or khad course. Kundlihar forms the major valley with an area of about 4 sq.km. Alluvium is loose to semi-consolidated conditions.

Beas River is main catchment in the study area. Naker khad is main tributaries of Beas river in the study area from Dehra Gopipur area.

Dug wells and tube wells are the main ground water abstraction structures. Ground water is being developed in the area by medium to deep tube wells, dug wells, and dug cum bored wells. The Aquifer map of the area is shown in Fig. 17 on next page. Further the information on various aquifer parameters. Aquifer disposition etc. has been given in Chapter 3 on Data Integration.

Table 8: Aquifer parameters delineated through Exploratory drilling				
Location	LATITUDE	LONGITUDE	SWL	Depth
Jalandhar Lad	31.9319	76.2372	-	30
Gummer	31.915	76.2833	5.1	98
Kundlihar	31.8811	76.2744	6.13	93
Jalandhar Lad	31.9127	76.2398	4.4	32
Paragpur	31.8303	76.2142	-	101
Panjiara	31.8303	76.2853	-	83
Dhanota	31.8303	76.3167	-	130
Seri	31.8244	76.2939	12.53	67.3
Saler	31.8133	76.3042	3.9	65
Gurkal	31.8133	76.325	-	89.5
Gured	31.7964	76.3164	10.3	72
Bhanged	31.7956	76.3189	13.1	46
Dger	31.7964	76.3272	5.79	45
Harmand-Ir	31.7625	76.3653	5.32	82
Gareru	31.99632	76.21962	2.26	118
Madhini	31.95967	76.21056	6.67	65
Sapari	31.89506	76.29576	1.74	63.5
Jeen	31.86903	76.28183	1.5	103
Guguroi	31.80714	76.35247	2.57	104



Age	Stratigraphy	Major Aquifer	Lithology	Ground Water Potential
Quaternary	Undiff.fluvial/aeolian/ coastal and glacial sediments	Unconsolidated	Gravel, Sand, Clay, Pebble, Boulder	Yield prospect very limited due superficial thickness
Pliocene-Pleiostocene	Upper Siwalik Gp	Upper Siwalik	Sandstone, Boulder, Coglomerate, Clay	Limited Yiels prospect
Miocene	Middle Siwalik Gp	Middle Siwalik	Sandstone, Gravel, Clay	Limited Yield Prospect
Miocene - Pliocene	Lower Siwalik Gp	Lower Siwalik	Micaceous Sandstone, Gravel, Purple Clay, Mudstone	Limited Yield Prospect

Fig 17: Aquifer Map of the study area in Dehra Valley

Chapter-III DATA COLLECTION AND GENERATION

3.1 Hydrogeological Data

Water Level Behavior: To know the water level and its behavior with respect to time and space, 21 dug wells have been inventoried for Ground Water Management Studies all over the area. The water levels were taken during the month of May, August, November and January of 2020 & 2021and on the basis of these data, pre-monsoon, post monsoon and seasonal fluctuation map have been prepared for the study area. The hydrogeological data of the inventoried dug wells are given in Table 9

In Study area, depth to water level shows wide variation. During pre-monsoon period (May 2020) it ranges from 1.1 mbgl (Daranga) to 11.88mbgl (Bohrjagir) (Fig.18) and post monsoon period (Nov.2020) ranges from 1.58 (Chaurna) to 12.1mbgl (Bohrhagir) (Fig.19).In major parts of study area, Seasonal Water Level Fluctuation ranges between less than 0.08 to 1.01 m.

Table 09 :Water level data (May & Nov 2020) GWMS and Aquifer Mapping Wells of Dehra Valley, Kangra and Hamirpur Districts Himachal Pradesh

LOCATION	Latitude (Decimal Degree)	Longitude (Decimal Degree)	Water Level, 2020 (mbgl)		2020 Fluctuation (m)
			May, 2020	Nov, 2020	
Chamukha	31.7835	76.29533	3.99	4.47	0.48
Kohr	31.76294	76.32469	3.95	4.55	0.6
Suggal	31.77319	76.39106	5.9	6.2	0.3
Putriyal	31.75536	76.43042	2.41	3.32	0.91
Kopra	31.80511	76.34989	0.99	2.47	1.48
Bohrjagir	31.78603	76.31961	11.09	12.1	1.01
Bannu Da Khu	31.8425	76.33078	2.85	3.3	0.45
Daranga	31.8675	76.31461	0.96	2.38	1.42
Pangehr	31.82964	76.27844	7.45	7.87	0.42
Kuhna	31.80956	76.28022	8.22	8.62	0.4
Chaurna	31.87308	76.29394	1.36	1.58	0.22

Kuru	31.87272	76.23739	1.63	1.89	0.26
Sunnhet	31.85539	76.21742	3.1	3.4	0.3
Khabali	31.91686	76.22989	6.95	8.1	1.15
Sherlohara	31.95653	76.19561	3.85	5.97	2.12
Gagher	31.98622	76.21831	2.4	2.29	0.11
Bhangwar	31.99261	76.23114	2	2.38	0.38
Paloti	31.96775	76.24247	1.91	3.34	1.43
Sapri	31.89386	76.29572	1.26	1.75	0.49
TikaDeol	31.90064	76.27856	1.55	2.45	0.9
Gummber	31.90872	76.28389	4.1	4.62	0.52

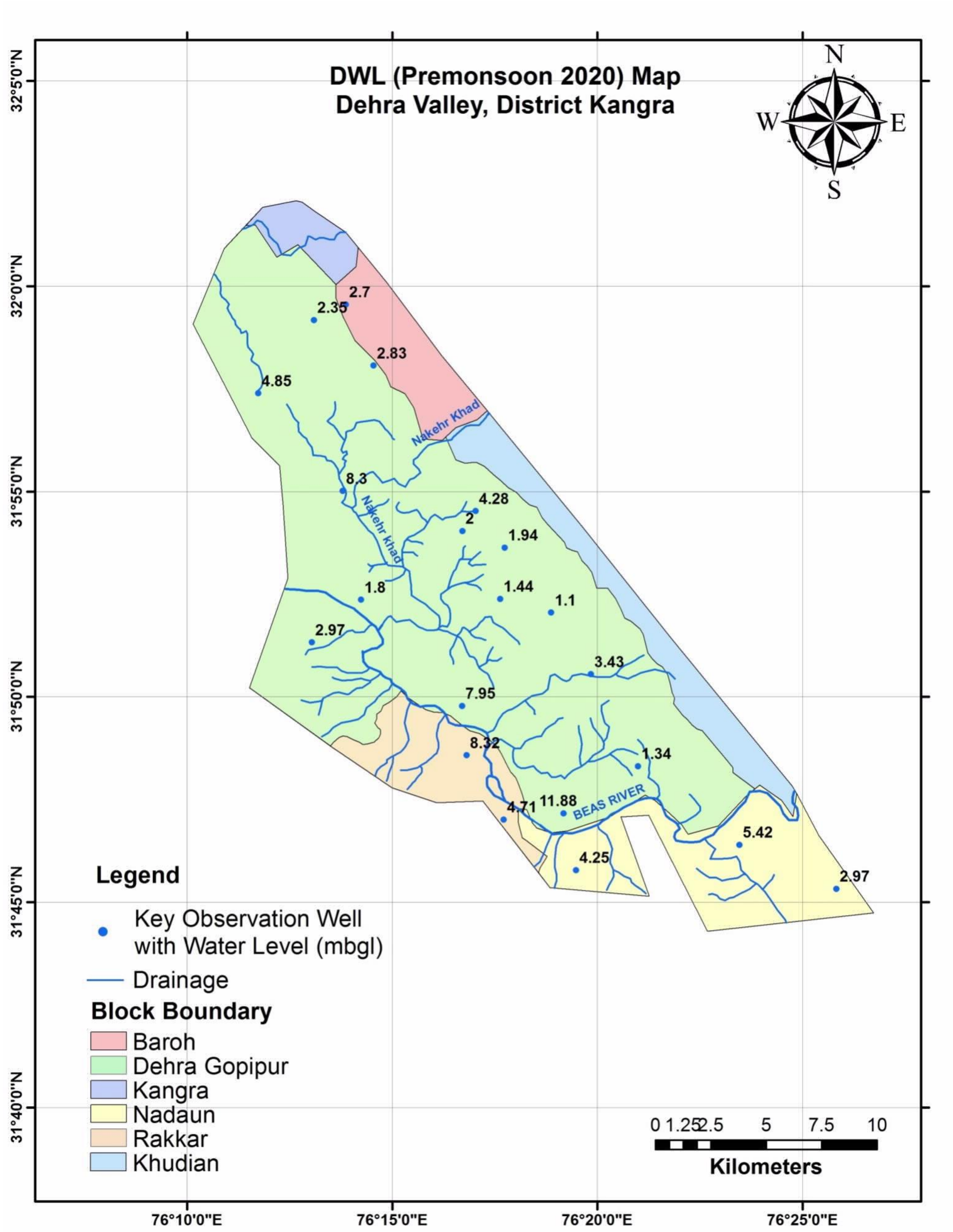


Fig 18: Depth Water Level – May 2020 in study area

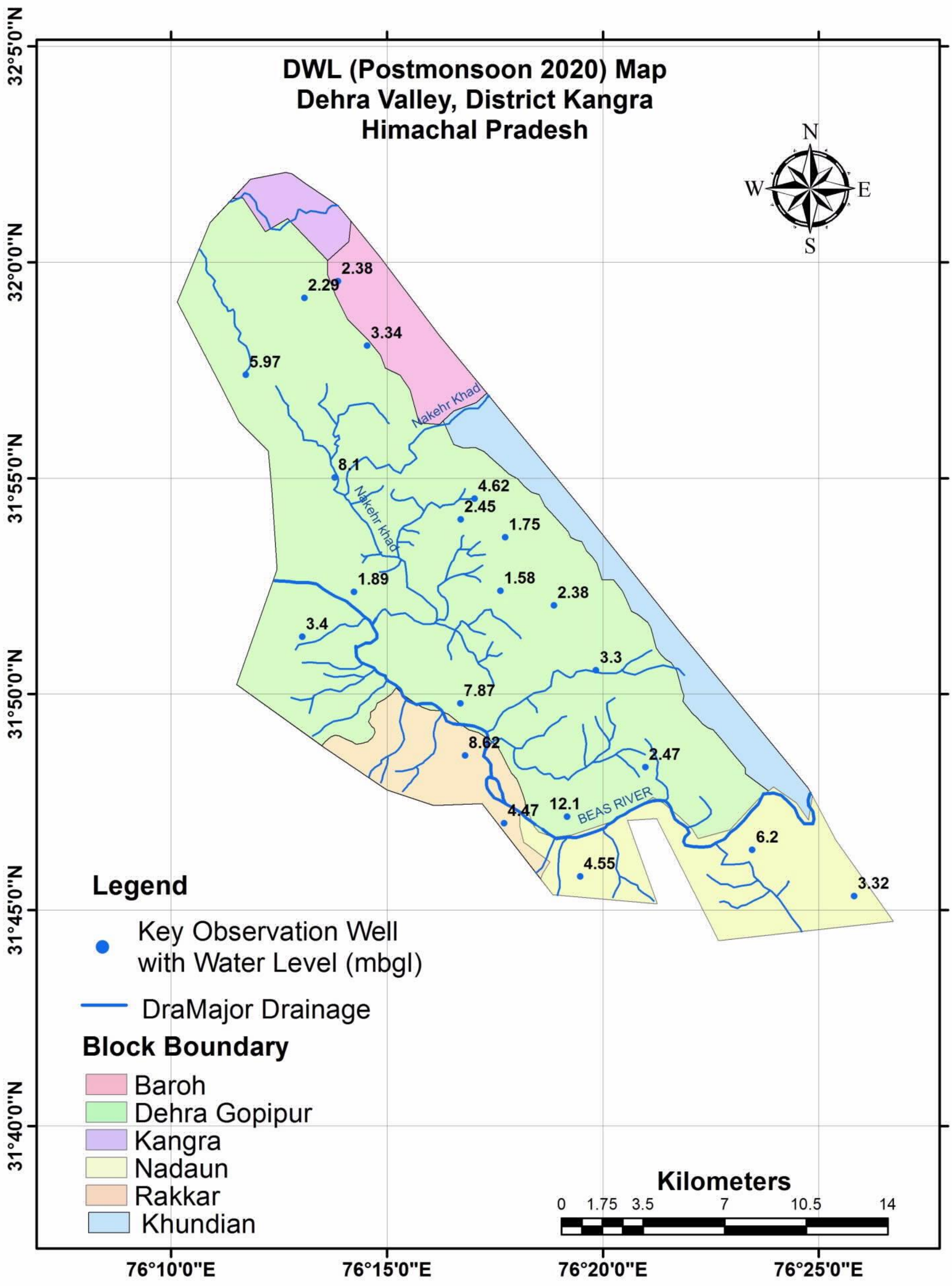


Fig 19: Depth Water Level – Nov 2020 in study area

3.2. Exploratory Drilling– CGWB & I& PH Wells

The Lithologs of all Exploratory Well of CGWB has been compiled and preparation of aquifer maps. The details are shown in Table 10.

Table10: Data availability of exploration wells in Parts of Dehra Valley.

Table of Wells in study Area			
Agency	**Well Depth (meters)**		
	<100	**100-150**	**>150**
CGWB	14	5	0
I & PH	-	-	-
Total	**14**	**5**	**0**

3.3Ground Water Quality

The water quality standards are laid down to evaluate suitability of water for intended uses and to safeguard water from degradation. These recommended limits form the basis of treatment needed for improvement in quality of water before use. In the formulation of water quality standards, the selection of parameters is considered depending upon its end use. Two types of standards are referred in India decipher the quality of water suitable for drinking purposes, namely Bureau of Indian Standards (BIS) and World Health Organisation (WHO) Standards.

Drinking Water

The BIS has laid down the standard specification for drinking water during 1983, which have been revised and updated from time to time. In order to enable the users to exercise their discretion, the maximum permissible limit has been prescribed especially where no alternative sources are available. It is medically established fact that water with concentration beyond permissible limits cause short term or permanent adverse health effects.

Standards for Chemical Parameters

The water quality standards as laid down in BIS standard (IS-10500, 1991), First Revision, 2003-2009 and WHO (2008) standards are summarized in Table 11 and Table 12 respectively. In addition separate standards for the use of Surface water i.e. lakes and rivers for drinking purposes have been laid down by BIS and have been given in table 13.

Table 11: Drinking water Standards - BIS (IS-10500, 1991)			
S. No.	**Parameters**	**Desirable limits (mg/l)**	**Permissible limits (mg/l)**
Essential Characteristics			
1	Colour Hazen unit	5	25
2	Odour	Unobjectionable	-

3	Taste	Agreeable	-
4	Turbidity (NTU)	5	10
5	pH	6.5 - 8.5	No relaxation
6	Total Hardness, $CaCO_3$	300	600
7	Iron (Fe)	0.3	1
8	Chloride (Cl)	250	1000
9	Residual Free Chlorine	0.2	-
10	Fluoride (F)	1	1.5
Desirable Characteristics			
11	Dissolved Solids	500	2000
12	Calcium (Ca)	75	200
13	Magnesium (Mg)	30	100
14	Copper (Cu)	0.05	1.5
15	Manganese (Mn)	0.1	0.3
16	Sulphate (SO_4)	200	400
17	Nitrate (NO_3)	45	100
18	Phenolic Compounds	0.001	0.002
19	Mercury (Hg)	0.001	No relaxation
20	Cadmium (Cd)	0.01	No relaxation
21	Selenium (Se)	0.01	No relaxation
22	Arsenic (As)	0.01	No relaxation
23	Cyanide (CN)	0.05	No relaxation
24	Lead (Pb)	0.05	No relaxation
25	Zinc (Zn)	5	15
26	Anionic Detergents (as MBAS)	0.2	1
27	Hexavelant Chromium	0.05	no relaxation
28	Poly Nuclear Hydrocarbons (as PAH)	-	-
29	Alkalinity	200	600
30	Aluminium (Al)	0.03	0.2
31	Boron (B)	1	5
32	Pesticides	Absent	0.001
33	Mineral Oil	0.01	0.03
34	Radioactive Material		
	Alpha Emmiters, Bq/l	-	.0.1
	Beta Emmiters, pci/l	-	1

NTU = Nephelometric Turbidity Unit

Table 12: Drinking Water Standards, WHO (2008)			
S. No.	**Parameters**	**Guideline value (mg/l)**	**Remarks**
1	Aluminium	0.2	
2	Ammonia	-	NAD
3	Antimony	0.005	
4	Arsenic	0.01	For excess skin cancer risk of 6 x 10^{-4}
5	Asbestos	-	NAD
6	Barium	0.3	
7	Beryllium	-	NAD
8	Boron	0.3	
9	Cadmium	0.003	
10	Chloride	250	
11	Chromium	0.05	
12	Color	-	Not Mentioned
13	Copper	2	ATO
14	Cyanide	0.07	
15	Dissolved Oxygen		NAD
16	Fluoride	1.5	Climatic conditions, volume of water consumed, and intake from other sources should be considered when setting national standards.
17	Hardness		NAD
18	Hydrogen Sulfide		NAD
19	Iron		NAD
20	Lead	0.01	It is recognized that not all water will meet the guideline value immediately; meanwhile, all other recommended measures to reduce the total exposure to lead should be implemented.
21	Manganese	0.5 (P)	ATO
22	Mercury (total)	0.001	-
23	Molybdenum	0.07	-
24	Nickel	0.02	-
25	Nitrate (as	50	The sum of the ratio of the concentration of each

	NO_3) Nitrite (as NO_2)		to its respective guideline value should not exceed 1.
26	Turbidity		Not Mentioned
27	pH		NAD
28	Selenium	0.01	-
29	Silver		NAD
30	Sodium	200	
31	Sulfate	500	
32	Inorganic Tin		NAD
33	TDS		NAD
34	Uranium	1.4	
35	Zinc	3	

NAD - No adequate data to permit recommendation

ATO - Appearance, taste or odour of the water

Table 13: Surface Water Quality Standards –BIS

Characteristic	**Tolerance Limit**				
	Class A	**Class B**	**Class C**	**Class D**	**Class E**
pH value	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
Dissolved Oxygen (mg/l), min.	6	5	4	4	--
BOD (5-days at 20° C, mg/l, min.	2	3	3	--	--
Total Coliform Organism, MPN/100ml, max	50	500	5000	--	--
Colour, Hazen units, max.	10	300	300	--	--
Odour	10	300	300	--	--
Taste	Tasteless	--	--	--	--
Total dissolved solids, mg/l, max.	500	--	1500	--	2100
Total hardness(as $CaCo_3$), mg/l, max.	300	--	--	--	--
Calcium hardness (as $CaCO_3$), mg/l, max.	200	--	--	--	--
Magnesium hardness (as $CaCO_3$), mg/l, max.	100	--	--	--	--
Copper (as Cu), mg/l, max.	1.5	--	1.5	--	--
Iron (as Fe), Mg/l, max.	0.3	--	0.5	--	--
Manganese (as Mn), mg/l, max.	0.5	--	--	--	--

Chlorides (as Cl), mg/l, max.	250	--	600	--	600
Sulphates (as SO_4), mg/l, max.	400	--	400	--	1000
Nitrates (as NO_3), mg/l, max.	20	--	50	--	--
Fluorides (as F), mg/l, max.	1.5	1.5	1.5	--	--
Phenolic compounds (as C_6H_5 OH), mg/l, max.	0.002	0.005	0.005	--	--
Mercury (as Hg), mg/l, max.	0.001	--	--	--	--
Cadmium (as Cd), mg/l, max.	0.01	--	0.01	--	--
Salenium (as Se), mg/l, max.	0.01	--	0.05	--	--
Arsenic (as As), mg/l, max.	0.05	0.2	0.2	--	--
Cyanide (as CN), mg/l, max.	0.05	0.05	0.05	--	--
Lead (as Pb), mg/l, max.	0.1	--	0.1	--	--
Zinc (as Zn), mg/l, max.	15	--	15	--	--
Chromium (as Cr^{6+}), mg/l, max.	0.05	--	0.05	--	--
Anionic detergents (as MBAS) mg/l, max.	0.2	1	1	--	--
Polynucleararomatic hydrocarbons, (a PAH)	0.2	--	--	--	--
Mineral oil, mg/l, max.	0.01	--	0.1	0.1	--
Barium (as Ba), mg/l, max.	1	--	--	--	--
Silver (as Ag), mg/l, max.	0.05	--	--	--	--
Pesticides	Absent	--	Absent	--	--
Alpha emitters, uC/ml, max.	10^{-9}	10^{-9}	10^{-9}		
Beta emitters, uC/ml, max.	10^{-8}	10^{-8}	10^{-8}	10^{-8}	10^{-8}
Free ammonia (as N), mg/l, max.	--	--	--	1.2	--
Electrical conductance at 25° C, mhos, max.	--	--	--	1000×10^{-6}	2250×10^{-6}
Free carbon dioxide (as CO), mg/l, max.	--	--	--	61	--
Sodium absorption ratio	--	--	--	--	26
Boron (as B), mg/l, max.	--	--	--	--	--
Percent sodium, max.	--	--	--	--	--

*Explanation for Symbols:

A: Drinking water sources without conventional treatment but after disinfection.

B: Organized outdoor Bathing.

C: Drinking water sources with conventional treatment followed by disinfection.

D: Propogation of wild life and Fisheries.

E: Irrigation, industrial cooling and controlled water disposal.

Standards for Bacteriological Parameters

Faecal contamination is widespread in most of the Rural Areas. The major bacteriological contamination and their limits are given below:

E. Coli is the more precise indicator of faecal pollution. The count of thermo-tolerant, coliform bacteria is an acceptable method however, if necessary, proper confirmatory tests of the sample should be carried out. As per Indian standard for drinking water - specification (First Revision) IS-10500:1991 BIS, ideally, all samples taken from the distribution system including consumers' premises should be free from coliform organisms. In practice, this is not always attainable. The following standard of water collected in the distribution system is therefore recommended when tested in accordance with IS 1622:1981.

a) 95 percent of samples should not contain any coliform organisms in 100 ml;

b) No sample should contain E. coli in 100 ml;

c) No sample should contain more than 10 coliform organism per 100 ml; and

d) Coliform organism should not be detectable in 100 ml of any two consecutive samples.

WHO has also suggested guidelines for bacteriological parameters are as follows (Table .14)

Table 14: Bacteriological quality of drinking water (WHO, 2008)	
Organisms	**Guideline Value**
All water intended for drinking	
E. Coli or thermo-tolerant coliform bacteria	Must not be detectable in any 100/ml sample.
Treated water entering the distribution system	
E. Coli or thermo-tolerant coliform bacteria	Must not be detectable in any 100/ml sample.
Total coliform bacteria	Must not be detectable in any 100/ml sample.
Treated water in the distribution system	
E. Coli or thermo-tolerant coliform bacteria	Must not be detectable in any 100/ml sample.
Total coliform bacteria	Must not be detectable in any 100/ml sample. In the case of large supplies, where sufficient samples are examined must not be present in 95% of sample taken throughout any 12 month period.

The detrimental effect of various pesticides/ organic compounds cannot be ignored.

The ground water sampling was carried out in the study areas through Ground Water Observation Wells in every year pre-monsoon period by CGWB. The water samples for both pre monsoon and post monsoon were collected during the year 2020 - 2021.To assess the impact of ground water quality, 25 numbers of water samples were collected from the study area of in 2020-2021, as per the list below:

Sr.No	Type of Source	Total Nos.
1	Dug Well	21 Nos.

Table 15: Details of Water Samples for Ground Water Quality in parts of Dehra Valley.

Sample No.	District	Block	Location	Latitude	Longitude	Source	Depth / Zone	Water Temp (^0C)	Type of Analysis / Constituents Required
D1	Kangra	Paragpur	Chamukha	31.7835	76.29533	Dug Well	Shallow	16	Basic
D1-A	Kangra	Paragpur	Chamukha	31.7835	76.29533	Dug Well	Shallow	16	Heavy Metals
D2	Kangra	Naduan	Kohr	31.76294	76.32469	Dug Well	Shallow	15	Basic
D3	Kangra	Naduan	Suggal	31.77319	76.39106	Dug Well	Shallow	17	Basic
D4	Hamirpur	Naduan	Putriyal	31.75536	76.43042	Dug Well	Shallow	16	Basic
D5	Kangra	Jwalaji	Kopra	31.80511	76.34989	Dug Well	Shallow	15	Basic
D6	Kangra	Dehra	Bohrjagir	31.78603	76.31961	Dug Well	Shallow	15	Basic
D6-A	Kangra	Dehra	Bohrjagir	31.78603	76.31961	Dug Well	Shallow	15	Heavy Metals
D7	Kangra	Dehra	Bannu Da Khu	31.8425	76.33078	Dug Well	Shallow	16	Basic
D8	Kangra	Dehra	Daranga	31.8675	76.31461	Dug Well	Shallow	17	Basic
D9	Kangra	Dehra	Pangehr	31.82964	76.27844	Dug Well	Shallow	17	Basic
D10	Kangra	Paragpur	Kuhna	31.80956	76.28022	Dug Well	Shallow	15	Basic
D11	Kangra	Jwalaji	Chaurna	31.87308	76.29394	Dug Well	Shallow	16	Basic
D12	Kangra	Dehra	Kuru	31.87272	76.23739	Dug Well	Shallow	15	Basic
D13	Kangra	Paragpur	Sunnhet	31.85539	76.21742	Dug Well	Shallow	16	Basic
D13-A	Kangra	Paragpur	Sunnhet	31.85539	76.21742	Dug Well	Shallow	16	Heavy Metals
D14	Kangra	Dehra	Khabali	31.91686	76.22989	Dug Well	Shallow	15	Basic
D15	Kangra	Dehra	Sherlohara	31.95653	76.19561	Dug Well	Shallow	15	Basic
D16	Kangra	Dehra	Gagher	31.98622	76.21831	Dug Well	Shallow	16	Basic
D17	Kangra	Dehra	Bhangwar	31.99261	76.23114	Dug Well	Shallow	16	Basic
D18	Kangra	Dehra	Paloti	31.96775	76.24247	Dug Well	Shallow	15	Basic

D19	Kangra	Dehra	Sapri	31.89386	76.29572	Dug Well	Shallow	18	Basic
D20	Kangra	Dehra	TikaDeol	31.90064	76.27856	Dug Well	Shallow	17	Basic
D21	Kangra	Dehra	Gummber	31.90872	76.28389	Dug Well	Shallow	18	Basic

All the collected samples are to be analyzed at chemical laboratory of CGWB, Chandigarh by adopting Standard methods of analysis (APHA)

pH

The pH is a numerical scale which express the degree of acidity or alkalinity of solution and represented by the equation pH= log1/aH^+= -log aH^+ or in other words pH may be defined as negative logarithmic of Hydrogen ion concentration.

Electrical conductivity

Electrical Conductivity can be defined as the ability of a solution to conduct an electric current and measured in micromhos /cm and reported at 25°C. Electrical Conductivity is a function of concentration of ions, charge and ionic mobility Electrical Conductivity is approximately indicative of ionic strength.

Chloride

Chloride is one of the most common constituent in groundwater and very stable as compared to other ions like SO_4, HCO_3, NO_3 etc.

Nitrate

Nitrate is one of the important pollution related parameter. Nitrate is the end product of the aerobic oxidation of nitrogen compounds. Mainly it is contributed by nitrogenous fertilizers, decomposition of organic matter in the soil, fixation of nitrogen by bacteria etc. Human and animal excreta may also add nitrate to water by bacterial decomposition. For drinking water maximum permissible limit of nitrate is 45 mg/l as per BIS 1991-Rev-2007.

High concentration of nitrate causes infant methaemoglobinaemia (Blue baby disease).Very high concentration of Nitrate causes gastric cancer and affects central nervous and cardiovascular system.

Fluoride

Fluoride is an important water quality parameter for accessing the water quality for drinking purpose. Fluoride is more abundant than chloride in the igneous and as well as sedimentary rocks. Fluoride differs from other halogen members due to high electronegative character.

Calcium

The calcium is a major constituent of various rocks. The precipitates (limestone) contain about 27.2% of calcium ions. It is one of the most common constituent present in natural water. Calcium minerals associated with sodium, aluminium, silica, sulphate, carbonate and Fluoride. Maximum permissible limit for calcium is 200 mg/l (Fig-2.25).

Magnesium

Magnesium is the 8th most abundant element in the solar system. It is available in various rocks .The maximum concentration of Magnesium, 4.53 % is found in the evaporates of sedimentary rocks. The concentration of Magnesium in natural water is mainly controlled by dissolved CO_2.

The concentration of Magnesium in springs, Ground Water Aquifers (Shallow & Deep) are within the maximum permissible of BIS (100 mg/l) for drinking water.

Sodium

Sodium is the abundant of the alkali element in the earth's crust. Most of the Sodium occurs in the Feldspars, Mica, amphiboles and Pyroxenes.

Potassium

Potassium in sedimentary rock is more abundant than Sodium. The main potassium minerals containing silicates are Orthoclase, micas. Evaporate beds may contain potassium salts.

Total Hardness (TH)

High concentration of carbonates, bicarbonates of calcium and magnesium, in ground water causes hardness. It causes scaling in water supply lines. High concentration of hardness in ground water is social economic problem; hence it is also an important water quality parameter. Hardness of water is the capacity to neutralize soap and is mainly caused by carbonates and bicarbonates of calcium, magnesium.

The results of chemical analysis of water samples collected during study are awaited from Chemical Lab. The results and spatial distribution thereof will be updated in the report as soon as the results are received.

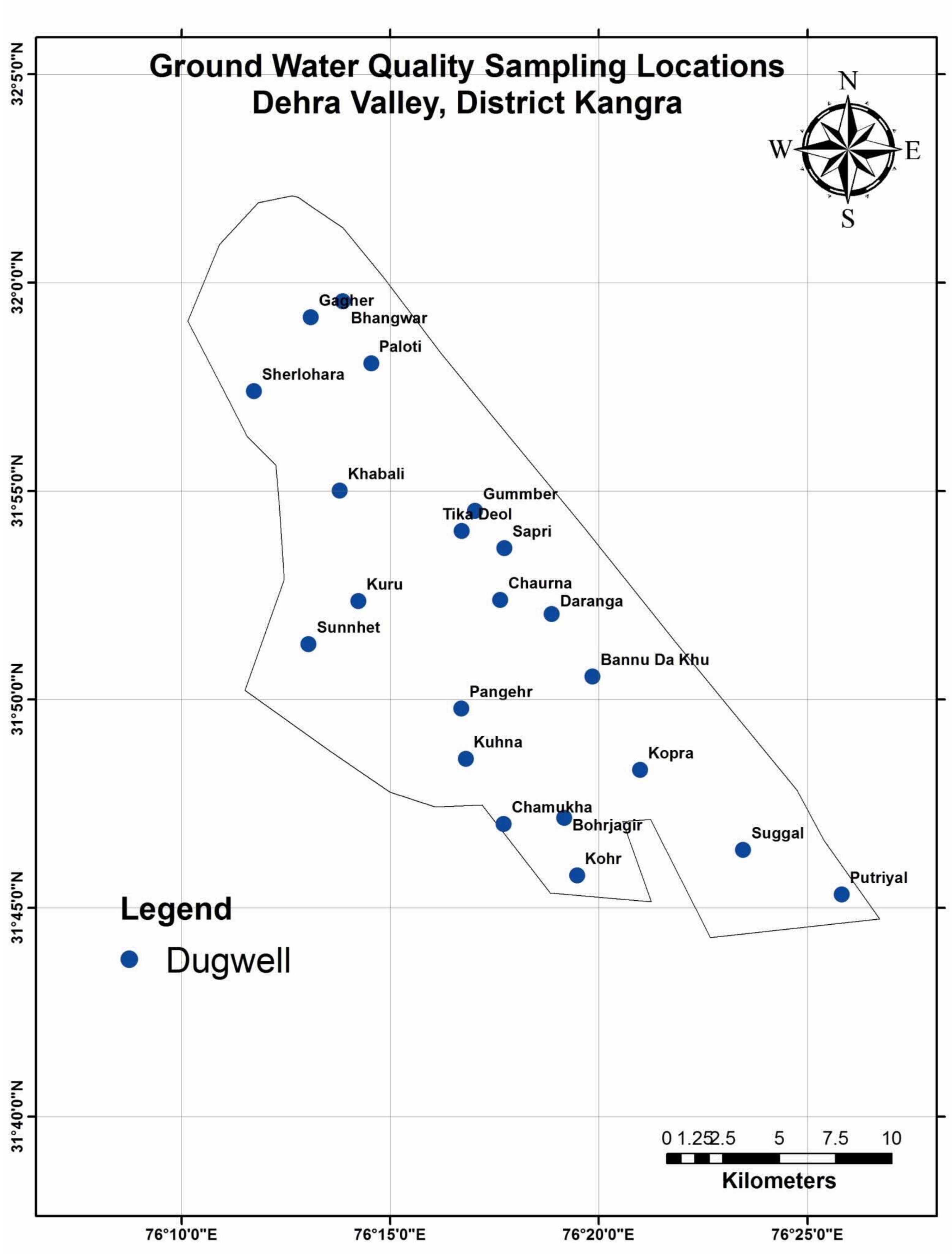


Fig. 20: Locations of GWQS in study area.

Chapter-IV

4.0 DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

All the available data have been validated and optimized for consideration to generate the aquifer map in study area. The wells optimization part is done based on the maximum depth & litholog The deepest well in each quadrant is selected and plotted on the map of 1.50000 scale with 5'X5'grid (9 x 9km) and is shown in Fig-9.0. The wells optimization part is done based on the maximum depth & litholog (Annexure – I).

4.1 Aquifer Parameter Ranges

In study area the exploration drilling was carried out by CGWB, the aquifer parameters range extracted and given in below Table-16

Table 16: Summary of exploration and hydraulic details in study area

Location	LATITUDE	LONGITUDE	SWL (m)	Discharge (lpm)	Drawdown (m)	Transmissivity (m^2/day)	Depth (m)
Gareru	31.99632	76.21962	2.26	0.00	-	-	118
Madini	31.95967	76.21056	6.67	90.00	9.33	29.70	65
Sapari	31.89506	76.29576	1.74	180.00	23.96	33.94	63.5
Jeen	31.86903	76.28183	1.5	30.00	-	-	103
Guguroi	31.80714	76.35247	2.57	0.00	-	-	104

3.2 Aquifer Geometry

To understand the lithological frame work and aquifer disposition in the sub surface aquifers, the litholog data of wells drilled by CGWB are used to compile, optimized and modeled into 2D (Fig. 21), 3D & Fence diagram (Fig. 22 & 23) by using the Rockswork software.

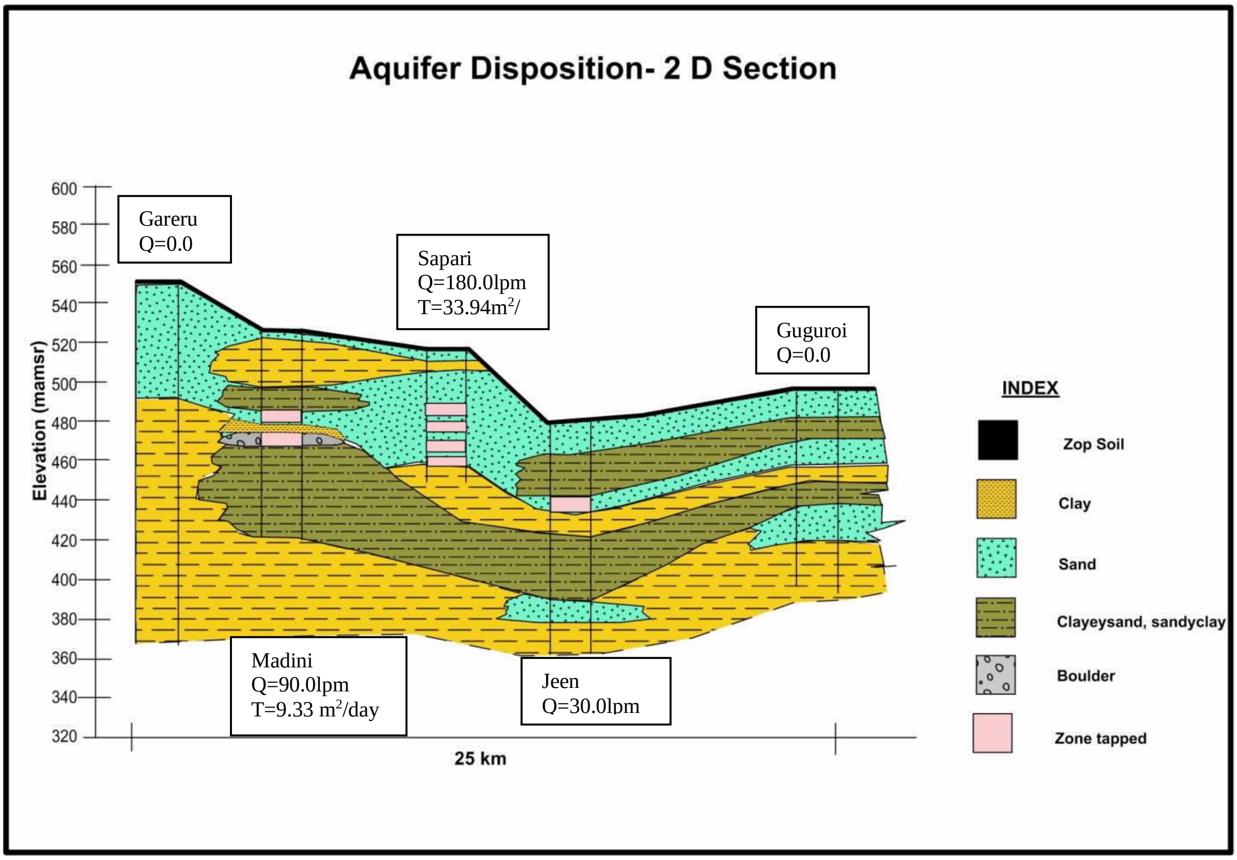


Fig.21 Auifer desposition- 2D Model

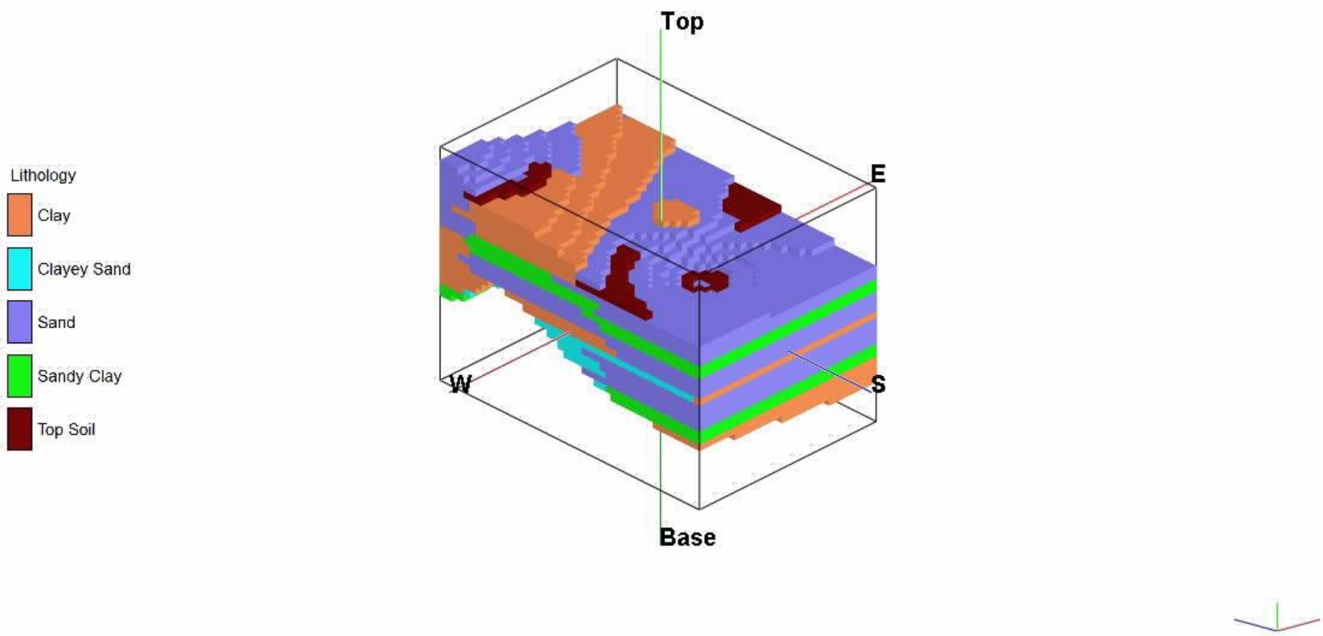


Fig.22. Aquifer disposition- 3D Model

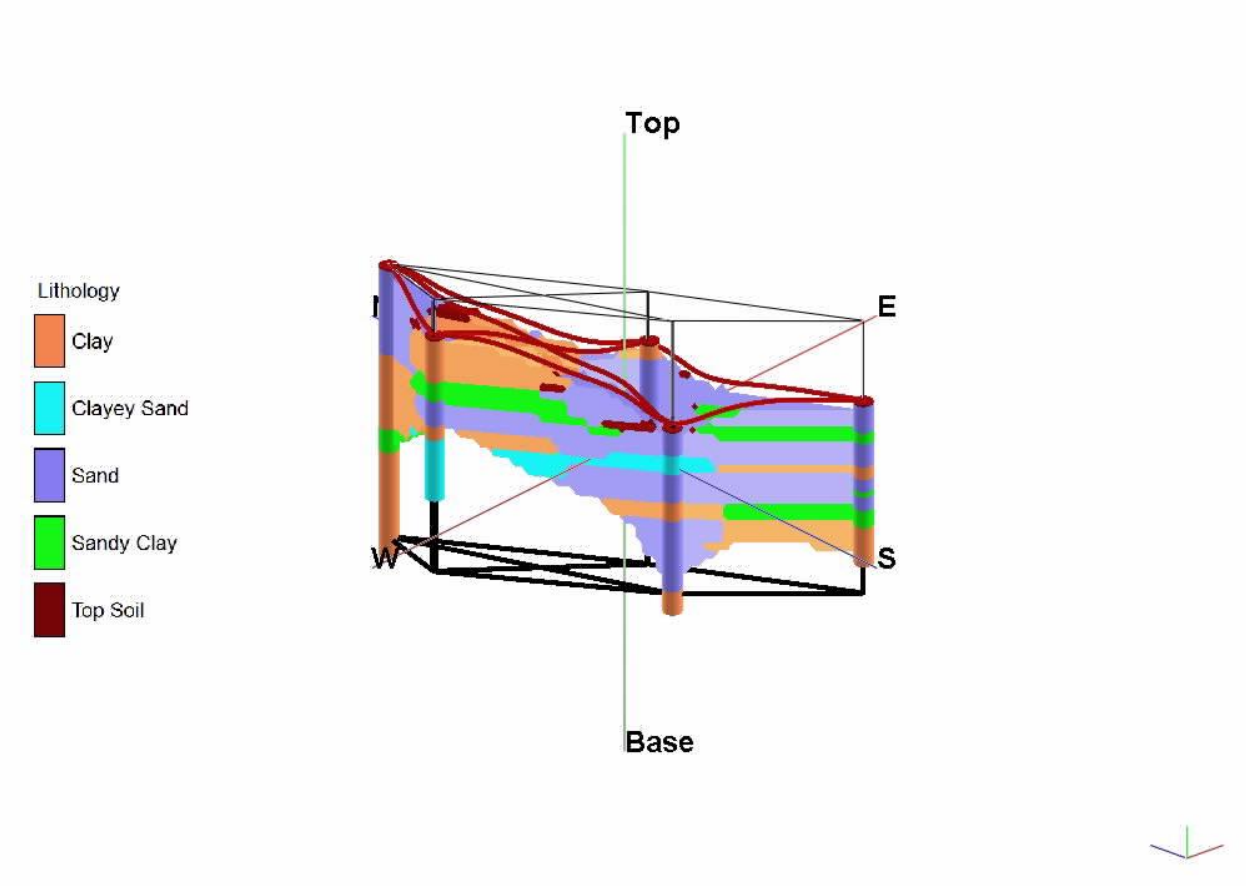


Fig.23. Fence Diagram

4.3 Aquifer Disposition: The lithology data of bore wells drilled under NAQUIM and previously drilled borehole was compiled. The 3-D models prepared using Rockworks, which shows deposition of Clay, Sand, Boulder. The encountered strata are mostly clay and sand. The whole area is covered by lower and middle siwaliks and upper siwalik. Ground water yield potential is very limited. Ground water is developed through no. of percolation wells for drinking water supplies and many shallow irrigation wells along the Naker khad and Beas river. From the 2-D cross section, the aquifers in the area are separated by a thick clay layer. A no. of bore wells tapping different aquifers is showing different level of discharge. Water level in the area is generally following the surface topography.

4.4 GROUND WATER RESOURCES

Rainfall is the major source for recharge to the groundwater body apart from the influent seepage from the rivers, irrigated fields and inflow from upland areas. The discharge from ground water mainly takes place from wells and tube wells; effluent seepages of ground water in the form of springs and base flow in streams.

Most of the study area is having more than 20% slopes. Based on SRTM, slope map of the area was prepared and areas having more than 20% slope were excluded. According to Ground Water Resource estimation of Indaura, Nurpur and Dharamshala-Palampur valley, of district Kangra is under safe category as per the GWRE-2020. Dehra valley falls under the Kangra District. Ground water Resource estimation of Dehra valley is not assessed separately in GWRE-2020. So, Ground water management plan of the Dehra valley is made on the basis of Demand and supply of water:

Table.17 Five years data of Water supply and water demand of Dehra Gopipur.

Year	Population	Rate of supply in LPD	Water requirement per	Water Demand/ year MLD	Water Supply/ year (MLD)
2016	5181	120	621720	355.04	370.46
2017	5243	120	629160	357.75	372.15
2018	5314	120	637680	360.86	369.31
2019	5386	120	646320	364.002	373.94
2020	5457	120	654840	367.13	372.60

Source: IPH, Dehra.

From the above data it is clearly seen that Water supply is more than water demand in successive five years. This suggests that further ground water development can take place in the study area.

V. GROUND WATER RELATED ISSUES

Major ground water related issues and their manifestation are:

- Runoff is very high due to topography: Due to sloping topography of the areas, type of soil, concentrated period of rainfall, most of the precipitation is lost as surface runoff.

- Low recharge of ground water due to lithology: due to presence of Siwalik sandstone Rainfall runoff is very high. Hence, Low Ground water potential due to low recharge of ground water.

- Most of the population of the study area is dependent on surface water for both domestic as well as irrigation use. It is mainly due to reason that groundwater yield potential in the area is low to moderate.

- Drying of springs/bowries: The drying up of springs can be attributed to three major factors – anthropogenic activities, climate change, and seismic events. Drying of springs due Disturbances at the catchment, change in land use pattern. Energization of spring nearby groundwater abstraction structures for demand.

- Siltation of surface water bodies: Due topography of the area, excessive runoff, all the surface water bodies are receive high level of silt. This siltation creates problem in the rate of ground water recharge form these bodies as well increase the maintenance cost of these water bodies, eg.- Naker Khad Check Dam cum Ground Water DAM is defunct due siltation.

VI. AQUIFER MANAGEMENT PLAN

An outline of the Aquifer Management Plan includes details regarding population, rainfall, average annual rainfall, agriculture and irrigation, water bodies, ground water resource availability, ground water extraction and water level behavior. Aquifer disposition and various cross sections have also been given.

Sustainable Management plan for C.D. block Dehra are as follows:-

Demand Side Management	Supply Side Management
1. Construction of tube well (575 nos.) @2.5 lakhs.	1. 1 nos check dam cum GW DAM similar to Naker Khad Scheme. 2. Desiltation and revival of Naker Khad Check DAM cum GW DAM. 3. Construction of percolation wells around khad, and revival of old percolation structures. 4. Construction of small check dam for surface use (20 nos.). 5. RWHS for surface use and recharge through dug wells.

The details of management plan are as follows:

Demand side management: Under demand side intervention, it is suggested to:

1. Construction of shallow depth tube wells under PMKSY. Based on the cropping areas 275 number of tube wells can be constructed having discharge 3-4 lps, which can be pumped for 12 hours a day for 120 days in an year.
2. In the study area huge volume of rainwater going waste as runoff. So small storage cum percolation tank can be made for recharge of ground water.
3. The study area is mainly depending upon the surface water for domestic and irrigation purpose. Shallow depth tube well promoted for irrigation purpose.
4. People’s participation is a must for any type of developmental activities. So proper awareness for utilization and conservation of water resources is required.

Supply side management:

The study area receives good rainfall, intensity. So, in the present valley area the construction of percolation wells also suggested around the khad for extracting the ground water.

1. Construction of 1 nos check dam cum GW DAM similar to Naker Khad Scheme. In this project of Naker khad scheme, the investigation has been carried out in the area to precisely identify the principal recharge area facilitating the replenishment of these dried granular horizons. The investigations have revealed that the possible area for such recharge would have been along the Beas river through a patch along the south of Dhawala village. It is proposed to construct one low height- Check Dam- Cum -Ground Water Dam across the Renta dawala (Dehra Tehsil) to harness surface and subsurface outflow.
2. Desiltation and revival of Naker Khad Check DAM cum GW DAM. Due topography of the area, excessive runoff, all the surface water bodies are receive high level of silt.
3. Construction of percolation wells around khad, and revival of old percolation structures. Many of the old percolation structure are defunct due to non- maintenance and siltation.
4. Construction of small check dam for surface use (20 nos.).
5. Augmentation of GW through Artificial Recharge structures.
6. Roof top rainwater harvesting practices can be adopted in hilly areas and urban areas, since the district receives fair amount of rainfall. RWHS for surface use and recharge of ground water through dug wells.
7. Traditional water storage systems spring, bowries are needed to be revived.
8. Recharge structures feasible in hilly areas are check dams and Gabion structures at suitable locations.

Lithology of Exploratory Bore Hole at Gareru, Tripal		
Depth (mbgl)	**Thickness (m)**	**Lithology**
0-1	1	Top Soil
1-43	42	Sandstone (Fine to medium grain)
43-55	12	Sandstone with clay content
55-88	33	Sticky Clay (Brown in colour)
88-103	15	Sticky Clay (Grey in colour)
103-118	15	Sandy Clay (Grey in colour)
118-186	68	Sticky Clay (Brown in colour)

Lithology of Exploratory Bore Hole at Guguroi		
Depth(mbgl)	**Thickness(m)**	**Lithology**
0-1	1	Top Soil
1-16	15	Boulder mixed with coarse sand
16-18	2	Sand, coarse grained
18-25	7	Sandy clay
25-40	15	Sandstone, Grey in colour
40-48	8	Clay, sticky in nature
48-56	8	Sandstone, reddish in colour
56-59	3	Sandy Clay
59-68	9	Sandstone
68-79	11	Sandy clay
79-104	225	Clay, sticky in nature

Lithology of Exploratory Bore Hole at Jeen, Kathog		
Depth (mbgl)	**Thickness (m)**	**Lithology**
0-16	16	Sand, medium to coarse grained, brown in colour, mixed with clay
16-28	12	Clayey Sand, Brown in colour, Sticky in nature
28-40	12	Sand, medium grain, Grey in colour
40-46	6	Sand, medium to coarse grained, Grey in colour
46-58	12	Clay, Brown in colour
58-91	33	Sand, fine grained, brown in colour, mixed with clay
91-103	12	Sand, fine grained, grey in colour
103-118	15	Clay, Grey in colour, Sticky in nature

Lithology of Exploratory Bore Hole at Madini		
Depth (mbgl)	**Thickness (m)**	**Lithology**
0-01	01	Top Soil
01-10	09	Clay, red in colour.
10-28	18	Clay, hard and sticky, red in colour
28-40	12	Clay mixed with fine grain sand (KANKAR)
40-46	06	Sand mixed with kankar
46-52	06	Sand, very fine grain.
52-56	04	Boulders: Sand fine to medium grain.
56-65	09	Clay with Kankar
65-104	39	Fine grained dry sand mixed with Clay, powdered form, reddish in colour.

Lithology of Exploratory Bore Hole at SSB, Sapari		
Depth (mbgl)	**Thickness (m)**	**Lithology**
0-01	01	Top soil
01-10	09	Sticky Clay, Brown in colour
10-19	09	Sandstone, Fine grain, powdery form
19-25	06	Nodular Sandstone, Grey in colour
25-37	12	Sandstone, Fine to medium grain
37-43	06	Sandstone, Very fine grain
43-61	18	Sandstone, Fine to medium grained
61-63.50	02.5	Clay, Red in colour, Sticky in nature

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