AQUIFER SYSTEMS OF HIMACHAL PRADESH

Compiled Under the Supervision of

Dr. S. C. Dhiman
Chairman

GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES
CENTRAL GROUND WATER BOARD
NORTH HIMALAYAN REGION, DHARAMSHALA

Under the Guidance of

Dr S. C. Dhiman

Chairman, CGWB

Team Leader

Shri Sunil Kumar, Suptd. Hydrogeologist

<u>Principal Contributors</u>

1. Shri S.K.Sinha, Scientist D

2. Shri S K Swaroop, Scientist B

<u>Contributors</u>

1. Shri Vidya Nand, Scientist C

2. Smt Gargee M.B . Sharma, Assistant Hydrogeologist

3. Smt Rachna Bhatti, Assistant Hydrogeologist

4. Shri Anukaran Kujur, Assistant Hydrogeologist

5. Shri J. K . Tandon Draftsman

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ध्रुव विजय सिंह
DHRUV VIJAI SINGH

सत्यमेव जयते

सचिव
भारत सरकार
जल संसाधन मंत्रालय
श्रम शक्ति भवन
रफी मार्ग, नई दिल्ली-110 001

SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES
SHRAM SHAKTI BHAWAN
RAFI MARG, NEW DELHI-110 001

13TH September 2012

MESSAGE

Ground water utilization has increased significantly during the last two decades. The unplanned and indiscriminate use of this vital resource has resulted in declining water levels and water quality deterioration in certain areas. The apparent stress on ground water resources is more often a management issue, and this needs to be addressed in a holistic manner, for its long term sustainability, through an integrated approach. Aquifer mapping is an essential step towards the effective management of ground water resources.

The atlas entitled **"Aquifer Systems of Himachal Pradesh"** is a step towards achieving the ultimate goal of aquifer wise management of ground water resources in Himachal Pradesh State.

I congratulate Central Ground Water Board, Ministry of Water Resources for its efforts to bring out this document containing data and information pertaining to various aspects of ground water including aquifer disposition in the State. I am sure this atlas will be of immense use to planners, policy makers, researchers and users involved in ground water sector.

(Dhruv Vijai Singh)

डॉ. एस. सी. धीमान
Dr. S. C. Dhiman

सत्यमेव जयते

अध्यक्ष
भारत सरकार
केन्द्रीय भूमि जल बोर्ड
जल संसाधन मंत्रालय
भूजल भवन एन.एच. 4 फरीदाबाद

Chairman
Government of India
Central Ground Water Board
Ministry of Water Resources
Bhujal Bhawan, NH-IV, Faridabad

Foreword

Availability of fresh water has always been a prime consideration in fostering the socio economic growth of the people. Rapid urbanization coupled with industrialization has resulted in increased demand of ground water at an alarming rate. Dependence on ground water is increasing continuously in order to supplement the domestic, agricultural and industrial requirements. In the last two decades there is a paradigm from development to management of Ground Water. The management of ground water is to be focussed on aquifers, which act as the repository of ground water.

To meet these challenges, it has become imperative to formulate aquifer management plan to establish the priorities for ground water use with community involvement at various levels of implementation. Central Ground Water Board over the years has generated enormous data on various aspects of ground water and has been utilised to prepare aquifer maps depicting their extent and characteristics and are compiled in the form of Atlas on "Aquifer Systems of Himachal Pradesh".

This will provide a framework for prioritizing the aquifer level management strategies and build inventory of the aquifers for better understanding of the groundwater resources. An attempt has been made to present various aquifer systems in the form of maps by integrating all thematic information to formulate the aquifer wise ground water management plans.

The sincere efforts of the dedicated team of officers of Central Ground Water Board, North Himalayan Region, Dharamshala is highly appreciated. I am sure this atlas would be of immense use in formulating scientifically viable implementable strategies for efficient management of ground water resources ensuring sustainability.

(Dr. S.C. Dhiman)

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Preamble

Himachal Pradesh is one of the hilly State in Himalayan Region with a geographical area of 55673 sq.km. The population of the State is 6.6 million, out of which 90 percent resides in rural areas. The high and rugged mountain ranges are thinly populated and valley areas are densely populated. Ground water irrigation through bore wells is confined to valley areas with a limited use of lift/tank irrigation. The main crop in the State is grown during the Kharif season and commercial crops such as apple, mango, litchi and flowers are grown during the other seasons. Fish and prawn farming are also popular in the State.

The average annual rainfall for the State is 1490 mm spreading over 65 rainy days. Lahaul & Spiti receives lowest rainfall (450 mm) and Dharamshala of Kangra district receives highest rainfall of 3000 mm. Snowfall occurs at higher elevations in Chamba, Shimla and Kinnaur districts. Geomorphologically, Himachal Region is an integrate mosaic of mountain ranges, hills and valleys having elevation upto 6500 m. The major mountain ranges fall under Dhauladhar ranges in Kangra district and Pir Panjal, Great Himalaya and Zanskar ranges in Lahaul Spiti District.

Chenab, Ravi, Beas, Satluj and Yamuna rivers drain the State with different size of catchment. Govind Sagar, Pong dam and Pandoh dam are the major water storage reservoirs in the State. In addition, there are 66 major lakes in the State which are being used for irrigation, domestic needs and ground water recharge. Structurally controlled springs of Himachal Pradesh are the major source for drinking water supply especially in hilly districts. More than 500 springs are tapped by district authorities for drinking purpose and for bottling of mineral water. The major glaciers of the State are Barashingi, Chandra, Badal, Bhaga and Keylong.

Geologically, the State is underlained by un-consolidated to consolidated rock formations of Archaen age to Recent age. The Recent alluvial deposits occupies the valley fills/ river courses and Tertiaries of Siwaliks & crystallines of Archaen occupies the Higher elevations. CGWB has constructed 182 exploratory wells down to 300m depth in the Alluvial and Sandstone aquifers. The discharges of tube wells varies generally from 100 lpm to 1000 lpm and at places goes to 3000 lpm.

Irrigation and Public health department, Govt. of HP has drilled 30,000 bore wells upto maximum depth 90 m in different parts of the State, and hand pumps/power pumps has been installed for domestic uses. About 1596 tube wells were constructed for public utility particularly for irrigation and domestic uses by same agencies.

The analysis of the exploratory wells data indicate that in Una, Nallagarh and Indaura valleys granular zones are limited to 150 m depth. Ground Water in the State is being monitored four times a year through network of 86 observation wells. The long term water level data analysis indicate that general water level in the valley varies from 5 to 10 m bgl. Deeper water levels of more than 20 m have been reported from the Kala Amb valley. The quality of surface water, spring and ground water of various depths is good and suitable for irrigation, domestic and drinking uses. All the chemical constituents are within permissible limits as per BIS standards except at few localized pockets in industrial areas of Baddi-Barotiwala in Solan district.

Total ground water availability of the State which includes dynamic and in-storage resources (27713 MCM). Ground water resource estimates of eight valleys of Himachal Pradesh as on March, 2009 reveals that overall the stage of ground water development is under safe category, except in Kala Amb and Una valleys wherein ground water is highly exploited for irrigation and industrial uses.

Conservation & Rain Water Harvesting and management of springs is the key to protect the ground water resources of the State. There is a need to adopt traditional wisdom along with innovative techniques developed by CGWB for construction of recharge structures, implementation of efficient irrigation practices, maintenance of existing khul/springs, benching and terracing of hill slopes through public participation.

The objective of preparation of this document is to define the extent of principal and major aquifer systems of the State with their characterisation on regional scale and depict aquifer wise ground water scenario along with major issues and challenges which needs immediate attention for sustainable management of ground water resources. Further Creating a baseline data in GIS platform for initiating National Aquifer Mapping Programme and demarcating priority areas for aquifer wise management of ground water resources on scientific and sustainable basis

The Atlas has been prepared keeping in view the utilities and user friendliness in understanding the ground water scenario by the stakeholders as well as professional Hydrogeologist. Simple presentation of tables is used to explain aquifer wise ground water scenario in the State. Attempt has been made to represent the correlations of various thematic layers such as climate, topographic, and geologic settings on the occurrence, movement and quality of ground water.

Based on the hydrogeological characteristics, the entire state has been classified into 10 Principal Aquifer Systems and 27 major aquifers. Alluvium is the most promising aquifer system which covers an area of 8% of the State. The sandstone aquifer occupies 16% area in the districts of Bilashpur, Chamba, Hamirpur, Kangra, Mandi, Una, Sairmaur, and Solan. The rest of the State is covered with the other aquifers constituting around 76% of the area. Among these, schist aquifer covers maximum of around 32% area of the State predominantly in districts of Chamba, Kinnaur and Lahaul Spiti.

An attempt has been made to prioritize areas based on the sustainability and quality related ground water issues and presented in the atlas. Various ground water management strategies have also been suggested.

Table 1: Administrative Divisions

Sl No	District Name	Area (Sq Km)	Number of Tehsils	Number of Development Blocks	Number of Towns
1	**Bilaspur**	1167	4	3	4
2	**Chamba**	6528	7	7	6
3	**Hamirpur**	1118	5	6	4
4	**Kangra**	5739	17	15	8
5	**Kinnaur**	6401	5	3	4
6	**Kullu**	5503	4	5	4
7	**Lahaul & Spiti**	13835	2	2	3
8	**Mandi**	3950	10	10	7
9	**Shimla**	5131	12	10	7
10	**Sirmaur**	2825	6	6	3
11	**Solan**	1936	7	5	8
12	**Una**	1540	4	5	3
Total		**55673**	**83**	**77**	**61**

Source:Himachalp.gov.in

Census 2011

ADMINISTRATIVE DIVISION

0 10 20 40 60 80

Kilometers

N

Legend

- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

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Table 2: River Basins of Himachal Pradesh

Sl No	Name of the Basin	Area		Number of Sub-Basin	Number of Water-sheds
		Sq Km	% of area		
1	Beas	16286	20	1	22
2	Chenab	11580	14	1	17
3	Ghaghar	6491	8	1	33
4	Indus	6898	8	1	10
5	Ravi	6003	7	1	9
6	Satluj	26729	32	2	30
8	Upper Ganga	439	1	1	2
9	Yamuna	9089	11	1	14
Total		**83515**	100	**9**	**137**

Area in Sq Km

RIVER BASINS

0 12.5 25 50 75 100

Kilometers

N

JAMMU & KASHMIR

CHENAB

INDUS

RAVI

CHAMBA

KYELONG

DHARAMSHALA

BEAS

KULLU

MANDI

HAMIRPUR

SUTLEJ

UNA

KALPA

BILASPUR

SHIMLA

SOLAN

YAMUNA

GHAGHAR

NAHAN

CHINA

PUNJAB

UTTRAKHAND

UPPER GANGA

Legend

Basin Boundary

State Capital

District Headquarters

District Boundary

State Boundary

International Boundary

River

National Highway

Railway

Water Bodies

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Government of India

Table 3: District wise Distribution of Principal Aquifer Systems

District Name	Alluvium	Sandstone	Shale	Limestone	Granite	Schist	Quartzite	BGC	Gneiss	Intrusives	Total Area
	Area (%)	Area (%)	Area (%)	Area (%)	Area (%)	Area (%)	Area (%)	Area (%)	Area (%)	Area (%)	
Bilaspur	170 15%	830 71%	165 14%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	**1164**
Chamba	185 3%	221 3%	65 1%	27 0%	513 8%	4985 77%	0 0%	451 7%	0 0%	51 1%	**6497**
Hamirpur	49 4%	1072 96%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	**1122**
Kangra	1682 29%	2527 44%	0 0%	0 0%	401 7%	1085 19%	20 0%	6 0%	0 0%	0 0%	**5720**
Kinnaur	112 2%	90 1%	631 10%	241 4%	417 6%	2322 36%	154 2%	1307 20%	1179 18%	0 0%	**6452**
Kullu	165 3%	0 0%	16 0%	54 1%	408 7%	1159 21%	1503 27%	387 7%	1816 33%	0 0%	**5508**
Lahaul & Spiti	682 5%	734 5%	491 4%	5197 37%	0 0%	4853 35%	88 1%	1366 10%	456 3%	0 0%	**13867**
Mandi	216 5%	1126 29%	289 7%	286 7%	454 11%	481 12%	963 24%	0 0%	132 3%	0 0%	**3948**
Shimla	153 3%	5 0%	131 3%	505 10%	452 9%	2270 44%	1115 22%	26 1%	455 9%	0 0%	**5113**
Sirmaur	206 7%	976 35%	538 19%	20 1%	69 2%	477 17%	509 18%	0 0%	0 0%	0 0%	**2795**
Solan	397 20%	512 26%	644 33%	0 0%	3 0%	53 3%	329 17%	0 0%	0 0%	12 1%	**1950**
Una	638 42%	899 58%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	**1537**
Grand Total	**4655**	**8991**	**2969**	**6331**	**2717**	**17685**	**4682**	**3542**	**4038**	**62**	**55673**

Area in sq km

% in respect of the total area of the district

PRINCIPAL AQUIFER SYSTEMS

0 12.5 25 50 75 100

Kilometers

N

JAMMU & KASHMIR

CHINA

PUNJAB

UTTARAKHAND

CHAMBA

KYELONG

DHARAMSHALA

KULLU

HAMIRPUR

MANDI

UNA

KALPA

BILASPUR

SHIMLA

SOLAN

NAHAN

Legend

Aquifers

- Alluvium
- Granite
- Sandstone
- Schist
- Gniess
- Quartzite
- Shale
- Intrusives
- Limestone
- Banded Gneissic Complex

- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

7

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Table 4: Aquifer Systems of Himachal Pradesh

Sl No	Principal Aquifer Systems		Aquifer Characteristics				Major Aquifers		Area Covered (Sq km)	Age
	Code	Name	DTW (Decadal Average) (m bgl)	Thickness of Aquifer */ Weathered Zone (m)	Granular / Fracture Zones Encountered (m bgl)	Yield (m3/ day)	Code	Name		
1	AL	Alluvium (4674 sq km) (8 %)	2-40	Upto 200 *	30-50	120-4665	AL01	Younger Alluvium (Clay/ Silt/Sand/ Calcareous concretions)	2100	Quarternary
2							AL03	Older Alluvium (Silt/Sand/ Gravel/Lithomargic clay)	65	Quarternary
3							AL06	Valley Fills	1999	Quarternary
4							AL07	Glacial Deposits	492	Quarternary
6	ST	Sandstone (8988 sq km) (16 %)	5-35	20 - 100 *	20-70	75-864	ST01	Sandstone/Conglomerate	6270	Upper Palaeozoic to Cenozoic
7							ST02	Sandstone with Shale	868	Upper Palaeozoic to Cenozoic
8							ST04	Sandstone with Clay	1323	Upper Palaeozoic to Cenozoic
9							ST05	Sandstone/Conglomerate	63	Proterozoic to Cenozoic
10							ST06	Sandstone with Shale	467	Proterozoic to Cenozoic
11	SH	Shale (2968 sq km) (5 %)	10-30	10-70 *	15-50	50-560	SH01	Shale with limestone	145	Upper Palaeozoic to Cenozoic
12							SH02	Shale with Sandstone	314	Upper Palaeozoic to Cenozoic
13							SH04	Shale	1531	Upper Palaeozoic to Cenozoic
14							SH05	Shale/Shale with Sandstone	979	Proterozoic to Cenozoic
15	LS	Limestone (6328 sq km) (11 %)	5-40	10-300 *	25-125	40-1600	LS02	Limestone / Dolomite	5438	Upper Palaeozoic to Cenozoic
16							LS03	Limestone/Dolomite	706	Proterozoic
17							LS04	Limestone with Shale	187	Proterozoic
18	GR	Granite (2716 sq km) (5 %)	3.5-30	15-95	18-60	30-1000	GR02	Acidic Rocks (Pegmatite, Granite, Syenite, Rhyolite etc.)	2717	Proterozoic to Cenozoic
19	SC	Schist (17679 sq km) (32%)	5-20	5-70	10-45	30-300	SC01	Schist	2655	Azoic to Proterozoic
20							SC02	Phyllite	3188	Azoic to Proterozoic
21							SC03	Slate	11843	Azoic to Proterozoic
22	QZ	Quartzite (4680 sq km) (8%)	8-20	8-50	15-30	25 - 350	QZ01	Quartzite	413	Proterozoic to Cenozoic
23							QZ02	Quartzite	4269	Azoic to Proterozoic
24	BG	Banded Gneissic Complex (3541 sq km) (6 %)		5-100	18 - 65	25-500	BG01	Banded Gneissic Complex (BGC)	3542	Azoic
25	GN	Gneiss (4037 sq km) (7 %)	5-18	5-100	18 - 65	25-500	GN01	Undifferentiated metasedimentaries/ Undifferentiated metamorphic	22	Azoic to Proterozoic
26							GN02	Gneiss	4016	Azoic to Proterozoic
27	IN	Intrusive (62 sq km) (0.11 %)	Not Explored so far				IN01	Basic Rocks (Dolerite, Anorthosite etc.)	62	Proterozoic to Cenozoic

DTW : Depth to water level

MAJOR AQUIFERS

0 12.5 25 50 75 100

Kilometers

N

JAMMU & KASHMIR

CHAMBA

KYELONG

DHARAMSHALA

KULLU

MANDI

HAMIRPUR

UNA

BILASPUR

KALPA

SHIMLA

SOLAN

NAHAN

CHINA

PUNJAB

UTTARAKHAND

Legend

- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
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- Water Bodies

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Table 5: Parliamentary Constituencies of Himachal Pradesh

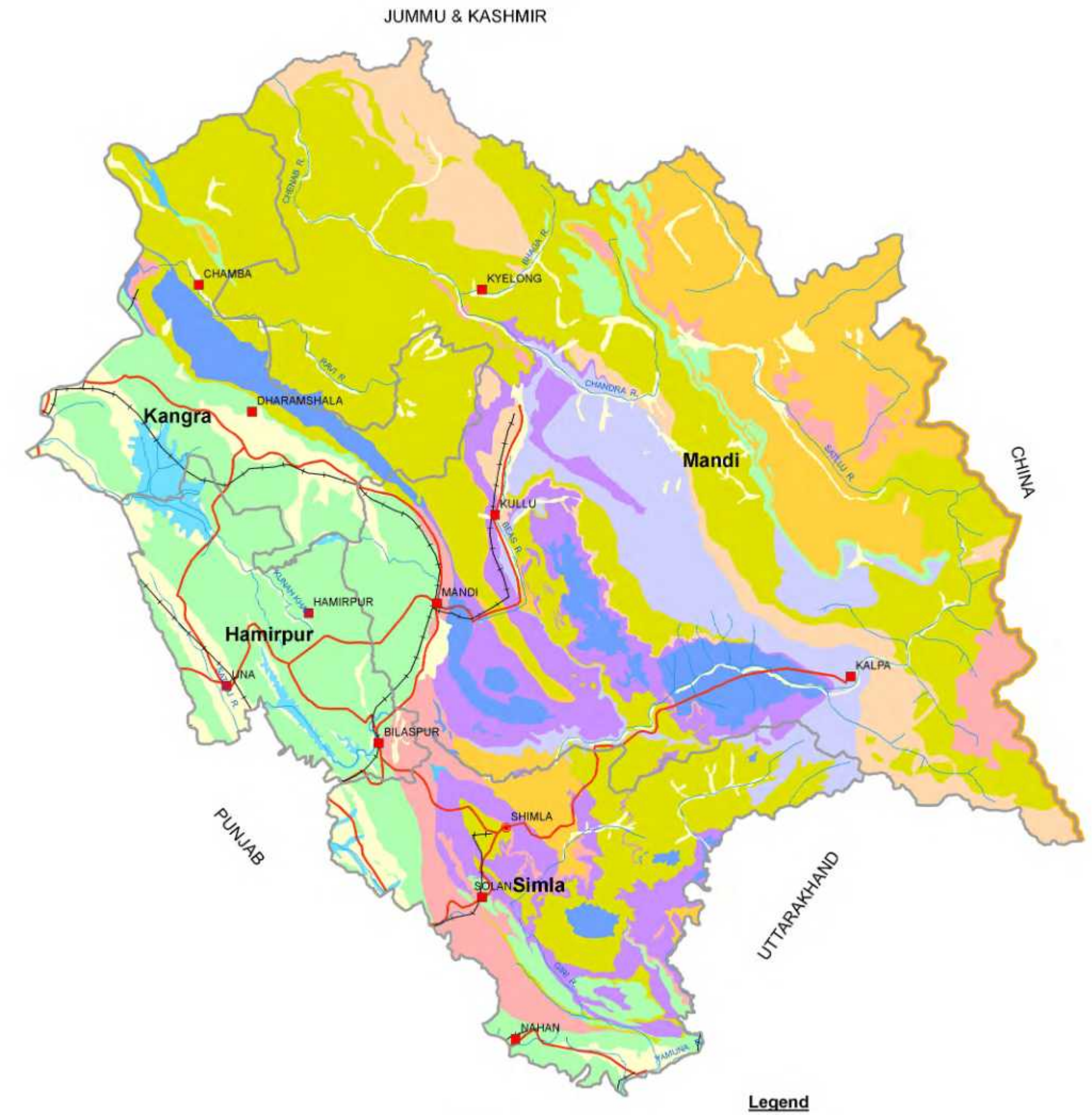
Sl No	Parliamentary Constituency	Alluvium	Sandstone	Shale	Limestone	Granite	Schist	Quartzite	BGC	Gneiss	Intrusives	Total Area
1	**Hamirpur**	1146	3481	186								**4813**
2	**Kangra**	1506	2088	65	28	841	3105	18	2		51	**7704**
3	**Mandi**	1316	1964	1451	5793	1694	12160	2907	3539	3721		**34545**
4	**Shimla**	687	1458	1266	510	184	2420	1757	1	317	11	**8611**
Total Area		**4655**	**8991**	**2969**	**6331**	**2718**	**17685**	**4682**	**3542**	**4038**	**62**	**55673**

PARLIAMENTRY CONSTITUENCIES

0 12.5 25 50 75 100

Kilometers

N



Legend

Aquifers

- Alluvium
- Granite
- Sandstone
- Schist
- Gniess
- Quartzite
- Shale
- Intrusives
- Limestone
- Banded Gneissic Complex

- Parliamentary Constituency
- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

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Table 6: Population Census - Himachal Pradesh

Sl No	District Name	Area (Sq.Km.)	Population				
			Total Population			Sex ratio (Females per 1000 males)	Density Number of persons per sq.km
			Persons	Males	Females		
1	**Bilaspur**	1167	382056	192827	189229	981	327
2	**Chamba**	6528	518844	260848	257996	989	79
3	**Hamirpur**	1118	454293	216742	237551	1096	406
4	**Kangra**	5739	1507223	748559	758664	1013	263
5	**KInnaur**	6401	84298	46364	37934	818	13
6	**Kullu**	5503	437474	224320	213154	950	79
7	**Lahaul & Spiti**	13835	31528	16455	15073	916	2
8	**Mandi**	3950	999518	496787	502731	1012	253
9	**Shimla**	5131	813384	424486	388898	916	159
10	**Sirmaur**	2825	530164	276801	253363	915	188
11	**Solan**	1936	576670	306162	270508	884	298
12	**Una**	1540	521057	263541	257516	977	338
Total		**55673**	**6856509**	**3473892**	**3382617**		

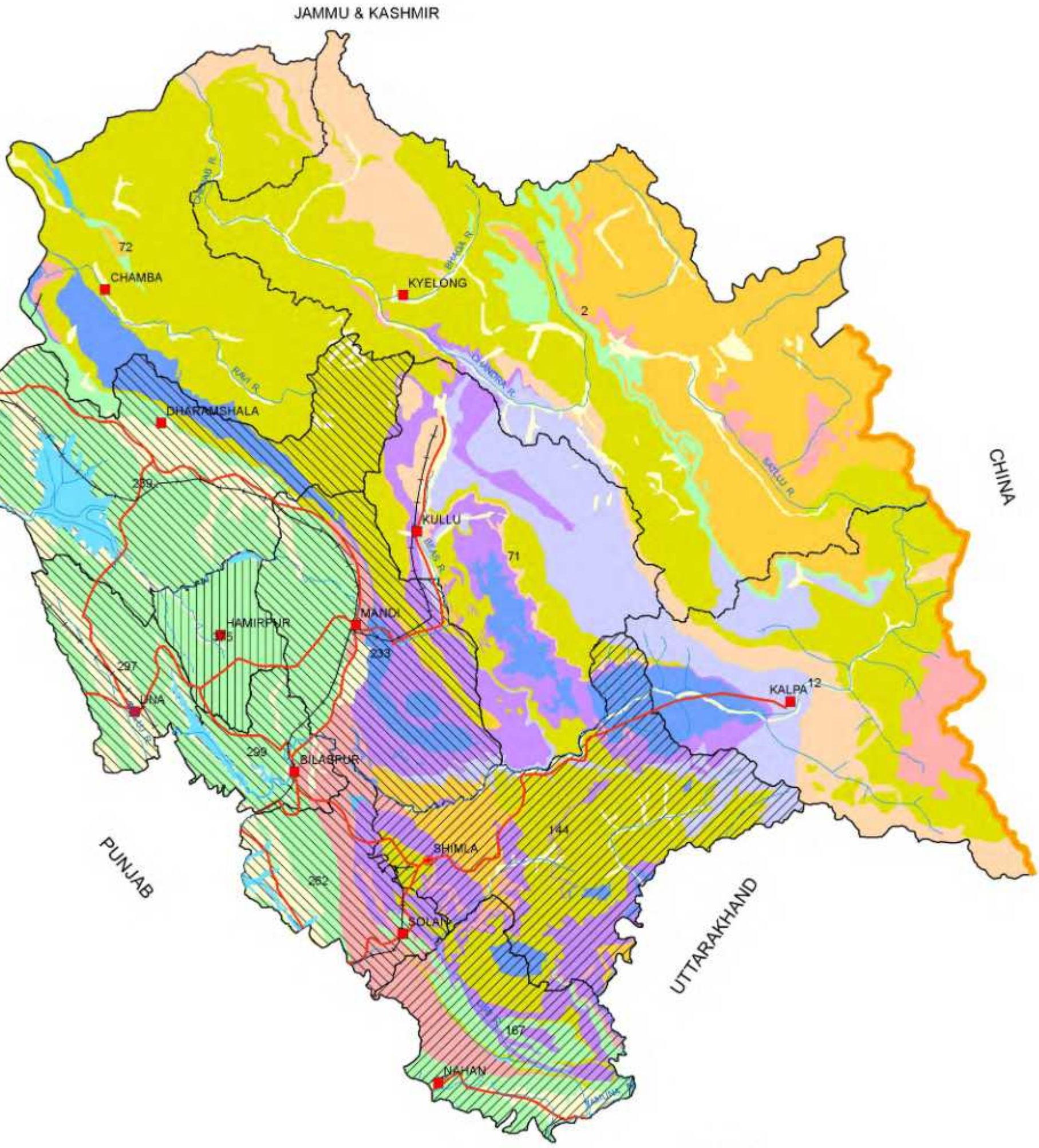
Source:Census 2011

POPULATION DENSITY

0 12.5 25 50 75 100

Kilometers

N



Legend

Population Density (Pers/Sq.Km)

- <100
- 100 - 200
- 200 - 300
- > 300

Aquifers

- Alluvium
- Granite
- Sandstone
- Schist
- Gniess
- Quartzite
- Shale
- Intrusives
- Limestone
- Banded Gneissic Complex

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- State Capital
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Table 7: Aquifer distribution - River Basin wise

Basin Name	Aluvium	Sandstone	Shale	Limestone	Granite	Schist	Quartzite	BGC	Gneiss	Intrusives	Total
Beas	747	5676	186	133	1191	2119	1710	374	1724	0	**13859**
Chenab	57	362	121	159	0	4955	98	1775	399	1	**7927**
Ghaghar	4	202	372	0	0	0	0	0	0	0	**577**
Indus	0	116	21	1152	0	75	0	3	0	0	**1367**
Ravi	0	68	55	27	336	4525	16	4	0	50	**5080**
Satluj	836	3472	1793	4873	1058	4153	1506	1145	1666	12	**20514**
Upper Ganga	0	0	0	0	0	145	0	192	0	0	**337**
Yamuna	194	825	442	187	187	2307	1402	114	355	0	**6013**
Total	**1838**	**10720**	**2988**	**6531**	**2772**	**18279**	**4732**	**3606**	**4144**	**62**	**55673**

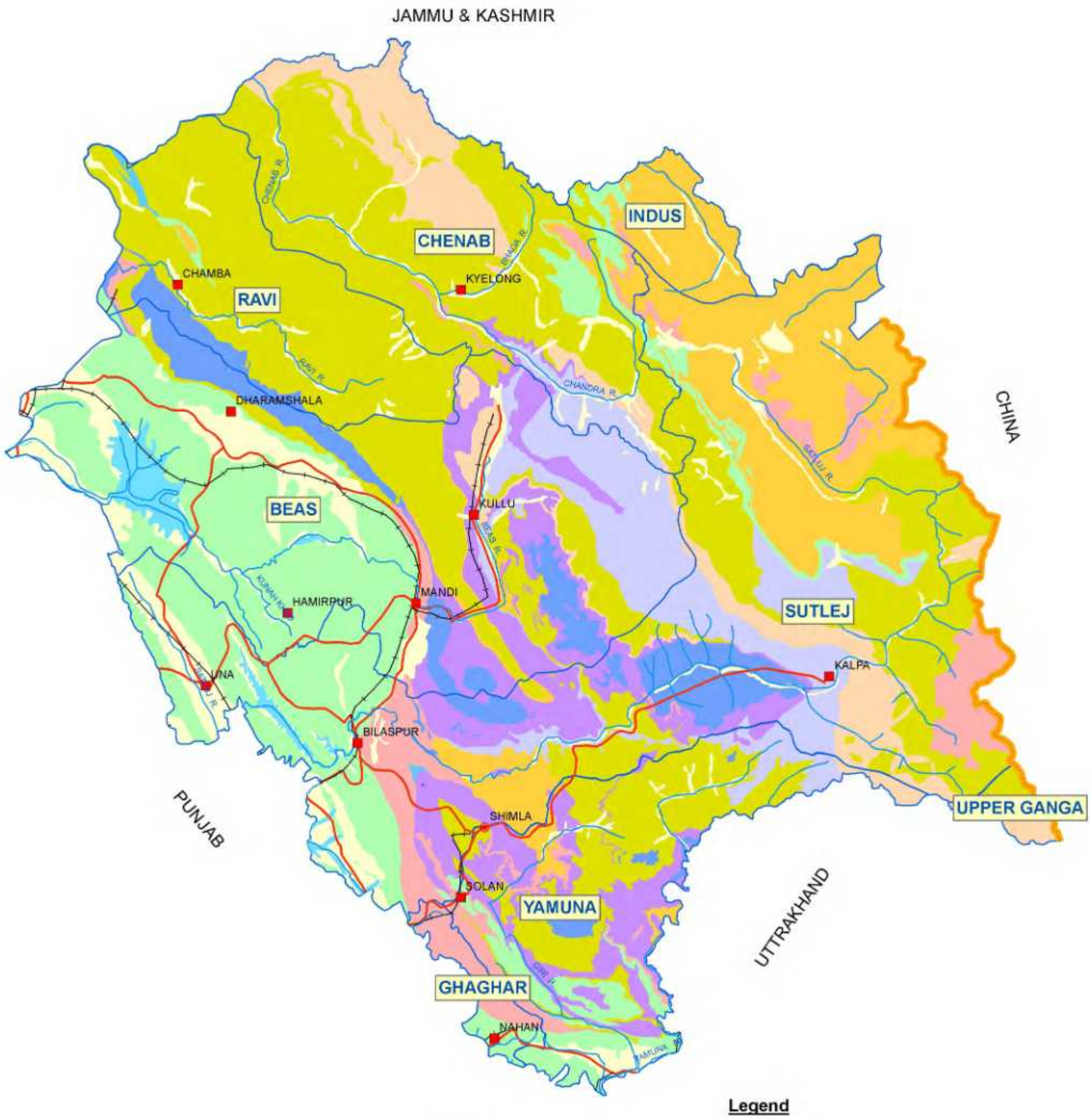
Area in sqkm

AQUIFERS - RIVER BASINWISE

0 12.5 25 50 75 100

Kilometers

N



Legend

Aquifers

- Basin Boundary
- Alluvium
- Granite
- Sandstone
- Schist
- Gniess
- Quartzite
- Shale
- Intrusives
- Limestone
- Banded Gneissic Complex

- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

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Table 8 a : Number of Gauge and Discharge Sites in Different Aquifers

Sl No	Aquifer Systems	Number of G & D Sites
1	Alluvium	4
4	Sandstone	0
5	Shale	0
6	Limestone	1
7	Granite	0
8	Schist	1
9	Quartzite	1
12	BGC	0
13	Gneiss	0
14	Intrusives	0
Total		7

Table 8 b: River Basin wise number of Gauge and Discharge Sites

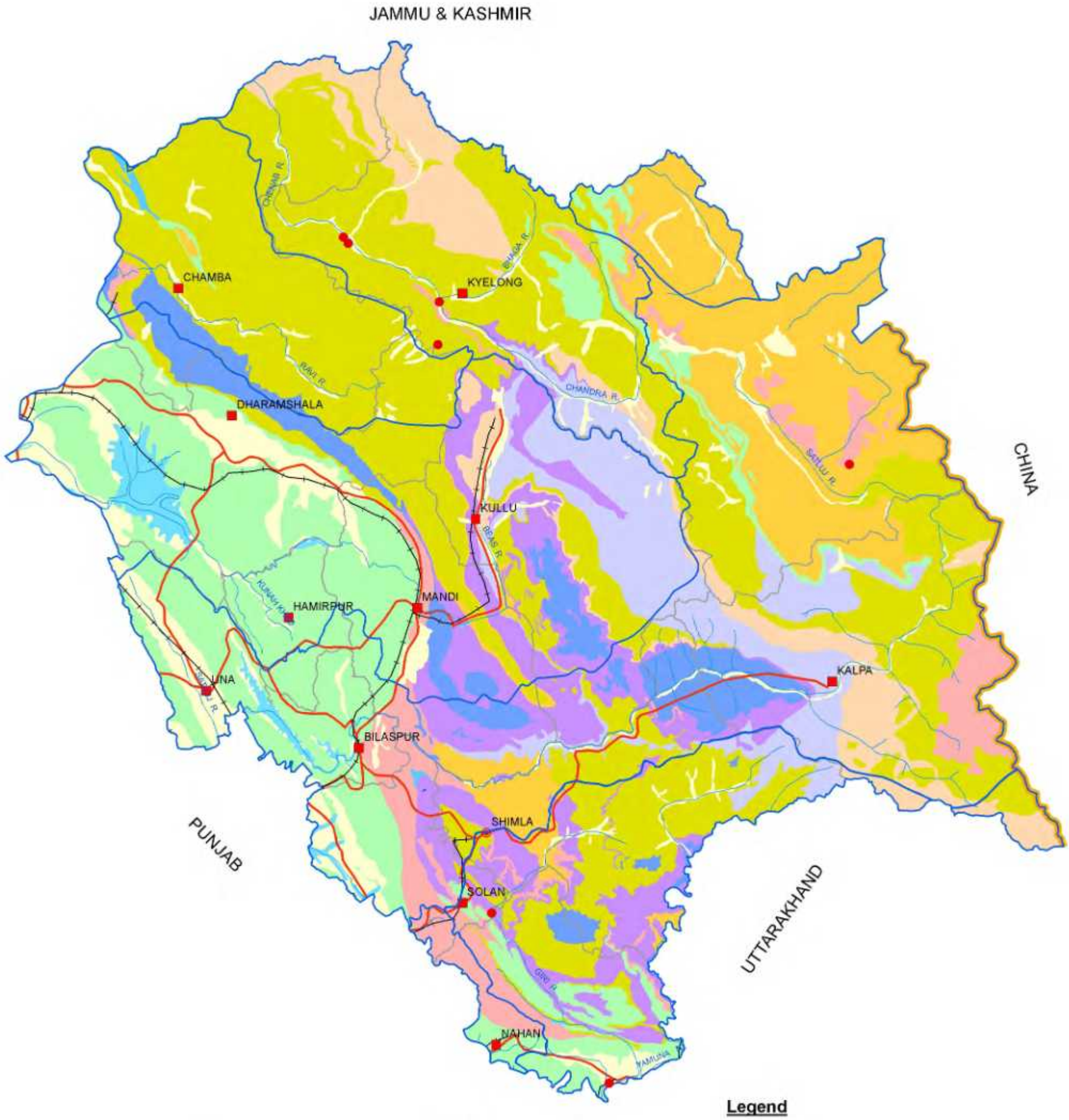
Sl No	Basin Name	Number of G & D Sites
1	Beas	0
2	Chenab	4
3	Ghaghar	0
4	Indus	0
5	Ravi	0
6	Satluj	1
8	Upper Ganga	0
9	Yamuna	2
	Total	7

Source: Central Water Commission

RIVER GAUGE AND DISCHARGE SITES

0 12.5 25 50 75 100
Kilometers

N



Legend

Aquifers

- Basin Bounadary
- Gauging and Discharge Site
- Alluvium
- Granite
- Sandstone
- Schist
- Gniess
- Quartzite
- Shale
- Intrusives
- Limestone
- Banded Gneissic Complex
- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

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Table 9: District wise & Aquifer wise distribution of Ground Water Exploratory Tube Wells/ Bore Wells

District Name	Alluvium	Sandstone	Shale	Limestone	Granite	Schist	Quartzite	BGC	Gneiss	Intrusives	Total
Bilaspur	2	1	0	NA	NA	NA	NA	NA	NA	NA	**3**
Chamba	0	0	0	0	0	0	NA	0	NA	0	**0**
Hamirpur	1	6	NA	NA	NA	NA	NA	NA	NA	NA	**7**
Kangra	46	15	NA	NA	1	1	0	0	NA	NA	**63**
Kinnaur	0	0	0	0	0	0	0	0	0	NA	**0**
Kullu	6	0	0	0	0	0	1	0	0	NA	**7**
Lahaul & Spiti	0	0	0	0	NA	0	0	0	0	NA	**0**
Mandi	4	7	2	1	0	1	1	NA	0	NA	**16**
Shimla	0	0	0	0	0	0	1	0	0	NA	**1**
Sirmaur	8	2	0	0	0	0	0	NA	NA	NA	**10**
Solan	4	1	2	NA	0	0	0	NA	NA	0	**7**
Una	27	9	NA	NA	NA	NA	NA	NA	NA	NA	**36**
Grand Total	**98**	**41**	**4**	**1**	**1**	**2**	**3**	**0**	**0**	**0**	**150**

NA : Aquifer not available

GROUND WATER EXPLORATORY WELLS

N

0 10 20 40 60 80

Kilometers

Legend

Aquifers

- Exploratory Tube Wells/ Bore Wells
- Alluvium
- Granite
- Sandstone
- Schist
- Gniess
- Quartzite
- Shale
- Intrusives
- Limestone
- Banded Gneissic Complex

- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

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Table 10 : District wise & Aquifer wise distribution of Groundwater Observation wells (Dug wells)

District Name	Alluvium	Sandstone	Shale	Limestone	Granite	Schist	Quartzite	BGC	Gneiss	Intrusives	Total No of Observation Wells (DW)
Bilaspur	0	0	0	NA	NA	NA	NA	NA	NA	NA	**0**
Chamba	0	0	0	0	0	0	NA	0	NA	0	**0**
Hamirpur	1	0	NA	NA	NA	NA	NA	NA	NA	NA	**1**
Kangra	19	9	NA	NA	0	0	0	0	NA	0	**28**
Kinnaur	0	0	0	0	0	0	0	0	0	NA	**0**
Kullu	3	0	0	0	0	0	0	0	0	NA	**3**
Lahaul & Spiti	0	0	0	0	NA	0	0	0	0	NA	**0**
Mandi	10	0	0	0	0	0	0	NA	0	0	**10**
Shimla	0	0	0	0	0	0	0	0	0	0	**0**
Sirmaur	9	3	0	0	0	0	0	NA	0	0	**12**
Solan	11	1	0	NA	0	0	0	0	NA	NA	**12**
Una	16	4	NA	NA	NA	NA	NA	NA	NA	NA	**20**
Grand Total	**69**	**17**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**86**

NA: aquifer not available

DW:Dugwells

GROUND WATER OBSERVATION WELLS

N

0 12.5 25 50 75 100

Kilometers

Legend

Aquifers

- Dug Wells
- Alluvium
- Granite
- Sandstone
- Schist
- Gniess
- Quartzite
- Shale
- Intrusives
- Limestone
- Banded Gneissic Complex

- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

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DEPTH TO WATER LEVEL

(PREMONSOON - 2011)

0 12.5 25 50 75 100

Kilometers

N

Legend

DTW (mbgl)

- < 5
- 5 - 10
- 10 - 20
- > 20

Aquifers

- Alluvium
- Granite
- Sandstone
- Schist
- Gniess
- Quartzite
- Shale
- Intrusives
- Limestone
- Banded Gneissic Complex

- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

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DEPTH TO WATER LEVEL

(POST-MONSOON -2011)

0 12.5 25 50 75 100

Kilometers

N

Legend

DTW (mbgl)

- < 5
- 5 - 10
- 10 - 20
- > 20

Aquifers

- Alluvium
- Sandstone
- Gniess
- Shale
- Limestone
- Granite
- Schist
- Quartzite
- Intrusives
- Banded Gneissic Complex

- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

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DEPTH TO WATER LEVEL

(PRE-MONSOON DECADAL MEAN 2002 - 2011)

0 12.5 25 50 75 100

Kilometers

N

Legend

DTW (mbgl)

- < 5
- 5 - 10
- 10 - 20
- > 20

Aquifers

- Alluvium
- Granite
- Sandstone
- Schist
- Gniess
- Quartzite
- Shale
- Intrusives
- Limestone
- Banded Gneissic Complex

- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

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DEPTH TO WATER LEVEL

(POST- MONSOON DECADAL MEAN 2002-2011)

0 12.5 25 50 75 100

Kilometers

N

Legend

DTW (mbgl)

- < 5
- 5 - 10
- 10 - 20
- > 20

Aquifers

- Alluvium
- Granite
- Sandstone
- Schist
- Gniess
- Quartzite
- Shale
- Intrusives
- Limestone
- Banded Gneissic Complex

- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

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Table 11: District Wise Range of Depth to Water Level

District Name	Alluvium								Sandstone							
	Premonsoon		Postmonsoon		Decadal (Pre)		Decadal (Post)		Premonsoon		Postmonsoon		Decadal (Pre)		Decadal (Post)	
	Min	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*
Hamirpur	2	5	0	2												
Kangra	2	20	2	10	0.76	20	0.72	20	0	10	0	10	0.76	20	0.72	20
Kullu	0	10	0	5	0.76	20	0.72	20				5	0.00	0.00	0.00	0.00
Mandi	0	40	0	20	0.76	20	0.72	10				20	0.76	10	0.72	10
Sirmaur	5	20	2	20	5.00	39.13	0.72	26.97	10	20	5	27	10.00	39.13	5.00	20
Solan	2	28	2	27	0.76	39.13	0.72	26.97	10	20	5	10	5.00	20	0.72	20
Una	0	20	0	10	0.76	20	0.72	20	2	10	2	5	0.76	20	0.72	20
Average Ranges	**11**	**143**	**6**	**94**	**0.76**	**39.13**	**0.72**	**26.97**	**22**	**60**	**12**	**77**	**0.76**	**39.1295**	**0.72**	**20**

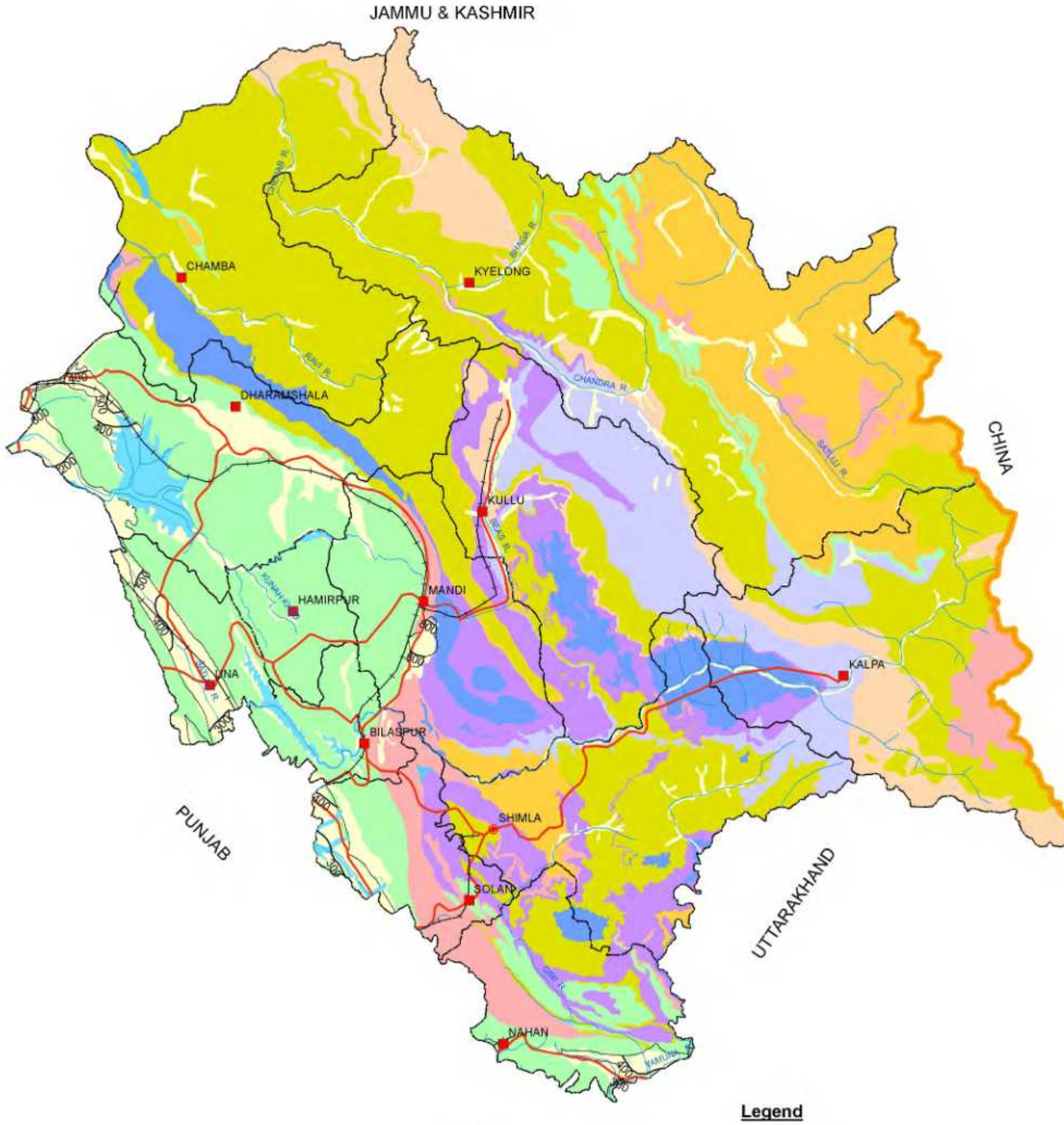
All figures in m bgl (meters below ground level)

WATER TABLE ELEVATION

0 12.5 25 50 75 100

Kilometers

N



Legend

Aquifers

- Alluvium
- Granite
- Sandstone
- Schist
- Gniess
- Quartzite
- Shale
- Intrusives
- Limestone
- Banded Gneissic Complex

- Water table Elevation Contour (m amsl)
- Ground Water Flow Direction
- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

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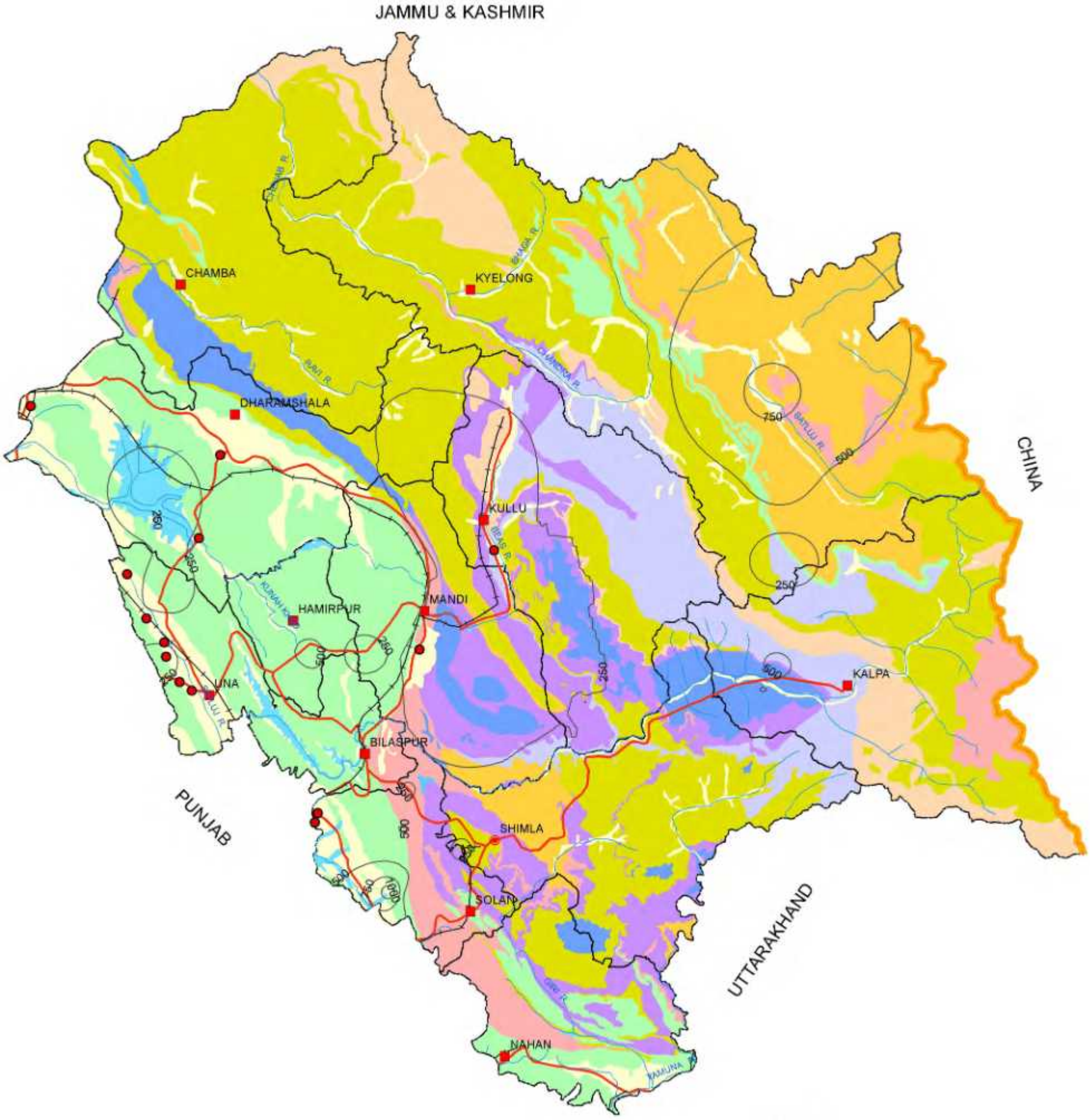
GROUND WATER QUALITY

0 12.5 25 50 75 100

Kilometers

N



Legend

Water Quality

- 500 Electrical Conductivity (micro-siemens/cm)
- Nitrate > 45 mg/l

Aquifers

- Alluvium
- Granite
- Sandstone
- Schist
- Gniess
- Quartzite
- Shale
- Intrusives
- Limestone
- Banded Gneissic Complex

- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

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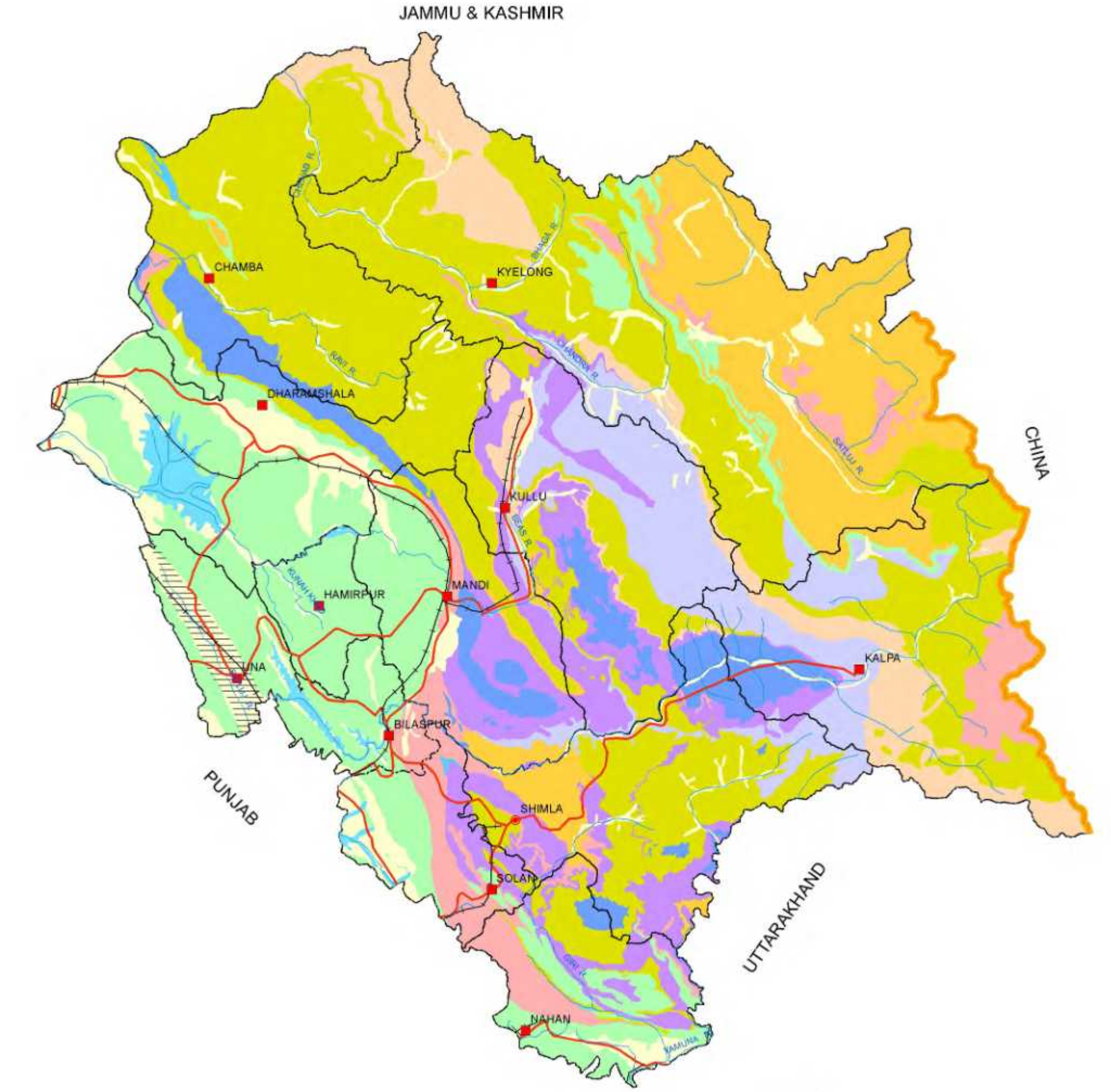
CATEGORIZATION OF GROUND WATER ASSESSMENT UNITS

N

0 12.5 25 50 75 100

Kilometers



Legend

Category

- Critical
- Over Exploited

Aquifers

- Alluvium
- Sandstone
- Gniess
- Shale
- Limestone
- Granite
- Schist
- Quartzite
- Intrusives
- Banded Gneissic Complex

- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

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Table 12: District wise Distribution and Characteristics of Alluvium Aquifer System

District Name	Major Aquifers (Area in sq km)				Aquifer Properties								
	Fluvioglacial	Older Alluvium	Fluvial	Glacial Deposit	Aquifer System	Type of Aquifer	Thickness	Zones Tapped	DTW (Decadal Avg)	Transmissivity	Yield	Specific Yield	Quality (EC in Micromhos/cm)
	AL01	AL03	AL06	AL07			m	m bgl	m bgl	m2/day	m3/day	%	
Bilaspur	159	0	11	0	Not explored								
Chamba	53	0	123	9	Not explored								
Hamirpur	49	0	0	0	Single	Unconfined to semiconfined	5-66		3-3.5	295	642	0.16	284
Kangra	1022	0	610	50	Single	Unconfined to semiconfined	15-225		4-65	8-1971	2-4838	0.16	100-600
Kinnaur	0	0	95	17	Not explored								
Kullu	33	0	123	9		Unconfined to semiconfined	10-13		2.07	583	1553	0.16	700
Lahaul & Spiti	135	0	249	299	Not explored								
Mandi	119	0	97	0	Single	Unconfined to semiconfined	59-133		18.07	25	181	0.16	365
Shimla	0	0	46	107	Not explored								
Sirmaur	141	65	0	0	Single	Unconfined to semiconfined	23-171		0.5-42	243-3336	104-4636	0.16	228-712
Solan	271	0	126	0	Single	Unconfined to semiconfined	36-149		31-38	11-63	613-2341	0.16	430-758
Una	118	0	520	0	Single	Unconfined to semiconfined	23-168		0.2-43	85-2600	567-4671	0.16	323-802
Total Area	**2100**	**65**	**1999**	**491**									

DTW : Depth to Water Level

m bgl : meters below ground level

ALLUVIUM - AQUIFER SYSTEM

0 12.5 25 50 75 100

Kilometers

N

Legend

Aquifers

- Fluvial (AL01)
- Older Alluvium (AL03)
- Fluvioglacial (AL06)
- Morainic (AL07)

- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

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BGC - AQUIFER SYSTEM

0 12.5 25 50 75 100

Kilometers

N

Legend

Aquifers

Banded Gneissic Complex (BG01)

State Capital

District Headquarters

District Boundary

State Boundary

International Boundary

River

National Highway

Railway

Water Bodies

Central Ground Water Board
North Himalayan Region
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GNEISS - AQUIFER SYSTEM

0 12.5 25 50 75 100

Kilometers

N

Legend

Aquifers

- Un-Diffferentiated Metamorphics(GN01)
- Gneiss (GN02)

- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

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Table 13: District wise Distribution and Characteristics of Sandstone Aquifer System

District Name	Major Aquifers (Area in Sq km)					Aquifer Properties								
	Sandstone/ Conglomer-ate	Sandstone with Shale	Sandstone with Clay	Sandstone/ Conglomer-ate	Sandstone with Shale	Aquifer Sys-tem	Type of Aq-uifer	Thickness	Zones Tapped	DTW (Decadal Average)	Transmissiv-ity	Yield	Specific Yield	Quality (EC in Mi-cromhos/ cm)
	ST01	ST02	ST04	ST05	ST06			m	m bgl	mbgl	m2/day	m3/day	%	
Bilaspur	726	0	104	0	0	Single	Unconfined to Semicon-fined	20-41						
Chamba	88	44	89	0	0	Not Explored								
Hamirpur	1067	0	5	0	0	Single	Unconfined to Semicon-fined	15-76	1.2-9.6		8-712	285-1552	0.16	281-550
Kangra	2328	0	198	0	0	Single	Unconfined to Semicon-fined	7-216	8-28		47-2985	22-2344	0.16	90-315
Klnnaur	0	90	0	0	0	Not Explored								
Lahaul & Spiti	0	734	0	0	0	Not Explored								
Mandi	198	0	928	0	0	Single	Unconfined to Semicon-fined	9-117	1.9-50		125	410	0.16	275
Shimla	0	0	0	0	5	Not Explored								
Sirmaur	503	0	0	63	410	Single	Unconfined to Semicon-fined	52-104	2-40		2376	316-2724	0.16	483
Solan	461	0	0	0	51	Single	Unconfined to Semicon-fined	55-148	28.6		68.75	860	0.16	630
Una	899	0	0	0	0	Single	Unconfined to Semicon-fined	36-178	2.2-40		1-1343	33-4737	0.16	82-555
Total Area	**6270**	**868**	**1323**	**63**	**467**									

DTW : Depth to Water Level
m bgl : meters below ground level

SANDSTONE - AQUIFER SYSTEM

0 12.5 25 50 75 100

Kilometers

N

Legend

Aquifers

- Sandstone (ST01)
- Sand Stone with Shale (ST02)
- Sandstone with Clay (ST04)
- Sandstone (ST05)
- Sandstone with Shale (ST06)

- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

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Table 14: District wise Distribution and Characteristics of Schist Aquifer System

District Name	Major Aquifers (Area in sq km)			Aquifer Properties								
	Schist	Phyllite	Slate	Aquifer System	Type of Aquifer	Thickness of Weathered Zone	Fractures Encountered	DTW (Decadal Average)	Transmissivity	Yield	Specific yield	Quality (EC in Micromhos/cm)
	SC01	SC02	SC03			m	m bgl	m bgl	m2/day	m3/day	%	
Chamba	647	0	4338									
Kangra	133	0	952									
Klnnaur	0	40	2281									
Kullu	188	588	383									
Lahaul & Spiti	185	1457	3211									
Mandi	30	6	446									
Shimla	1367	863	41	Single	Unconfined to semiconfined	15-76		1.26	70	1689		
Sirmaur	95	234	148									
Solan	11	0	43									
Total Area	2655	3188	11842									

DTW : Depth to Water Level

m bgl : meters below ground level

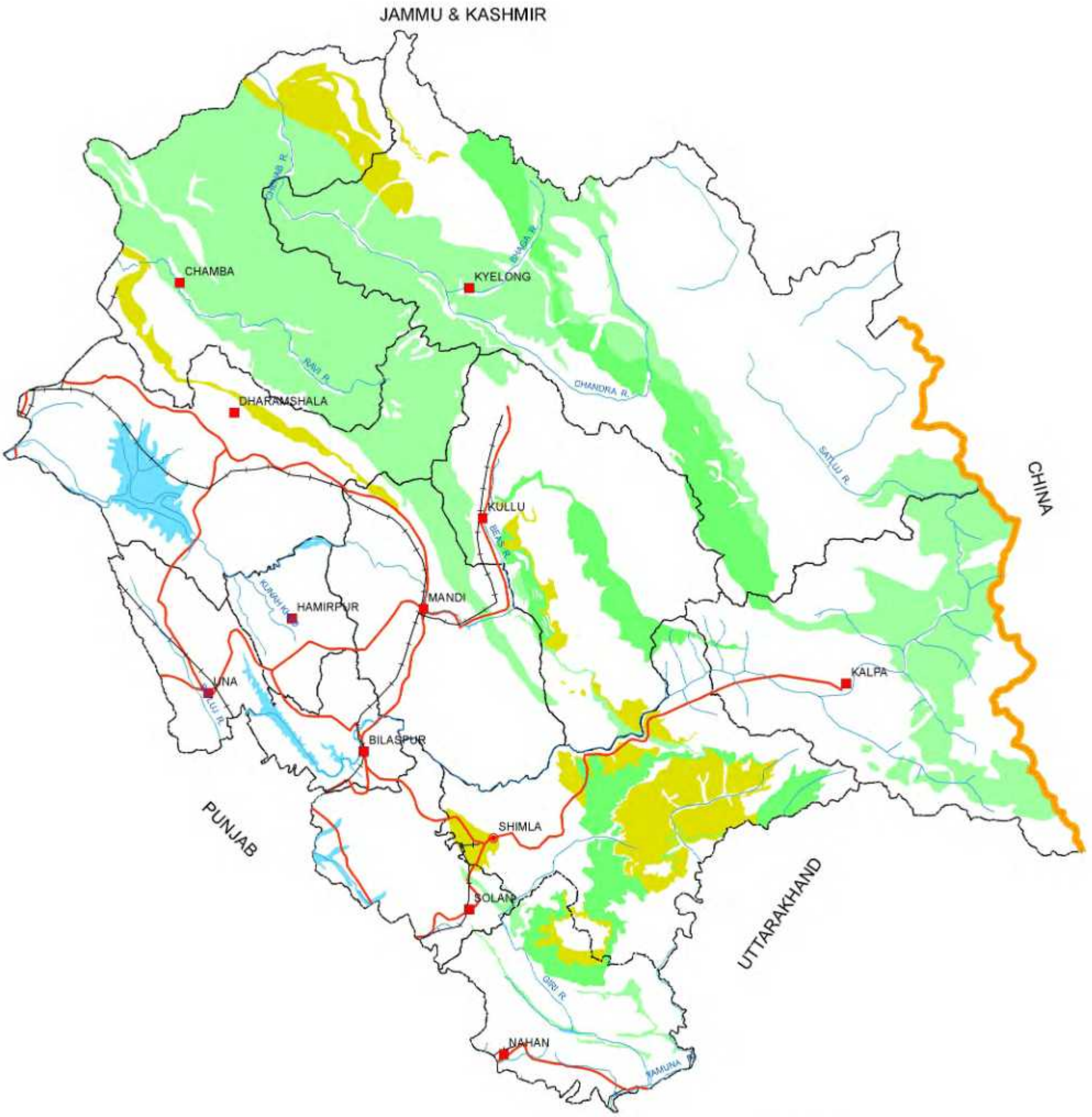
Unexplored Except in Shimla District

SCHIST - AQUIFER SYSTEM

0 12.5 25 50 75 100

Kilometers

N



Legend

Aquifers

- Schist (SC01)
- Phyllite (SC02)
- Slate (SC03)

- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

Central Ground Water Board
North Himalayan Region
Ministry of Water Resources
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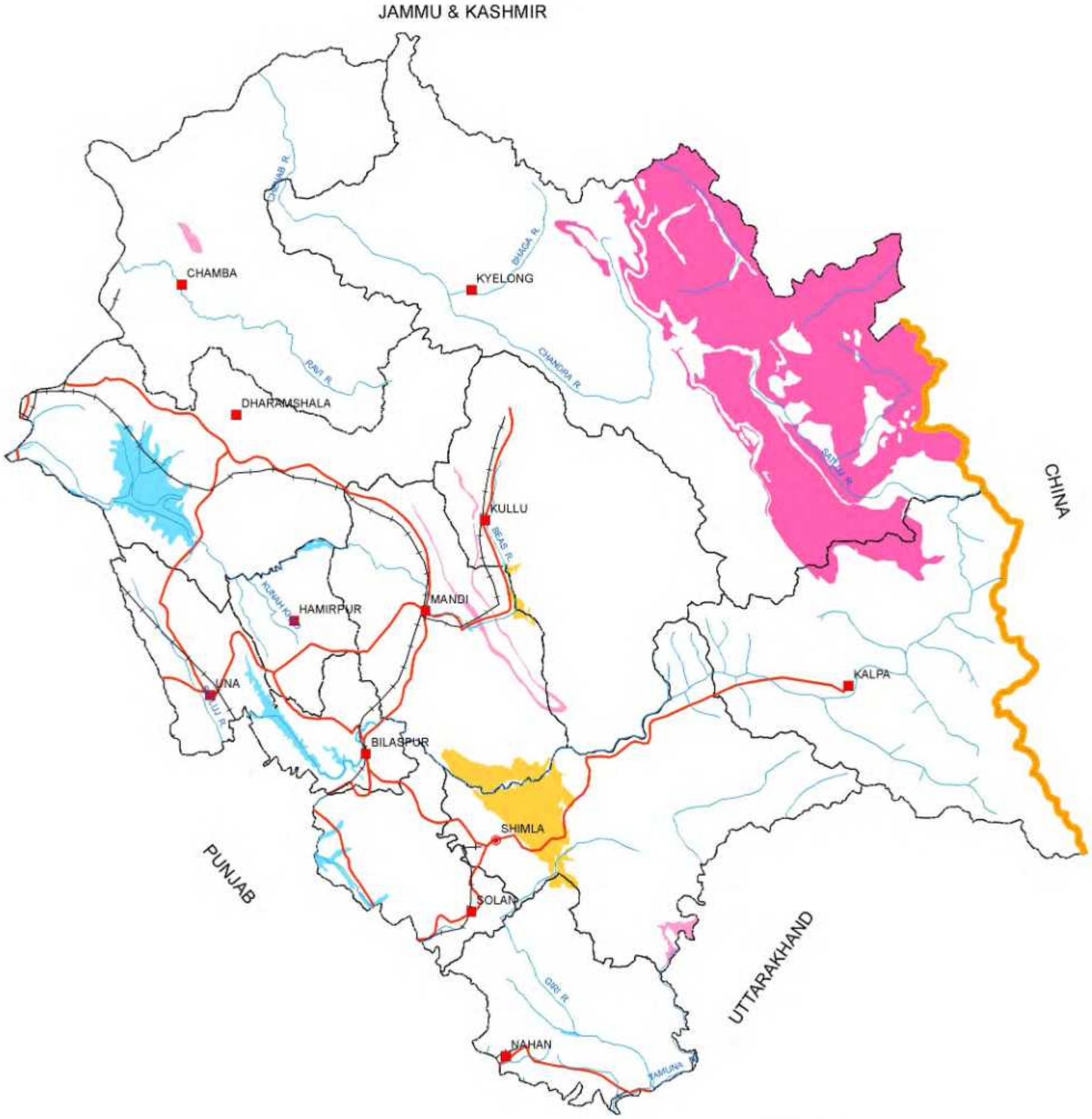
LIMESTONE - AQUIFER SYSTEM

0 12.5 25 50 75 100

Kilometers

N



Legend

Aquifers

- Limestone /Dolomite (LS02) (Semi-Consolidated)
- Limestone/ Dolomites (LS03) (Consolidated)
- Limestone with Shale (LS04)

- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

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Government of India

GRANITE - AQUIFER SYSTEM

0 12.5 25 50 75 100
Kilometers

N

Legend

Aquifers

Acid Rocks (GR02) (Granite)

State Capital
District Headquarters
District Boundary
State Boundary
International Boundary
River
National Highway
Railway
Water Bodies

Central Ground Water Board
North Himalayan Region
Ministry of Water Resources
Government of India

SHALE - AQUIFER SYSTEM

0 12.5 25 50 75 100

Kilometers

N

JAMMU & KASHMIR

CHAMBA

KYELONG

DHARAMSHALA

KULLU

MANDI

HAMIRPUR

UNA

BILASPUR

SHIMLA

SOLAN

NAHAN

KALPA

CHINA

PUNJAB

UTTARAKHAND

RAVI R.

BHAGA R.

CHANDRA R.

SUTLUJ R.

BEAS R.

KUNHALI KH.

SIRSA R.

GIRI R.

YAMUNA

Legend

Aquifers

- Shale with Limestone (SH01)
- Shale with Sandstone (SH02)
- Shale (SH04)
- Shale/Shale with Sandstone (SH05)

- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

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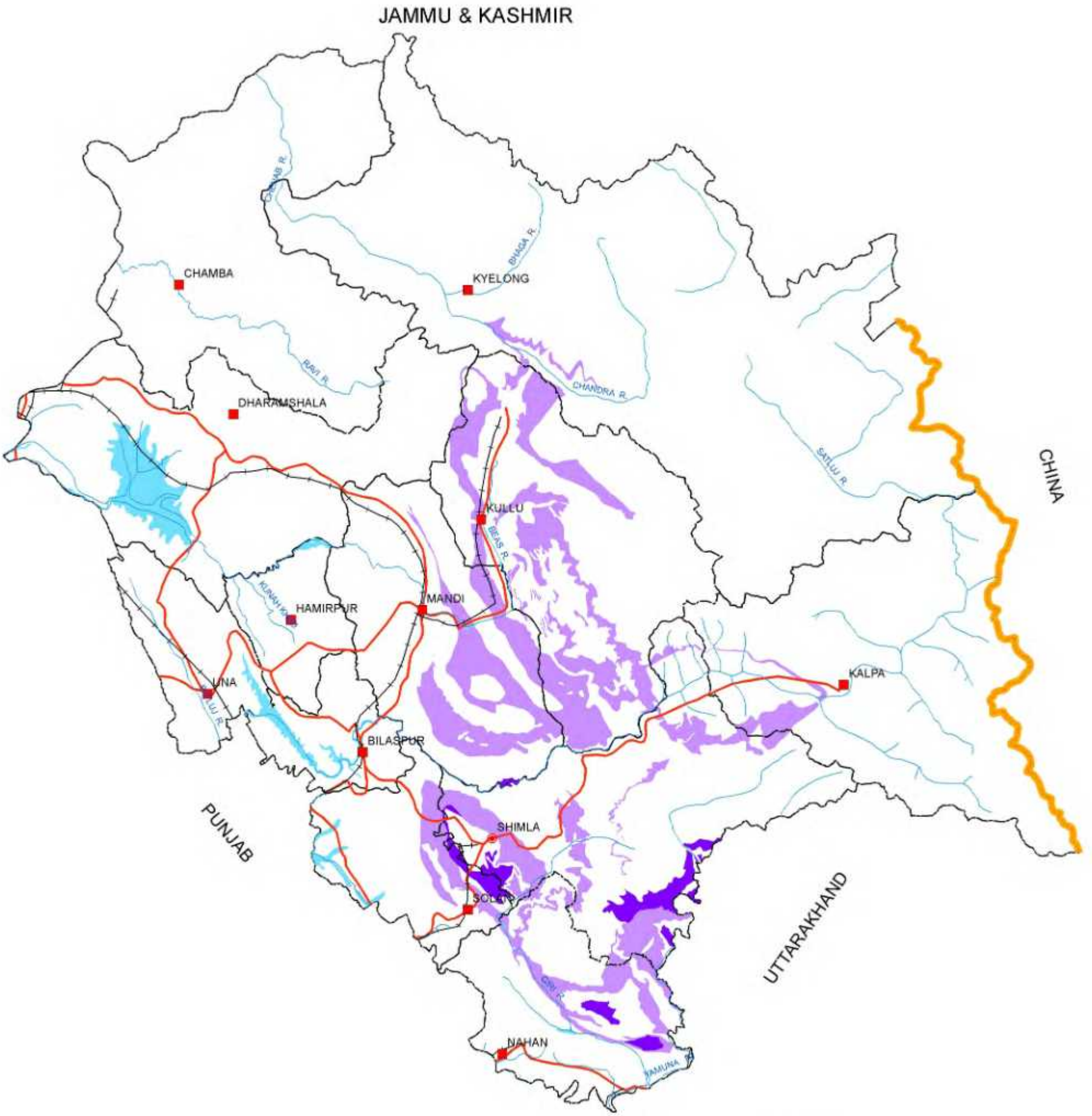
QUARTZITE - AQUIFER SYSTEM

0 12.5 25 50 75 100

Kilometers

N



Legend

Aquifers

- Quartzite (QZ01)
- Quartzite (QZ02)

- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

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Government of India

Table 15: Valley Wise Annual Ground Water Resource and Unit Recharge

Sl No	Name of the Valley	Name of Aquifer	Total Annual Ground Water Resource	Area of Assessment unit	Unit Recharge/per unit area
			(ham)	(hect)	(m)
1	**Indaura**	Alluvium	788090.17	26545	**29.69**
2	**Nurpur**	Alluvium	527340.76	23775	**22.18**
3	**Balh**	Alluvium	88327.74	9500	**9.30**
4	**Paonta**	Alluvium	353726.63	15627	**22.64**
5	**Kala Amb**	Alluvium	2156.41	250	**8.63**
6	**Nalagarh**	Alluvium	165919.81	23849	**6.96**
7	**Una**	Alluvium	1077761.60	49300	**21.86**
8	**Hum**	Alluvium	27102.86	2200	**12.32**

ANNUAL REPLENISHABLE RECHARGE

0 12.5 25 50 75 100

Kilometers

N

Legend

Unit Recharge (m/yr)

> 0.25

1200 Isohyet (cm) (Normal)

Aquifers

- Alluvium
- Granite
- Sandstone
- Schist
- Gniess
- Quartzite
- Shale
- Intrusives
- Limestone
- Banded Gneissic Complex

- State Capital
- District Headquarters
- District Boundary
- State Boundary
- International Boundary
- River
- National Highway
- Railway
- Water Bodies

Central Ground Water Board
North Himalayan Region
Ministry of Water Resources
Government of India

Table 16: District wise Area Prioritized for Artificial Recharge

District Name	Alluvium	Sandstone	Shale	Limestone	Granite	Schist	Quartzite	BGC	Gneiss	Intrusives	Total
Bilaspur	15.1	85.7	42.4								143.2
Chamba	24.2	12.0			12.6	97.3		11.0			157.1
Hamirpur	13.9	157.8									171.7
Kangra	239.2	212.0			0.0	9.1					460.4
Kinnaur	16.8		19.6		16.9	51.1	0.4	17.6	71.7		194.3
Kullu	54.3		0.6	9.3	18.7	77.4	125.3	26.0	47.8		359.3
Lahul & Spiti	21.9		13.6	40.3		72.4	5.0		10.1		163.2
Mandi	38.7	133.7	61.3	25.2	33.3	20.6	60.1		8.0		380.8
Shimla	32.1		28.9	62.7	58.6	321.8	163.3		15.0		682.3
Sirmaur	179.2	386.5	45.7		9.5	41.7	54.1				716.6
Solan	179.5	95.4	101.6		1.4	3.2	44.3				425.3
Una	339.5	163.2									502.7
Grand Total	1154.4	1246.2	313.7	137.5	151.0	694.6	452.4	54.6	152.6		4356.9

Area in sq km

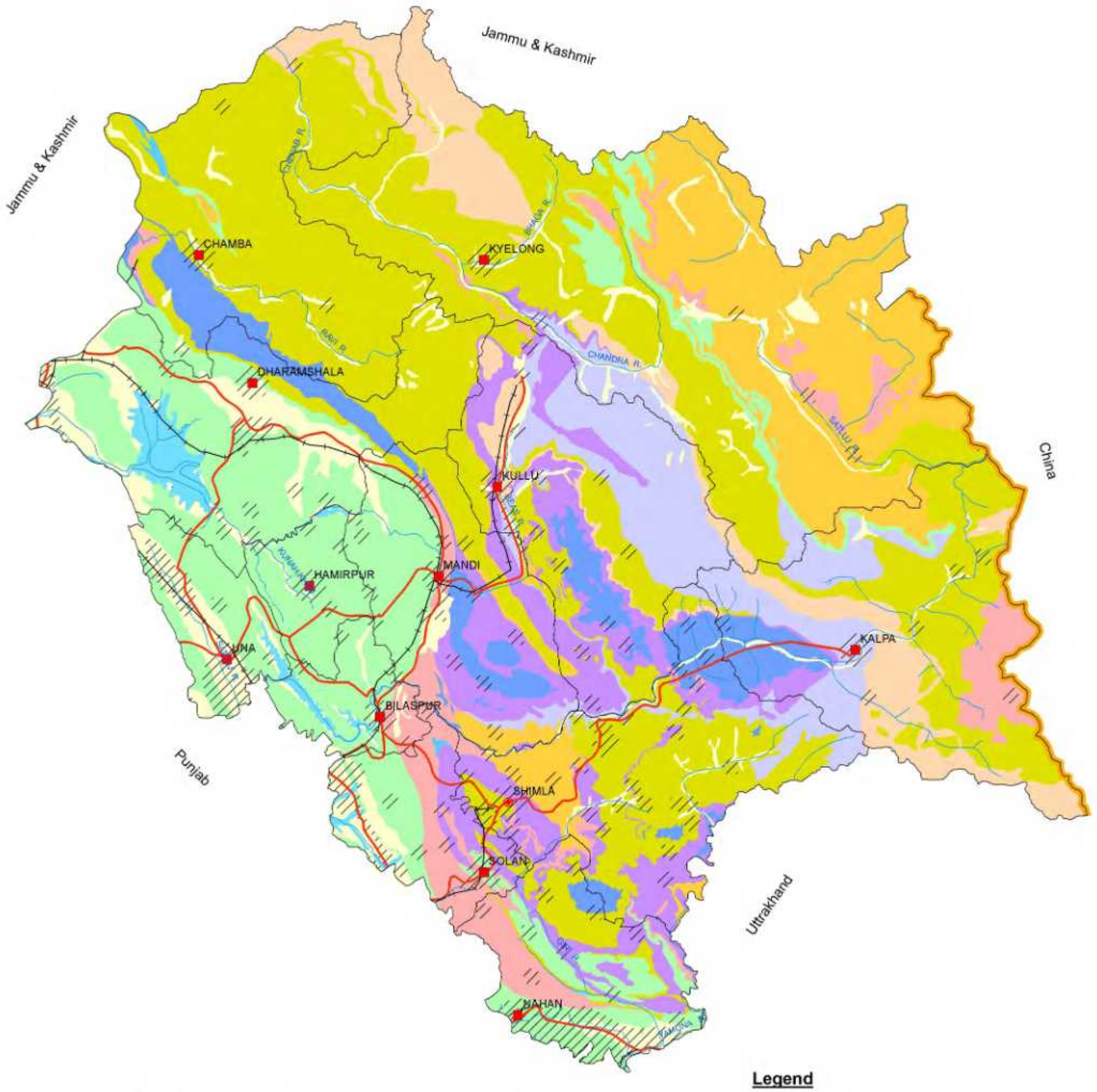
ARTIFICIAL RECHARGE - PRIORITY AREA

(Aquifer Management Plan)

0 12.5 25 50 75 100

Kilometers

N



Legend

Management Plan

- GW Recharge - Priority Area

Aquifers

- Alluvium
- Granite
- Sandstone
- Schist
- Gniess
- Quartzite
- Shale
- Intrusives
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Table 17: District Wise Area Delineated for Water Conservation and Harvesting

District Name	Alluvium	Sandstone	Shale	Limestone	Granite	Schist	Quartzite	BGC	Gneiss	Intrusives	Total
Bilaspur	7.3	147.9	5.2								**160.4**
Chamba	83.5	116.6	25.0	14.5	480.7	2002.5		371.4		24.4	**3118.6**
Hamirpur	0.9	103.7									**104.6**
Kangra	220.3	947.7			393.4	340.5	13.7	5.3			**1920.8**
Kinnaur	40.4				342.4	133.8	130.7	655.2	522.0		**1824.6**
Kullu	60.8		1.6	26.8	327.6	531.4	1112.7	269.1	1025.1		**3355.1**
Lahul & Spiti	45.4		0.3			195.7		1036.7	4.4		**1282.4**
Mandi	13.4	86.3	50.8	182.0	384.1	369.7	798.6		115.5		**2000.4**
Shimla	111.4	0.7	29.9	79.0	424.6	1828.3	536.0	17.5	182.4		**3209.8**
Sirmaur	43.9	394.5	202.3	0.8	68.1	339.2	179.6				**1228.4**
Solan	65.8	138.3	181.7		0.3	9.1	56.3				**451.5**
Una	58.4	387.4									**445.8**
Grand Total	**751.7**	**2323.0**	**496.8**	**303.1**	**2421.1**	**5750.1**	**2827.7**	**2355.1**	**1849.4**	**24.4**	**19102.4**

Area in sq km

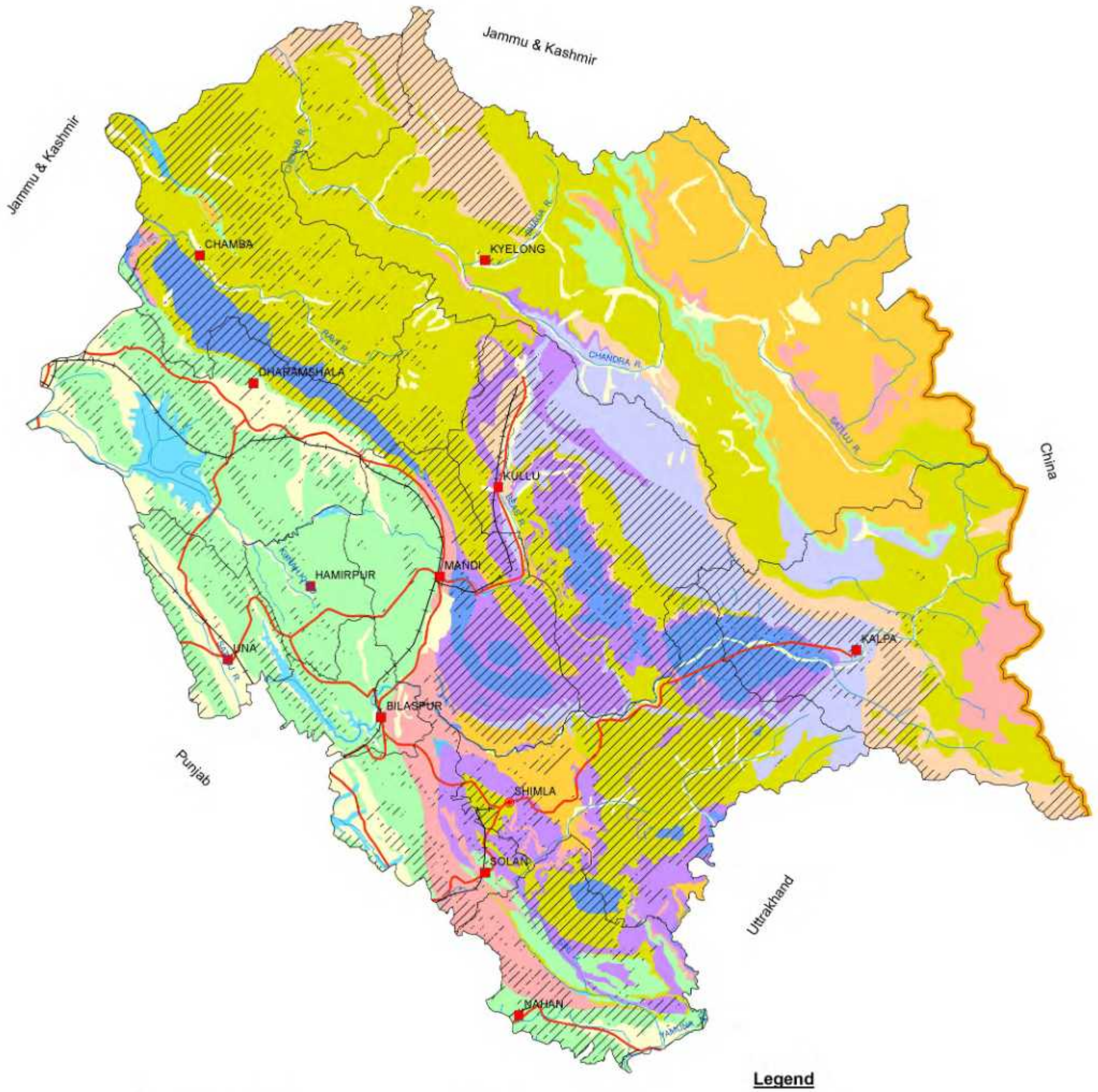
WATER CONSERVATION AND HARVESTING - PRIORITY AREA

(Aquifer Management Plan)

0 12.5 25 50 75 100

Kilometers

N



Legend

Management Plan

- Water Conservation and Harvesting - Priority Area

Aquifers

- Alluvium
- Granite
- Sandstone
- Schist
- Gniess
- Quartzite
- Shale
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- State Capital
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Table 18: District Wise Area Suitable for Ground Water Development

District Name	Alluvium	Sandstone	Shale	Limestone	Granite	Schist	Quartzite	BGC	Gneiss	Intrusives	Total
Kangra	1011.0	103.1									**1114.1**
Kullu	70.3					1.1	3.5	11.1	14.3		**100.3**
Mandi	117.2	11.5	2.9		3.9		0.0				**135.5**
Sirmaur	145.2	23.5				0.0					**168.7**
Solan	254.8	32.0									**286.9**
Una	450.2	25.3									**475.5**
Grand Total	**2048.7**	**195.5**	**2.9**		**3.9**	**1.2**	**3.5**	**11.1**	**14.3**		**2281.0**

Area in sq km

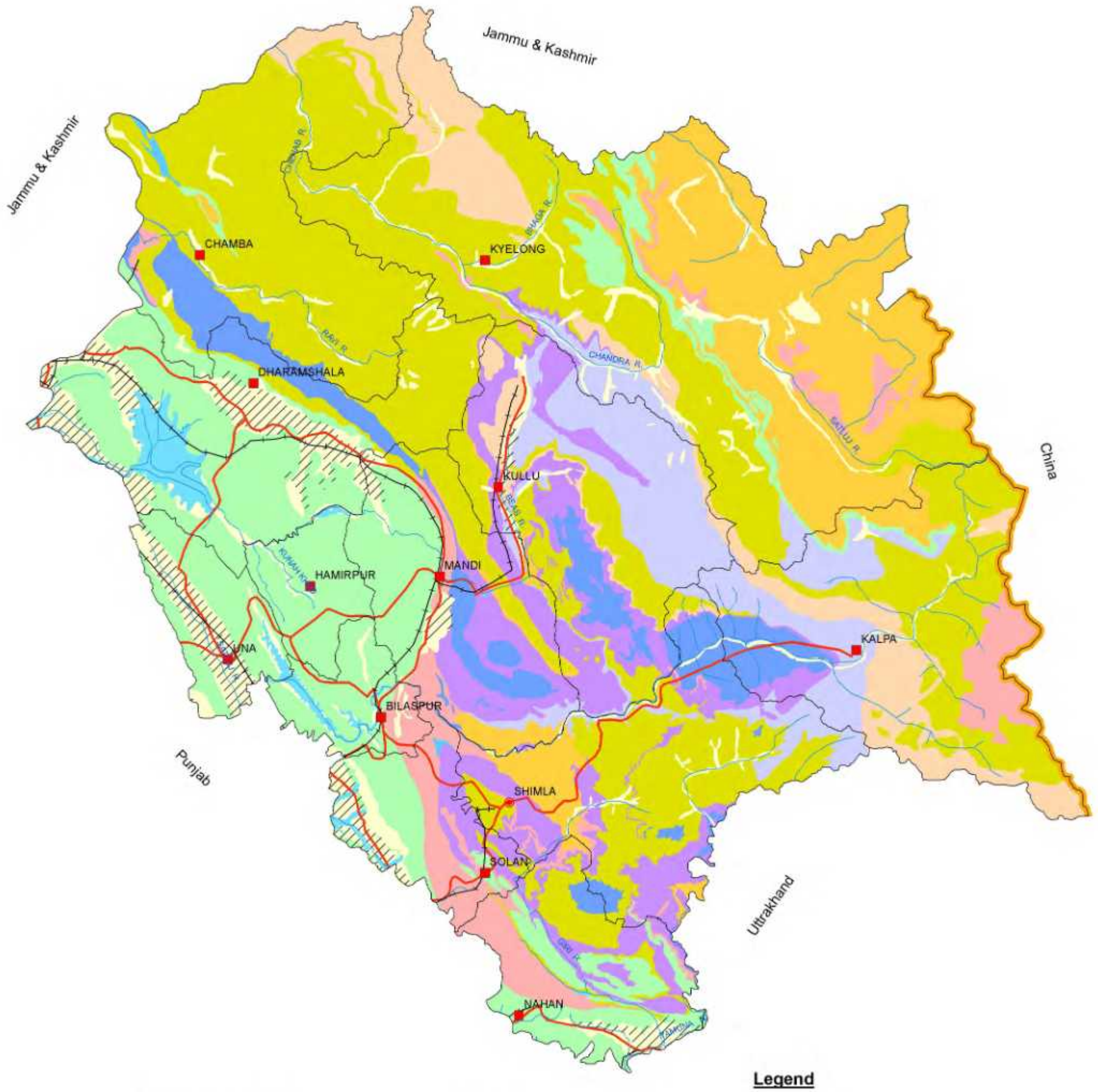
SUITABLE AREA FOR GROUND WATER DEVELOPMENT

(Aquifer Management Plan)

0 12.5 25 50 75 100

Kilometers

N



Legend

Management Plan

Suitable Areas for GW Development with Sustainable Measures

Aquifers

- Alluvium
- Granite
- Sandstone
- Schist
- Gniess
- Quartzite
- Shale
- Intrusives
- Limestone
- Banded Gneissic Complex

- State Capital
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Way Forward

Increased thrust on Ground Water usage, expected demands from various sectors Vis– Vis resource availability calls for paradigm shift in water management practices. Isolated approach has been promulgated by various departments, academia, NGOs and Vos for water management. There is need to synergize the efforts made by various stakeholders and develop a management frame work for sustenance of this resource using multidisciplinary approach.

The present endeavor of delineation of the aquifers on 1:250,000 scale is a proactive approach integrating available data of CGWB and other agencies. This has helped in development of a synoptic view of aquifers and preparation of aquifer wise management plan. Since, ground water is being developed locally by community/ individually, there is need to delineate local aquifers on larger scale and establish their potential. This compilation will form base for detailed aquifers mapping at 1:50,000 or larger scales . Further, to achieve the objectives of the National Aquifer Mapping Program proposed during 12th Five Year Plan, the following road map is envisaged :-

- The aquifer maps presented in the atlas on the 1:250,000 scale will form the base of the detailed aquifer mapping to be taken up on 1:50,000 scale.
- Defining priority areas on the basis of water management issues of the state .
- Defining grid size and depth of drilling up to which data is to be collected.
- Data gaps identification on proposed grid at 1:50,000 map using DGPS survey / orthographic data of the Remote Sensing.
- Taking up hydrogeological / Hydrochemical/ geophysical studies and wells construction details at gaps sites.
- In valleys areas, three dimensional conceptual model of the area along with isopach, thickness of saturation zones, thickness of weathered zones, thickness of valley fills and depth of valley floor etc may be prepared .
- In the Hilly areas studies may be taken using non-conventional techniques such as remote sensing with limited field checks. The mapping of the springs and their springsheds along with their pereniality and discharges can be taken up for improvement of discharges and sustainability.
- Preparation of Aquifer Management Plan after delineation of Surplus Resource Areas, GW Resources depleting and water scarce areas, Special industrial zones, Water intensive crop areas, Recreation activities etc.
- Demarcation of Aquifer for remediation, aquifers needed regulation and ares for springsheds development.

The data collected through these studies need to be integrated in GIS format and fed in to numerical models to simulate present and future scenario for suggesting optimal water utilization strategies. The model out put need to be shared with stakeholders for participatory management of the ground water resources at village level and reorientation of the water utilization pattern of the area.

Central Ground Water Board
North Himalayan Region
Dove Cottage, Ram Nagar
Dharamshala, Himachal Pradesh—176215
Phone: 01892-227160, Fax: —01892 –223535
Email– rdnhr-cgwb@nic.in