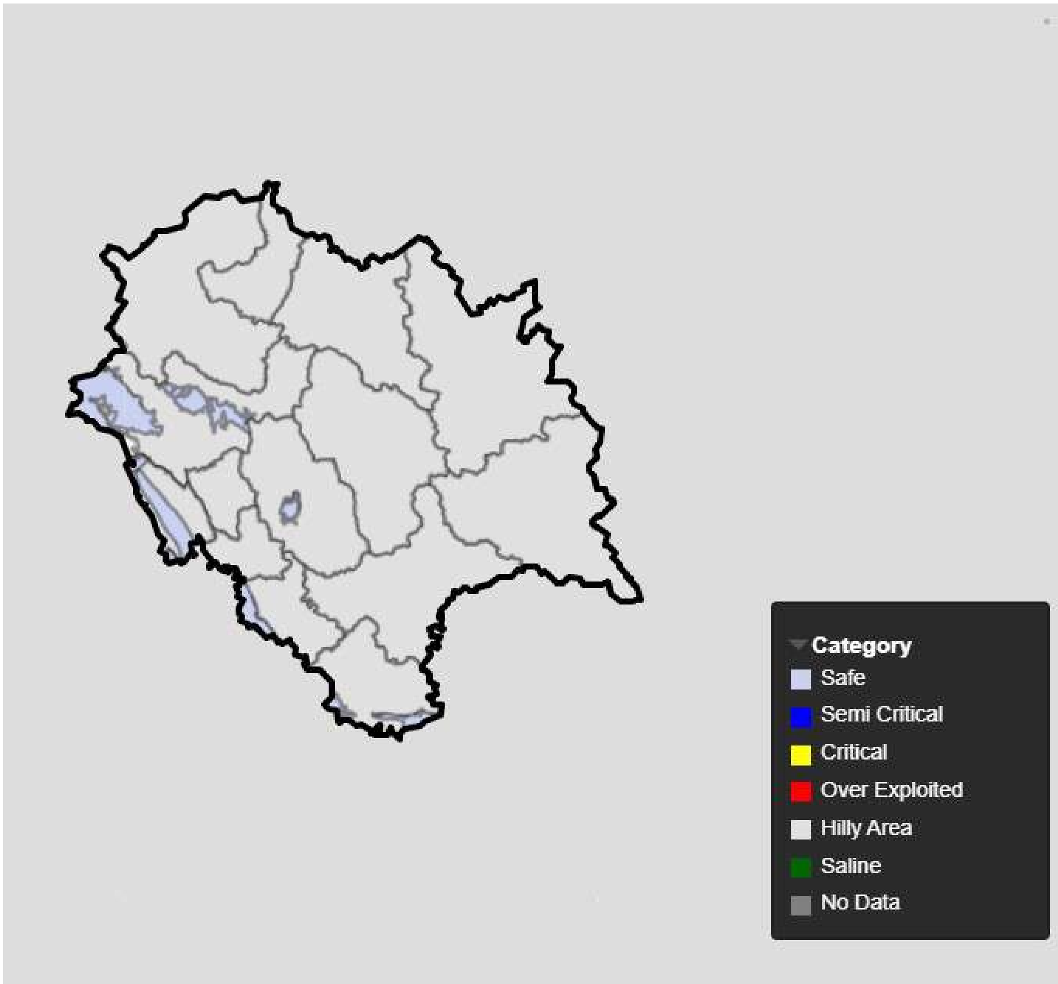
DYNAMIC GROUND WATER RESOURCES OF HIMACHAL PRADESH

(March 2023)



MINISTRY OF JAL SHAKTI
DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION
CENTRAL GROUND WATER BOARD
NORTHERN HIMALAYAN REGION
DHARAMSALA (H.P.)

&

GROUND WATER ORGANISATION
JAL SHAKTI VIBHAG
UNA (H.P.)

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A Report by:

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Dr. A. K. Sharma,IAS
Special Secretary(JSV)
GoHP

Ellerslie
Shimla-171002

FOREWORD

Groundwater is an important source of water in Himachal Pradesh as it is critical component of overall aquatic system. Ground water resources, though replenishable, yet exhaustible. The increasing demand on this resource over the years has led to water scarcity in many parts of the State. During the past two decades, the water level in many parts has been falling rapidly due to increase in extraction & over-exploitation. There is a continuous growth in demand, especially in critical and over-exploited regions of the country. In the state of Himachal Pradesh, story is little different. All of the ten valleys assessed for Dynamic Ground Water Resource in Himachal Pradesh state fall under safe category. It is time to stimulate investigation oriented quantitative and qualitative assessment of ground water which is basic to formulation of plans for its exploitation, management & conservation.

The joint study conducted by Central Ground Water Board & Ground Water Organisation under Jal Shakti Vibhag, Himachal Pradesh is aimed at having database of ground water resources of the state, and would prove to be helpful for future planning in ground water domain. Being a hilly state, only 6.2 percent of its total area that comprises of intermountain valleys is used for groundwater resource development. This area is very small compared to adjacent states and needs scientific inputs from all geoscientists for its sustainable management and smooth development in state. Himachal Pradesh Government is very keen to improve its water resources; as a result, the state has implemented National Hydrology Project and formulated Himachal Pradesh Ground Water (Regulation and Control of Development and Management) Act, 2005.

This study will be very useful and supportive for water management, conservation and sustainable development of this precious resource for all the user agencies in the state.

(Dr. A. K. Sharma)

PREFACE

The efficient management and development of ground water resources is dependent on a reliable database on ground water resources. Estimation of ground water resource on the administrative basis as recommended in GEC-15 is not applicable to the state of Himachal Pradesh, as the terrain is hilly with intermountain valleys. Keeping this in view, the resource estimation has been carried out for the major valleys only based on watershed. During the Ground Water Resource Estimation 2020 the estimation was made for ten valleys. In the present report same ten major valleys are taken for assessment.

This report presents the ground water resources database prepared based on rainfall and water level fluctuation from year the 2012 to 2022, whereas ground water draft data was taken as on March 2023. The report is a valley wise compilation of annual replenishable ground water resources, natural losses, available ground water resources, gross ground water draft, allocation for domestic and industrial uses, and balance ground water resource for domestic use and thus the stage of development was arrived at, based on watershed area having slope less than 20%.

In all the ten valley areas assessed, the stage of ground water development is <70. The overall stage of ground water development in the state of Himachal Pradesh is 34.95%. The report specifies that at present there is sufficient scope for the future development of ground water resources in Himachal Pradesh.

The report is the outcome of efforts made by Shri Bhavnesh Shamra, Senior Hydrogeologist, Ground Water Organisation, Jal Shakti Vibhag, Govt. of Himachal Pradesh. Dr. Sanjay Pandey, Scientist 'B', Sh. Prasant Kumar Singh, Senior Technical Assistant (Hg.) and all other officers of Central Ground Water Board, Northern Himalayan Region and Ground Water Organisation. The report is prepared under the overall supervision of Sh. Basant Kumar Oraon, Regional Director, Central Ground Water Board, NHR, Dharamshala. Bringing out this report is highly appreciated.

This report contains very useful data for all planners and user agencies dealing with the development of ground water resources and it is hoped that it will be utilized fully for real time management of ground water resources.

27/12/23

(J. N. Bhagat)
Head of Office

CONTENTS

ANNEXURES

TABLES

FIGURES:

CHAPTER 1

INTRODUCTION

I. BACKGROUND FOR RE-ESTIMATING THE GROUND WATER RESOURCES OF THE STATE:

The first attempt to estimate the ground water resources of the country was made in the year 1979. The committee known as ‘Ground Water Over-exploitation committee’ was constituted by the Agriculture Refinance and Development Corporation (ARDC) of Govt. of India. Based on the methodology and norms recommended by the above committee, the ground water resources were assessed. Subsequently, the necessity was felt to refine the methodologies and the “Ground Water Estimation Committee (GEC)” headed by the Chairman, CGWB came into existence. Based on the detailed surveys and the studies by the various offices and projects of CGWB, the committee recommended the revised methodology in 1984 (GEC-84) for estimation of ground water resources and the resources of the state was estimated accordingly. In 1997, the Ground Water Estimation Committee reviewed the previous studies and work done in various states and suggested a modified methodology in 1997 (GEC-97) for computation of groundwater resources. The need to revise the GEC was felt again with changing groundwater use pattern. The revised and latest methodology GEC 2015 recommends aquifer wise ground water resource assessment. Ground water resources have two components – Replenishable ground water resources or Dynamic ground water resources and In-storage resources or Static resources. GEC 2015 recommends the estimation of Replenishable and in-storage ground water resources for both unconfined and confined aquifers. Wherever the aquifer geometry has not been firmly established for the unconfined aquifer, the in-storage ground water resources have to be assessed in the alluvial areas up to the depth of bed rock or 300 m whichever is less. In the case of hard rock aquifers, the depth of assessment would be limited to 100 m

Most of the area of Himachal Pradesh is hilly having slopes of more than 20% and underlain by hard rocks except a few small intermountain valleys. These valleys are underlain by alluvium, fluvial and fluvio-glacial deposits. The groundwater resources for Himachal Pradesh are therefore calculated only for these valleys. Administrative map, base map along with assessment unit demarcation is given in **Fig-1.**

II. CONSTITUTION OF STATE-LEVEL COMMITTEE FOR GROUND WATER RESOURCES ESTIMATION

The Permanent State Level Committee for Ground Water Resource Estimation has been constituted vide Government of Himachal Pradesh Notification No.IPH-B(A)3-1/2019-II-L dated 18th January 2023 **(Annexure-A).** The Secretary, Jal Shakti Vibhag, Govt. of Himachal Pradesh is the Chairman of this committee. List of the committee members are as follows:

1.	Secretary (JSV)	Chairman
2.	Engineer-in-Chief (JSV)	Member
3.	Director (Industries)	Member
4.	Director (Urban Development)	Member
5.	Director, (Agriculture)	Member
6.	Director (Rural Development)	Member
7.	All Chief Engineers (JSV)	Member
8.	Superintending Engineer (GSWSSC)	Member
9.	Superintending Engineer (P & I) II	Member
10.	Superintending Engineer (Hydrology)	Member
11.	H.P. Water Management Board, Chief Engineer (D & M)	Member
12.	Chief General Manager, NABARD	Member
13.	Sr. Hydrogeologist, GWO, Una	Member
14.	Regional Director, CGWB	Member Secretary

III. BRIEF OUTLINE OF THE PROCEEDINGS OF THE RESOURCES ESTIMATION INCLUDING THE OUTCOME OF VARIOUS MEETINGS

The State Level Committee for Ground Water Resource Estimation has been constituted vide Government of Himachal Pradesh Notification No.IPH-B(A)3-1/2019-II-L dated 18th January 2023 (Annexure-A), The Member Secretary of the committee requested for input data of various variables for computation of ground water resources. The meeting of State Ground Water Coordination Committee (SGWCC) & State Level Committee on Ground Water Resource Estimation of Himachal Pradesh held on 19.06.2023 under the chairmanship of Secretary (JSV) to the Government of Himachal Pradesh (Annexure-B). A letter, No. JSV-B(F)10-5/2023 on dated 20.06.2023(Annexure-C) received from Secretary, JSV, to the Government of Himachal Pradesh, in which he suggested that the Dynamic Ground Water Resource Assessment 2023 Valleys will be kept as assessment units as per previous practice and no change in the assessment unit boundary is warranted. Subsequently, the data was received through e-mail on dated 04.08.2023 from GWO office, Una (Annexure-D).

All the computations were done online through IN-GRES portal which has been jointly developed by Central ground Water Board and IIT Hyderabad. All the data variables were fed into the IN-GRES portal and valley-wise assessment has been carried out.

CHAPTER 2

HYDROGEOLOGICAL CONDITION OF HIMACHAL PRADESH

DESCRIPTION OF ROCK TYPES WITH AREA COVERAGE

The area of Himachal Pradesh can be subdivided into following four stratigraphical zones and valley areas.

I. Outer Himalayan Zone

This zone is also known as the Siwalik hill ranges predominantly of low lying hills extending from NW to SE. The Siwalik are further sub-divided into upper. Middle and Lower. The Eocenes are represented by Kasauli, Dagshai and some other formations. The Siwaliks are separated from Eocenes by the Main Boundary Thrust.

II. Lower Himalayan Zone

This lies between main boundary thrust and central Himalayan thrust. This is composed of granites and other sediments of Krol belt.

III. Higher Himalayan Zone

This occupies the eastern part of the state covering Southern part of the Spiti region. The granites and granites-gneisses are well out cropped intermittently within the metamorphics of Spiti region and along Satluj river. This region is highly disturbed by tectonic activity.

IV. Tethys Himalayan Zone

Towards the north of higher Himalayan zone in Spiti valley, a nearly complete sequence of fossiliferous Paleozoic strata is exposed.

V. Valley areas

In addition to above zones, valleys fill deposits occur within the older formations. Valley fills mainly constitute boulders, cobbles, pebbles, gravels, sands interbedded with clays and sometimes associated with moronic deposits. Valley fills in the state whereas major moraine deposits occur in Kangra, Palampur, Lahaul and Spiti districts. The recent morainic formations occur in higher elevations.

Ten major valleys of Himachal Pradesh have been assessed as compared to eight valleys in previous assessment. The details of the valleys are as below:

Sr No	Assessment Unit	District	Area of Assessment unit (Sq Km.)
1	Nurpur-Indora Valley	Kangra	1024
2	Dharamshala-Palampur Valley	Kangra	452
3	Balh Valley	Mandi	107
4	Chauntra Valley	Mandi	52
5	Paonta Valley	Sirmour	276
6	Kala Amb Valley	Sirmour	82
7	Nalagarh Valley	Solan	336
8	Una Valley (Satluj Catchment)	Una	1045
9	Una Valley (Beas Catchment)	Una	65
10	Hum Valley	Una	29
	Total Area		3468

The number and area of present assessment units are same as compared to previous study. In the present assessment study, boundaries of all the assessment units have been drawn using Digital Elevation profile data acquired through Shuttle Radar Topography Mission (SRTM) satellite data having 30m resolution and the boundaries of assessment units have been taken considering slopes worked out using SRTM data, hydrogeological & watershed boundaries, lithological boundaries of the assessment unit areas taken from Groundwater Prospect Maps, prepared by NRSA, Deptt. of Space, Govt. of India, using GIS software. Accordingly the slope map created for the present study is attached as Fig-3 & Aquifer wise detail of assessment units is shown in Fig-1. Hydrogeological formation wise maps of assessment units are shown in Fig-10 to Fig-18 .

HYDROMETEOROLOGY

I. Climate

In Himachal Pradesh, climatic conditions are highly diversified due to variation in elevation (450 – 6500m). In general the climate of this area is distinct from the Punjab plains due to shorter and less severe summer, higher precipitation and colder and more prolonged winter. The two main climatic characteristics of the region are the seasonal rhythm of weather and the vertical zoning. The climatic conditions vary from hot sub-humid tropical in the southern low tracts to temperate, cold alpine and glacial in the northern and eastern high mountains. Lahaul and Spiti experience drier conditions as they are almost cut off by the high mountain ranges.

Popularly the year is divided into three seasons. These are monsoon season (June-September), winter season (October to February) and summer season (March to May). In the Himachal Pradesh, there is much diversity in climatic condition due to variation in elevation (450-6,500m amsl). In general, the various climatic zones ranges from sub-tropical (450-900 m amsl) to warm temperate.

II. Rainfall

Generally rainfall increases from south to north. Beyond Kulu, the rainfall again decreases due to rain-shadow effect towards Lahaul & Spiti and Kinnaur. Spiti is the driest (below 50 cm). About 70% of annual rainfall is received during June to September, 20% from October to March and 10% from April to May. In Lahaul and Spiti, winter and spring precipitation is greater than the summer and the autumn. Pre monsoon showers occur in June and Post monsoon showers continue till the first week of October but the total amount of both is low. Highest normal monthly rainfall may take place in July or August. Dharamsala gets maximum (1055.3mm) in July while Dalhousie (620mm) in August. Dharamsala receives the Maximum rainfall (3200mm). Simla and Nurpur falls in rainfall zone of 1500-2000mm and Dalhousie, Dharamsala, Kangra, Palampur and Jogindernagar lie in a zone exceeding 2000mm but beyond this zone of maximum rainfall there is a gradual decrease towards Mandi, Rampur, Kulu, Kalpa and Keylong. Most of Lahaul and Spiti receive less then 500mm of rainfall. The number of rainy days varies from 48 at Keylong to 99 at Dharamsala. Precipitation is also received in the form of snow. The average snowfall above 3000m amsl is about 4m lasting for more than 4 months.

The annual rainfall of the valley areas for the assessment year is given with the spatial distribution of Normal Rainfall is shown in **Fig-2.**

III. HYDROGEOLOGICAL UNITS

Most of the formations form the ground water horizons depending upon their tendency towards weathering, structural setup, depositional sequence and their topographic location. These formations are having either primary or secondary porosities.

i). Valley Fills

Valley fills occur either as major/minor valley/piedmont deposits. The major valley fills are Nurpur and Indora in Kangra district, Balh valley in Mandi district, Paonta valley and Kala Amb valley in Sirmaur district, Nalagarh valley in Solan district and Una valley & Hum valley in Una district Chauntra valley in Mandi district, Dharamshala Palampur valley in Kangra district and covers an area of 346800 hectares. Apart from this there are numerous valley fill deposits occurring locally and their areas are so small in size that these have not been considered for Ground Water resource estimation. The valley fills forms a potential aquifer in Kangra, Mandi, Sirmaur, Solan and Una district. Ground water occurs under phreatic to confined conditions in these districts.

The discharge of wells generally ranges between 15 to 25 lps with transmissivity value ranging up to 2000m^2/day.

ii). Hard Rocks

In the Himachal Pradesh, Himalayan region is divisible into two geotectonic zones separated from each other by a tectonic line. The Paleocene rocks of lesser Himalayas trending NW-SE bounded in the north by Krol Thrust and in the south by main Boundary Thrust. North of this tectonic line there is a thick pile of more or less continuous sequences of sedimentary rocks ranging in age from Precambrian to Cretaceous. South of Middle Himalayan Suture, there is sequence of formations from Precambrian to Recent. These fracture or fault zones are forming potential ground water zones in low topographic areas. Ground water in the hard rock area is either developed through bore wells or springs. The Exploratory well drilled in Shimla yielded about 30lps with a Transmissivity of 626 m^2/day. Springs are yielding sometimes more than 40 lps and are utilized for both drinking and irrigation purposes. Springs exist in many places where favorable conditions exist mainly along structurally weak zones. These are major source of water supply in the State.

IV. GROUND WATER LEVEL CONDITIONS

1) Pre monsoon water level (May 2022)

The depth to water level, recorded during May 2022 (Table - 1), ranged between 0.82 m (Mandi District) and 29.79 m bgl (Solan District) (Table-3). Out of 83 stations monitored, the majority of 71 NHS (87.65%) recorded DTWL, in the range between 2 - 20 m bgl. 6 stations (7.22%), recorded shallow water levels, less than 2 m bgl and 6 stations (7.23%), recorded deep water levels, more than 20 m bgl in the state.

Depth to Water Table
Distribution of Percentage of Observation Wells

2022/May

State Himachal Pradesh

	No. of Wells Analysed	Depth to Water Table (mbgl)		No. / Percentage of Wells Showing Depth to Water Table (mbgl) in the Range of					
		Min	Max	0.0 - 2.0	2.0 - 5.0	5.0 - 10.0	10.0 - 20.0	20.0 - 40.0	> 40.0
HAMIRPUR	3	2.79	10.53	0	2	0	1	0	0
KANGRA	25	1.06	15.00	2	14	5	4	0	0
KULLU	2	0.92	8.65	1	0	1	0	0	0
MANDI	7	0.82	5.63	2	3	2	0	0	0
SIRMAUR	10	2.18	27.65	0	1	3	5	1	0
SOLAN	7	12.61	29.79	0	0	0	4	3	0
UNA	29	1.10	29.30	1	10	11	5	2	0
Total	83	0.82	29.79	6	30	22	19	6	0

Table 1:District wise number & % of NHS distribution, in different DWL of May 2022

A perusal of the DTWL map of May 2022 shows that the shallow water level area of less than 2 m bgl, occurs in eastern and southern part of Kangra-Palampur valley, northern part of Kullu valley and southern part of Balh valley in Mandi District. 2-5 m bgl and 5-10 m bgl water level occupies in most of the monitoring area of all the valleys of Himachal Pradesh, mainly in Kangra- Palampur valley, Nurpur- Indora valley, southern part of Kullu valley and Balh Valley. Water level 10-20 m bgl in shown northern part of Kangra Palampur valley and northern part of Indora valley. Deeper water levels, between 20-40m bgl are shown in Nalagarh and western part of Paonta valley.

2) Decadal average of May (2012-2021) to May 2022

Decadal water level fluctuation has been worked out by comparing water level data of May 2022 with the average mean of 10 years water level data of May (2012-2021) and frequency distribution in various ranges is presented in Table -2.

A perusal of Table-2 shows that out of 83 stations analysed, 36 stations (43.37%) have shown rise and 47 stations (56.63%), have shown fall in water level. 32 stations (88.89%) are showing rise in water level between 0 to 2 m, 2 stations (5.55%) between 2 to 4 m and 2 stations (5.56%), more than 4 m. Out of 47 stations, 40 stations (85.10%) show fall in water level between 0 to 2 m, 5 stations (10.64 %) between 2 to 4 m and 2 stations (4.26%) more than 4 m. A minimum rise in water level of 0.01 m was noticed in Una Districts and the maximum rise of 9.34 m is noticed in Sirmaur District. Similarly, the minimum fall of 0.00 m is noticed in Kangra District & maximum fall of 6.05 m is noticed in Kangra District.

A perusal of map of Decadal Variation - Average of May (2012 - 2021) with May 2022 reveals fall less than 2 m, in all the valleys of Kullu District, and part of Bahl valley under Mandi District. Central part of Una valley is also showing fall Una District except at some places in Indaura valley, Balh valley & Kangra-Palampur valley and Nurpur valley, which is showing rise. A fall is 2- 4 m and >4 m is shwon in Nurpur valley,central part of Kullu valley and Nalagarh Valley.

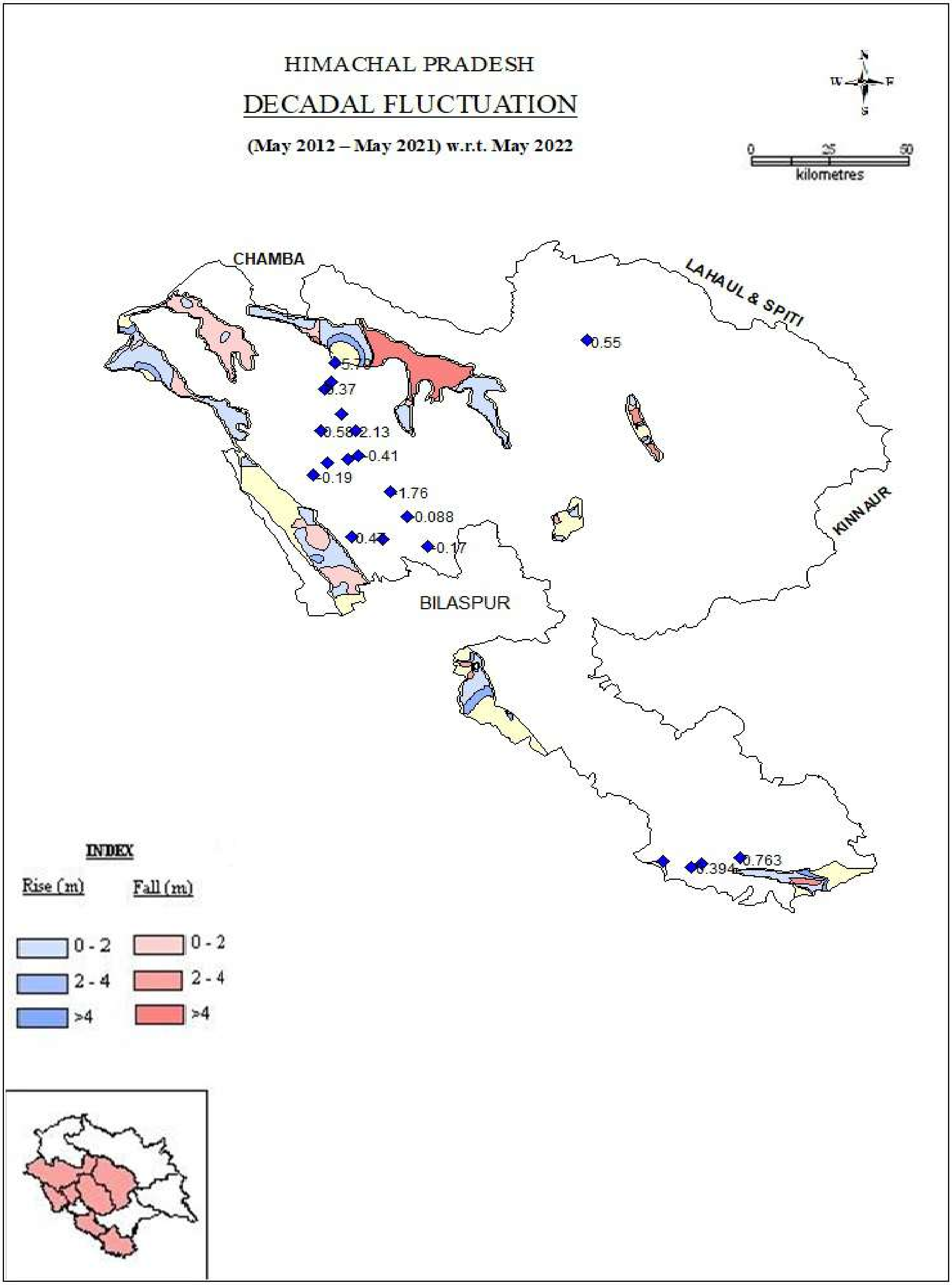
District Wise - Fluctuation of Water Level with Mean and Selected Period

10 Years Mean (2012 May - 2021 May) - 2022/May

State : Himachal Pradesh

District Name	No. of Wells	Range of Fluctuation				No. of Wells/Percentage Showing Fluctuation						Total No. of Wells	
		Rise (m)		Fall (m)		Rise (m)			Fall (m)			Rise	Fall
		Min	Max	Min	Max	0 to 2	2 to 4	>4	0 to 2	2 to 4	>4		
HAMIRPUR	3	-	-	0.08	1.76	0	0	0	3 100%	0	0	0	3
KANGRA	25	0.04	1.62	0.00	6.05	6 24.00 %	0	0	16 64.00%	2 8.00 %	1 4.00%	6	19
KULLU	2	-	-	0.16	2.38	0	0	0	1 50.00%	1 50.00 %	0	0	2
MANDI	7	1.43	1.43	0.09	1.39	1 14.29 %	0	0	6 85.71%	0	0	1	6
SIRMAUR	10	0.05	9.34	0.02	1.03	5 50.00 %	0	1 10.00%	4 40.00%	0	0	6	4
SOLAN	7	0.21	7.20	4.70	4.70	4 57.14 %	1 14.29%	1 14.29%	0	0	1 14.29%	6	1
UNA	29	0.01	2.44	0.08	3.66	16 55.17 %	1 3.45%	0	10 34.48%	2 6.90 %	0	17	12
Total	83	1.43	1.43	0.00	6.05	32	2	2	40	5	2	36	47

Table-2: District wise number & % of NHS distribution in different Decadal Water Level Fluctuation Range for May (2012-2021) to May 2022


HIMACHAL PRADESH
DECADAL FLUCTUATION
(May 2012 – May 2021) w.r.t. May 2022
0 25 50
kilometres
CHAMBA
LAHAUL & SPITI
KINNAUR
BILASPUR
0.55
0.37
0.58
2.13
0.41
0.19
1.76
0.088
0.17
0.394
0.763
INDEX
Rise (m)
Fall (m)
0 - 2
2 - 4
>4
0 - 2
2 - 4
>4

3) Post monsoon water level (November 2022)

The depth to water level recorded during November 2022 ranged between 0.54 m bgl in (Kangra District) to 36.25 m bgl in (Sirmour District) (Table-3). Out of 84 stations monitored, the majority of 63 NHS (75%) recorded DTWL in the range between 2-20 m bgl. 16 stations (19.05%), recorded shallow water levels, less than 2 m bgl and 5 stations (5.95%), recorded deep water levels, more than 20 m bgl in the State.

A perusal of the DTWL map for November 2022 shows that the shallow water level areas of less than 2 m observed in southern part of Kangra Palampur valley and southern part of Balh valley. Water level of 2-5 m & 5-10 m bgl is observed in major part of Kangra Palampur valley, Indaura-Nurpur valley, Balh valley,Una Valley, Nalagargh valley Paonta valley respectively. 10-20 m bgl water levelis shown in Una, Nalagah, Kangra-Palampur valley and Paonta valley only. Deeper water level more than 20 m is confined mainly in northern part of Paonta valley in Sirmaur District, northern part of Nalagarh valley of Solan District and northern part of Una valley.

Depth to Water Table
Distribution of Percentage of Observation Wells

2022/Nov

State **Himachal Pradesh**

	No. of Wells Analysed	Depth to Water Table (mbgl)		No. / Percentage of Wells Showing Depth to Water Table (mbgl) in the Range of					
		Min	Max	0.0 - 2.0	2.0 - 5.0	5.0 - 10.0	10.0 - 20.0	20.0 - 40.0	> 40.0
HAMIRPUR	1	2.02	2.02	0	1	0	0	0	0
KANGRA	22	0.54	10.05	7	10	4	1	0	0
KULLU	1	6.82	6.82	0	0	1	0	0	0
MANDI	6	1.91	4.56	1	5	0	0	0	0
SIRMAUR	13	1.79	36.25	1	2	2	6	2	0
SOLAN	10	5.40	29.32	0	0	2	7	1	0
UNA	31	0.75	29.10	7	11	6	5	2	0
Total	84	0.54	36.25	16	29	15	19	5	0

Table- 3: Depth to Water Level – November 2022

4) Decadal average of November (2012-2021) to November 2022

Decadal water level fluctuation has been worked out by comparing water level data of November 2022 with the average water level data of November for 10 years (2012-2021) and frequency distribution in various ranges in Table- 4.

A perusal of Table-15 shows that out of 84 stations analyzed, 27 stations (32.14%) have shown rise and 57 stations (67.86%), have shown fall in water level. 23 stations (85.19%) are showing rise in water level between 0 to 2m, 4 stations (14.81 %) between 2 to 4m. and no stations (0%), more than 4 m.

Out of 57 stations, 52 stations (91.23%) show fall in water level between 0 to 2 m, 3 station (5.26%) between 2 to 4 m and 2 station (3.51 %) more than 4 m.

A minimum rise in water level of 0.07 m was noticed in Kangra District and the maximum rise of 3.64 m is noticed in Solan District. Similarly, the minimum fall of 0.01 m is noticed in Una District & maximum fall of 18.29 m is noticed in Sirmour District.

A perusal of map of Decadal average of November (2012-2021) to November 2022 reveals rise in water level less than 2 m is shown in whole part of Kangra- Palampur valley & Indaura valley of Kangra District except a few places, major part of Nalagarh valley, Balh valley, a couple of places in Paonta valley. The fall between 2 to 4 m was noticed in, Una valley and Paonta valley. Similarly, rise is noticed in all the valleys from 0-2 m except Kullu Valley.

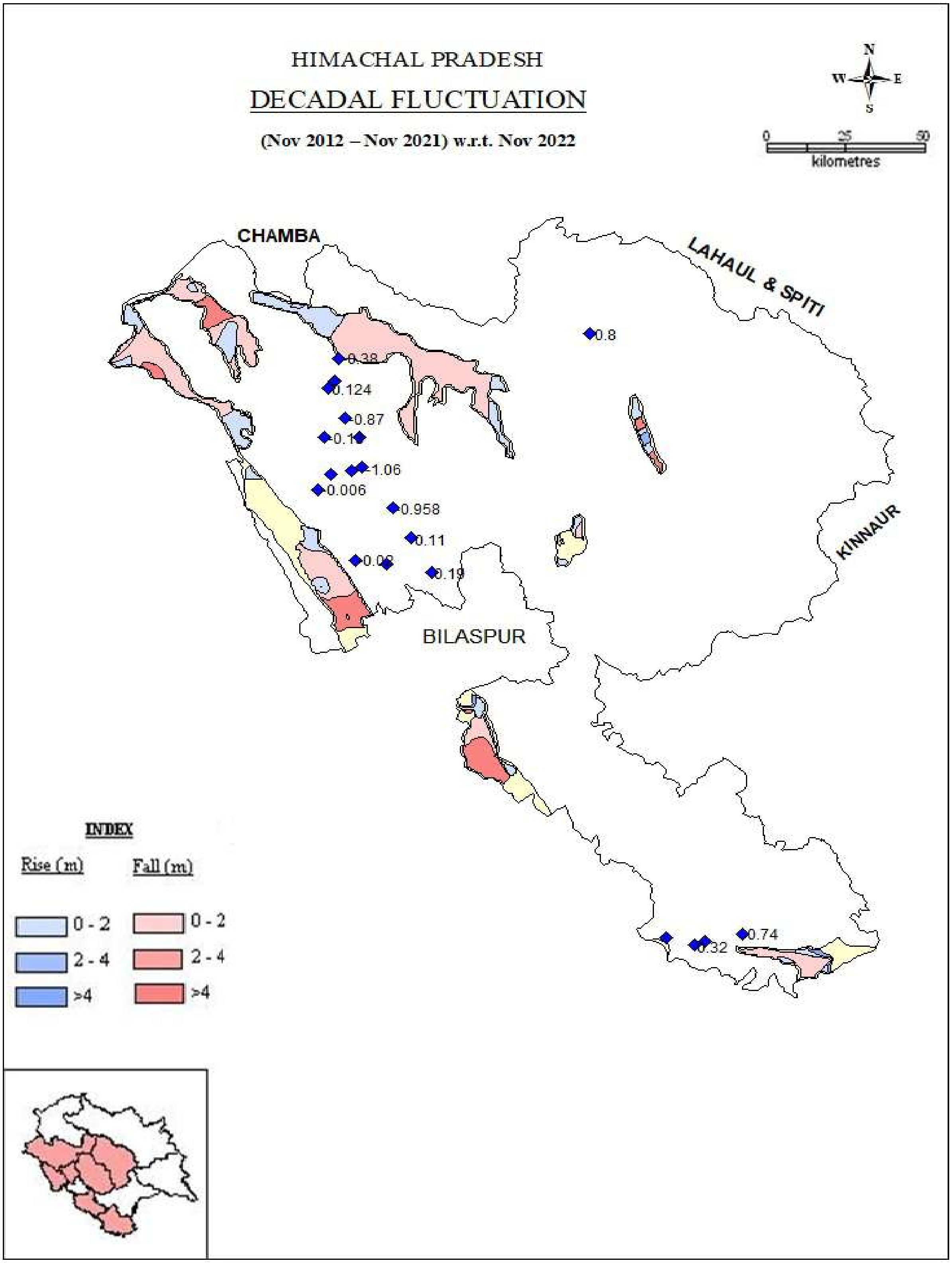
District Wise - Fluctuation of Water Level with Mean and Selected Period

10 Years Mean (2012 Nov - 2021 Nov) - 2022/Nov

State : Himachal Pradesh

District Name	No. of Wells	Range of Fluctuation				No. of Wells/Percentage Showing Fluctuation						Total No. of Wells	
		Rise (m)		Fall (m)		Rise (m)			Fall (m)			Rise	Fall
		Min	Max	Min	Max	0 to 2	2 to 4	>4	0 to 2	2 to 4	>4		
HAMIRPUR	1	0.17	0.17	-	-	1 100 %	0	0	0	0	0	1	0
KANGRA	22	0.07	0.88	0.05	1.26	9 40.91 %	0	0	13 59.09%	0	0	9	13
KULLU	1	-	-	0.78	0.78	0	0	0	1 100%	0	0	0	1
MANDI	6	0.18	2.01	0.28	0.89	2 33.33 %	1 16.67%	0	3 50.00%	0	0	3	3
SIRMAUR	13	0.37	0.77	0.05	18.29	3 23.08 %	0	0	8 61.54%	1 7.69 %	1 7.69%	3	10
SOLAN	10	0.15	3.64	0.22	0.57	3 30.00 %	1 10.00%	0	6 60.00 %	0	0	4	6
UNA	31	0.10	2.30	0.01	8.05	5 16.13 %	2 6.45 %	0	21 67.74%	2 6.45%	1 3.23 %	7	24
Total	84	0.17	0.37	0.00	18.29	23	4	0	52	3	2	27	57

Table-4: Decadal Fluctuation November (2012-2021) to November 2022


HIMACHAL PRADESH
DECADAL FLUCTUATION
(Nov 2012 – Nov 2021) w.r.t. Nov 2022
N
W
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0
25
50
kilometres
CHAMBA
LAHAUL & SPITI
KINNAUR
BILASPUR
0.8
0.38
0.124
0.87
0.11
1.06
0.006
0.958
0.11
0.19
0.74
0.32
INDEX
Rise (m)
Fall (m)
0 - 2
2 - 4
>4
0 - 2
2 - 4
>4

GROUND WATER QUALITY

The study of chemical characteristics of 151 water samples of ground water and spring water collected from ground Water Monitoring Stations of Una, Kangra, Solan, Mandi, Sirmour, Chamba, Bilaspur, Kullu and Solan districts reveal that ground water is fresh with electrical conductance and major ions within permissible limits as set down by BIS 2001 Standards.

The Ranges (Minimum and Maximum) of various parameters in different districts of H.P. are given in **Table below.** A perusal of Table shows that in the entire state, the, Flouride concentration ranges from traces to 1.40 except Chakgyani (Artesian Piezometer) in Chamba district which is 6.4 mg/l.

S. No.	District (No of Samples)		pH	EC µS/cm at 25°C	HCO_3	Cl	SO_4	NO_3	F	Ca	Mg	Na	K	Total Hardness as $CaCO_3$
					(in mg/l)									
1.	KANGRA (52)	Min	7.44	190	49	7	0	0	0.14	12	4.9	6	0.6	80
		Max	8.85	1100	366	107	120	130	0.80	92	56	74	126	400
2.	UNA (33)	Min	8.23	262	43	18	0	0	0.01	6	1.2	15	0.6	95
		Max	8.69	735	177	227	201	78	2.60	98	58	95	22	295
3.	MANDI (17)	Min	8.39	219	61	21	0	1	0.16	14	1.2	3	1.1	70
		Max	8.68	815	159	156	121	43	0.65	54	43	61	24	290
4.	KULLU (2)	Min	8.41	300	98	25	0	6	0.19	36	13	4	6	150
		Max	8.58	389	116	43	10	90	0.24	54	15	12	6.2	190
5.	HAMIRPUR (6)	Min	8.39	216	43	21	0	1	0	8	6.1	18	1.3	70
		Max	8.49	312	110	71	0	17	0.20	22	19	30	10.5	120
6.	SOLAN (14)	Min	8.38	255	49	11	0	10	0.22	10	2.4	22	0.6	60
		Max	8.52	945	128	231	154	53	1.40	54	55	163	6	360
7.	SIRMOUR (19)	Min	8.39	175	61	7	0	0	0.15	12	4.9	7	1	65
		Max	8.69	700	238	99	0	33	2.20	30	23	115	8.9	160
8.	CHAMBA (13)	Min	8.37	140	43	11	0	0	0.15	8	3.6	1	0.4	55
		Max	8.64	362	122	46	24	11	6.40	24	27	43	9.1	170
9.	BILASPUR (4)	Min	7.38	210	61	25	0	3	0.29	12	9.7	17	2.3	70
		Max	8.61	390	98	57	10	38	1.40	26	16	34	9.4	130
HIMACHAL PRADESH (151)		Min	7.38	140	43	7	0	0	0	6	1.2	1	0.4	55
		Max	8.85	1100	366	231	201	130	6.40	98	58	163	126	400

Table 5: Range of Chemical Quality in Shallow Aquifers of Himachal Pradesh (May 2022)

CHAPTER-3

GROUND WATER RESOURCES ESTIMATION METHODOLOGY

The revised methodology GEC 2015 recommends aquifer wise ground water resource assessment. Ground water resources have two components – Replenishable ground water resources or Dynamic Ground Water Resources and In-storage Resources or Static Resources. GEC 2015 recommends estimation of Replenishable and in-storage ground water resources for both unconfined and confined aquifer. Wherever the aquifer geometry has not been firmly established for the unconfined aquifer, the in-storage ground water resources have to be assessed in the alluvial areas up to the depth of bed rock or 300 m whichever is less. In case of hard rock aquifers, the depth of assessment would be limited to 100 m. In case of confined aquifers, if it is known that ground water extraction is being taken place from this aquifer, the dynamic as well as in-storage resources are to be estimated. If it is firmly established that there is no ground water extraction from this confined aquifer, then only in-storage resources of that aquifer has to be estimated.

3.1 Periodicity of Assessment

Keeping in view of the rapid change in Ground Water Extraction, the committee recommends more frequent estimation of Ground Water Resources. As per recommendation of Committee, the resources are to be assessed every year from 2022 onwards. As per the present practice, there was a considerable time lag between assessment and publication of the results; however the introduction of INGRES has made it possible to reduce the time lag and the results can be reported within the successive water year.

3.2 Ground Water Assessment Unit

This methodology recommends aquifer wise ground water resource assessment. An essential requirement for this is to demarcate lateral as well as vertical extent and disposition of different aquifers. A watershed with well-defined hydrological boundaries is an appropriate unit for ground water resource estimation if the principal aquifer is other than alluvium. Ground water resources worked out on watershed as a unit, may be apportioned and presented on administrative units (block/ taluka/ mandal/ firka). This would facilitate local administration in planning of ground water management programmes. Areas occupied by unconsolidated sediments (alluvial deposits, aeolian deposits, coastal deposits etc.) usually have flat topography and demarcation of watershed boundaries may not be possible in such areas. Until Aquifer Geometry is established on appropriate scale, the existing practice of using watershed in hard rock areas and blocks/ mandals/ firkas in soft rock areas may be continued.

The ground water resources assessment were carried out based on the guidelines of Ministry of Water Resources, RD & GR which broadly follows the methodology recommended by Ground Water Resources Estimation Committee, 2015. The salient features of the methodology are enumerated in the following paragraphs.

The ground water recharge is estimated season-wise both for monsoon season and non- monsoon season separately. The following recharge and discharge components are assessed in the resource assessment - recharge from rainfall, recharge from canal, return flow from irrigation, recharge from tanks and ponds and recharge from water conservation structures and discharge through ground water draft.

The ground water resources of any assessment unit is the sum of the total ground water availability in the principal aquifer (mostly unconfined aquifer) and the total ground water availability of semi-confined and confined aquifers existing in that assessment unit. The total ground water availability of any aquifer is the sum of Dynamic ground water resources and the In-storage or Static resources of the aquifer.

3.3 Ground Water Assessment of Unconfined Aquifer

As mentioned earlier, assessment of ground water includes assessment of dynamic and in- storage ground water resources. The development planning should mainly depend on dynamic resource only as it gets replenished every year. Changes in static or in-storage resources reflect impacts of ground water mining. Such resources may not be replenishable annually and may be allowed to be extracted only during exigencies with proper recharge planning in the succeeding excess rainfall years.

3.3.1 Dynamic Ground Water Resources

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

Inflow – Outflow = Change in Storage (of an aquifer) **1**

Equation 1 can be further elaborated as -

$$\Delta S = R_{RF} + R_{STR} + R_{C} + R_{SWI} + R_{GWI} + R_{TP} + R_{WCS} \pm VF \pm LF - GE - T - E - B \qquad 2$$

Where,

ΔS – Change in storage

R_{RF} – Rainfall recharge

R_{STR}- Recharge from stream channels

R_c – Recharge from canals

R_{SWI} – Recharge from surface water irrigation

R_{GWI}- Recharge from ground water irrigation

R_{TP}- Recharge from Tanks and Ponds

R_{WCS} – Recharge from water conservation structures

VF – Vertical flow across the aquifer system

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

GE-Ground Water Extraction

T- Transpiration

E- Evaporation

B-Base flow

It is preferred that all the components of water balance equation should be estimated in an assessment unit. The present status of database available with Government and non- government agencies is not adequate to carry out detailed ground water budgeting in most of the assessment units. Therefore, it is proposed that at present the water budget may be restricted to the major components only taking into consideration certain reasonable assumptions. The estimation is to be carried out using lumped parameter estimation approach keeping in mind that data from many more sources if available may be used for refining the assessment.

3.3.2 Rainfall Recharge

It is recommended that ground water recharge should be estimated on ground water level fluctuation and specific yield approach since this method takes into account the response of ground water levels to ground water input and output components. This, however, requires adequately spaced representative water level measurement for a sufficiently long period. It is proposed that there should be at least three spatially well distributed observation wells in the assessment unit, or one observation well per 100 sq. Km. Water level data should also be available for a minimum period of 5 years (preferably 10years), along with corresponding rainfall data. Regarding frequency of water level data, three water level readings during pre and post monsoon seasons and in the month of January/ May preferably in successive years, are the minimum requirements. It would be ideal to have monthly water level measurements to record the peak rise and maximum fall in the ground water levels. In units or subareas where adequate data on ground water level fluctuations are not available as specified above, ground water recharge may be estimated using rainfall infiltration factor method only. The rainfall recharge during non-monsoon season may be estimated using rainfall infiltration factor method only.

3.3.3 Ground water level fluctuation method

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

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

Where,

ΔS – Change in storage

R_{RF} – Rainfall recharge

R_{STR}- Recharge from stream channels

R_{SWI} – Recharge from surface water irrigation (Lift Irrigation)

R_{GWI}- Recharge from ground water irrigation

R_{TP}- Recharge from tank and ponds

R_{WCS} – Recharge from water conservation structures

VF – Vertical flow across the aquifer system

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

GE-Ground water Extraction

T- Transpiration

E- Evaporation

B-Base flow

Whereas the water balance equation in command area will have another term Recharge due to canals (R_C) and the equation will be as follows:

$$\Delta S = R_{RF} + R_{STR} + R_C + R_{SWI} + R_{GWI} + R_T + R_{WCS} \pm VF \pm LF - GE - T - E - B \qquad 4$$

A couple of important observations in the context of water level measurement must be followed. It is important to bear in mind that while estimating the quantum of ground water extraction, the depth from which ground water is being extracted should be considered, and certain limit should be fixed. First, by estimating recharge by Water Level Fluctuation method, rise in water level (pre to post monsoon Water Level observed in a dug well) is considered and in estimating the draft from dug wells and bore wells (shallow and deep) drop in water level is considered. One should consider only the draft from the same aquifer for which the resource is being estimated.

The change in storage can be estimated using the following equation:

$$\Delta S = \Delta h * A * S_Y \quad (5)$$

Where

ΔS – Change in storage

Δh - rise in water level in the monsoon season A - area for computation of recharge

Sy - Specific Yield

Substituting the expression in equation 5 for storage increase ΔS in terms of water level fluctuation and specific yield, the equations 3 and 4 becomes,

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

$$\mathbf{R_{RF} = h \times Sy \times A - R_{C} - R_{STR} - R_{SWI} - R_{GWI} - R_{TP} - R_{WCS} \pm VF \pm LF + GE + T + E +} \quad (7)$$

The recharge calculated from equation 6 in case of non-command sub units and equation 7 in case of command sub units and poor ground water quality sub units gives the rainfall recharge for the particular monsoon season. However, it may be noted that in case base flow/ recharge from stream and through flow have not been estimated, the same may be assumed to be zero.

The rainfall recharge obtained by using equation 6 and equation 7 provides the recharge in any particular monsoon season for the associated monsoon season rainfall. This estimate is to be normalised for the normal monsoon season rainfall as per the procedure indicated below.

Normalization of Rainfall Recharge

Let Ri be the rainfall recharge and ri be the associated rainfall. The subscript i takes values 1 to N where N is number of years data is available which is at least 5. The rainfall recharge, Ri is obtained as per equation 6 and equation 7 depending on the sub unit for which the normalization is being done.

$$\mathbf{R_i = h \times Sy \times A - R_{STR} - R_{SWI} - R_{GWI} - R_{TP} - R_{WCS} \pm VF \pm LF + GE + T + E + B} \quad (8)$$

$$\mathbf{R_i = h \times Sy \times A - R_{C} - R_{STR} - R_{SWI} - R_{GWI} - R_{TP} - R_{WCS} \pm VF \pm LF + GE + T + E + B} \quad (9)$$

where,

R_i= Rainfall recharge estimated in the monsoon season for the i^{th} particular year

h= Rise in ground water level in the monsoon season for the i^{th} particular year

Sy =Specific yield

A= Area for computation of recharge

GE = Ground water extraction in monsoon season for the i^{th} particular year

B= Base flow the monsoon season for the i^{th} particular year

R_C = Recharge from canals in the monsoon season for i^{th} particular year

R_{STR}= Recharge from stream channels in the monsoon season for i^{th} particular year

R_{SWI} = Recharge from surface water irrigation including lift irrigation in the monsoon season for the i^{th} particular year

R_{GWI} = Recharge from groundwater irrigation in the monsoon season for the i^{th} particular year

R_{WCS} =Recharge from water conservation structures in the monsoon season for the i^{th} particular year

R_{TP}= Recharge from tanks and ponds in the monsoon season for the i^{th} particular year

LF= Recharge through Lateral flow/ Through flow across assessment unit boundary in the monsoon season for the i^{th} particular year

VF – Vertical flow across the aquifer system in the monsoon season for the i^{th} particular year

T- Transpiration in the monsoon season for the i^{th} particular year E- Evaporation in the monsoon season for the i^{th} particular year

After the pairs of data on Ri and ri have been obtained as described above, a normalisation procedure is to be carried out for obtaining the rainfall recharge corresponding to the normal monsoon season rainfall. Let r(normal) be the normal monsoon season rainfall obtained on the basis of recent 30 to 50 years of monsoon season rainfall data. Two methods are possible for the normalization procedure.

The first method is based on a linear relationship between recharge and rainfall of the form

$$\mathbf{R = ar} \qquad \mathbf{10}$$

where,

R = Rainfall recharge during monsoon season

r = Monsoon season rainfall

a = a constant

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

$$R_{rf}(\text{normal}) = \frac{\sum_{i=1}^{N}\left[R_i \times \frac{r(\text{normal})}{r_i}\right]}{N} \qquad \mathbf{11}$$

Where,

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

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

r(normal) - Normal monsoon Season rainfall.

r_i - Rain fall in the monsoon season for the i^{th} year.

N - No, of years data is available.

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

$$\mathbf{R = ar+b} \qquad \mathbf{12}$$

where,

R = Rainfall recharge during monsoon season

r = Monsoon season rainfall

a and b = constants.

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

$$a = \frac{NS_4 - S_1 S_2}{NS_3 - S_1^2} \qquad \mathbf{13}$$

$$b = \frac{S_2 - aS_1}{N} \qquad \mathbf{14}$$

Where

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

The rainfall recharge during monsoon season for normal monsoon rainfall condition is computed as below:

$$R_{rf}\,(normal) = a \times r(normal) + b \qquad 15$$

3.3.4 Rainfall Infiltration Factor method

The rainfall recharge estimation based on Water level fluctuation method reflects actual field conditions since it takes into account the response of ground water level. However the ground water extraction estimation included in the computation of rainfall recharge using Water Level Fluctuation approach is often subject to uncertainties. Therefore, it is recommended to compare the rainfall recharge obtained from Water Level Fluctuation approach with that estimated using Rainfall Infiltration Factor Method.

Recharge from rainfall is estimated by using the following relationship -

$$R_{rf} = RFIF * A * (R - a)/1000 \qquad 16$$

Where,

R_{rf} = Rainfall recharge in ham A = Area in Hectares

RFIF = Rainfall Infiltration Factor R = Rainfall in mm

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

The relationship between rainfall and ground water recharge is a complex phenomenon depending on several factors like runoff coefficient, moisture balance, hydraulic conductivity and Storativity/ Specific yield of the aquifer etc. In this report, certain assumptions have been adopted for computation of Rainfall recharge factor. These assumptions may be replaced with actual data in case such area specific studies are available. At the same time, it is important to bring in elements of rainfall distribution and variability into sharpening the estimates of precipitation. Average rainfall data from nearby rain gauge stations may be considered for the Ground water assessment unit and the average rainfall may be estimated by the Theisen polygon or isohyet methods. Alternatively other advanced methods may also be used.

The threshold limit of minimum and maximum rainfall event which can induce recharge to the aquifer is to be considered while estimating ground water recharge using rainfall infiltration factor. The minimum threshold limit is in accordance with the relation shown in equation 16 and the maximum threshold limit is based on the premise that after a certain limit, the rate of storm rains are too high to infiltrate the ground and they will only contribute to surface runoff. It is suggested that 10% of Normal annual rainfall be taken as Minimum Rainfall Threshold and 3000 mm as Maximum Rainfall limit. While computing the rainfall recharge, 10% of the normal annual rainfall is to be deducted from the monsoon rainfall and balance rainfall would be considered for computation of rainfall recharge. The same recharge factor may be used for both monsoon and non-monsoon rainfall, with the condition that the recharge due to non-monsoon rainfall may be taken as zero, if the normal rainfall during the non-monsoon season is less than 10% of normal annual rainfall. In using the method based on the specified norms, recharge due to both monsoon and non-monsoon rainfall may be estimated for normal rainfall, based on recent 30 to 50 years of data.

3.3.5 Percent Deviation

After computing the rainfall recharge for normal monsoon season rainfall using the water table fluctuation method and Rainfall Infiltration Factor method these two estimates have to be compared with each other. A term, Percent Deviation (PD) which is the difference between the two expressed as a percentage of the former is computed as

$$PD = \frac{Rrf\ (normal, wtfm) - Rrf\ (normal, rifm)}{Rrf\ (normal, wtfm)} X100 \qquad \textbf{17}$$

where,

Rrf (normal, wlfm) = Rainfall recharge for normal monsoon season rainfall estimated by the water level fluctuation method

Rrf (normal, rifm) = Rainfall recharge for normal monsoon season rainfall estimated by the rainfall infiltration factor method

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

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

the rainfall infiltration factor method.

3.3.6 Recharge from other Sources

Recharge from other sources constitute recharges from canals, surface water irrigation, ground water irrigation, tanks and ponds and water conservation structures in command areas where as in non-command areas the recharge due to surface water irrigation, ground water irrigation, tanks and ponds and water conservation structures are possible.

Recharge from Canals: Recharge due to canals is to be estimated based on the following formula:

$$R_C = WA * SF * Days \quad (18)$$

Where:

R_C= Recharge from Canals WA=Wetted Area

SF= Seepage Factor

Days= Number of Canal Running Days.

3.3.7 Recharge from Surface Water Irrigation: Recharge due to applied surface water irrigation, either by means of canal outlets or by lift irrigation schemes is to be estimated based on the following formula:

$$R_{SWI} = AD*Days*RFF \quad (19)$$

Where:

R_{SWI} = Recharge due to applied surface water irrigation

AD= Average Discharge

Days=Number of days water is discharged to the Fields

RFF= Return Flow Factor

3.3.8 Recharge from Ground Water Irrigation: Recharge due to applied ground water irrigation is to be estimated based on the following formula:

$$R_{GWI} = GE_{IRR}*RFF \quad (20)$$

Where:

R_{GWI} = Recharge due to applied ground water irrigation GE_{IRR}= Ground Water Extraction for Irrigation

RFF= Return Flow Factor

3.3.9 Recharge due to Tanks and Ponds: Recharge due to Tanks and Ponds is to be estimated based on the following formula:

$$\mathbf{R_{TP} = AWSA * RF} \qquad \mathbf{21}$$

Where:

R_{TP} = Recharge due to Tanks and Ponds

AWSA= Average Water Spread Area

RF= Recharge Factor

3.3.10 Recharge due to Water Conservation Structures: Recharge due to Water Conservation Structures is to be estimated based on the following formula:

$$\mathbf{R_{WCS} = GS * RF} \qquad \mathbf{22}$$

Where:

R_{WCS} = Recharge due to Water Conservation Structures

GS= Gross Storage = Storage Capacity multiplied by number of fillings.

RF= Recharge Factor

3.4 Lateral flow along the aquifer system (Through flow)

In equations 6 and 7, if the area under consideration is a watershed, the lateral flow across boundaries can be considered as zero in case such estimates are not available. If there is inflow and outflow across the boundary, theoretically, the net inflow may be calculated using Darcy law, by delineating the inflow and outflow sections of the boundary. Besides such delineation, the calculation also requires estimate of transmissivity and hydraulic gradient across the inflow and outflow sections. These calculations are most conveniently done in a computer model. It is recommended to initiate regional scale modelling with well-defined flow boundaries. Once the modelling is complete, the lateral through flows (LF) across boundaries for any assessment unit can be obtained from the model. In case Lateral Flow is calculated using computer model, the same should be included in the water balance equation.

3.5 Base flow and Stream Recharge

If stream gauge stations are located in the assessment unit, the base flow and recharge from streams can be computed using Stream Hydrograph Separation method, Numerical Modelling and

Analytical solutions. If the assessment unit is a watershed, a single stream monitoring station at the mouth of the watershed can provide the required data for the calculation of base flow. Any other information on local-level base flows such as those collected by research centres, educational institutes or NGOs may also be used to improve the estimates on base flows.

Base flow separation methods can be divided into two main types: non-tracer-based and tracer-based separation methods. Non-tracer methods include Stream hydrograph analysis, water balance method and numerical ground water modelling techniques. Digital filters are available for separating base flow component of the stream hydrograph.

Hydro-chemical tracers and environmental isotope methods also use hydrograph separation techniques based on mass balance approach. Stream recharge can also be estimated using the above techniques.

Base flow assessment and Stream recharge should be carried out in consultation with Central Water Commission in order to avoid any duplicity in the estimation of total water availability in a river basin.

3.6 Vertical Flow from Hydraulically Connected Aquifers

This can be estimated provided aquifer geometry and aquifer parameters are known. This can be calculated using the Darcy's law if the hydraulic heads in both aquifers and the hydraulic conductivity and thickness of the aquitard separating both the aquifers are known. Ground water flow modelling is an important tool to estimate such flows. As envisaged in this report regional scale modelling studies will help in refining vertical flow estimates.

3.7 Evaporation and Transpiration

Evaporation can be estimated for the aquifer in the assessment unit if water levels in the aquifer are within the capillary zone. It is recommended to compute the evaporation through field studies. If field studies are not possible, for areas with water levels within 1.0 mbgl, evaporation can be estimated using the evaporation rates available for other adjoining areas. If depth to water level is more than 1.0m bgl, the evaporation losses from the aquifer should be taken as zero.

Transpiration through vegetation can be estimated if water levels in the aquifer are within the maximum root zone of the local vegetation. It is recommended to compute the transpiration through field studies. Even though it varies from place to place depending on type of soil and vegetation, in the absence of field studies the following estimation can be followed. If water levels are within 3.5m bgl, transpiration can be estimated using the transpiration rates available for other areas. If it is greater than 3.5m bgl, the transpiration should be taken as zero.

For estimating evapotranspiration, field tools like Lysimeters can be used to estimate actual evapotranspiration. Usually agricultural universities and IMD carry out lysimeter experiments and archive the evapotranspiration data. Remote sensing based techniques like SEBAL (Surface Energy Balance Algorithm for Land) can be used for estimation of actual evapotranspiration. Assessing offices may apply available lysimeter data or other techniques for estimation of evapotranspiration. In case where such data is not available, evapotranspiration losses can be empirically estimated from PET data provided by IMD.

3.8 Recharge during Monsoon Season

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

3.9 Recharge during Non-Monsoon Season

The rainfall recharge during non-monsoon season is estimated using Rainfall Infiltration factor Method only when the non-monsoon season rainfall is more than 10% of normal annual rainfall. The sum of non-monsoon rainfall recharge and the recharge from other sources and lateral and vertical flows into the sub unit and stream inflows during non-monsoon season is the total recharge during non-monsoon season for the sub unit. Similarly this is to be computed for all the sub units available in the assessment unit.

3.10 Total Annual Ground Water Recharge

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

3.11 Annual Extractable Ground Water Recharge (EGR)

The Total Annual Ground Water Recharge cannot be utilised for human consumption, since ecological commitments need to be fulfilled, before the extractable resources is defined. The National Water Policy, 2012 stresses that the ecological flow of rivers should be maintained. Therefore Ground water base flow contribution limited to the ecological flow of the river should be determined which will be deducted from Annual Ground Water Recharge to determine Annual

Extractable Ground Water Resources (EGR). The ecological flows of the rivers are to be determined in consultation with Central Water Commission and other concerned river basin agencies.

In case base flow contribution to the ecological flow of rivers is not determined then following assumption is to be followed. In the water level fluctuation method, a significant portion of base flow is already accounted for by taking the post monsoon water level one month after the end of rainfall. The base flow in the remaining non-monsoon period is likely to be small, especially in hard rock areas. In the assessment units, where river stage data are not available and neither the detailed data for quantitative assessment of the natural discharge are available, present practice (GEC 1997) of allocation of unaccountable natural discharges to 5% or 10% of annual recharge may be retained. If the rainfall recharge is assessed using water level fluctuation method this will be 5% of the annual recharge and if it is assessed using rainfall infiltration factor method, it will be 10% of the annual recharge. The balance will account for Annual Extractable Ground Water Resources (EGR).

3.12 Estimation of Ground Water Extraction

Groundwater draft or extraction is to be assessed as follows.

$$\mathbf{GE_{ALL} = GE_{IRR} + GE_{DOM} + GE_{IND}} \qquad \mathbf{23}$$

Where,

GE_{ALL}=Ground water extraction for all uses

GE_{IRR}=Ground water extraction for irrigation

GE_{DOM} =Ground water extraction for domestic uses

GE_{IND} = Ground water extraction for industrial uses

3.12.1 Ground Water Extraction for Irrigation (GE_{IRR}):

The single largest component of the groundwater balance equation in large regions of India is the groundwater extraction and, the precise estimation of ground water extraction is riddled with uncertainties. Therefore it is recommended that at least two of the three methods for estimation of ground water extraction may be employed in each assessment sub unit. The methods for estimation of ground water extraction are as follows.

Unit Draft Method: -In this method, season-wise unit draft of each type of well in an assessment unit is estimated. The unit draft of different types (eg. Dug well, Dug cum bore well, shallow tube well, deep tube well, bore well etc.) is multiplied with the number of wells of that particular type to obtain season-wise ground water extraction by that particular structure. This method is being widely practiced in the country. There are several sources which maintain records on well census. These include Minor Irrigation Census conducted by MoWR, RD, GR, Government of India, and data maintained at the Tehsil level. It is recommended that a single source of well census should be maintained for resources computation at all India level. Minor Irrigation Census of MoWR, RD, GR would be the preferred option.

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

Power Consumption Method: –Ground water extraction for unit power consumption (electric) is determined. Extraction per unit power consumption is then multiplied with number of units of power consumed for agricultural pump sets to obtain total ground water extraction for irrigation. Direct metering of ground water draft in select irrigation and domestic wells and in all wells established for industrial purpose may be initiated. Enforcing fitting of water meters and recording draft in all govt. funded wells could also be a feasible option. The unit drafts obtained from these sample surveys can be used to assess ground water extraction. In addition to metering, dedicated field sample surveys (instantaneous discharge measurements) can also be taken up.

3.12.2 Ground Water Extraction for Domestic Use (GE_{DOM}):

There are several methods for estimation of extraction for domestic use (GE_{DOM}). Some of the commonly adopted methods are described here.

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

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

$$GE_{DOM} = \text{Population X Consumptive Requirement X Lg}$$

Where,

Lg = Fractional Load on Ground Water for Domestic Water Supply

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

3.12.3 Ground water Extraction for Industrial use (GE_{IND}): The commonly adopted methods for estimating the extraction for industrial use are as below:

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

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

$$GE_{IND} = \text{Number of industrial units} \times \text{Unit Water Consumption} \times Lg \qquad \mathbf{25}$$

Where,

Lg = Fractional load on ground water for industrial water supply

The load on Ground water for Industrial water supply can be obtained from water supply agencies in the Industrial belt. Other important sources of data on ground water extraction for industrial uses are - Central Ground Water Authority, State Ground Water Authority, National Green Tribunal and other Environmental Regulatory Authorities.

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

3.13 Stage of Ground Water Extraction

The stage of ground water extraction is defined by,

$$\text{Stage of Ground Water Extraction}(\%) = \frac{\text{Existing gross ground water extraction for all uses}}{\text{Annual Extractable Ground water Resources}} \text{ X } 100 \qquad \mathbf{26}$$

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

3.14 Validation of Stage of Ground Water Extraction

The assessment based on the stage of ground water extraction has inherent uncertainties. The estimation of ground water extraction is likely to be associated with considerable uncertainties as it is based on indirect assessment using factors such as electricity consumption, well census and area irrigated from ground water. The denominator in equation 26, namely Annual Extractable Ground Water Resources also has uncertainties due to limitations in the assessment methodology, as well as uncertainties in the data. In view of this, it is desirable to validate the „Stage of Ground Water Extraction" with long term trend of ground water levels.

Long term Water Level trends are to be prepared for a minimum period of 10 years for both pre-monsoon and post-monsoon period. The Water level Trend would be average water level trend as obtained from the different observation wells in the area.

In interpreting the long term trend of ground water levels, the following points may be kept in view. If the pre and post monsoon water levels show a fairly stable trend, it does not necessarily mean that there is no scope for further ground water development. Such a trend indicates that there is a balance between recharge, extraction and natural discharge in the unit. However, further ground water development may be possible, which may result in a new stable trend at a lower ground water level with associated reduced natural discharge.

If the ground water resource assessment and the trend of long term water levels contradict each other, this anomalous situation requires a review of the ground water resource computation, as well as the reliability of water level data. The mismatch conditions are enumerated below.

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

In case, the category does not match with the water level trend given above, a 'reassessment" should be attempted. If the mismatch persists even after reassessment, the sub unit may be categorized based on Stage of Ground Water Extraction of the reassessment. However, the sub unit should be flagged for strengthening of observation well network and parameter estimation.

3.15 Categorization of Assessment Units

As emphasized in the National Water Policy, 2012, a convergence of Quantity and Quality of ground water resources is required while assessing the ground water status in an assessment unit. Therefore, it is recommended to separate estimation of resources where water quality is beyond permissible limits for the parameter salinity.

3.15.1 Categorization of Assessment Units Based on Quantity:

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

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

In addition to this Category every assessment sub unit should be tagged with potentiality tag indicating its ground water potentiality viz. Poor Potential (Unit Recharge <0.025m), Moderately Potential (Unit Recharge in between 0.025 and 0.15m) and Highly Potential (Unit Recharge > 0.15m)

3.15.2 Categorization of Assessment Units Based on Quality

GEC 1997 proposed categorization of assessment units based on ground water extraction only. To adequately inform management decisions, quality of ground water is also an essential criterion. The Committee deliberated upon the possible ways of categorizing the assessment units based on ground water quality in the assessment units. It was realized that based on the available water quality monitoring mechanism and available database on ground water quality it may not be possible to categorize the assessment units in terms of the extent of quality hazard. As a trade-off, the Committee recommends that each assessment unit, in addition to the Quantity based categorization (safe, semi-critical, critical and over-exploited) should bear a quality hazard identifier. Such quality hazards are to be based on available ground water monitoring data of State Ground Water Departments and/or Central Ground Water Board. If any of the three quality hazards in terms of Arsenic, Fluoride and Salinity are encountered in the assessment sub unit in mappable units, the assessment sub unit may be tagged with the particular Quality hazard.

3.16 Allocation of Ground Water Resource for Utilization

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

$$\textbf{Alloc} = \textbf{22 X N X } \mathbf{L_g} \textbf{ mm per year} \qquad \textbf{27}$$

Where

Alloc= Allocation for domestic water requirement

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

L_g = fractional load on ground water for domestic and industrial water supply (<_ 1.0)

In deriving equation 27, it is assumed that the requirement of water for domestic use is 60 lpd per head. The equation can be suitably modified in case per capita requirement is different. If by chance, the estimation of projected allocation for future domestic needs is less than the current domestic extraction due to any reason, the allocation must be equal to the present day extraction. It can never be less than the present day extraction as it is unrealistic.

3.17 Net Annual Ground Water Availability for Future Use

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

3.18 Additional Potential Resources under Specific Conditions

3.18.1 Potential Resource Due to Spring Discharge: Spring discharge constitutes an additional source of ground water in hilly areas which emerges at the places where ground water level cuts the surface topography. The spring discharge is equal to the ground water recharge minus the outflow through evaporation and evapotranspiration and vertical and lateral sub- surface flow. Thus Spring Discharge is a form of "Annual Extractable Ground Water Recharge". It is a renewable resource, though not to be used for Categorization. Spring discharge measurement is to be carried out by volumetric measurement of discharge of the springs. Spring discharges multiplied with time in days of each season will give the quantum of spring resources available during that season. The committee recommends that in hilly areas with substantial potential of spring discharges, the discharge measurement should be made at least 4 times a year in parity with the existing water level monitoring schedule.

Potential ground water resource due to springs = Q x No of days **28**

Where

Q = Spring Discharge

No of days= No of days spring yields.

3.18.2 Potential Resource in Waterlogged and Shallow Water Table Areas:

The quantum of water available for development is usually restricted to long term average recharge or in other words "Dynamic Resources". But the resource calculated by water level fluctuation approach is likely to lead to under-estimation of recharge in areas with shallow water table, particularly in discharge areas of sub-basin/ watershed/ block/ taluka and waterlogged areas. In such cases rejected recharge may be substantial and water level fluctuations are subdued resulting in under- estimation of recharge component. It is therefore, desirable that the ground water reservoir should be drawn to optimum limit before the onset of monsoon, to provide adequate scope for its recharge during the following monsoon period.

In the area where the ground water level is less than 5m below ground level or in waterlogged areas, the resources up to 5m below ground level are potential and would be available for development in addition to the annual recharge in the area. It is therefore recommended that in such areas, ground water resources may be estimated up to 5m bgl only assuming that where water level is less than 5m bgl, the same could be depressed by pumping to create space to receive recharge from natural resources. It is further evident that these potential recharge would be available mostly in the shallow water table areas which would have to be demarcated in each sub-basin/ watershed/ block/ taluka/ mandal.

The computation of potential resource to ground water reservoir can be done by adopting the following equation:

Potential ground water resource in shallow water table areas = (5-D) x A x S_Y 29

Where

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

A= Area of shallow water table Zone

S_Y = Specific Yield

The planning of future minor irrigation works in the waterlogged and shallow water table areas as indicated above should be done in such a way that there should be no long term adverse effects of lowering of water table up to 5m and the water level does not decline much below 5m in such areas. The behavior of water table in the adjoining area which is not water logged should be taken as a bench mark for development purposes.

This potential recharge to ground water is available only after depression of water level up to 5m bgl. This is not an annual resource and should be recommended for development on a very cautious approach so that it does not adversely affect the ground water potentials in the overall area.

3.18.3 Potential Resource in Flood Prone Areas: Ground water recharge from a flood plain is mainly the function of the following parameters-

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

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

Potential ground water resource in Flood Prone Areas = 1.4 x N x A/1000 30

Where

N = No of Days Water is Retained in the Area A = Flood Prone Area

3.19 Apportioning of Ground Water Assessment from Watershed to Development Unit:

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

A block may comprise of one or more watersheds, in part or full. First, the ground water assessment in the subareas, command, non-command and poor ground water quality areas of the watershed may be converted into depth unit (mm), by dividing the annual recharge by the respective area. The contribution of this subarea of the watershed to the block, is now calculated by multiplying this depth with the area in the block occupied by this sub-area. This procedure must be followed to calculate the contribution from the sub-areas of all watersheds occurring in the block, to work out the total ground water resource of the block.

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

3.20 Assessment of In-Storage Ground Water Resources or Static Ground Water Resources

The quantum of ground water available for development is usually restricted to long term average recharge or dynamic resources. Presently there is no fine demarcation to distinguish the dynamic resources from the static resources. While water table hydrograph could be an indicator to distinguish dynamic resources, at times it is difficult when water tables are deep. For sustainable ground water development, it is necessary to restrict it to the dynamic resources. Static or in-storage ground water resources could be considered for development during exigencies that also for drinking water purposes. It is also recommended that no irrigation development schemes based on static or in-storage ground water resources be taken up at this stage.

Assessment of In-storage ground water resources has assumed greater significance in the present context, when an estimation of Storage Depletion needs to be carried out in Over- exploited areas. Recently Remote Sensing techniques have been used in GRACE studies, to estimate the depletion of Ground Water Resources in North West India. Such estimation presents larger scale scenario. More precise estimation of ground water depletion in the over-exploited area based on actual field data can be obtained by estimating the Change in In-storage during successive assessments. Thus In-storage computation is necessary not only for estimation of emergency storage available for utilization in case of natural extremities (like drought) but also for an assessment of storage depletion in over-exploited areas for sensitising stakeholders about the damage done to the environment.

The computation of the static or in-storage ground water resources may be done after delineating the aquifer thickness and specific yield of the aquifer material. The computations can be done as follows:-

$$\mathbf{SGWR = A * (Z_2 - Z_1) * S_Y} \qquad \mathbf{31}$$

Where,

SGWR = Static or in-storage Ground Water Resources

A = Area of the Assessment Unit

Z_2 = Bottom of Unconfined Aquifer

Z_1 = Pre-monsoon water level

S_Y = Specific Yield in the In storage Zone

3.21 Assessment of Total Ground Water Availability in Unconfined Aquifer

The sum of Annual Exploitable Ground Water Recharge and the In storage ground water resources of an unconfined aquifer is the Total Ground Water Availability of that aquifer.

3.22 Ground Water Assessment of Confined Aquifer System

Assessment of ground water resources of confined aquifers assumes crucial importance, since over-exploitation of these aquifers may lead to far more detrimental consequences than to those of shallow unconfined aquifers. If the piezometric surface of the confined aquifer is lowered below the upper confining layer so that desaturation of the aquifer occurs, the coefficient of storage is no longer related to the elasticity of the aquifer but to its specific yield. In view of the small amounts of water released from storage in the confined aquifers, large scale pumpage from confined aquifers may cause decline in piezometric levels amounting to over a hundred meter and subsidence of land surface posing serious geotectonical problems.

It is recommended to use ground water storage approach to assess the ground water resources of the confined aquifers. The co-efficient of storage or storativity of an aquifer is defined as the volume of water it releases or takes into storage per unit surface area of the aquifer per unit change in head. Hence the quantity of water added to or released from the aquifer (V) can be calculated as follows

$$\mathbf{\Delta V = S\ \Delta h} \qquad \mathbf{32}$$

If the areal extent of the confined aquifer is A then the total quantity of water added to or released from the entire aquifer is

$$Q = A\,\Delta V = SA\,\Delta h \qquad 33$$

Where

Q = Quantity of water confined aquifer can release (m^3)

S = Storativity

A = Areal extent of the confined aquifer (m^2)

Δh = Change in Piezometric head (m)

Most of the storage in confined aquifer is associated with compressibility of the aquifer matrix and compressibility of water. Once the piezometric head reaches below the top confining bed, it behaves like an unconfined aquifer and directly dewaters the aquifer and there is a possibility of damage to the aquifer as well as topography. Hence ground water potential of a confined aquifer is nothing but the water available for use without damaging the aquifer. Hence the resources available under pressure are only considered as the ground water potential. The quantity of water released in confined aquifer due to change in pressure can be computed between piezometric head (h_t) at any given time 't' and the bottom of the top confining layer (h_o) by using the following equation.

$$Q_p = SA\Delta h = SA\,(h_t - h_0) \qquad 34$$

If any development activity is started in the confined aquifer, then there is a need to assess the dynamic as well as in storage resources of the confined aquifer. To assess the ground water resources of the confined aquifer, there is a need to have sufficient number of observation wells tapping exclusively that particular aquifer and proper monitoring of the piezometric heads is also needed.

3.22.1 Dynamic Ground Water Resources of Confined Aquifer

To assess the dynamic ground water resources the following equation can be used with the pre and post monsoon piezometric heads of the particular aquifer.

$$Q_D = SA\Delta h = SA\,(h_{POST} - h_{PRE}) \qquad 35$$

Where

Q_D = Dynamic Ground Water Resource of Confined Aquifer (m^3)

S = Storativity

A = Areal extent of the confined aquifer (m^2)

Δh = Change in Piezometric head (m)

h_{post} =Piezometric head during post-monsoon period(m amsl)

h_{PRE} = Piezometric head during pre-monsoon period(m amsl)

3.22.2 In storage Ground Water Resources of Confined Aquifer

For assessing the in storage ground water potential of a confined aquifer, one has to compute the resources between the pre monsoon piezometric head and bottom of the top confining layer. That can be assessed using the following formula:

$$Q_I = SA\Delta h = SA\,(h_{PRE} - h_0) \qquad 36$$

Where

Q_I =In storage Ground Water Resource of Confined Aquifer (m^3)

S = Storativity

A = Areal extent of the confined aquifer (m^2)

Δh = Change in Piezometric head (m)

h_0 = Bottom level of the top confining layer (m amsl)

h_{PRE} = Piezometric head during pre-monsoon period(m amsl)

If the confined aquifer is not being exploited for any purpose, the dynamic and static resources of the confined aquifer need not be estimated separately. Instead the in storage of the aquifer can be computed using the following formula.

$$Q_p = SA\Delta h = SA\,(h_{POST} - h_0) \qquad 37$$

Where

Q_p = In storage Ground Water Resource of the confined aquifer or the Quantity of water under pressure (m^3)

S = Storativity

A = Areal extent of the confined aquifer (m^2)

Δh = Change in Piezometric head (m)

H_{POST} =Piezometric head during post-monsoon period (m amsl) h_0 =
Bottom of the Top Confining Layer (m amsl)

The calculated resource includes small amount of dynamic resource of the confined aquifer also, which replenishes every year. But to make it simpler this was also computed as part of the static or in-storage resource of the confined aquifer.

CHAPTER 4

PROCEDURE FOLLOWED IN THE PRESENT ASSESSMENT INCLUDING ASSUMPTIONS

a) METHODOLOGY

Estimation of Ground Water resources has been carried out based on the methodology recommended by the Ground Water Estimation Committee (GEC-15). Salient features of the methodology and norms adopted in this report are given below.

i) Ground Water Computations:

The rainfall recharge computation presented in this report is for the year 2021-22, whereas extraction calculations have been done up to March 2022. Himachal Pradesh experiences rainfall caused by SW monsoon, which generally commences by second week of June. The monsoon period has been taken as 4 months i. e. from June to September and 8 months (October to May) have been considered as non-monsoon period. Data for ground water extraction has been collected by the Ground Water Organisation, Department of Irrigation and Public Health and rainfall data from Indian Meteorological Deptt.

ii) Unit of Computation:

The unit of computation proposed in the methodology is 'watershed'. But in Himachal Pradesh due to hilly terrain and local watersheds, it is not possible to compute water resources by taking watershed as a unit. Only valley areas have been taken for computation of water resources **(Fig-1)**. The details of the Ground water Administrative units and Assessment units of Himachal Pradesh are given in **Fig-1**.

iii) Gross Ground Water Extraction:

Ground Water extraction for various uses in valley areas have been estimated according to the methodology. Data variables used in dynamic ground water resources of Himachal Pradesh are rainfall, water level fluctuations and number of ground water abstraction structures and are given in **Annexure VI.** Parameters used in the assessment of dynamic ground water resources of the state indicating the value of Specific yield, rainfall infiltration factor and season wise unit extraction is given in **Annexure VIII** . The details of ground water extraction are given as below.

iii a). Domestic Extraction: Ground Water extraction for domestic use has been estimated based on the water supply schemes of Jal Shakti Vibahg for the year 2021-22. Minor irrigation census data of dugwells has also been incorporated in domestic extraction.

iii b). Irrigation Extraction:

The main structure constructed for irrigation are tubewells, percolation wells and dugwells constructed by private individuals, Jal Shakti Vibahg- Himachal Pradesh and CGWB. The valley wise data for these structures was made available by GWO, Jal Shakti Vibhag for the year 2021-22.

iii c). Industrial Extraction:

Ground water in the state is mostly used for domestic and irrigation purposes. However ground water extraction for industrial use for Indora valley, Paonta valley, Kala Amb valley, Nalagarh valley, Una valley and Hum valley has been included while assessing the ground water extraction.

iii d). Allocation for Domestic and Industrial Requirement for the Year 2025

Ground Water extraction for domestic use has been estimated based on the population of valley areas only. The population figures of the 2011 census have been projected to the year of assessment considering the decadal growth rate up to the year 2025 as given in **Annexure-IX.** Domestic extraction has been calculated by taking consumption of 70 lpd per head as per Govt. of Himachal Pradesh norms.

CHAPTER 5

COMPUTATION OF GROUND WATER RESOURCES ESTIMATION IN HIMACHAL PRADESH

a) SALIENT FEATURES OF THE DYNAMIC GROUND WATER RESOURCE ASSESSMENT

- Estimation of Ground Water resources has been carried out based on the methodology recommended by the Ground Water Estimation Committee (GEC-2015) through IN-GRES portal.
- Type of assessment unit is valley.
- There are ten assessment units in the state.
- Rainfall data used for the computation of the recharge of the year 2021-22 *(Source: IMD).*
- Water level data used for the year 2011 to 2021 of Ground Water Monitoring Stations of CGWB & shallow piezometers of Jal Shakti Vibhag, Govt. of Himachal Pradesh.
- Census 2011 data is used for the computation of allocation for domestic and industrial requirement.
- Year of projection for allocation for domestic water supply is up to 2025.

b) ASSESSMENT UNIT-WISE METHOD ADOPTED FOR COMPUTING RAINFALL RECHARGE DURING MONSOON SEASON (WLF/RIF)

i) Recharge from other Sources:

The main irrigation structures in the state are dugwells, tubewells, percolation wells and ponds. As the average water levels in all the major valley areas ranges from 0 to 10 m and considering the type of crop as non paddy, the recharge has been taken as 25% of the irrigation extraction. In Hum valley the water levels are deeper (>100m), therefore considering the type of crop as non paddy the recharge has been taken as 5% of irrigation extraction as per GEC 2015. Recharge from ground water irrigation, surface water bodies and surface water irrigation is given in **Annexure-IX.**

Recharge from various sources during monsoon and non monsoon season has been given in **Annexure-IX.**

ii). Recharge from Monsoon Rainfall:

Recharge has been computed using both water level fluctuation method as well as rainfall infiltration factor method. The Annual rainfall is given in **Annexure VII.**

Recharge computation by water level fluctuation method:-

Recharge from rainfall using water level fluctuation method has been estimated using the following relation

$$\mathbf{Rwtf = h \times Sy \times A + D_G - R_C - R_{SW} - R_T - R_{GW} - R_{WC}}$$

Whereas **Rwtf** = possible recharge by water table fluctuation method,

h = rise in water level in the monsoon season

A = area for computation of recharge

Sy = specific yield

D_G = Gross Ground Water extraction for monsoon season

R_C= Recharge due to seepage from canals during monsoon season

R_{SW}= Recharge from surface water irrigation during monsoon season

R_T= Recharge from tanks & ponds during monsoon season

R_{GW}= Recharge from ground water irrigation during monsoon season

R_{WC}= Recharge from water conservation structures during monsoon season

The specific yield value in case of valley fill deposits which includes boulders, cobbles, gravels, sand etc. has been taken as **0.16.**

Rainfall recharge computed by this method has been normalized on the normal monsoon rainfall using the procedure recommended by GEC-15 using the relation:

Rrf (Normal wtfm)= NMR X Rwtf / AMR

Where,

Rrf (Normal wtfm) = Normalised rainfall recharge

NMR = Normal Monsoon Rainfall

Rwtf =Computed Rainfall Recharge

AMR = Actual Monsoon Rainfall in the year of assessment

For computation of recharge by WTF method, the water level data of Ground Water Monitoring Stations of CGWB & shallow piezometers of Jal Shakti Vibhag, Himachal Pradesh of 2019-20 has been considered.

iii) Recharge from Non Monsoon Rainfall:

Recharge from rainfall during non-monsoon period has been computed by Rainfall Infiltration Factor Method described above.

Recharge from sources other than rainfall: The other sources which contribute towards recharge of ground water resources are seepage from canal, return flow from surface water irrigation, recharge from tanks and ponds, recharge from water conservation structures. Recharge from rainfall during monsoon and non monsoon season has been given in **Annexure IX**.

iv). Recharge Computation by Rainfall Infiltration Factor Method during Monsoon:

Rainfall recharge during monsoon period have been computed using, normal monsoon rainfall (Indian Meteorological Deptt.). The rainfall infiltration factor for valley fill have been taken as **0.22** as recommended by GEC 2015.

The equation used for computation of recharge is

$$\mathbf{R_{rf}\,(Normal\ rifm) = NMR \times A \times RIF}$$

Where as $\mathbf{R_{rf}}$ (Normal rifm)= recharge from rainfall by rainfall infiltration factor method, **NMR** = Normal Monsoon Rainfall, **A** = Area of valley in hectare, **RIF** = Rainfall Infiltration Factor

v). Percent Deviation

The results from the two methods (water level fluctuation and rainfall infiltration method) have been compared using percent deviation using the following relation:

P. D. = 100x {R $_{rf}$ (Normal wtfm) - R $_{rf}$ (Normal rifm)}/ R $_{rf}$ (Normal rifm)

Where, **P. D.** = Percent deviation, **R $_{rf}$ (Normal wtfm)** = Recharge from (Normalised rainfall as computed by water table fluctuation method), **R $_{rf}$ (Normal rifm)** = Recharge from (Normalised rainfall as computed by Rainfall infiltration factor method).

After computation of the percent deviation the following criteria as recommended by the methodology (GEC 2015) has been adopted to compute the recharge from rainfall:

i) if P. D ≥ -20 & $\leq +20$ then R_{rf} (Normal) = R_{rf} (Normal wtfm)

ii)if P. D. < -20 then R_{rf} (Normal) = 0.8 X R_{rf} (Normal rifm)

iii)if P. D. > 20 then R_{rf} (Normal) = 1.2 X R_{rf} (Normal rifm)

The following **Annexure-VI** gives the value of Percent Deviation along with the Normalized Monsoon recharge from the rainfall.

vi). Total Annual Recharge:

Total annual recharge was computed as arithmetic sum of recharge from Monsoon, Non-Monsoon Rainfall & recharge from other sources during monsoon and non monsoon season and is given in **Annexure IX**.

c). TOTAL GROUND WATER RESOURCES OF HIMACHAL PRADESH

i). Net Annual Ground Water Extractability:

Net annual ground water Extractability has been computed by deducting the unaccounted natural discharge. As per GEC '15 methodologies, an allowance is kept for natural discharge during non-monsoon season by deducting 5% of annual replenishable ground water resource and adding the

Additional potential recharge. Total Annual Ground Water Recharge, provision for Natural Discharges and Net Annual Ground Water Availability is given in **Annexure IX**.

ii). Stage of Ground Water Extraction:

Stage of ground water development has been computed using the relation:

$$\textbf{Stage of ground water Extraction} = \frac{\textbf{100 x Gross ground water extraction for all uses}(D_G)}{\textbf{Annual extractable ground water resources}}$$

The stage of ground water development and pre and post monsoon water level trend of all assessment units is given in **Annexure X & XI**.

As per the current assessment, all the ten assessment units in Hiamchal Pradesh falls under the safe category. The valley wise stage of Ground water extraction and categorisation is given in ANNEXURE X

iii). Net annual ground water extractability for future use:

Net ground water availability for future use has been computed using the relation

$$R = A - (B + C)$$

Where, R = Net annual ground water extractable for future irrigation use

A = Net available ground water resource

B = Gross ground water extraction for domestic and irrigation

C = Allocation for domestic and industrial water supply

Net Ground Water extractability, existing Gross Ground Water Extraction for Irrigation and existing ground water extraction for domestic and industrial water supply is given in Annexure IX. Existing Ground Water Extraction for all uses, Provision for domestic and Industrial requirement supply up to 2025 and Net Ground Water Availability for Future irrigation development is given in **Annexure IX**. Stage of Ground Water Extraction of all Assessment units is given in **Annexure IX**.

e) COMPARISON WITH EARLIER GROUND WATER RESOURCE ESTIMATION

Ground Water Resource Estimation of Himachal Pradesh was carried out earlier as per GEC-97 Methodology as on March 2004, March 2009, March 2011 and in March 2013. GEC-15 adopted for Ground Water Resource Estimation from March 2017 and continued in March 2020 and March 2022 now as on March 2023.

Estimation of ground water resources on watershed basis as recommended in GEC-97 was not applicable to the state of Himachal Pradesh due to hilly terrain with intermountain valleys. In Ground Water Resource estimation as on March, 2013, eight valleys were considered as the Ground Water Resource Assessment units. The valley wise Area, Net Ground Water availability, Existing Gross Ground Water Extraction, Net Ground Water Availability for Future Irrigation Development and Stage of Ground Water Extraction is given in **Table below**

S. No.	Name of Valley	Area (ha)	Net Ground Water Extractability (ham)	Existing Gross Ground Water Extraction for all uses (ham)	Net Ground Water Extractability for future Irrigation Development (ham)	Stage of Ground Water Extraction (%)
1	Indora	26545	10038.64	5263.72	4774.92	**52.43**
2	Nurpur	23775	7035.39	3021.53	4013.86	**42.95**
3	Balh	9500	2825.59	912.77	1912.82	**32.30**
4	Paonta	15627	7702.97	2174.46	5528.51	**28.23**
5	Kala Amb	250	96.58	545.32	-448.74	**564.63**
6	Nalagarh	23849	7941.86	4332.31	3609.55	**54.55**
7	Una	49300	16903.11	20966.28	-4063.17	**124.04**
8	Hum	2200	563.45	561.04	-16.05	**99.57**
Total		**151046**	**53107.59**	**37777.43**	**15311.70**	**71.13**

Table 6 : Stage of Ground Water Extraction as on March 2011

In Ground water resource estimation as on March, 2013, actual extraction data as on March 2013 was used for estimation. Resource estimation is carried out for all the eight valleys. For the calculation of Ground water recharge from other sources in Una valley, the surface water irrigation from Babhohr Sahib lift irrigation scheme, ponds & water conservation structures and ponds in Hum valley are added with the recharge from ground water irrigation. The water conservation structures constructed in Una valley by Swan project has also been considered for ground water recharge. Stage of Ground Water Extraction as on March 2013 is given in **Table below.**

S. No.	Name of Valley	Area (ha)	Net Ground Water Extractability (ham)	Existing Gross Ground Water Extraction for all uses (ham)	Net Ground Water Extractability for future Irrigation Development (ham)	Stage of Ground Water Extraction (%)
1	Indora	26545	10892.94	7523.32	4942.65	**69.07**
2	Nurpur	23775	11958.75	3537.92	9505.56	**29.58**
3	Balh	9500	2605.08	898.87	1557.34	**34.50**
4	Paonta	15627	6219.27	887.14	4691.10	**14.26**
5	Kala Amb	250	82.01	336.95	-8.05	**410.86**
6	Nalagarh	23849	8189.74	3899.04	4661.07	**47.61**
7	Una	49300	12844.41	9559.66	4503.63	**74.43**
8	Hum	2200	597.45	539.46	-33.01	**90.29**
Total		**151046**	**53389.65**	**27182.36**	**29820.29**	**50.91**

Table 7: Stage of Ground Water Extraction as on March 2013

S. No.	Name of Valley	Area (ha)	Net Ground Water Extractability (ham)	Existing Gross Ground Water Extraction for all uses (ham)	Net Ground Water Extractability for future Irrigation Development (ham)	Stage of Ground Water Extraction (%)
1	Indora	26545	11198.502	13223.66	0	**118**
2	Nurpur	23775	12089.592	4068.23	7150.58	**34**
3	Balh	9500	2482.2	889.83	5074.1	**36**
4	Paonta	15627	6123.258	1323.95	1143.51	**22**
5	Kala Amb	250	117.576	411.61	0	**350**
6	Nalagarh	23849	7683.858	8515.07	0	**111**
7	Una	49300	7100.937	10480.11	0	**148**
8	Hum	2200	582.012	411.09	0	**71**
Total		**151046**	**47377.935**	**39323.55**	**13368.19**	**74**

Table 8: Stage of Ground Water Extraction as on March 2017

S. No	Name of Valley	Area (ha)	Net Ground Water Extractability (ham)	Existing Gross Ground Water Extraction for all uses (ham)	Net Ground Water Extractability for future Irrigation Development (ham)	Stage of Ground Water Extraction (%)
1	Nurpur Indora Valley	102400	34498.55	10133.34	24365.21	29.37
2	Dharmshala Palampur Valley	45200	16527.93	2283.47	14254.24	13.76
3	Balh Valley	10700	2163.93	895.65	1268.28	41.39
4	Chauntra Valley	5200	1268.76	130.21	1051.57	17.12
5	Paonta Valley	27600	6937.82	1548.74	5381.07	22.44
6	Kala Amb Valley	8200	1539.48	423.54	1115.94	27.51
7	Nalagarh Valley	33600	14629.61	8548.68	6757.66	58.43
8	Una Valley (Satluj Basin)	104500	18037.76	11001.96	5543.11	60.99
9	Una Valley (Beas Basin)	6500	820.30	257.20	563.10	31.35
10	Hum Valley	2900	690.49	401.34	289.14	58.12
Total		**151046**	**97114.63**	**35709.33**	**60589.32**	**36.77**

Table 9: Stage of Ground Water Extraction as on March 2020

S. No	Name of Valley	Area (ha)	Net Ground Water Extractability (ham)	Existing Gross Ground Water Extraction for all uses (ham)	Net Ground Water Extractability for future Irrigation Development (ham)	Stage of Ground Water Extraction (%)
1	Nurpur Indora Valley	102400	31640.6	8651.56	22989	27.34
2	Dharmshala Palampur Valley	45200	13845.8	2711.88	11133.9	19.59
3	Balh Valley	10700	2374.45	895.6	1478.8	37.72
4	Chauntra Valley	5200	889.14	217.18	671.96	24.43
5	Paonta Valley	27600	6230.68	1556.8	4673.93	24.99
6	Kala Amb Valley	8200	1804.13	423.55	1380.59	23.48
7	Nalagarh Valley	33600	15311.2	8766.03	6757.66	57.25
8	Una Valley (Satluj Basin)	104500	16276.6	11349.1	4927.44	69.73
9	Una Valley (Beas Basin)	6500	713.39	247.17	466.22	34.65
10	Hum Valley	2900	706.37	409.14	297.23	57.92
Total		**346800**	**89792.36**	**35228.01**	**54776.73**	**39.23**

Table 10: Stage of Ground Water Extraction as on March 2022

S. No	Name of Valley	Area (ha)	Net Ground Water Extractability (ham)	Existing Gross Ground Water Extraction for all uses (ham)	Net Ground Water Extractability for future Irrigation Development (ham)	Stage of Ground Water Extraction (%)
1	Nurpur Indora Valley	102400	37453.32	8660.27	28793.05	23.12
2	Dharmshala Palampur Valley	45200	12324.36	2922.60	9401.76	23.71
3	Balh Valley	10700	2803.74	895.65	1908.09	31.94
4	Chauntra Valley	5200	5007.79	217.18	4790.60	4.34
5	Paonta Valley	27600	7544.93	1556.75	5988.18	20.63
6	Kala Amb Valley	8200	1523.11	423.58	1099.53	27.81
7	Nalagarh Valley	33600	15381.31	8781.84	6599.47	57.09
8	Una Valley (Satluj Basin)	104500	17736.04	11345.48	6390.56	63.97
9	Una Valley (Beas Basin)	6500	950.87	247.17	703.70	25.99
10	Hum Valley	2900	727.66	409.70	317.96	56.30
Total		**346800**	**101453.1**	**35460.22**	**65992.9**	**34.95**

Table 11: Stage of Ground Water Extraction as on March 2023

Comparison of Net Ground Water Extractable for future irrigation and Stage of Ground Water Extraction as on March 2011, 2013, 2017, 2020, 2022 & 2023 is given in **Table-13.**

Name of Valley	Area (ha)	Net Ground Water Extractability for future Irrigation Development (ham) **(2011)**	Stage of Ground Water Extraction (%) **(2011)**	Net Ground Water Extractability for future Irrigation Development (ham) **(2013)**	Stage of Ground Water Extraction (%) **(2013)**	Net Ground Water Extractability for future Irrigation Development (ham) **(2017)**	Stage of Ground Water Extraction (%) **(2017)**	Net Ground Water Extractability for future Irrigation Development (ham) **(2020)**	Stage of Ground Water Extraction (%) **(2020)**	Net Ground Water Extractability for future Irrigation Development (ham) **(2022)**	Stage of Ground Water Extraction (%) **(2022)**	Net Ground Water Extractability for future Irrigation Development (ham) **(2023)**	Stage of Ground Water Extraction (%) **(2023)**
Indora	26545	4774.92	52.43	4942.65	69.07	00	118	24365.21	29.27	22989	27.34	28793.05	23.12
Nurpur	23775	4013.86	42.95	9505.56	29.58	7150.58	34						
Balh	9500	1912.82	32.30	1557.34	34.50	5074.10	36	1268.28	41.39	1478.8	37.72	9401.76	23.71
Paonta	15627	5528.51	28.23	4691.10	14.26	1143.51	22	5381.07	22.44	4673.93	24.99	1908.09	31.94
Kala Amb	250	-448.74	564.63	-8.05	410.86	00	350	1115.94	27.51	1380.59	23.48	4790.60	4.34
Nalagarh	23849	3609.55	54.55	4661.07	47.61	00	111	6757.66	58.43	6757.66	57.25	5988.18	20.63
Una valley Sutlej Basin	49300	-4063.17	124.04	4503.63	74.43	00	148	5543.11	62.81	4927.44	69.73	1099.53	27.81
Hum	2200	-16.05	99.57	-33.01	90.29	00	71	289.14	58.12	297.23	57.92	6599.47	57.09
Chauntra Valley	--	--	--	--	--	--	--	1051.57	17.12	671.96	24.43	6390.56	63.97
Dharmshala Palampur Valley	--	--	--	--	--	--	--	14254.24	13.76	11133.9	19.59	703.70	25.99
Una Valley (Beas Basin)	--	--	--	--	--	--	--	257.2	31.35	466.22	34.65	317.96	56.30
Total	**151046**	**15311.70**	**71.13**	**29820.29**	**50.91**	**00**	**74**	**35709.33**	**36.25**	**54776.73**	**39.23**	**65992.9**	**34.95**

Table 12: Comparison of Net Ground Water Extractability for Future Irrigation and Stage of Ground Water Development

Comparison of Stage of Ground Water Extraction in Himachal Pradesh as on March 2023								
Sr. No.	**Assessment Unit**	**District**	**SOE (2020) (%)**	**Category 2020**	**SOE (2022) (%)**	**Category 2022**	**SOE (2023) (%)**	**Category 2023**
1	Nurpur - Indora Valley	Kangra	29.27	Safe	27.34	Safe	23.12	Safe
2	Dharamshala-Palampur Valley	Kangra	13.76	Safe	19.59	Safe	23.71	Safe
3	Balh Valley	Mandi	41.39	Safe	37.72	Safe	31.94	Safe
4	Chauntra Valley	Mandi	17.12	Safe	24.43	Safe	4.34	Safe
5	Paonta Valley	Sirmour	22.44	Safe	24.99	Safe	20.63	Safe
6	Kala Amb Valley	Sirmour	27.51	Safe	23.48	Safe	27.81	Safe
7	Nalagarh Valley	Solan	58.43	Safe	57.25	Safe	57.09	Safe
8	Una Valley (Satluj Basin)	Una	62.81	Safe	69.73	Safe	63.97	Safe
9	Una Valley (Beas Basin)	Una	31.35	Safe	34.65	Safe	25.99	Safe
10	Hum Valley	Una	58.12	Safe	57.92	Safe	56.30	Safe
	Total		36.25		39.23		**34.95**	

Table 13: Comparison of Stage of Ground Water Extraction as on March 2023

Result of GWRA-2023: In comparison with GWRA-2022 Stage of Extraction (SOE) in GWRA-2023 is 4.28 % lesser. The reason for lowering of Stage of Extraction (SOE) in GWRA-2023 attributes to increase in rainfall recharge and increase in recharge from other sources.

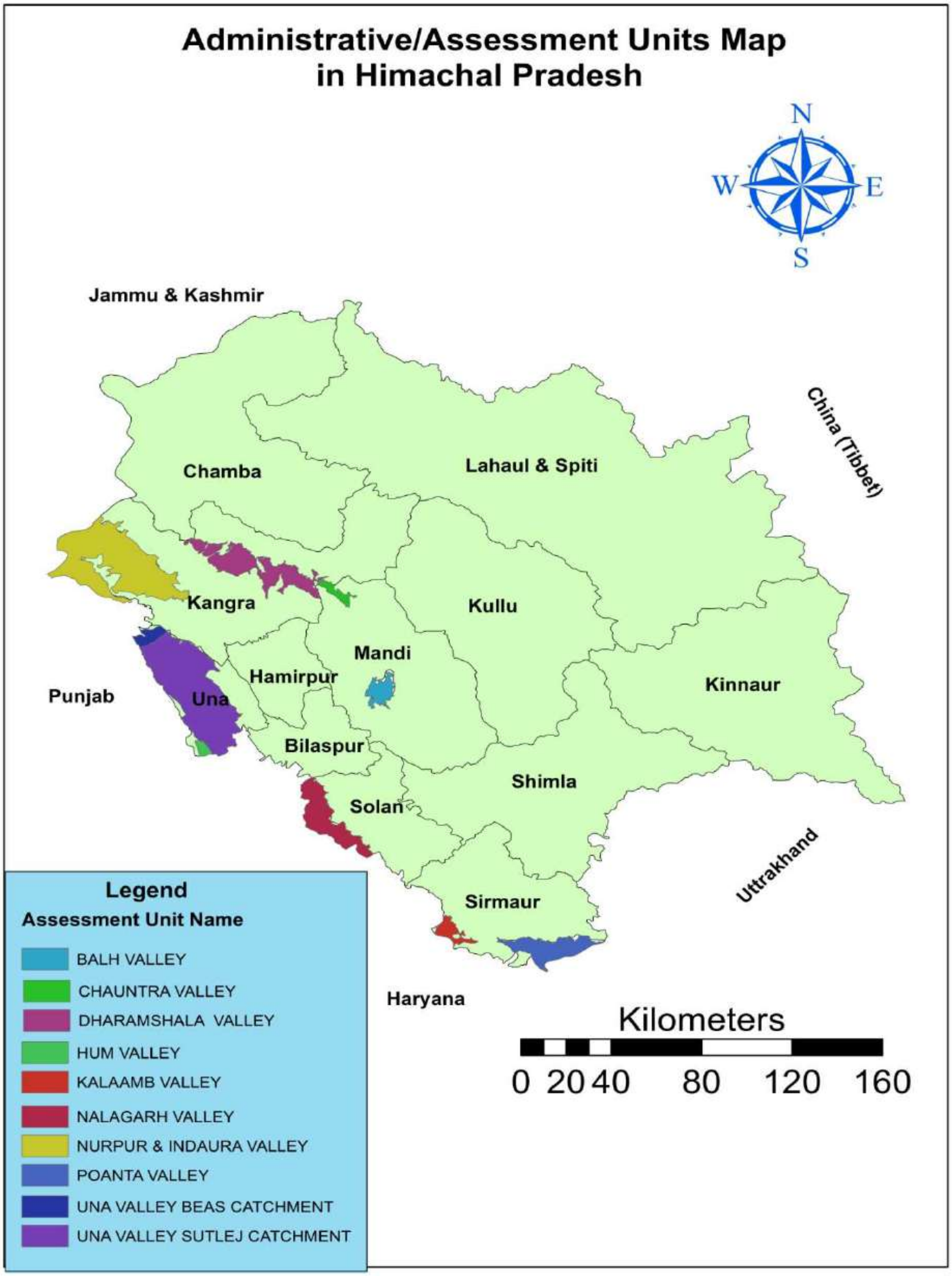

Administrative/Assessment Units Map
in Himachal Pradesh
N
W
E
S
Jammu & Kashmir
China (Tibbet)
Chamba
Lahaul & Spiti
Kangra
Kullu
Mandi
Hamirpur
Kinnaur
Punjab
Una
Bilaspur
Shimla
Solan
Uttrakhand
Sirmaur
Haryana
Legend
Assessment Unit Name
BALH VALLEY
CHAUNTRA VALLEY
DHARAMSHALA VALLEY
HUM VALLEY
KALAAMB VALLEY
NALAGARH VALLEY
NURPUR & INDAURA VALLEY
POANTA VALLEY
UNA VALLEY BEAS CATCHMENT
UNA VALLEY SUTLEJ CATCHMENT
Kilometers
0 20 40 80 120 160

Fig-1

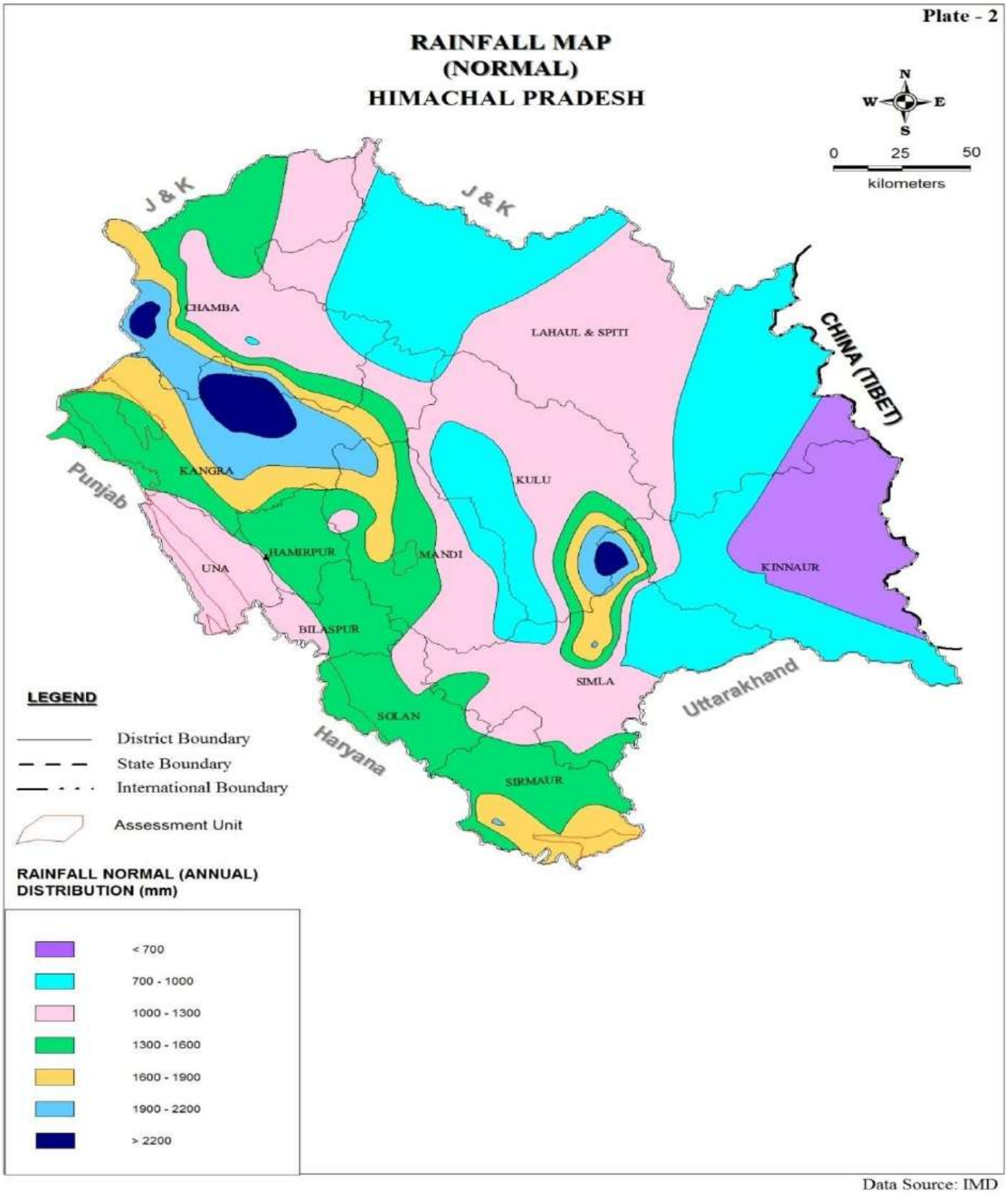
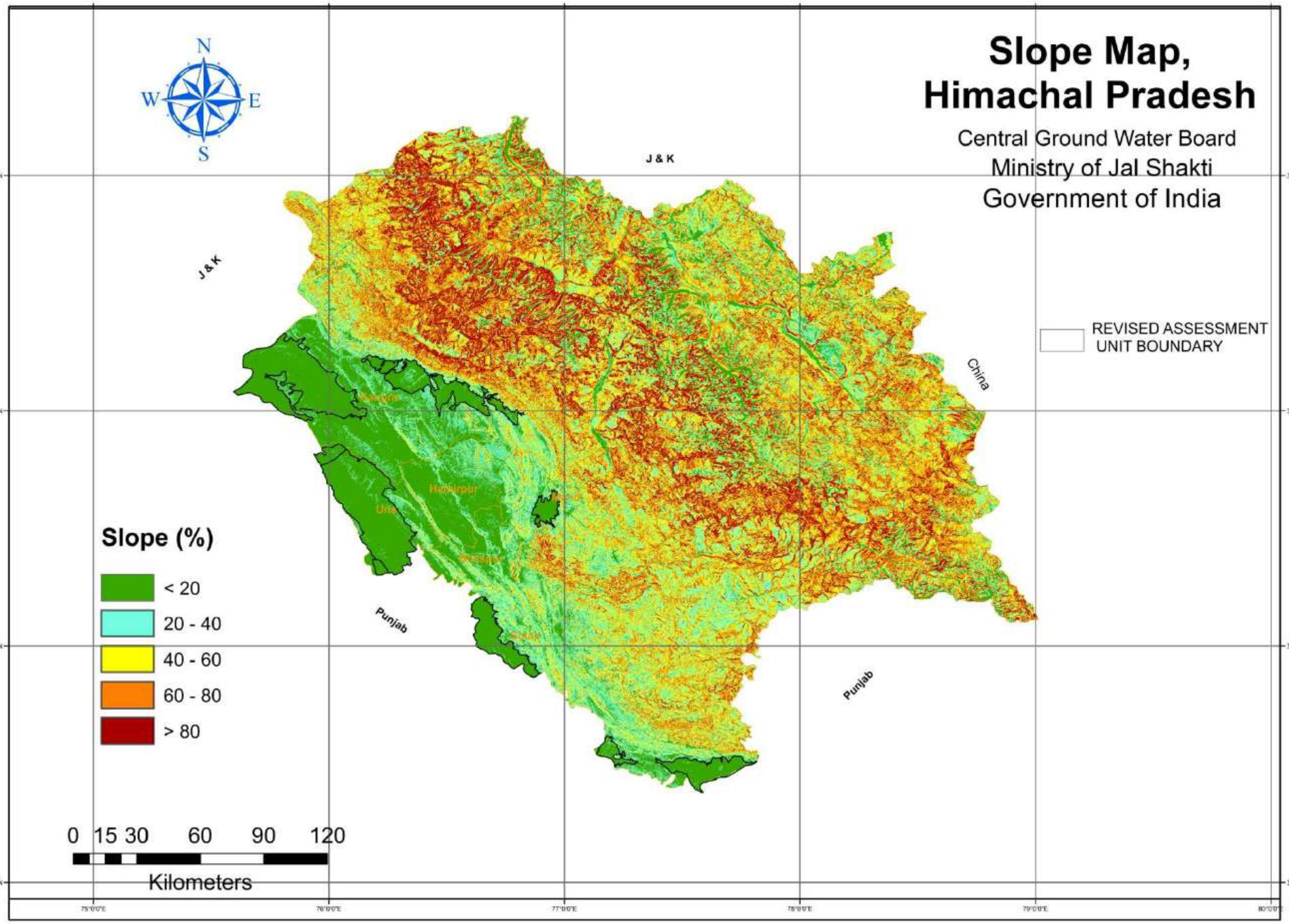


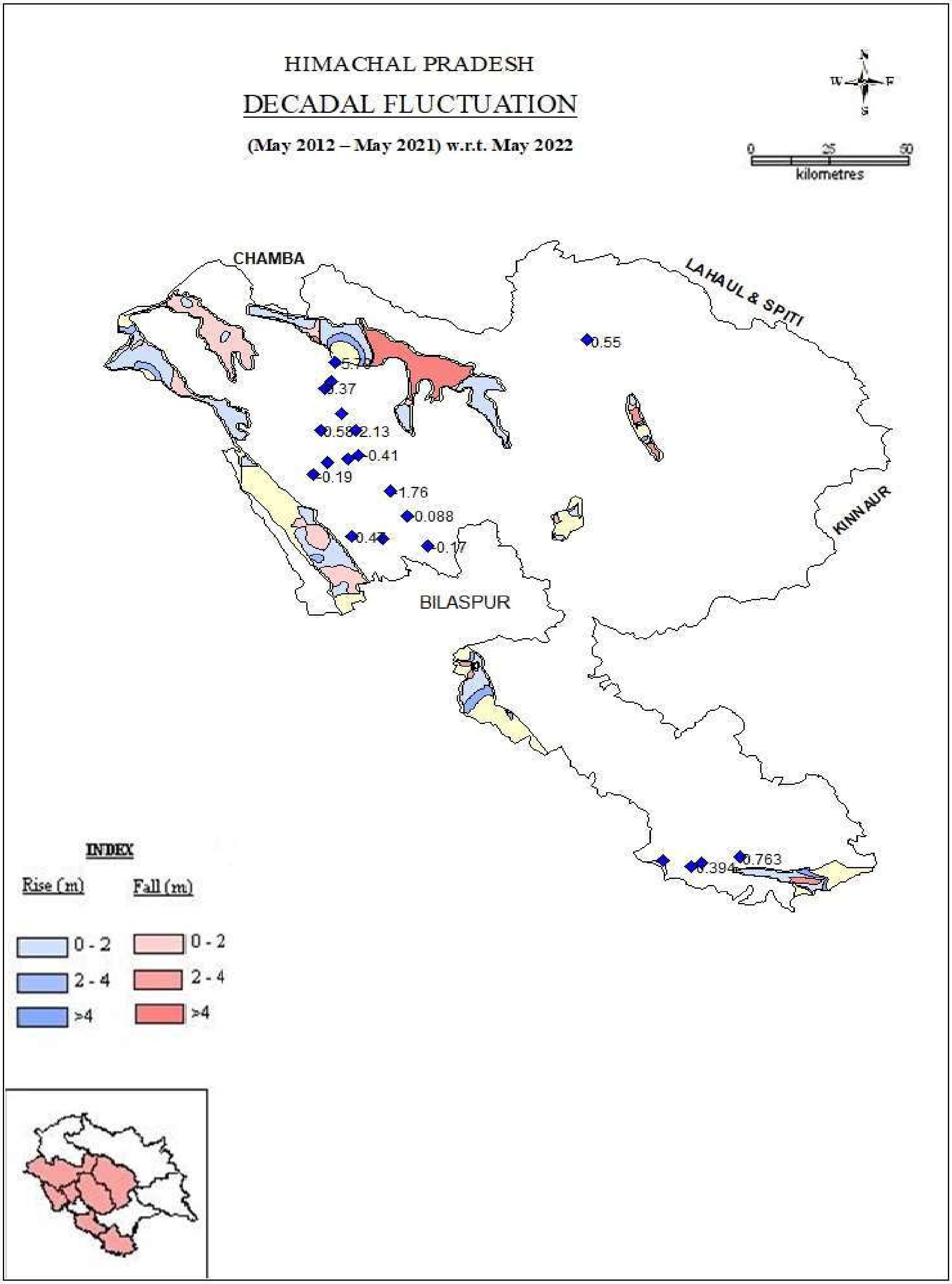
Plate - 2
RAINFALL MAP
(NORMAL)
HIMACHAL PRADESH
N
W
E
S
0
25
50
kilometers
J & K
J & K
CHINA (TIBET)
CHAMBA
LAHAUL & SPITI
KANGRA
KULU
Punjab
HAMIRPUR
MANDI
UNA
KINNAUR
BILASPUR
SIMLA
Uttarakhand
SOLAN
Haryana
SIRMAUR
LEGEND
District Boundary
State Boundary
International Boundary
Assessment Unit
RAINFALL NORMAL (ANNUAL)
DISTRIBUTION (mm)
< 700
700 - 1000
1000 - 1300
1300 - 1600
1600 - 1900
1900 - 2200
> 2200
Data Source: IMD

Fig-2



Slope Map,
Himachal Pradesh
Central Ground Water Board
Ministry of Jal Shakti
Government of India
N
S
E
W
J & K
J & K
China
Punjab
Punjab
REVISED ASSESSMENT UNIT BOUNDARY
Slope (%)
< 20
20 - 40
40 - 60
60 - 80
> 80
0 15 30 60 90 120
Kilometers

Fig- 3



HIMACHAL PRADESH
DECADAL FLUCTUATION
(May 2012 – May 2021) w.r.t. May 2022
N
W
E
S
0
25
50
kilometres
CHAMBA
LAHAUL & SPITI
KINNAUR
BILASPUR
0.55
2.13
0.41
0.19
1.76
0.088
0.17
INDEX
Rise (m)
Fall (m)
0 - 2
2 - 4
>4
0 - 2
2 - 4
>4

Fig-4

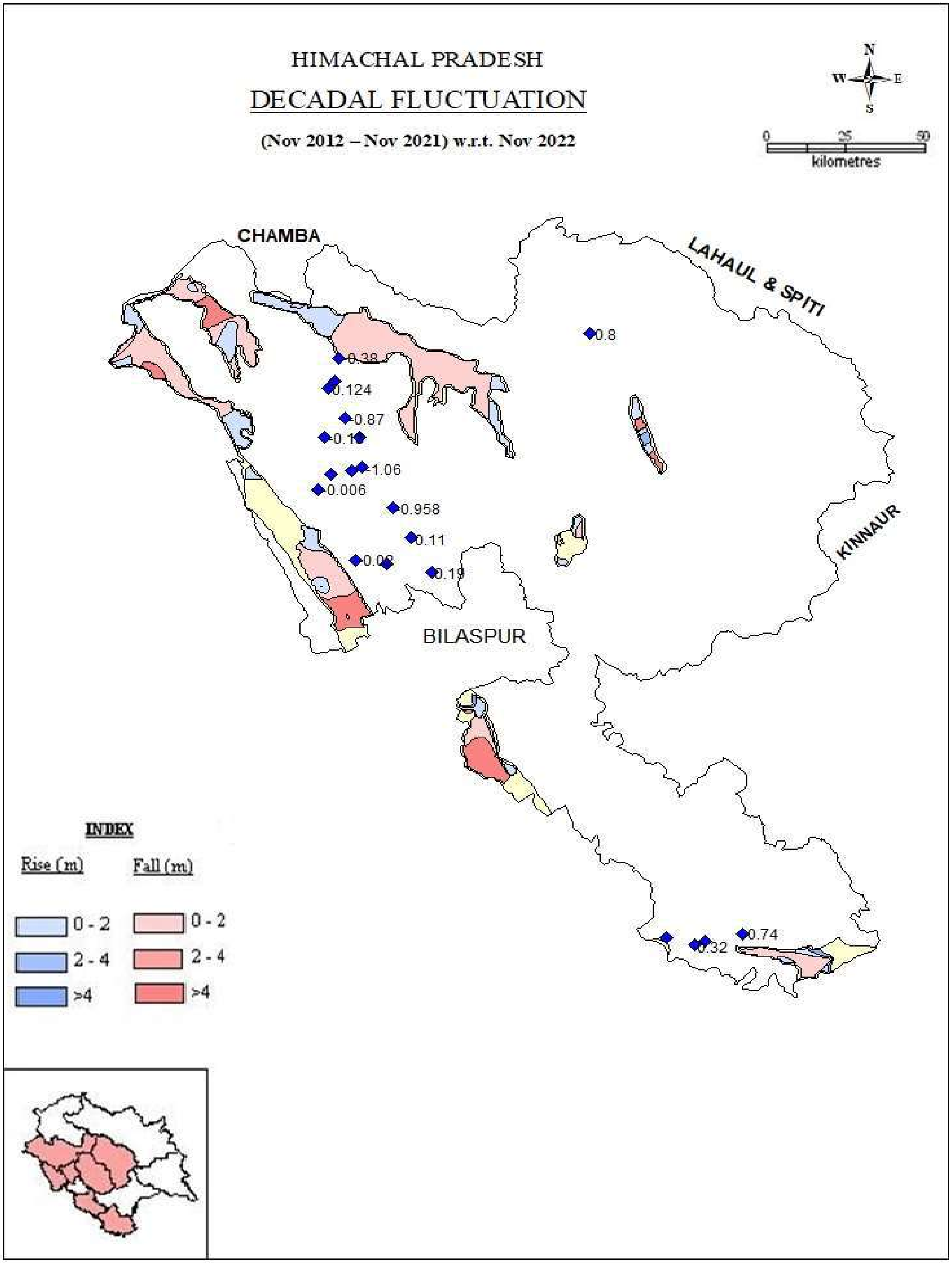

HIMACHAL PRADESH
DECADAL FLUCTUATION
(Nov 2012 – Nov 2021) w.r.t. Nov 2022
N
W
E
S
0
25
50
kilometres
CHAMBA
LAHAUL & SPITI
KINNAUR
BILASPUR
0.8
0.124
0.87
1.06
0.006
0.958
0.11
0.74
INDEX
Rise (m)
Fall (m)
0 - 2
2 - 4
>4
0 - 2
2 - 4
>4

Fig-5

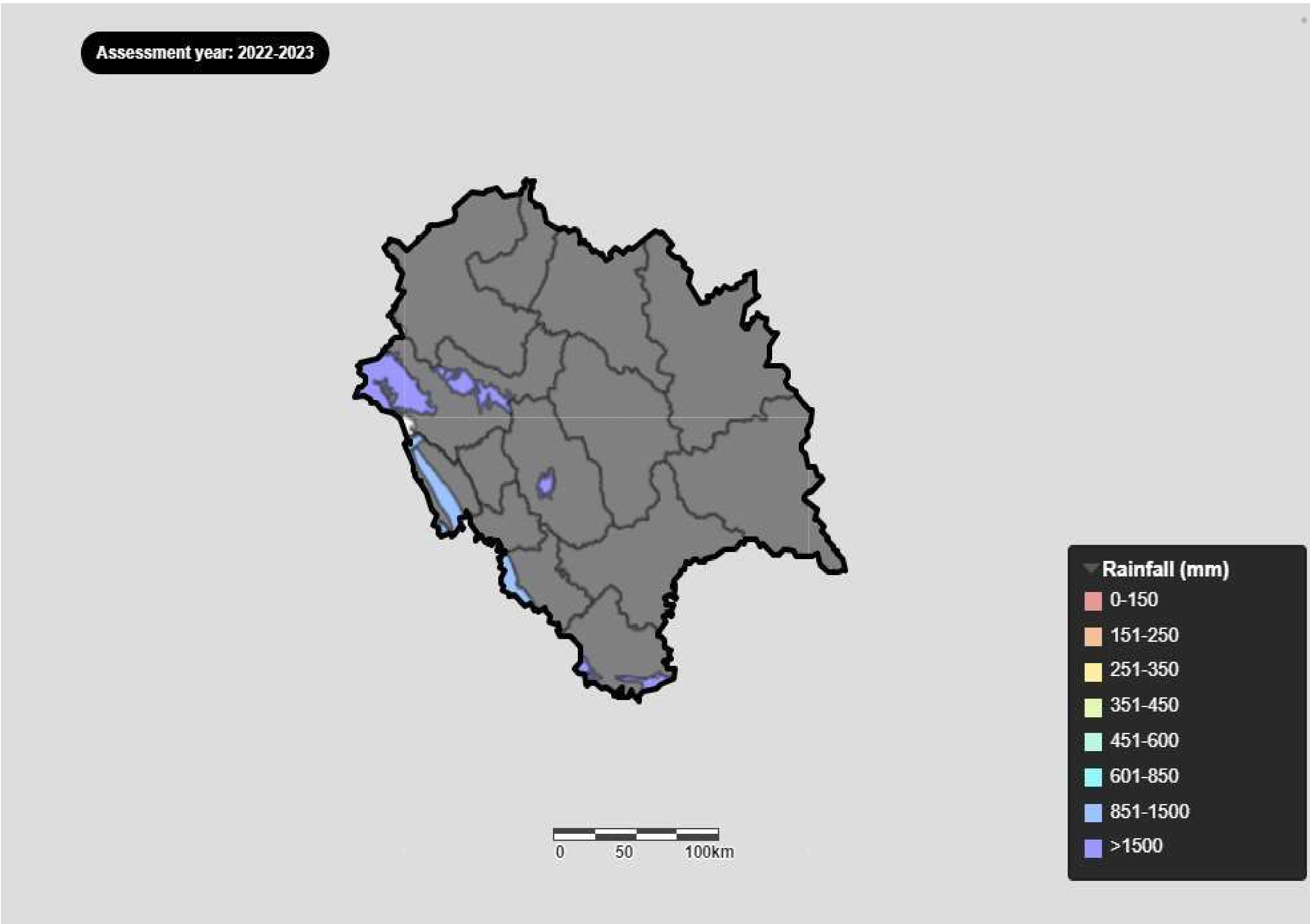


Fig-6 : Rainfall Map

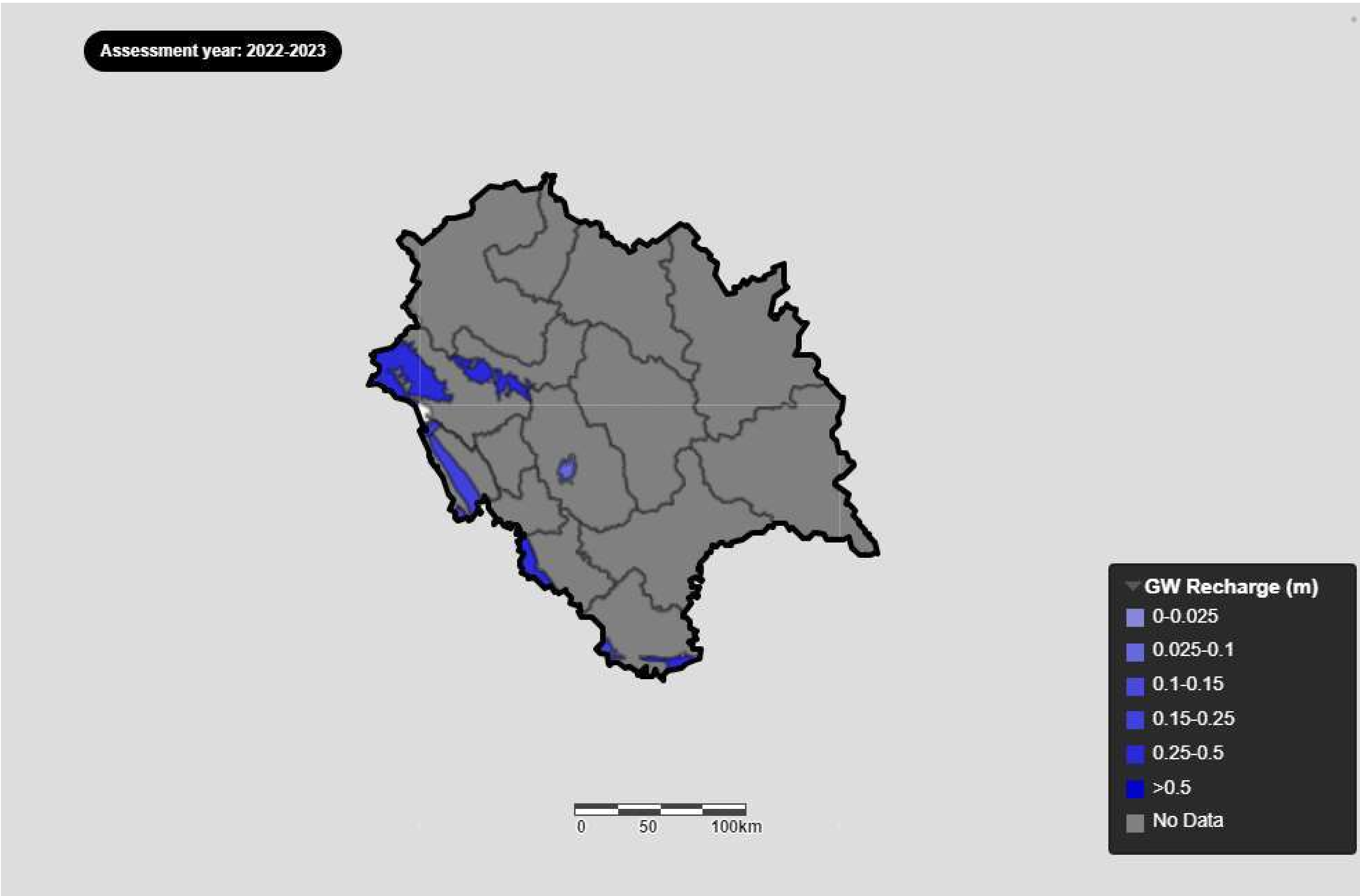


Fig-7: Ground Water Recharge (m)

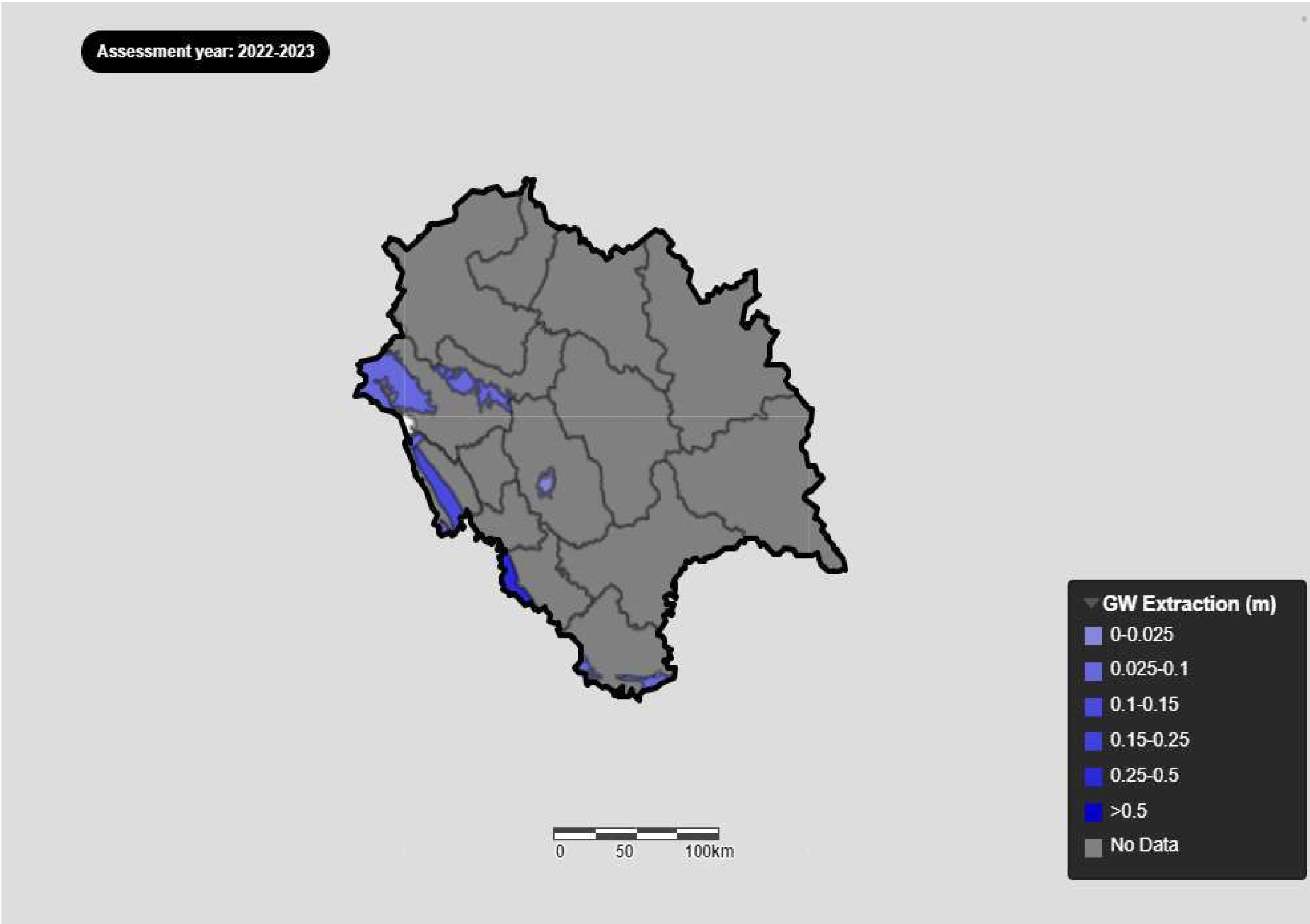


Fig-8 Ground Water Extraction (m)

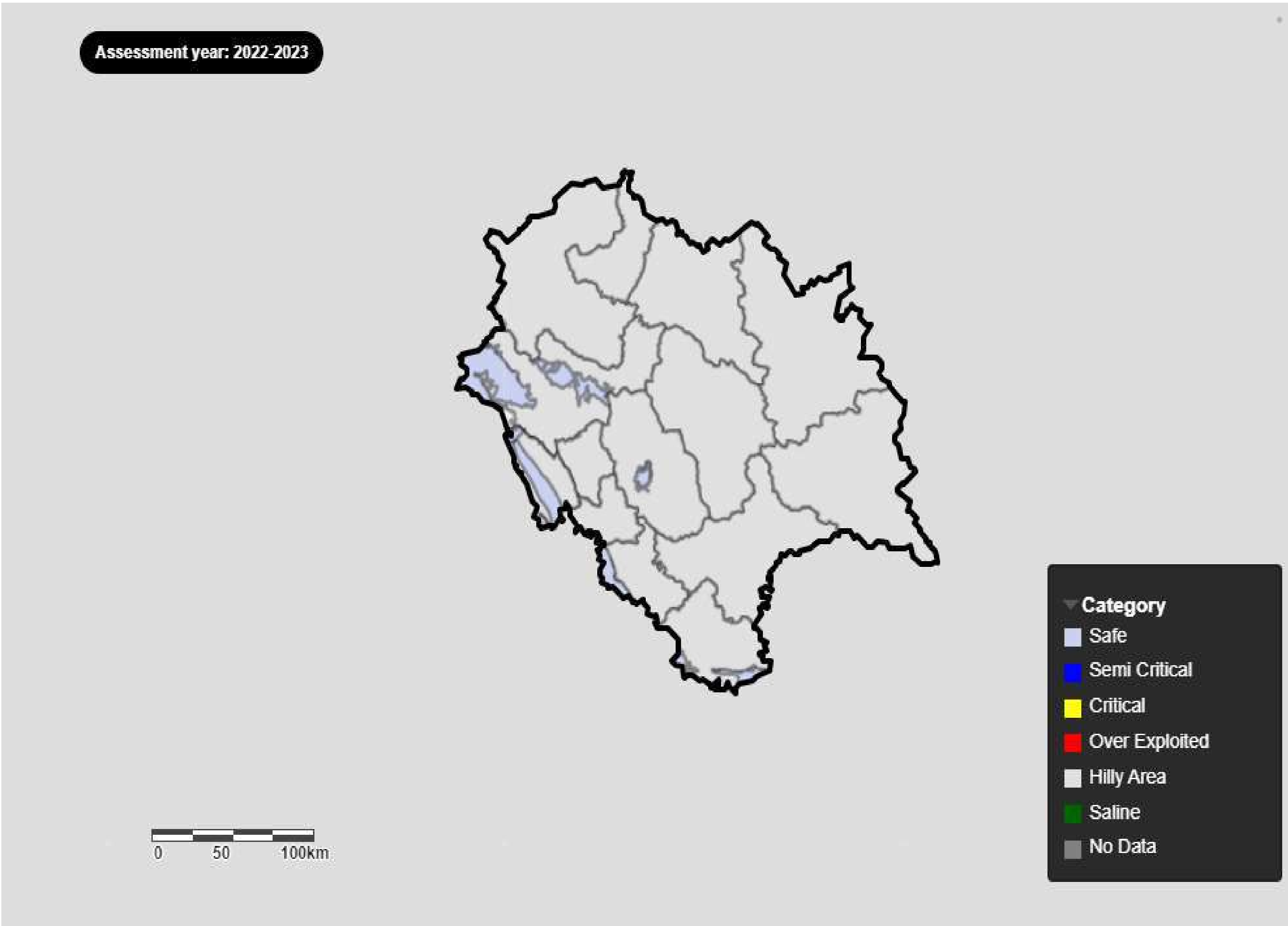


Fig-9 Categorisation of Assessment Units

Annexure - A

Government of Himachal Pradesh
Jal Shakti Vibhag

No. IPH-B(A)3-1/2019-II-L Dated Shimla-171002, the 18/01/2023

Notification

The Governor, Himachal Pradesh is pleased to order to constitute Ground Water Resource Assessment Cell in Jal Shakti Vibhag for assisting State Level Committee constituted for Dynamic Ground Water Resources in Himachal Pradesh:-

1. Senior Hydrologist, Ground Water Organization, JSV, Una
2. Representative or Scientist, CGWB, Dharmshala.
3. Junior Hydrologist, CWO, JSV, HP, Una.

BY ORDER

(Amitabh Avasthi)
Secretary (JSV) to the
Government of Himachal Pradesh

Endst. No. as above Dated Shimla-2 the 18/01/ 2023
Copy to:

1. The Secretary, Government of India, Ministry of Jal Shakti, Department of Water Resources, River Development & Ganga Rejuvention, Shram Shakti Bhawan, Rafi Marg, New Delhi-110001.
2. The Joint Secretary, Government of India, Ministry of Jal Shakti, Department of Water Resources, River Development & Ganga Rejuvenation, Shram Shakti Bhawan, Rafi Marg, New Delhi-110001.
3. All Head of Departments in Himachal Pradesh.
4. All Divisional Commissioners in Himachal Pradesh.
5. All Deputy Commissioners in Himachal Pradesh.
6. All Members of H.P. Water Management Board.
7. All Members of Assessment cell.
8. All Members of State Level Committee.
9. The Engineer-in-Chief (JSV), Jal Shakti Bhawan, Tutikandi, HP Shimla-5.
10. The Director, Government of India, M&A Directorate, SDA Complex, Shimla-9.
11. The Regional Director, Central Ground Water Board, NHR, Dove Cottage, Ramnagar, P.O. Ramnagar, Dharamshala, Himachal Pradesh-176215.

Raksha

(Raksha Sharma)
Under Secretary (JSV) to the
Government of Himachal Pradesh

Government of Himachal Pradesh
Jal Shakti Vibhag

No. IPH-B(A)3-1/2019-II-L Dated Shimla-171002, the 18/01/2023

Notification

The Governor, Himachal Pradesh is pleased to order to constitute a State Level Committee for assessment of Dynamic Ground Water Resources in Himachal Pradesh with the following composition:-

(1) The Secretary(JSV)	Chairman
(2) The Engineer-in-Chief(JSV)	Member
(3) The Director(Industries)	Member
(4) The Director(UD)	Member
(5) The Director(Agriculture)	Member
(6) The Director(RD)	Member
(7) All the Chief Engineers(JSV)	Member
(8) The Superintending Engineer, GSWSSC	Member
(9) The Superintending Engineer(P&I)II	Member
(10) The Superintendent Engineer(Hydrology)	Member
(11) HP Water Management Board, Chief Engineer(D&M)	Member
(12) The Chief General Manager, NABARD	Member
(13) Sr. Hydrologist, Ground Water Organization, Una	Member
(14) The Regional Director, Central Ground Water Board Dharamshala.	Member Secretary

The Committee may co-opt any other Member(s)/Special invite(s),if necessary.

2. **Terms and References:** The broad terms and reference of the Committee would be as follows:-

(I) To estimate Dynamic Ground Water Resource of the state of Himachal Pradesh through 'INDIA-Ground Water Resource Estimation System(IN-GRES)" software/web based application developed by CGWS in collaboration with IIT, Hyderabad. IN-GRES is based on methodology recommended by Groundwater Resource Estimation Committee (GEC)-215.

(II) To estimate the status of utilization of annual replenishable groundwater resource of Himachal Pradesh.

3. **Time Frame:** The committee will submit its report on before April month of every year.

4. **Expenditure:-** Expenditure on account of TA/DA to official members of the Committee will be met from the source which they draw their salaries and that of non-official Members, will be borne by the Department of Jal Shakti Vibhag.

BY ORDER

(Amitabh Avasthi)
Secretary (JSV) to the
Government of Himachal Pradesh

Endst. No. as above Dated Shimla-2 the 18/01/2023

Copy to:

1. The Secretary, Government of India, Ministry of Jal Shakti, Department of Water Resources, River Development & Ganga Rejuvention, Shram Shakti Bhawan, Rafi Marg, New Delhi-110001.
2. The Joint Secretary, Government of India, Ministry of Jal Shakti, Department of Water Resources, River Development & Ganga Rejuvenation, Shram Shakti Bhawan, Rafi Marg, New Delhi-110001.
3. All Head of Departments in Himachal Pradesh.
4. All Divisional Commissioners in Himachal Pradesh.
5. All Deputy Commissioners in Himachal Pradesh.
6. All Members of H.P. Water Management Board.
7. ~~All~~ Members of State Level Committee.
8. The Engineer-in-Chief (JSV), Jal Shakti Bhawan, Tutikandi, HP Shimla-5.
9. The Director, Government of India, M&A Directorate, SDA Complex, Shimla-9.
10. The Regional Director, Central Ground Water Board, NHR, Dove Cottage, Ramnagar, P.O. Ramnagar, Dharamshala, Himachal Pradesh-176215.

(Raksha Sharma)
Under Secretary (JSV) to the
Government of Himachal Pradesh

Annexure - B

No. JSV-B(F)10-5/2023
Government of Himachal Pradesh
Jal Shakti Vibhag

From

The Secretary (JSV) to the
Government of Himachal Pradesh

To

The Regional Director,
Central Ground Water Board, NHR, Dove, Cottage,
Ram Nagar, Dharmshala(H.P)

Dated: Shimla- 171002, the 04 /07/2023.

Subject: **Proceedings of the meeting of State Ground Water Coordination Committee (SGWCC) & State Level Committee on Ground Water Resource Estimation of Himachal Pradesh held on 19-06-2023 under the Chairmanship of Secretary (JSV) to the Government of Himachal Pradesh.**

Sir,

I am directed to refer to the above cited subject and to enclose herewith copy of proceedings of above meeting duly approved by Secretary (JSV) to the Government of Himachal Pradesh for information and further circulation to all concerned.

Yours faithfully,

(Raksha Sharma)
Deputy Secretary (JSV) to the
Government of Himachal Pradesh

Proceedings of the meeting of State Ground Water Coordination Committee (SGWCC) & State Level Committee on Ground Water Resource Estimation of Himachal Pradesh held on 19.06.2023 under the Chairmanship of Secretary (JSV) to the Government of Himachal Pradesh.

A meeting was held on 19.06.2023 under the Chairmanship of Sh. Amitabh Avasthi, Secretary (JSV) to the Government of Himachal Pradesh and Chairman of the Committee. At the outset of the meeting, Shri J.N. Bhagat, Regional Director, CGWB, NHR welcomed Sh. Amitabh Avasthi, Secretary (JSV) and other Members of SGWCC. The proceedings started with following agenda circulated to all Members, through e-mail. List of participants who attended the meeting is attached at **Annexure-A.**

AGENDA 1:
To be considered "Block" as the assessment unit in Ground Water Resource Assesment-2023 (GWRA-2023).

Dr.Sanjay Pandey, Scientist-B, CGWB, NHR, Dharamshala apprised the committee that the fundamental unit for assessment of Ground Water Resources of Himachal Pradesh is 'valley' and majority of States are having 'block' as ground water assessment unit. In view of National Compilation of Dynamic Ground Water Resources of India, the "Block" or its equivalent may be taken as ground water assessment unit. The matter of keeping block as assessment unit for Dynamic Ground Water Resource Assessment 2023 was discussed that as the State is predominantly a hilly region having slopes more than 20% and under lane by hard rocks and only few small intermountain valleys are having ground water potential. Keeping in view the physical and hydrogeological conditions in the State, only 3468 sq km area is taken up for ground water assessment out of 55673 sq km, falling under 10 assessment units in the intermountain valleys. Most of the assessment units comprise of both semi-consolidated deposits as well as alluvium as aquifer and hydrological boundary will be suitable for GWRA-2023 in Himachal Pradesh. If block wise would have been carried out than large numbers of fragmented blocks will come out as assessment units. Detailed discussion were held on the revision of assessment area and after detailed deliberations the committee agreed that for the Dynamic Ground Water Resource Assessment 2023 valleys will be kept as assessment units as per previous practice and no change in the assessment unit boundary is warranted. A proposal in this regard will be submitted by Superintending Engineer (P&I-II), Jal Shakti Vibhag with reference of D.O letter from the Ministry of Jal Shakti and the same will be requested to allow the State to make assessment as per past practice i.e on valley basis.

AGENDA 2:

Review of the status of Ground Water resource Assesment-2023

Dr.Sanjay Pandey, Scientist-B explained the timeline in carrying out Ground Water Resources Assesment-2023. Shri Bhavnesh Sharma, Senior HG, GWO explained that there is no change in area of all assessment units and the extent of hydrogeological boundaries are same as in previous assessment. Collection of data like variables used in calculating recharge from other sources e.g. Surface Irrigation Schemes, Canals, Water Conservation Structures, and Tanks& Ponds is under progress, data pertaining to ground water extraction and rainfall is under progress. Worthy Secretary directed to finish the GWRA-2023 within stipulated time by strictly adhering to the timeline.

AGENDA 3:

Sites for construction of piezometers and installation of DWLRs

Shri J.N. Bhagat, Regional Director apprised Sh. Amitabh Avasthi, Secretary (JSV) that CGWB has planned to install 205 Piezometer well and installation of DWLRs with telemetry system in the State for ground water monitoring. Shri J.N. Bhagat further, sought support and co-operation from State agencies for installation of these wells at identified locations. Worthy Secretary, Jal Shakti Vibhag and Chairman assured that the Deputy Commissioners will be requested to issue directions to the concerned revenue authorities to help and assist the CGWB team to install the piezometer wells at identified sites. A detailed note alongwith selected sites will be provided by Engineer-in-Chief/Superintending Engineer (P&I-II), Jal Shakti Vibhag in this regard.

AGENDA 4:

Formation of Technical Advisory Committee (TAC) and State level Nodal Agency (SLNA)" and Revision of Master Plan 2025

Dr.Sanjay Pandey, Scientist-B apprised the committee about the Technical Advisory Committee & SLNA and placed the Guidelines for the Formation of Technical Advisory

Committee & SLNA in the meeting. Detailed discussion were held in this regard and as the formation of SLNA needs estimation and arrangement of fund for establishment of GIS labs with GIS Experts at District & State Levels for preparation of thematic layers in 1:10000 scale for preparation of implementable DPRs at the village/ Gram Panchayat level for which the above matter will be carried out with the higher authorities. A reference containing details of funds required will be submitted by Superintending Engineer (P&I-II), Jal Shakti Vibhag to the Government in this regard. For Revision of Master Plan 2025, ENC (JSV) apprised the Worthy Secretary that for Jal Shakti Abhiyaan district wise master plan are already being prepared and it has been decided that revision shall be carried out by incorporating the district wise master plan and Jal Shakti Vibhag will be act as major partner with CGWB, NHR for Revision of Master Plan 2025.

The meeting ended with vote of thanks

Annexure-A

THE LIST OF THE OFFICERS WHO ATTENDED MEETING ON 19.06.2023

1. **Meeting of State Level Committee on Ground Water Resource Estimation of Himachal Pradesh as on March 2023.**
2. **7th meeting of State Ground Water Coordination Committee (SGWCC).**

1. Sh. Amitabh Avasthi, Secretary (JSV) to the Government of Himachal Pradesh and Chairman of the Committee.
2. Smt. Raksha Sharma, Deputy Secretary (JSV) to the Government of Himachal Pradesh
3. Er. Sanjeev Kaul, Engineer-in-Chief, Jal Shakti Vibhag Jal Shakti Bhawan, Shimla
4. Er. Anju Sharma, Chief Engineer, South Zone, Jal Shakti Vibhag Shimla, JSV, Jal Shakti Bhawan, Shimla
5. Sh. Bhavnesh Sharma, Senior Hydrologist,GWO, Jal Shakti Vibhag, Una
6. Sh. Puneet Guleria, State Geologist, Geological Wing, Deptt. Of Industries, Shimla
7. Sh. J.N.Bhagat, Regional Director & Member Secretary, CGWB, Dharamshala
8. Dr. Sanjay Pandey, Sc-B, CGWB, Dharamshala
9. Sh. G.R Chauhan (Consultant), Department of Agriculture, H.P, Shimla-05.
10. Sh. Sanjay Kumar, Section Officer, JSV-B Section, H.P Secretariat.

Annexure - C

No. JSV-B(f) 10-5/2023

Himachal Pradesh
Jal Shakti Vibhag

To

Sh. Satish Kumar,
Member,
Central Ground Water Board,
Ministry of Jal Shakti,
Deptt. of WR, RD&GR, GOI.

Dated: Shimla-171005, the 20th June, 2023.

Subject: **Regarding meeting of State Ground Water Co-ordination Committee (SGWCC) meeting held on 19.06.2023.**

This has reference to the discussion held during the course of State Ground Water Co-ordination Committee (SGWCC) meeting held at Shimla on 19.06.2023. During the course of meeting the matter of keeping block as assessment unit for Dynamic Ground Water Resource Assessment 2023 was taken up. It was discussed that as Himachal Pradesh is predominantly a hilly State having slopes more than 20% and underlane by hard rocks and only few small intermontane valleys are having ground water potential. Keeping in view the physical and hydrogeological conditions in the State, only 3468 sq km area is taken up for ground water assessment out of 55673 sq km, falling under 10 assessment units in the intermontane valleys. Most of the assessment units comprise of both semi-consolidated deposits as well as alluvium as aquifer and the boundaries of the assessment units have been taken considering hydrogeological and watershed boundaries as per the recommendations of Ground Water Resource Estimation Committee (GEC) 2015. It was also discussed that the area of these 10 assessment units fall under 25 Community Development blocks and will make these units very small without serving any useful purpose. It was therefore, decided by the committee that for the Dynamic Ground Water Resource Assessment 2023 valleys will be kept as assessment units.

Keeping in view the above facts it is informed that for the Dynamic Ground Water Resource Assessment 2023 valleys will be kept as assessment units as per previous practice and no change in the assessment unit boundary is warranted.

This is for information please.

Yours sincerely,

(Amitabh Avasthi)
Secretary (Jal Shakti) to the
Govt. of Himachal Pradesh,
Shimla-2.

Annexure - D

Email **rdnhr cgwb**

Data for GWRE 2023

From : replygwo@rediffmail.com Fri, Aug 04, 2023 02:43 PM
Sender : replygwo@rediffmail.com 1 attachment
Subject : Data for GWRE 2023
To : Basant Kumar Oraon <rdnhr-cgwb@nic.in>

Sir,
Please find the data for extraction for GWRE 2023 attached as
collected from filed divisions for further necessary action at your end please.

with regards,
Bhavnesh Sharma
Senior Hydrogeologist,
Ground Water Organisation,
JAL SHAKTI VIBHAG, UNA (H.P)-174303
Phone No. 01975-227097

CGWB_GWRE_data_2023.zip
6 MB

Annexure - E

Meeting Notice

No. JSV-B(F)10-5/2023
Government of Himachal Pradesh
Jal Shakti Vibhag

From

The Pr. Secretary (JSV) to the
Government of Himachal Pradesh.

To

1. The Engineer-in-Chief,
   Jal Shakti Vibhag, Himachal Pradesh
   Jal Shakti Bhawan, Tuttikandi, Shimla-5
2. The Director, Industries,
   Majitha House, Chotta Shima-171002, H.P
3. The Director, Urban Development,
   Palika Bhawan, Talland, Shimla-2, H.P.
4. The Director, Agriculture,
   Krishi Bhawan, Boileauganj,Shimla-5, H.P.
5. The Director, Rural Development,
   29 SDA Complex, Kusumpti, Shimla-9, H.P.
6. The Chief Engineers, South Zone (JSV),H.P
7. The Deputy General Manager, NABARD,
   33 DA Commercial Complex, Dev Nagar, Kusumpti, Shimla-9, H.P.
8. The Superintendent Engineer (Hydrology),
   Jal Shakti Bhawan, Tutikandi, Shimla, H.P.
9. The Superintending Engineer (P&I) Jal Shakti Bhawan, Tutikandi, Shimla, H.P.
10. Chief Engineer (D&M), Jal Shakti Bhawan, Tutikandi, Shimla-171005.

Dated Shimla-2, the 21/09/**2023**

Subject **Regarding meeting of State Level Committee for assessment of Dynamic Ground Water Resources for the assessment year 2023.**

Sir,

I am directed to refer to the above cited subject and to say that the meeting of State Level Committee for assessment of Dynamic Ground Water Resource for the assessment year 2023 to approve the report on "Ground Water Resources Estimation of Himachal Pradesh compiled jointly by CGWB, NIHR, Dharmshala and Jal Shakti Vibhag, has been fixed on 23-09-2023 at 4:00 PM in Committee Room Armsdale Buidling , H.P Secretariat, Shimla-2 under the Chairmanship of Special Secretary (JSV) to the Government of Himachal Pradesh.

You are, therefore, requested to attend the aforesaid meeting as per venue & schedule.

Yours faithfully,

(Raksha Sharma)
Deputy Secretary (JSV) to the
Government of Himachal Pradesh

Endst. No. as above dated Shimla-2 the 21/09/2023

Copy is forwarded to followings:

1. All Chief Engineers, Jal Shakti Vibhag, H.P (excluding Chief Engineer, South Zone). They are requested to join the meeting through video conference, link of which will be shared shortly through email.
2. The Regional Director, Central Ground Water Board, Ministry of Jal Shakti,NHR, Dove Cottage, Ramnagar, P.O Ramnanagar, Dharamshala-176215. He is requested to join the meeting through video conference, link of which will be shared shortly through email.
3. The Hydrologist, Ground Water Organization, JSV, Una, H.P. He is requested to join the meeting through video conference, link of which will be shared shortly through email.
4. Section Officer, R&I-II, H.P. Secretriat, Shimla-2. He is requested to reserve the Committee Room, Armsdale, H.P. Secretariat, Shimla-2 for the said meeting.
5. The Director, NIC, Himachal Pradesh with request to provide the link of video conference by email sectionofficeriphb@gmail.com. Further, it is also requested to provide one technical person who can technically cooperate during video conference.

Rakesh

Deputy Secretary (JSV) to the
Government of Himachal Pradesh

Annexure - F

No. JSV-B(F)10-5/2023
Government of Himachal Pradesh
Jal Shakti Vibhag

From

The Pr. Secretary (JSV) to the
Government of Himachal Pradesh

To

The Regional Director,
Central Ground Water Board, NHR, Dove, Cottage,
Ram Nagar, Dharmshala(H.P)

Dated: Shimla- 171002, the 30 /09/2023.

Subject: **Proceeding of meeting held on 23-09-2023 under the Chairmanship of Special Secretary(JSV) to the Government of Himachal Pradesh regarding State Level Committee of Ground Water Resource Estimation of Himachal Pradesh as on March 2023.**

Sir,

I am directed to refer to the above cited subject and to enclose herewith copy of proceedings of above meeting duly approved for your information and further circulation to all concerned for taking necessary action.

Yours faithfully,

(Dr. A.K Sharma)
Special Secretary (JSV) to the
Government of Himachal Pradesh

Proceeding of meeting held on 23.09.2023 under the Chairmanship of Special Secretary (JSV) to the Government of Himachal Pradesh regarding State Level Committee on Ground Water Resource Estimation of Himachal Pradesh as on March 2023.

At the outset, Sh. J. N. Bhagat, Regional Director, CGWB, NHR welcomed Dr. Ashwani Kumar Sharma, Special Secretary (JSV) to the Government of Himachal Pradesh. Chairman and other Members of State Ground Water Co-ordination Committee (SGWCC). The list of participants is attached as **Annexure-A**

The meeting started with the agenda to approve the report on Dynamic Ground Water Resources of Himachal Pradesh as on March 2023, compiled on the basis of GEC-2015, jointly by Jal Shakti Vihag, H.P. and Central Ground Water Board, NHR, Dharamshala.

- The outcome of the report was shared in the form of Power Point Presentation (PPT) by Sh. Sanjay Pandey, Scientist-B, CGWB, NHR Dharamshala
- During the presentation, discussion was held regarding assessment unit boundaries, Sh. Sanjay Pandey, explained that earlier the assessment units were mapped mainly on topographic sheets. The areas having slopes less than 20% including areas fall in alluvial formation and the areas having semi consolidated formation were taken in to account in the present study.
- In the present assessment study, boundaries of all the units having slopes less than 20% have been drawn with the help of Digital Elevation Profile Data acquired through Shuttle Radar Topography Mission (**SRTM**) satellite data having 30 m resolution.
- The boundaries of the assessment units have been taken considering hydrogeological and watershed boundaries, the lithological boundaries of the areas have been taken from Groundwater Prospect Maps, prepared by NRSA, Department of Space, Government of India, using GIS software.
- During presentation, details of IN-GRES portal were described by Sh. Bhavnesh Sharma, Senior Hydrogeologist, GWO.
- GWRA as on march 2023 is carried out through IN-GRES, stage of Ground Water extraction and Categorization is as under :-

Stage of Ground Water Extractions in Himachal Pradesh as on March 2023					
Sr No	**Assessment Units/Valley**	**District**	**Area of Assessment units (Sq. Km.)**	**Stage of Development (%)**	**Categorization**
1	Nurpur-Indora Valley	Kangra	1024.00	23.12	Safe
2	Dharamshala-Palampur Valley	Kangra	452.00	23.71	Safe
3	Balh Valley	Mandi	107.00	31.94	Safe
4	Chauntra Valley	Mandi	52.00	4.34	Safe

5	Paonta Valley	Sirmour	276.00	20.63	Safe
6	Kala Amb Valley	Sirmour	82.00	27.81	Safe
7	Nalagarh Valley	Solan	336.00	57.09	Safe
8	Una Valley (Satluj Catchment)	Una	1045.00	63.97	Safe
9	Una Valley (Beas Catchment)	Una	65.00	25.99	Safe
10	Hum Valley	Una	29.00	56.30	Safe
	Total		**3468.00**	**34.95**	

- The Chairman cum Special Secretary (JSV) to the Government of Himachal Pradesh asked about the implementation of this report in agriculture and other concerned Government departments. The Chairman also asked about reason for the change in the stage of Ground Water Development of all assessment units compared to assessment year of 2022. In the response to this, Sh. Sanjay Pandey, Scientist-B, CGWB explained that the change in stage of Ground Water is mainly due to increase in Ground Water recharge.

- The Chairman cum Special Secretary (JSV) to the Government of Himachal Pradesh suggested to distribute the report of Ground Water Resource Assessment-2023 to all Ground Water user departments in Himachal Pradesh at all levels, and recommendations should be given to the all Ground Water user departments like Agriculture, Horticulture, Forest, Co-operative societies etc in Himachal Pradesh so that departments can prepare their own water management plan as per categorization of the assessment areas. Sh. Sanjay Pandey, Scientist-B, CGWB, NHR, Dharamshala informed to Chairman about NAQUIM study done by CGWB, NHR, Dharamshala in valley area of Himachal Pradesh and apprised that valley wise NAQUIM reports containing aquifer management plan are already uploaded on CGWB website which can be access by all departments and stake holders. In view of the above discussion & deliberations, the report on Dynamic Ground Water Resources of Himachal Pradesh as on March 2023 was approved by the committee.

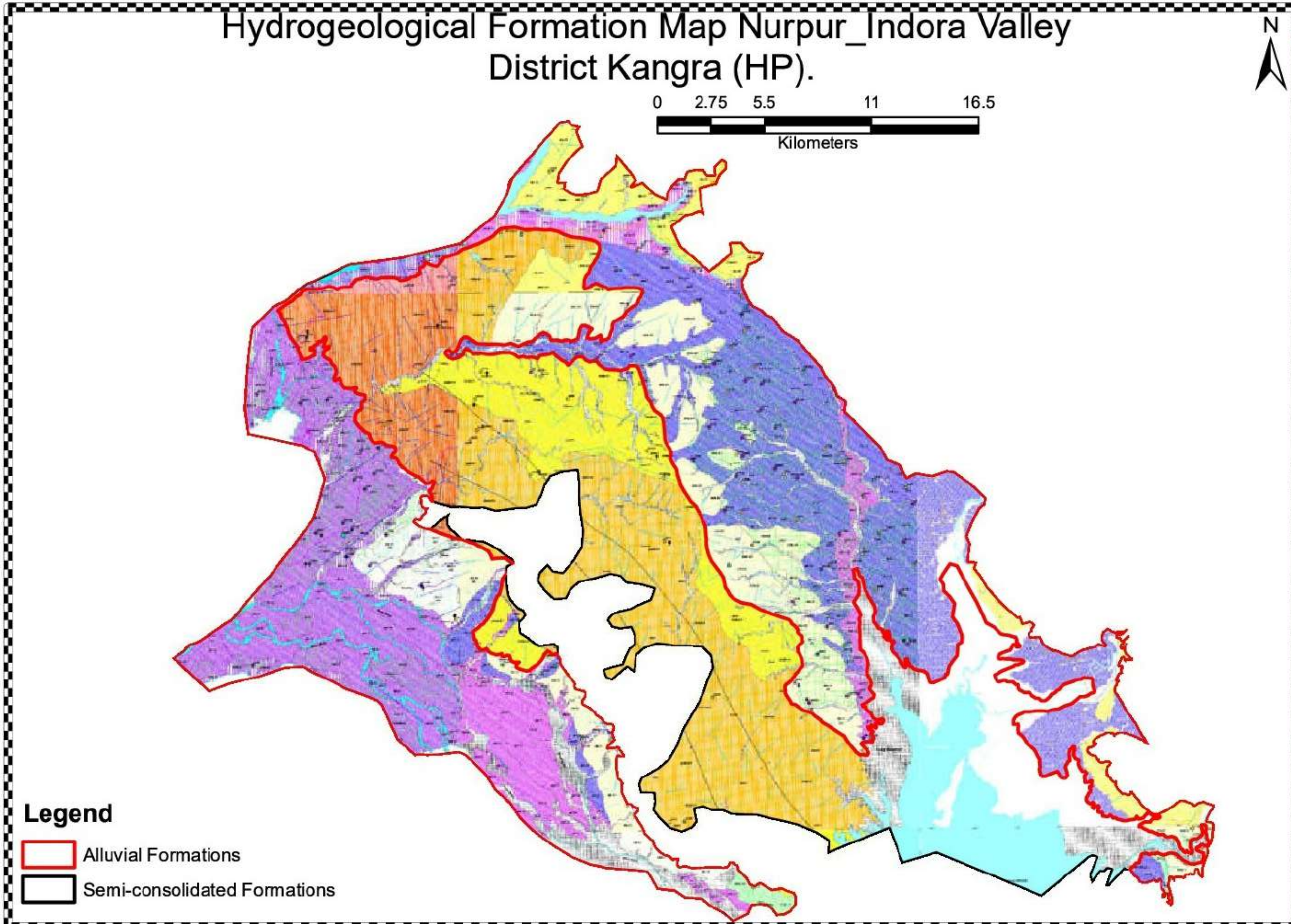
Meeting ended with the vote of thanks to the chair.

Annexure- A

List of Participants

1. Dr. Ashwini Kumar Sharma, Special Secretary (JSV) to the Government of Himachal Pradesh, Shimla-2, HP.
2. Smt. Raksha Sharma, Deputy Secretary (JSV) to the Government of Himachal Pradesh, Shimla-2, HP.
3. Er. Neerja Gupta, Executive Engineer (P & I -II)-cum Himachal Pradesh Ground Water Authority, Himachal Pradesh, Shimla-5, HP.
4. Er. Akshay Tandon, Civil Engineer/Urban Planner, Urban Develop Department, HP.
5. Sh. Suresh Sharma, Joint Director, Department of Agriculture, Shimla-5, HP.
6. Sh. Pankaj Maurya, (AMRUT), Urban Develop Department, HP.
7. Sh. Bhavnesh Sharma, Senior Hydrogeologist, GWO, Jal Shakti Vibhag, Una, HP.
8. Sh. J. N. Bhagat, Head of Office, CGWB, NHR, Dharamshala, HP
9. Sh. Sanjay Pandey, Scientist-B, CGWB, NHR, Dharamshala, HP
10. Sh. Manohar Kumar, Assistant Hydrogeologist, CGWB, NHR, Dharamshala, HP
11. Sh. Devinder Kumar, Assistant Hydrogeologist, CGWB, NHR, Dharamshala, HP
12. Sh. Prasant Kumar Singh, S.T.A. (Hg.), CGWB, NHR, Dharamshala, HP

Fig. -10



Hydrogeological Formation Map Nurpur_Indora Valley
District Kangra (HP).
N
0
2.75
5.5
11
16.5
Kilometers
Legend
Alluvial Formations
Semi-consolidated Formations

Fig.-11

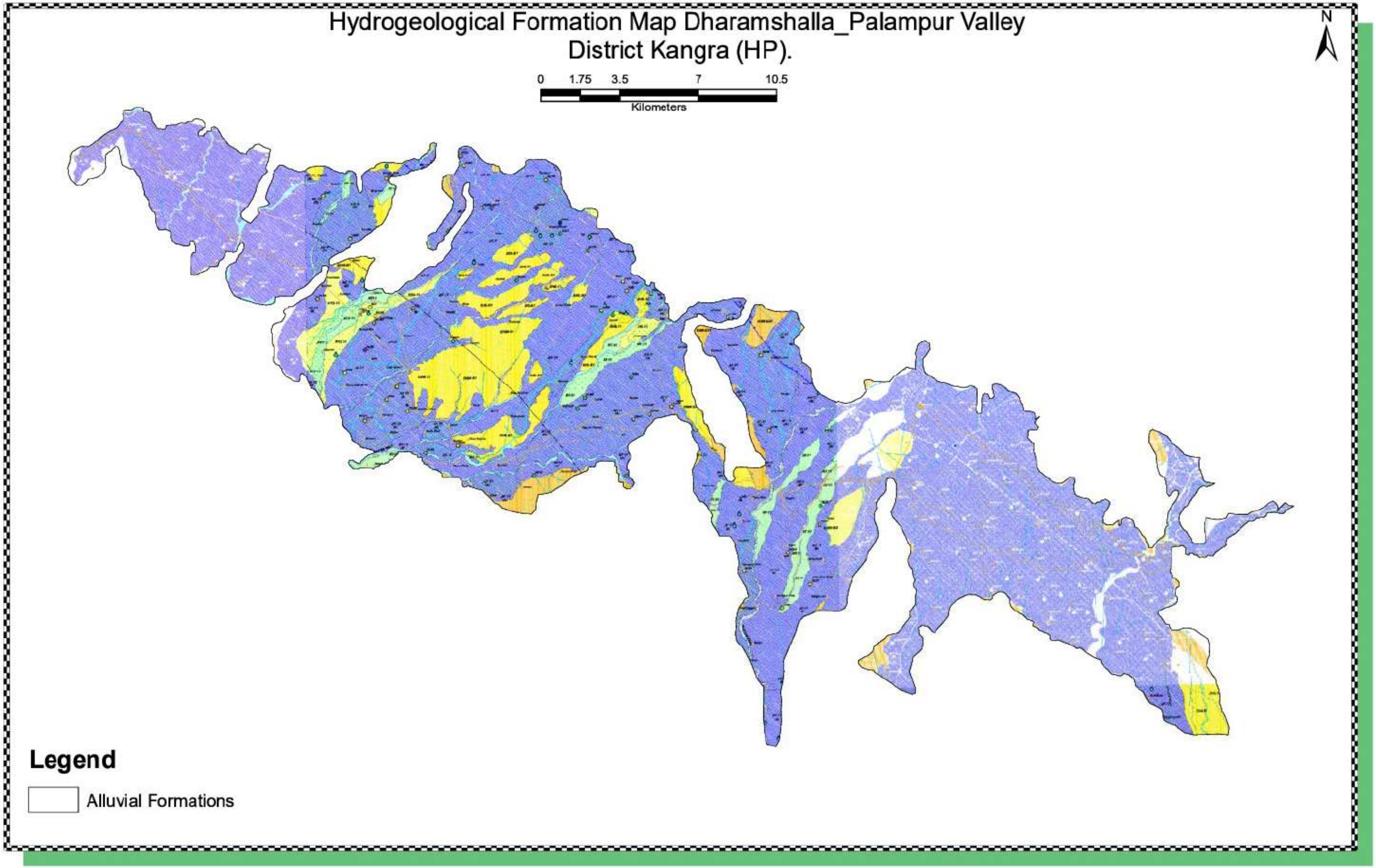

Hydrogeological Formation Map Dharamshalla_Palampur Valley
District Kangra (HP).
0 1.75 3.5 7 10.5
Kilometers
N
Legend
Alluvial Formations

Fig.-12

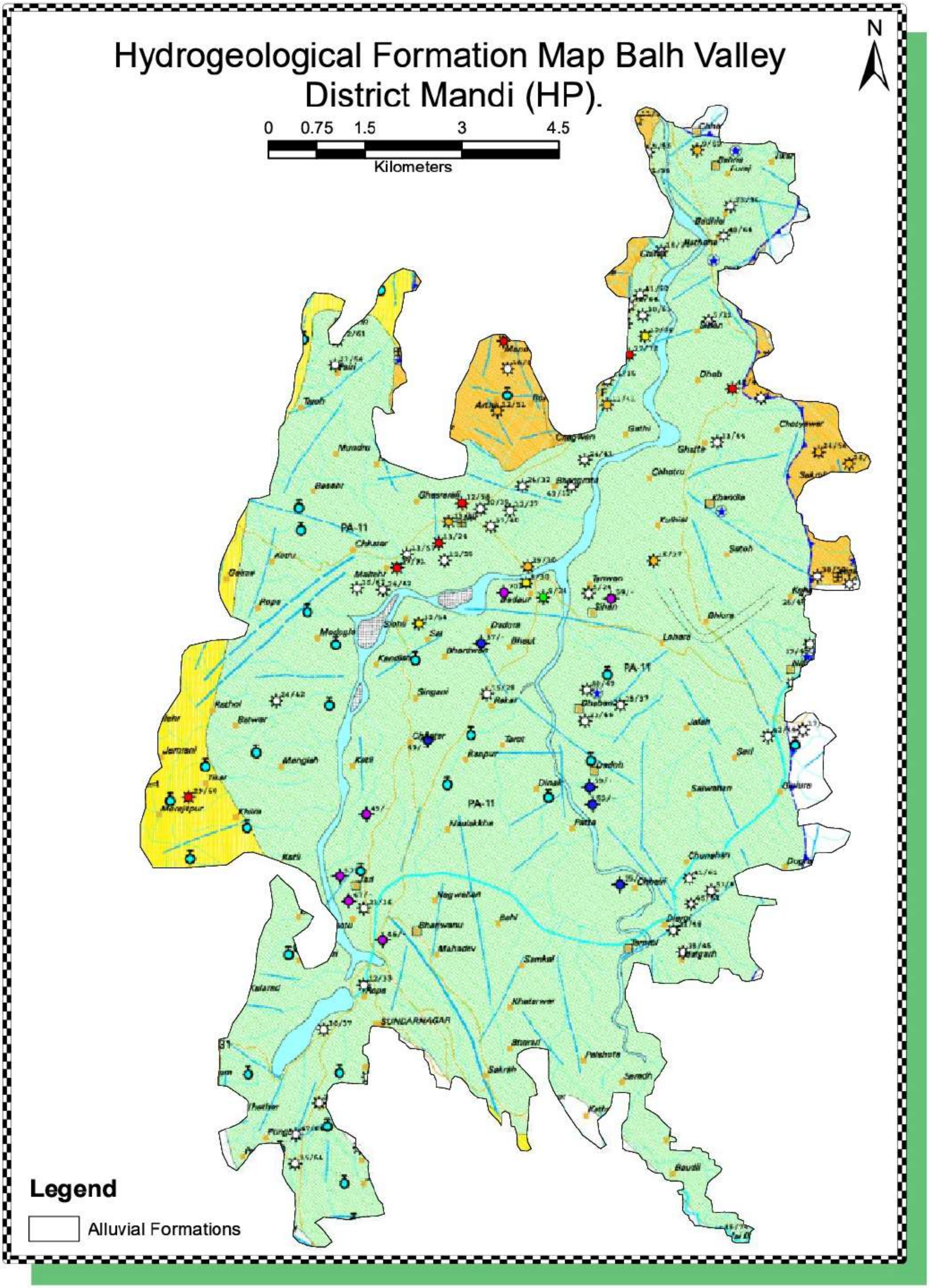
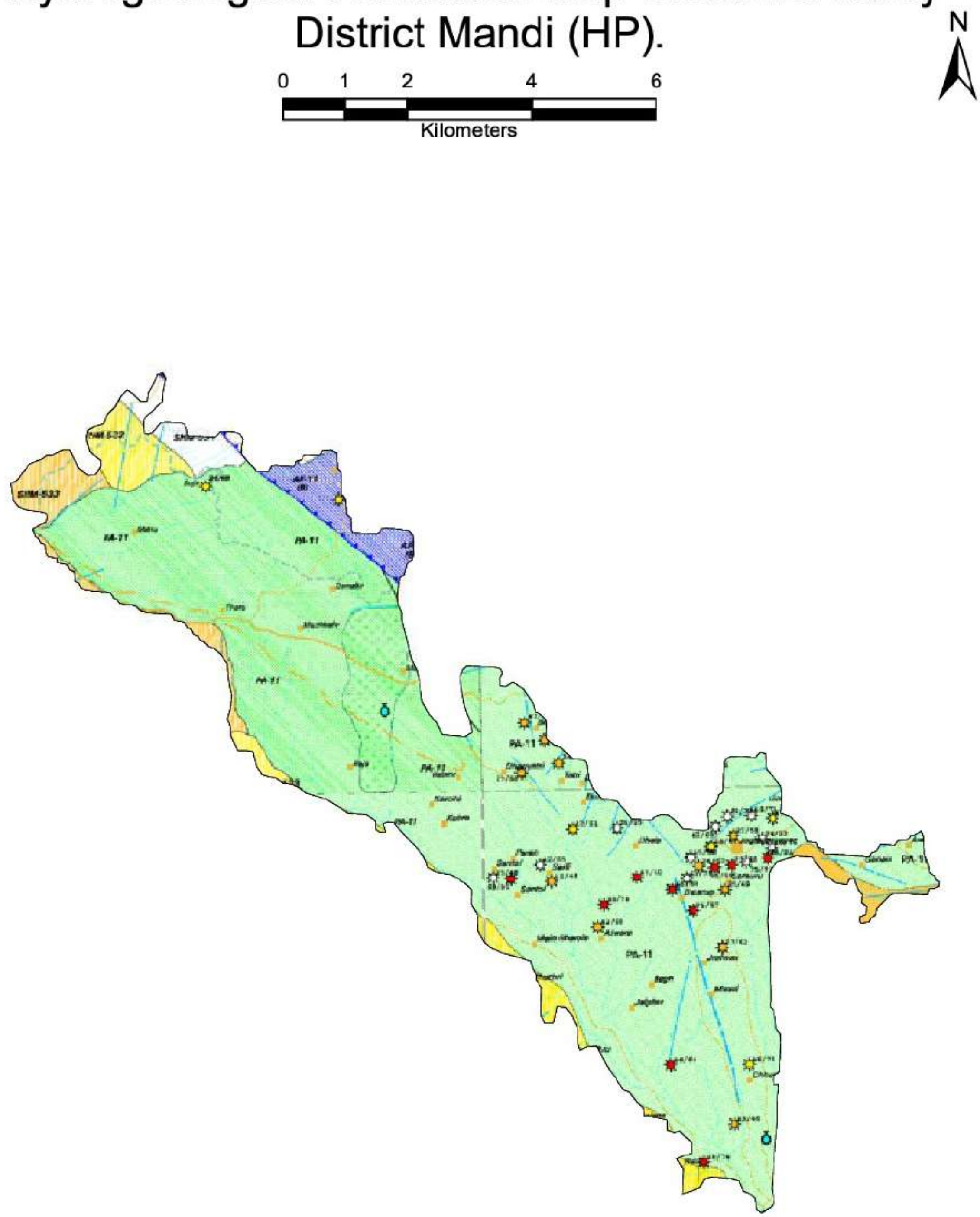

Hydrogeological Formation Map Balh Valley
District Mandi (HP).
N
0 0.75 1.5 3 4.5
Kilometers
PA-11
SUNDARNAGAR
Legend
Alluvial Formations

Fig.-13

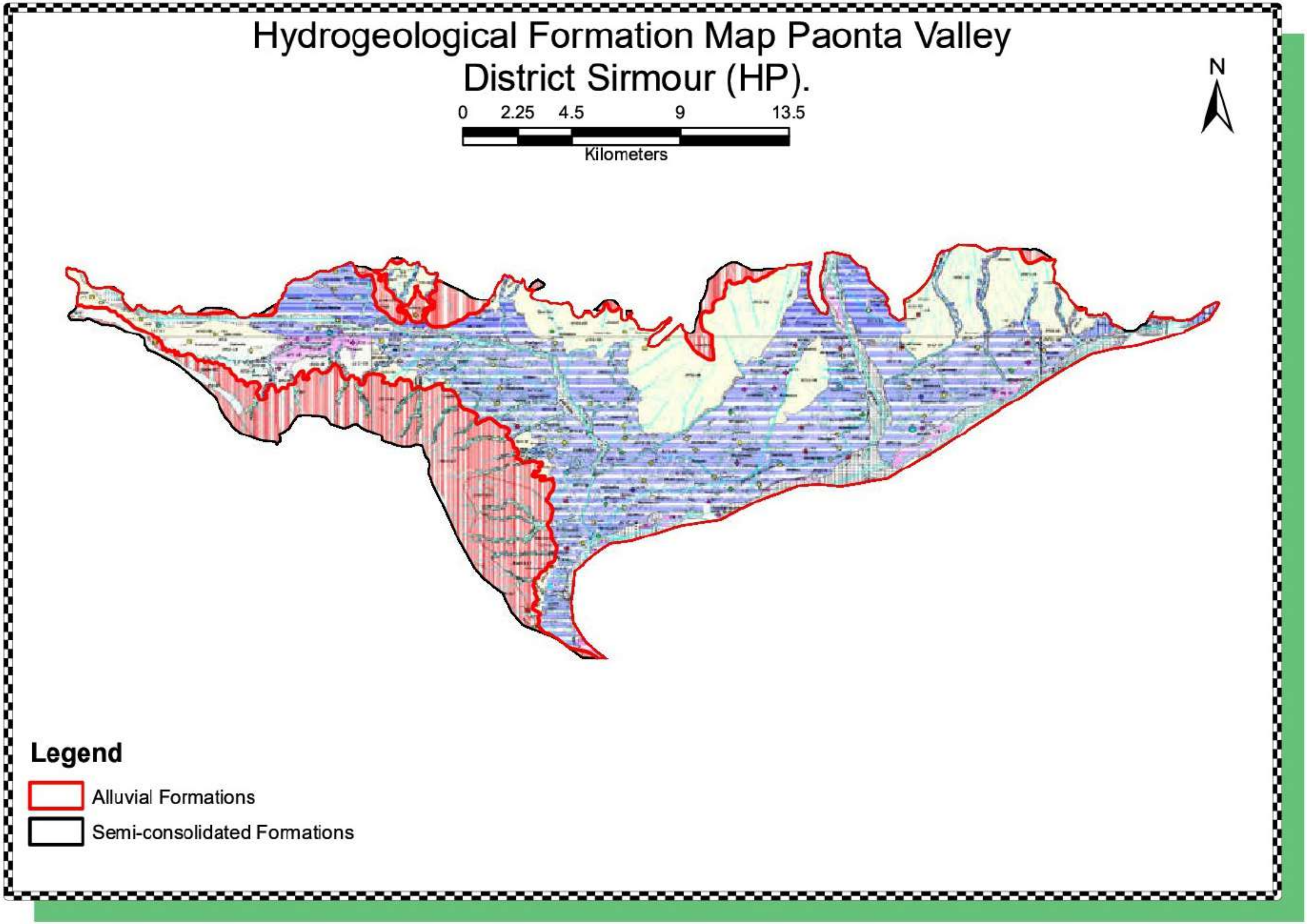
Hydrogeological Formationl Map Chauntra Valley District Mandi (HP).



Legend

Alluvial Formations

Fig.-14



Hydrogeological Formation Map Paonta Valley
District Sirmour (HP).
0
2.25
4.5
9
13.5
Kilometers
N
Legend
Alluvial Formations
Semi-consolidated Formations

Hydrogeological Formation Map Kala Amb Valley District Sirmour (HP).

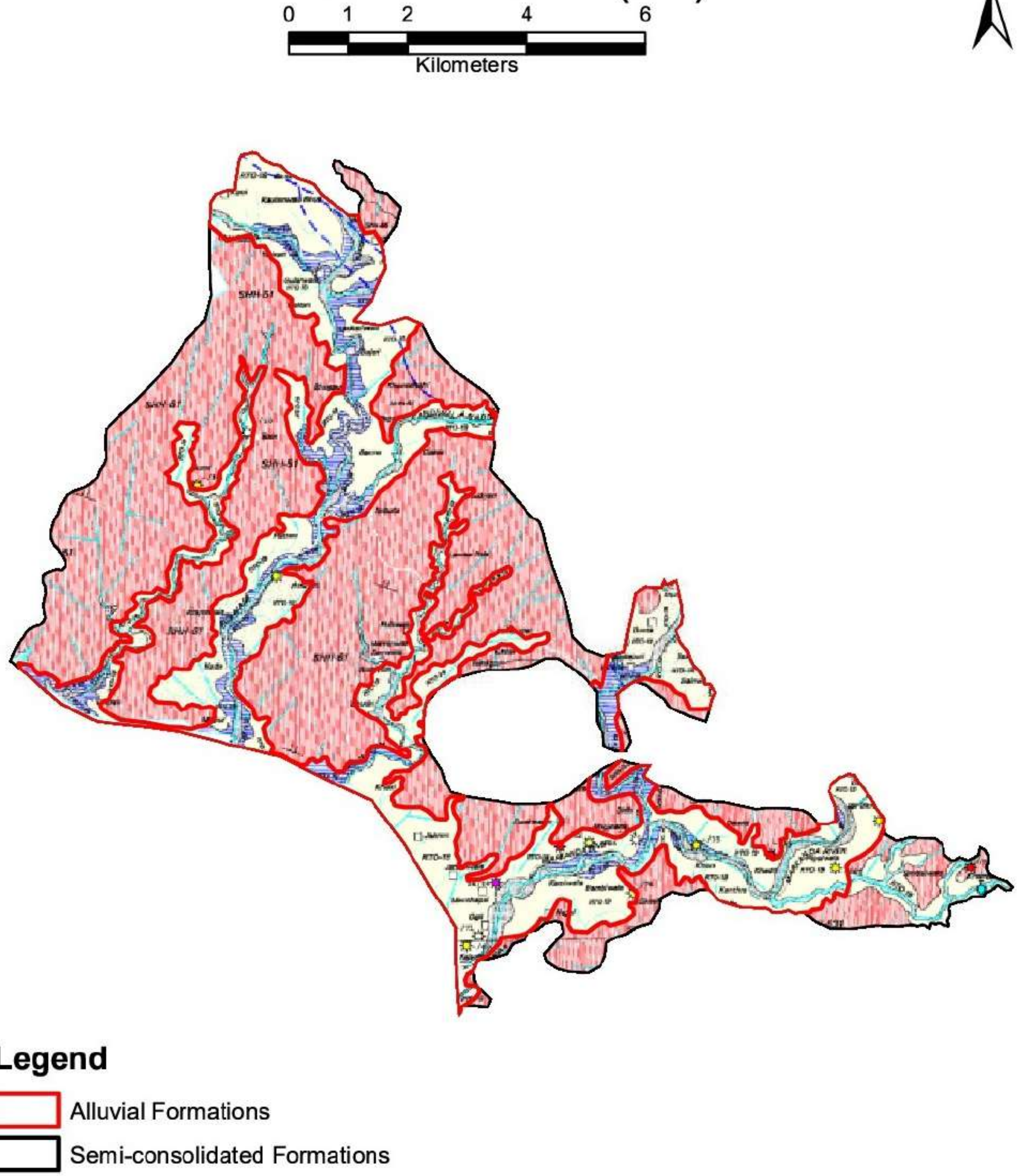


Fig.-16

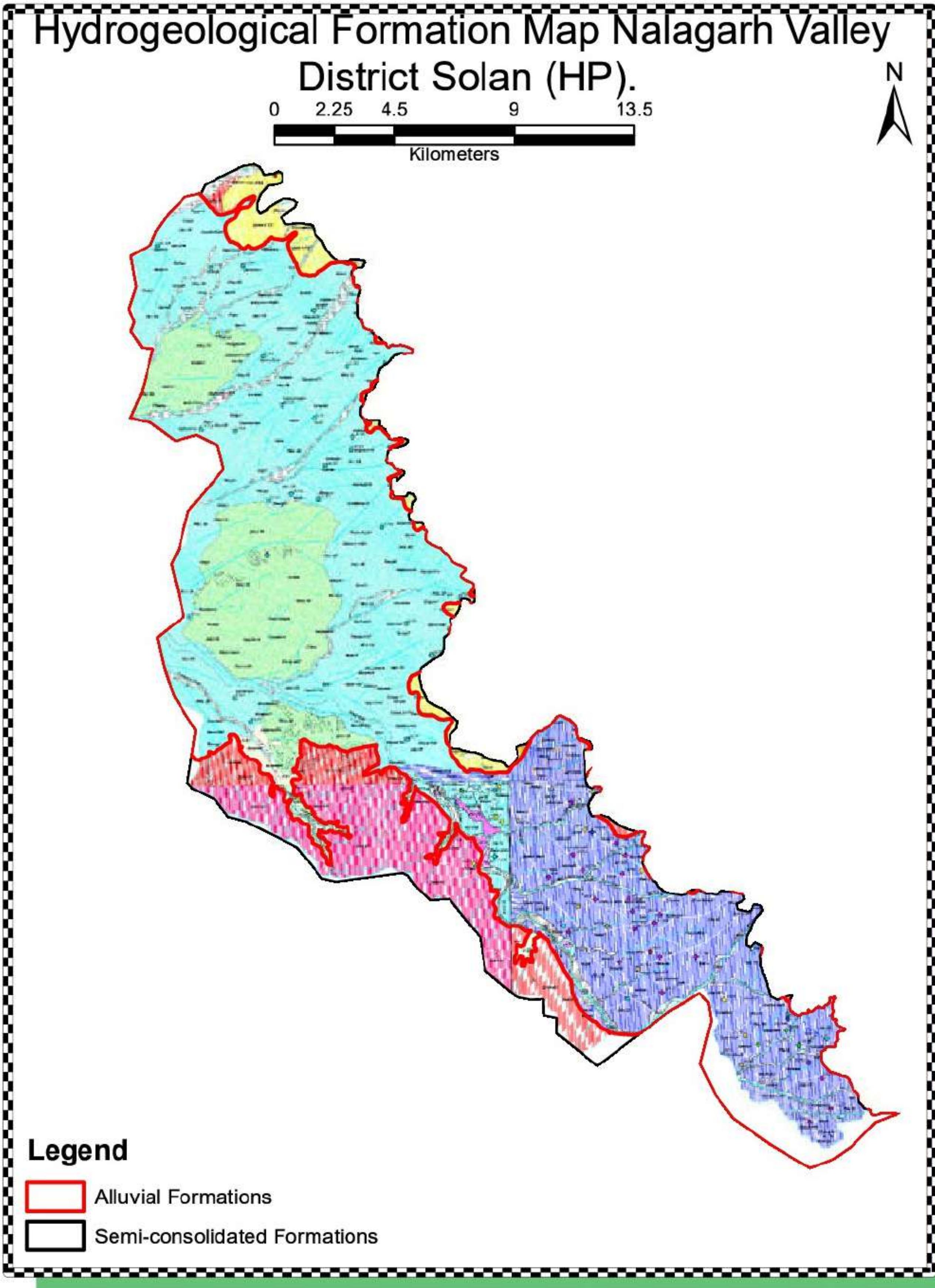
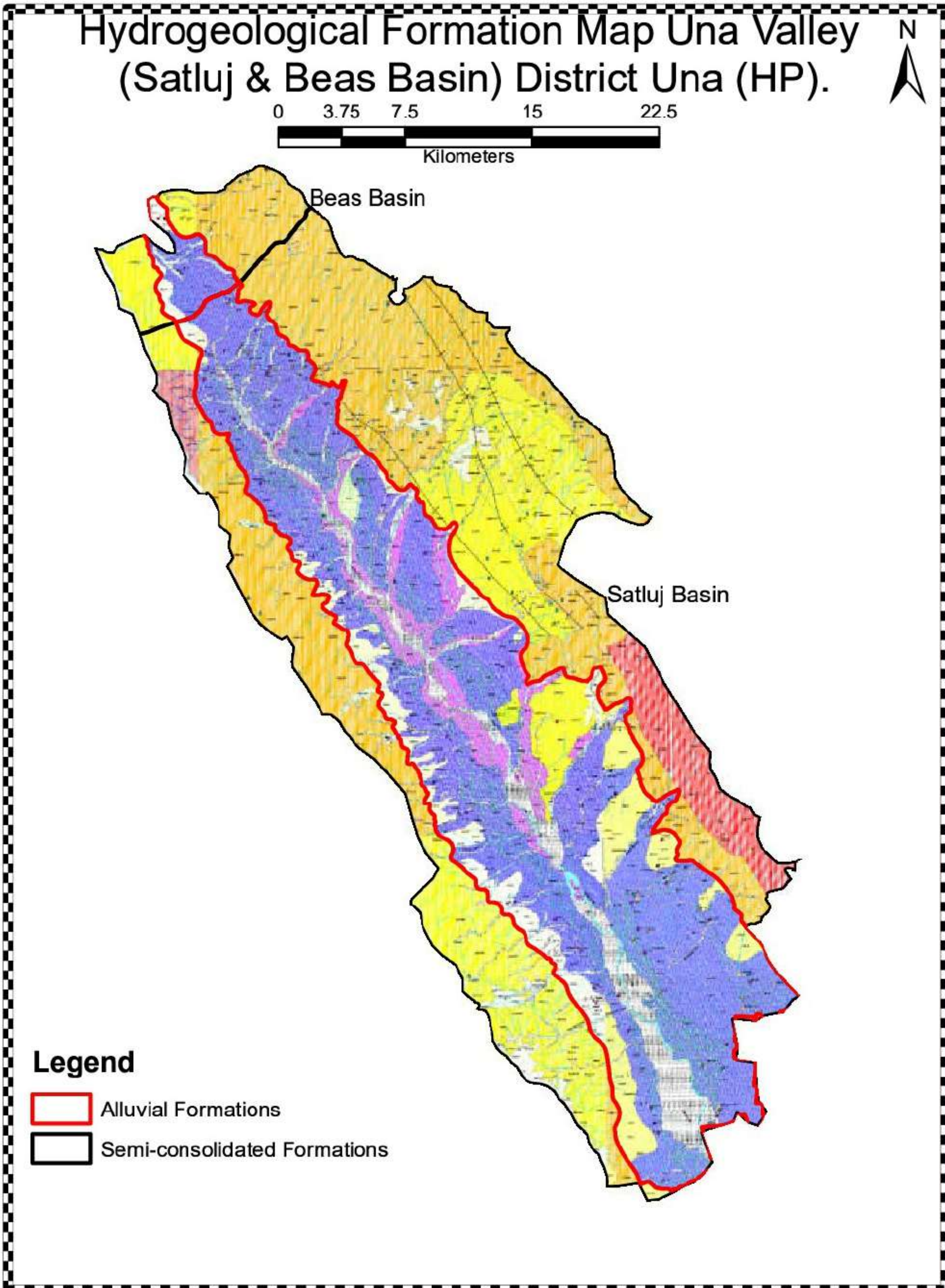
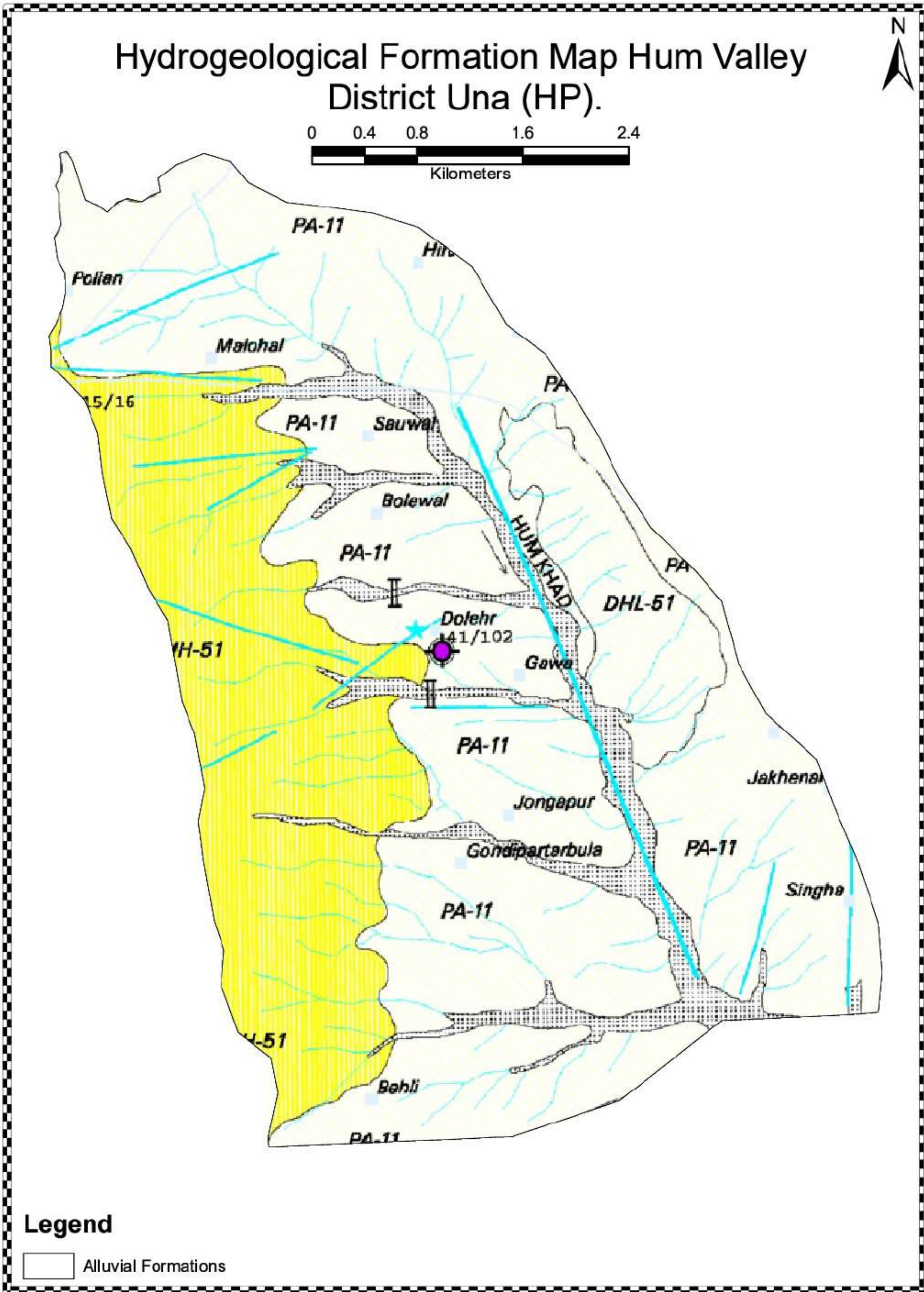

Hydrogeological Formation Map Nalagarh Valley
District Solan (HP).
0 2.25 4.5 9 13.5
Kilometers
N
Legend
Alluvial Formations
Semi-consolidated Formations

Fig.-17



Hydrogeological Formation Map Una Valley
(Satluj & Beas Basin) District Una (HP).
N
0
3.75
7.5
15
22.5
Kilometers
Beas Basin
Satluj Basin
Legend
Alluvial Formations
Semi-consolidated Formations

Fig.-18



Hydrogeological Formation Map Hum Valley
District Una (HP).
N
0
0.4
0.8
1.6
2.4
Kilometers
PA-11
Polian
Malohal
15/16
Sauwal
Bolewal
HUM KHAD
DHL-51
Dolehr
41/102
Gawa
Jakhenal
Jongapur
Gondipartarbula
Singha
Behli
Legend
Alluvial Formations

Annexure-I

DATA VARIABLES USED IN DYNAMIC GROUND WATER RESOURCES OF HIMACHAL PRADESH
(As on March-2023)

Sl. No.	Assessment Unit	Command/ Non command/Poor GW Quality	Rainfall (Average annual Normal) (mm)* *After subtracting 10% of NMR		Average Pre monsoon Water Level (mbgl)	Average Post monsoon Water Level (mbgl)	Average Fluctuation (mbgl)
			Monsoon	Non-Monsoon			
1.	Nurpur-Indora Valley (Kangra District)	Non-Command	1582.1	437.7	5.2	4.42	0.78
2.	Dharamshala Palampur Valley (Kangra District)	Non-Command	1582.1	437.7	6.41	4.75	1.66
3.	Balh Valley (Mandi District)	Non-Command	1093.4	496.1	3.05	3.6	-0.55
4.	Chauntra Valley (Mandi District)	Non-Command	1093.4	496.1	29.59	26.16	3.43
5.	Paonta Valley (Sirmour District)	Non-Command	1324.6	248.6	9.87	8.23	1.64
6.	Kala Amb Valley (Sirmour District)	Non-Command	1324.6	248.6	6.03	6.89	-0.86
7.	Nalagarh Valley (Solan District)	Non-Command	1000.1	366.1	14.14	12.31	1.83
8.	Una Valley Satluj Basin (Una District)	Non-Command	862.7	248.0	7.93	7.43	0.5
9.	Una Valley Beas Basin (Una District)	Non-Command	862.7	248.0	8.13	6.63	1.5
10.	Hum Valley (Una District)	Non-Command	862.7	248.0	144.25	140.4	3.85

Annexure-II

Extraction Data Variables Used in GWRE 2023									
Sr No	Name of Valley	Domestic Use		Irrigation Use		Industrial Extraction		Water Storage	
		No of Structures	Gw Draft in ham	No of Structures	Gw Draft in ham	No of Structures	Gw Extraction in ham	No of Structures	Pondage
1	Indora Nurpur Valley	735	2967.61	1891	5667.1	26	40.71	10	4.36
2	Dharamshala Palampur Valley	2791	2921.34	2	1.25	_	_	_	_
3	Balh Valley	454	632.7	88	262.9	_	_	_	_
4	Chauntra Valley	170	130.305	_	_	_	_	_	_
5	Paonta Valley	75	759.2	522	628.87	64	168.68	_	_
6	Kala Amb valley	27	202.85	37	101.8	77	118.92	_	_
7	Nalagarh Valley	119	1213.01	205	2651.37	223	4917.46	78	8458.61
8	Una Valley (Satluj Basin)	4257	2814.33	5283	8372.29	173	158.85	197	344.82
9	Una Valley (Beas Basin)	67	122.52	33	121.31	2	2.01	_	_
10	Hum Valley	4	103.94	18	299.62	6	6.14	41	49.12
	Total	8699	11867.8	8079	18106.5	571	5412.77	326	8858.353

Senior Hydrogeologist
GWO, JSV Una.

Annexure-III

Extraction Data Variables Used in GWRE 2023				
Sr No	Name of Valley	Surface Irrigation		
		No of Structures	CCA (hectare)	Discharge (ham)/day
1	Indora Nurpur Valley	2	14483.68	111.54
2	Dharamshala Palampur Valley	1	2123	45.88
3	Balh Valley	_	_	_
4	Chauntra Valley	_	_	_
5	Paonta Valley	4	3608.77	36.05
6	Kala Amb valley			
7	Nalagarh Valley	23	2283.65	11.79
8	Una Valley (Satluj Basin)	1	3563	12.31
9	Una Valley (Beas Basin)	_	_	_
10	Hum Valley	1	1122	0.835780822
	Total	**32**	**27184.1**	**218.4057808**

Senior Hydrogeologist
GWO, JSV Una.

Annexure IV

GENERAL DESCRIPTION OF THE GROUND WATER ASSESSMENT UNIT OF THE HIMACHAL PRADESH
(As on March, 2023)

Type of Assessment Unit: Valley area of the District

Sl. No.	Name of Assessment Unit	Type of rock formation	Total Geographical Area (Sq. KM)	Hilly Area	Ground Water Recharge Worthy Area			Flood Prone Area	Bottom of the unconfined aquifer in soft rock areas and depth of weathered zone and/or maximum depth of fractures under unconfined zone
					Command area	Non-command area (Valley area)	Poor ground water quality area		
1	2	3	4	5	6	7	8	9	
1.	**A. Nurpur & Indora valley (Kangra District)**	Valley fill	1024	**Nil**	**Nil**	1024	**Nil**	**Nil**	
2.	**B Dharamshala Palampur Valley**	Valley fill	452	**Nil**	**Nil**	452	**Nil**	**Nil**	
3.	**A. Balh valley Mandi District**	Valley fill	107	**Nil**	**Nil**	107	**Nil**	**Nil**	
4.	**A. Paonta Valley Sirmour District**	Valley fill	276	**Nil**	**Nil**	276	**Nil**	**Nil**	
5.	**B. Kala Amb Valley Sirmour District**	Valley fill	82	**Nil**	**Nil**	82	**Nil**	**Nil**	
6	**A. Nalagarh valley Solan District**	Valley fill	336	**Nil**	**Nil**	336	**Nil**	**Nil**	
7	**A. Una valley (Sutlej Catchment) Una Dist**	Valley fill	1045	**Nil**	**Nil**	1045	**Nil**	**Nil**	
8	**B. Hum valley Una District**	Valley fill	29	**Nil**	**Nil**	29	**Nil**	**Nil**	
9	**Una Valley Beas Catchment**	**Valley fill**	65	**Nil**	**Nil**	65	**Nil**	**Nil**	
10	**Chauntra Valley Mandi District**	**Valley fill**	52	**Nil**	**Nil**	52	**Nil**	**Nil**	

Annexure V

GENERAL DESCRIPTION OF THE ADMINISTRATIVE UNIT OF THE HIMACHAL PRADESH
(As on March, 2023)

Type of Administrative Unit: Valley

S.No	DISTRICT	ASSESSMENT UNIT	Total Geographical Area(ha)					
			Recharge Worthy				Hilly Area	**Total**
			C	NC	PQ	**Total**		
1	MANDI	BALH VALLEY	0	10,700	0	10,700	28,800	39,500
2		CHAUNTRA VALLEY	0	5,200	0	5,200	0	5,200
3	KANGRA	DHARAMSHALA PALAMPUR VALLEY	0	45,200	0	45,200	0	45,200
4	UNA	HUM VALLEY	0	2,900	0	2,900	3,679	6,579
5	SIRMOUR	KALA AMB VALLEY	0	8,200	0	8,200	0	8,200
6	SOLAN	NALAGARH VALLEY	0	33,600	0	33,600	0	33,600
7	KANGRA	NURPUR & INDAURA VALLEY	0	1,02,400	0	1,02,400	0	1,02,400
8	SIRMOUR	POANTA VALLEY	0	27,600	0	27,600	0	27,600
9	UNA	UNA VALLEY BEAS CATCHMENT	0	6,500	0	6,500	0	6,500
10		UNA VALLEY SUTLEJ CATCHMENT	0	1,04,500	0	1,04,500	0	1,04,500
		TOTAL	0	3,46,800	0	3,46,800	32,479	3,79,279

Annexure VI

DATA VARIABLES USED IN DYNAMIC GROUND WATER RESOURCES OF HIMACHAL PRADESH
(As on March, 2023)

Sl.No.	Assessment Unit	Command/ Non command/Poor GW Quality	Rainfall (Average annual Normal) (mm)* *After subtracting 10% of NMR		Average Pre monsoon Water Level (mbgl)	Average Post monsoon Water Level (mbgl)	Average Fluctuation (mbgl)
			Monsoon	Non- Monsoon			
1.	**Nurpur-Indora Valley** (Kangra District)	**Non-Command**	1582.1	437.7	5.2	4.42	0.78
2.	**Dharamshala Palampur Valley** (Kangra District)	**Non-Command**	1582.1	437.7	6.41	4.75	1.66
3.	**Balh Valley** (Mandi District)	**Non-Command**	1093.4	496.1	3.05	3.6	-0.55
4.	**Chauntra Valley** (Mandi District)	**Non-Command**	1093.4	496.1	29.59	26.16	3.43
5.	**Paonta Valley** (Sirmour District)	**Non-Command**	1324.6	248.6	9.87	8.23	1.64
6.	**Kala Amb Valley** (Sirmour District)	**Non-Command**	1324.6	248.6	6.03	6.89	-0.86
7.	**Nalagarh Valley** (Solan District)	**Non-Command**	1000.1	366.1	14.14	12.31	1.83
8.	**Una Valley Satluj Basin** (Una District)	**Non-Command**	862.7	248.0	7.93	7.43	0.5
9.	**Una Valley Beas Basin** (Una District)	**Non-Command**	862.7	248.0	8.13	6.63	1.5
10.	**Hum Valley** (Una District)	**Non-Command**	862.7	248.0	144.25	140.4	3.85

SOURCE: RAINFALL DAT; IMD, WATER LEVEL DATA; CGWB & JSV

Annexure VI (contd…) DATA VARIABLES USED IN DYNAMIC GROUND WATER RESOURCES OF THE HIMACHAL PRADESH (As on March 2023)

Sr.No.	Assessment Unit	Assessment Sub-Unit	Type of Structures	Irrigation	Domestic	Industrial
1	**Nurpur Indora Valley** (Kangra District)	Non Command	DW (Manual Lift)	1891	735	26
			DW with electric/diesel pump			
			STW			
			Others (Percolation well)			
2	**(Dharamshala Palampur Valley)**(Kangra District)	Non Command	DW (Manual Lift)			
			DW with electric/diesel pump			
			STW			
			Others (Percolation well)	2	2791	0
3	**Balh Valley** Mandi District	Non Command	DW (Manual Lift)			
			DW with electric/diesel pump			
			STW			
			Others (Percolation well)	88	454	0
4	**Chauntra Valley** Mandi District	Non Command	DW (Manual Lift)			
			DW with electric/diesel pump			
			STW			
			Others (Percolation well)	0	170	0
5	**Paonta Valley** (Sirmour District	Non Command	DW (Manual Lift)			
			DW with electric/diesel pump			
			STW			
			Others (Percolation well)	522	75	64
6	**Kala Amb Valley** (Sirmour District)	Non Command	DW (Manual Lift)			
			DW with electric/diesel pump			
			STW			
			Others (Percolation well)	37	27	77
7	A. Nalagarh Valley (Solan District	Non Command	DW (Manual Lift)			
			DW with electric/diesel pump			
			STW			
			Others (Percolation well)	205	119	223

Sr.No.	Assessment Unit	Assessment Sub-Unit	Type of Structures	Irrigation	Domestic	Industrial
8	**Una Valley Satluj Basin** (Una District)	Non Command	DW (Manual Lift)			
			DW with electric/diesel pump			
			STW			
			Others (Percolation well)	5283	4257	173
9	**Una Valley Beas Basin** (Una District)	Non Command	DW (Manual Lift)			
			DW with electric/diesel pump			
			STW			
			Others (Percolation well)	33	67	2
10	**Hum Valley** (Una District)	Non Command	DW (Manual Lift)			
			DW with electric/diesel pump			
			STW			
			Others (Percolation well)	18	4	6

SOURCE: JAL SHAKTI VIBHAG, GOVT. OF HP

Annexure VII

The Annual rainfall of the valley areas (in mm)
2023

Name of Assessment Unit	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Monsoon	Non-Monsoon
Nurpur Indora Valley, DharmshalaPalampur valley District Kangra	197	57.6	6.9	2.2	66.3	117	614.6	614.7	256.5	59.7	12.8	5.7	1602.8	408.2
Balh Valley, Chauntra Valley District Mandi	151.3	73.1	8.5	11	95.6	128.4	451.3	496.8	139.7	53.1	6.2	2.4	1216.2	401.2
Paonta/ Kala Amb Valley District Sirmaur	264	100.9	0.4	0.2	83.1	84.4	381.6	278.6	318.6	80.3	0.1	0.5	1063.2	529.5
Nalagarh Valley District Solan	248.1	83.9	2.4	1.4	70.9	111.9	381.7	306.5	177.3	45.7	0.9	0.2	977.4	453.5
Hum/Una Valley District Una	177	40.1	0.9	1.7	17.6	107.3	325.4	148.1	164.2	11.8	0	0.7	745	249.8

Source: Indian Meteorological Department (https://mausam.imd.gov.in/shimla/)

Annexure VIII

PARAMETERS USED IN THE ASSESSMENT OF DYNAMIC GROUND WATER RESOURCES OF HIMACHAL PRADESH (As on March, 2023)

Sl. No.	Assessment Unit	Specific Yield *(in fraction)*		Rainfall Infiltration Factor *(in fraction)*		Area Wise Extraction (ham)					
						Irrigation		Domestic		Industrial	
		Formation	*Value*	*Formation*	*Value*	*Com*	*Non-Com*	*Com*	*Non-Com*	*Com*	*Non-Com*
1.	Balh Valley	Valley Fill	0.16	Valley Fill	0.22	--	262.92	--	632.73	--	00
2.	Chauntra Valley	Valley Fill	0.16	Valley Fill	0.22	--	0	--	217.175	--	00
3.	Dharamshala Palampur Valley	Valley Fill	0.16	Valley Fill	0.22	--	1.26	--	2921.34	--	00
4.	Hum Valley	Valley Fill	0.16	Valley Fill	0.22	--	299.62	--	103.94	--	6.14
5.	Kala Amb Valley	Valley Fill	0.16	Valley Fill	0.22	--	101.8	--	202.85	--	118.924
6.	Nalagarh Valley	Valley Fill	0.16	Valley Fill	0.22	--	2651.37	--	1213.01	--	4917.46
7.	Nurpur & Indaura Valley	Valley Fill	0.16	Valley Fill	0.22	--	5651.95	--	2967.61	--	40.71
8.	Poanta Valley	Valley Fill	0.16	Valley Fill	0.22	--	628.871	--	759.20	--	168.676
9.	Una Valley Beas Catchment	Valley Fill	0.16	Valley Fill	0.22	--	121.307	--	122.52	--	3.338
10	Una Valley Sutlej Catchment	Valley Fill	0.16	Valley Fill	0.22	--	8372.29	--	2814.33	--	158.85
					TOTAL	--	**18091.4**	--	**11954.7**	--	**5414.1**

Annexure IX

ASSESSMENT OF DYNAMIC GROUND WATER RESOURCES OF HIMACHAL PRADESH (As on March, 2023) (in ham)

Sr. NO.	Assessment Unit/District	Area (ha)	Command/ non Command /Total	Rainfall Recharge	Recharge from other sources	Ground Water Recharge (ham)	Enviormental Flows (10% of GW recharge in RIF method & 5 % of GW recharge in WTF)	Net Annual Ground Water Extractability	Existing Grosss ground water extraction for Irrigation	Existing Gross Ground Water extraction for domestic water supply	Existing Gross Ground Water extraction for Industrial Purpose	Existing gross ground water extraction for All uses (11+12+13)
									11	12	13	14
1	Nurpur Indora Valley (Kangra District)	102400	Command	–	-	-	-		–	–		
			Non-Command	24207.8	17407.0	41614.8	4161.48	37453.32	5651.95	2967.61	40.71	8660.27
			Total	24207.8	17407.0	41614.8	4161.48		5651.95	2967.61	40.71	
2	Dharmshala Palampur Valley (Kangra District)	45200	Command	–	–	–	–					
			Non-Command	13323.13	370.60	13693.73	1369.37	12324.36	1.26	2921.34	0.00	2922.6
			Total	13323.13	370.60	13693.73	1369.37		1.26	2921.34	0.00	
3	Balh Valley Mandi District	10700	Command	–	–	–	–					
			Non-Command	3032.24	83.02	3115.26	311.52	2803.74	262.92	632.73	0.00	895.65
			Total	3032.24	83.02	3115.26	311.52		262.92	632.73	0.00	
4	Chauntra Valley (Mandi District)	5200	Command	–	–	–	–	5007.79				
			Non-Command	1424.75	3846.61	5271.36	263.57		0.00	217.175	0.00	217.18
			Total	1424.75	3846.61	5271.36	263.57		0.00	217.175	0.00	
5	Paonta Valley (Sirmour District)	27600	Command	–	-	–	–	7544.93				
			Non-Command	8184.12	199.14	8383.26	838.33		628.9	759.196	168.676	1556.75
			Total	8184.12	199.14	8383.26	838.33		628.9	759.196	168.676	
6	Kala Amb Valley (Sirmour District)	8200	Command	–	–	–	–					
			Non-Command	1666.89	25.45	1692.34	169.23	1523.11	101.8	202.85	118.924	423.58
			Total	1666.89	25.45	1692.34	169.23		101.8	202.85	118.924	
7	Nalagarh Valley (Solan District)	33600	Command	–								
			Non-Command	7630.74	8560.12	16190.85	809.54	15381.31	2651.37	1213.01	4917.46	8781.84
			Total	7630.74	8560.12	16190.85	809.54		2651.37	1213.01	4917.46	

Sr. NO.	Assessment Unit/District	Area (ha)	Command/ non Command /Total	Rainfall Recharge	Recharge from other sources	Ground Water Recharge (ham)	Enviormental Flows (10% of GW recharge in RIF method & 5 % of GW recharge in WTF)	Net Annual Ground Water Extractability	Existing Grosss ground water extraction for Irrigation	Existing Gross Ground Water extraction for domestic water supply	Existing Gross Ground Water extraction for Industrial Purpose	Existing gross ground water extraction for All uses (11+12+13)
									11	12	13	14
8	**Una Valley (Satluj Basin) (Una District)**	**104500**	Command	–				17736.04				11345.48
			Non-Command	13207.30	6499.42	19706.71	1970.67		8372.29	2814.33	158.85	
			Total	13207.30	6499.42	19706.71	1970.67		8372.29	2814.33	158.85	
9	**Una Valley (Beas Basin) (Una District)**	**6500**	Command	–	–	–	–	950.87				247.17
			Non-Command	1018.11	38.41	1056.52	105.65		121.31	122.52	3.338	
			Total	1018.11	38.41	1056.52	105.65		121.31	122.52	3.338	
10	**Hum Valley (Una District)**	**2900**	Command					727.66				409.70
			Non-Command	590.02	175.94	765.96	38.3		299.62	103.94	6.14	
			Total	590.02	175.94	765.96	38.3		299.62	103.94	6.14	

Annexure IX (contd…)

ASSESSMENT OF DYNAMIC GROUND WATER RESOURCES OF HIMACHAL PRADESH (As on March, 2023) (in ha m)

S.N.	Assessment Unit/District	Area (ha)	Rainfall Recharge	Recharge from other sources	Ground Water Recharge (ham) Col(4+5)	Environmental Flows	Annual Extractable Ground Water Resource (ham) Col(7-6)	Ground Water Extraction for all Uses	Provision for domestic supply upto 2025	Net Ground Water Extractability for future use (ham)	Stage of Ground Water Extraction (%)
1	2	3	4	5	6	7	8	9	10	11	12
1	Nurpur Indora Valley	102400	24207.80	17407.00	41614.8	4161.48	37453.32	8660.27	2967.61	28793.05	23.12
2	Dharmshala Palampur Valley	45200	13323.13	370.60	13693.73	1369.37	12324.36	2922.60	2921.34	9401.76	23.71
3	Balh Valley	10700	3032.24	83.02	3115.26	311.52	2803.74	895.65	632.73	1908.09	31.94
4	Chauntra Valley	5200	1424.75	3846.61	5271.36	263.57	5007.79	217.18	217.18	4790.60	4.34
5	Paonta Valley	27600	8184.12	199.14	8383.26	838.33	7544.93	1556.75	759.20	5988.18	20.63
6	Kala Amb Valley	8200	1666.89	25.45	1692.34	169.23	1523.11	423.58	202.85	1099.53	27.81
7	Nalagarh Valley	33600	7630.74	8560.12	16190.85	809.54	15381.31	8781.84	1213.01	6599.47	57.09
8	Una Valley (Satluj Basin)	104500	13207.30	6499.42	19706.71	1970.67	17736.04	11345.48	2814.33	6390.56	63.97
9	Una Valley (Beas Basin)	6500	1018.11	38.41	1056.52	105.65	950.87	247.17	122.52	703.70	25.99
10	Hum Valley	2900	590.02	175.94	765.96	38.3	727.66	409.70	103.94	317.96	56.30
	TOTAL	346800	74285.1	37205.71	111490.8	10037.66	101453.1	35460.22	11954.71	65992.9	34.95

Annexure X

ASSESSMENT OF DYNAMIC GROUND WATER RESOURCES OF HIMACHAL PRADESH ASSESSMENT UNIT-WISE CATEGORIZATION (As on March, 2023)

Sl. No.	Assessment Unit/Sub Unit*	Stage of Ground Water Extraction (%)	Pre-monsoon		Post-monsoon		Category (Safe/ Semi-critical/ Critical/ Over-exploited)
			Water level Trend	Is there a significant decline (Yes/ No)	Water level Trend	Is there a significant decline (Yes/ No)	
1	**A. Nurpur & Indora valley**(Kangra District)	**23.12**	Falling	**No**	Falling	**No**	**Safe**
2.	**B Dharamshala Palampur Valley**	**23.71**	Falling	**No**	Falling	**No**	**Safe**
3.	**A. Balh valley** Mandi District	**31.94**	Falling	**No**	Falling	**No**	**Safe**
4.	**A. Paonta Valley** Sirmour District	**20.63**	Falling	**No**	Falling	**No**	**Safe**
5.	**B. Kala Amb Valley** Sirmour District	**27.81**	Falling	**No**	Falling	**Yes**	**Safe**
6.	**A. Nalagarh valley** Solan District	**57.09**	Falling	**No**	Falling	**Yes**	**Safe**
7.	**A. Una valley (Sutlej Catchment)** Una Dist	**63.97**	Falling	**No**	Falling	**No**	**Safe**
8.	**B. Hum valley** Una District	**56.30**		**Long Term Data Not Available**			**Safe**
9.	**Una Valley** Beas Catchment	**25.99**	Falling	**No**	Falling	**No**	**Safe**
10.	**Chauntra Valley**	**4.34**	Falling	**No**	Falling	**No**	**Safe**

Annexure XI

ASSESSMENT OF DYNAMIC GROUND WATER RESOURCES OF HIMACHAL PRADESH ADMINISTRATIVE UNIT-WISE CATEGORIZATION (As on March, 2023)

Sl. No.	Assessment Unit/Sub Unit*	C. D. BLOCK	Stage of Ground Water Extraction (%)	Pre-monsoon		Post-monsoon		Category (Safe/ Semi-critical/ Critical/ Over-exploited)
				Water level Trend	Is there a significant decline (Yes/ No)	Water level Trend	Is there a significant decline (Yes/ No)	
1	A. Nurpur & Indora valley(Kangra District)	Nurpur, Indaura, Fatehpur, Jwali, Dehra Gopipur, Jaswan	23.12	Falling	No	Falling	No	Safe
2.	B Dharamshala Palampur Valley	Kangra, Palampur, Dharamshala, Baijnath	23.71	Falling	No	Falling	No	Safe
3.	A. Balh valley Mandi District	Mandi Sundernagar	31.94	Falling	No	Falling	No	Safe
4.	A. Paonta Valley Sirmour District	Paonta Sahib, Nahan	20.63	Falling	No	Falling	No	Safe
5.	B. Kala Amb Valley Sirmour District	Nahan	27.81	Falling	No	Falling	Yes	Safe
6.	A. Nalagarh valley Solan District	Nalagarh, Baddi	57.09	Falling	No	Falling	Yes	Safe
7.	A. Una valley (Sutlej Catchment) Una Dist	Amb, Una, Bangana, Haroli	63.97	Falling	No	Falling	No	Safe
8.	B. Hum valley Una District	Haroli	56.30		No observation Wells			Safe
9.	Una Valley Beas Catchment	Amb	25.99	Falling	No	Falling	No	Safe
10.	Chauntra Valley	Jogindernagar, Baijnath	4.34	Falling	No	Falling	No	Safe

CONTRIBUTORS

CENTRAL GROUND WATER BOARD, NHR, DHARAMSHALA

1. Shri J. N Bhagat, Scientist 'D'
2. Shri Sanjay Pandey, Scientist 'B'
3. Shri Prasant Kumar Singh, STA (Hg.)

GROUND WATER ORGANISATION, JAL SHAKTI VIBHAG, HIMACHAL PRADESH

1. Shri Bhavnesh Sharma, Senior Hydrogeologist
2. Shri Vinod Srivastava, Junior Hydrogeologist
3. Shri Kalit Rana, STA
4. Shri Dinesh Bhardwaj, STA
5. Shri Vinod Chauhan , STA
6. Shri Anil Sood, STA
7. Shri Rakesh Sharma, STA
8. Shri Chanchal Kumar, STA
9. Shri Vinod Sharma, STA
10. Shri Devesh Kumar, STA
11. Ms. Ajay Kiran, STA