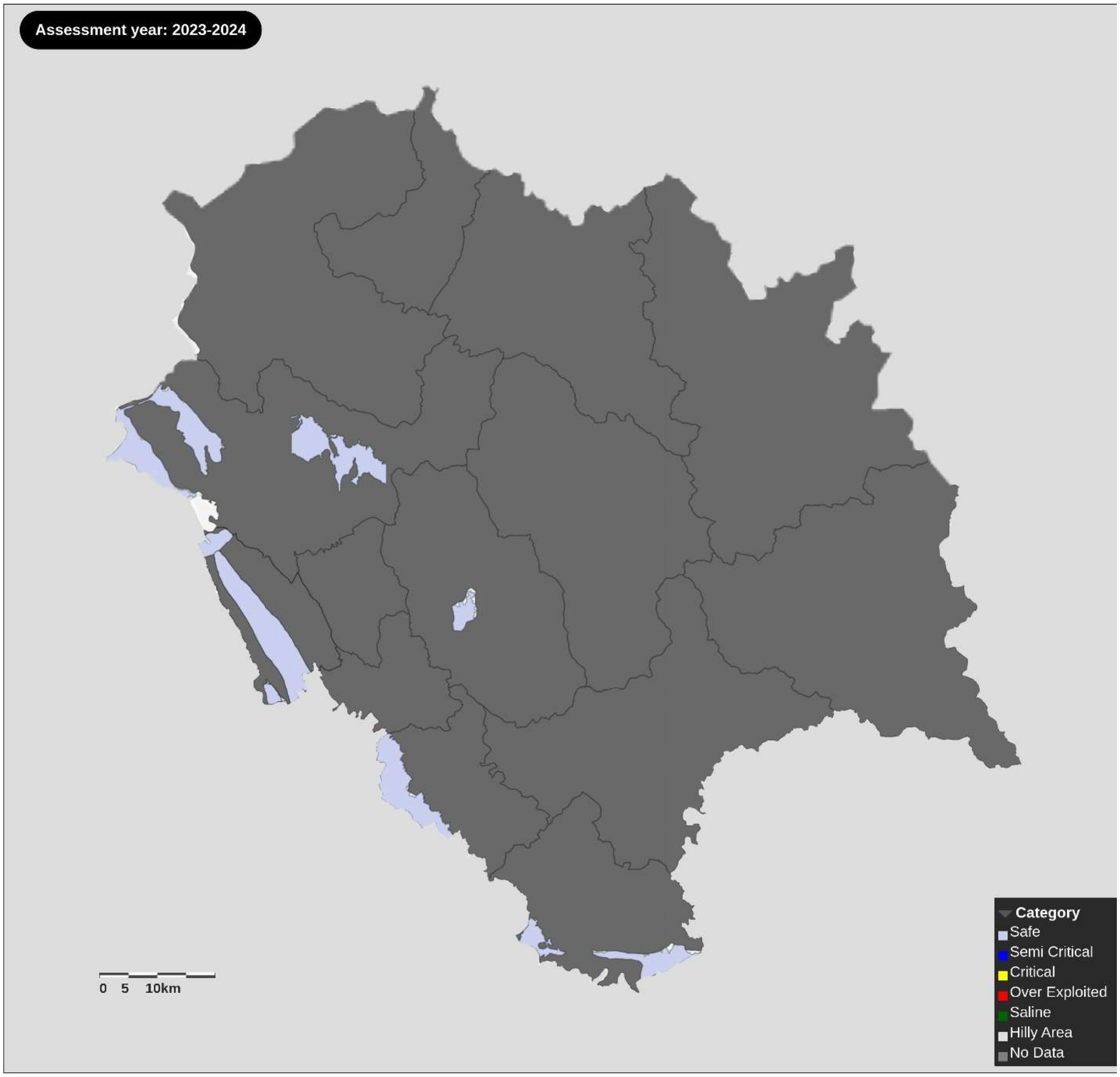
DYNAMIC GROUND WATER RESOURCES OF HIMACHAL PRADESH

(March 2024)



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.)

DHARAMSHALA
JANUARY-2025

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A Report by:

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JANUARY-2025

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FOREWORD

Ground water is a major source of water in India & globally. In India, more than 85 % of water supplies for domestic use in rural area, 50% of water for urban areas and 55% of irrigation water requirement are being met through groundwater. In Himachal Pradesh, situation is little different. Most of the drinking water schemes and irrigation schemes are based on spring sources and river water in hilly areas and tube wells and dug wells in valley are as of Himachal Pradesh. However, ground water remains an important source of water for Himachal as it forms critical part of overall aquatic system.

Ground water resources, although replenishable, but are not inexhaustible. The increasing demand on this resource over the years has led to water scarcity in many parts of the world. During the past two decades, the water level in many parts of the county has been falling rapidly due to increase in extraction & resulted into over-exploitation of this resource. 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 investigations oriented towards 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 inter mountain 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 helpful and supportive for water management, conservation and sustainable development of this precious resource for all the user agencies in the State.

(Onkar Chand Sharma), IAS

टी. एस. अनीता श्याम
सदस्य (दक्षिण)
T. S. Anitha Shyam
Member (South)

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

PREFACE

Groundwater plays an important role in the Nation's economic growth and forms a vital component of our ecological system. India’s agricultural productivity, industrial output, and domestic water supply are heavily reliant on groundwater. However, rising water demands have led to excessive groundwater extraction in many parts of India, exceeding the annual replenishment leading to decline in groundwater level. A thorough assessment of this hidden resources is essential for developing strategies for management and regulatory measures. Since 2022, it has been decided to carry out the estimation of the Dynamic Groundwater Resources of the nation every year to provide the planners, decision makers and all stakeholders with reliable data/information for taking timely measures for sustainable management of groundwater resources.

The assessment of dynamic groundwater resources of the Country is based on the Groundwater Estimation Methodology of 2015 (GEC-2015), which comprehensively factors in all relevant parameters contributing to groundwater recharge and extraction. The Dynamic Groundwater Resource Assessment of 2024 (GWRA-2024) for all States and Union Territories is a collaborative effort involving both the respective State/UT Ground Water Departments and the Central Ground Water Board, utilizing the INDIA-Ground Water
Resource Estimation System (IN-GRES) Software.

I extend my heartfelt appreciation to the dedicated officers of CGWB, CHQ, for their significant role in compiling the national-level data. My gratitude also goes to the officers of CGWB and State Ground Water Nodal Departments for their relentless efforts in conducting assessments for their respective States and Union Territories according to the planned schedule.

The valuable contributions of the CLEG and SLC members in refining the National Report are also acknowledged. I hope this national compilation will serve as an important document for planners, decision-makers, and all concerned stakeholders in prioritizing actions necessary to ensure the sustainability of groundwater resources in the country.

(T. S. Anitha Shyam)
Member (South) &
Member Secretary (CLEG)

Faridabad
December 2024

मनोहर कुमार
कार्यालय प्रमुख
Manohar Kumar
Head of Office

सत्यमेव जयते

भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास
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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 2014 to 2023, whereas ground water draft data was taken as on March 2024. 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 35.48%. 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. Manohar Kumar, Head of Office, 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.

Manohar Kumar

(Manohar Kumar)
Head of Office

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DYNAMIC GROUND WATER RESOURCES OF HIMACHAL PRADESH 2024

AT A GLANCE

1.	Total Annual Ground Water Recharge	1.1127701 bcm
2.	Annual Extractable Ground Water Resources	1.0103758 bcm
3.	Annual Ground Water Extraction	0.3585094 bcm
4.	Stage of Ground Water Extraction	35.48 %

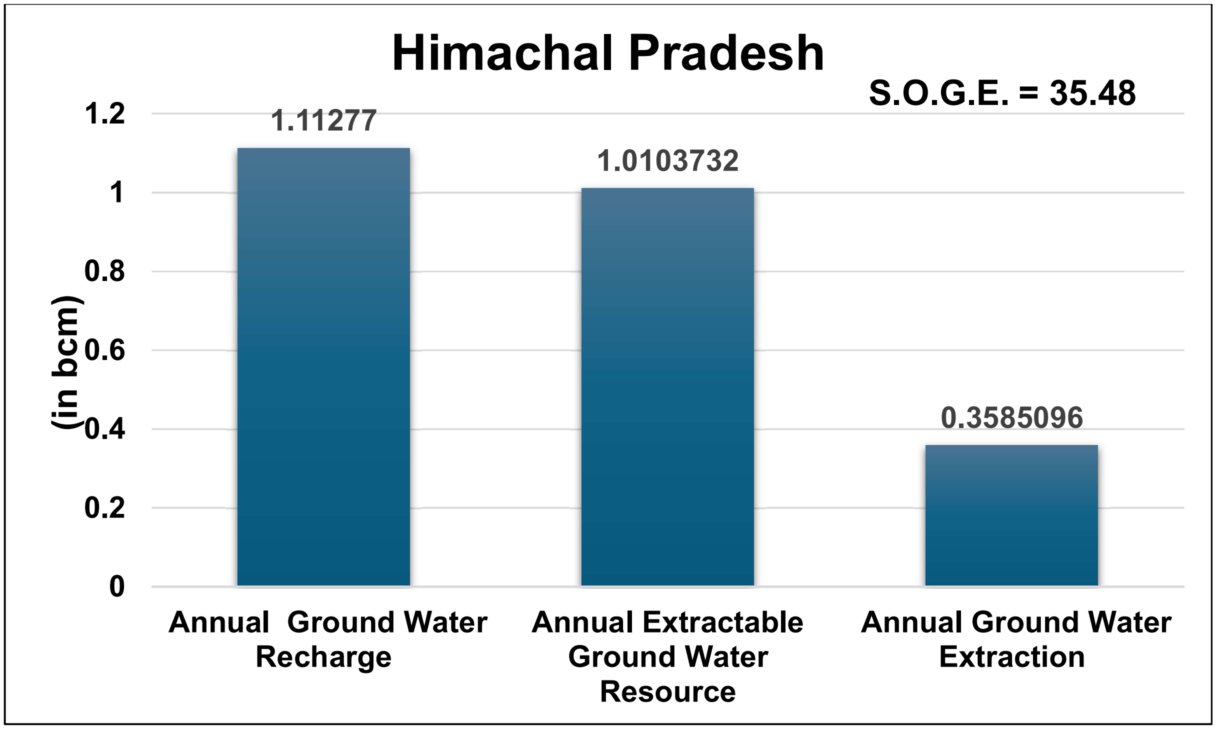
CATEGORIZATION OF ASSESSMENT UNITS

(Blocks/ Mandals/ Taluks)

Sl.No	Category	Number of Assessment Units		Recharge worthy Area		Annual Extractable Ground Water Resource	
		Number	**%**	**in lakh sq. km**	%	**(in bcm)**	%
1	Safe	10	100	3468	100	1.0104	100
2	Semi Critical						
3	Critical						
4	Over-Exploited						
5	Saline						
	TOTAL	**10**	**100**	**3468**	**100**	**1.0104**	**100**

EXECUTIVE SUMMARY

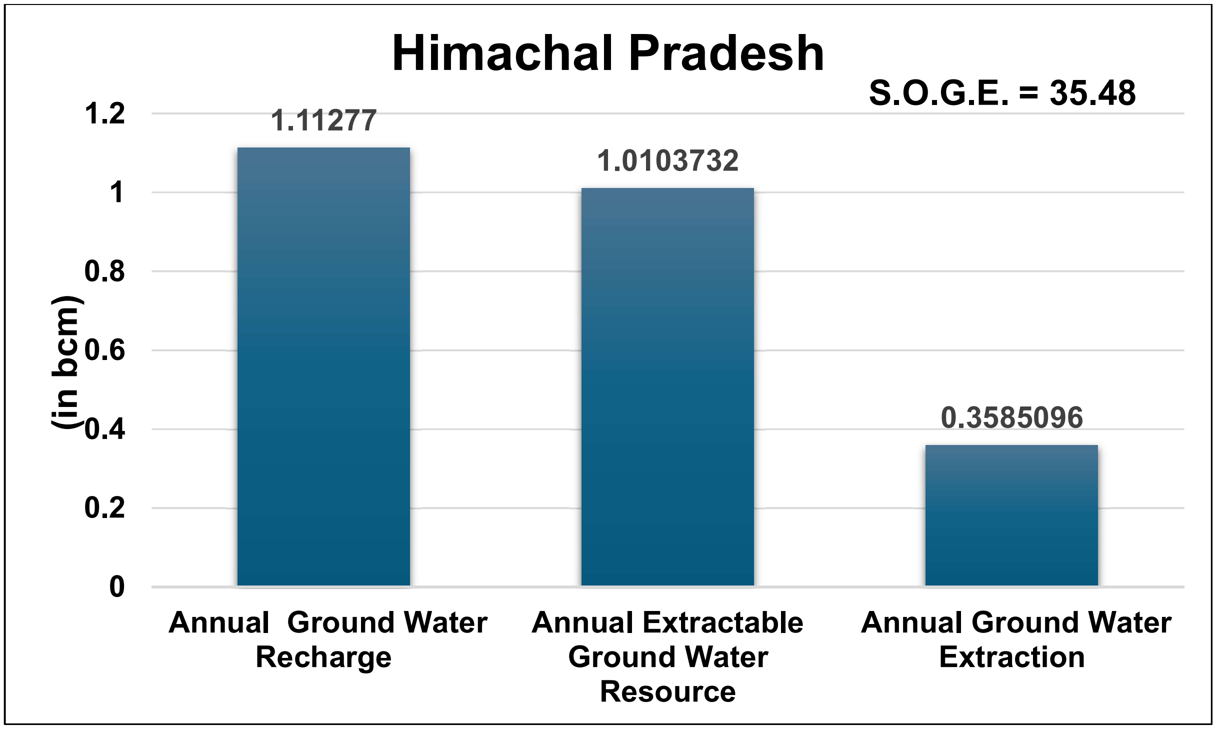
- The diverse physiographic, climatic, topographic and geologic conditions have given rise to diversified groundwater situation in different parts of the state. The rock formations ranging in age from Archean to Recent occupy the State and control the occurrence and movement of ground water depending upon aquifer composition, structure and deposition. Hilly and mountainous parts with steep slopes mainly constitute the run off areas and have low ground water potential. In valley and low-lying areas, unconsolidated / semi-consolidated formations form potential aquifers.
- In consolidated formations the water availability is restricted to weathered mantle, joints/fractures, weak planes, bedding planes and limestone caverns. The limestone associated with phyllite and quartzite forms potential aquifers. In granites, potentiality of the aquifer is highly dependable on the fracture intensity. In granitic aquifers the discharge ranges between 1-3 lps. Groundwater in hard rock areas is either developed though bore wells or natural springs are tapped for both drinking and irrigation purposes.
- In the unconsolidated formations the occurrence and movement of ground water is highly dependent on lithology particularly the presence of clay content. The unconsolidated formations are confined to valley areas, having good yield prospects that can sustain moderate to high-capacity deep tube wells. The yield of the tube wells depends on the thickness of the total granular zones available within the aquifers tapped which ranges from 5-40 lps in different valleys. The Ground water resources have been assessed valley-wise.
- Total Annual Ground Water Recharge of the State has been assessed as 1.113 bcm and Annual Extractable Groundwater Resources is 1.01 bcm. The Current Annual Ground Water Extraction for all uses is 0.36 bcm and Stage of Ground Water Extraction is 35.48 %. Out of the 10 assessment units, all the ten assessment units have been categorized as 'Safe' and there is no saline assessment unit in the State.
- Similarly, out of 3468 sq. km recharge worthy area of the State, 100 % under 'Safe' categories of assessment units. Out of total 1010.3732 mcm annual extractable ground water resources of the State, 1010.3732 mcm (100 %) are under 'Safe' categories of assessment units.
- As compared to 2023 assessment, the Total Annual Ground Water Recharge slightly increases from 1.11 to 1.113 bcm and Annual Extractable Ground Water resources remain same from 1.01 to 1.01 bcm. However, there is increase in Ground Water Extraction from 0.3546 to 0.3585 of the State. The Stage of Ground Water Extraction has increases from 34.95 % to 35.48



Dynamic Ground Water Recourses Scenario 2024– Himachal Pradesh

कार्यकारी सारांश

- विविध भौतिक, जलवायु, स्थलाकृतिक और भूगर्भिक स्थितियों ने राज्य के विभिन्न भागों में भूजल की स्थिति में विविधता ला दी है। आर्कियन से लेकर हाल की आयु तक की चट्टान संरचनाएं राज्य में व्याप्त हैं और जलभृत संरचना, संरचना और निक्षेपण के आधार पर भूजल की घटना और गति को नियंत्रित करती हैं। खड़ी ढलानों वाले पहाड़ी और पर्वतीय हिस्से मुख्य रूप से अपवाह क्षेत्र बनते हैं और इनमें भूजल की क्षमता कम होती है। घाटी और निचले इलाकों में, असंगठित/अर्ध-समेकित संरचनाएं संभावित जलभृत बनाती हैं।
- समेकित संरचनाओं में पानी की उपलब्धता अपक्षयित मेंटल, जोड़ों/फ्रैक्चर, कमजोर समतल, बेडिंग प्लेन और चूना पत्थर की गुफाओं तक सीमित होती है। कठोर चट्टान वाले क्षेत्रों में भूजल या तो बोरवेल के जरिए विकसित किया जाता है या पीने और सिंचाई दोनों उद्देश्यों के लिए प्राकृतिक झरनों का दोहन किया जाता है।
- असंगठित संरचनाओं में भूजल की घटना और गति लिथोलॉजी विशेष रूप से मिट्टी की सामग्री की उपस्थिति पर अत्यधिक निर्भर है। असंगठित संरचनाएं घाटी क्षेत्रों तक ही सीमित हैं, जिनमें अच्छी उपज की संभावनाएं हैं जो मध्यम से उच्च क्षमता वाले गहरे ट्यूबवेल को बनाए रख सकती हैं। ट्यूबवेल की उपज टैप किए गए एक्वीफर्स के भीतर उपलब्ध कुल दानेदार क्षेत्रों की मोटाई पर निर्भर करती है जो विभिन्न घाटियों में 5-40 एलपीएस तक होती है। भूजल संसाधनों का घाटी-वार मूल्यांकन किया गया है।
- राज्य का कुल वार्षिक भूजल पुनर्भरण 1.113 बीसीएम और वार्षिक निष्कर्षण योग्य भूजल संसाधन 1.01 बीसीएम आंका गया है 10 मूल्यांकन इकाइयों में से, सभी दस मूल्यांकन इकाइयों को 'सुरक्षित' के रूप में वर्गीकृत किया गया है और राज्य में कोई खारा मूल्यांकन इकाई नहीं है।
- इसी तरह, राज्य के 3468 वर्ग किलोमीटर पुनर्भरण योग्य क्षेत्र में से, 100% मूल्यांकन इकाइयों की 'सुरक्षित' श्रेणियों के अंतर्गत है। राज्य के कुल 1010.3732 एमसीएम वार्षिक निष्कर्षण योग्य भूजल संसाधनों में से, 1010.3732 एमसीएम (100%) मूल्यांकन इकाइयों की 'सुरक्षित' श्रेणियों के अंतर्गत हैं।
- 2023 के मूल्यांकन की तुलना में, कुल वार्षिक भूजल पुनर्भरण 1.11 से 1.113 बीसीएम तक थोड़ा बढ़ जाता है और वार्षिक निष्कर्षण योग्य भूजल संसाधन 1.01 से 1.01 बीसीएम तक समान रहते हैं। हालांकि, राज्य के भूजल निष्कर्षण में 0.3546 से 0.3585 तक की वृद्धि हुई है। भूजल निष्कर्षण का स्तर 34.95% से बढ़कर 35.48% हो गया है



गतिशील भूजल संसाधन परिदृश्य 2024- हिमाचल प्रदेश

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 along with assessment unit's demarcation is given in **Fig-1.**

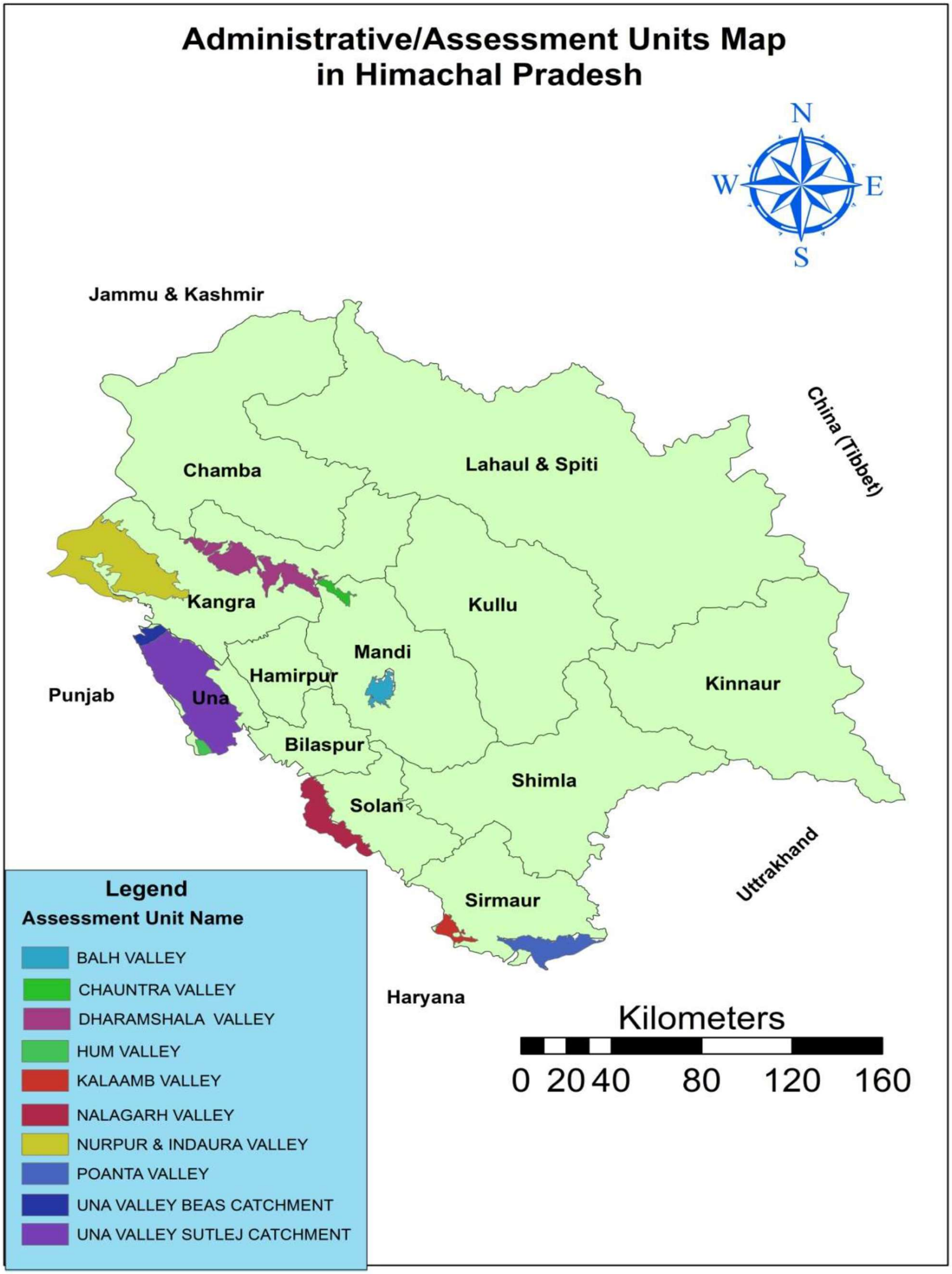


Fig:1 Administrative map along with assessment units

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. Hydrologist, GWO, Una	Member
14.	Regional Director, CGWB	Member Secretary

Table-1: List of the committee members

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 first meeting of State Ground Water Coordination Committee (SGWCC) & State Level Committee on Ground Water Resource Estimation of Himachal Pradesh held on 05.07.2024 under the chairmanship of Secretary (JSV) to the Government of Himachal Pradesh (Annexure-B). In that meeting The Secretary, JSV, to the Government of Himachal Pradesh, said that the Dynamic Ground Water Resource Assessment 2024 Valleys will be kept as assessment units as per previous practice and no change in the assessment unit boundary is warranted.

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

GROUND WATER RESOURCE ESTIMATION METHODOLOGY

Ground water resource as in 2024 have been estimated following the guidelines mentioned in the GEC 2015 methodology using appropriate assumptions depending on data availability. The principal attributes of GEC 2015 methodology are given below:

It is also important to add that as it is advisable to restrict the groundwater development as far as possible to annual replenishable resources, the categorization also considers the relation between the annual replenishment and groundwater development. An area devoid of ground water potential may not be considered for development and may remain safe whereas an area with good groundwater potential may be developed and may become over exploited over a period. Thus, water augmentation efforts can be successful in such areas, where the groundwater potential is high and there is scope for augmentation.

2.1. GROUND WATER ASSESSMENT OF UNCONFINED AQUIFER

Though the assessment of ground water resources includes assessment of dynamic and in-storage resources, the development planning should mainly focus on dynamic resource as it gets replenished on an annual basis. Changes in static or in-storage resources normally reflect long-term impacts of ground water mining. Such resources may not be replenishable annually and may be allowed to be extracted only during exigencies with proper planning for augmentation in the succeeding excess rainfall years.

2.1.1. Assessment of Annually Replenishable or Dynamic Ground Water Resources

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

$$\boldsymbol{Inflow - Outflow = Change\ in\ Storage(of\ an\ aquifer)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(\mathbf{1})$$

Equation (1) can be further elaborated as –

$$\boldsymbol{\Delta S = R_{RF} + R_{STR} + R_C + R_{SWI} + R_{GWI} + R_{TP} + R_{WCS} \pm VF \pm LF - GE - T - E - B} \ldots\ldots..(\mathbf{2})$$

Where,

ΔS - Change is 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 & 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

Due to lack of data for all the components in most of the assessment units, at present the water budget has been assessed based on major components only, taking into consideration certain reasonable assumptions. The estimation has been 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.

2.1.1.1. Rainfall Recharge

Ground water recharge has been estimated on ground water level fluctuation and specific yield approach since this method considers the response of ground water levels to ground water input and output components. In units or subareas where adequate data on ground water level fluctuations are not available, ground water recharge is estimated using rainfall infiltration factor method only. The rainfall recharge during non-monsoon season has been estimated using rainfall infiltration factor method only.

2.1.1.1.1. Ground Water Level Fluctuation Method

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

$$\boldsymbol{\Delta S = R_{RF} + R_{STR} + R_{SWI} + R_{GWI} + R_{TP} + R_{WCS} \pm VF \pm LF - GE - T - E - B} \dots\dots\dots\dots\dots\dots\dots..(\mathbf{3})$$

Where,

ΔS - Change is storage
R_{RF} - Rainfall recharge
R_{STR} - Recharge from stream channels
R_{SWI} - Recharge from surface water irrigation
R_{GWI} - Recharge from ground water irrigation
R_{TP} - Recharge from Tanks& 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 have another term i.e., Recharge due to canals (R_C) and the equation is as follows:

$$\boldsymbol{\Delta S = R_{RF} + R_{STR} + R_{C} + R_{SWI} + R_{GWI} + R_{TP} + R_{WCS} \pm VF \pm LF - GE - T - E - B} \dots\dots\dots\dots...(\mathbf{4})$$

The change in storage has been estimated using the following equation:

$$\boldsymbol{\Delta S = \Delta h \times A \times S_Y} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.\dots\dots\dots\dots\dots\dots..(\mathbf{5})$$

Where,

ΔS - Change is storage
Δh - rise in water level in the monsoon season
A - Area for computation of recharge
S_Y - Specific Yield

Substituting the expression in equation (5) for storage increase ΔS in terms of water level fluctuation and specific yield, the equations (3) & (4) becomes (6) & (7) for non-command and command sub-units,

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

$$R_{RF} = \Delta h \times A \times S_Y - R_{STR} - R_C - R_{SWI} - R_{GWI} - R_{TP} - R_{WCS} \pm VF \pm LF + GE + T + E + B \dots \dots \dots . (7)$$

Where base flow/ recharge to/from streams have not been estimated, the same is assumed to be zero. The rainfall recharge obtained by using equation (6) and (7) provides the recharge in any particular monsoon season for the associated monsoon season rainfall. This estimate has been normalized for the normal monsoon season rainfall as per the procedure indicated below.

Normalization of Rainfall Recharge

Let R_i be the rainfall recharge and r_i be the associated rainfall. The subscript "i" takes values 1 to N where N is the number of years for which data is available. This should be at least 5. The rainfall recharge, R_i is obtained as per equation (6) & equation (7) depending on the sub-unit for which the normalization is being done.

After the pairs of data on R_i and r_i have been obtained as described above, a normalisation procedure is carried out for obtaining the rainfall recharge corresponding to the normal monsoon season rainfall. Let r(normal) be the normal monsoon season rainfall obtained as the average of recent 30 to 50 years of monsoon season rainfall. Two methods are possible for the normalisation procedure. The first method is based on a linear relationship between recharge and rainfall of the form

$$R = ar \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots .. \dots \dots \dots . (8)$$

Where,

R = Rainfall recharge during monsoon season
r = Monsoon season rainfall
a = a constant

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

$$R_{RF}(normal) = \frac{\sum_{i=1}^{N} \left[R_i \frac{r(normal)}{r_i} \right]}{N} \dots \dots \dots \dots \dots \dots \dots \dots \dots .. \dots \dots \dots \dots \dots \dots .. (9)$$

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- Rainfall in the monsoon season for the i^{th} year
N - No. of years for which 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,

$$R_{RF}(normal) = a \times r(normal) + b \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots .. (10)$$

Where,

R_{RF}(normal) - Normalized Rainfall Recharge in the monsoon season
r(normal) - Normal 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 has been followed in the second method is as given below:

$$a = \frac{NS_4 - S_1 S_2}{NS_3 - S_1^2} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (11)$$

$$b = \frac{S_2 - aS_1}{N} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots. (12)$$

Where,

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

2.1.1.1.2. 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, the rainfall recharge obtained from water level fluctuation approach has been compared with that estimated using rainfall infiltration factor method. Recharge from rainfall is estimated by using the following relationship –

$$R_{RF} = RFIF \times A \times \frac{(R - a)}{1000} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (13)$$

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 threshold limit of minimum and maximum rainfall event which can induce recharge to the aquifer is considered while estimating ground water recharge using rainfall infiltration factor method. The minimum threshold limit is in accordance with the relation shown in equation (13) and the maximum threshold limit is based on the premise that after a certain limit, the rate of storm rain is too high to contribute to infiltration and they will only contribute to surface runoff. Thus, 10% of Normal annual rainfall has been taken as minimum rainfall threshold and 3000 mm as maximum rainfall limit. While computing the rainfall recharge, 10% of the normal annual rainfall has been deducted from the monsoon rainfall and balance rainfall is considered for computation of rainfall recharge. The same recharge factor is used for both monsoon and non-monsoon rainfall, with the condition that the recharge due to non-monsoon rainfall is 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 has been estimated for normal rainfall, based on recent 30 to 50 years of data.

2.1.1.1.3. Percent Deviation

After computing the rainfall recharge for normal monsoon season rainfall using the ground water level fluctuation method and rainfall infiltration factor method these two estimates is compared with each other. A term, Percent Deviation (PD) which is the difference between the two expressed as a percentage of the later is computed as

$$PD = \frac{R_{RF}(normal, wtfm) - R_{RF}(normal, rifm)}{R_{RF}(normal, rifm)} \times 100 \dots\dots\dots\dots\dots\dots.\dots\dots\dots. (14)$$

Where,

R_{RF} (normal, wlfm) = Rainfall recharge for normal monsoon season rainfall estimated by the ground water level fluctuation method

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

2.1.1.2. Recharge from Other Sources

Recharge from other sources constitutes recharges from canals, surface water irrigation, ground water irrigation, tanks & ponds and water conservation structures in command areas where as in non-command areas it constitutes the recharge due to surface water irrigation, ground water irrigation, tanks & ponds and water conservation structures. The methods of estimation of recharge from different sources are used in the assessment as follows.

Sl. No.	Source	Estimation Formula	Parameters
1	Recharge from Canals	$R_C = WA \times SF \times Days$	R_C = Recharge from Canals WA = Wetted Area SF = Seepage Factor Days = Number of Canal Running Days
2	Recharge from Surface Water Irrigation	$R_{SWI} = AD \times Days \times RFF$	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	Recharge from Ground Water Irrigation	$R_{GWI} = GE_{IRR} \times RFF$	R_{GWI} = Recharge due to applied ground water irrigation GE_{IRR} = Ground Water Extraction for Irrigation RFF = Return Flow Factor
4	Recharge due to Tanks & Ponds	$R_{TP} = AWSA \times N \times RF$	R_{TP} = Recharge due to Tanks & Ponds AWSA = Average Water Spread Area N = Number of days Water is available in the Tank/Pond RF = Recharge Factor
5	Recharge due to Water Conservation Structures	$R_{WCS} = GS \times RF$	RWCS = Recharge due to Water Conservation Structures GS = Gross Storage = Storage Capacity multiplied by number of fillings. RF = Recharge Factor

2.1.1.3. Evaporation and Transpiration

Evaporation is estimated for the aquifer in the assessment unit if water levels in the aquifer are within the capillary zone. For areas with water levels within 1.0mbgl, evaporation is estimated using the evaporation rates available for other adjoining areas. If depth to water level is more than 1.0mbgl, the evaporation losses from the aquifer is taken as zero. Transpiration through vegetation has been estimated if water levels in the aquifer are within the maximum root zone of the local vegetation. If water levels are within 3.5mbgl, transpiration is estimated using the transpiration rates available for other areas. If it is greater than3.5m bgl, the transpiration has been taken as zero.

2.1.1.4. Recharge During Monsoon Season

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

2.1.1.5. 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 & out of the sub unit and stream inflows & outflows during non-monsoon season is the total recharge/ accumulation during non-monsoon season for the sub unit. Similarly, this is to be computed for all the sub units available in the assessment unit.

2.1.1.6. Total Annual Ground Water Recharge

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

2.1.1.7. Annual Extractable Ground Water Resource (EGR)

The Annual Extractable Ground Water Resource (EGR) is computed by deducting the Total Annual Natural Discharge from Total Annual Ground Water Recharge.
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, allocation of unaccountable natural discharges to 5% or 10% of annual recharge is considered. If the rainfall recharge is assessed using water level fluctuation method this has been taken 5% of the annual recharge and if it is assessed using rainfall infiltration factor method, 10% of the annual recharge is considered. The balance is account for Annual Extractable Ground Water Resources (EGR).

2.1.1.8. Estimation of Ground Water Extraction

Ground water draft or extraction is assessed as follows.

$$GE_{ALL} = GE_{IRR} + GE_{DOM} + GE_{IND} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (15)$$

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

2.1.1.8.1. Ground Water Extraction for Irrigation (GE_{IRR})

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.
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.

2.1.1.8.2. Ground Water Extraction for Domestic Use (GE_{DOM})

There are several methods for estimation of extraction for domestic use(GEDOM). 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 extraction.
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.

$$GE_{DOM} = Population \times Consumptive\ Requirement \times L_g \ldots\ldots\ldots\ldots.\ldots\ldots\ldots\ldots\ldots\ldots. (16)$$

Where,

L_g = 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.

2.1.1.8.3. 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 is determined. Numbers of Industrial units which are dependent on ground water are multiplied with unit water consumption to obtain ground water extraction for industrial use.

$$GE_{IND} = Number\ of\ Industrial\ Units \times Unit\ Water\ Consumption \times L_g \ldots\ldots\ldots..\ldots\ldots\ldots. (17)$$

Where,

L_g = 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. 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.

2.1.1.9. Stage of Ground Water Extraction

The stage of ground water extraction is defined by,

$$\boldsymbol{Stage\ of\ GW\ Extraction} = \frac{\boldsymbol{Existing\ Gross\ GW\ Extraction\ for\ all\ Uses}}{\boldsymbol{Annual\ Extractable\ GW\ Resources}} \times \mathbf{100} \ldots\ldots\ldots\ldots\ldots (\mathbf{18})$$

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.

2.1.1.10. Validation of Stage of Ground Water Extraction

The assessment based on the stage of ground water extraction has inherent uncertainties. 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 prepared for a minimum period of 10 years for both pre-monsoon and post-monsoon period. 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%	Significant decline in 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

2.1.1.11. Categorisation of Assessment Unit

2.1.1.11.1. Categorisation of Assessment Unit Based on Quantity

The categorisation 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

2.1.1.11.2. Categorisation of Assessment Unit Based on Quality

As it is not possible to categorize the assessment units in terms of the extent of quality hazard, based on the available water quality monitoring mechanism and database on ground water quality, 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. 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 has been tagged with the particular Quality hazard.

2.1.1.12. Allocation of Ground Water Resource for Utilisation

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 based on population has been 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. In situations where adequate data is not available to make this estimate, the following empirical relation has been utilized.

$$\boldsymbol{Alloc = 22 \times N \times L_g mm\ per\ year} \dots\dots\dots\dots\dots\dots\dots.\dots\dots\dots\dots\dots\dots\dots.(\mathbf{19})$$

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 water supply (≤ 1.0)

2.1.1.13. 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 is 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 has been projected as zero.

2.1.1.14. Additional Potential Resources under Specific Conditions

2.1.1.14.1. Potential Resource Due to Spring Discharge

Spring discharge occurs 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 has not been used for Categorisation. Spring discharge measurement has been 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.

$$\boldsymbol{Potential\ ground\ water\ resource\ due\ to\ springs = Q \times No.of days} \dots\dots\dots\dots..\dots\dots.(\mathbf{20})$$

Where,

Q = Spring Discharge
No of days = No of days spring yields.

2.1.1.14.2. Potential Resource in Waterlogged and Shallow Water Table Areas

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. The computation of potential resource to ground water reservoir in shallow water table areas has been done by adopting the following equation:

$$\textit{Potential groundwater resource in shallow water table areas}$$
$$= (5 - D) \times A \times S_Y \dots\dots\dots..(21)$$

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

2.1.1.14.3. 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 resource from flood plain may be estimated on the same norms as for ponds, tanks and lakes. This has been calculated over the water spread area and only for the retention period using the following formula.

$$\textit{Potential groundwater resource in Flood Prone Areas}$$
$$= 1.4 \times N \times \frac{A}{1000} \dots\dots\dots\dots\dots\dots\dots...(22)$$

Where,

N = No. of Days Water is Retained in the Area

A = Flood Prone Area

2.1.1.15. 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 has been 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 has been 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.

The total ground water resource of the block has been 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.

2.2. GROUND WATER ASSESSMENT IN URBAN AREAS

The Assessment of Ground Water Resources in urban areas is similar to that of rural areas. Because of the availability of draft data and slightly different infiltration process and recharge due to other sources, the following few points are to be considered.

- Even though the data on existing ground water abstraction structures are available, accuracy is somewhat doubtful and individuals cannot even enumerate the well census in urban areas. Hence the difference of the actual demand and the supply by surface water sources as the withdrawal from the ground water resources has been considered for the assessment.

- The urban areas are sometimes concrete jungles and rainfall infiltration is not equal to that of rural areas unless and until special measures are taken in the construction of roads and pavements. Hence, 30% of the rainfall infiltration factor has been taken into consideration for urban areas as an adhoc arrangement till field studies in these areas are done and documented field studies are available.

- Because of the water supply schemes, there are many pipelines available in the urban areas and the seepages from these channels or pipes are huge in some areas. Hence this component has been included in the other resources and the recharge has also been considered. The percent losses have been collected from the individual water supply agencies, 50% of which has been considered as recharge to the ground water system.

- In the urban areas in India, normally, there is no separate channels either open or sub surface for the drainage and flash floods. These channels also recharge to some extent the ground water reservoir. As on today, there is no documented field study to assess the recharge. The seepages from the sewerages, which normally contaminate the ground water resources with nitrate also contribute to the quantity of resources and hence same percent as in the case of water supply pipes has been taken as norm for the recharge on the quantity of sewerage when there is sub surface drainage system. If estimated flash flood data is available, the same percent has been used on the quantum of flash floods to estimate the recharge from the flash floods.

- Urban areas with population more than 10 lakhs, has been considered as urban assessment unit while assessing the dynamic ground water resources.

2.3. GROUND WATER ASSESSMENT IN WATER LEVEL DEPLETION ZONES

There are areas where ground water level shows a decline even in the monsoon season. The reasons for this may be any one of the following: (a) There is a genuine depletion in the ground water regime, with ground water extraction and natural ground water discharge in the monsoon season (outflow from the region and base flow) exceeding the recharge. (b) There may be an error in water level data due to inadequacy of observation wells.

If it is concluded that the water level data is erroneous, recharge assessment has been made based on rainfall infiltration factor method. If, on the other hand, water level data is assessed as reliable, the ground water level fluctuation method has been applied for recharge estimation. As ΔS in equation 3& 4 is negative, the estimated recharge will be less than the gross ground water extraction in the monsoon season. It must be noted that this recharge is the gross recharge minus the natural discharges in the monsoon season. The immediate conclusion from such an assessment in water depletion zones is that the area falls under the over-exploited category which requires micro level study.

2.4. NORMS HAS BEEN USED IN THE ASSESSMENT

2.4.1. Specific Yield

Recently under Aquifer Mapping Project, Central Ground Water Board has classified all the aquifers into 14 Principal Aquifers which in turn were divided into 42 Major Aquifers. Hence, it is required to assign Specific Yield values to all these aquifer units. The values recommended in the ***Table-2.1*** has been followed in the present assessments, unless sufficient data based on field studies are available to justify the minimum, maximum or other intermediate values

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
1	Alluvium	AL01	Younger Alluvium (Clay/Silt/Sand/ Calcareous concretions)	Quaternary	10	8	12
2	Alluvium	AL02	Pebble / Gravel/ Bazada/ Kandi	Quaternary	16	12	20
3	Alluvium	AL03	Older Alluvium (Silt/Sand/Gravel/Lithomargic clay)	Quaternary	6	4	8
4	Alluvium	AL04	Aeolian Alluvium (Silt/ Sand)	Quaternary	16	12	20
5	Alluvium	AL05	Coastal Alluvium (Sand/Silt/Clay)	Quaternary	10	8	12
6	Alluvium	AL06	Valley Fills	Quaternary	16	12	20
7	Alluvium	AL07	Glacial Deposits	Quaternary	16	12	20
8	Laterite	LT01	Laterite / Ferruginous concretions	Quaternary	2.5	2	3
9	Basalt	BS01	Basic Rocks (Basalt) - Weathered, Vesicular or Jointed	Mesozoic to Cenozoic	2	1	3
10	Basalt	BS01	Basic Rocks (Basalt) - Massive Poorly Jointed	Mesozoic to Cenozoic	0.35	0.2	0.5
11	Basalt	BS02	Ultra Basic - Weathered, Vesicular or Jointed	Mesozoic to Cenozoic	2	1	3
12	Basalt	BS02	Ultra Basic - Massive Poorly Jointed	Mesozoic to Cenozoic	0.35	0.2	0.5
13	Sandstone	ST01	Sandstone/Conglomerate	Upper Palaeozoic to Cenozoic	3	1	5
14	Sandstone	ST02	Sandstone with Shale	Upper Palaeozoic to Cenozoic	3	1	5
15	Sandstone	ST03	Sandstone with shale/ coal beds	Upper Palaeozoic to Cenozoic	3	1	5

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
16	Sandstone	ST04	Sandstone with Clay	Upper Palaeozoic to Cenozoic	3	1	5
17	Sandstone	ST05	Sandstone/Conglomerate	Proterozoic to Cenozoic	3	1	5
18	Sandstone	ST06	Sandstone with Shale	Proterozoic to Cenozoic	3	1	5
19	Shale	SH01	Shale with limestone	Upper Palaeozoic to Cenozoic	1.5	1	2
20	Shale	SH02	Shale with Sandstone	Upper Palaeozoic to Cenozoic	1.5	1	2
21	Shale	SH03	Shale, limestone and sandstone	Upper Palaeozoic to Cenozoic	1.5	1	2
22	Shale	SH04	Shale	Upper Palaeozoic to Cenozoic	1.5	1	2
23	Shale	SH05	Shale/Shale with Sandstone	Proterozoic to Cenozoic	1.5	1	2
24	Shale	SH06	Shale with Limestone	Proterozoic to Cenozoic	1.5	1	2
25	Limestone	LS01	Miliolitic Limestone	Quarternary	2	1	3
26	Limestone	LS01	KarstifiedMiliolitic Limestone	Quarternary	10	5	15
27	Limestone	LS02	Limestone / Dolomite	Upper Palaeozoic to Cenozoic	2	1	3
28	Limestone	LS02	Karstified Limestone / Dolomite	Upper Palaeozoic to Cenozoic	10	5	15
29	Limestone	LS03	Limestone/Dolomite	Proterozoic	2	1	3
30	Limestone	LS03	Karstified Limestone/Dolomite	Proterozoic	10	5	15
31	Limestone	LS04	Limestone with Shale	Proterozoic	2	1	3
32	Limestone	LS04	Karstified Limestone with Shale	Proterozoic	10	5	15
33	Limestone	LS05	Marble	Azoic to Proterozoic	2	1	3
34	Limestone	LS05	Karstified Marble	Azoic to Proterozoic	10	5	15
35	Granite	GR01	Acidic Rocks (Granite,Syenite, Rhyolite etc.) - Weathered , Jointed	Mesozoic to Cenozoic	1.5	1	2

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
36	Granite	GR01	Acidic Rocks (Granite,Syenite, Rhyolite etc.)-Massive or Poorly Fractured	Mesozoic to Cenozoic	0.35	0.2	0.5
37	Granite	GR02	Acidic Rocks (Pegmatite, Granite, Syenite, Rhyolite etc.) - Weathered, Jointed	Proterozoic to Cenozoic	3	2	4
38	Granite	GR02	Acidic Rocks (Pegmatite, Granite, Syenite, Rhyolite etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	0.35	0.2	0.5
39	Schist	SC01	Schist - Weathered, Jointed	Azoic to Proterozoic	1.5	1	2
40	Schist	SC01	Schist - Massive, Poorly Fractured	Azoic to Proterozoic	0.35	0.2	0.5
41	Schist	SC02	Phyllite	Azoic to Proterozoic	1.5	1	2
42	Schist	SC03	Slate	Azoic to Proterozoic	1.5	1	2
43	Quartzite	QZ01	Quartzite - Weathered, Jointed	Proterozoic to Cenozoic	1.5	1	2
44	Quartzite	QZ01	Quartzite - Massive, Poorly Fractured	Proterozoic to Cenozoic	0.3	0.2	0.4
45	Quartzite	QZ02	Quartzite - Weathered, Jointed	Azoic to Proterozoic	1.5	1	2
46	Quartzite	QZ02	Quartzite- Massive, Poorly Fractured	Azoic to Proterozoic	0.3	0.2	0.4
47	Charnockite	CK01	Charnockite - Weathered, Jointed	Azoic	3	2	4
48	Charnockite	CK01	Charnockite - Massive, Poorly Fractured	Azoic	0.3	0.2	0.4
49	Khondalite	KH01	Khondalites, Granulites - Weathered, Jointed	Azoic	1.5	1	2
50	Khondalite	KH01	Khondalites, Granulites - Mssive, Poorly Fractured	Azoic	0.3	0.2	0.4
51	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Weathered, Jointed	Azoic	1.5	1	2
52	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Massive, Poorly Fractured	Azoic	0.3	0.2	0.4
53	Gneiss	GN01	Undifferentiated metasedimentaries/ Undifferentiated	Azoic to Proterozoic	1.5	1	2

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
			metamorphic - Weathered, Jointed				
54	Gneiss	GN01	Undifferentiated metasedimentaries/ Undifferentiated metamorphic - Massive, Poorly Fractured	Azoic to Proterozoic	0.3	0.2	0.4
55	Gneiss	GN02	Gneiss -Weathered, Jointed	Azoic to Proterozoic	3	2	4
56	Gneiss	GN02	Gneiss-Massive, Poorly Fractured	Azoic to Proterozoic	0.3	0.2	0.4
57	Gneiss	GN03	Migmatitic Gneiss - Weathered, Jointed	Azoic	1.5	1	2
58	Gneiss	GN03	Migmatitic Gneiss - Massive, Poorly Fractured	Azoic	0.3	0.2	0.4
59	Intrusive	IN01	Basic Rocks (Dolerite, Anorthosite etc.) - Weathered, Jointed	Proterozoic to Cenozoic	2	1	3
60	Intrusive	IN01	Basic Rocks (Dolerite, Anorthosite etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	0.35	0.2	0.5
61	Intrusive	IN02	Ultrabasics (Epidiorite, Granophyre etc.) - Weathered, Jointed	Proterozoic to Cenozoic	2	1	3
62	Intrusive	IN02	Ultrabasics (Epidiorite, Granophyre etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	0.35	0.2	0.5

Table-2.1: Norms Recommended for Specific Yield

2.4.2. Rainfall Infiltration Factor

The values mentioned in ***Table-2.2*** has been used in the present assessment. The recommended Rainfall Infiltration Factor values has been used for assessment, unless sufficient data based on field studies are available to justify the minimum, maximum or other intermediate values.

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
1	Alluvium	AL01	Younger Alluvium (Clay/Silt/Sand/ Calcareous concretions)	Quaternary	22	20	24
2	Alluvium	AL02	Pebble / Gravel/ Bazada/ Kandi	Quaternary	22	20	24

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
3	Alluvium	AL03	Older Alluvium (Silt/Sand/Gravel/Lithomargic clay)	Quaternary	22	20	24
4	Alluvium	AL04	Aeolian Alluvium (Silt/ Sand)	Quaternary	22	20	24
5	Alluvium	AL05	Coastal Alluvium (Sand/Silt/Clay) -East Coast	Quaternary	16	14	18
5	Alluvium	AL05	Coastal Alluvium (Sand/Silt/Clay) - West Coast	Quaternary	10	8	12
6	Alluvium	AL06	Valley Fills	Quaternary	22	20	24
7	Alluvium	AL07	Glacial Deposits	Quaternary	22	20	24
8	Laterite	LT01	Laterite / Ferruginous concretions	Quaternary	7	6	8
9	Basalt	BS01	Basic Rocks (Basalt) - Vesicular or Jointed	Mesozoic to Cenozoic	13	12	14
9	Basalt	BS01	Basic Rocks (Basalt) - Weathered	Mesozoic to Cenozoic	7	6	8
10	Basalt	BS01	Basic Rocks (Basalt) - Massive Poorly Jointed	Mesozoic to Cenozoic	2	1	3
11	Basalt	BS02	Ultra Basic - Vesicular or Jointed	Mesozoic to Cenozoic	13	12	14
11	Basalt	BS02	Ultra Basic - Weathered	Mesozoic to Cenozoic	7	6	8
12	Basalt	BS02	Ultra Basic - Massive Poorly Jointed	Mesozoic to Cenozoic	2	1	3
13	Sandstone	ST01	Sandstone/Conglomerate	Upper Palaeozoic to Cenozoic	12	10	14
14	Sandstone	ST02	Sandstone with Shale	Upper Palaeozoic to Cenozoic	12	10	14
15	Sandstone	ST03	Sandstone with shale/ coal beds	Upper Palaeozoic to Cenozoic	12	10	14
16	Sandstone	ST04	Sandstone with Clay	Upper Palaeozoic to Cenozoic	12	10	14
17	Sandstone	ST05	Sandstone/Conglomerate	Proterozoic to Cenozoic	6	5	7
18	Sandstone	ST06	Sandstone with Shale	Proterozoic to Cenozoic	6	5	7
19	Shale	SH01	Shale with limestone	Upper Palaeozoic to Cenozoic	4	3	5

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
20	Shale	SH02	Shale with Sandstone	Upper Palaeozoic to Cenozoic	4	3	5
21	Shale	SH03	Shale, limestone and sandstone	Upper Palaeozoic to Cenozoic	4	3	5
22	Shale	SH04	Shale	Upper Palaeozoic to Cenozoic	4	3	5
23	Shale	SH05	Shale/Shale with Sandstone	Proterozoic to Cenozoic	4	3	5
24	Shale	SH06	Shale with Limestone	Proterozoic to Cenozoic	4	3	5
25	Limestone	LS01	Miliolitic Limestone	Quarternary	6	5	7
27	Limestone	LS02	Limestone / Dolomite	Upper Palaeozoic to Cenozoic	6	5	7
29	Limestone	LS03	Limestone/Dolomite	Proterozoic	6	5	7
31	Limestone	LS04	Limestone with Shale	Proterozoic	6	5	7
33	Limestone	LS05	Marble	Azoic to Proterozoic	6	5	7
35	Granite	GR01	Acidic Rocks (Granite,Syenite, Rhyolite etc.) - Weathered , Jointed	Mesozoic to Cenozoic	7	5	9
36	Granite	GR01	Acidic Rocks (Granite,Syenite, Rhyolite etc.)-Massive or Poorly Fractured	Mesozoic to Cenozoic	2	1	3
37	Granite	GR02	Acidic Rocks (Pegmatite, Granite, Syenite, Rhyolite etc.) - Weathered, Jointed	Proterozoic to Cenozoic	11	10	12
38	Granite	GR02	Acidic Rocks (Pegmatite, Granite, Syenite, Rhyolite etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3
39	Schist	SC01	Schist - Weathered, Jointed	Azoic to Proterozoic	7	5	9
40	Schist	SC01	Schist - Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3
41	Schist	SC02	Phyllite	Azoic to Proterozoic	4	3	5
42	Schist	SC03	Slate	Azoic to Proterozoic	4	3	5
43	Quartzite	QZ01	Quartzite - Weathered, Jointed	Proterozoic to Cenozoic	6	5	7

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
44	Quartzite	QZ01	Quartzite - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3
45	Quartzite	QZ02	Quartzite - Weathered, Jointed	Azoic to Proterozoic	6	5	7
46	Quartzite	QZ02	Quartzite- Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3
47	Charnockite	CK01	Charnockite - Weathered, Jointed	Azoic	5	4	6
48	Charnockite	CK01	Charnockite - Massive, Poorly Fractured	Azoic	2	1	3
49	Khondalite	KH01	Khondalites, Granulites - Weathered, Jointed	Azoic	7	5	9
50	Khondalite	KH01	Khondalites, Granulites - Mssive, Poorly Fractured	Azoic	2	1	3
51	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Weathered, Jointed	Azoic	7	5	9
52	Banded Gneissic Complex	BG01	Banded Gneissic Complex - Massive, Poorly Fractured	Azoic	2	1	3
53	Gneiss	GN01	Undifferentiated metasedimentaries/ Undifferentiated metamorphic - Weathered, Jointed	Azoic to Proterozoic	7	5	9
54	Gneiss	GN01	Undifferentiated metasedimentaries/ Undifferentiated metamorphic - Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3
55	Gneiss	GN02	Gneiss -Weathered, Jointed	Azoic to Proterozoic	11	10	12
56	Gneiss	GN02	Gneiss-Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3
57	Gneiss	GN03	Migmatitic Gneiss - Weathered, Jointed	Azoic	7	5	9
58	Gneiss	GN03	Migmatitic Gneiss - Massive, Poorly Fractured	Azoic	2	1	3
59	Intrusive	IN01	Basic Rocks (Dolerite, Anorthosite etc.) - Weathered, Jointed	Proterozoic to Cenozoic	7	6	8
60	Intrusive	IN01	Basic Rocks (Dolerite, Anorthosite etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3

Sl. No.	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
61	Intrusive	IN02	Ulrta Basics (Epidiorite, Granophyre etc.) - Weathered, Jointed	Proterozoic to Cenozoic	7	6	8
62	Intrusive	IN02	Ulrta Basics (Epidiorite, Granophyre etc.) - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3

Table-2.2: Norms Recommended for Rainfall Infiltration Factor

2.4.3. Norms for Canal Recharge

The Norms suggested in ***Table-2.3*** has been used for estimating the recharge from Canals, where sufficient data based on field studies are not available.

Formation	Canal Seepage factor ham/day/million square meters of wetted area		
	Recommended	Minimum	Maximum
Unlined canals in normal soils with some clay content along with sand	17.5	15	20
Unlined canals in sandy soil with some silt content	27.5	25	30
Lined canals in normal soils with some clay content along with sand	3.5	3	4
Lined canals in sandy soil with some silt content	5.5	5	6
All canals in hard rock area	3.5	3	4

Table-2.3: Norms Recommended for Recharge due to Canals

2.4.4. Norms for Recharge Due to Irrigation

The Recommended Norms are presented in ***Table-2.4***.

DTW m bgl	Ground Water		Surface Water	
	Paddy	Non-paddy	Paddy	Non-paddy
≤ 10	45.0	25.0	50.0	30.0
11	43.3	23.7	48.3	28.7
12	40.4	22.1	45.1	26.8
13	37.7	20.6	42.1	25.0
14	35.2	19.2	39.3	23.3
15	32.9	17.9	36.7	21.7
16	30.7	16.7	34.3	20.3
17	28.7	15.6	32.0	18.9
18	26.8	14.6	29.9	17.6
19	25.0	13.6	27.9	16.4
20	23.3	12.7	26.0	15.3
21	21.7	11.9	24.3	14.3
22	20.3	11.1	22.7	13.3
23	18.9	10.4	21.2	12.4
24	17.6	9.7	19.8	11.6
≥ 25	20.0	5.0	25.0	10.0

Table-2.4: Norms Recommended for Recharge from Irrigation

2.4.5. Norms for Recharge due to Tanks & Ponds

As the data on the field studies for computing recharge from Tanks & Ponds are very limited, for Seepage from Tanks & Ponds has been used as 1.4 mm / day in the present assessment.

2.4.6. Norms for Recharge due to Water Conservation Structures

The data on the field studies for computing recharge from Water Conservation Structures are very limited, hence, the norm recommended by GEC-2015 for the seepage from Water Conservation Structures is 40% of gross storage during a year which means 20% during monsoon season and 20% during non-monsoon Season is adopted.

2.4.7. Unit Draft

The methodology recommends to use well census method for computing the ground water draft. The norm used for computing ground water draft is the unit draft. The unit draft can be computed by field studies. This method involves selecting representative abstraction structure and calculating the discharge from that particular type of structure and collecting the information on how many hours of pumping is being done in various seasons and number of such days during each season. The Unit Draft during a particular season is computed using the following equation:

$$\boldsymbol{Unit\ Draft = Discharge\ in\ m^3/hr \times No.of\ pumping\ hours\ in\ a\ day \times No.of\ days} \dots\dots\dots \boldsymbol{(29)}$$

But the procedure that is being followed for computing unit draft does not have any normalization procedure. Normally, if the year in which one collects the draft data in the field is an excess rainfall year, the abstraction from ground water will be less. Similarly, if the year of the computation of unit draft is a drought year the unit draft will be high. Hence, there is a requirement to devise a methodology that can be used for the normalization of unit draft figures. The following are the two simple techniques, which are followed for normalization of Unit Draft. Areas where, unit draft values for one rainfall cycle are available for at least 10 years second method shown in equation 31 is followed or else the first method shown in equation 30 has been used.

$$\boldsymbol{Normalised\ Unit\ Draft} = \frac{\boldsymbol{Unit\ Draft} \times \boldsymbol{Rainfall\ for\ the\ year}}{\boldsymbol{Normal\ Rainfall}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots.\ldots\ldots\ldots (\mathbf{30})$$

$$\boldsymbol{Normalised\ Unit\ Draft} = \frac{\sum_{i=1}^{n} \boldsymbol{Unit\ Draft_i}}{\boldsymbol{Number\ of\ Years}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (\mathbf{31})$$

2.5. INDIA -GROUNDWATER RESOURCE ESTIMATION SYSTEM (IN-GRES)

"INDIA-GROUNDWATER RESOURCE ESTIMATION SYSTEM (IN-GRES) is a Software/Web-based Application developed by CGWB in collaboration with IIT-Hyderabad. It provides common and standardized platform for Ground Water Resource Estimation for the entire country and its pan-India operationalization (Central and State Governments). The system takes 'Data Input' through Excel as well as Forms, compute various ground water components (recharge, extraction etc.) and classify assessment units into appropriate categories (safe, semi-critical, critical and over-exploited). The Software uses GEC 2015 Methodology for estimation and calculation of Groundwater resources. It allows for unique and homogeneous representation of groundwater fluxes as well as categories for all the assessment units (AU) of the country.

URL of IN-GRES →http://ingres.iith.ac.in

CHAPTER 3
RAINFALL

Generally, rainfall increases from south to north. Beyond Kullu, 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. Dharamshala gets maximum (1055.3mm) in July while Dalhousie (620mm) in August. Dharamshala receives the Maximum rainfall (3200mm). Simla and Nurpur falls in rainfall zone of 1500-2000mm and Dalhousie, Dharamshala, 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 than 500mm of rainfall. The number of rainy days varies from 48 at Keylong to 99 at Dharamshala. 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.**

Month	23-Jan		
District	Act (mm)	Nor (mm)	Dep (%)
Bilaspur	48.6	47.7	2
Chamba	140.6	119.6	18
Hamirpur	54.5	52.8	3
Kangra	115.9	72.5	60
Kinnaur	71.9	101.7	-29
Kullu	95	88	8
Lahaul & Spiti	101.9	103.1	-1
Mandi	39.9	62.8	-37
Shimla	54.3	63.3	-14
Sirmaur	57.3	47.1	22
Solan	35.7	55.1	-35
Una	64	40	60
Sub-Division HP	87.3	85.3	2

Month	23-Feb		
District	Act (mm)	Nor (mm)	Dep (%)
Bilaspur	1.6	62.8	-97
Chamba	27	153.5	-82
Hamirpur	9.8	67.3	-85
Kangra	6.6	91.3	-93
Kinnaur	25	104.3	-76
Kullu	68	103.6	-34
Lahaul & Spiti	50.9	122.6	-58
Mandi	11.7	68.8	-83
Shimla	23.7	76.4	-69
Sirmaur	1.2	63.7	-98
Solan	2.9	66.3	-96
Una	0.3	57.8	-99
Sub-Division HP	29.5	101.8	-71

Month	23-Mar		
District	**Act (mm)**	**Nor (mm)**	**Dep (%)**
Bilaspur	82.5	51.8	59
Chamba	118	177.4	-33
Hamirpur	59.6	55.5	7
Kangra	93.3	87.8	6
Kinnaur	31.1	115.5	-73
Kullu	70.9	134.1	-47
Lahaul & Spiti	21.2	145.2	-85
Mandi	82.5	72.2	14
Shimla	97	81.7	19
Sirmaur	106.3	52	104
Solan	83	61.9	34
Una	48.8	45	9
Sub-Division HP	66.7	113.4	-41

Month	23-Apr		
District	**Act (mm)**	**Nor (mm)**	**Dep (%)**
Bilaspur	82.4	26.7	208
Chamba	127	92.9	37
Hamirpur	66.2	32	107
Kangra	87.7	46.1	90
Kinnaur	102.1	76.3	34
Kullu	169.6	80	112
Lahaul & Spiti	76.1	74.5	2
Mandi	122	51	139
Shimla	139.4	53.7	160
Sirmaur	68.1	31.6	116
Solan	94.5	33.1	185
Una	31.4	25.3	24
Sub-Division HP	103.5	64	62

Month	23-May		
District	Act (mm)	Nor (mm)	Dep (%)
Bilaspur	93.7	39.4	138
Chamba	166.1	98.5	69
Hamirpur	75.6	42.8	77
Kangra	133	55.1	141
Kinnaur	55.9	57.6	-3
Kullu	158.5	69.5	128
Lahaul & Spiti	76.1	59.3	28
Mandi	139.1	69.2	101
Shimla	136	69.8	95
Sirmaur	168	42.5	295
Solan	175.7	49.3	256
Una	74.3	32.4	129
Sub-Division HP	116.8	63.3	84

Month	23-Jun		
District	Act (mm)	Nor (mm)	Dep (%)
Bilaspur	156.8	102.1	54
Chamba	139.2	121.8	14
Hamirpur	167.2	114.1	47
Kangra	207.2	181.4	14
Kinnaur	40	41.8	-4
Kullu	104	86.9	20
Lahaul & Spiti	16.1	47.8	-66
Mandi	289.4	171.5	69
Shimla	161.1	110.4	46
Sirmaur	229.8	165.8	39
Solan	252.6	137.3	84
Una	96.3	103.8	-7
Sub-Division HP	121.7	101.1	20

Month	23-Jul		
District	Act (mm)	Nor (mm)	Dep (%)
Bilaspur	458.9	272.2	69
Chamba	493.7	305.7	61
Hamirpur	470.1	328.5	43
Kangra	654.9	589.3	11
Kinnaur	188.7	65.9	186
Kullu	518.3	184	182
Lahaul & Spiti	191.6	131.5	46
Mandi	540.6	386.5	40
Shimla	577.8	210.2	175
Sirmaur	1095.3	437	151
Solan	734.5	303.3	142
Una	404	329	23
Sub-Division HP	448.9	255.9	75

Month	23-Aug		
District	Act (mm)	Nor (mm)	Dep (%)
Bilaspur	597.2	316.8	89
Chamba	177.8	291.7	-39
Hamirpur	646.5	400.6	61
Kangra	720.4	631.5	14
Kinnaur	32.6	77.6	-58
Kullu	122.1	180.2	-32
Lahaul & Spiti	4.2	117.6	-96
Mandi	681.5	395.3	72
Shimla	253.3	196.4	29
Sirmaur	244.6	402.1	-39
Solan	466.1	287.9	62
Una	355.6	372.2	-4
Sub-Division HP	247.6	256.8	-4

Month	23-Sep		
District	Act (mm)	Nor (mm)	Dep (%)
Bilaspur	121.8	128	-5
Chamba	91.8	134.2	-32
Hamirpur	104.8	130	-19
Kangra	228	220.2	4
Kinnaur	17.1	62.5	-73
Kullu	56.2	96.9	-42
Lahaul & Spiti	15.4	86	-82
Mandi	70.6	144.2	-51
Shimla	35.3	110.5	-68
Sirmaur	108.8	178.9	-39
Solan	45.9	145.8	-69
Una	141.8	148	-4
Sub-Division HP	69.6	120.6	-42

Month	23-Oct		
District	Act (mm)	Nor (mm)	Dep (%)
Bilaspur	31.1	13	139
Chamba	68.2	34.5	98
Hamirpur	25.3	20.9	21
Kangra	25.4	27.7	-8
Kinnaur	10.3	22.7	-55
Kullu	39.1	24.8	58
Lahaul & Spiti	10.3	23.9	-57
Mandi	23.3	19.9	17
Shimla	33.4	25.8	30
Sirmaur	28.1	28.8	-3
Solan	31.8	21.3	49
Una	23.4	18.7	25
Sub-Division HP	27.3	25.1	9

Month	23-Nov		
District	Act (mm)	Nor (mm)	Dep (%)
Bilaspur	18.1	10.6	71
Chamba	22.2	34.8	-36
Hamirpur	18	8.9	103
Kangra	26.2	14.5	81
Kinnaur	5.5	16.3	-67
Kullu	13.4	27.7	-52
Lahaul & Spiti	6.1	23.6	-74
Mandi	10.7	13.4	-20
Shimla	7.8	12.6	-38
Sirmaur	1.4	7.7	-82
Solan	10.7	13.2	-19
Una	28.7	9.1	215
Sub-Division HP	12.2	19.7	-38

Month	23-Dec		
District	Act (mm)	Nor (mm)	Dep (%)
Bilaspur	10.3	24.6	-58
Chamba	11.6	53.2	-78
Hamirpur	2.7	26.3	-90
Kangra	6.2	35.2	-82
Kinnaur	0	32.4	-99
Kullu	5.4	41.5	-87
Lahaul & Spiti	7.7	47.9	-84
Mandi	3.1	25.7	-88
Shimla	4.4	27	-84
Sirmaur	1.1	29.1	-96
Solan	5.3	32.5	-84
Una	7.3	20.5	-64
Sub-Division HP	5.8	38.1	-85

Monthly Normal rainfall (in mm) Year-2023															
District	Jan	Feb	Mar	Apr	May	June	July	August	September	October	November	December	Monsoon Rainfall	Non-Monsoon Rainfall	Total Rainfall
Kangra	72.50	91.30	87.80	46.10	55.10	181.40	589.30	631.50	220.20	27.70	14.50	35.20	1622.4	430.2	2052.6
Mandi	62.8	68.8	72.2	51	69.2	171.5	386.5	395.3	144.2	19.9	13.4	25.7	1097.5	383	1480.5
Sirmaur	47.1	63.7	52	31.6	42.5	165.8	437	402.1	178.9	28.8	7.7	29.1	1183.8	302.5	1486.3
Solan	55.1	66.3	61.9	33.1	49.3	137.3	303.3	287.9	145.8	21.3	13.2	32.5	874.3	332.7	1207
Una	40	57.8	45	25.3	32.4	103.8	329	372.2	148	18.7	9.1	20.5	953	248.8	1201.8

Table-3.1: Monthly Normal Rainfall in Districts of Assessment Units

Source: IMD, Shimla

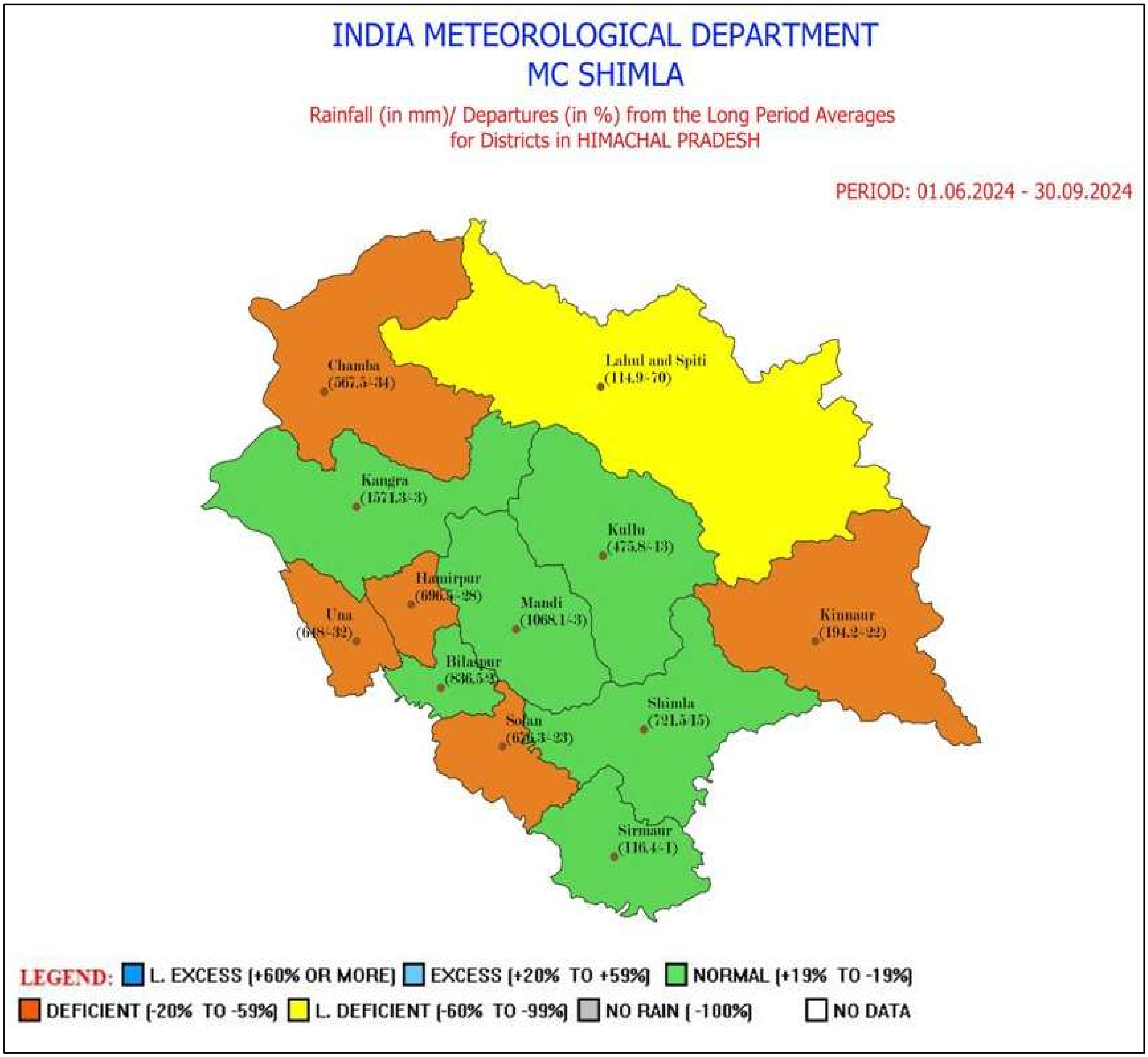


Fig-2: Rainfall Map

Source: IMD, Shimla

CHAPTER 4

HYDROGEOLOGICAL SETUP 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

Table 4.1: Details of Assessment Units

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-25 & Aquifer wise detail of assessment units is shown in Fig-1. Hydrogeological formation wise maps of assessment units are shown in Fig-16 to Fig-24.

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.

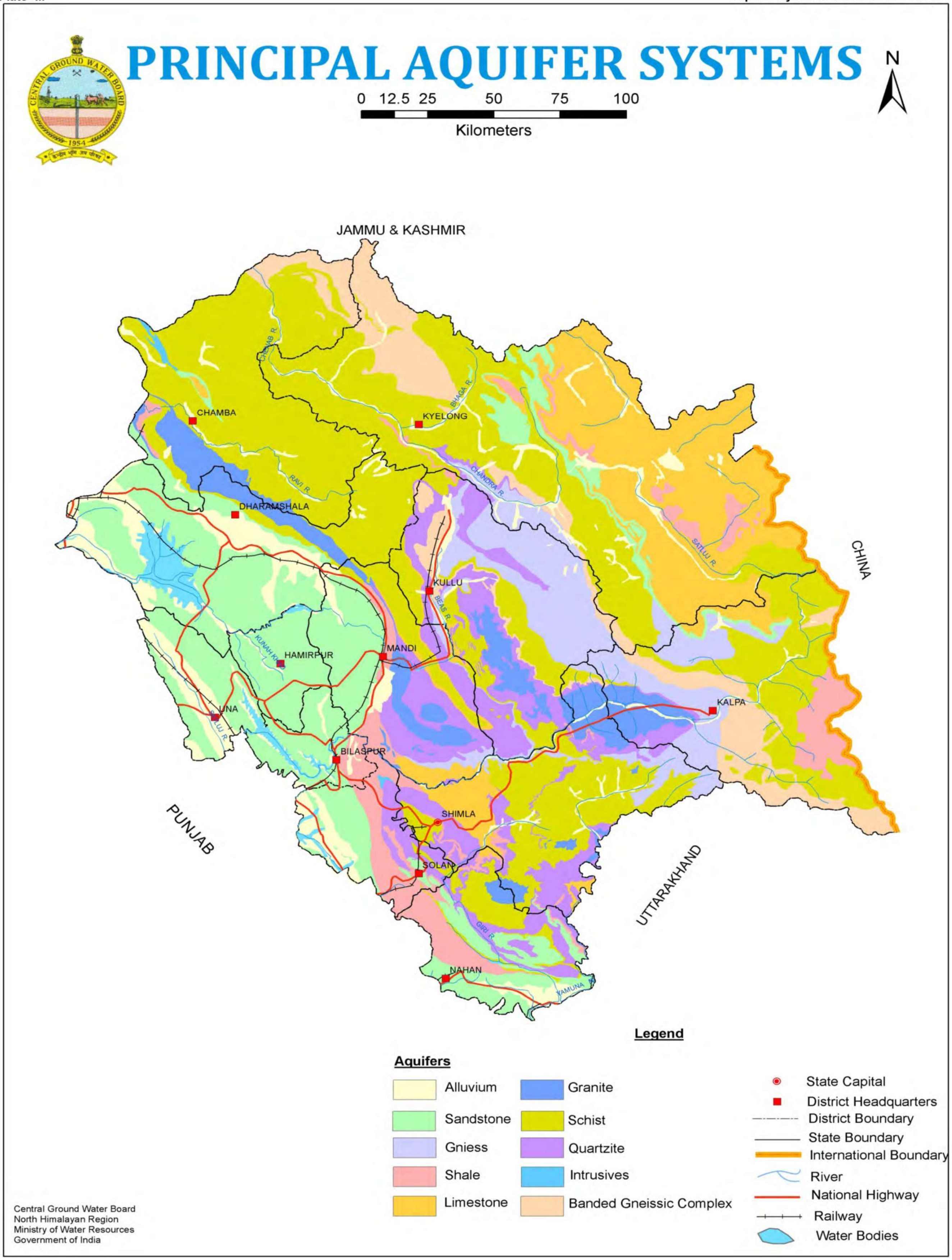


Fig-3 Principle Aquifer System

CHAPTER-5

GROUND WATER LEVEL SCENARIO IN HIMACHAL PRADESH

5.1 GROUND WATER LEVEL SCENARIO (2023)

The ground water level in the state is monitored regularly to have a review over the changes in ground water regime. The maps generated from these data help in identifying the areas, which are under water level rising and water level declining. With the help of these maps, suitable measures as per the demand of the area can be adopted for the sustainable ground water development. It also helps the planners to formulate the future strategy in various fields of ground water development.

For the purpose of presentation, the water levels and their changes are shown separately in alluvial and hard rock areas because of aquifer discontinuity. As discussed earlier, the major alluvial areas are Indura-Nurpur and Kangra-Palampur valley in District Kangra, Una valley in District Una, Balh valley in District Mandi, Nalagarh valley in District Solanand Paonta valley in District Sirmaur. In hard rock areas point values are given at places.

The water level is being monitored in the State four times in a year

1. May : 20th to 30th : represents water level of Pre-monsoon perioc
2. August : 20th to 30th : represents peak monsoon water level.
3. November : 1st to 10th : represents water level of Post-monsoon period.
4. January : 1st to 10th : represents the recession stage of water level

The data has been analyzed for each set of measurement and report has been prepared which include following maps to understand the groundwater regime in the area.

The depth to water level, seasonal fluctuation and annual fluctuation has been presented in Annexure-I, II and III. The decadal mean fluctuation has been tabulated in Annexure-IV. The ground water behavior in the seven Districts of Himachal Pradesh has been discussed below.

A. Depth to water level maps : Water level scenario for the month in the area.

B. Seasonal fluctuation maps : Water level fluctuation in comparison to Pre-monsoon and Post-monsoon

C. Annual fluctuation maps : Water level fluctuation in comparison to same month with the previous year.

D. Decadal mean fluctuation maps : Water level fluctuation in the month of measurement with reference to the decadal average for the same month.

GROUNDWATER LEVEL DATA OF PRE-MONSOON 2023

The depth to water level, recorded during May 2023 (Annexure - I), ranged between 0.27 m (Mandi District) and 97.35 m bgl (Solan District in Pz) (Table-4). Out of 176 stations monitored, the majority of 159 NHS (90.34%) recorded DTWL, in the range between 2 - 20 m bgl. 32 stations (18.18%), recorded shallow water levels, less than 2 m bgl and 17 stations (9.66%), recorded deep water levels, more than 20 m bgl in the state.

Depth to Water Level
Distribution of monitoring wells
May-23

State: Himachal Pradesh

District	No. of wells Analysed	Depth to water level		No of well showing depth to water table (mbgl) in the range of					
		Min.	Max.	0-2	2-5	5-10	10-20	20-40	> 40
Una	39	1.78	31.31	3	14	13	6	3	0
Solan	19	1.88	97.35	1	1	4	9	3	1
Sirmaur	23	1.63	41.03	4	5	4	8	1	1
Hamirpur	8	2.18	33.00	0	3	2	2	1	0
Bilaspur	12	0.5	67.72	2	3	4	1	1	1
Kangra	57	0.78	45.01	15	25	8	5	3	1
Mandi	10	0.27	8.21	3	6	1	0	0	0
Kullu	5	0.5	40.58	2	1	1	0	0	1
Chamba	3	1.54	4.59	2	1	0	0	0	0
Total	176			32	59	37	31	12	5

Table-5: District wise number & % of NHS distribution, in different DWL of May 2023

A perusal of the DTWL map of May 2023 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.

GROUNDWATER LEVEL DATA OF POST-MONSOON 2023

The depth to water level recorded during November 2023 (Annexure-I) ranged between 0.05 m bgl in (Bilaspur District) to 93.05 m bgl in (Sirmour District in Pz) (Table-6). Out of 183 stations monitored, the majority of 167 NHS (91.26%) recorded DTWL in the range between 2-20 m bgl. 42 stations (22.95%), recorded shallow water levels, less than 2 m bgl and 16 stations (8.74%), recorded deep water levels, more than 20 m bgl in the State.

A perusal of the DTWL map for November 2023 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 Level
Distribution of monitoring wells
Nov-23

State: Himachal Pradesh

District	No. of wells Analysed	Depth to water level		No of well showing depth to water table (mbgl) in the range of					
		Min.	Max.	0-2	2-5	5-10	10-20	20-40	> 40
Una	42	0.84	30.78	7	18	8	6	3	0
Solan	19	2.46	93.05	0	2	6	8	2	1
Sirmaur	14	1.35	30.99	3	8	4	6	3	0
Hamirpur	9	1.39	29.23	2	2	2	2	1	0
Bilaspur	12	0.05	65.31	3	5	2	0	1	1
Kangra	58	0.55	45.06	21	24	7	3	2	1
Mandi	10	0.47	4.78	3	7	0	0	0	0
Kullu	5	2.27	46.06	2	1	1	0	0	1
Chamba	4	2.61	17.46	1	2	0	1	0	0
Total	183			42	69	30	26	12	4

Table- 6: Depth to Water Level–November 2023

5.1.0 Fluctuation of Groundwater Level:

Annual fluctuation in water level of GWMS during different monitoring periods were analysed and discussed below.

Comparison of Pre-monsoon 2023 to Pre-monsoon 2022

Annual fluctuation of water level, has been worked out by comparing depth to water level of May 2022, with May 2023 and the data is presented in Annexure – III and its frequency distribution in various rise and fall ranges is given in Table-9.

Out of the 140 stations analysed, 71 stations (50.71%) have shown rise in water level ranging from 0.01 (Una District) to 7.57 m (Kangra District), whereas 69 stations (49.29 %) have shown fall ranging from 0.04 m (Sirmaur and Kangra District) to 6.42 m (Kangra District).

Out of 71 stations which have shown rise in water level, 64 stations (90.14%) show rise between the range of 0 to 2 m, 4 station (5.63%) has shown rise between 2 to 4 m and 3 station (4.23 %) shown rise more than 4 m.

Similarly, for 69 stations which have shown fall in water level, 66 stations (95.66%) show fall between the range of 0 to 2 m, 2 stations (2.89%) have shown fall between 2 to 4 m and 1 stations (1.45%) has shown fall more than 4 m.

A perusal of map of Annual Water Level Fluctuation for May 2022 to May 2023 shows fall in water level in majority of monitoring areas, specially in Una valley and Indora-Nurpur valley, except a couple of areas. Fall of 0-2 m in shown in Kangra-Palampur valley of Kangra District, Kullu Valley, major part of Nurpur and Indaura Valley and small pockets of Una Valley. Fall >4 m is noticed in small pockets of Nurpur valley and Indora Valley. Rise in water level is noticed in Kangra Palampur valley, small pockets of Una valley, northern part of Kullu valley and southern of Part of Balh valley.

District Wise Fluctuation and Frequency Distribution from Different Ranges from One Period to Other

From Year: May-22 To Year: May-23

State: Himachal Pradesh

District	No. of wells Analysed	Range of fluctuation (m)				No of well showing fluctuation in the range of						Total No. of Wells	
		Rise		Fall		Rise			Fall			Rise	Fall
		Min	Max	Min	Max	0 to 2	2 to 4	> 4	0 to 2	2 to 4	> 4		
Una	33	0.01	1.58	0.15	2.25	11	0	0	21	1	0	11	22
Solan	14	0.04	1.02	0.21	2.61	3	0	0	10	1	0	3	11
Sirmaur	20	0.07	0.88	0.04	1.45	5	0	0	15	0	0	5	15
Hamirpur	6	0.37	0.84	0.32	0.46	3	0	0	3	0	0	3	3
Bilaspur	4	0.19	1.88	0	0	4	0	0	0	0	0	4	0
Kangra	49	0.1	7.57	0.04	6.42	29	3	2	14	0	1	34	15
Mandi	9	0.19	2.03	0	1.02	6	1	0	2	0	0	7	2
Kullu	2	0.76	1.36	0	0	2	0	0	0	0	0	2	0
Chamba	3	0.0	5.13	0	0.26	1	0	1	1	0	0	2	1
Total	140					64	4	3	66	2	1	71	69

Table-7: District wise number &% of NHS distribution in different Annual Water Level Fluctuation with Range (May 2022 - May 2023)

Comparison of November 2023 to Post-monsoon 2022

November 2023 to November 2022

Annual fluctuation of water level has been worked out by comparing DTWL of November 2022 with November 2023 and data is presented in Annexure –III and its frequency distribution in various rise and fall ranges is given in Table-11.

Out of the 160 stations, 111 stations (69.38%) have shown rise in water level ranging from 0.01m (Mandi and Solan District) to 5.48 m (Kangra District) whereas 49 stations (30.62%) have shown fall ranging from 0.01 m (Kangra District) to 2.44 m (Una District).

Out of 111 stations which have shown rise in water level, 94 stations (84.68%) show rise between the range of 0 to 2 m, 12 station (10.81%) between 2 to 4 m and remaining 5 stations (4.5%) shows more than 4 m. Similarly, for the 49 stations which have shown fall in water level, 47 stations

(95.92%) show fall between the range of 0 to 2m, 2 station (4.08 %) has shown fall between 2 to 4 m and 0 stations (0%) shown fall more than 4 m.

A perusal of map of annual fluctuation of November 2022 to November 2023 showing fall in water levels in Nurpur Indora valley and central part of Una valley, Paonta Valley, Balh Valley and Nalagarh Vally. Similarly rise in water level 0-2 m is noticed along the fringe areas of all monitoring valleys except Kullu Valley and Balh Valley (Mandi District).

District Wise Fluctuation and Frequency Distribution from Different Ranges from One Period to Other

From Year: Nov-22 To Year: Nov-23

State: Himachal Pradesh

District	No. of wells Analysed	Range of fluctuation (m)				No of well showing fluctuation in the range of						Total No. of Wells	
		Rise		Fall		Rise			Fall			Rise	Fall
		Min	Max	Min	Max	0 to 2	2 to 4	> 4	0 to 2	2 to 4	> 4		
Una	35	0.05	4.63	0.21	2.44	26	2	2	4	1	0	30	5
Solan	15	0.01	5.21	0	0.96	9	4	1	1	0	0	14	1
Sirmaur	21	0.06	5.26	0.02	0.26	13	1	1	6	0	0	15	6
Hamirpur	8	0.13	3.81	0	0	6	2	0	0	0	0	8	0
Bilaspur	6	0.6	1.97	0.6	2.31	2	0	0	3	1	0	2	4
Kangra	58	0.02	5.48	0.01	1.77	29	2	1	26	0	0	32	26
Mandi	9	0.01	2.27	0.05	0.47	5	1	0	3	0	0	6	3
Kullu	5	0.04	0.65	0	0.75	3	2	0	2	0	0	3	2
Chamba	3	0	0	0.3	0.49	1	2	0	2	0	0	1	2
Total	160					94	12	5	47	2	0	111	49

Table-8: Annual Fluctuation-November 2022 to November 2023

Comparison of Pre-Monsoon 2023 with decadal mean of Pre-Monsoon (2013 to 2022)

Decadal Fluctuations

The decadal variations were analyzed considering the decadal average of water level and the water level for the respective period.

Decadal average of May (2013-2022) to May 2023

Decadal water level fluctuation has been worked out by comparing water level data of May 2023 with the average mean of 10 years' water level data of May (2013-2022) and is presented in Annexure-IV and frequency distribution in various ranges is presented in Table -13.

A perusal of Table-13 shows that out of 107 stations analysed, 59 stations (55.14%) have shown rise and 48 stations (44.86%), have shown fall in water level. Out of 59 stations which shows rise in water level, 44 stations (74.58%) are showing rise in water level between 0 to 2 m, 11 stations (18.64%) between 2 to 4 m and 4 stations (6.78%), more than 4 m. Out of 48 stations, 38 stations (79.17%) show fall in water level between 0 to 2 m, 3 stations (6.25 %) between 2 to 4 m and 7 stations (14.58%) more than 4 m. A minimum rise in water level of 0.06 m was noticed in Una Districts and the maximum rise of 27.81 m is noticed in Una District. Similarly, the minimum fall of 0.10 m is noticed in Una District & maximum fall of 6.70 m is noticed in Solan District.

A perusal of map of Decadal Variation - Average of May (2013 - 2022) with May 2023 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 (May-2013 to May-2022) - May-2023

State: Himachal Pradesh

District	No. of wells Analysed	Range of fluctuation (m)				No of well showing fluctuation in the range of						Total No. of Wells	
		Rise		Fall		Rise			Fall			Rise	Fall
		Min	Max	Min	Max	0 to 2	2 to 4	> 4	0 to 2	2 to 4	> 4		
Una	32	0.06	17.81	0.01	1.92	10	2	1	19	0	0	13	19
Solan	11	2.13	2.32	0.13	6.70	0	2	0	4	3	2	2	9
Sirmaur	12	0.16	14.26	0.23	6.33	3	0	2	5	0	2	5	7
Hamirpur	4	0.33	0.69	0.04	0.33	2	0	0	2	0	0	2	2
Kangra	37	0	4.68	0.06	5.41	23	5	1	6	0	2	29	8
Mandi	8	0.32	2.75	0.17	4.07	4	1	0	2	0	1	5	3
Kullu	3	0.10	3.13	0	0	2	1	0	0	0	0	3	0
Total	107					44	11	4	38	3	7	59	48

Table-9: District wise number & % of NHS distribution in different Decadal Water Level Fluctuation Range for May (2013-2022) to May 2023

Comparison of Decadal average of November (2013-2022) to Post-Monsoon November 2023

Decadal water level fluctuation has been worked out by comparing water level data of November 2023 with the average water level data of November for 10 years (2013-2022) and is presented in Annexure - IV and frequency distribution in various ranges in Table 15.

A perusal of Table-15 shows that out of 107 stations analyzed, 72 stations (67.29%) have shown rise and 35 stations (32.71%), have shown fall in water level. Out of 72 stations which shows rise in water level, 66 stations (91.67%) are showing rise in water level between 0 to 2 m, 3 stations (4.16 %) between 2 to 4 m. and 3 stations (4.16%), more than 4 m.

Out of 35 stations, 32 stations (91.43%) show fall in water level between 0 to 2 m, 1 station (2.86%) between 2 to 4 m and 2 station (5.71 %) more than 4 m.

A minimum rise in water level of 0.08 m was noticed in Sirmaur District and the maximum rise of 4.81 m is noticed in Una District. Similarly, the minimum fall of 0.01 m is noticed in Una District & maximum fall of 6.06 m is noticed in Sirmour District.

A perusal of map of Decadal average of November (2013-2022) to November 2023 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.

District Wise Fluctuation of Water Level with Mean and Selected Period

10 Years Mean (Nov-2013 to Nov -2022) - Nov-2023

State: Himachal Pradesh

District	No. of wells Analysed	Range of fluctuation (m)				No of well showing fluctuation in the range of						Total No. of Wells	
		Rise		Fall		Rise			Fall			Rise	Fall
		Min	Max	Min	Max	0 to 2	2 to 4	> 4	0 to 2	2 to 4	> 4		
Una	32	0.23	4.81	0.01	3.51	20	1	2	8	1	0	23	9
Solan	11	0.23	4.59	0.10	4.62	6	2	1	1	0	1	9	2
Sirmaur	12	0.08	0.78	0.12	6.06	7	0	0	4	0	1	7	5
Hamirpur	4	0.19	1.59	0	0	4	0	0	0	0	0	4	0
Kangra	37	0	1.71	0.03	0.72	21	0	0	16	0	0	21	16
Mandi	8	0.10	1.47	0.28	0.49	5	0	0	3	0	0	5	3
Kullu	3	0.26	1.43	0	0	3	0	0	0	0	0	3	0
Total	107					66	3	3	32	1	2	72	35

Table-10: Decadal Fluctuation November (2013-2022) to November 2023

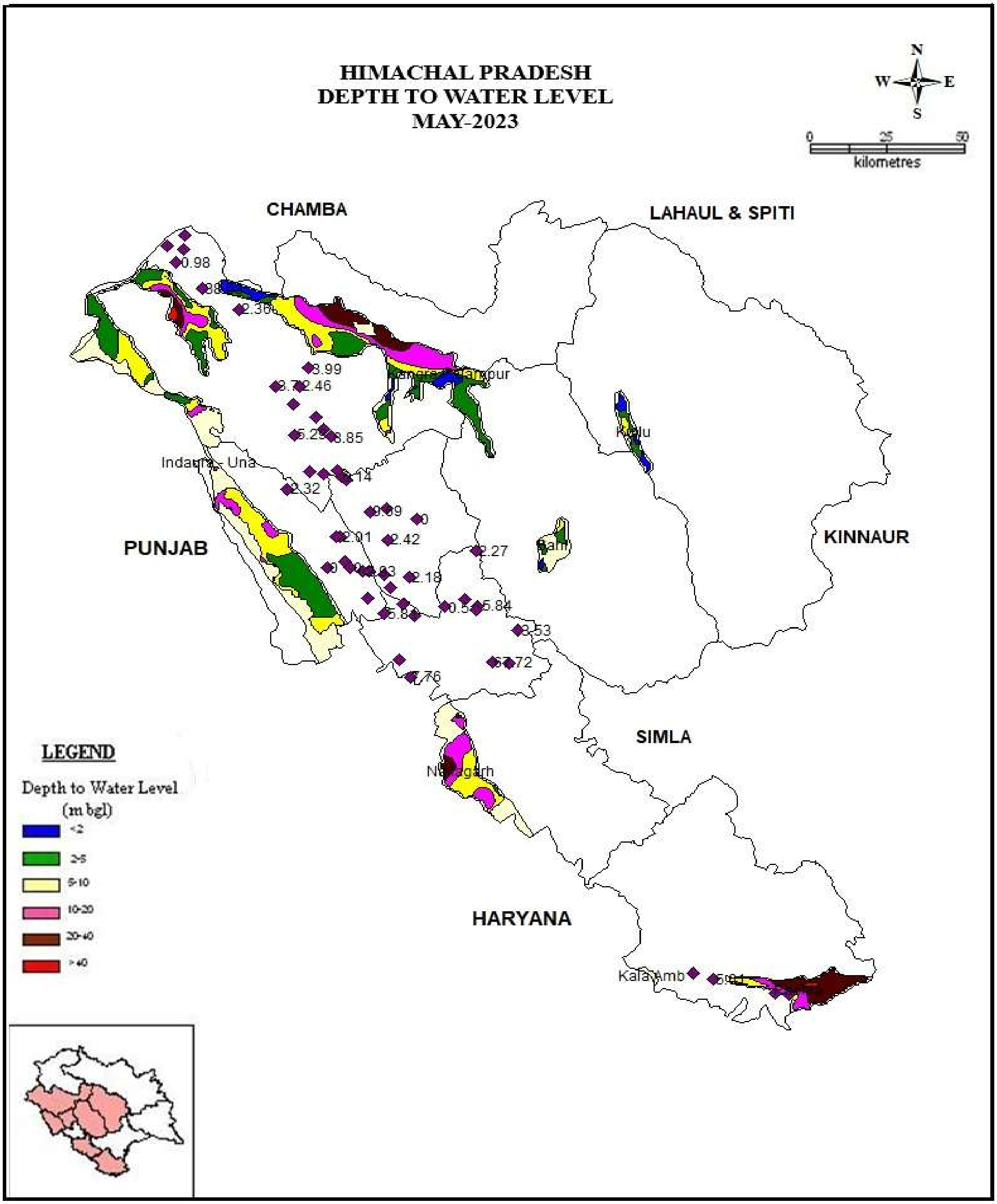


Fig-4 Map: DTWL (Pre monsoon 2023)

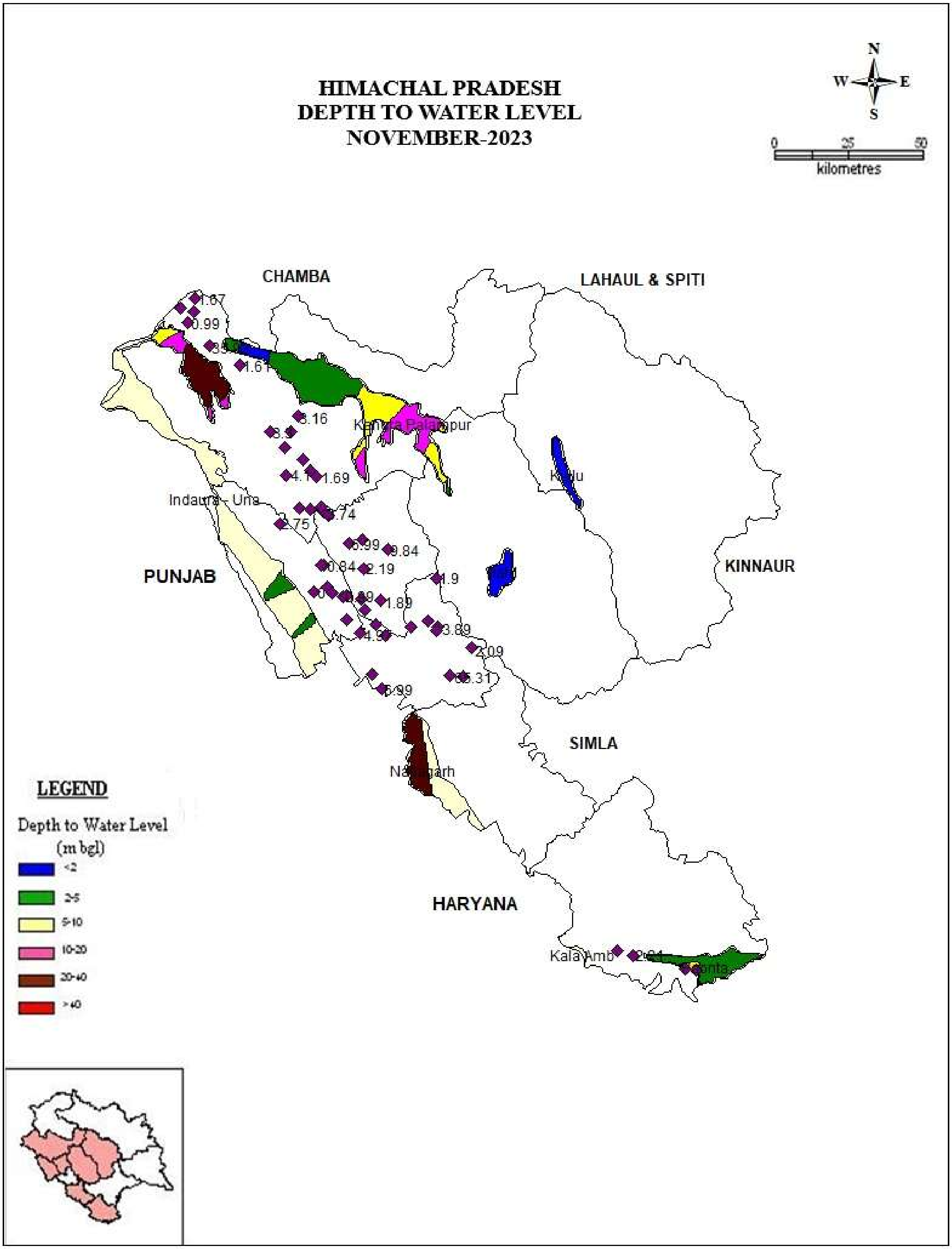


Fig -5 Map: DTWL (Post monsoon 2023)

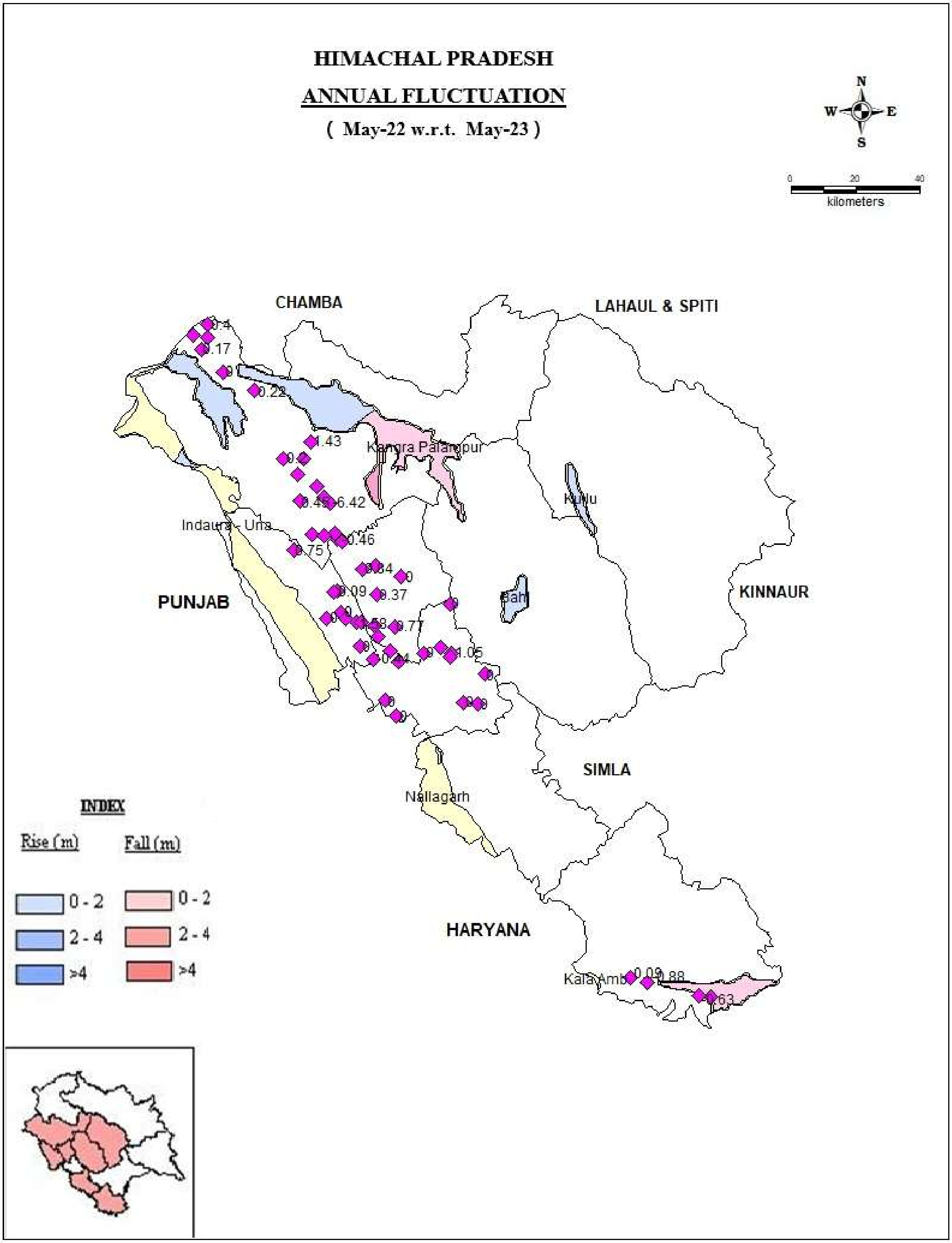


Fig -6 Map: Groundwater Level Fluctuation : (Pre-monsoon 2022 compared to Pre-monsoon 2023)

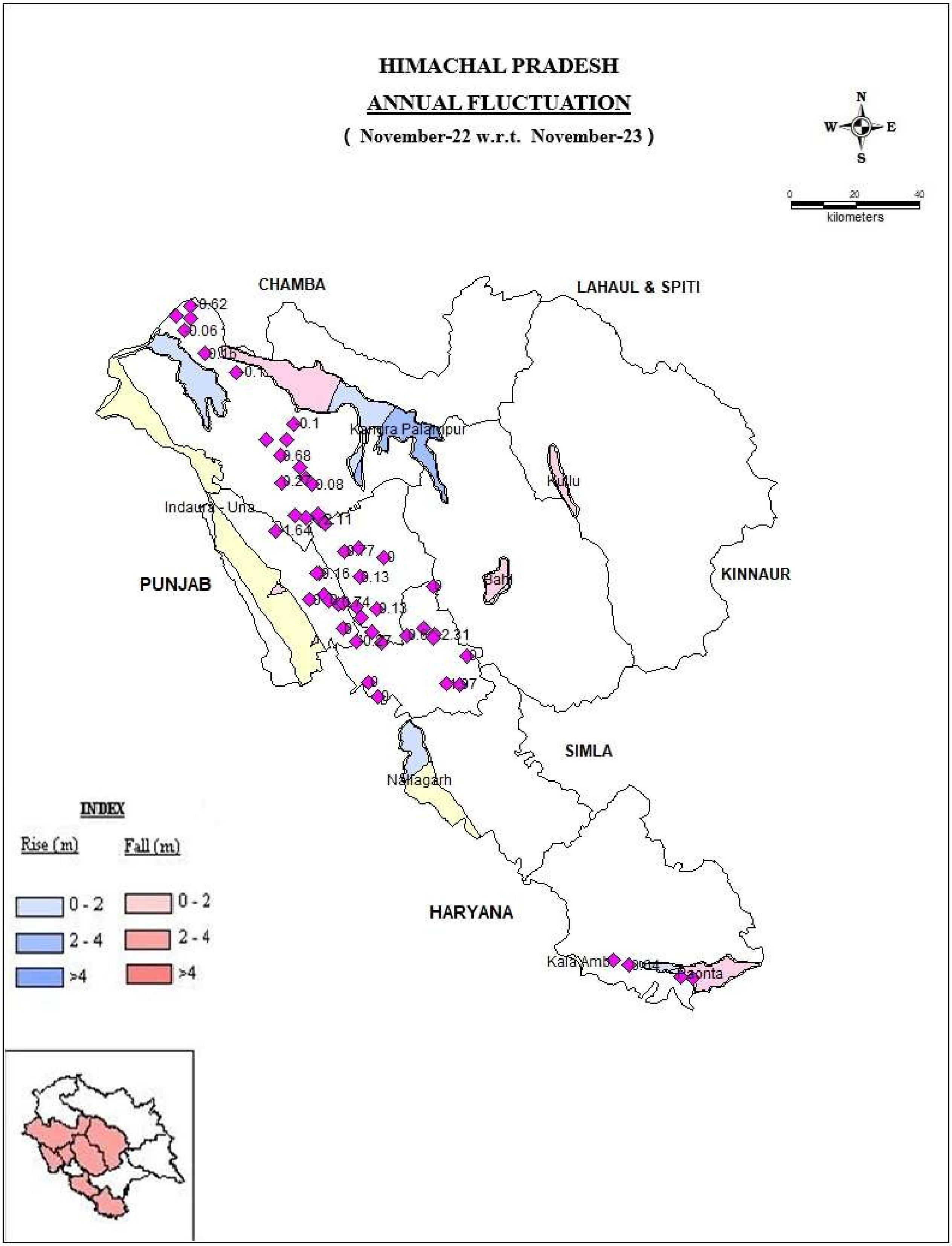


Fig -7 Map: Groundwater Level Fluctuation: November 2022 compared to November 2023

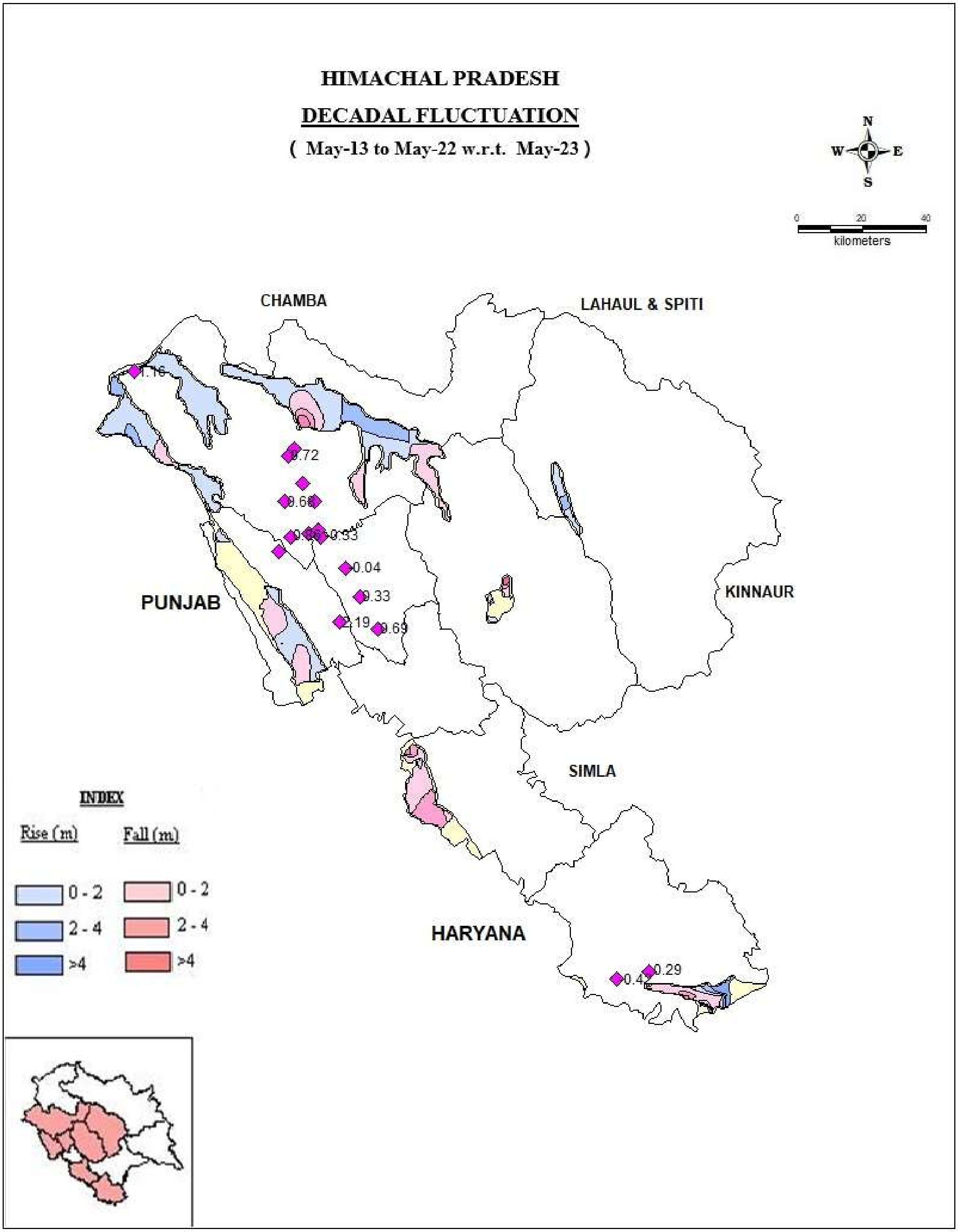


Fig -8 Map: Decadal water level fluctuation with mean Pre-Monsoon (2013 to 2022) and Pre-Monsoon 2023

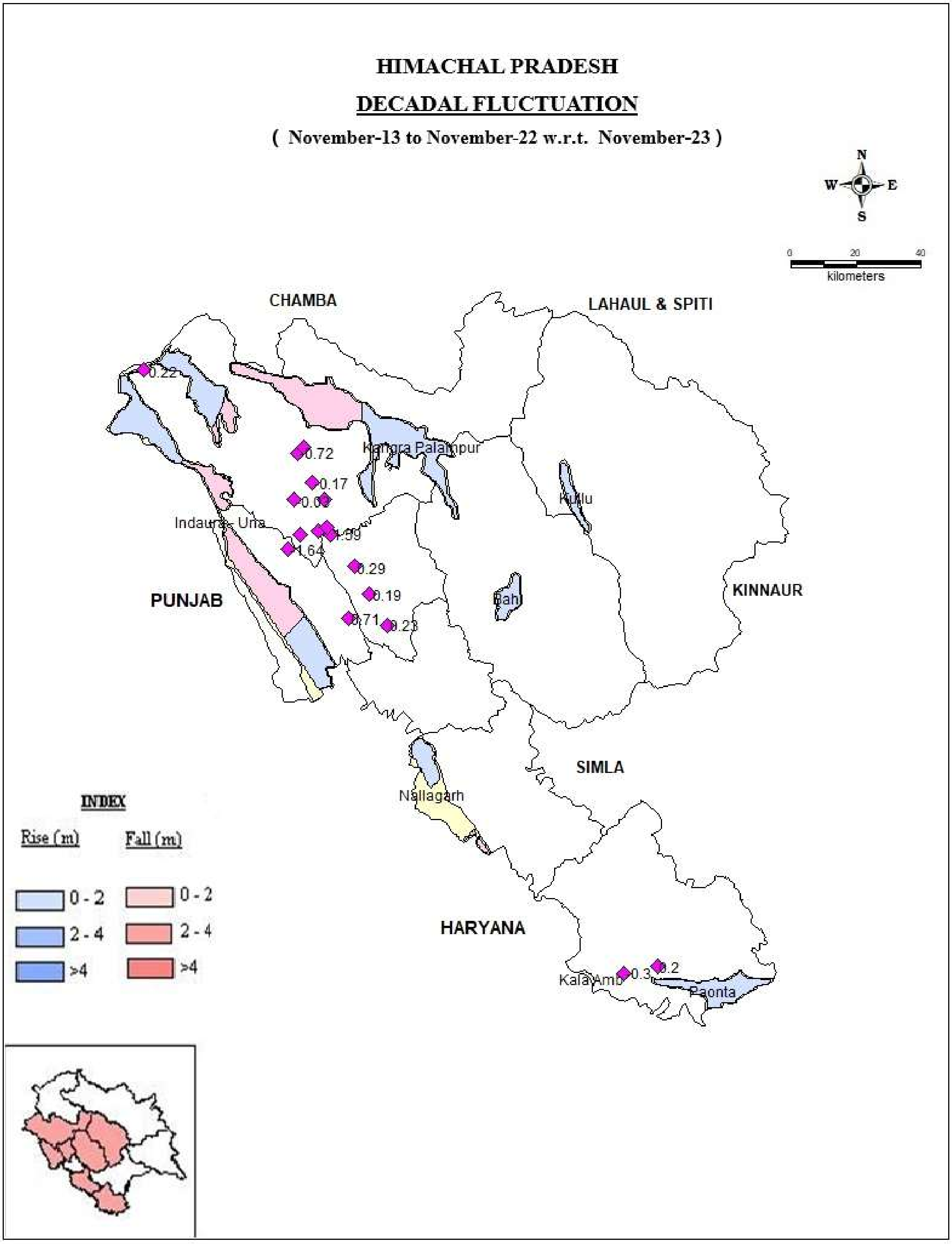


Fig -9 Map: Decadal water level fluctuation with mean Post-Monsoon (2013 to 2022) and Post-Monsoon 2023

CHAPTER 6

GROUND WATER RESOURCES OF THE HIMACHAL PRADESH

6.1. ANNUAL GROUND WATER RECHARGE

S. No.	States / Union Territories	Ground Water Recharge					Total Natural Discharges	Annual Extractable Ground Water Resource
		Monsoon Season		Non-monsoon Season		Total Annual Ground Water Recharge		
		Recharge from rainfall	Recharge from other sources	Recharge from rainfall	Recharge from other sources			
1	Himachal Pradesh	0.6104	0.17868	0.12665	0.19703	1.11277	0.1024	1.01037

Table-11.1: Annual Ground Water Recharge

Total Ground water recharge in Himachal Pradesh through all sources (in Monsoon Season + Non-Monsoon Season) = 1.11277 bcm

6.2. ANNUAL EXTRACTABLE GROUND WATER RESOURCES

S. No.	States / Union Territories	Ground Water Recharge					Total Natural Discharges	Annual Extractable Ground Water Resource
		Monsoon Season		Non-monsoon Season		Total Annual Ground Water Recharge		
		Recharge from rainfall	Recharge from other sources	Recharge from rainfall	Recharge from other sources			
1	Himachal Pradesh	0.6104	0.17868	0.12665	0.19703	1.11277	0.1024	1.01037

Table-11.2 :Annual Extractable Ground Water Resources

Annual Extractable Ground Water in Himachal Pradesh (after deduction of Total Natural Discharge) = 1.01037 bcm

6.3. ANNUAL TOTAL GROUND WATER EXTRACTION

S. No.	States / Union Territories	Current Annual Ground Water Extraction			
		Irrigation	Industrial	Domestic	Total
1	Himachal Pradesh	0.1852	0.05669	0.11662	0.35851

Table-11.3 Annual Total Ground Water Extraction

Annual Total Ground Water Extraction in Himachal Pradesh through all sources (Irrigation + Industrial + Domestic) = 0.35851 bcm

6.4. STAGE OF GROUND WATER EXTRACTION

S. No.	States / Union Territories	Name of District	Stage of Ground Water Extraction (%)
1	Himachal Pradesh	Kangra	22.70
2		Mandi	16.30
3		Sirmaur	23.26
4		Solan	57.89
5		Una	63.72
	Total		35.48

Table-11.4 Stage of Ground Water Extraction

Total Stage of Ground Water Extraction in Himachal Pradesh = 35.48%

6.5. CATEGORIZATION OF ASSESSMENT UNITS

Sl. No	State	District	Assessment Unit Name	Assessment Unit Type	Total Area of Assessment Unit (Ha)	Recharge Worthy Area(Ha)	Stage of Ground Water Extraction (%)	Categorization (Over-Exploited/Critical/Semi-Critical/Safe/Saline)
1	H.P.	Kangra	Indora Nurpur Valley	Valley	102400	102400	21.78	Safe
2	H.P.	Kangra	Dharamshala Palampur Valley	Valley	45200	45200	25.5	Safe
3	H.P.	Mandi	Balh Valley	Valley	39500	10700	42.39	Safe
4	H.P.	Mandi	Chauntra Valley	Valley	5200	5200	2.77	Safe
5	H.P.	Sirmour	Paonta Valley	Valley	27600	27600	20.13	Safe
6	H.P.	Sirmour	Kala Amb valley	Valley	8200	8200	38.12	Safe
7	H.P.	Solan	Nalagarh Valley	Valley	33600	33600	57.89	Safe
8	H.P.	Una	Una Valley (Satluj Basin)	Valley	104500	104500	65.8	Safe
9	H.P.	Una	Una Valley (Beas Basin)	Valley	6500	6500	25.85	Safe
10	H.P.	Una	Hum Valley	Valley	6579	2900	62.11	Safe

Table-11.5 Categorisation of Assessment Units

All 10 Assessment Units of Himachal Pradesh falls under **Safe** Category.

6.6. COMPARISON WITH PREVIOUS ASSESSMENT

S.N.	Assessment Year	Ground Water Recharge (Ham)				Annual Ground Water Extraction (Ham)				Stage of Ground Water Extraction (%)
		Monsoon Season		Non-Monsoon Season		Domestic	Industrial	Irrigation	Total	
		Recharge from Rainfall	Recharge from Other Sources	Recharge from Rainfall	Recharge from Other Sources					
1	2022-2023	61639.88	17735.44	12645.22	19470.25	11954.70	5414.10	18091.39	35460.22	34.95
2	2023-2024	61040.48	17867.89	12665.48	19703.15	11661.68	5669.18	18520.09	35850.94	35.48
3	Difference	599.4	132.45	20.26	232.9	293.02	255.08	428.69	390.72	0.53
		Decrease	Increase	Increase	Increase	Decrease	Increase	Increase	Increase	Increase

Table-11.6 Comparison with previous assessment

As compared with previous year Recharge from rainfall decreases in this assessment year where as Extraction increases for Industrial and Irrigation purpose. The overall Stage of groundwater extraction increases by 0.53% in 2023-2024 assessment year from previous 2022-2023 assessment year.

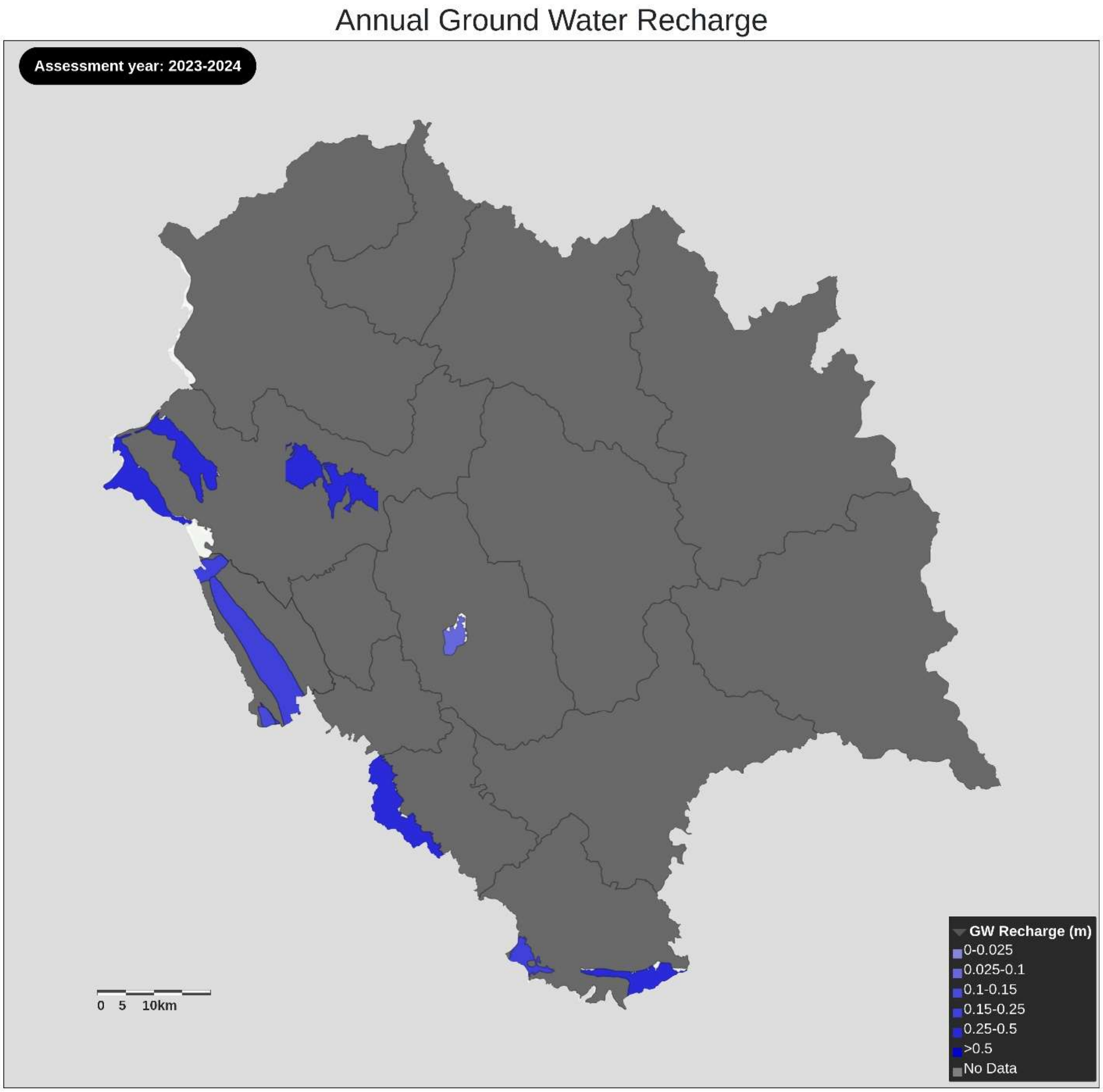


Fig-10 Annual Ground Water Recharge

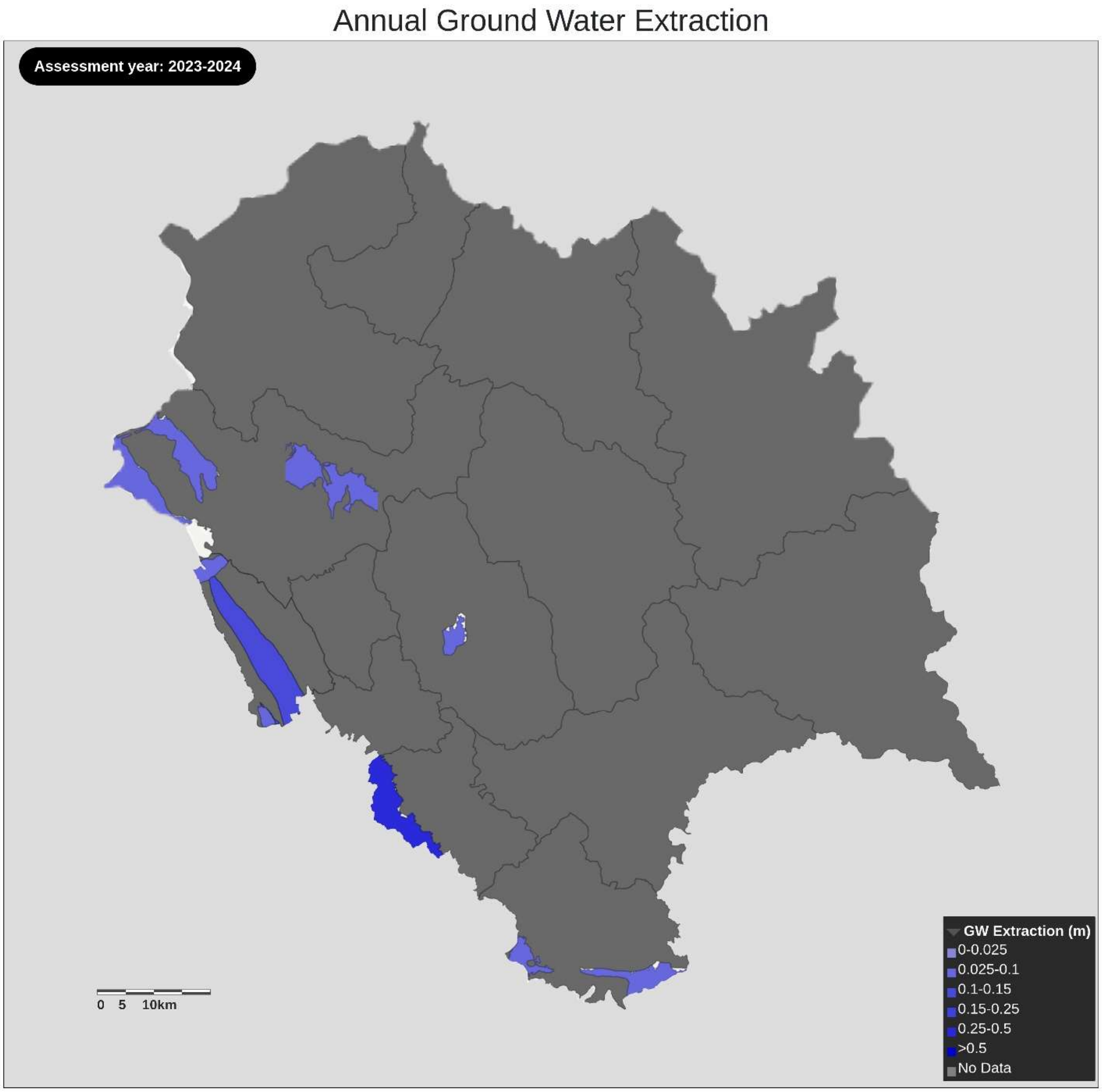


Fig-11 Annual Ground Water Extraction

Categorization of Assessment Unit

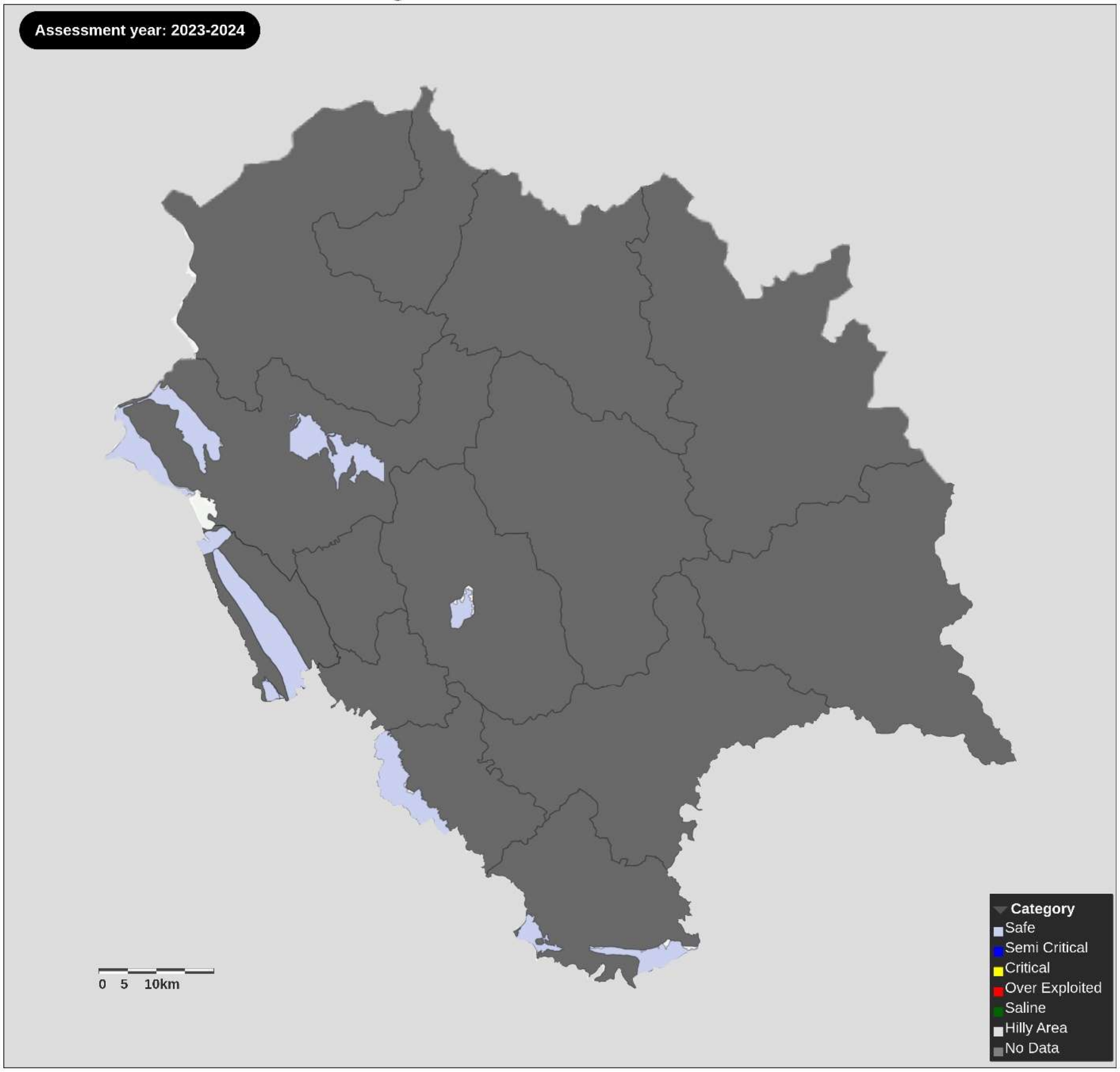


Fig-12 Categorisation of Asssessment Unit

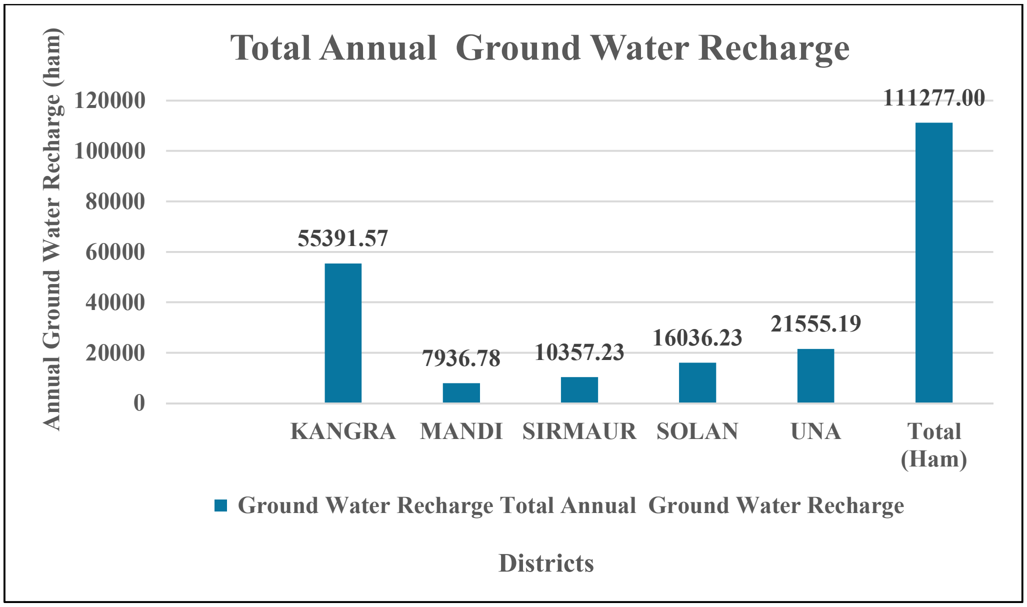


Fig-13 Total Annual Ground Water Recharge

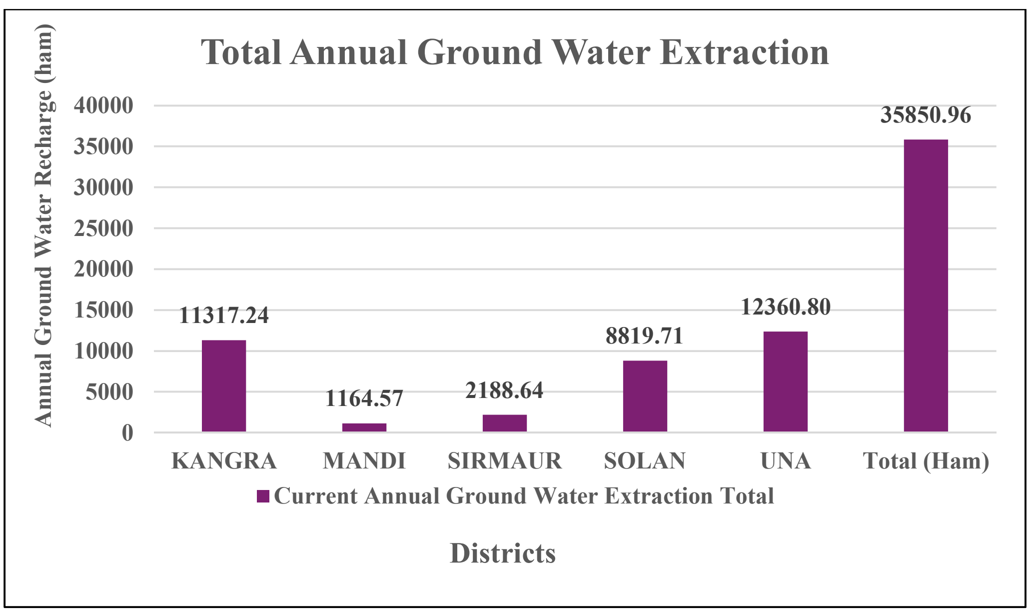


Fig-14 Bar Diagram with District Wise Recharge & Extraction figures

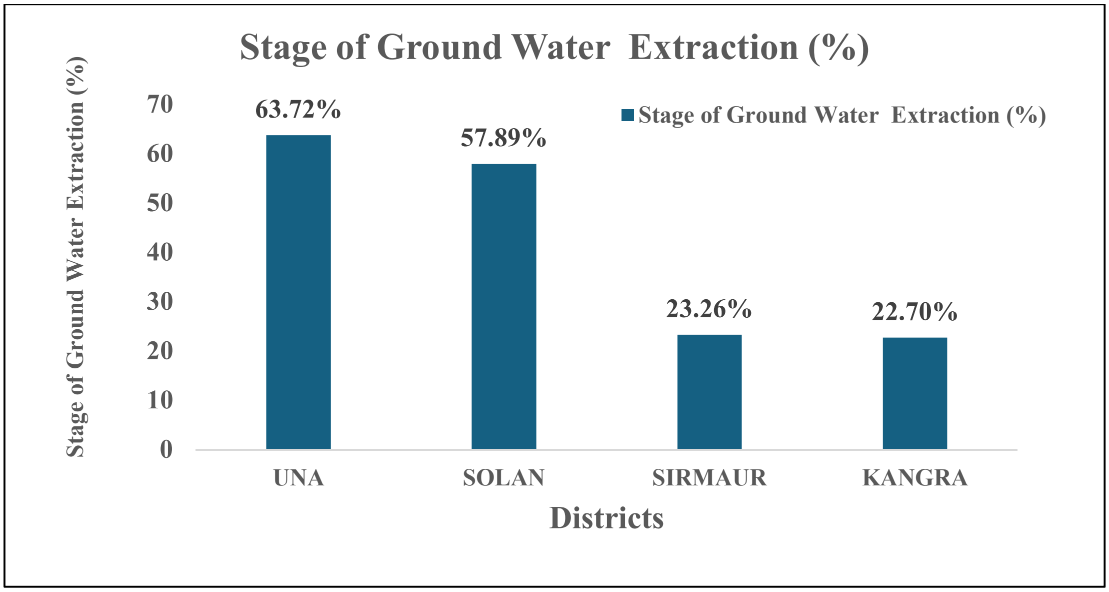
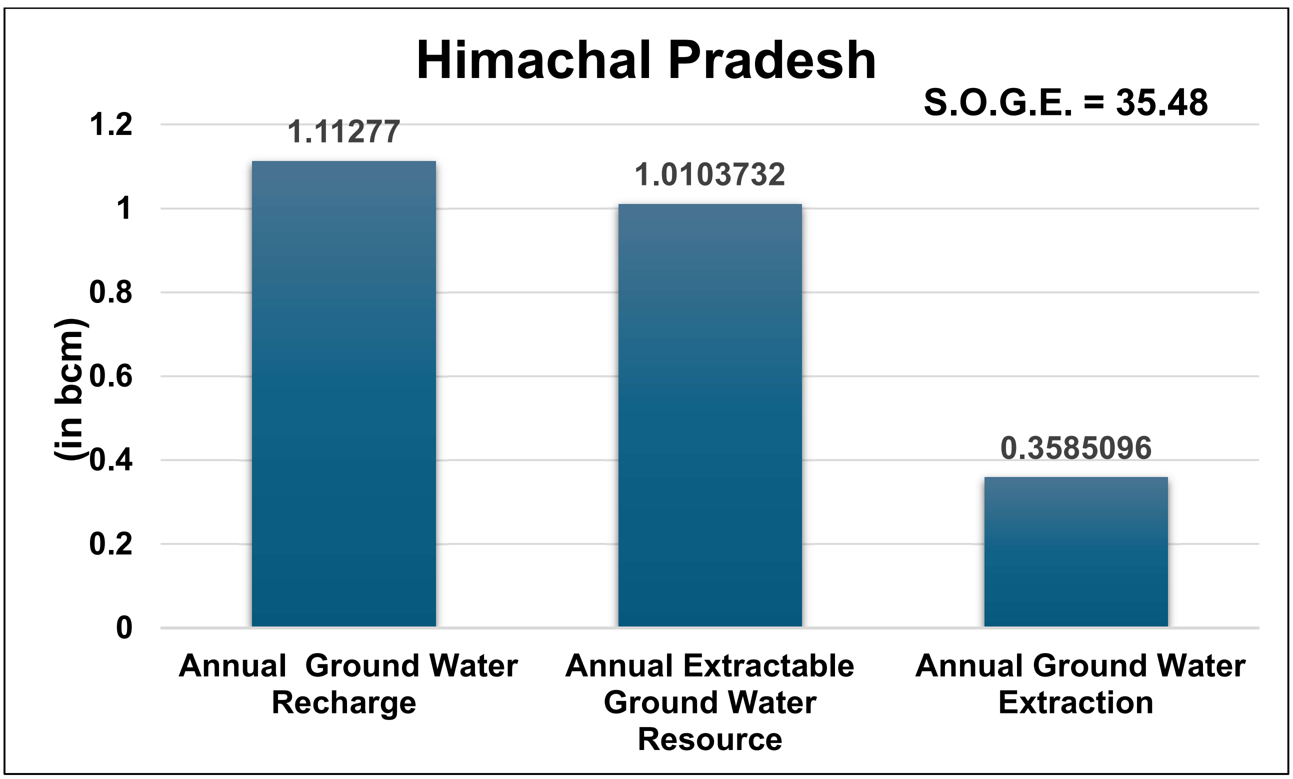


Fig -15 Bar Diagram of SoE of all the Districts in Decreasing order

CHAPTER 7

CONCLUSIONS

1. Total Ground water recharge in Himachal Pradesh through all sources (in Monsoon Season + Non-Monsoon Season) = 1.11277 bcm
2. Annual Extractable Ground Water in Himachal Pradesh (after deduction of Total Natural Discharge) = 1.01037 bcm
3. Annual Total Ground Water Extraction in Himachal Pradesh through all sources (Irrigation + Industrial + Domestic) = 0.35851 bcm
4. Total Stage of Ground Water Extraction in Himachal Pradesh = 35.48%
5. All 10 Assessment Units of Himachal Pradesh falls under **Safe** Category.
6. As compared with previous year Recharge from rainfall decreases in this assessment year whereas Extraction increases for Industrial and Irrigation purpose. The overall Stage of groundwater extraction increases by 0.53% in 2023-2024 assessment year from previous 2022-2023 assessment year.



Dynamic Ground Water Recourses Scenario 2024– Himachal Pradesh

Annexure-I

Ground water resources availability, utilization and stage of extraction (as in 2024)

GROUND WATER RESOURCES OF HIMACHAL PRADESH, 2024															
(in bcm)															
S. No.	States / Union Territories	Ground Water Recharge					Total Natural Discharges	Annual Extractable Ground Water Resource	Current Annual Ground Water Extraction				Annual GW Allocation for for Domestic Use as on 2025	Net Ground Water Availability for future use	Stage of Ground Water Extraction (%)
		Monsoon Season		Non-monsoon Season		Total Annual Ground Water Recharge			Irrigation	Industrial	Domestic	Total			
		Recharge from rainfall	Recharge from other sources	Recharge from rainfall	Recharge from other sources										
1	Himachal Pradesh	0.6104	0.17868	0.12665	0.19703	1.11277	0.1024	1.01037	0.1852	0.05669	0.11662	0.35851	0.11662	0.65186	35.48

Annexure-II

District-wise ground water resources availability, utilization and stage of extraction (as in 2024)

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024															
HIMACHAL PRADESH															
S. No.	Name of District	Ground Water Recharge					Total Natural Discharges	Annual Extractable Ground Water Resource	Current Annual Ground Water Extraction				Annual GW Allocation for for Domestic Use as on 2025	Net Ground Water Availability for future use	Stage of Ground Water Extraction (%)
		Monsoon Season		Non-monsoon Season		Total Annual Ground Water Recharge			Irrigation	Industrial	Domestic	Total			
		Recharge from rainfall	Recharge from other sources	Recharge from rainfall	Recharge from other sources										
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	KANGRA	30927.94	8072.45	6602.99	9788.19	55391.57	5539.15	49852.42	5915.44	40.17	5361.09	11317.24	5361.09	38535.18	22.70
2	MANDI	2853.77	2226.46	919.30	1937.25	7936.78	793.69	7143.09	277.80	0.00	886.77	1164.57	886.77	5978.52	16.30
3	SIRMAUR	9229.43	102.61	904.10	121.09	10357.23	949.51	9407.72	726.52	492.00	970.12	2188.64	970.12	7219.08	23.26
4	SOLAN	5908.31	4256.62	1567.81	4303.49	16036.23	801.81	15234.42	2651.37	4917.46	1250.88	8819.71	1250.88	6414.71	57.89
5	UNA	12121.03	3209.75	2671.28	3553.13	21555.19	2155.52	19399.67	8948.96	219.01	3192.83	12360.80	3192.83	7038.87	63.72
	Total(Ham)	61040.48	17867.89	12665.48	19703.15	111277.00	10239.68	101037.32	18520.09	5668.64	11661.69	35850.96	11661.69	65186.36	35.48
	Total(Bcm)	0.610405	0.178679	0.12665	0.19703	1.11277	0.1024	1.0103732	0.1852	0.05669	0.11662	0.35851	0.11662	0.651864	35.48

Annexure-III(A)

Categorization of blocks/ mandals/ taluks in India (as in 2024) for the State/UT

CATEGORIZATION OF BLOCKS/ MANDALS/ TALUKAS IN INDIA (2024)													
S.No.	State/Union Territories	Total No. of Assessed Units	Safe		Semi-Critical		Critical		Over-Exploited		Saline	
	States		Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%
1	Himachal Pradesh	10	10	100.0	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL

Annexure III (B)

District Wise Categorization of blocks/ mandals/ taluks for the State/UT (as in 2024)

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024													
HIMACHAL PRADESH													
S.No	Name of District	Total No. of Assessed Units	Safe		SemiCritical		Critical		OverExploited		Saline	
			No.	%	No.	%	No.	%	No.	%	No.	%
1	KANGRA	2	2	100								
2	MANDI	2	2	100								
3	SIRMAUR	2	2	100								
4	SOLAN	1	1	100								
5	UNA	3	3	100								
	Total	10	10	100								

Annexure III (C)
Annual Extractable Ground Water Resource of Assessment Units under Different Category for the State/UT (as in 2024)

ANNUAL EXTRACTABLE RESOURCE OF ASSESSMENT UNITS UNDER DIFFERENT CATEGORIES IN INDIA(2024)										
S.No.	State/Union Territories	Total Annual Extractable Resource of Assessed Units (in mcm)	Safe		Semi-Critical		Critical		Over-Exploited	
			Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%	Total Annual Extractable Resource (in mcm)	%
1	Himachal Pradesh	1010.37	1010.37	100.00						
	Grand Total									

Annexure- III (D)
District Wise Annual Extractable Ground Water Resource of Assessment Units under Different Category for the State/UT (as in 2024)

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024										
Himachal Pradesh										
S.No	Name of District	Total Annual Extractable Resource of Assessed Units (in Mcm)	Safe		Semi-Critical		Critical		Over-Exploited	
			Annual Extractable Resource (in Mcm)	%	Annual Extractable Resource (in Mcm)	%	Annual Extractable Resource (in Mcm)	%	Annual Extractable Resource (in Mcm)	%
1	KANGRA	498.5242	498.5242	100						
2	MANDI	71.4309	71.4309	100						
3	SIRMAUR	94.0772	94.0772	100						
4	SOLAN	152.3442	152.3442	100						
5	UNA	193.9967	193.9967	100						
	Total	**1010.3732**	**1010.3732**	100						

Annexure- III (E)

Recharge Worthy Area of Assessment unit under Different Category for the State/UT (as in 2024)

AREA OF ASSESSMENT UNITS UNDER DIFFERENT CATEGORIES IN INDIA (2024)												
S.No.	States/Union Territories	Total Recharge Worthy Area of Assessed Units (in sq.km)	Safe		Semi-Critical		Critical		Over-Exploited		Saline	
			Recharge Worthy Area (in sq.km)	%	Recharge Worthy Area (in sq.km)	%	Recharge Worthy Area (in sq.km)	%	Recharge Worthy Area (in sq.km)	%	Recharge Worthy Area (in sq.km)	%
1	Himachal Pradesh	3468.00	3468.00	100								
	Grand Total											

Annexure III (F) District Wise Recharge Worthy Area of Assessment unit under Different Category for the State/UT (as in 2024)

DYNAMIC GROUND WATER RESOURCES OF INDIA, 2024												
NAME OF STATE												
S.No	Name of District	Total Recharge Worthy Area of Assessed Units (in sq.km)	Safe		Semi-Critical		Critical		Over-Exploited		Saline	
			Recharge Worthy Area of Assessed Units (in sq.km)	%	Recharge Worthy Area of Assessed Units (in sq.km)	%	Recharge Worthy Area of Assessed Units (in sq.km)	%	Recharge Worthy Area of Assessed Units (in sq.km)	%	Recharge Worthy Area of Assessed Units (in sq.km)	%
1	KANGRA	1476	1476	100								
2	MANDI	159	159	100								
3	SIRMAUR	358	358	100								
4	SOLAN	336	336	100								
5	UNA	1139	1139	100								
	Total	**3468**	**3468**	100								

Annexure IV (A)
Categorization of Over Exploited, Critical and Semi Critical blocks/ mandals/ taluks (as in 2024)

CATEGORISATION OF ASSESSMENT UNIT, 2024							
HIMACHAL PRADESH							
S.NO	Name of District	S.NO	Name of Semi-Critical Assessment Units	S.NO	Name of Critical Assessment Units	S.NO	Name of Over-Exploited Assessment Units
ABSTRACT							
Total No. of Assessed Units		Number of Semicritical Assessment Units		Number of Critical Assessment Units		Number of Over Exploited Assessment Units	
10		0		0		0	

Annexure IV (B)
Quality problems in Assessment units (as in 2024)

QUALITY PROBLEMS IN ASSESSMENT UNITS, 2024							
NAME OF STATE							
S. No	Name of District	S. No	Name of Assessment Units affected by Fluoride	S. No	Name of Assessment Units affected by Arsenic	S. No	Name of Assessment Units affected by Salinity
ABSTRACT							
Total Number of Assessed Units		Number of Assessment Units affected by Fluoride		Number of Assessment Units affected by Arsenic		Number of Assessment Units affected by Salinity	
10		0		0		0	

Annexure V (A)
Summary of Assessment units improved or deteriorated from 2023 to 2024 assessment

State-Wise Summary Of Assessmet Units Improved Or Deteriorated From 2024 To 2023 Assessment							
S. No.	Name of States / Union Territories	Total Number of Asssessed Units	Number of Assessment Units Improved	Number of Assessment Units Deteriorated	Number of Assessment Units With No Change	Number of Assessment Units Newly formed or Previous Assessment Units Reorganized	Remarks
1	**Himachal Pradesh**	**10**	0	0	10	0	Safe

Annexure V (B)
Comparison of categorization of assessment units (2023 to 2024)

COMPARISON OF CATEGORIZATION OF ASSESSMENT UNITS (2024 AND 2023)									
NAME OF STATE									
S. No	Name of District	Name of Assessment Unit	Stage of Ground Water Extraction (%) in 2023	Categorization 2023	Name of District	Name of Assessment Unit	Stage of Ground Water Extraction (%) in 2024	Categorization 2024	Remark
Improved									
1									
2									
3									
4									
5									
6									
7									
8									

COMPARISON OF CATEGORIZATION OF ASSESSMENT UNITS (2024 AND 2023)									
NAME OF STATE									
S. No	Name of District	Name of Assessment Unit	Stage of Ground Water Extraction (%) in 2023	Categorization 2023	Name of District	Name of Assessment Unit	Stage of Ground Water Extraction (%) in 2024	Categorization 2024	Remark
Deteriorated									
1									
2									
3									
4									
5									
6									
7									
8									
9									

Annexure VI
Assessment Unit Wise Report (Attribute Table)

Annexure VI

Sl. No	State	District	Assessment Unit Name	Assessment Unit Type	Total Area of Assessment Unit (Ha)	Recharge Worthy Area(Ha)	Recharge from Rainfall-Monsoon Season	Recharge from Other Sources-Monsoon Season	Recharge from Rainfall-Non Monsoon Season	Recharge from Other Sources-Non Monsoon Season	Total Annual Ground Water (Ham) Recharge	Total Natural Disharges (Ham)	Annual Extractable Ground Water Resource (Ham)	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Industrial Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (Over-Exploited/Critical/Semi-Critical/Safe/Saline)	Urban Aus or not
1	Himachal Pradesh	Kangra	Indora Nurpur Valley	Valley	102400	102400	19948.8	7905.89	4258.99	9584.15	41697.84	4169.78	37528.06	5914.19	40.17	2219.37	8174.27	2219.37	29353.79	21.78	Safe	No
2	Himachal Pradesh	Kangra	Dharamshala Palampur Valley	Valley	45200	45200	10979.1	166.56	2344	204.04	13693.73	1369.37	12324.36	1.25	0	3141.72	3142.97	3141.72	9181.39	25.5	Safe	No
3	Himachal Pradesh	Mandi	Balh Valley	Valley	39500	10700	1775.31	109.06	618.65	208.04	2711.06	271.11	2439.95	277.8	0	756.46	1034.26	756.46	1405.69	42.39	Safe	No
4	Himachal Pradesh	Mandi	Chauntra Valley	Valley	5200	5200	1078.46	2117.4	300.65	1729.21	5225.72	522.58	4703.14	0	0	130.31	130.31	130.31	4572.83	2.77	Safe	No
5	Himachal Pradesh	Sirmour	Paonta Valley	Valley	27600	27600	7704.98	94.66	728.19	105.19	8633.02	863.3	7769.72	631.14	168.68	764.38	1564.2	764.38	6205.52	20.13	Safe	No
6	Himachal Pradesh	Sirmour	Kala Amb valley	Valley	8200	8200	1524.45	7.95	175.91	15.9	1724.21	86.21	1638	95.38	323.32	205.74	624.44	205.74	1013.56	38.12	Safe	No
7	Himachal Pradesh	Solan	Nalagarh Valley	Valley	33600	33600	5908.31	4256.62	1567.81	4303.49	16036.23	801.81	15234.42	2651.37	4917.46	1250.88	8819.71	1250.88	6414.71	57.89	Safe	No
8	Himachal Pradesh	Una	Una Valley (Satluj Basin)	Valley	104500	104500	10757.6	3133.14	2449.73	3414.69	19755.13	1975.51	17779.62	8525.2	207.79	2966.37	11699.36	2966.37	6080.26	65.8	Safe	No
9	Himachal Pradesh	Una	Una Valley (Beas Basin)	Valley	6500	6500	883.92	18.19	134.19	20.22	1056.52	105.65	950.87	121.31	2.01	122.52	245.84	122.52	705.03	25.85	Safe	No
10	Himachal Pradesh	Una	Hum Valley	Valley	6579	2900	479.54	58.42	87.36	118.22	743.54	74.36	669.18	302.45	9.21	103.94	415.6	103.94	253.58	62.11	Safe	No

Annexure-VII

No.JSB-F010/1/2024
Government of Himachal Pradesh
Jal Shakti Vibhag

From:

The Additional Chief Secretary (Jal Shakti) to the
Government of Himachal Pradesh

To

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

Dated: Shimia- 171002, the 18 /11/2024

Subject: **Proceeding of the meeting held on 08-10-2024 under the Chairmanship of Additional Chief Secretary (Jal Shakti) to the Government of Himachal Pradesh regarding State Level Committee on Ground Water Resource Estimation of Himachal Pradesh as on March, 2024.**

Sir,

I am directed to refer to the above cited subject and to enclose herewith an approved copy of proceedings of above referred meeting for information and further circulation to all concerned.

Yours faithfully,

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

Endst No. As above Dated Shimla-2, the /2024

Copy is forwarded to Engineer-in-Chief, Jal Shakti Vibhag, Tutikandi, Shimla- 05 for information and further necessary action.

Deputy Secretary (JS) to the
Government of Himachal Pradesh

Proceeding of the meeting held on 08.10.2024 under the Chairmanship of Additional Chief Secretary (Jal Shakti) to the Government of Himachal Pradesh regarding State Level Committee on Ground Water Resource Estimation of Himachal Pradesh as on March 2024.

At the outset, Sh. Sanjay Pandey, Scientist B, CGWB, NHR welcomed Sh. Onkar Chand Sharma, IAS, Additional Chief Secretary (Jal Shakti) to the Government of Himachal Pradesh, Chairman and other Members of State Level Committee on Ground Water Resource Estimation, Himachal Pradesh.

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 2024, compiled on the basis of GEC-2015, jointly by Central Ground Water Board, NHR, Dharamshala and Jal Shakti Vibhag, Himachal Pradesh.

- The outcome of the report was shared in the form of Power Point Presentation (PPT) by Sh. Prasant Kumar Singh, STA (Hg), 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 assessment areas fall in alluvial formation and the areas having semi consolidated formation having slopes less than 20% were taken into 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. Bhavesh Sharma, Senior Hydrogeologist, GWO.

- GWRA as on march 2024 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 2024					
Sr No	**Assessment Units/Valley**	**District**	**Area of Assessment units (Sq. Km.**	**Stage of Extraction**	**Categorization**
1	Nurpur-lndora Valley	Kangra	1024.00	21.78	Safe
2	Dharamshala Palampur Valle	Kangra	452.00	25.5	Safe
3	Balh Valley	Mandi	107.00	42.39	Safe
4	Chauntra Valley	Mandi	52.00	2.77	Safe
5	Paonta Valley	Sirmour	276.00	20.13	Safe
6	Kala Amb Valley	Sirmour	82.00	38.12	Safe
7	Nalagarh Valley	Solan	336.00	57.89	Safe
8	Una Valley (Satluj Catchment)	Una	1045.00	65.8	Safe
9	Una Valley (Beas Catchment)	Una	65.00	25.85	Safe
10	Hum Valley	Una	29.00	62.11	Safe
	Total		3468.00	35.48	

- The Chairman cum Additional Chief Secretary(Jal Shakti) asked about the long term water level fluctuation and groundwater level trend analysis comparison for those assessment areas (Baddi Barotiwala Nalagarh and Kala Amb valleys) having- large number of water intensive units and facing groundwater level decline.ln the response to this, Sh. Sanjay Pandey, Scientist-B, CGWB explained how groundwater withdrawal is taking fromdeep aquifers instead of shallow unconfined aquifer in these areas resulted declining in water level in deeper aquifer.
- Worthy Chairman cum Additional Chief Secretary suggested to demarcate the groundwater zones (shallow and deeper groundwater level areas) within the same assessment valley with the help of thematic maps of long term water level fluctuation and groundwater level trend. Such maps which will be helpful to manage and regulate the groundwater within same assessment unitin pragmatic manner. Worthy Chairman directed to prepare a report on the depletion of natural water resources in the State due to urbanization over the years on the basis of previous studies. He has also suggested to conduct a meeting very soon to discuss about the groundwater zonation of those assessment unit areas where groundwater level is declining at alarming rate.

- In view of increasing trend of Urbanization, worthy Chairman suggested to incorporate the latest land use data in such study. This approach will affect the quantity of natural recharge from rainfall and recharge from other sources.
- 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 2023. 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 Additional Chief Secretary (Jal Shakti) suggested to distribute the report of Ground Water Resource Assessment-2024 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, Cooperative 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 2024 was approved by the committee.
    - **Meeting ended with the vote of thanks to the chair.**

Annexure- A

List of Participants

1. Smt. Raksha Sharma, Deputy Secretary (Jal Shakti) to the Government of H.P, Shimla-2,
2. Er. Joginder Chauhan, Chief Engineer (SZ), JSV, HP, Shimla-5.
3. Er. Anil Mehta, Chief Engineer (D&M), JSV, HP, Shimla-5.
4. Er. Sumit sood, SE (P I & II), JSV, HP, Shimia-5.
5. Sh. Rajender Chauhan, Project Officer, Urban Develop Department, HP.
6. Sh. Suresh Sharma, Joint Director, Department of Agriculture, Shimla-5, HP.
7. Sh. Vijay Negi, AGM, NABARD, Shimla
8. Sh. Bhavnesh Sharma, Senior Hydrogeologist, GWO, Jal Shakti Vibhag, Una, HP.
9. Er. Anil Jaswal, Executive Engineer, Hydrology, C&M Division, Shimla-4, H.P.
10. Sh. Sanjay Pandey, Scientist-B, CGWB, NHR, Dharamshala, H.P.
11. Sh. Amit Moudgal, Divisional Engineer, Department of Agriculture, Shimla-5, HP.
12. Sh. Manohar Kumar, Assistant Hydrogeologist, CGWB, NHR, Dharamshala, HP
13. Sh. Vijay Kumar Negi, AM, NABARD, Shimla
14. Sh. Sunil Verma, Assistant Geologist, Geological Wing, H.P.
15. Sh. Atul Sharma, Geological Wing, Directorate of Industries H.P.
16. Sh. Prasant Kumar Singh, S.T.A. (Hg.), CGWB, NHR, Dharamshala, HP

Annexure-A

Government of Himachal Pradesh
Jal Shakti Vibhag

No. IPH-B(A)3-1/2019-II-L Dated Shimia-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 Jal Shakti, Department of Water Resources, River Development & Ganga Rejuvenation, hram 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 Phawan, 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 Shimia-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)-2015.

(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 Rejuvenation, 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 Shákti 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 Pradésh-176215.

Raksha

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

Annexure-B

No.JSB-A010/2/2024
Government of Himachal Pradesh
Jal Shakti Vibhag

From

The Additional Chief Secretary (Jal Shakti) 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 16 /09/2024

Subject: Proceeding of meeting of State Ground Water Coordination Committee (SGWCC) & State Level Committee on Ground Water Resource Estimation of Himachal Pradesh held on 05-07-2024.

Sir,

I am directed to refer to the above cited subject and to enclose herewith copy of proceedings of above referred meeting dully approved by the Government for information and further circulation to all concerned.

Yours faithfully,

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

Endst No. As above Dated Shimla-2, the 16 /09/2024

Copy is forwarded to Engineer-in-Chief, Jal Shakti Vibhag, Tutikandi, Shimla-05 for information and further necessary action.

Deputy Secretary (JS) to the
Government of Himachal Pradesh

Proceedings of meeting of State Ground Water Coordination Committee (SGWCC) & State Level Committee on Ground Water Resource Estimation of Himachal Pradesh held on 05.07.2024.

A meeting of SGWCC & SLC was held on 05.07.2024 under the Chairmanship of Dr. Ashwani Kumar Sharma, Special Secretary (Jal Shakti) to the Government of Himachal Pradesh in the Conference Hall of the Armsdale Building. At the outset of the meeting, Dr. Sanjay Pandey, Scientist-B, CGWB, NHR welcomed Dr. Ashwani Kumar Sharma, Special Secretary (Jal Shakti) and other Members of the said Committee. The proceedings started with the agenda circulated to all Members. List of participants who attended the meeting is attached.

AGENDA 1:

Review of the Ground Water Resource Assessment-2024 status and strict adherence to the timeline for GWRA-2024.

Dr. Sanjay Pandey, Scientist-B explained the timeline in carrying out Ground Water Resource Assesment-2024. Shri Bhavnesh Sharma, Senior HG, GWO apprised the status of the collection of data and their variables used for resource estimation. As per Sh. Bhavnesh Sharma, data in calculating recharge from other sources e.g. Surface Irrigation Schemes, Canals, Water Conservation Structures, Tanks/Ponds and data pertaining to ground water extraction is under progress. Worthy Special Secretary directed to finish the GWRA-2024 within stipulated time by strictly adhering to the timeline.

AGENDA 2:

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 discussions were held in this regard after that Dr. Ashwani Kumar Sharma, Special Secretary (Jal Shakti) and Chairman of the Committee opined to re- examine the setup of this Committee in Himachal Pradesh state in the terms of reference in details.

AGENDA 3:

Sharing of Ground Water Level data of all Piezometers from JSV, Himachal Pradesh.

Dr. Sanjay Pandey, Scientist-B requested the Chairman to share the ground water level data of all piezometers of JSV, Himachal Pradesh on regular basis. Dr. Ashwani Kumar Sharma, IAS, Special Secretary (Jal Shakti) and Er. Anju Sharma, Engineer-in-Chief, JSV, ensured that the data will be shared with CGWB, NHR, Daharamshala on the quarterly basis. Dr. Ashwani Kumar Sharma, Special Secretary (Jal Shakti) opined for sharing of ground water year book from CGWB, NHR, Dharamshala.

AGENDA 4:

Formation of State Level Committee for Ground Water Assessment and Management

Dr. Sanjay Pandey, Scientist-B apprised the Committee about the Member's DO. letter dated 27.06.2024 from CGWB, CHQ, Faridabad which concerned about the 10th meeting of National Inter-Departmental Steering Committee (NISC) Chaired by the Secretary (WR, RD & GR) that the existing SGWCC and SLC are required to be merged to form a single Committee for better coordination. As both the SGWCC (for NAQUIM studies) and SLC (for Resource Assessment) have similar composition and deal with related activities, it has been requested to subsume the TOR of SGWCC with that of SLC. The Committee may be named as the State Level Committee for Ground Water Assessment and Management or as deemed fit. Detailed discussions were held in this regard and Dr. Ashwani Kumar Sharma, Special Secretary (Jal Shakti) agreed to form State Level Committee for Ground Water Assessment and Management for which request be sent to the Additional Chief Secretary (Jal Shakti) to the Government of Himachal Pradesh.

AGENDA 5:

To be considered "Block" as the assessment unit in Ground Water Resource Assessment 2024 (GWRA-2024)

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 2024 was discussed that as the State is predominantly a hilly region having slopes more than 20% and underlain 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-2024 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 was held on the revision of assessment area and after detailed deliberations the Committee agreed that for the Dynamic Ground Water Resource Assessment 2024, the valleys will be kept as assessment units as per previous practice and no change in the assessment unit boundary is warranted. The needful be done accordingly.

The meeting ended with vote of thanks to the Chair.

THE LIST OF THE OFFICERS WHO ATTENDED ONLINE MEETING ON 05.07.2024

1. Dr. Ashwani Kumar Sharma, Special Secretary (Jal Shakti) to the Govt. of HP, and Chairman of the Committee.
2. Smt. Raksha Sharma, Deputy Secretary (Jal Shakti) to the Govt. of HP, Shimla-2.
3. Er. Anju Sharma, Engineer-in-Chief, Jal Shakti Vibhag, H.P., Jal Shakti Bhawan, Shimla-5.
4. Er. J.S Chauhan, Chief Engineer, South Zone, Shimla, Jal Shakti Vibhag, H.P., Jal Shakti Bhawan, Shimia
5. Er. Anil Mehta, Chief Engineer (D&M), Jal Shakti Vibhag, H.P., Jal Shakti Bhawan, Shimla
6. Sh. Kushal Deep, AGM, NABARD, SDA Complex, Kusumpti, Shimia-9.
7. Er. VikasKapur, SE(D), Jal Shakti Vibhag, Hamirpur Zone, Hamirpur
8. Er. B. B. Goel, SE(D), Jai Shakti Vibhag, Mandi zone, Mandi, H.P.
9. Er. Sumit Sood, SE P & 1-11, Jal Shakti Vibhag Shimla, Jal Shakti Bhawan, Shimla-5.
10. Er. Vishal Jaswal, SE(D), Jal Shakti Vibhag, Dharamshala Zone, Dharamshala, H.P.
11. Sh. Suresh Sharma, JDA-I, Department of Agriculture, H.P., Shimla-4.
12. Sh. Bhavnesh Sharma, Senior. Hg., GWO, Jai Shakti Vibhag, Una, H.P.
13. Dr. Sanjay Pandey, Sc-B, CGWB, Dharamshala, H.P.
14. Sh. Prasant Kumar Singh, STA(Hg), CGWB, Dharamshala, H.P.
15. Sh. Pankaj Maurya, M & E Expert, AMRUT, Urban Development, Shimla-2.

Fig-16

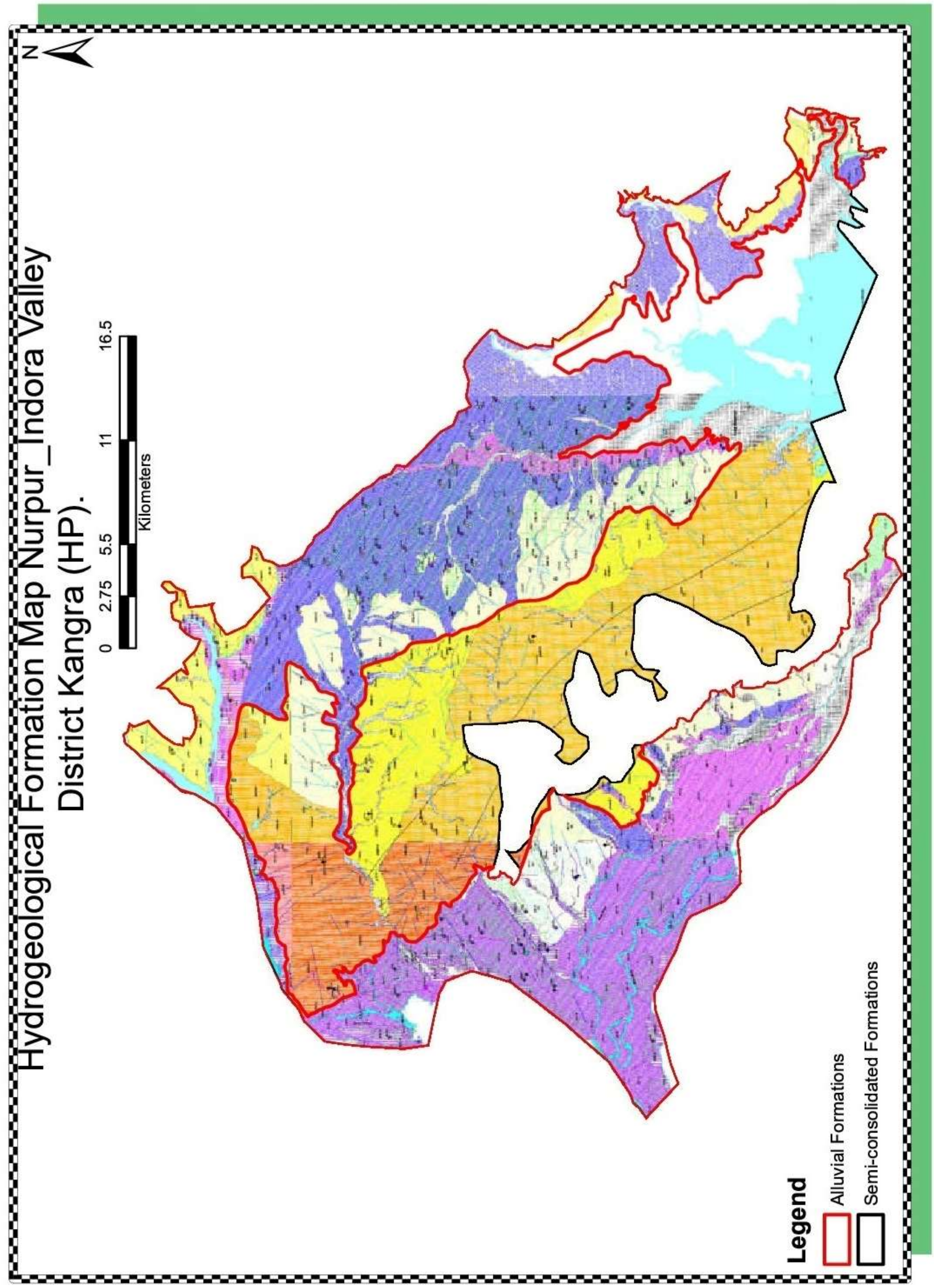


Fig: 16 Hydrogeological Formation Map Nurpur-Indora Valley

Fig.-17

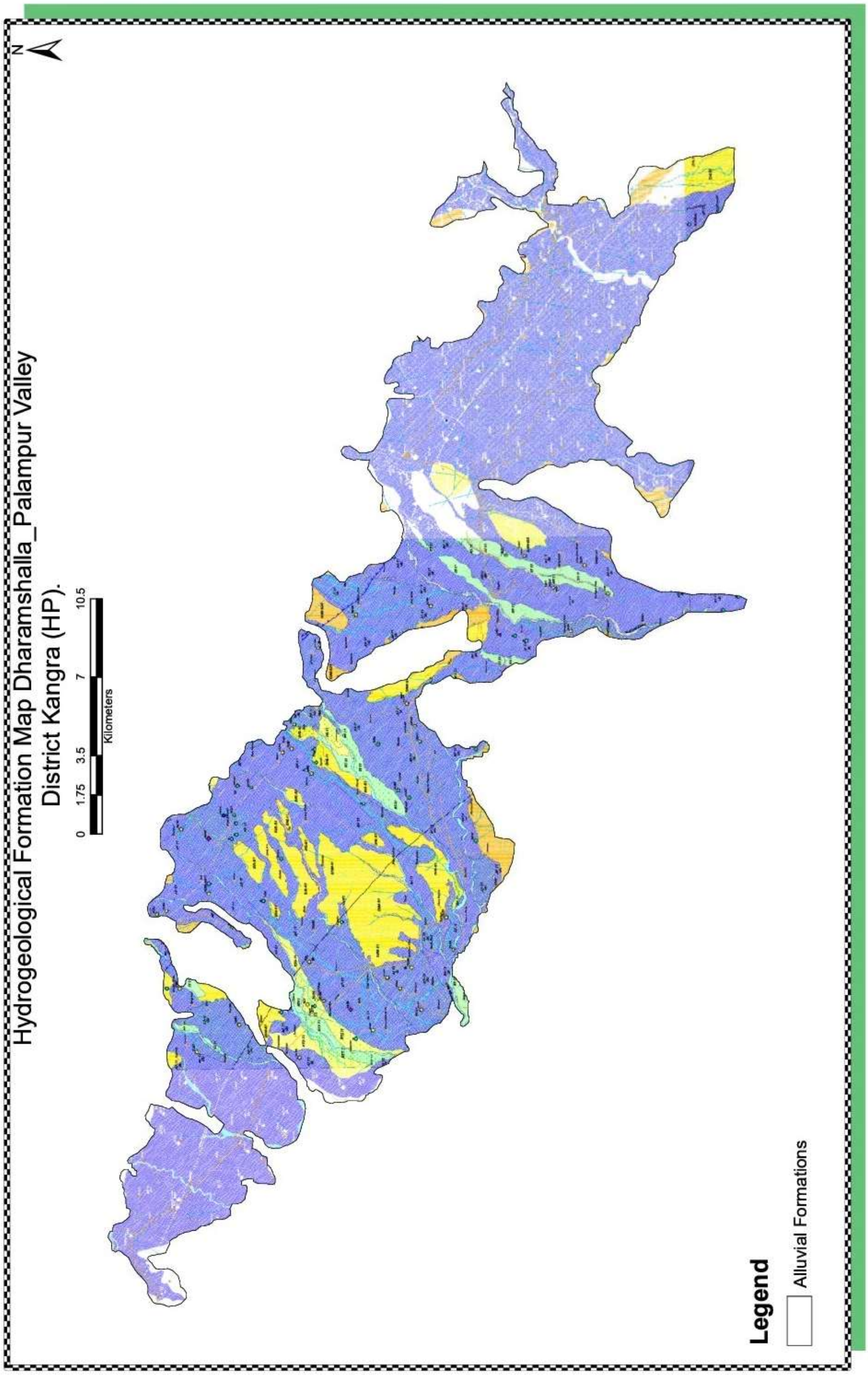


Fig: 17 Hydrogeological Formation Map Dharamshala-Palampur Valley

Fig.-18

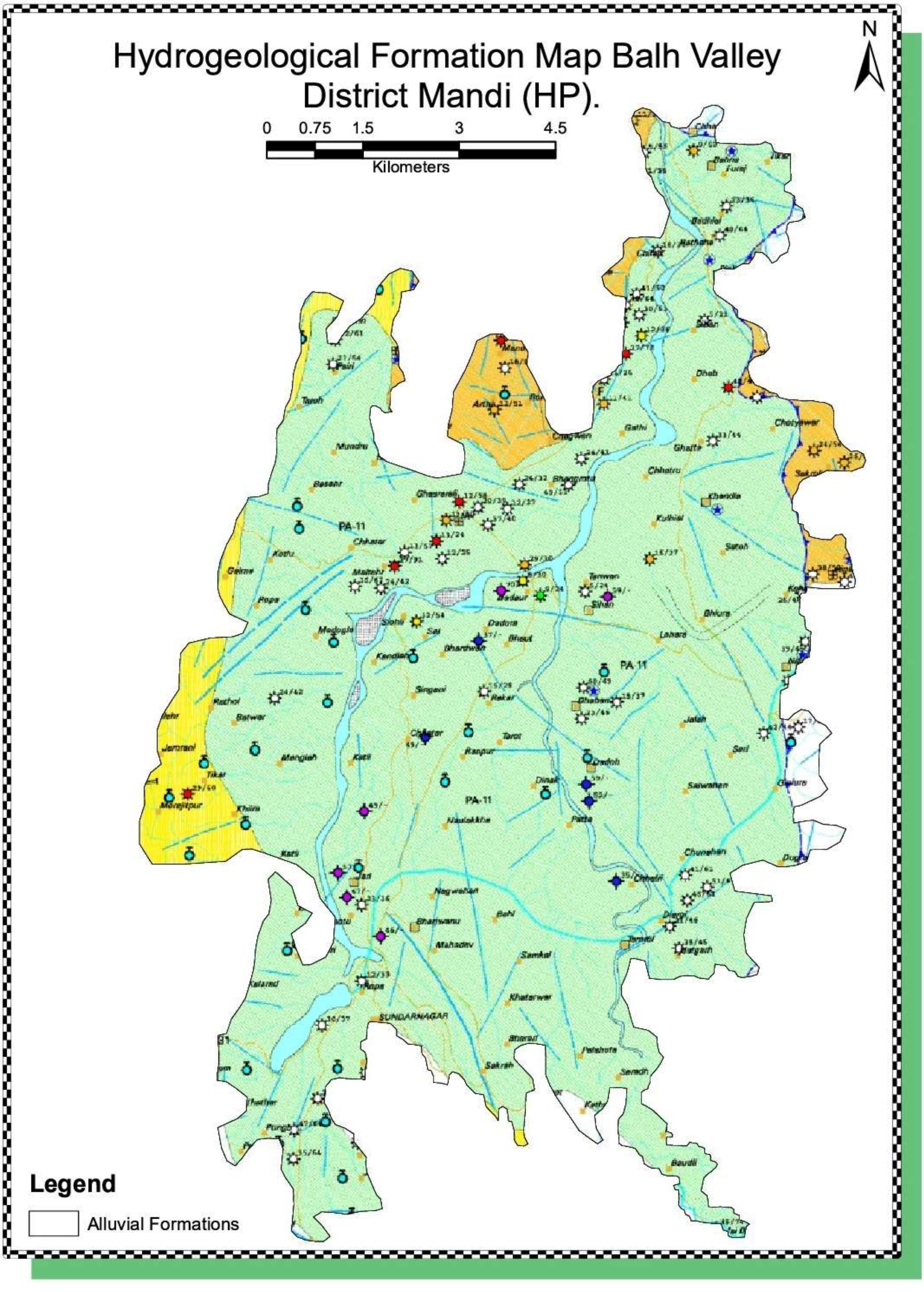


Fig: 18 Hydrogeological Formation Map Balh Valley

Fig.-19

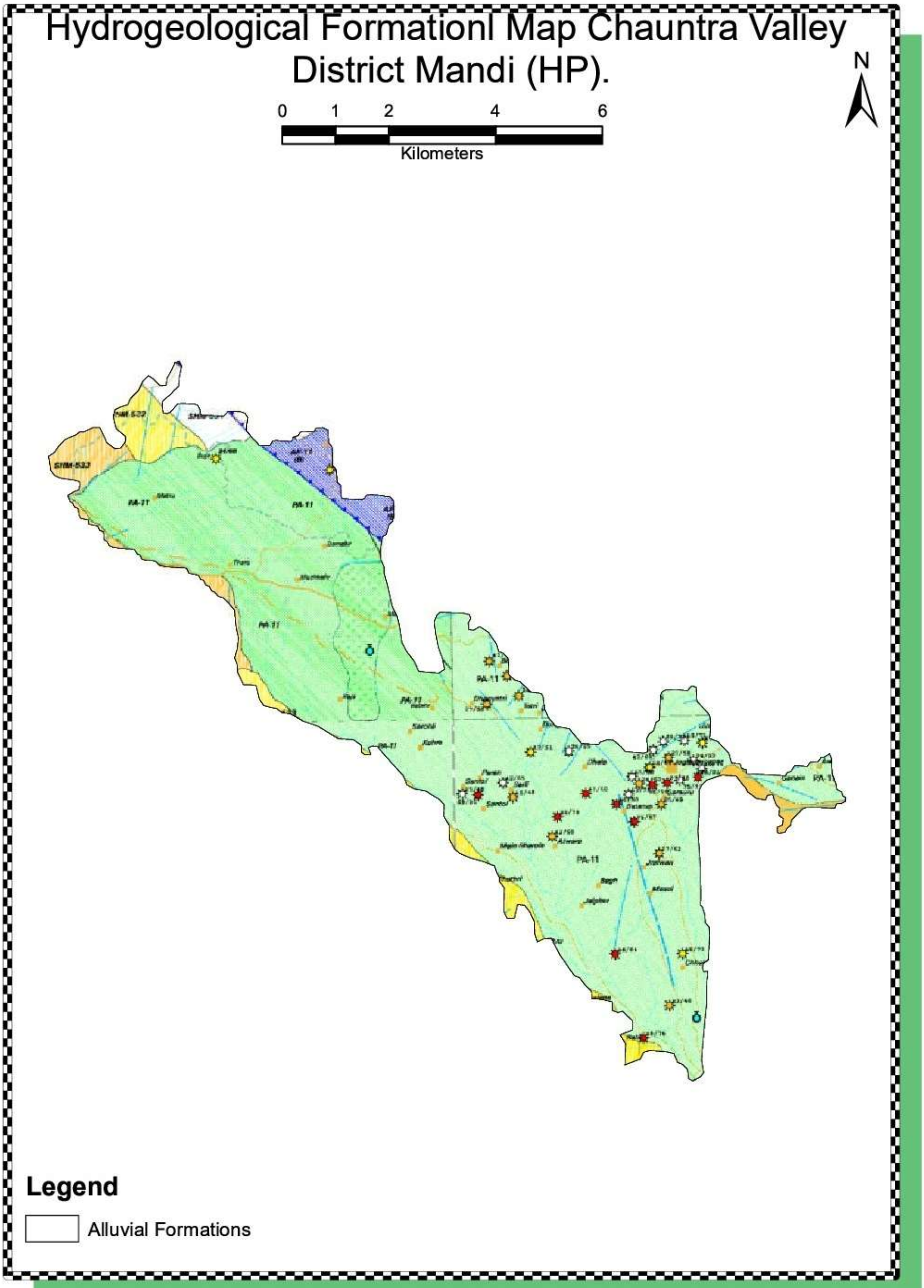


Fig: 19 Hydrogeological Formation Map Chauntra Valley

Fig.-20

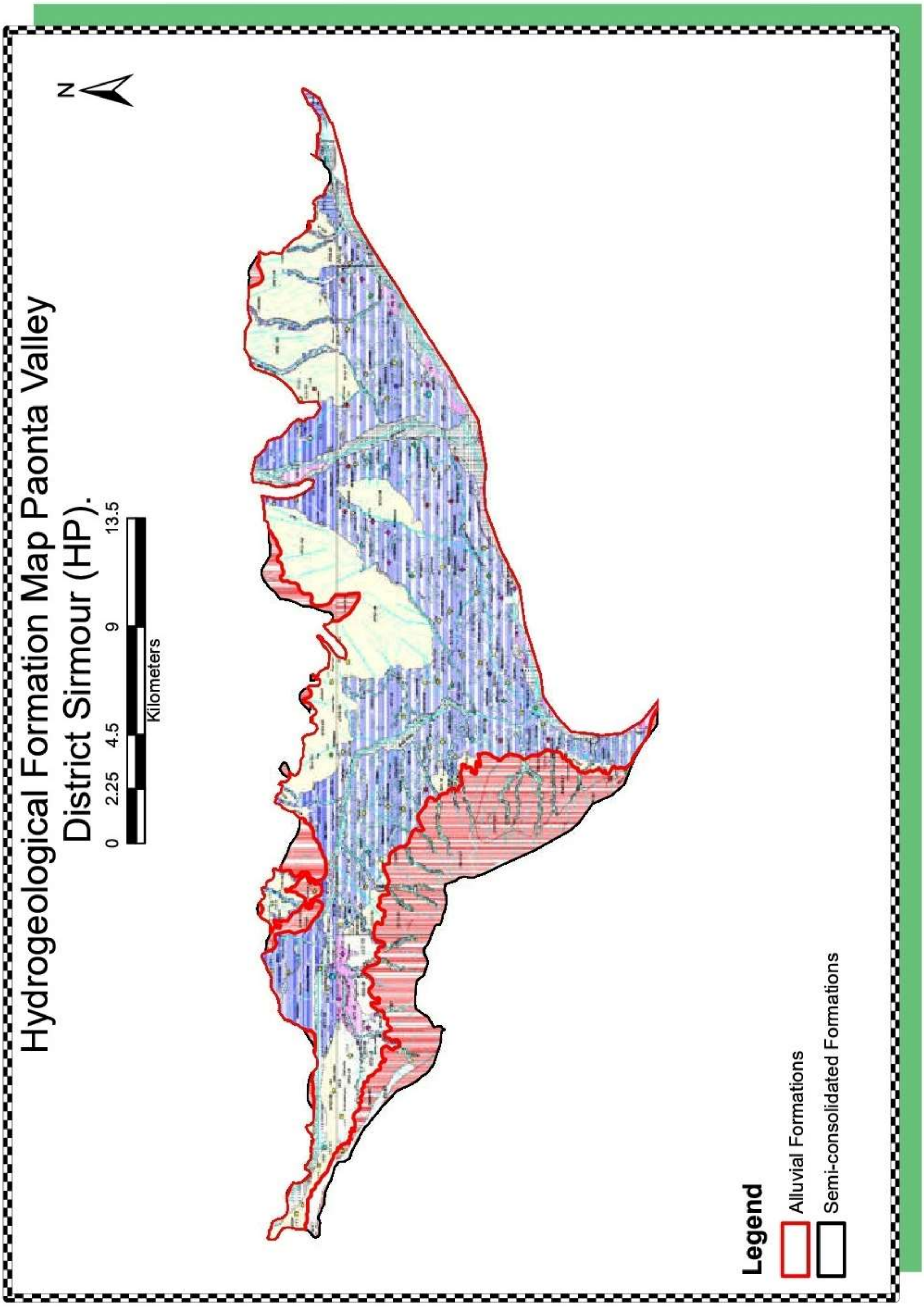


Fig: 20 Hydrogeological Formation Map Paonta Valley

Fig.-21

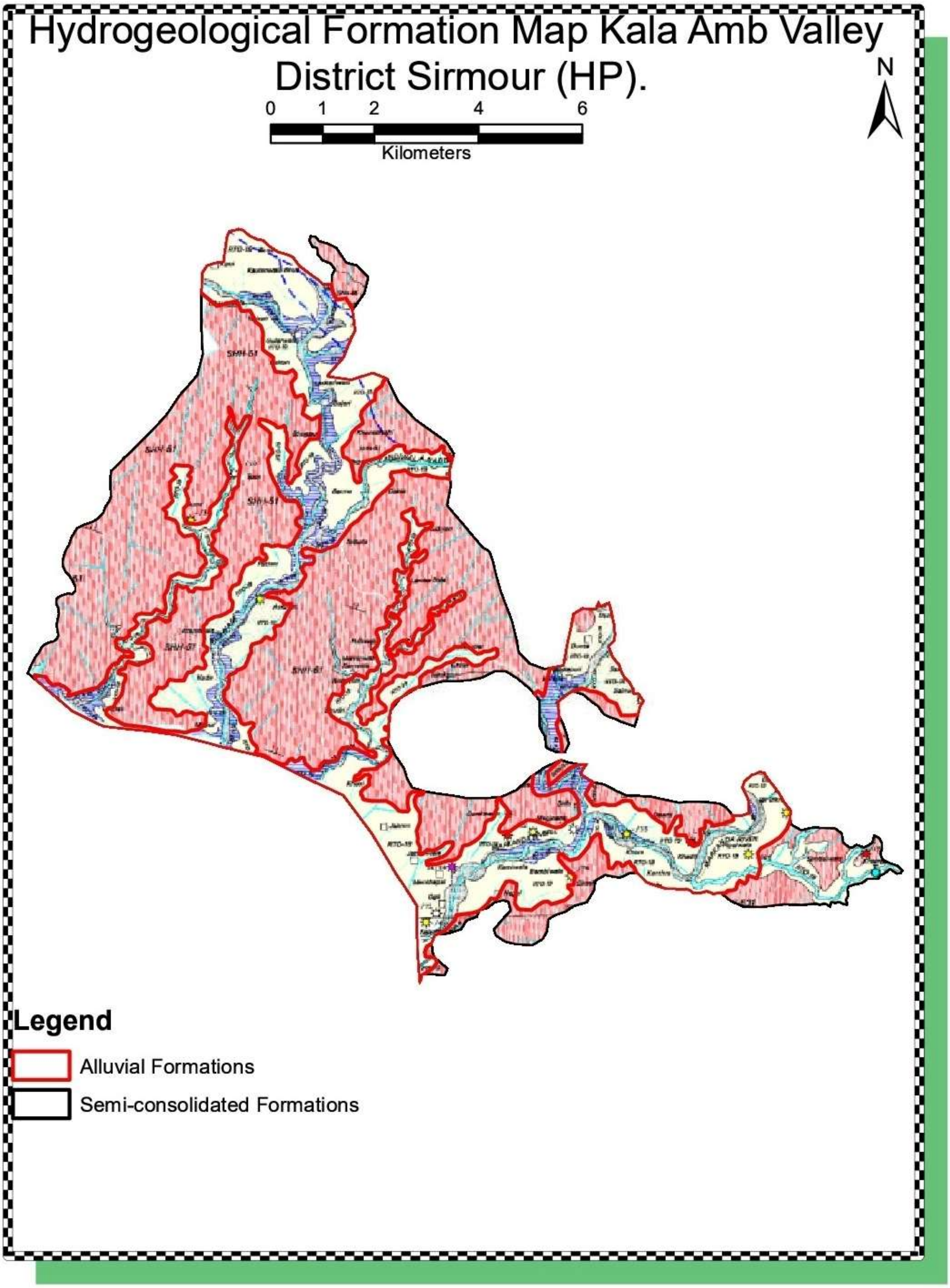


Fig: 21 Hydrogeological Formation Map Kala Amb Valley

Fig.-22

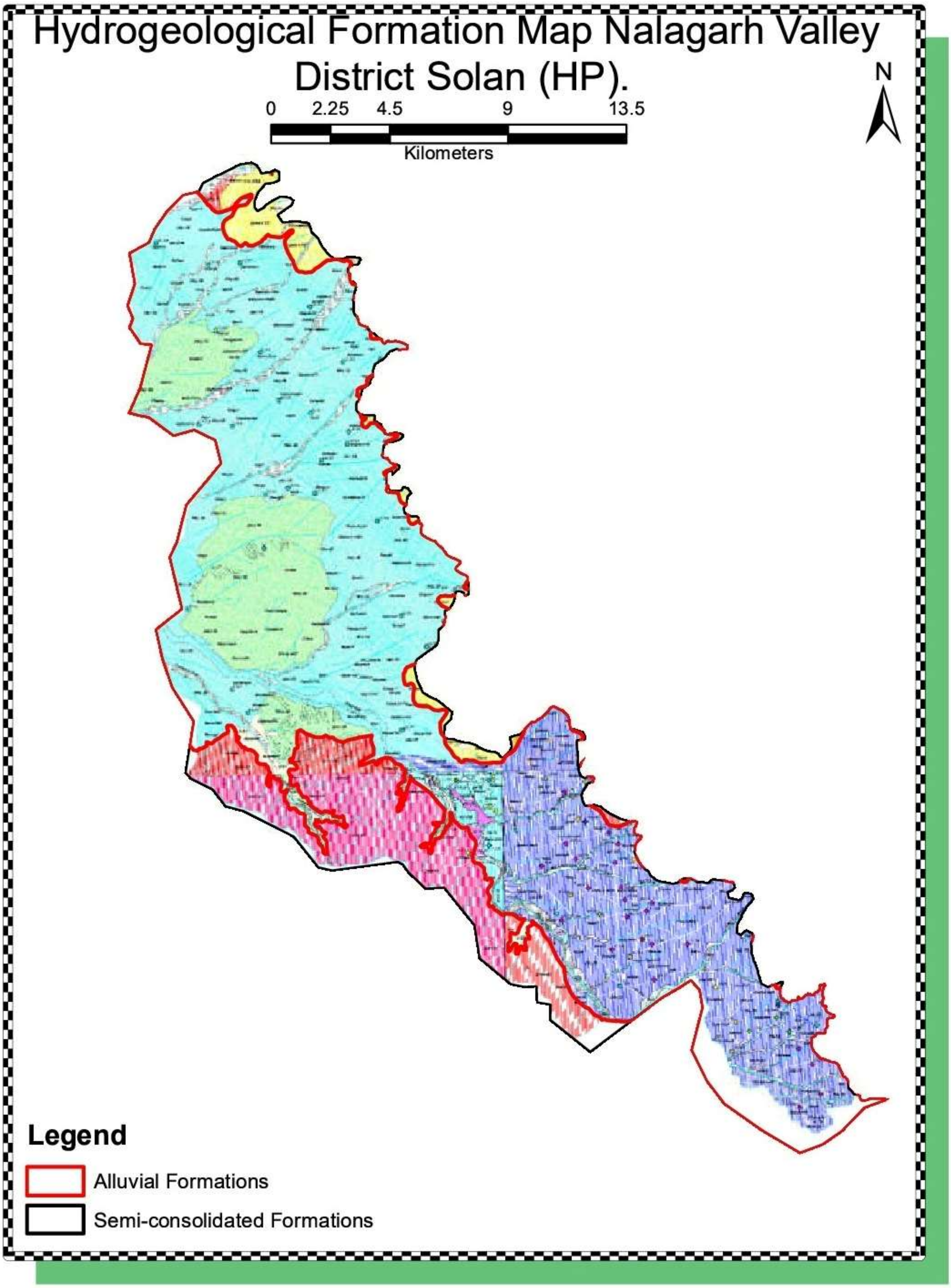


Fig: 22 Hydrogeological Formation Map Nalagarh Valley

Fig.-23

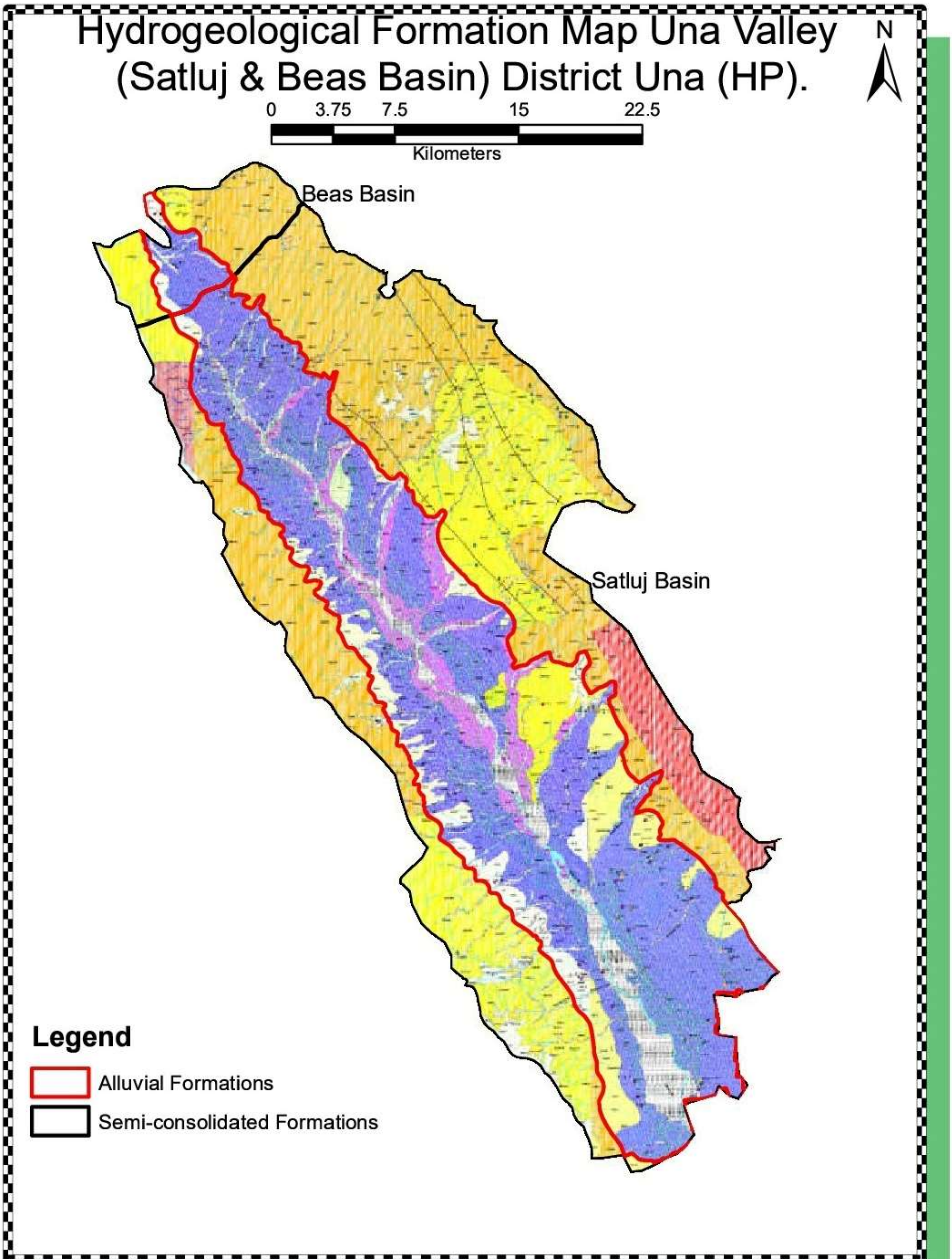


Fig: 23 Hydrogeological Formation Map Una Valley (Satluj & Beas Basin)

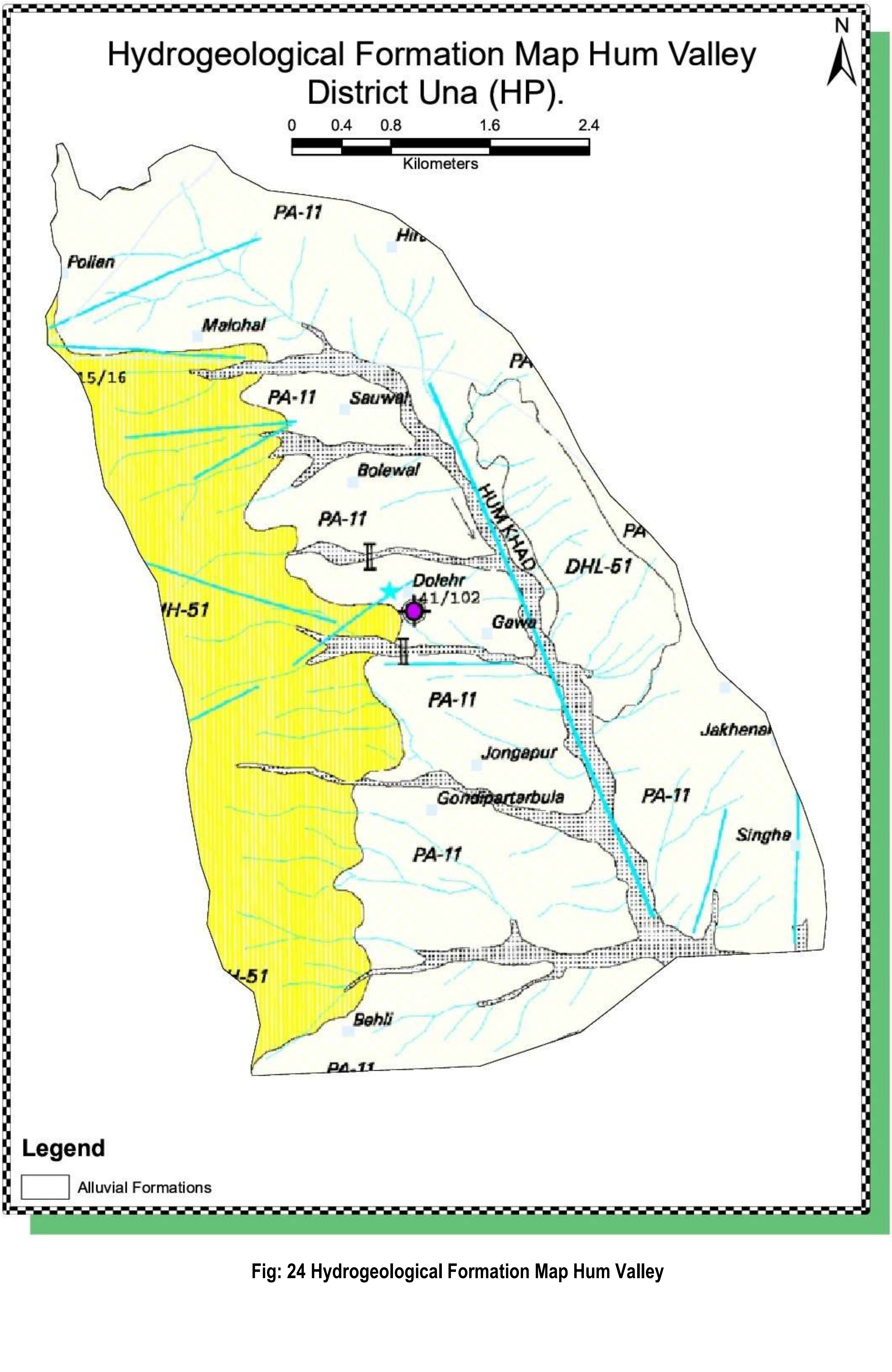


Fig: 24 Hydrogeological Formation Map Hum Valley

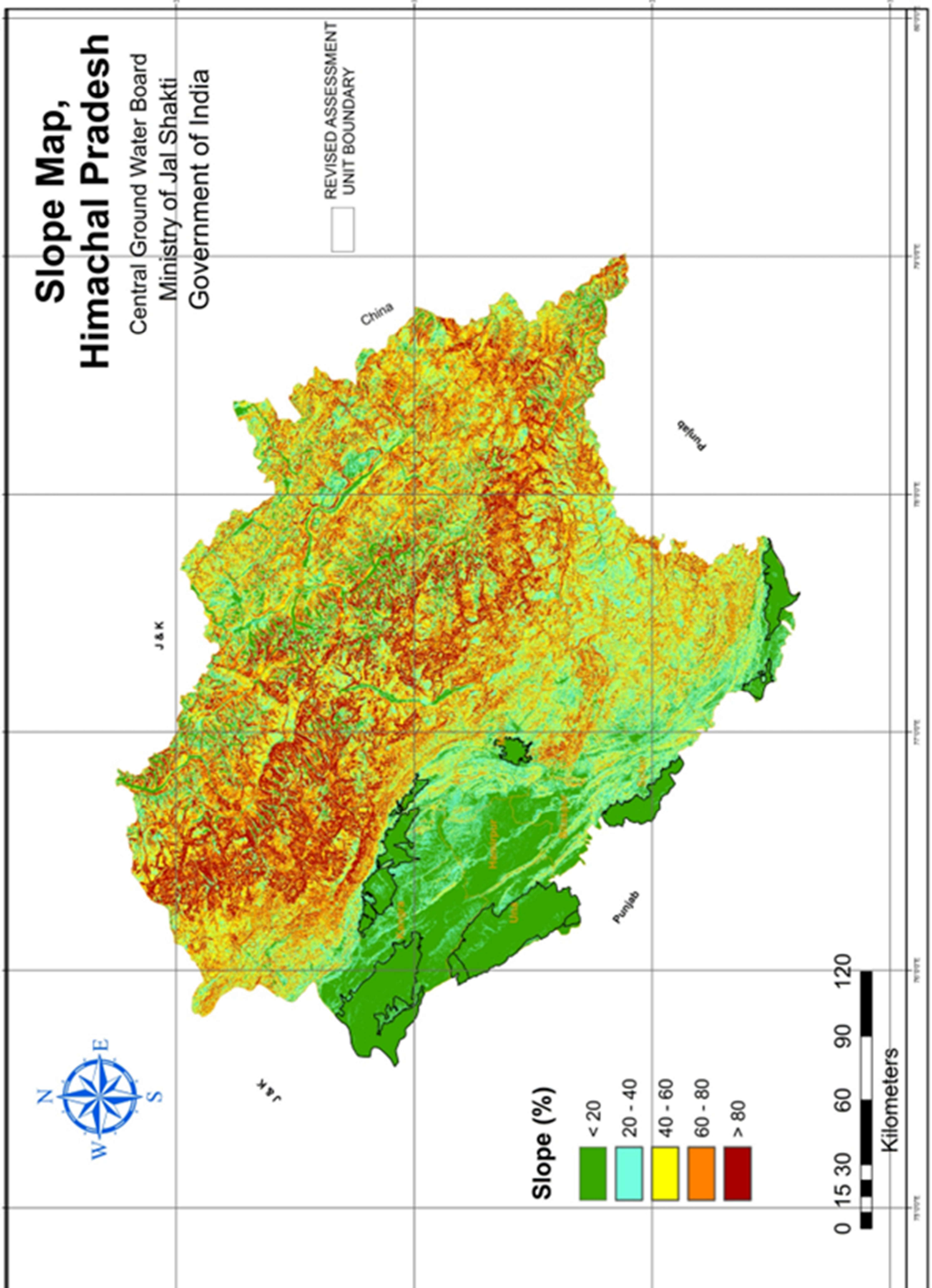


Fig.-25 Slope Map

CONTRIBUTORS

CENTRAL GROUND WATER BOARD, NHR, DHARAMSHALA

1. Shri Manohar Kumar, Scientist ‘B’ & Head of Office
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 Kalit Rana, STA
3. Shri Dinesh Bhardwaj, STA
4. Shri Rakesh Sharma, STA
5. Shri Chanchal Kumar, STA
6. Shri Vinod Sharma, STA
7. Shri Devesh Kumar, STA
8. Ms. Ajay Kiran, STA

TEAM INGRESS

1. Dr. KBVN Phanindra, Professor, IIT, Hyderabad
2. Sh. M. Prem Chand, Research Scholar, IIT, Hyderabad