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केंद्रीय भूमि जल बोर्ड

भारत सरकार

जल शक्ति मंत्रालय

जल संसाधन, नदी विकास और गंगा संरक्षण विभाग

CENTRAL GROUND WATER BOARD

Government of India

Ministry of Jal Shakti

Department of Water Resources,

River Development & Ganga Rejuvenation

AQUIFER MAPS AND GROUND WATER MANAGEMENT PLAN

HINGOLI DISTRICT, MAHARASHTRA

AAP 2019-20

मध्य क्षेत्र, नागपुर

Central Region, Nagpur

मार्च 2021 /मार्च 2021

AQUIFER MAPS AND GROUND WATER MANAGEMENT PLAN
HINGOLI DISTRICT, MAHARASHTRA
CONTRIBUTORS

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HINGOLI DISTRICT AT A GLANCE

1. GENERAL INFORMATION			
	Geographical Area	:	4827 Sq. km.
	Administrative Divisions (2011)	:	Taluka-5; Hingoli, Sengaon, Aundha (Nagnath), Kalmnuri and Basmath
	Villages (Census 2011)	:	710 Nos.
	Population	:	11,77,345
	Rainfall 2019	:	940.7 mm
	Normal rainfall	:	956.3 mm
	Long term rainfall Trend (1998-2019)	:	Falling trend 4.61 mm/year
2. GEOMORPHOLOGY AND DRAINAGE			
	Major Physiographic unit	:	Part of Western Ghats, Malhivra hill range and Penganga plain
	Major Drainage	:	Penganga, Purna, Kayadhu Rivers
3. LAND USE (2017-18) ***(sources: DSA 2018)***			
	Forest Area	**:**	**213.73 sq. km. (4.55 %)**
	Cultivable Area	**:**	**3811.64 sq. km. (81.22 %)**
	Net Area Sown	**:**	**3811.64 sq. km. (81.22 %)**
	Area Sown more than Once		**1164.52 Sq. km. (24.81%)**
4.	**SOIL TYPE**	**:**	**67% area of the district is covered by clayey and clay loam soil**
5. PRINCIPAL CROPS (2018)			
	Oil Seeds	:	2298.99 sq. km.
	Pulses	:	1287.01 sq. km.
	Cereals	:	584.48 sq. km.
	Cotton	:	447.23 sq. km.
	Sugarcane	:	17.14 sq. km.
6.	**HORTICULTURAL CROPS**		
	Banana	:	19.99 sq. km.
	Citrus fruit	:	9.75 sq. km.
	Mango	:	3.74 sq. km.
	Others	:	1.86 sq. km.
7. IRRIGATION BY DIFFERENT SOURCES (2006-07) – Nos. / Potential Created (ha)/ Potential Utilized(ha)			
	Dug wells	:	29049/75956/75924
	Shallow Tube/Bore wells Deep Bore wells	:	3000 / 8111 /8086 340 /1056 /1056
	Other Minor Surface Sources	:	7352 /23525 /23024
	Net Irrigated Area	:	44401 ha
8. GROUND WATER MONITORING WELLS (As on March 2019)			
	Dug wells	:	29
	Piezometers	:	Nil
9. GEOLOGY			
	Recent	:	Alluvium (River Alluvium)

	Late Cretaceous-Eocene	:	Deccan Traps Basalt
10. HYDROGEOLOGY			
	Water Bearing Formation	:	Alluvium- Sand and Gravel Under phreatic condition
			Deccan Traps: Basalt weathered, amygdaloidal, fractured and jointed. Under phreatic to semi-confined.
	Depth to water level in Shallow Aquifer		
	Pre-monsoon Depth to Water Level (May-2019)	:	3.95 to 20.9 mbgl
	Post-monsoon Depth to Water Level (Nov.-2019)	:	0.2 to 9.0 mbgl
	Depth to water level in Deeper Aquifer		
	Post- monsoon Water Level (Nov. 2019)	:	6.53 to 112 mbgl
	Water level Trend (2010-19)		
	Pre- monsoon Water Level Trend (2010-2019)	:	Rise: 0.0048 to 0.5145 m/year
			Fall: 0.0030 to 1.9524 m/year
	Post-monsoon Water Level Trend (2010-2019)	:	Rise: 0.0018 to 0.6386 m/year
			Fall: 0.0606 to 0.9376 m/year
11. GROUND WATER EXPLORATION (As on March 2019)			
			Basalt
	Wells Drilled (CGWB)	:	EW-10, Pz-03, **Total -13**
	Depth Range	:	30.00 to 200.2 mbgl
	SWL		3.1 to 112.4 mbgl
	Discharge	:	0.14 to 3.77 lps
	Transmissivity	:	0.51 to 15.17 m^2/day
12. GROUND WATER QUALITY			
	The quality of ground water is generally alkaline and suitable for drinking and irrigation purposes except Fluoride and Nitrate affected Villages.		
	Type of Water	:	Ca-Cl and Ca-HCO_3
13. DYNAMIC GROUND WATER RESOURCES- (2017)			
	Net Annual Ground Water Availability	:	738.16 MCM
	Total Draft (Irrigation + Domestic+ Industrial)	:	392.15 MCM
	Projected Demand (Domestic + Industrial)	:	74.08 MCM
	Stage of Ground Water Development	:	53.13 %
	Category		**Safe**
14.	MAJOR GROUND WATER PROBLEMS AND ISSUES		

	Declining water level trend of more than 0.2 m/year has been observed in major parts of Basmath, Hingoli and Sengaon blocks and in parts of Kalmnuri and Aundha blocks. Shallow aquifer is affected by Nitrate contamination at many places and deeper aquifers are affected by high Fluoride concentration. About 50% area of the district is having low yield potential (<1 lps) The area has experienced declining rainfall trend 4.6 m/year and nine time's moderate drought.		
15.	**Aquifer Management Plan**		
	Supply side Management	:	Proposed AR structures: 41 Percolation tanks – 41 Check dams – 121 Leading to additional 8.80 MCM recharge
	Demand side Management	:	Area proposed for Drip irrigation: Sugarcane area: 17.14 sq.km Cotton area: 13.0 sq.km Ground water saving: 9.77 MCM
	Expected Benefits	:	221.34 sq. km additional Area proposed for Irrigation through 8632 Dugwells and 1439 Borewells.

AQUIFER MAPS AND GROUND WATER MANAGEMENT PLAN
HINGOLI DISTRICT, MAHARASHTRA

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AQUIFER MAPS AND GROUND WATER MANAGEMENT PLAN HINGOLI DISTRICT, MAHARASHTRA

1. INTRODUCTION

National Aquifer Mapping (NAQUIM) has been taken up in XII five-year plan by CGWB to carry out detailed hydrogeological investigation on 1:50,000 scale. The NAQUIM has been prioritized to study Over-exploited, Critical and Semi-Critical blocks as well as the other stress areas recommended by the State Govt. Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical analyses is applied to characterize the quantity, quality and sustainability of ground water in aquifers.

The vagaries of rainfall, inherent heterogeneity & poor sustainability of hard rock aquifers, over exploitation of once copious alluvial aquifers, lack of regulatory mechanism has a detrimental effect on ground water scenario of the Country in last decade or so. Thus, prompting the paradigm shift from "**traditional groundwater development concept**" to "**modern groundwater management concept**".

Varied and diverse hydrogeological settings demand precise and comprehensive mapping of aquifers down to the optimum possible depth at appropriate scale to arrive at the robust and implementable ground water management plans. The proposed management plans will provide the **"Road Map"** for ensuring sustainable management and equitable distribution of ground water resources, thereby primarily improving drinking water security and irrigation coverage. Thus, the crux of NAQUIM is not merely mapping, but reaching the goal-that of ground water management through community participation. The aquifer maps and management plans will be shared with the administration of Hingoli district, Maharashtra for its effective implementation.

The activities under NAQUIM are aimed at:

- Identifying the aquifer geometry,
- Aquifer characteristics and their yield potential
- Quality of water occurring at various depths,
- Aquifer wise assessment of ground water resources
- Preparation of aquifer maps and
- Formulate ground water management plan

1.1 About the Area

Hingoli district is a one of the districts of the Marathwada Region in Maharashtra State. Hingoli district became full-fledged district of Maharashtra from 1st May 1999 bifurcating from Parbhani District. It is situated in the eastern part of Maharashtra between North Latitude 19° 14' and 20° 01', and East Longitude 76° 16' and 77° 28'. The total area of the district is 4827 sq. km. and falls in parts of survey of India degree sheets 56 A & E. The district is demarcated by Penganga River in the east and Purna River in south. The district is bounded by Washim and Yavatmal districts in north, Parbhani district in west and Nanded district at south eastern side. Hingoli was known in history by different names like Wingoli, Vingmul, Lingili etc. In ancient times

Hingoli was one of the main villages of Narsi parganas of Washim district. In the year 1903 Nizam has formed army base at Hingoli.

The district headquarters is located at Hingoli Town. For administrative convenience, the district is divided into 5 blocks viz., Aundha (Nagnath) Basmath, Hingoli, Sengaon, Kalmnuri, and It has a total population of 11, 77,345 as per 2011 Census. The district has 5 towns/blocks and 710 villages. The entire district lies in Penganga and Purna sub basins of Godavari basin. Penganga, Purna and Kayadhu are the main rivers flowing through the district. Kayadhu river is a tributary of Penganga river. The district is categorized as safe as per Ground Water Resources Estimation 2017. The Administrative and Index map of the Hingoli district is presented in **Figure 1.1 and Figure 1.2**.

Hingoli district has been taken up under NAQUIM study in the year 2019-20 (AAP 2019-20)

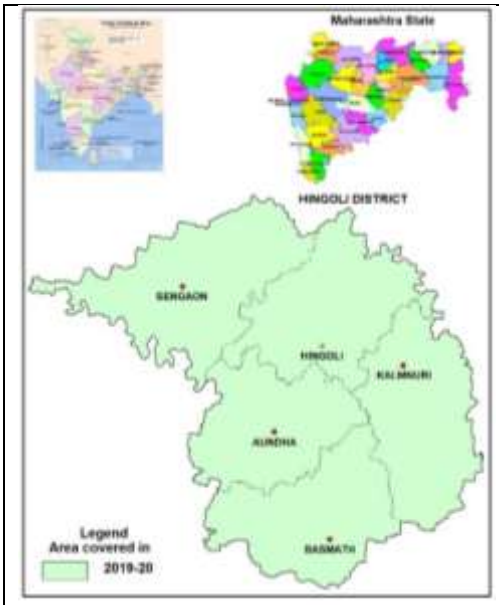


Figure 1.1 : Index map, Hingoli District

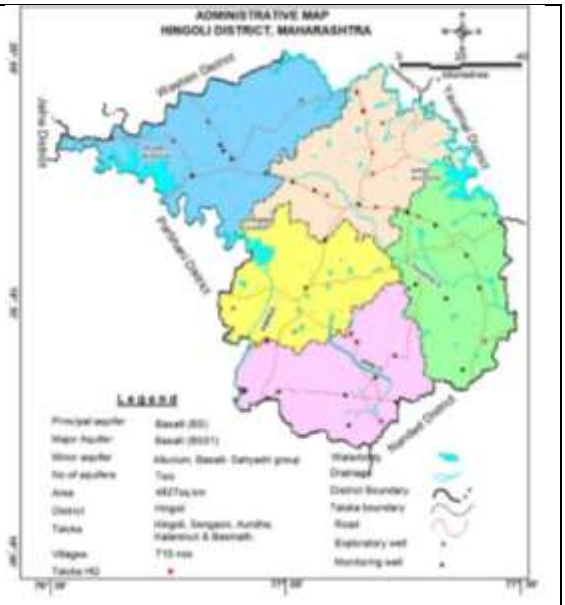


Figure 1.2 : Administrative map, Hingoli District

Ground water exploration in the district has been taken up in different phases since 1997-98. During 1997-98 purpose-built piezometers have been constructed through outsourcing and in 2004-05 ground water exploration was carried out in drought affected blocks namely Hingoli, Kalmnuri and Aundha (Nagnath) blocks.

The ground water exploration has been carried out in hard rock areas occupied by Deccan Trap Basalt. Existing ground water exploration data has been used for establishing the geometry, disposition, and potential of aquifers of the district. A total of 10 EWs and 03 Piezometers have been constructed in the year 1997-98 and 2004-05**.** Apart from this piezometer data of GSDA also been utilized for maps preparation. Salient Features of Ground Water Exploration are given in **Annexure-I** and details of exploration under NAQUIM are given in **Annexure-II**.

To assess the ground water regime, 29 existing ground water monitoring stations of CGWB and 51 monitoring stations of GSDA being monitored 4 times in a

year are used to acquire micro level hydrogeological data to decipher the water level scenario, sub-surface lithological disposition and hydrogeological setup of shallow aquifer (Aquifer-I). The details of monitoring wells are given in **Annexure-III**. Locations of existing ground water monitoring stations and exploratory wells are shown in **Figure 1.3**.

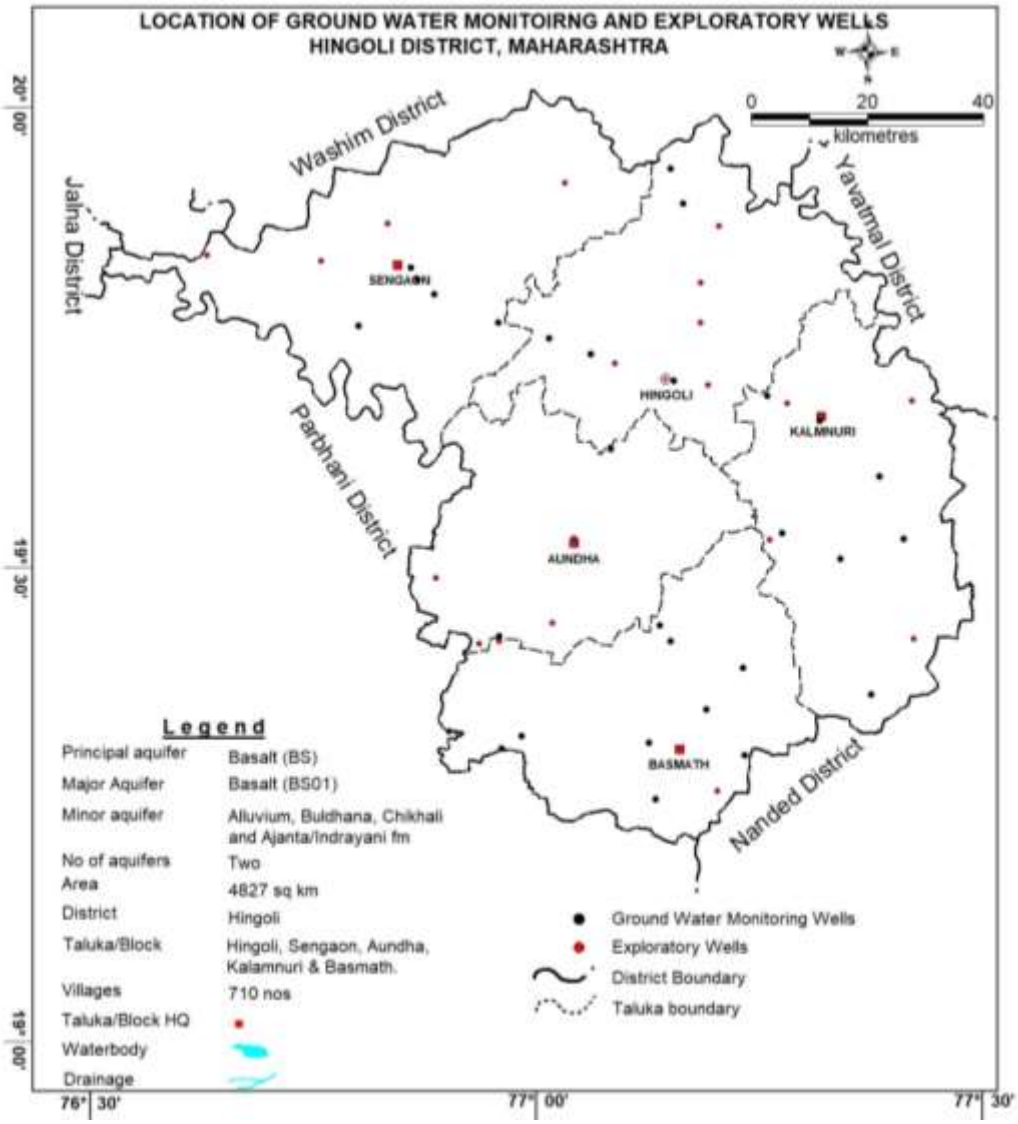


Figure 1.3: Locations of Existing Exploratory and Ground Water Monitoring Wells

1.2 Geomorphology, Drainage and Soil Types

The district forms a part of the Deccan Plateau. The area represents a plateau with low to moderate relief and it has few mesa and butte structures. In general, the ground surface slope in the district is towards south and southeast with general elevation of 450 m amsl.

The Malhivra hill ranges of the district divides Penganga and Kayadhu basin. 598 mts is highest point from msl in Mal Hiwara village of Hingoli tahsil while on the other hand 400 m amsl is the lowest point which lies in Basmath block of district.

Geomorphologically, District has plateaus or high plain or table lands with its elevations ranging from 400 to 598 m amsl, usually consisting of relatively flat terrain that is

raised significantly above the surrounding area with one or more sides having steep slopes and surrounded by a flood plain, an area adjacent to both the edges along the Kayadhu River in south eastern and northern sides of the study area.

Maximum area of district is covered with Slightly Dissected Plateaus (SDP)-27% area of the district; Plateau Weathered (PLWS)-21% area of the district with 1 to 2 m weathered thickness depending upon the extent of weathering and thickness of soil cover and Plateau Weathered under canal command (PLC)-19% area of the District. The geomorphology of the area is shown in **Figure 1.4**

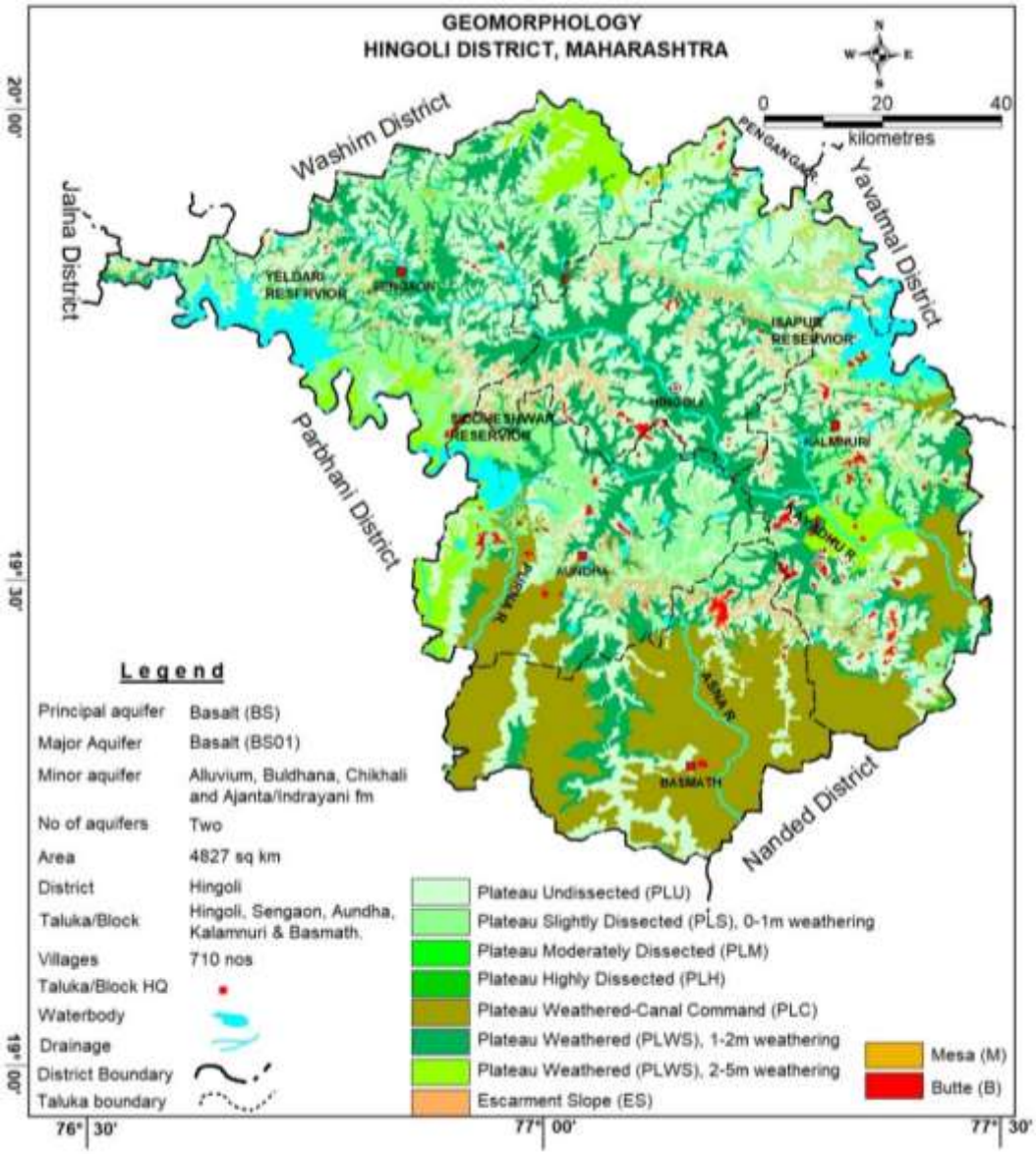


Figure 1.4: Geomorphology, Hingoli District

Entire district lies in the Penganga and Purna sub basins of Godavari basin. There are three main drainage systems viz: (1) Penganga (2) Purna and (3) Kayadhu rivers. The river Penganga originates from Ajanta hills in Aurangabad. It enters the district from Sengaon Taluka in the north eastern corner and by making a journey of about 80.45 Kilometres in the district moves towards Yavatmal district. Isapur Dam, an irrigation project, is constructed on the river. It is one of the most important rivers of Deccan plateau and whole district of Hingoli falls in its great basin. The direct

tributary of the Penganga river is Kayadhu river. This tributary rise from the hill ranges near Risod block of Washim district. The length of the river in the district is 80.50 kms. It is an ephemeral river and dries up in summer. The Purna river rises from Ajnata hill ranges. It enters the district from Jalna district. After making a journey of nearly 100 kms it moves towards Parbhani district. Yeldari dam, an irrigation project and also caters to hydroelectricity production and Sidheshwar dam, an irrigation and also caters to drinking water supplies, are constructed on the river.

The district is well drained by rivers system forming dendritic type of drainage pattern. The district has been divided into 24 watersheds.

Soil plays a very important role in the agricultural activities and forest growth of the area. The fertility of the soil from agricultural point of view depends upon the texture and structure which controls the retaining and transmitting capacity of the soil to hold the moisture content and various nutrients such as nitrogen, phosphorous and potassium present in the parent rock. The process of formation of the soil in the area is influenced by the climate, geology, vegetation and topography.

The Soils of the district are derived from the basaltic lava flows. Thickness of the soil cover is less in northern and western regions where ground elevations are higher and consequently soil regur, gravels, murum are transported down to lower regions through gravity, water and winds. Soils in central, southern and eastern regions of the district near the banks of Penganga and Purna rivers are thicker. Here soils are black and rich in plant nutrients with depth ranging from 1 to 2 m.

Based on the thematic map, it has been observed that a major part of the district is occupied by clayey and clay loam soil types. Nearly 67 % of the area is covered by clayey soils; of which shallow to deep clayey soil, with 0 to > 1 m depth, cover 54% area followed by clay loam soil covering 12 % area of the district. Remaining part of the district is covered by sandy clay loam, Gravelly clay loam, Gravelly clay, Gravelly sandy loam, Gravelly sandy clay loam and silty clay soils. Depth of soil is more in the vicinity of main drainages and shallow away from river channels and least in hilly terrains. The thematic map of soil distribution in the district is shown in **Figure 1.5.**

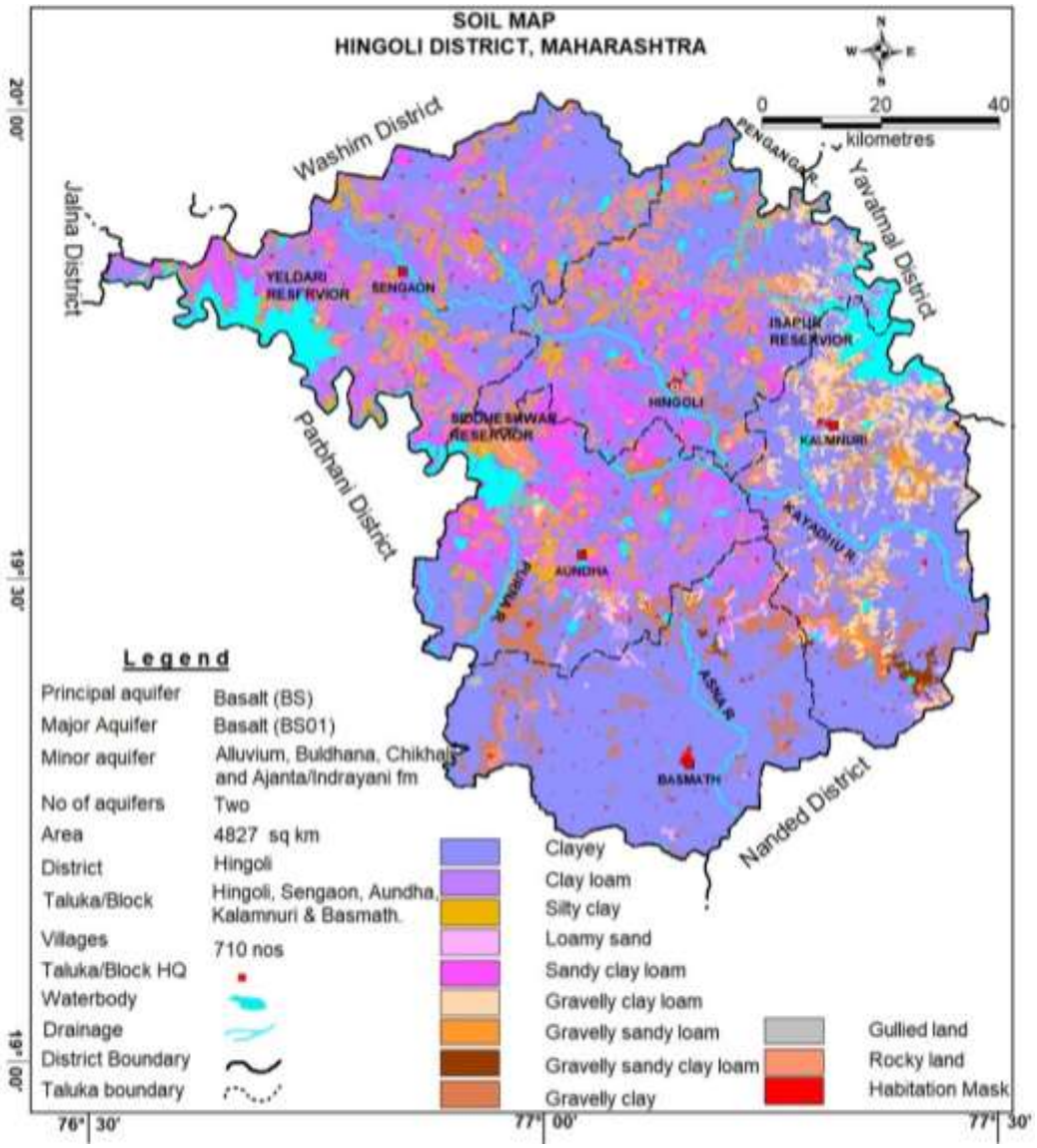


Figure 1.5 : Soils, Hingoli District

1.3 Climate and Rainfall

The district has dry and tropical climate with hot summer and mild winter with humid SW monsoon season of moderate rainfall. The climate can be divided into three main seasons viz, Hot to warm humid monsoon season from June to September, Cool dry winter season from October to February and Hot dry summer season from March to June. The minimum temperature of the district is 12.7°C and the maximum is 41.7°C.

The block wise annual rainfall data (2010-2019) of Hingoli district is shown in **Table 1.1.**

Table 1.1: Block wise Annual rainfall data (2010-2019)

Year	Aundha (Nagnath0	Basmath	Hingoli	Kalmnuri	Sengaon	District Average
2010	991.00	1223.00	1400.20	1368.00	1254.40	1247.32
2011	875.10	667.00	989.60	585.30	704.60	764.32
2012	684.00	772.90	776.00	685.30	636.00	710.84
2013	1295.70	994.50	1326.10	1153.80	1149.90	1184.00
2014	714.60	482.00	469.10	555.60	607.70	565.80
2015	696.30	441.40	812.50	686.80	810.20	689.44
2016	1064.30	994.50	1024.80	907.30	800.50	958.28
2017	815.00	631.70	659.40	495.90	655.50	651.50
2018	775.30	714.70	683.00	811.60	584.80	713.88
2019	877.50	884.60	973.60	1068.40	885.10	937.84
Decadal Average	878.88	780.63	911.43	831.80	808.87	
Normal RF	**911.50**	**1040.90**	**946.60**	**983.70**	**898.90**	**956.30**

The normal rainfall of the district is 956.3 mm spread over 22 years varying from 42 to 80 rainy days. Annual rainfall data of 1998-2019 is analysed and presented in **Figure 1.6**. This indicates that maximum rainfall occurred in 2010 (1246.9 mm) and minimum rainfall in 2008 (510.7 mm). The rainfall trend analysis shows that there is a falling trend @ 4.61 mm/year.

The rainfall analysis shows that the departure of annual rainfall from the normal rainfall, expressed in terms of percentage, varied from -47 to +30 percent. The departure percent analysed denotes the rainfall variation pattern with respect to normal rainfall during the period. The area experienced 2 times (9%) excess rainfall, 11 times (50%) normal rainfall and 9 times (41%) moderate drought conditions as given in **Table 1.2**. The coefficient of variation of the annual rainfall from the mean rainfall has been observed to be 28 % indicating that a range of ±28% of the mean rainfall varying from 598 to 1062.9 mm was received in the area during the period. Significantly, the analysis indicates that the 598 was minimum assured rainfall to have been received during the period, however exceptional years 2008 and 2014 falling out of this range were there in which the less rainfall was received during the period in the area. The isohyet map of the district is depicted in **Figure 1.7.**

Based on rainfall data analysis it is observed that:

- Decadal Average Annual rainfall varies from 780.63 (Basmath block) to 911.43 mm (Hingoli block).
- The Normal annual rainfall in the district varies between 898.9 mm in Sengaon block and 1040.9 mm in Basmath block.

Table 1.2: Long Term Rainfall Analysis (1998 to 2019) of Hingoli District

PERIOD = 1998 to 2019					
Year	**Annual Rainfall (mm)**	**Normal Rainfall (mm)**	**Departure (%)**	**No of Rainy days**	**Category**
1998	1084.8	956.3	13	80	NORMAL
1999	629.4	956.3	-34	57	MODERATE
2000	635.8	956.3	-34	47	MODERATE
2001	810.0	956.3	-15	54	NORMAL
2002	1215.2	956.3	27	44	EXCESS
2003	956.1	956.3	0	62	NORMAL
2004	613.7	956.3	-36	53	MODERATE
2005	1109.9	956.3	16	55	NORMAL
2006	1155.2	956.3	21	44	NORMAL
2007	731.3	956.3	-24	49	NORMAL
2008	510.7	956.3	-47	48	MODERATE
2009	659.6	956.3	-31	53	MODERATE
2010	1246.9	956.3	30	67	EXCESS
2011	764.1	956.3	-20	54	NORMAL
2012	711.1	956.3	-26	52	MODERATE
2013	1174.8	956.3	23	66	NORMAL
2014	549.1	956.3	-43	42	MODERATE
2015	718.9	956.3	-25	57	NORMAL
2016	954.4	956.3	0	60	NORMAL
2017	640	956.3	-33	51	MODERATE
2018	710.6	956.3	-26	49	MODERATE
2019	940.7	956.3	-2	72	NORMAL

No. of years = 22		
NORMAL RAINFALL = 956.3 mm		
STANDARD DEVIATION = 233.96 mm		
COEFFICIENT OF VARIATION = 28%		
MEAN=830.4		
MEDIAN=731.3		
SLOPE= -4.6 mm/Year		
INTERCEPT= 895.02 mm		
EQUATION OF TREND LINE= -4.618 X +895.02		
CATEGORY	NUMBER OF YEARS	% OF TOTAL YEARS
DEPARTURES		
POSITIVE	7	32
NEGATIVE	15	68
DROUGHTS		
MODERATE	9	41
SEVERE	0	0
ACUTE	0	0
NORMAL & EXCESS R/F		
NORMAL	11	50
EXCESS	2	9

NOTE: Departure: EXCESS RAINFALL: > +25; NORMAL RAINFALL: +25 TO -25; MODERATE DROUGHT: -25 TO -50; SEVERE DROUGHT: -50 TO -75; ACUTE DROUGHT: < -75

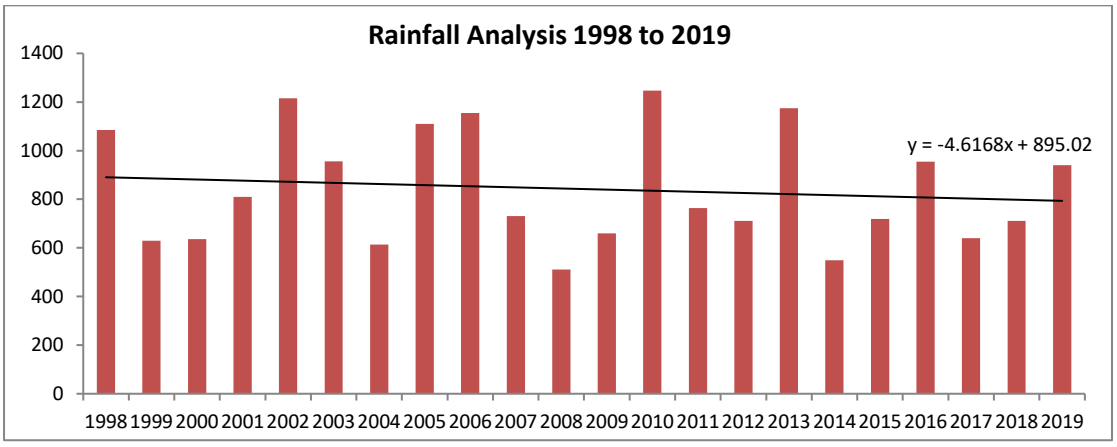
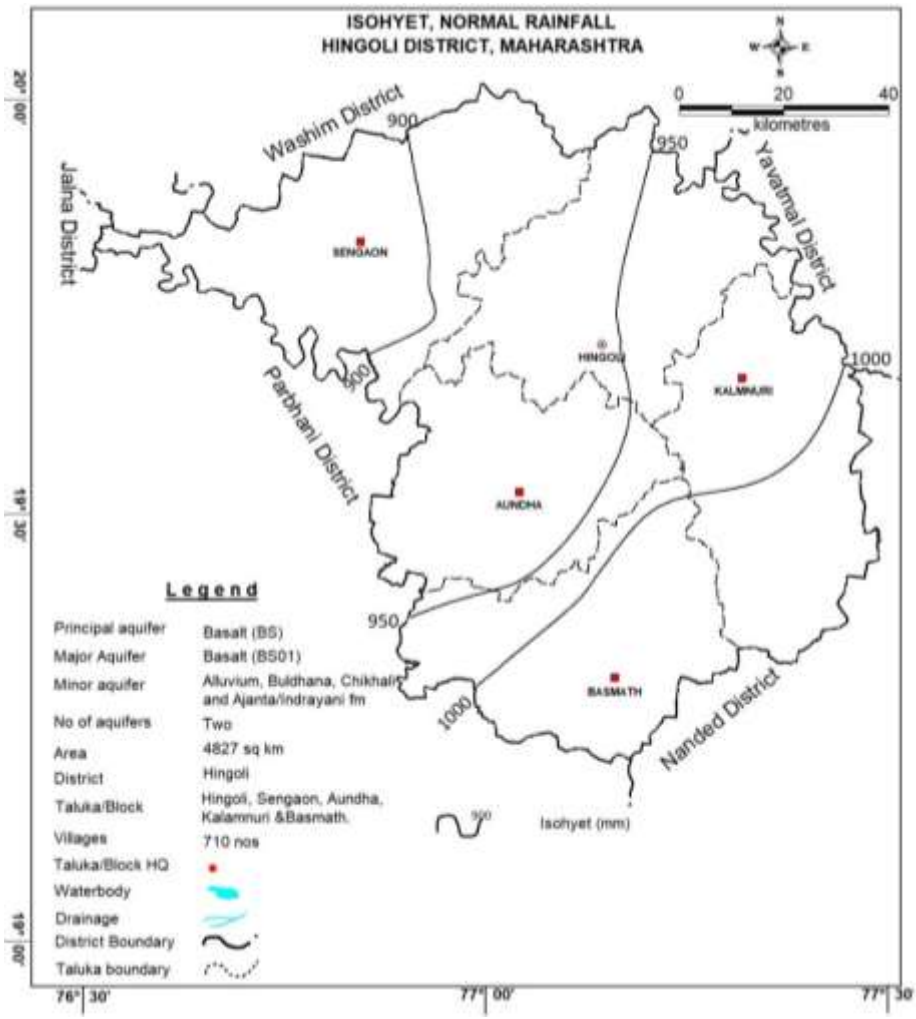


Figure 1.6 : Annual Rainfall Pattern (1998-2019)



(Rainfall in mm)

Figure 1.7: Isohyet map of Hingoli District

1.4 Geology

Geologically, The Basalt (Deccan traps) is the major rock formation in the district. A major part of the district is underlain by a sequence of basaltic lava flows while alluvium occupies a very small portion along the course of major rivers. The Deccan Trap has succession of flows in the elevation range and are normally horizontally disposed over a wide stretch and give rise to table-land type of topography also known as plateau. These flows occur in layered sequence ranging in thickness from few centimetres to tens of meters. Each individual flow is massive at the bottom and becomes gradually vesicular/amygdaloidal towards top. The flows are separated from each other by marker horizon known as bole bed, however, the bole beds are discontinuous and generally inconsistent. The generalized geological sequence of the area is given in **Table 1.3** and the Geological Map of the district is depicted in **Figure 1.8.**

Table 1.1: Generalized Geological sequence Hingoli district

Geologic Period	Stratigraphic unit	Formation	lithology	Nature and Characteristics
Sub-Recent to Recent	River Alluvium	Sand, silt and clay	Clay, mixed with sand and gravel	Brown calcareous silt, fine sand mixed with clay and silt.
Late Cretaceous to Eocene	Deccan trap (Sahyadri Group)	Buldhana/ Purandhargarh formation	3 “aa” and 3 “compound Pahoehoe” flows	Basalt; Dark Grey, dense, moderately to highly porphyritic
		Chikhli/Diveghat formation	2 “aa” and 3 “compound Pahoehoe” flows	Basalt; Dark fine grained, Sparsely porphyritic
		Ajanta/Indrayani formation	4 “aa” and 10 “compound Pahoehoe” flows	Basalt; Dark, medium grained, Sparsely to Moderately porphyritic

(GSI: DRM FIRST EDITION 2001)

Alluvium:

Alluvium occurs as small patches along the course of Penganga and Purna rivers. These alluvial deposits have individual extent from 1 to 20 Km^2 and 5 to 30 m thickness. It comprises beds and lenses of sands, gravels and boulders in a matrix of clays. These granular zones form aquifers in which groundwater occurs under Phreatic and semi-confined conditions. The porosity of these granular zones ranges from 10 to 15 %.

Deccan trap basalt:

It consists of horizontal basaltic flow units and is of dark gray in color. Both **“aa”** and **“pahoehoe”** types of flow are present in the district. A typical pahoehoe unit comprises of basal vesicular part with pipe amygdule’s, middle massive part and top vesicular part with spherical vesical. The “aa” flows are massive with persistent fragmentary top and impersistent clinkary base. The lava assemblages belong to Ajanta, Chikhli and Purandargarh Formations.

Ajanta Formations occupies an extensive area in the districts and comprises of 14 flows, of which 10 are “compound Pahoehoe” in nature and 4 are “aa” in nature. The massive part is dark, medium grained sparsely to moderately porphyritic. The Chikhali Formations comprises 3 “compound Pahoehoe” and 2 “aa” type. The massive part is dark, fine grained and sparsely porphyritic. The Purandargah/Buldhana Formations comprise of 3 “compound Pahoehoe” flows and 3 “aa” flows. The massive part is dense, dark grey and moderately to highly porphyritic in nature.

Inter-trappean beds:

These are represented by red boles and the exposures are seen near Hingoli on road to Washim, near Aundha and near Siddheshwar dam site. These beds are clayey in nature.

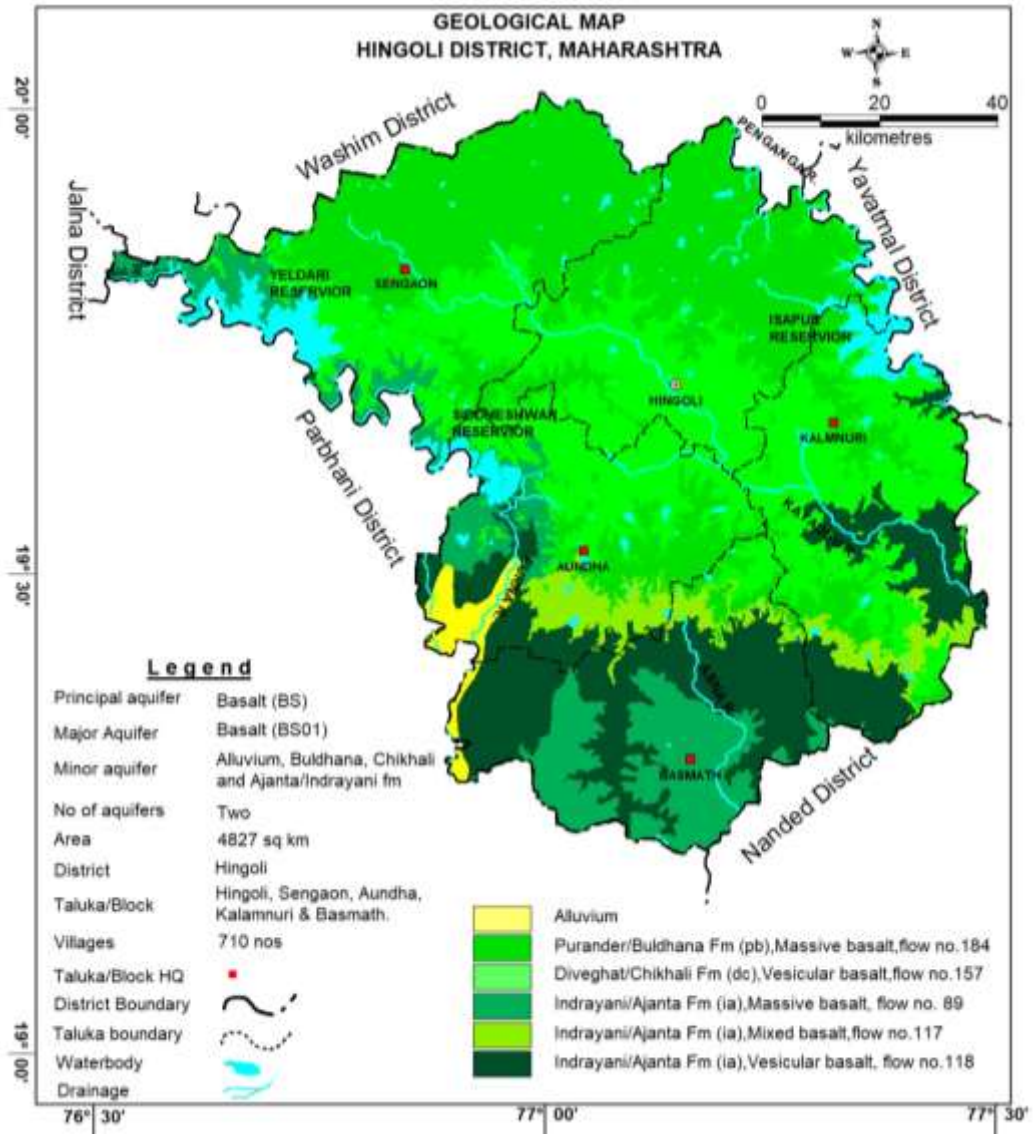


Figure 1.8: Geological Map, Hingoli district

2. HYDROGEOLOGY

Major part of the district is underlain by a sequence of basaltic lava flows (Deccan Trap) while alluvium occupies a small portion. The alluvium consisting of clay, Silt, Sand and Gravel occurs along the course of major rivers. The thickness of alluvium is very shallow. A map depicting hydrogeology of Hingoli district is presented in **Figure 2.1.**

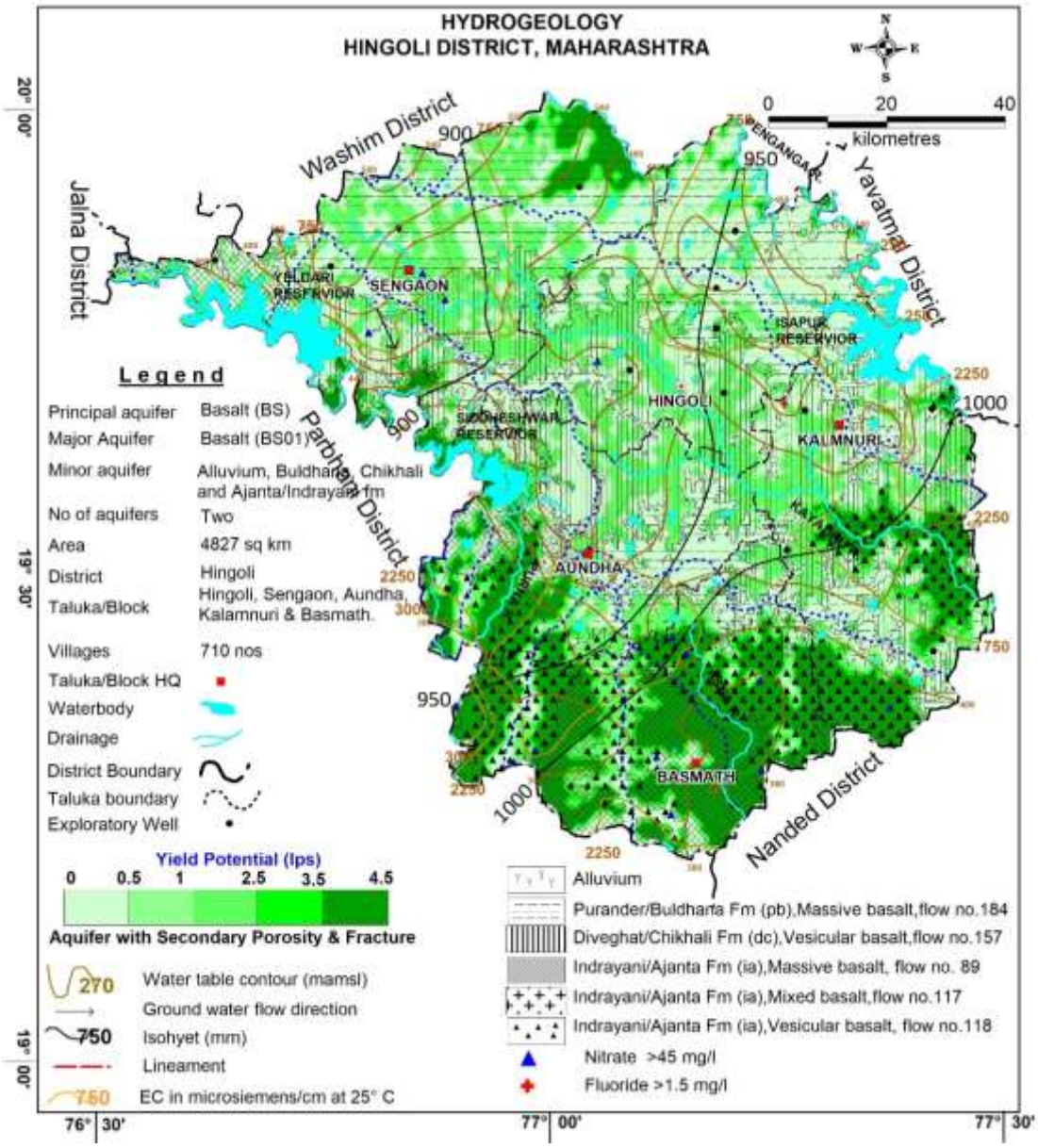


Figure 2.1: Hydrogeology, Hingoli District

Alluvium occurs as small patches along banks, flood plains and meanders of main rivers. These alluvium patches have individual areal extent from 1 to 20 Km^2 and thickness 5 to 30 m. It comprises beds and lenses of sands, gravels and boulders in a matrix of clays. These granular zones form the aquifers in which groundwater occurs under Phreatic and semi-confined conditions. The porosity of these granular zones ranges from 10 to 15 %.

The basaltic lava flows belonging to the Deccan Traps occupy about 99% of the area of the district. The formation is very thick and comprises scores of lava flows of 5 to 25 meters individual thickness. Each flow comprises a lower zone of 40 to 70% hard, massive basalt which is devoid of primary porosity and permeability. The upper zone of 30 to 60% is vesicular basalt which has very limited primary porosity as the vesicles are of very small size and are found invariably filled with secondary minerals. However, the formation comprises secondary porosity and permeability acquired due to weathering, jointing, shearing, fracturing etc. When the thickness of these zones is appreciable (30 to 60% of a flow), the flow forms an aquifer of moderate potential. These structural and composite characteristics are repeated in all the lava flows in the area and thus evolves a multiple aquifer system which generally extends to depths of 150 to 250 meters.

Apart from the inherent properties of lava flows, the topography also plays an important role in groundwater potential of basaltic area. Hills and higher grounds are the least potential areas as the rocks are hard, compact and resistant to weathering. The steep gradient causes rainwater to run off rapidly without much infiltration. In contrast, the valleys depressions and areas of lower elevations are the most potential areas as the rocks are weaker, prone to weathering due to joints and fractures. In addition, rainwater runoff is less and infiltration is more.

Deccan basalts are hydro geologically in-homogeneous rocks. The weathered and jointed /fractured parts of the rock form the potential horizons for ground water storage and movement. The vesicles are of very small size generally varying from 1 to 5 mm and are invariably found filled with secondary minerals such as zeolites, calcite, silica etc., thereby reducing the primary porosity to almost nil however when weathered it forms potential aquifers. The existence of multiple aquifers is characteristic of basalt and is indicative of wide variation in the joint/fracture pattern and intensity. The potential of the aquifer is the function of nature of porous space and permeability of aquifer and it depends mainly upon the degree of weathering, intensity of joints\fractures and topographic setting of the aquifer. Due to wide variation in secondary openings, the aquifers in area are of smaller extent, generally localized. In general Ground water occurs under phreatic/unconfined to semi-confined conditions in basalts. Shallow Aquifer is generally tapped by the dug wells and average depth of dug wells ranges from 12.00 to 15.00 m with yield varying up to 100 m^3/day. The deeper Aquifer is being tapped by bore wells with depth ranging from 40 to 200 m.

- The vesicular/ zeolitic basalts are highly susceptible to weathering as interconnected vesicles form conduits from weathering agents. It is generally seen that “Pahoehoe” flows contain uniformly distributed vesicles and when weathered have good porosity and permeability and constitute potentials aquifers.

Water Table Contour

Based on the Premonsoon water level data, a Premonsoon water table contour map has been prepared and presented in **figure 2.2**. The map depicts occurrence and movement of ground water in the district. The ground water flow lines are marked to show the direction of ground water flow. The elevation of water table ranges from

380 to 550 m amsl and generally follows the topography. In general, the ground water movement is towards the south and south east. Though there is a hydraulic continuity between the trappeans units, still due to the heterogeneous nature of the rock formation constituting the aquifer, there is wide variation in the water table gradient from 2 to 20 m/km. The ground water movement is generally sluggish in the alluvial areas with high permeable zones and in the areas of convergent ground water flow. Such areas have been demarcated as ground water potential zones. In area of low permeability, the water table contours are closely spaced indicating steep gradient.

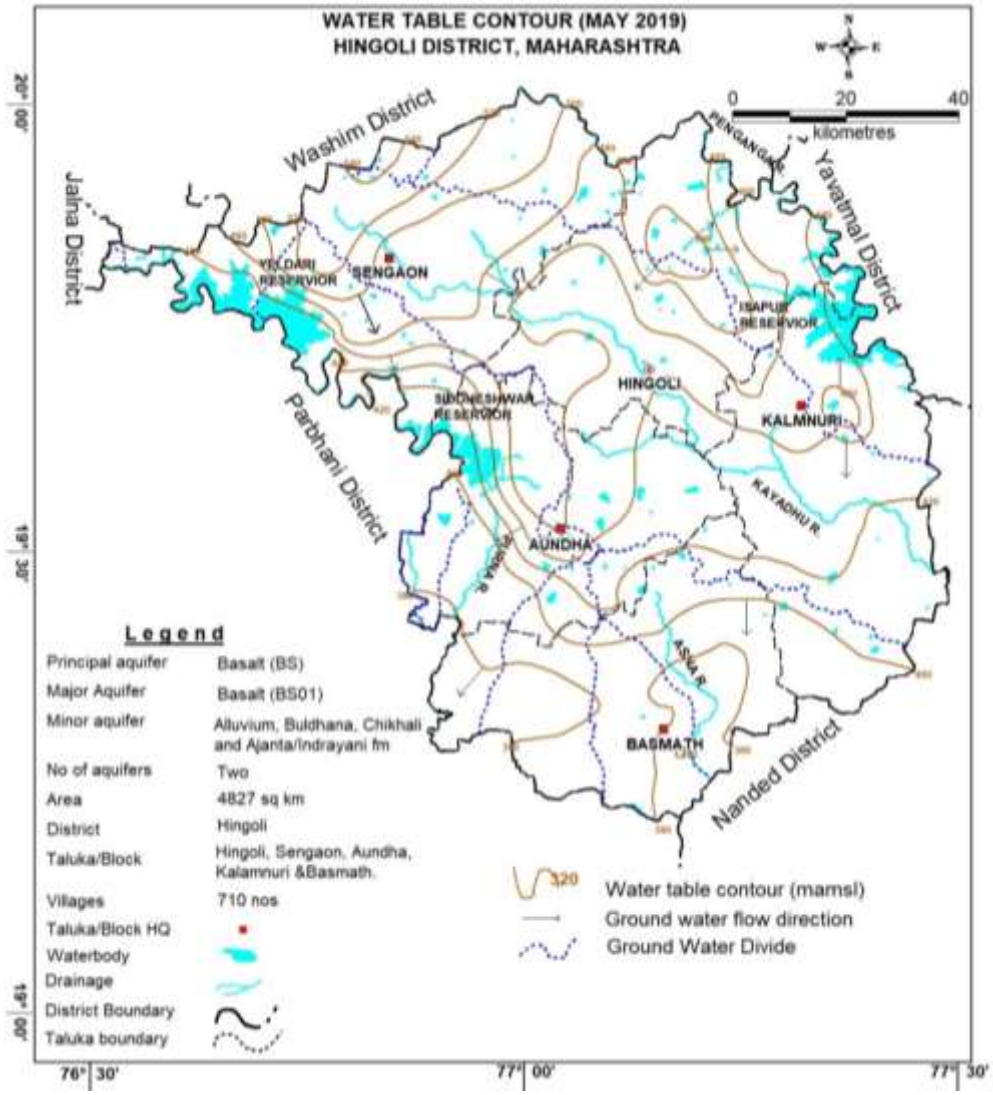


Figure 2.2: Water Table Contour, Hingoli district

2.1 Major Aquifer Systems

Deccan Trap Basalt of Late Cretaceous to Eocene age is the major rock formation in the district covering entire district. Although, Alluvium occurs in a narrow tract along the major rivers in the district and the aquifers in alluvium are of local extent and limited potential. A map depicting hydrogeological features is presented in **Figure 2.3.**

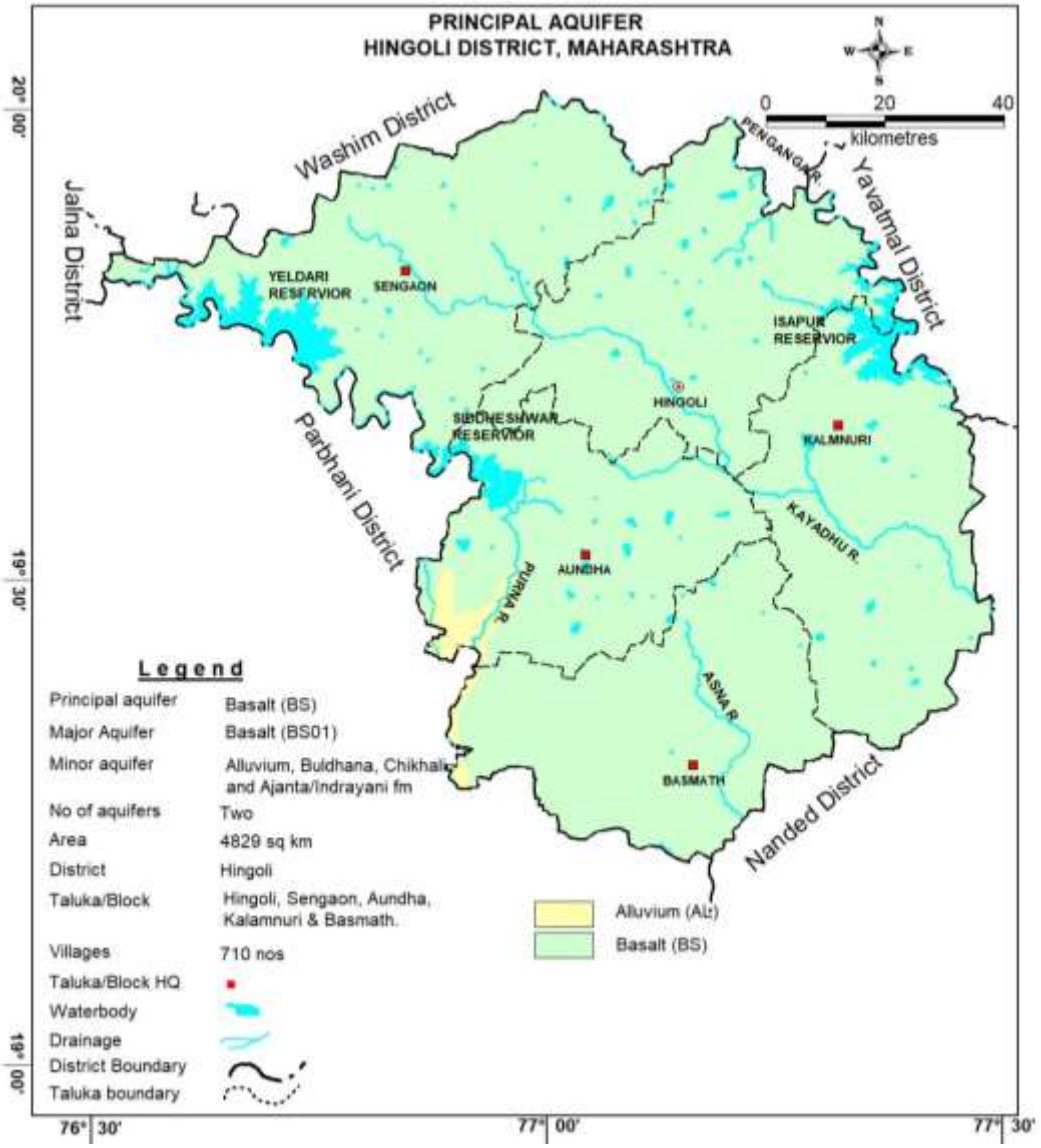


Figure 2.3: Principal Aquifers, Hingoli district

Based on the ground water exploration carried out in the district so far, aquifer wise characteristics have been delineated and are shown in **Table 2.1.** The aquifer units found in each of the formation are given below:

Basalt

Two aquifer systems, Aquifer I and Aquifer 2 Have been identified in Basaltic region.

Aquifer-I: Aquifer-I in Basalt formation is observed in the depth range of 6 to 22 m bgl with water levels of 0.2 to 20.9 mbgl and thickness of weathered/fractured zone varies from 8 to 15 m. The yield of the aquifer varies up to 200 m^3/day. Depth of occurrence of aquifer -I is depicted in **Figure 2.4** and Yield in the **Figure 2.5.**

Aquifer- II: Aquifer-II in Basalt formation is observed in the depth range of 61 to 196 mbgl with water levels of 6 to 112 mbgl and thickness of weathered/fractured zone varying from 1 to 9 m. The aquifer-II is exploited mainly by bore wells and yield

of the aquifer generally varies up to 2.5 lps. Depth of occurrence of Aquifer-II is depicted in **Figure 2.6** and yield in the **Figure 2.7.**

Table 2.1: Aquifer Characteristic of Major aquifers of Hingoli district

Major Aquifer	Basalt	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered/ Jointed Basalt	Jointed/Fractured Basalt
Depth to bottom of Aquifer (mbgl)	6 to 22	61 to 196
Weathered/ Fractures zones encountered (mbgl)	up to 22	up to 196
Weathered/Fractured rocks thickness (m)	8 to 15	1 to 9
SWL (mbgl)	0.2 to 20.9	6.53 to 112
Transmissivity (m2/day)	*30 to 50	0.51 to 15.17 m2/day
Specific Yield/ Storativity (Sy/S)	0.02	*0.00003 to 0.00005
Yield	up to 200 m3/day	up to 2.5 lps
Sustainability	2 to 5 hrs	to 3 hrs
*Values taken from Risod block, washim district.		

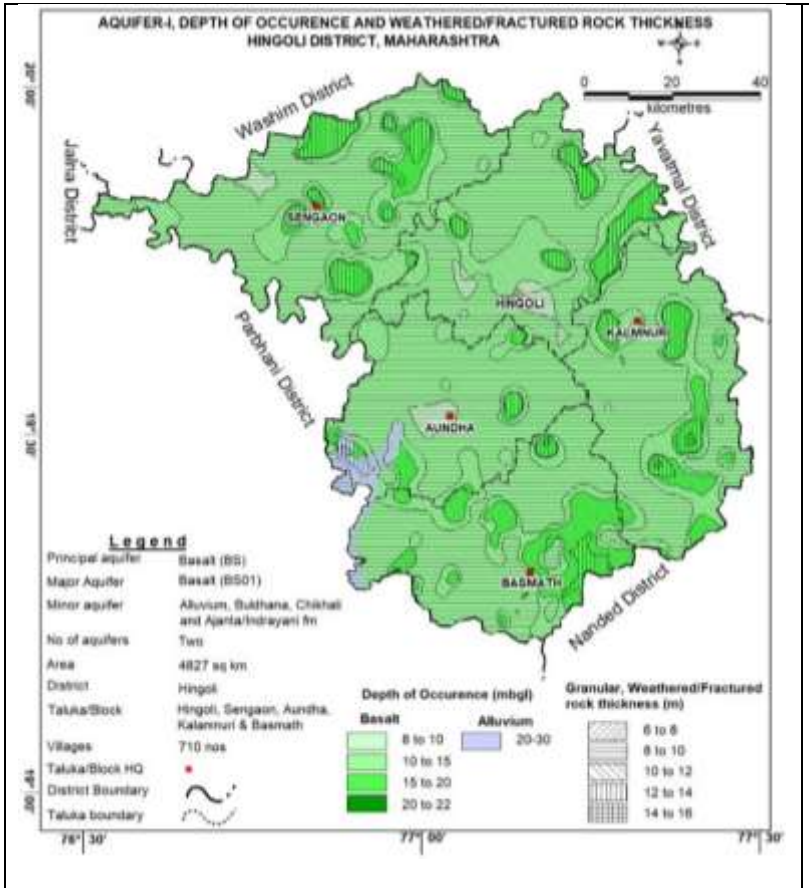


Figure 2.4: Depth of Occurrence and Granular Zone/ Fractured rock thickness-Aquifer-I

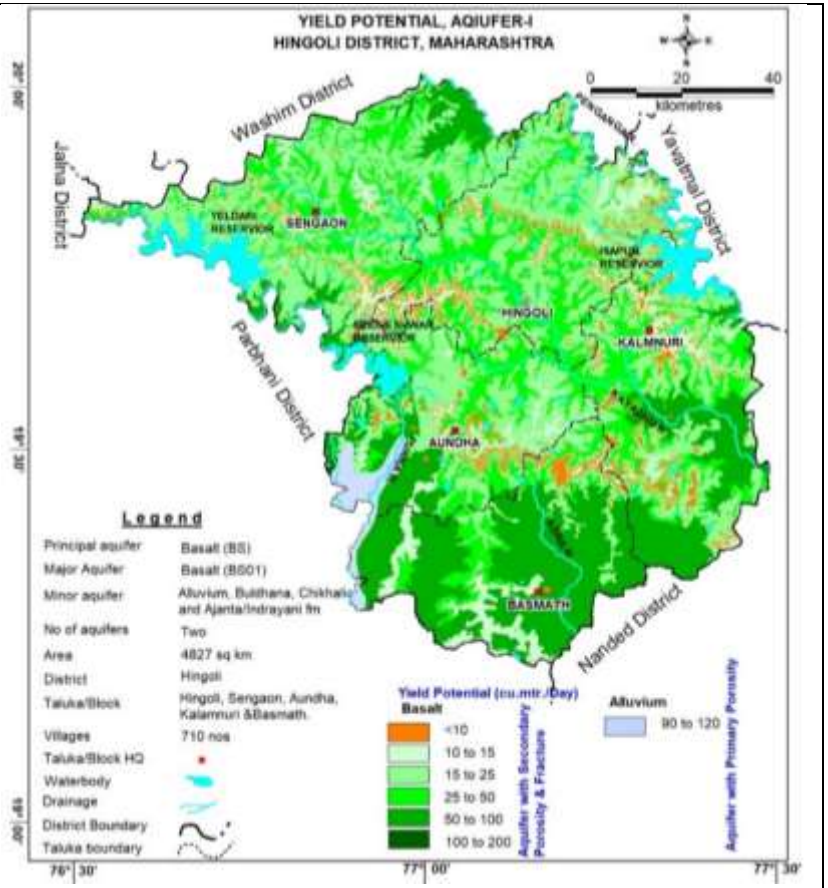


Figure 2.5: Yield Potential Aquifer-I

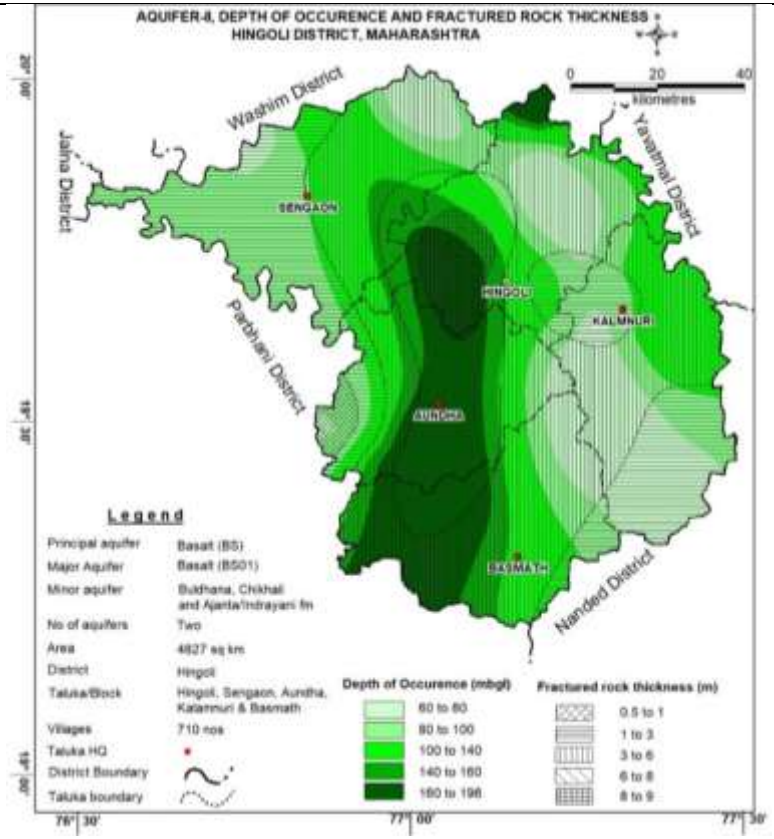


Figure 2.6: Depth of Occurrence and Fractured rock thickness - Aquifer-II

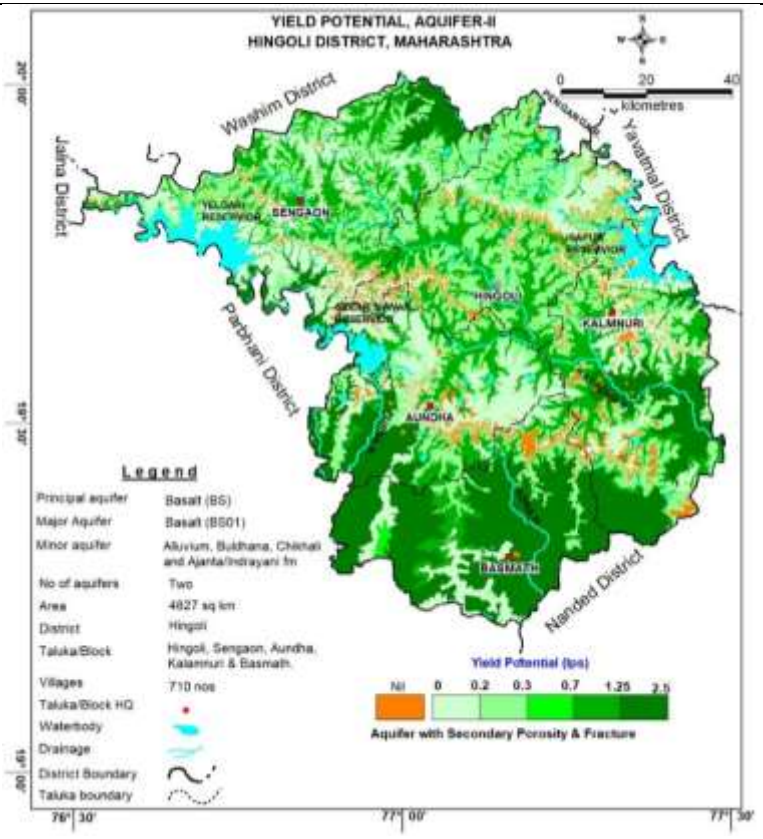


Figure 2.7: Yield Potential, Aquifer-II

2.2 Aquifer Parameters

Aquifer parameters have been obtained from ground water exploratory drillings carried out in the basalt covered areas of the district. The transmissivity of basaltic aquifers in the district is generally less than 20 m^2/day. Dug wells are the most common ground water extraction structures in the area. The yield of dug wells during the post monsoon season varies between 80 to 615 m^3/ day. The specific capacity of well gives an idea about the productivity of the well and is controlled by diameter and depth. The specific capacity of the dug wells varies from 25 to 976 lpm/m/dd. The pumping tests conducted on 3 exploratory wells in the areas indicate the transmissivity range from 0.51 to 15.17 m^2/day.

2.3 3-D and 2-D Aquifer Disposition

Based on the existing data, aquifer disposition in 3D, Fence diagram, 3D Bar diagram, various hydrogeological sections have been prepared along section lines to understand the subsurface disposition of aquifer systems shown in Figure 2.8 to 2.13.

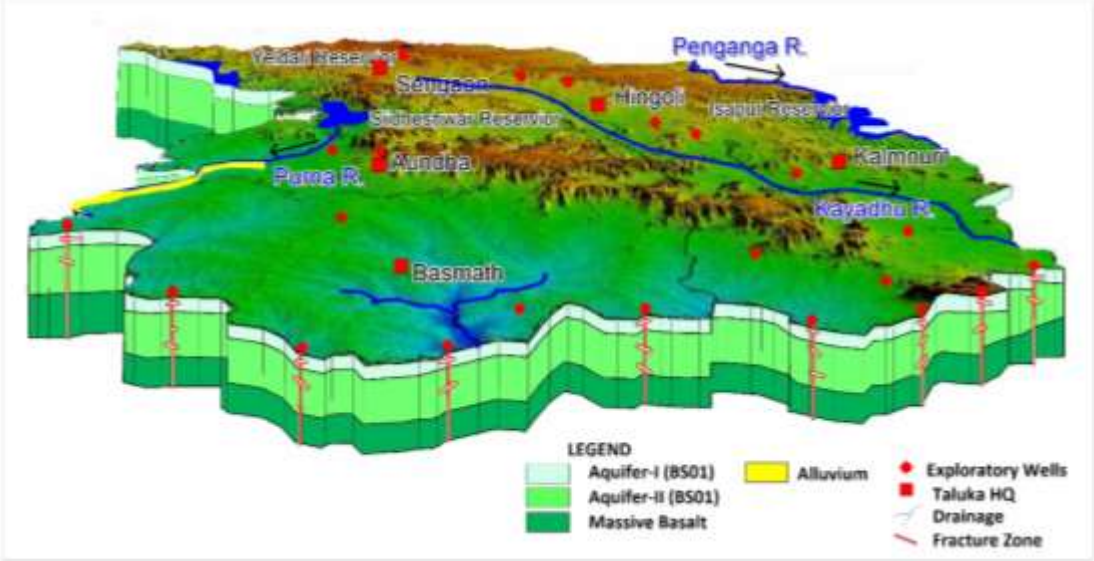


Figure 2.8: 3D Aquifer Disposition

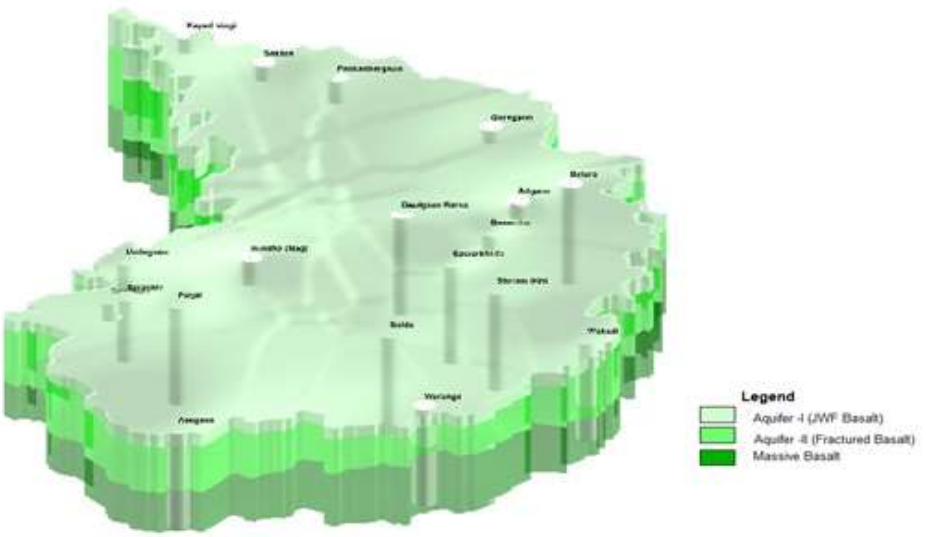


Figure 2.9: 3D Aquifer Disposition-Stratigraphic Model

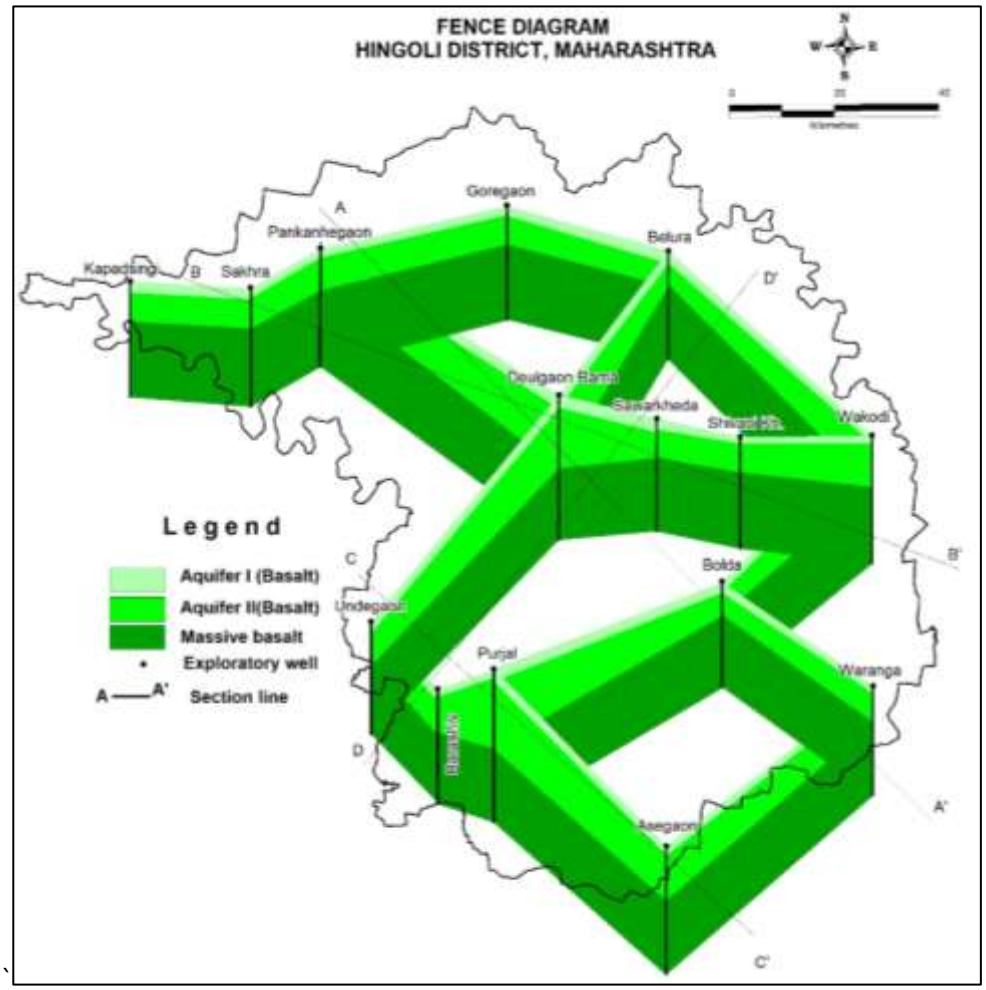


Figure 2.10: 3D Fence Diagram

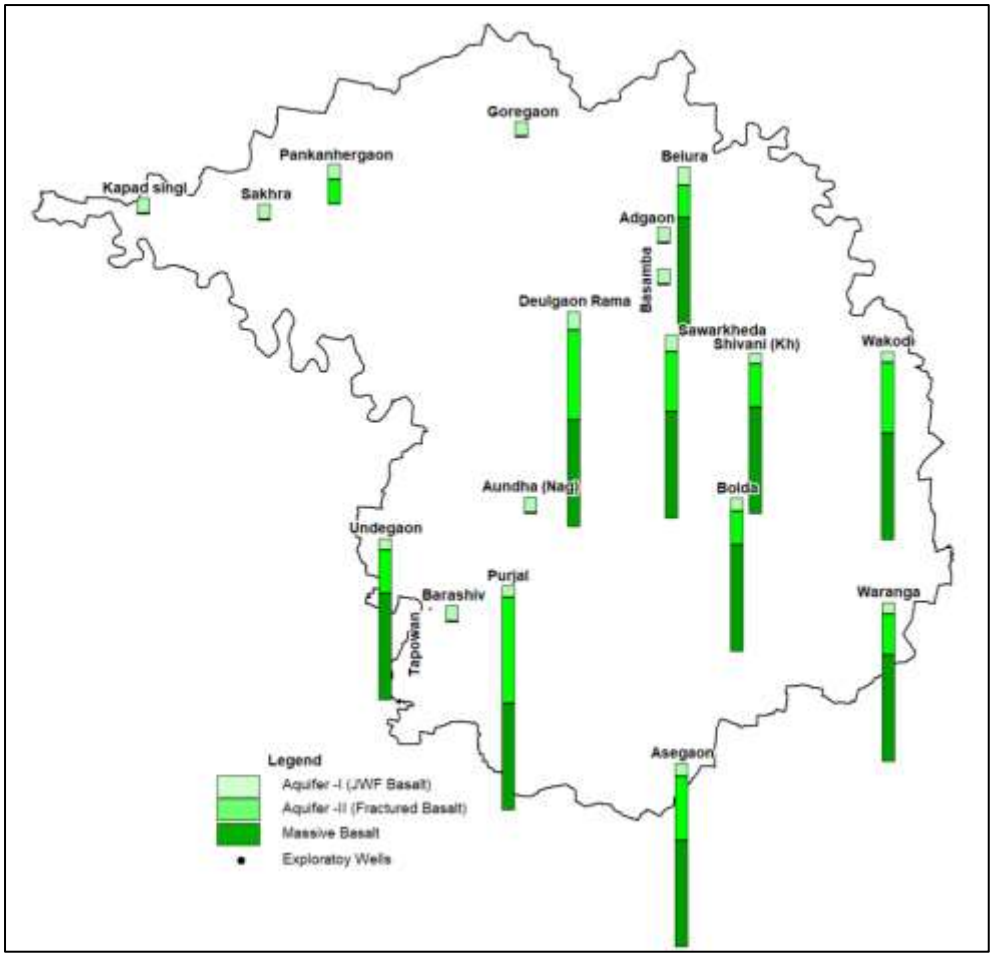


Figure 2.11: 3D-Bar Diagram

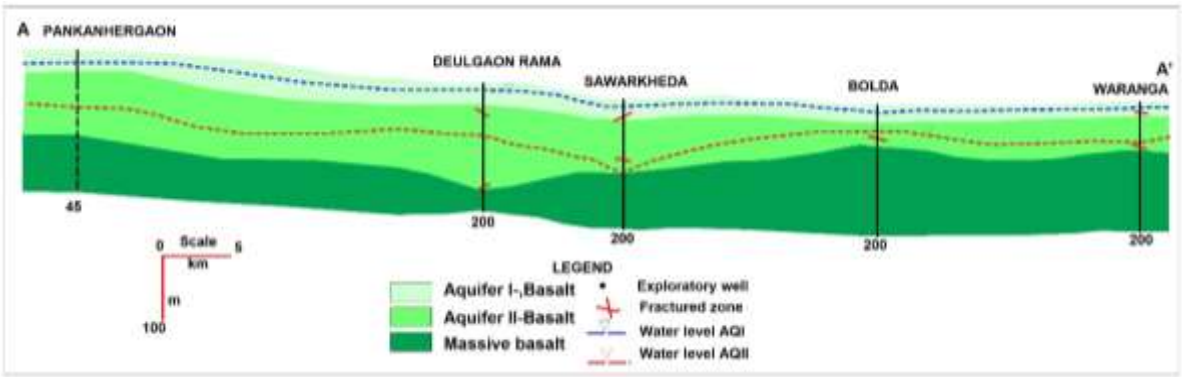


Figure 2.12: Lithological section (A-A')

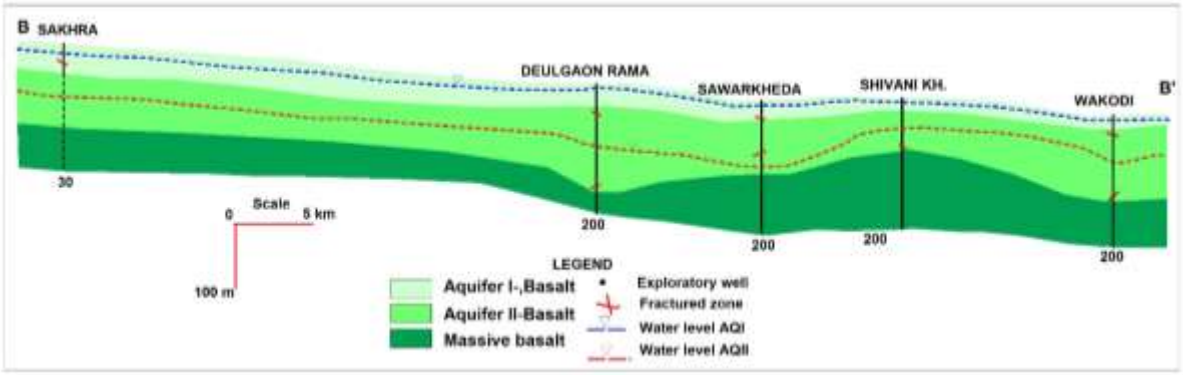


Figure 2.13: Lithological section (B-B')

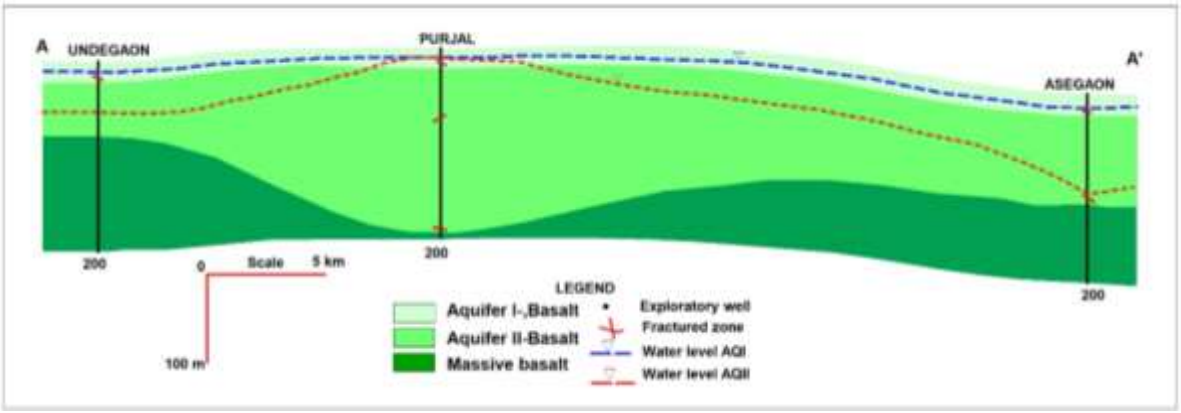


Figure 2.14 : Lithological section (C-C')

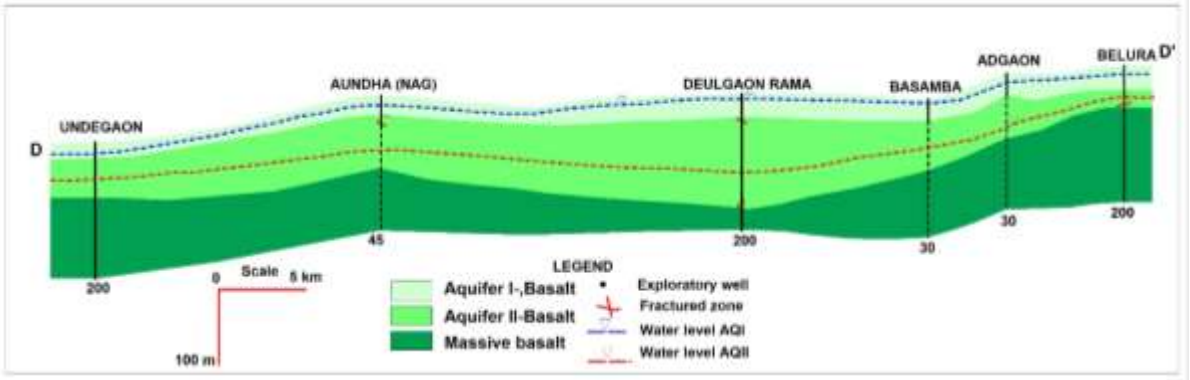


Figure 2.15: Lithological section (D-D')

3. WATER LEVEL SCENARIO

3.1 Depth to Water Level (Aquifer-I/Shallow Aquifer)

Central Ground Water Board periodically monitors 29 Ground Water monitoring wells four times a year i.e. in May (Pre monsoon), August, November (Post monsoon) and January in the district. Apart from this data, the data obtained of 51 wells from GSDA has also been used for preparation of depth to water level maps of the district. Pre-monsoon and post monsoon water level data are given in **Annexure-III and IV**.

The depth to water levels during May 2019 were found ranging from 3.95 (Umara, Kalmnuri block) to 20.9 mbgl (Khandegaon, Basmath block). Shallow water level within 5 mbgl are observed in small, isolated patch in Kalmnuri block covering only 19 sq. km. area of the block. Water levels between 5 and 10 mbgl have been observed in eastern and western parts of the district and isolated patches in northern part of the district covering about 1322 sq. km. The depth to water level between 10 to 20 mbgl has been observed in major part of the district. Deeper water levels of more than 20 mbgl are observed in isolated patches in southern part of the district in Basmath block covering 65 sq. km area of the district. The pre monsoon depth to water level map is depicted in **Figure 3.1.**

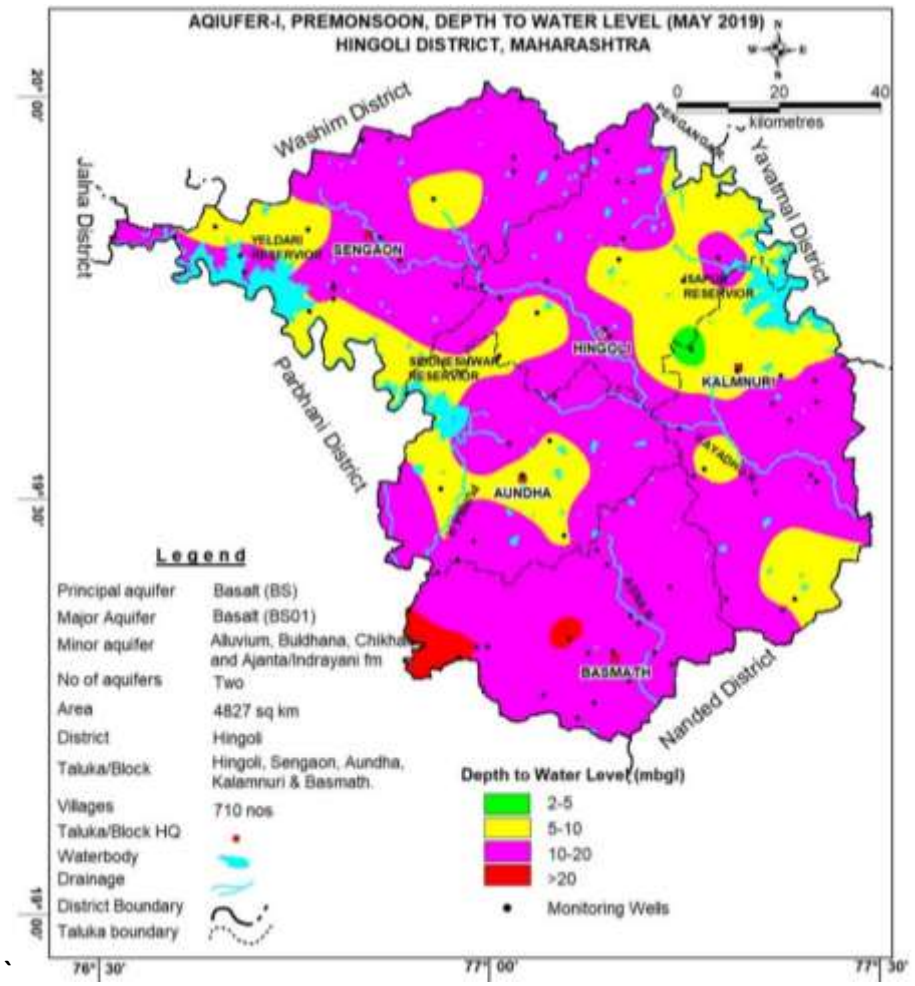


Figure 3.1 : DTWL, Shallow Aquifer (May 2019)

The depth to water levels in the district during Nov. 2019 were found ranging from 0.2 (Bibgavhan, Kalmnuri block) to 9.0 mbgl (Aral, Basmath block). Shallow water levels less than 2 mbgl have been observed in 997 sq. km area in eastern and western parts of districts covering Sengaon, Hingoli, Aundha (Nagnath) blocks; isolated patches are also observed in Kalmnuri and Basmath blocks. Water levels between 2-5 mbgl have been observed in major part of district. Water levels between 5 and 10 mbgl are observed in southern half of the district and isolated patches in eastern and northern parts of the district covering about 406 sq km area. Spatial variation in post monsoon depth to water levels is shown in **Figure 3.2.**

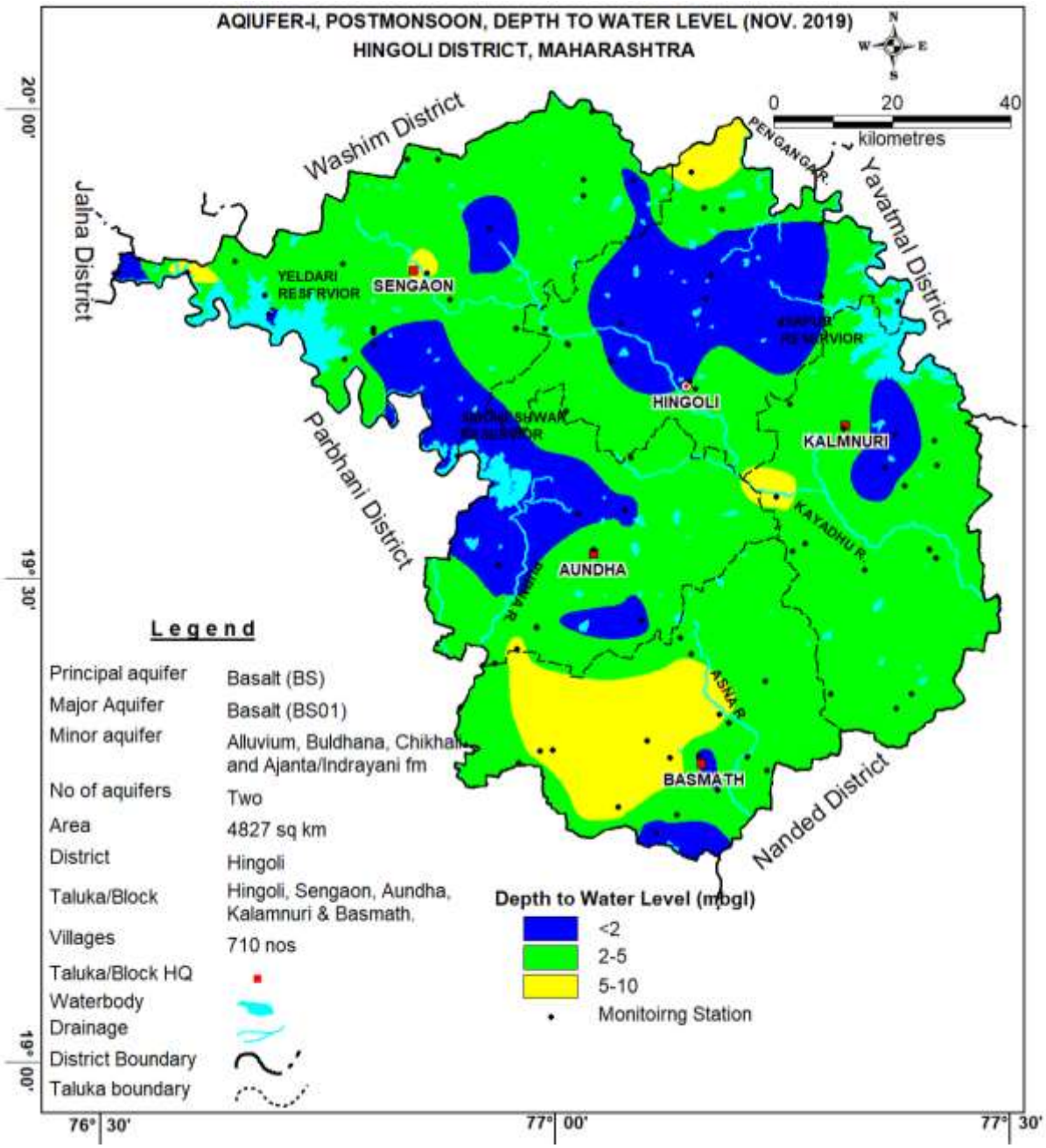


Figure 3.2: DTWL, Shallow Aquifer (Nov. 2019)

3.2 Depth to Water Level (Aquifer-II/ Deeper Aquifer)

Data of 15 exploratory wells has been used for preparation of depth to water level maps of the Deeper Aquifer of the district. The post-monsoon (November 2019) depth to water level in Hingoli District ranges from 6.53 (Purjal, Aundha block) to 112 mbgl (Asegaon, Basmath block). The depth to water level less than 10 mbgl has been observed as isolated patches in Aundha (Nagnath) and Sengaon blocks. Water level between 10 and 20 mbgl has been observed in northern part of Sengaon block and southern part of Aundha blocks. Water level between 20 to 30 mbgl has been observed in parts of all the blocks except Kalmnuri block. The deeper water level more than 30 mbgl are observed in major part of Basmath, Kalmnuri and Hingoli blocks and parts of Aundha (Nagnath) and Sengaon blocks. This may be due to low potential of the deeper aquifer in the district. The postmonsoon depth to water level for Aquifer-II is given in **Figure 3.3.**

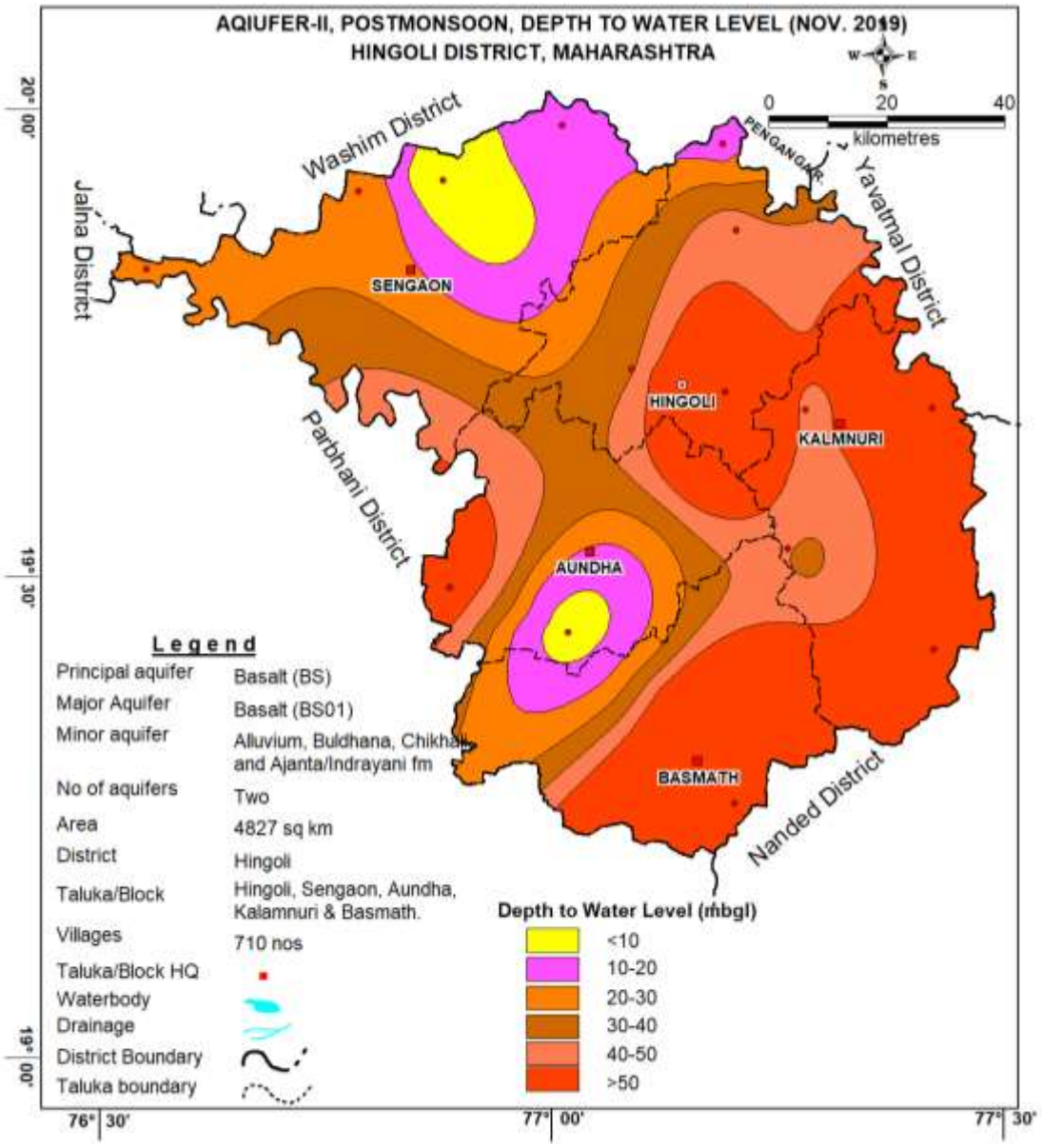
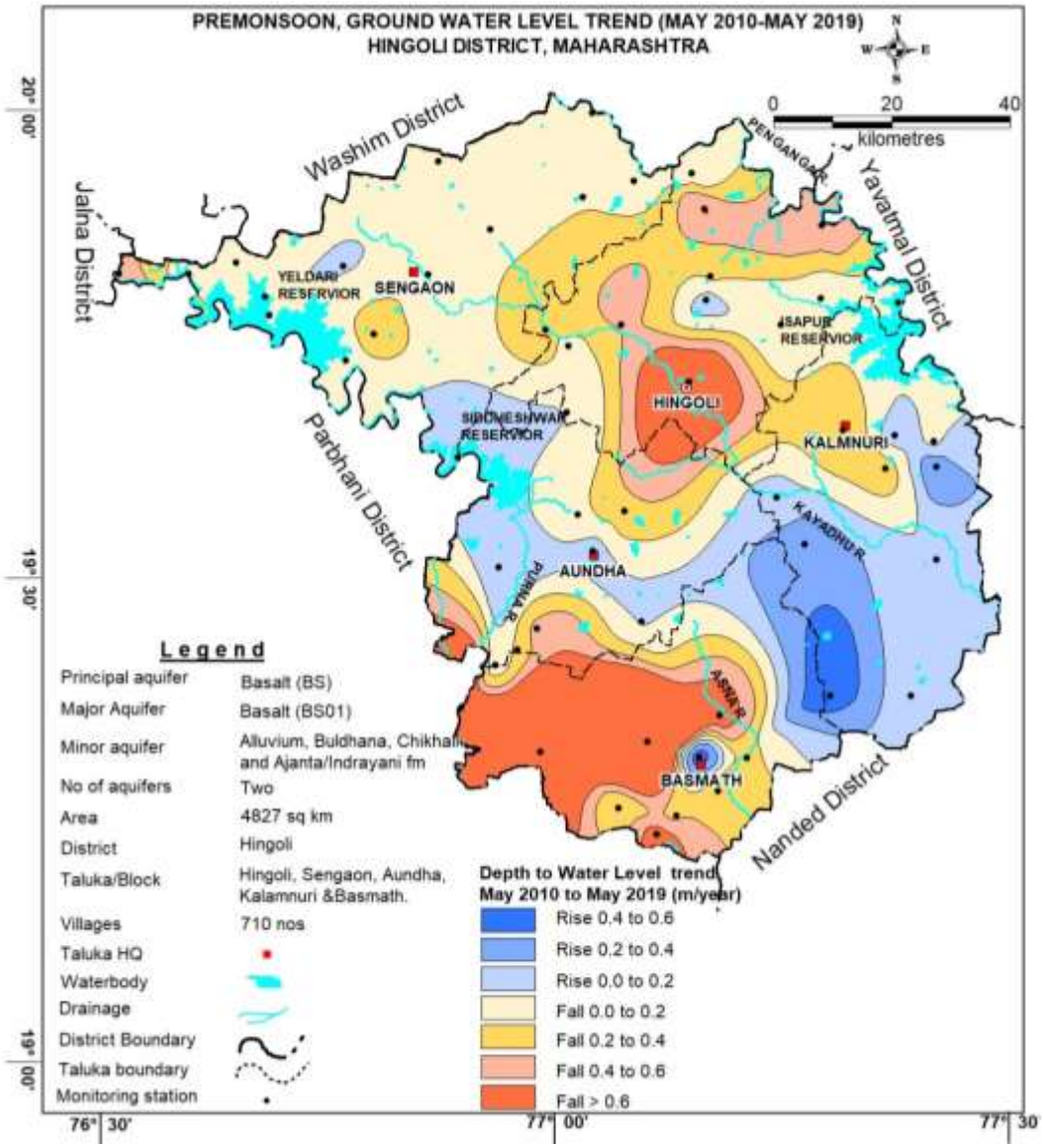


Figure 3.3: DTWL, Deeper Aquifer (Nov. 2019)

3.3 Water Level Trend (2010-2019)

During pre-monsoon period, rising water level trend has been recorded at 14 stations ranging from 0.0048 (Sakhara, Sengaon block) to 0.5145 m/year (Redgaon, Kalmnuri block) while falling trend was observed in 43 stations varying from 0.003 (Karanjala, Hingoli block) to 1.952 m/year (Khandegaon, Basmath block).

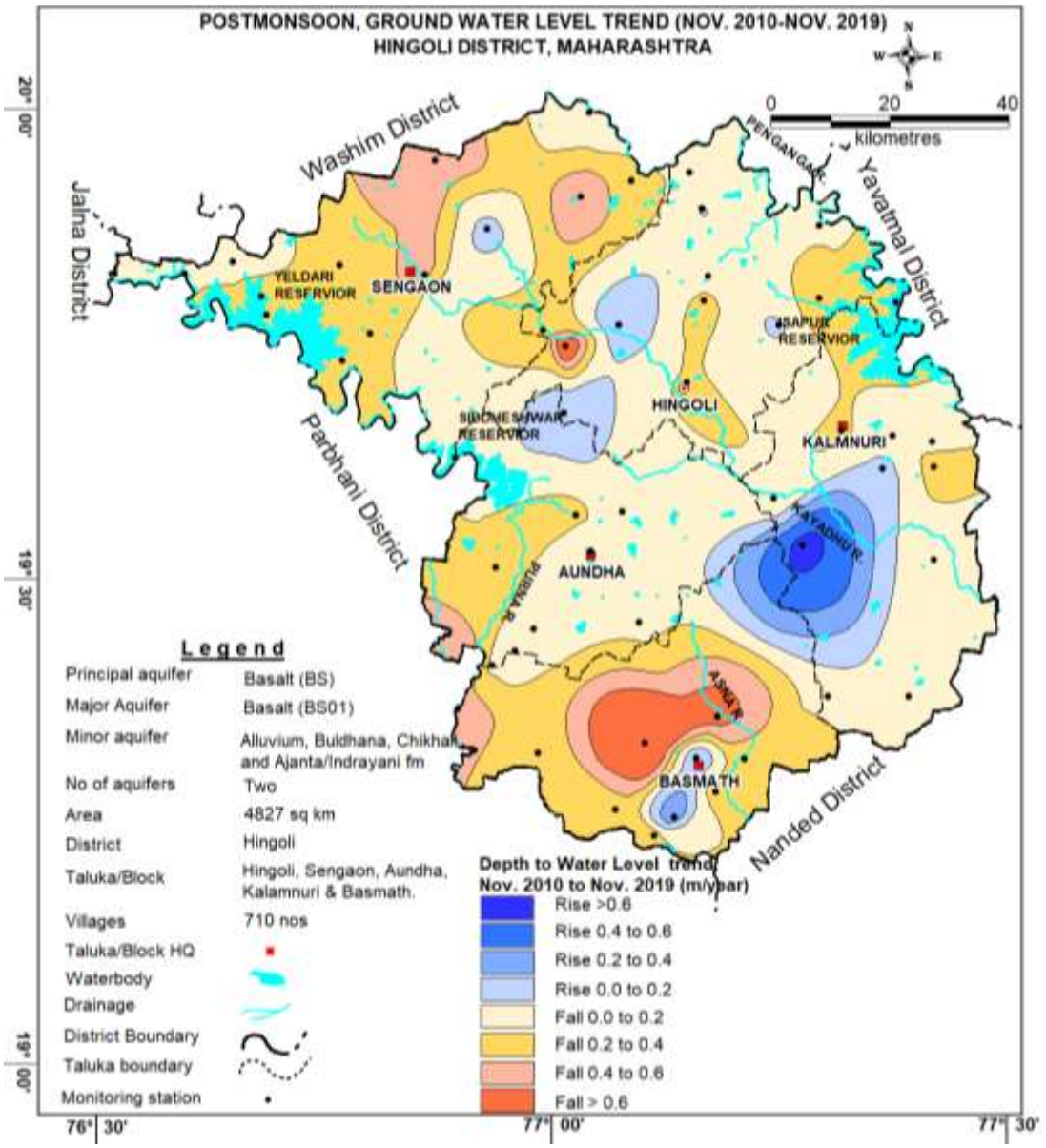
During pre-monsoon period, declining water level trend has been observed in about 3547 sq. km. area i.e., 75 % of the area. Significant decline of more than 0.20 m/year has been observed in 1839 sq. km., i.e., 39% of the area covering major parts of Basmath and Hingoli blocks and parts of Kalmnuri, Aundha and Sengaon blocks. Rise in water level trend has been observed in 1181 sq km area covering major part of Kalmnuri block and part of Aundha block and small isolated patches are observed in all other blocks. **(Figure 3.4)**



Fall @>0.2m/year 1839 Sq. km. (about 39 % area of the district)

Figure 3.4: Pre-monsoon Decadal Trend (2010-19)

During post monsoon period, rise in water level trend has been recorded at 9 stations and ranges from 0.0018 (Adgaon, Hingoli block) to 0.6386 m/year (Bolda, Kalmnuri block) while falling trend was observed at 48 stations varying from 0.0606 (Bhagvati, Sengaon block) to 0.9376 m/year (Khandegaon, Basmath block). Rising water level trend has been observed in parts of the Kalmnuri, Hingoli and Aundha blocks and small isolated patches in Basmath and Sengaon blocks covering about 548 sq. km. area. Fall in water level trend has been observed in 4180 sq. km. area covering major part of the district. Significant decline, more than 0.20 m/year has been observed in 1961 sq. km. area covering major parts of Basmath and Sengaon blocks and parts of Aundha (Nagnath), Hingoli and Kalmnuri blocks. **(Fig 3.6)** These declines may be due to the exploitation of ground water or low and erratic rainfall recevied in these areas. Water level trend data (2010-19) of observation wells of CGWB and GSDA is given in Annexure-V.

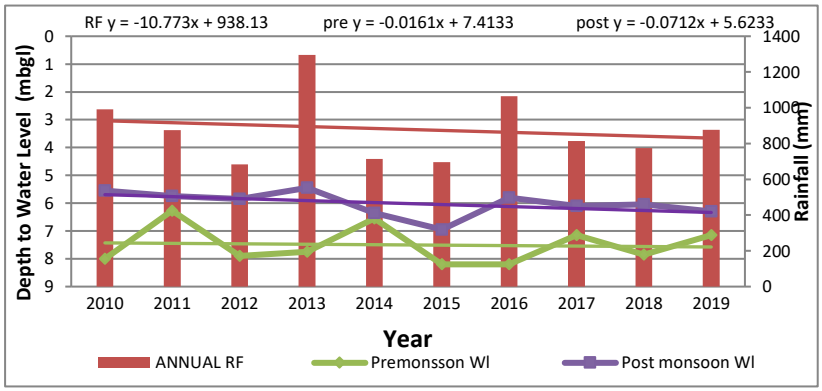
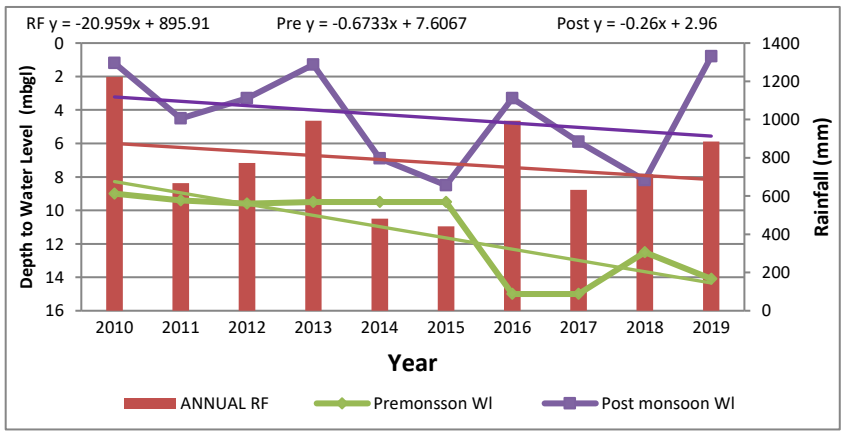


Fall @>0.2m/year 1961 Sq. km. (about 41.48% of the district)

Figure 3.5 : Post monsoon Decadal Trend (2010-19)

3.4 Hydrograph Analysis

The variation in short term and long-term water level trends may be due to variation in natural recharge from rainfall and withdrawal of groundwater for various agricultural, domestic and industrial requirements. The analysis of hydrographs shows that the annual rising limbs in hydrographs indicate the natural recharge of groundwater regime due to monsoon rainfall, as the monsoon rainfall is the sole source of natural recharge to the ground water regime. However, continuous increase in the groundwater draft is indicated by the recessionary limb. The figure 3.7 shows selected hydrographs (time series) of water levels.

Hydrograph (2010-19), village Aundha, Aundha (Nagnath) Block, Hingoli District 	Formation: Basalt Type of Well: Dug Well Premonsoon Water level trend shows falling trend @ 0.016 m/year and postmonsoon Water level shows falling trend @ 0.071 m/ year. Declining Rainfall trend @10.77 mm/ year Water level behaviour in conformity with rainfall
Hydrograph (2010-19), village Loni Bk, Basmath Block, Hingoli District 	Formation: Basalt Type of Well: Dug Well Premonsoon and post monsoon Water level trends are showing falling trend @ 0.67 and 0.26 m/year respectively. Declining Rainfall trend @20.95 mm/ year Water level behaviour in conformity with rainfall, falling rainfall trend affecting recharge

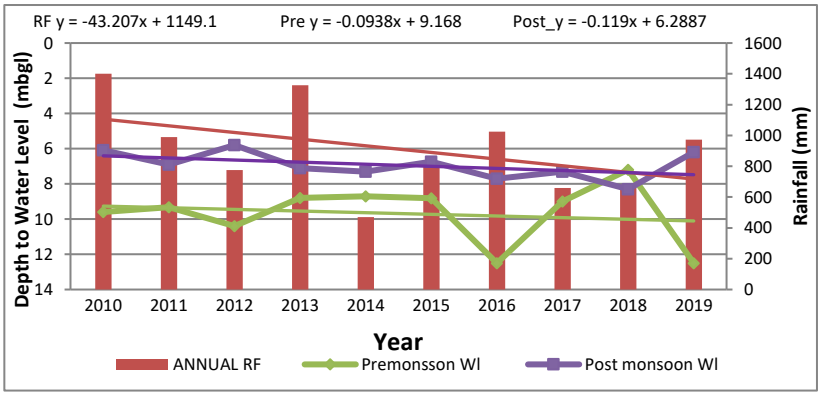
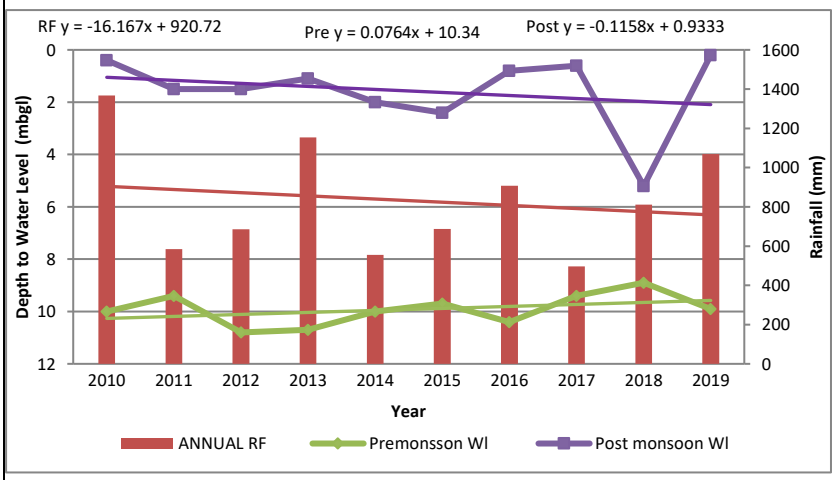
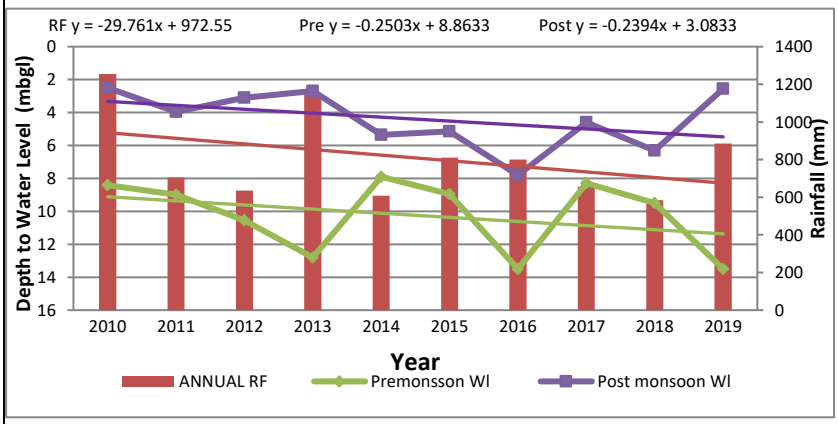
Hydrograph (2010-19), village Kanhergaon, Hingoli Block, Hingoli District 	Formation: Basalt Type of Well: Dug Well Premonsoon and postmoonsoon Water level trends showing falling trend @ 0.093 m/year and 0.119 m/year respectively. Fallng Rainfall trend @43.07 mm/ year Water level behaviour in conformity to rainfall, falling rainfall trend affecting recharge
Hydrograph (2010-19), village Bibgavan, Kalmnuri Block, Hingoli District 	Formation: Basalt Type of Well: Dug Well Premonsoon Water level trend showing rising trend @0.076 Postmonsoon water level trend showing falling trend @ 0.115 m/year respectively. Falling Rainfall trend @16.16 mm/ year Water level behaviour not in conformity to rainfall, falling rainfall trend affecting recharge
Hydrograph (2010-19), village Hatta, Sengaon Block, Hingoli District 	Formation: Basalt Type of Well: Dug Well Premonsoon and postmoonsoon Water level trend showing falling trend @ 0.250 and 0.239 m/year respectively. Falling Rainfall trend @29.76 mm/year water level behaviour in conformity with rainfall.

Figure 3.6: Behaviour of water level with time

4. GROUND WATER QUALITY

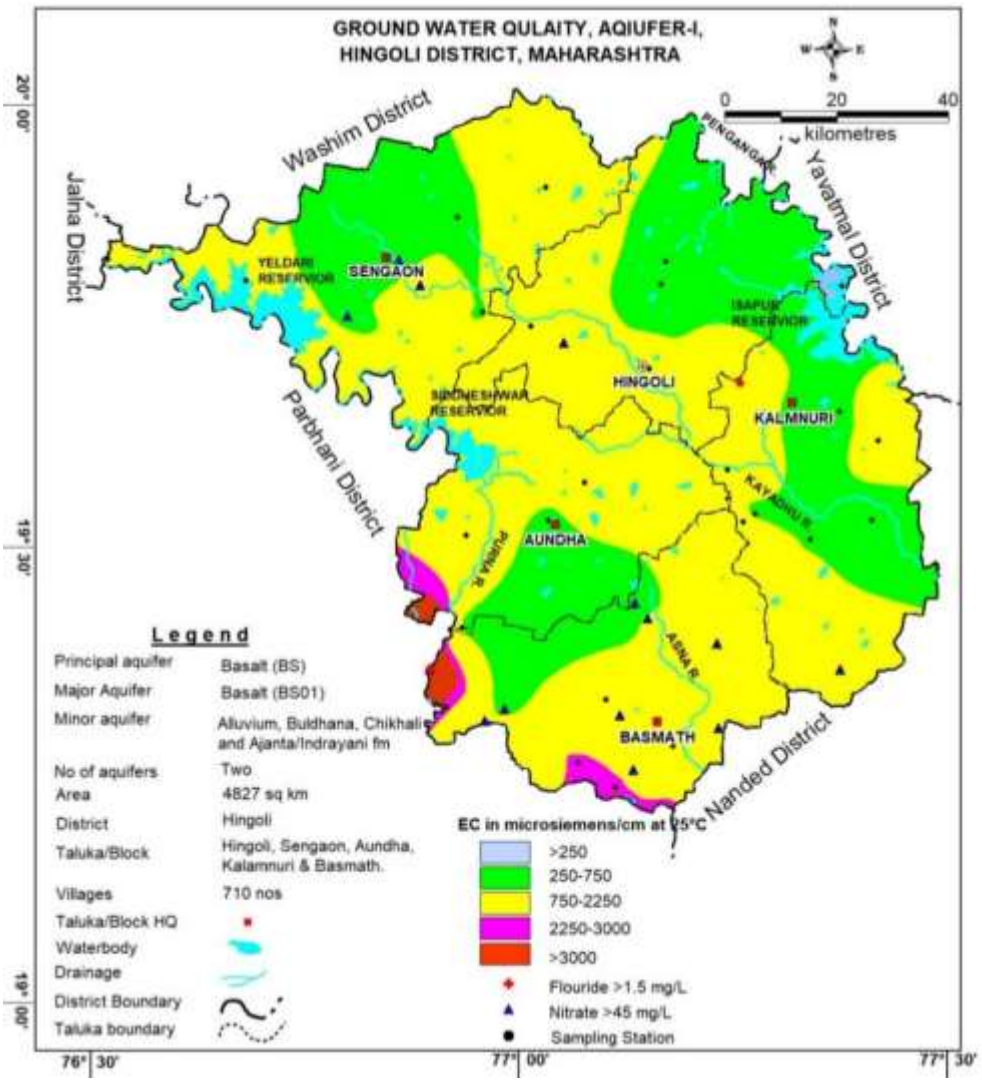
Ground water samples are being collected every year from GWM wells during pre-monsoon period (May). Ground water quality data of 40 monitoring wells of CGWB and GSDA representing shallow aquifer has been utilised to decipher the quality scenario of shallow aquifer. 51 exploratory wells-tubewells/borewells data of CGWB and GSDA representing deeper aquifer has been utilised to decipher the quality scenario of deeper aquifer. The aquifer wise ranges of different chemical constituents present in ground water are given in Table 4.1. The details of chemical analysis are given in Annexure VI and VII.

Table 4.1: Aquifer wise ranges of chemical constituents in Hingoli district

Constituents	Shallow aquifer		Deeper aquifer	
	Min	Max	Min	Max
pH	7.0	8.5	7.3	8.5
EC (µS/cm)	233	4380	404	2200
TDS (mg/l)	151	2840	263	1378
TH (mg/l)	76	664	30	560
Ca (mg/l)	18	240	2	114
Mg (mg/l)	5	112	1	140
Na (mg/l)	16	121	2	426
K (mg/l)	0.9	23.4	0.8	4
HCO3 (mg/l)	137	416	49	299
Cl (mg/l)	14	580	28	521
SO4 (mg/l)	7	398	1	305
NO3 (mg/l)	1.83	150	3.52	60

Distribution of Electrical Conductivity in Shallow Aquifer:

The concentration of EC in shallow aquifer varies from 233 (Gadibori, Hingoli block) to 4380 µS/cm (Sawangi Bk., Basmath block). Out of 40 samples collected from dug wells, only 3 samples are having EC more than 2250 µS/cm. Concentration of EC >2250 µS/cm has been observed in western and southern peripheral part of the district covering Basmath and Aundha blocks covering 94 sq. km. area. The ground water is potable in major part of district. The distribution of electrical conductivity in shallow aquifers is shown in **Figure 4.1** and analytical data is presented in Table 4.2.



(EC >2250 µS/cm in 94 sq. km. area)

Figure 4.1: Ground Water Quality, Aquifer-I

Distribution of Electrical Conductivity in Deeper Aquifer:

The concentration of EC in deeper aquifer varies from 404 (Khudaj, Sengaon block) to 2200 µS/cm (Deulgaon Rama, Hingoli block). The ground water is potable in major parts of the district. The distribution of electrical conductivity in deeper aquifers is shown in **Figure 4.2** and analytical data is presented in Table 4.2.

Table 4.2: Aquifer wise Electrical conductivity analytical data

S. No.	EC (µS/cm)	shallow aquifer		Deeper Aquifer	
		No. of samples	% of samples	No. of samples	% of samples
1	< 250	1	2.50	-	-
2	>250-750	14	35.0	14	27.45
3	>750-2250	22	55.0	37	72.55
4	2250-3000	2	5.00	-	-
5	3000-5000	1	2.50	-	-
	Total samples	40	100%	51	100%

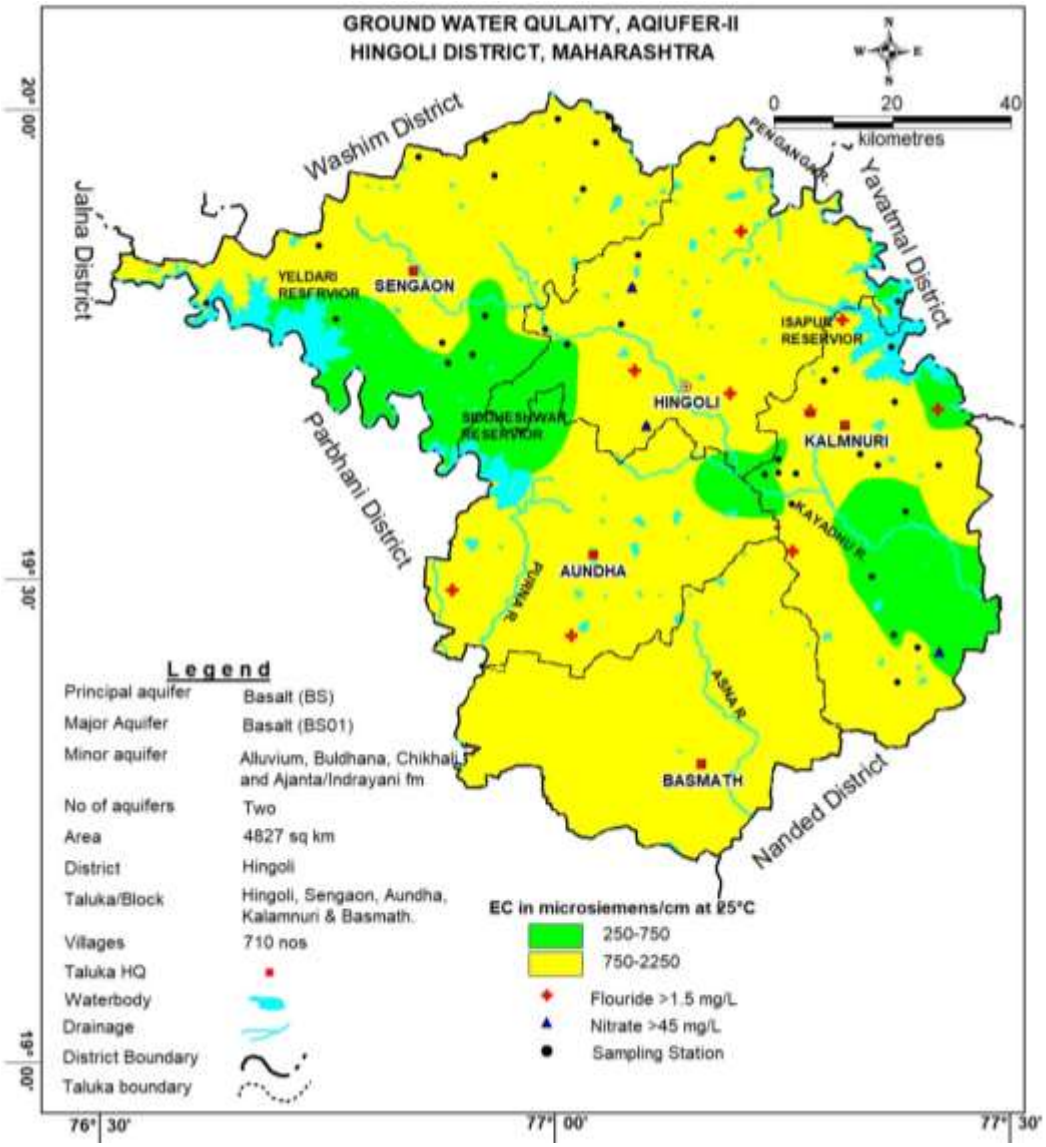


Figure 4.2: Ground Water Quality, Aquifer-II

Nitrate:

Nitrogen in the form of dissolved nitrate, a nutrient for vegetation and the element is essential to all living beings. The major contribution in ground water is from sewage, waste disposal, nitrate fertilizer and decaying of organic matter. From shallow aquifer, 40 samples were analyzed; out of these 14 water samples show the nitrate concentrations exceeding the desirable limit of 45 mg/l. In Hingoli district nitrate concentration varies from 1.83 (Kalgaon, Hingoli block) to 150 mg/l (Basmath Shivar, Basmath block). As per BIS (2012) the desirable limit is 45 mg/l. The high concentration of Nitrate may be due to domestic waste and sewage in the urban and rural parts of district.

In deeper aquifer, water samples from 51 wells were analysed, out of these 5 water samples show nitrate concentration exceeding the desirable limit of 45 mg/l. In deeper aquifer nitrate concentration ranges from 3.52 (Khudaj,

Sengaon block) to 60 mg/l (Waranga, Kalmnuri block). The deeper aquifer is also affected by nitrate contamination; it may be due to percolation of nitrate contaminants from the ground surface as there are no other reasons for nitrate contamination in deeper aquifers. Aquifer wise nitrate concentration is given in Table 4.3.

Fluoride:

In shallow aquifer, concentration of fluoride ranges from 0.04 to 2.3 mg/l. out of 40 samples analysed, only 2 samples show fluoride concentration more than 1.5 mg/l. In shallow aquifer, the highest concentration of fluoride is found in Umara, Kalmnuri block (2.30 mg/l). In Deeper Aquifer, concentration of fluoride ranges from 0.01 to 10.7 mg/l. Out of 51 samples analysed, only 10 samples show fluoride concentration more than 1.5 mg/l. In Deeper aquifer, the highest concentration of fluoride is found in Deulgaon Rama (10.7 mg/L) in Hingoli block; it may be due to the geogenic reasons. Aquifer wise fluoride concentration is given in Table 4.3.

Table 4.3: Aquifer wise Nitrate and Fluoride concentration

	No_3 > 45 mg/l		**fluoride >1.5 mg/l**	
Block	**No of samples**	**No of samples**	**No of samples**	**No of samples**
	Shallow Aquifer	**Deeper Aquifer**	**Shallow Aquifer**	**Deeper Aquifer**
Aundha	1			2
Basmath	9	1	1	1
Hingoli	1	2		3
Kalmnuri	1	2	1	4
Sengaon	2			
Grand Total	**14**	**5**	**2**	**10**

4.1 Suitability of Ground Water for Drinking Purpose

In shallow aquifer, 2.5 % samples are having TDS more than maximum permissible limit (MPL) and 52.5% of samples have TDS concentration above the Desirable limit (DL) but below the MPL. The water from areas where TDS values are higher than MPL is not fit for drinking purpose if directly consumed without treatment. It is also seen that about 2.5 to 5 % samples are beyond the maximum permissible limit for the parameters like TDS, TH, Ca, Nitrate and Fluoride indicating that the water is not suitable for drinking purpose. Concentration of Chemical constituents in shallow Aquifer is given in **Table 4.4.**

Table 4.4: Concentration of Chemical constituents in shallow Aquifer

Parameter	Drinking water Standards (IS-10500-2012)		Total no of ground water samples	Shallow aquifer					
				Samples (<DL)		Samples (DL-MPL)		Samples (>MPL)	
	DL	MPL		No	%	No	%	No	%
pH	6.5-8.5	-	40	40	100	-	-	-	-
TDS	500	2000	40	18	45	21	52.5	1	2.5
TH	300	600	40	17	42.5	22	55	1	2.5
Ca (mg/L)	75	200	40	22	55	17	42.5	1	2.5
Mg (mg/L)	30	100	40	14	35	26	65	-	-
Cl (mg/L)	250	1000	40	37	92.5	3	7.5	-	-
SO_4 (mg/L)	200	400	40	39	97.5	1	2.5	-	-
NO_3 (mg/L)	45	No relaxation	40	26	65	14	35	-	-
F (mg/L)	1	1.5	40	34	85	4	10	2	5

(Here, DL- Desirable Limit, MPL- Maximum Permissible Limit)

In Deeper aquifer, 71 % of samples have TDS concentration above the Desirable limit (DL) but below the MPL. It is also seen that about 3.92 to 19.6 % samples are beyond the maximum permissible limit for the parameters like Ca, Mg, NO_3 and Fluoride indicating that the water is not suitable for drinking purpose. Concentration of Chemical constituents in Deeper Aquifer is given in **Table 4.5.**

Table 4.5: Concentration of Chemical Constituents in Deeper Aquifer

Parameter	Drinking water Standards (IS-10500-2012)		Total no of ground water samples	Deeper aquifer					
				Samples (<DL)		Samples (DL-MPL)		Samples (>MPL)	
	DL	MPL		No	%	No	%	No	%
pH	6.5-8.5	-	51	51	100	-	-	-	-
TDS	500	2000	51	15	29.4	36	70.6		0.00
TH	300	600	51	42	82.4	9	17.6		0.00
Ca (mg/L)	75	200	51	38	74.5	11	21.6	2	3.92
Mg (mg/L)	30	100	51	25	49.0	24	47.1	2	3.92
Cl (mg/L)	250	1000	51	46	90.2	5	9.8	-	-
SO_4 (mg/L)	200	400	51	48	94.1	3	5.9	-	-
NO_3 (mg/L)	45	No relaxation	51	46	90.2	5	9.8	-	-
F (mg/L)	1	1.5	51	35	68.62	6	11.76	10	19.60

Here, DL- Desirable Limit, MPL- Maximum Permissible Limit)

4.2 Suitability of Ground Water for Irrigation

The quality of Irrigation water affects the productivity, yield and quality of the crops. The quality of irrigation water depends primarily on the presence of dissolved salts and their concentrations. The Electrical Conductivity (EC), Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC) are the most important quality criteria, which assess the water quality and its suitability for irrigation.

Electrical Conductivity (EC)

The concentration of dissolved ions in the water is represented by the electrical conductivity. The classification of water for irrigation, based on the EC values is given in Table 4.6 and details are as follows: -

Low Salinity Water (EC: < 250 µS/cm): This water can be used for irrigation with most crops on most soils with little likelihood that salinity will develop.

Medium Salinity Water (EC: 250 – 750 µS/cm): This water can be used if moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.

High Salinity Water (EC: 750 – 2250 µS/cm): This water cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.

Very High Salinity Water (EC: >2250 µS/cm): This water is not suitable for irrigation under ordinary condition. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching and very salt tolerant crops should be selected.

Table 4.6 Classification of Ground water for Irrigation based on EC values

S. No	Water Quality Type	EC in µS/cm	Shallow aquifer		Deeper Aquifer	
			No. of Samples	% of samples	No. of samples	% of samples
1	Low Salinity Water	< 250	1	2.50	-	-
2	Medium Salinity Water	>250-750	14	35.00	14	27.45
3	High Salinity Water	>750-2250	22	55.00	37	72.55
4	Very High Salinity Water	> 2250	3	7.50	-	-
Total			40		51	

In shallow aquifer, maximum numbers of samples fall under the category of medium to high salinity type of water. In deeper aquifer, maximum numbers of samples fall under the category of medium to high salinity type of water. In the areas where very high salinity prevails (>2250 µS/cm), ground water can be used for irrigation for very high salt tolerant crops and with proper soil and crop management practices.

Sodium Adsorption Ratio (SAR)

Excess of sodium in water renders it unsuitable for irrigation on soil containing exchangeable Calcium and Magnesium ions. Soil containing exchangeable Calcium and Magnesium takes up sodium of irrigation water in exchange for Calcium and Magnesium, the ratio reflects the Sodium hazard. The SAR indicates the relative activity of the Sodium ions in exchange reactions with the soil. The main problem with high sodium concentration is its effect on soil permeability, hardening of soil & water irrigation system. Sodium also contributes directly to the total salinity of the water and may be toxic to sensitive crops such as fruit trees. The higher value of SAR indicates soil structure damage.

In shallow aquifer, of the 20 samples analysed, all the samples are having SAR value less than 10. In deeper aquifer, out of 10 samples, 1 sample (Deulgaon Rama, Hingoli block) is having SAR value more than 10 in Hingoli block. The classification of ground water samples based on SAR values for its suitability for irrigation purpose is shown in Table 4.7.

Table 4.7: Classification of Ground water for Irrigation based on SAR values

Characteristics	Quality	SAR value							
	Total Number of GW samples	< 10		10-18		18-26		> 26	
		Good		Good to Permissible		Doubtful		Bad (Unsuitable)	
		No	%	No	%	No	%	No	%
Shallow Aquifer	20	20	100	-	-	-	-	-	-
Deeper Aquifer	10	9	90	1	10	-	-	-	-
Total	30	29	96.66	1	3.33	-	-	-	-

Residual Sodium Carbonate (RSC)

Residual Sodium Carbonate (RSC) is considered to be superior to SAR as a measure of sodacity particularly at low salinity levels. Calcium reacts with bi-carbonate and precipitate as $CaCO_3$. Magnesium salt is more soluble in water so the chances of it getting precipitated is very less. When calcium and magnesium are lost from the water, the proportion of sodium is increased resulting in the increase in sodium hazard. This hazard is evaluated in terms of RSC. The classification of ground water samples based on RSC values for its suitability for irrigation purpose is shown in Table 4.8.

Table 4.8: Classification of Ground water for Irrigation based on RSC values

Characteristics	Quality	RSC values (meq/L)					
		< 1.25		1.25-2.50		> 2.50	
		Good		Doubtful		Bad (Unsuitable)	
	Total No of GW samples	No	%	No	%	No	%

Shallow Aquifer	20	19	95	1	5	-	-
Deeper Aquifer	10	8	80.0	1	10	1	10
Total	30	27	90.00	2	6.66	1	3.33

In shallow aquifer, it is observed that out of 21 samples, only 1 sample (Chikli, Hingoli block) shows RSC values more than 1.25 meq/L indicating that the ground water of the area is not suitable for irrigation while in deeper aquifer, out of 10 samples, 2 samples show RSC more than 1.25 meq/L indicating that the ground water of the area is not suitable for irrigation.

5. GROUND WATER RESOURCES

5.1 Ground Water Resources – Aquifer-I

Central Ground Water Board and Ground Water Survey and Development Agency (GSDA), Maharashtra have jointly estimated the ground water resources of Hingoli district based on GEC-2015 methodology. Block wise ground water resources are given in Table 5.1, and graphical representations of the resources on the map are shown in **Figure-5.1**.

Ground Water Resource estimation was carried out for 4827 sq. km. area out of which 1692 sq. km. is under canal command and 2970 sq. km. is in non-command. About 164.69 sq. km. area is hilly and this is not considered for resource estimation. As per the estimation, the Annual extractable ground water resources are 738.17 MCM. The total Extraction is estimated at 392.15 MCM with irrigation sector being the major consumer having a draft of 370.53 MCM. The domestic and industrial water requirements are worked out at 21.61 MCM. The net ground water availability for future use is estimated at 293.56 MCM. Stage of ground water development varies from 41.12 % (Hingoli) to 61.39% (Basmath). The overall stage of ground water development for the district is 53.13%. Block wise assessments indicate that all the blocks in the district fall under "Safe" category.

Table 5.1: Ground water resources, Aquifer-I (Shallow aquifer), Hingoli district (2017)

(in MCM)

Administrative Unit	Annual Extractable Ground Water Recharge	Annual Ground Water Extraction-irrigation use	Annual Ground Water Extraction-industrial use	Annual Ground Water Extraction-domestic use	Total Extraction	Annual GW Allocation for Domestic Use as on 2025	Net Ground Water Availability for future use	Stage of Ground Water Extraction	Category
Aundha (Nagnath)	149.48	65.73	0	6.521	72.2527	14.6806	68.5456	48.34	Safe
Basmath	196.27	115.12	0.0102	5.37	120.51	15.5558	64.3404	61.4	Safe
Hingoli	121.61	46.27	0.0084	3.74	50.019	14.5786	63.235	41.13	Safe
Kalmnuri	142.26	81.24	0.0068	3.77	85.017	12.2233	48.3088	59.76	Safe
Sengaon	128.55	62.16	0	2.20	64.361	17.0444	49.1307	50.07	Safe
Total	738.17	370.53	0.0253	21.61	392.155	74.0827	293.5605	53.13	Safe

5.2 Ground Water Resources – Aquifer-II

The ground water resources of Aquifer-II (Basalt) were also assessed to have the correct quantification of resources so that proper management strategy can be framed. The total resources of aquifer-II have been estimated as 37.57

MCM. Block wise summarized Ground Water Resources of Aquifer-II are given in **Table 5.2.**

Table 5.2: Ground Water Resources of Aquifer-II (Deeper aquifer)

Block	Aquifer	Area (Sq km)	Mean Thickness (m)	Average of Sy	Average of S	Average Piezometric head	Resources above confining layer (MCM)	Resource within confining Aquifer (MCM)
Aundha (Nagnath)	Basalt Aq-II	924.2	3.75	0.002	0.0000145	76	1.018	6.93
Basmath	Basalt Aq-II	764.36	3.00	0.002	0.0000145	4	0.044	4.59
Hingoli	Basalt Aq-II	948.32	5.50	0.002	0.0000145	11.5	0.158	10.43
Kalmnuri	Basalt Aq-II	948.91	3.00	0.002	0.0000145	20.5	0.282	5.69
Sengaon	Basalt Aq-II	1241.21	4.00	0.002	0.0000145	55.5	0.999	9.93
Grand Total							2.502	37.57

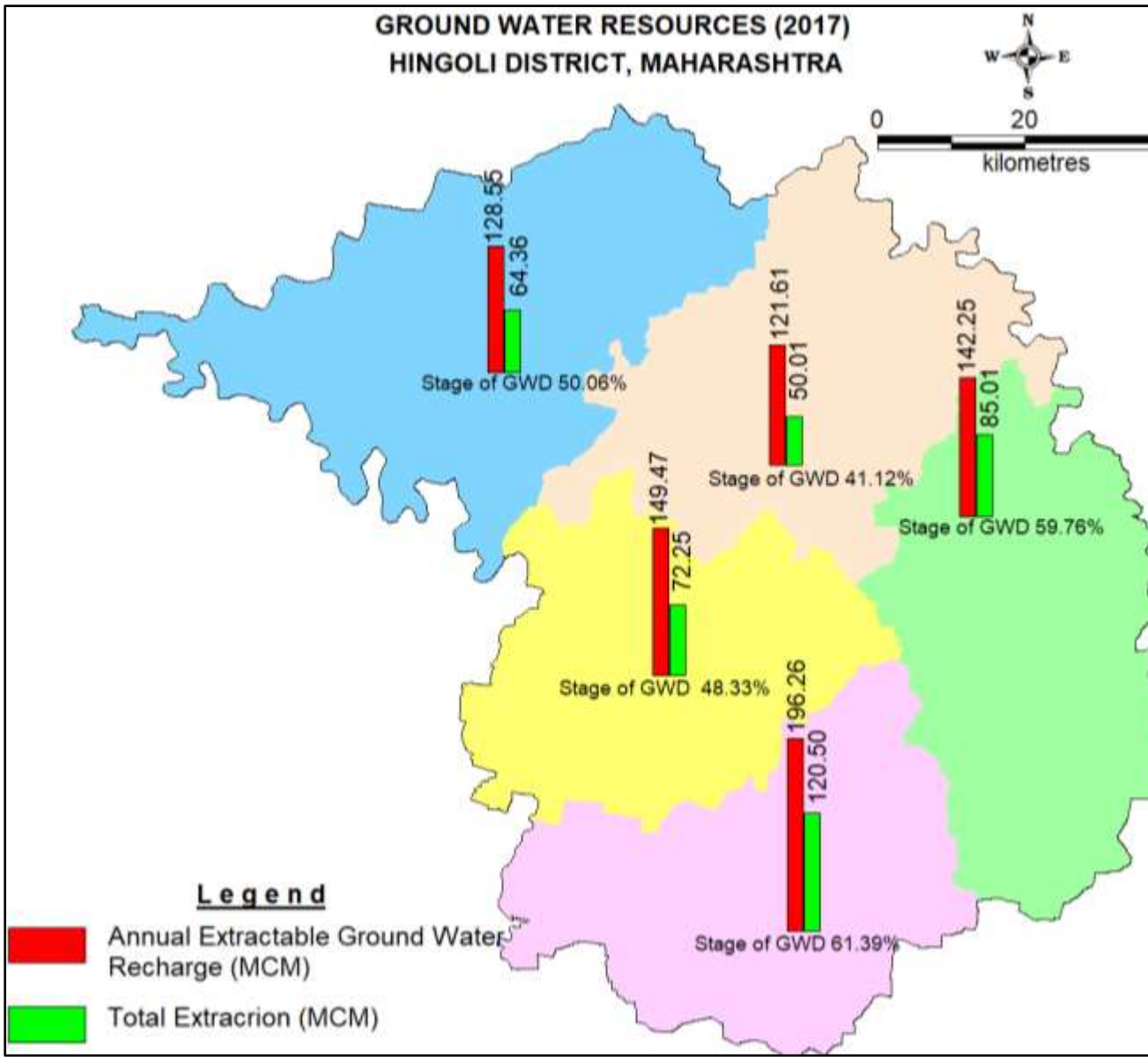
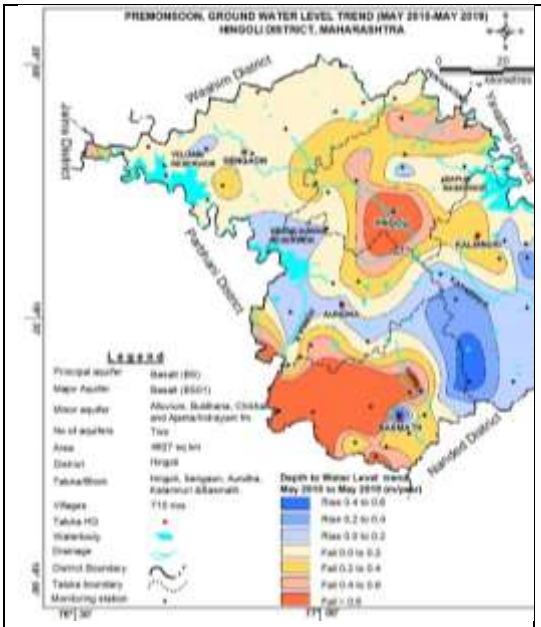


Figure 5.1: Ground Water Resources (2017), Hingoli district

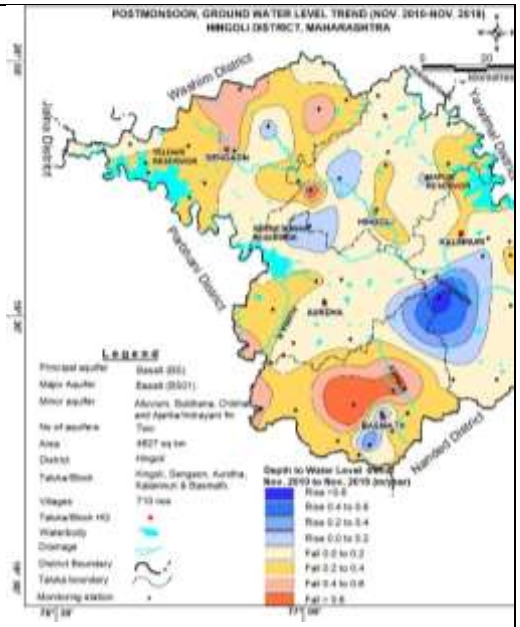
6. GROUND WATER RELATED ISSUES

6.1 Declining Water Level Trend

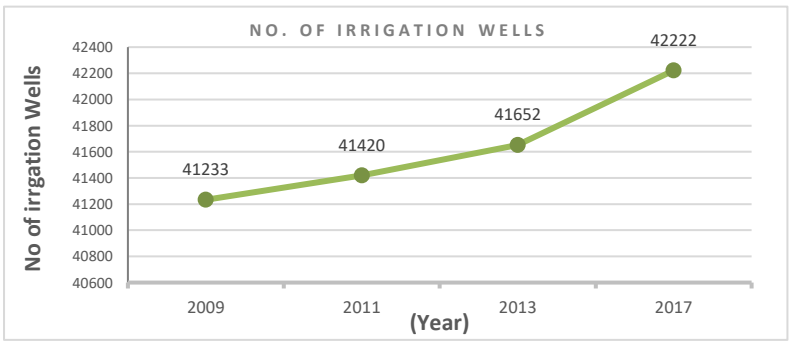
The ground water exploitation has resulted in decline of water levels over the period of time. In premonsoon season, decline of more than 0.20 m/year has been observed in 1839 sq. km., i.e., 39 % area covering major parts of Basmath and Hingoli blocks and parts of Kalmnuri, Aundha (Nagnath) and Sengaon blocks. In post monsoon season, decline of more than 0.20 m/year has been observed in 1961 sq. km., i.e., 41.48 % area covering in major parts of Basmath and Sengaon blocks and parts of Aundha (Nagnath), Hingoli and Kalmnuri blocks. The decline may be because the area has experienced increased irrigation draft and number of irrigation wells, in addition to this the district has received continuously less annual rainfall than the normal rainfall between the period from 2010-19.



Premonsoon Fall @>0.2/year in 1839 Sq. km.



Postmonsoon Fall@>0.2/year in 1961 Sq. km.



Ref: GWR-CGWB and GSDA

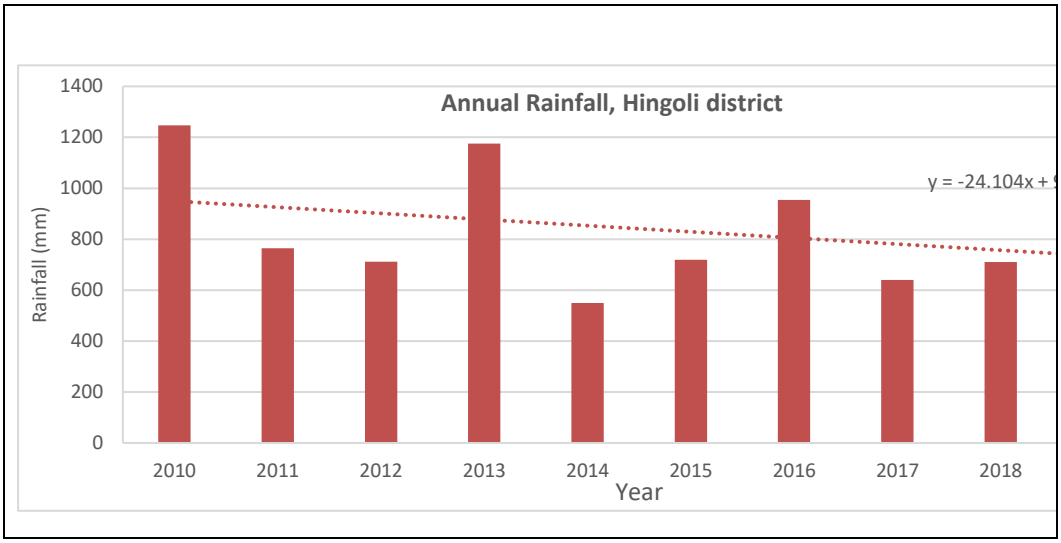


Figure 6.2: Issue- Declining Trends, Hingoli district

6.2 Rainfall and Droughts

Based on the rainfall analysis from 1998 to 2019 it is observed that, nine times moderate drought were faced by the Hingoli district. Based on the block wise rainfall analysis from 1998 to 2019 it is observed that Basmath, Hingoli and Sengaon blocks have experienced declining rainfall trend ranging from 5.75 to 11.26 mm/year. All the blocks experienced Moderate droughts 3 to 7 times during last 22 years period.

Table 6.1: Block wise Rainfall Analysis

Category	**Aundha (Nagnath) block**	**Basmath block**	**Hingoli block**	**Kalmnuri block**	**Sengaon block**
Period	1998-2019	1998-2019	1998-2019	1998-2019	1998-2019
No of Years	22	22	22	22	22
Normal Rainfall (mm)	911.5	1040.9	946.6	983.7	898.9
Standard Deviation (mm)	220	258	306	272	255
Coefficient of Variation (%)	26%	31%	33%	34%	31%
Rainfall Trend/Slope (mm/year)	1.257	-11.26	-5.75	1.131	-9.901
Departures (No. of years)					
Positive	11	10	11	10	8
Negative	11	12	11	12	14
Droughts					

Category	Aundha (Nagnath) block	Basmath block	Hingoli block	Kalmnuri block	Sengaon block
Moderate	3 times (2000, 2003,2008)	6 times (2000, 2007, 2008,2014, 2015,2017))	7 times (1999,2000, 2003, 2008 2014,2017, 2018)	7 times (1999, 2003,2008 ,2009,2011, 2014, 2017)	6 times (1999, 2003, 2008,2009, 2014,2018)
Severe	Nil	Nil	Nil	Nil	Nil
Acute	Nil	Nil	Nil	Nil	Nil
Normal & Excess R/F (% of years)					
Normal	59	50	45	45	46
Excess	27	23	23	23	27

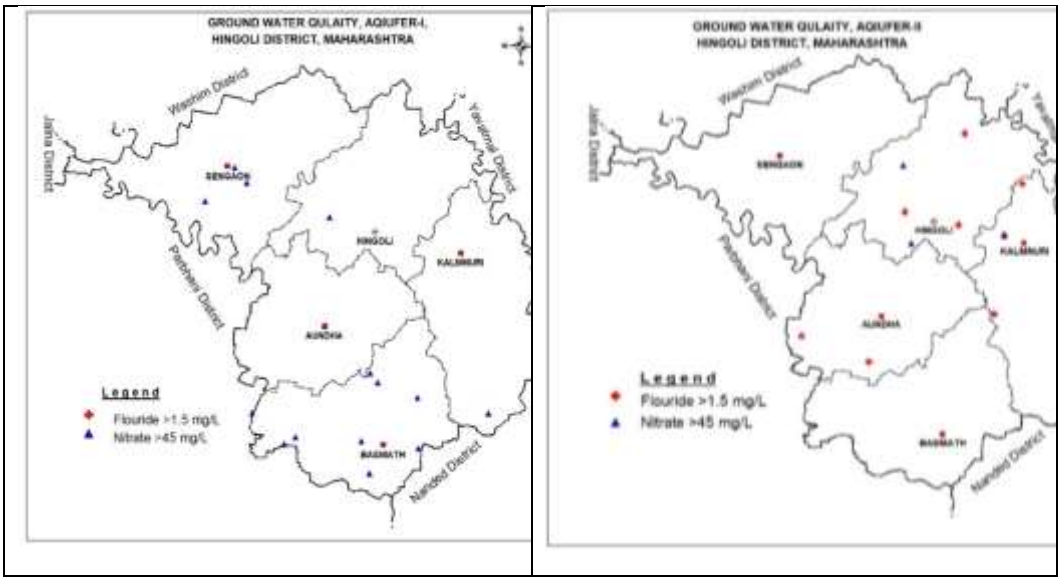
6.3 Ground Water Quality Hazard

Nitrate:

High nitrate (> 45 mg/l) is observed in 35% samples in shallow Aquifer. The major contribution to ground water is from sewage, waste disposal, nitrate fertilizer and decaying of organic matter. In shallow Aquifer nitrate concentration varies between 1.83 (Kalgaon, Hingoli block) to 150 mg/l (Basmath Shivar, Basmath block).

Fluoride:

In Deeper Aquifer, concentration of fluoride ranges from 0.04 to 10.7 mg/l. Out of 51 samples analysed, 10 samples show fluoride concentration more than 1.5 mg/l. In Deeper aquifer, the highest concentration of fluoride is found in Deulgaon Rama (10.7 mg/L) in Hingoli block; it may be due to the geogenic reasons.



Block	No of locations showing NO3 >45 mg/L	No of locations showing F >1.5 mg/L	Block	No of locations showing NO3 >45 mg/L	No of locations showing F >1.5 mg/L
Aundha (Nagnath)	1		Aundha (Nagnath)		2
Basmath	9	1	Basmath	1	1
Hingoli	1		Hingoli	2	3
Kalmnuri	1	1	Kalmnuri	2	4
Sengaon	2		Sengaon		
Grand Total	14	2	Grand Total	5	10

6.4 Sustainability

A major part of the district is occupied by basaltic rock formation that inherently consists of limited extent of porous and pervious zone; absence of primary porosity; predominance of secondary porosity that has evolved from prevailing erratic joint pattern, absence of primary porosity and also, low rainfall results in poor sustainability of the aquifers. However, the erratic nature of existing joints/fractures pattern results in highly varying yield capacities of the aquifers in the area. In the area depth of potential aquifers is generally restricted up to 30 m. The potential of the fracture zones reduces substantially below 100 m depth. About 50% of area of the district is having low yield potential (<1 lps). In the district alluvium occurs along the major drainage/ valley fills and has shallow thickness (up to 30 m) with limited extent and with yield potential varying from 90 to 120 m^3/day. However, moderate to high yield potential areas are found in southern part of district.

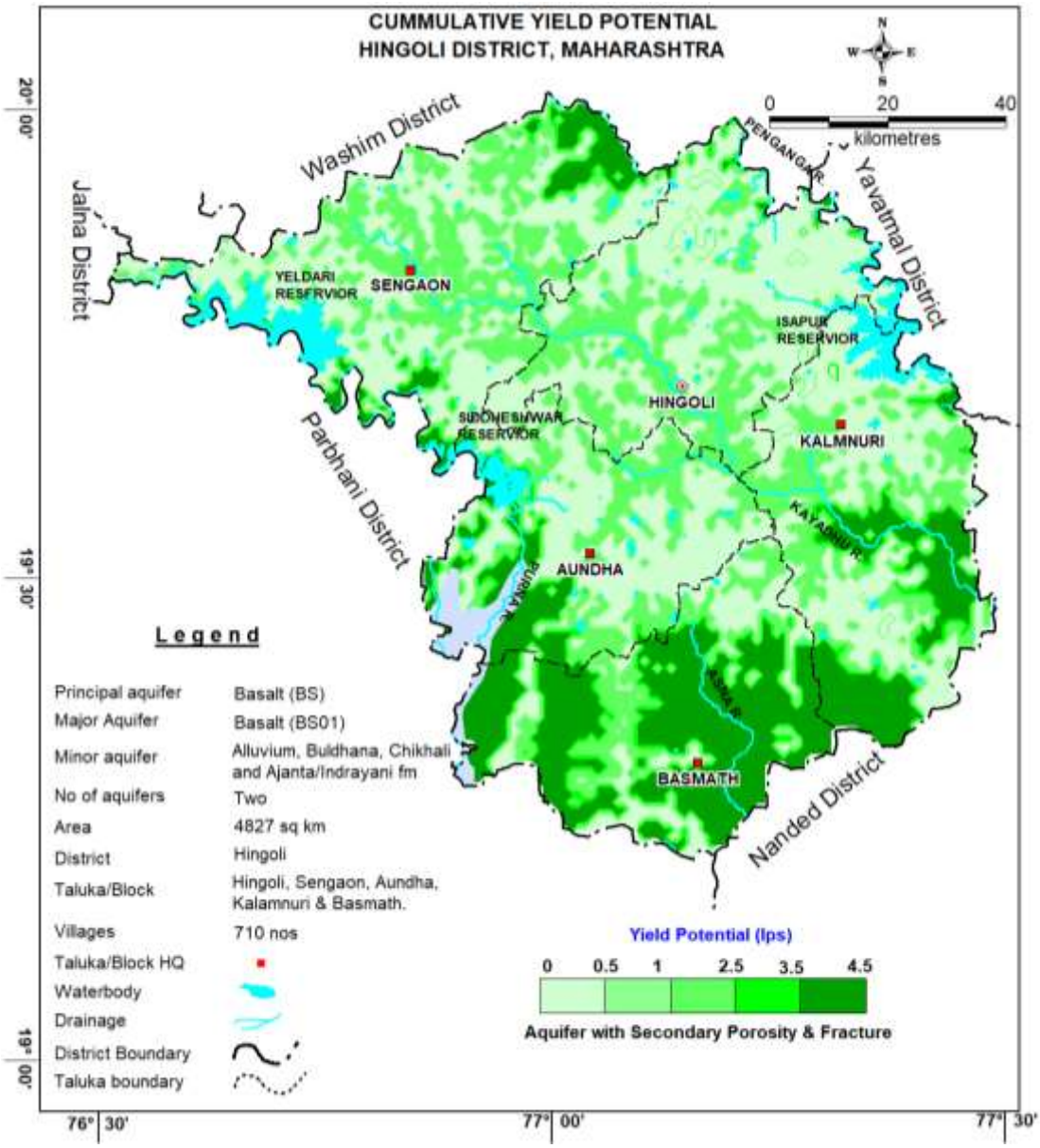


Figure 6.2: Cumulative Yield Potential

6.5 Ground Water Resources

Even though the district continues to be in safe category, the stage of ground water development has increased over the period of time from 2004 to 2017 from 23.99% (2004) to 53.13 % (2017)

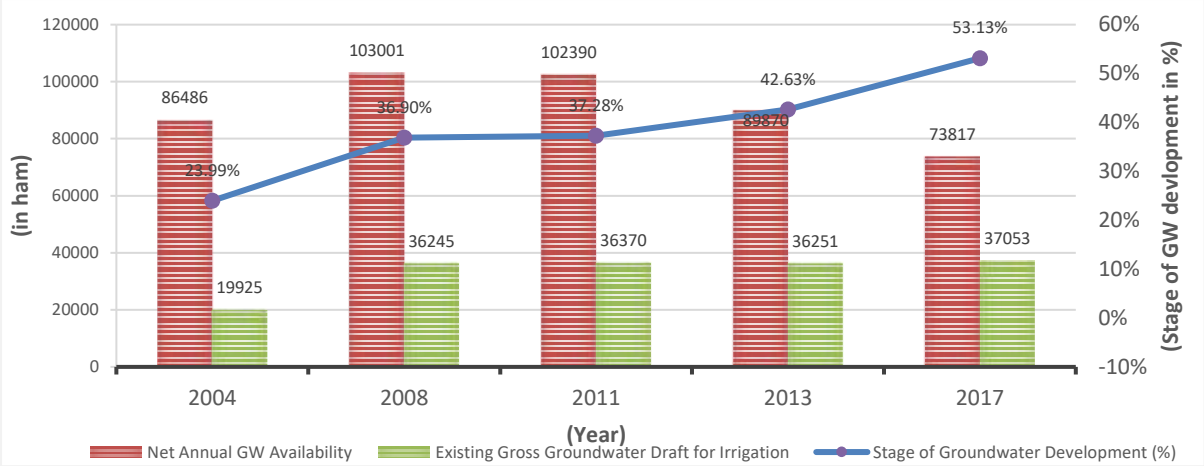


Figure 6.3: Draft Vs Availability Over the time

7. GROUND WATER MANAGEMENT PLAN

A comprehensive ground water resources management plan has been proposed to arrest further decline in water levels. The management plan comprises two components namely supply-side management and demand side management. The supply side management is proposed based on surplus surface water availability and the unsaturated thickness of aquifer whereas the demand side management is proposed by use of micro irrigation techniques and change in cropping pattern.

7.1 Supply Side Management

The supply side management of ground water resources can be done through the artificial recharge by utilization of surplus runoff available within river sub basins and micro watersheds. Also, it is necessary to understand the unsaturated aquifer volume available for recharge. The unsaturated volume of aquifer was computed based on the area feasible for recharge, unsaturated depth below 5 mbgl and the specific yield of the aquifer. The table 7.1 gives the block wise volume available for the recharge.

Table 7.1: Area feasible and volume available for Artificial Recharge

Block	Geographical Area (sq. km.)	Area feasible for recharge (sq. km.)	Unsaturated Volume (MCM)
Aundha (Nagnath)	924.20	128.17	256.34
Basmath	764.36	5.31	10.62
Hingoli	948.32	217.45	434.9
Kalmnuri	948.91	49.66	99.32
Sengaon	1241.21	124.20	248.4
Grand Total	4827.00	524.79	1049.58

The total unsaturated volume available for artificial recharge is 1049.58 MCM ranging from 10.62 MCM in Basmath block to 434.9 MCM in Sengaon block. The available surplus runoff can be utilized for artificial recharge through construction of percolation tanks and Check dams at suitable sites.

Only 11.74 MCM of surplus water is available for recharge. This surplus water can be utilized for constructing 41 percolation tanks and 121 check dams at suitable sites (Table 7.2). The number of feasible artificial recharge structures was calculated by considering recharge of 0.20 MCM per percolation tanks and 0.03 MCM per check dam. This intervention should lead to recharge of about 8.80 MCM/year considering a 75% efficiency. Tentative locations of these structures are given in **Figure 7.1** and details also given in **Annexures VIII and IX.**

The rainwater harvesting in urban areas can be adopted in 25% of the household with 50 m^2 roof area. A total of 1.93 MCM potential can be generated by taking 80% runoff coefficient. However, the recharge through household rainwater harvesting may not be economically viable.

Table 7.2: Proposed Artificial Recharge Structures

Block	Geographical Area (sq. km.)	Area feasible for recharge (sq. km.)	Unsaturated Volume (MCM)	Surplus water available for AR (MCM)	Proposed number of structures		Total recharged @ 75 % efficiency (MCM)
					PT	CD	
Aundha	924.20	128.17	256.34	2.87	10	29	2.15
Basmath	764.36	5.31	10.62	0.12	0	4	0.09
Hingoli	948.32	217.45	434.9	4.86	17	49	3.65
Kalmnuri	948.91	49.66	99.32	1.11	4	11	0.83
Sengaon	1241.21	124.20	248.4	2.78	10	28	2.09
Total	**4827.00**	**524.79**	**1049.58**	**11.74**	**41**	**121**	**8.80**

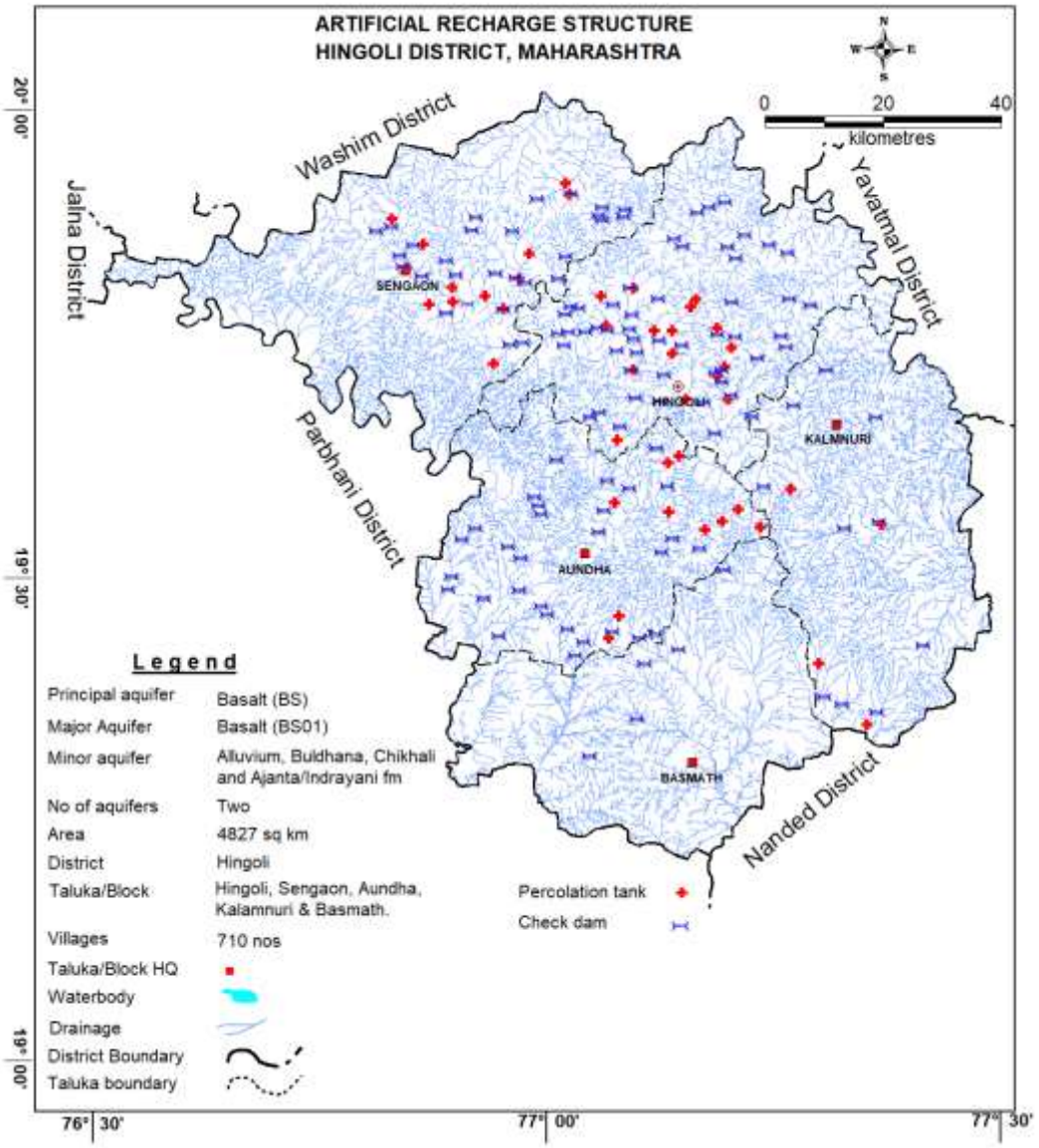


Figure 7.1: Location of Proposed Artificial Recharge Structures

7.2 Demand Side Management

The Demand Side Management is proposed in areas where the Stage of Ground Water Development is relatively high and adopting micro-irrigation techniques for water intensive crops (Sugarcane/Cotton/Banana) or change in cropping pattern or both are required to save water.

It is proposed to cover about 17.14 sq. km area under sugarcane cultivation in Hingoli, Kalamnri and Sengaon talukas under drip irrigation. this would save about 9.77 MCM of water per year. Similarly, about 13.0 sq. km of area under cotton crop can be brought under drip irrigation, which may lead to saving of about 3.38 MCM per year. Thus, the total saving of water due to demand side intervention would be about 13.15 MCM/Year (Table 7.3). Change in cropping patterns is not proposed in any of the blocks. **Fig 7.2** depicts the proposed demand side interventions.

Table 7.3: Area proposed for Micro irrigation Techniques and water saving through Demand side interventions.

Taluka	Sugarcane Area proposed to be covered under drip (sq.km)	Cotton Area proposed to be covered under drip (sq.km)	Sugarcane - Volume of Water expected to be saved with drip irrigation @.57m (MCM)	Cotton - Volume of Water expected to be saved with drip irrigation @0.26m (MCM)	Total Volume of water expected to be saved (MCM)
Aundha (Nagnath)	0.00	1.00	0.00	0.26	0.26
Basmath	0.00	12.00	-	3.12	3.12
Hingoli	0.08	-	0.05	0.00	0.05
Kalamnuri	16.95	-	9.66	0.00	9.66
Sengaon	0.11	-	0.06	0.00	0.06
TOTAL	**17.14**	**13.00**	**9.77**	**3.38**	**13.15**

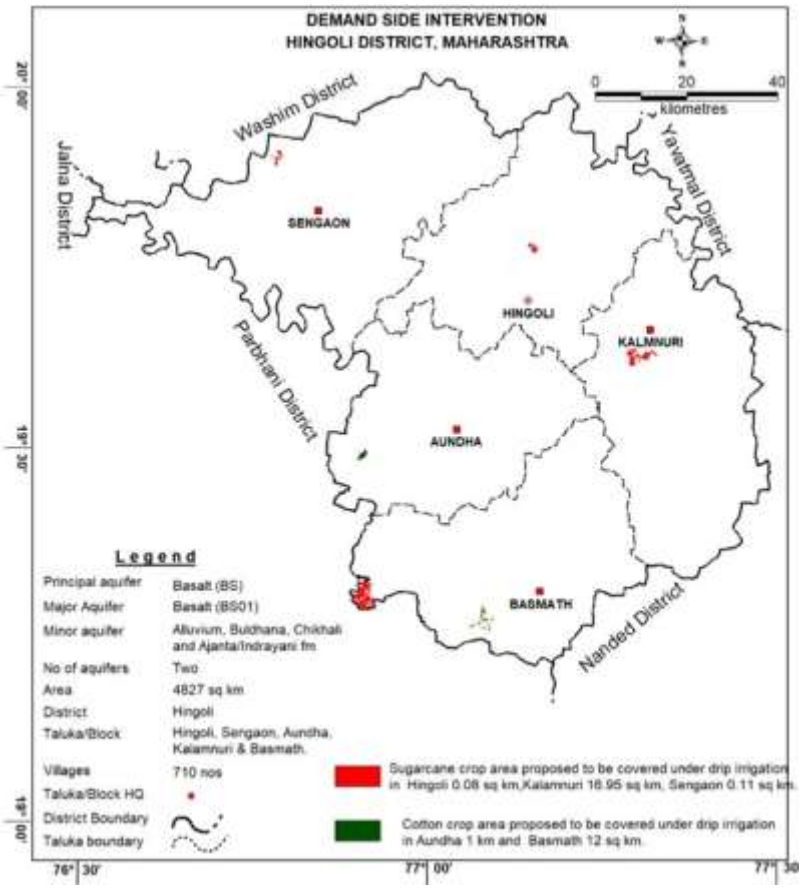


Figure 7.2: Demand Side Intervention

7.3 Expected Benefits

The impact of implementation of groundwater management plans on the groundwater system in the district is evaluated and the outcome shows significant improvement in groundwater scenario in all blocks (Table 7.4). The Stage of ground water development gets reduced and comes below 70%.

Table 7.4: Expected benefits after management options

Block	Annual Available Resource (MCM)	Total volume of water expected to be recharged/ conserved by Supply Side Intervention (MCM)	Total GW resource available after supply side interventions (MCM)	Gross Annual Draft (MCM)	Total volume of water expected to be saved due to Demand Side Interventions (MCM)	Total GW Draft after Demand side measures (MCM)	Stage of GWD after Supply and demand side interventions (%)
Aundha (Nagnath)	149.48	2.15	151.63	72.25	0.26	71.99	47.48
Basmath	196.27	0.09	196.36	120.50	3.12	117.38	59.78
Hingoli	121.61	3.63	125.24	50.02	0.05	49.97	39.90
Kalamnuri	142.26	0.83	143.09	85.02	9.66	75.36	52.67

Block	Annual Available Resource (MCM)	Total volume of water expected to be recharged/ conserved by Supply Side Intervention (MCM)	Total GW resource available after supply side interventions (MCM)	Gross Annual Draft (MCM)	Total volume of water expected to be saved due to Demand Side Interventions (MCM)	Total GW Draft after Demand side measures (MCM)	Stage of GWD after Supply and demand side interventions (%)
Sengaon	128.55	2.1	130.64	64.36	0.06	64.3	49.22
TOTAL	**738.17**	**8.8**	**746.98**	**392.15**	**13.15**	**379**	**50.74**

7.4 Development Plan

The ground water development plan has been proposed with the view of developing the additional ground water resources available after supply side interventions to bring the stage of ground water development up to 70%. The 143.87 MCM of ground water generated can bring additional 221.34 sq. km. Kharif Crop area under assured ground water irrigation with average crop water requirement of 0.65 m by constructing 8632 Dug wells and 1439 Bore wells. Block wise details are given in Table 7.5. The area feasible for ground development is shown in Figure 7.3.

Table 7.5: Block wise additional area under assured GW Irrigation.

Block	Balance GWR available for GW Development after STAGE OF GWD is brought to 70% (MCM)	Proposed No. of DW @1.5 ham for 90% of GWR Available)	Proposed No. of BW @1 ham for 10% of GWR Available)	Additional Area (sq.km.) proposed to be brought under assured GW irrigation with av. CWR of 0.65 m after 70% stage of GWD is achieved (Sq. km.)
Aundha (Nagnath)	34.15	2049	342	52.54
Basmath	20.07	1204	201	30.88
Hingoli	37.70	2262	377	58.00
Kalmnuri	24.80	1488	248	38.16
Sengaon	27.15	1629	271	41.77
Total	**143.87**	**8632**	**1439**	**221.34**

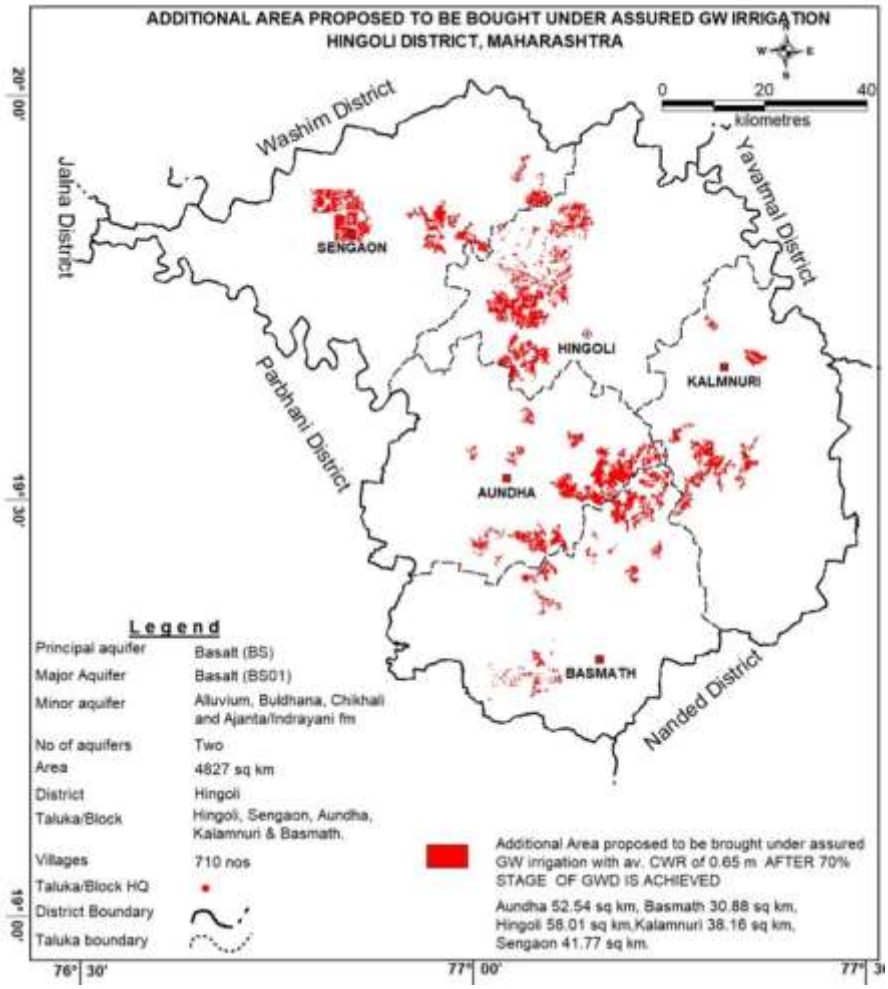


Figure 7.3: Additional area Proposed to be bought under Assured GW irrigation

8. SUM UP

The study was carried out based on the data available in-house as well as acquired from State Govt. departments and in pursuit to fill up the data gaps, generated data in-house, prepared GIS maps for various themes. All the available data was brought on GIS platform and an integrated approach was adopted for preparation of block wise aquifer maps and aquifer management plans of the district.

Hingoli district covering an area of about 4827 sq. km. with 164.69 sq. km. being hilly terrain is occupied by Basalt formation. The stage of ground water development of the district is 53.13%. The area has witnessed declining water level, low rainfall and drought; low yield potential of aquifers and Ground Water Quality hazards (No_3 and F) are the major issues in the district. Declining water level trend of more than 0.20 m/year has been observed in 1839 sq. km. (39% area of the total area) during pre-monsoon period (2010-19). Declining water level trend of more than 0.20 m/year has been observed in 1961 sq.km (41.48% area of the total area) during post monsoon period (2010-19). These declines may be due to less rainfall or exploitation of ground water resources more than the annual recharge in these areas.

The management plan has been proposed to manage the ground water resources and to arrest further decline in water levels. The management plan comprises two components namely supply-side management and demand side management.

About 11.74 MCM of surplus water is available for recharge. This surplus water can be utilized for constructing additional percolation tanks and check dams.

As a part of Supply side management, 41 percolation tanks and 121 check dams can be constructed at suitable sites utilizing 1174 MCM water available for recharg41 percolation tanks and 121 check dams at suitable sites. This may lead to additional recharge of about 8.80 MCM at 70% efficiency.

As a part of Demand side Management, it is proposed to bring about 17.14 sq. km area under sugarcane cultivation in Hingoli, Kalamnri and Sengaon talukas under drip irrigation. this would save about 9.77 MCM of water per year. Similarly, about 13.0 sq. km of area under cotton crop can be brought under drip irrigation, which may lead to saving of about 3.88 MCM per year. Thus, there would be saving of about 13.15 MCM of ground water.

The ground water development plan has been proposed with the view of developing the additional ground water resources available after supply side interventions to bring the stage of ground water development up to 70%. The 143.87 MCM of ground water generated can bring additional 221.34 sq. km. Kharif Crop area under assured ground water irrigation with average crop water requirement of 0.65 m by constructing 8632 Dug wells and 1439 Bore wells

IEC activities and capacity building activities needs to be aggressively propagated to establish the institutional framework for participatory ground water management. These types of programmes have helped the general public

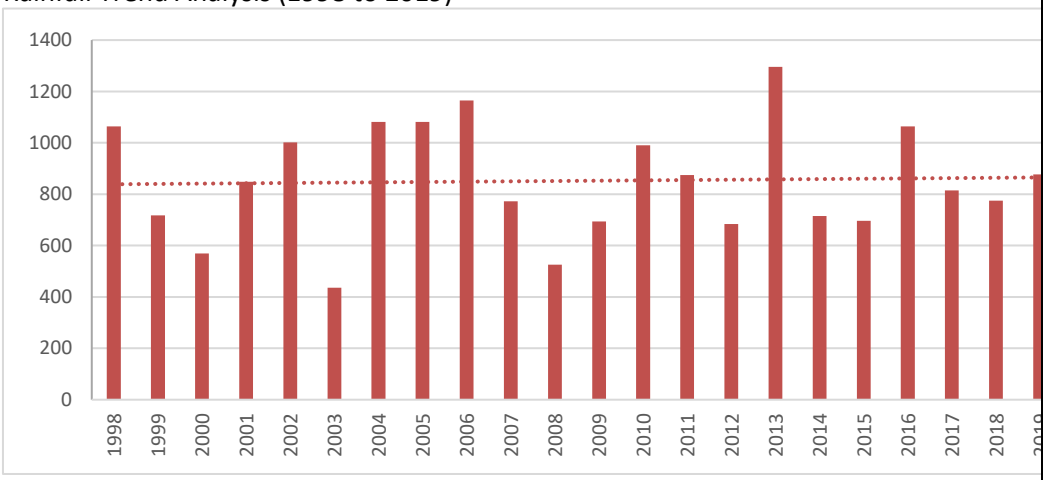
to understand the problems, that they will face in future if the ground water is continued to be exploited in unplanned way and also sewage wastes is not properly managed resulting in ground water pollution.

These interventions also need to be supported by regulations for deeper aquifer and hence it is recommended to regulate/ban deeper tube wells/bore wells of more than 60 m depth in these blocks, so that the deeper ground water resources are protected for future generation and serve as ground water sanctuary in times of distress/drought.

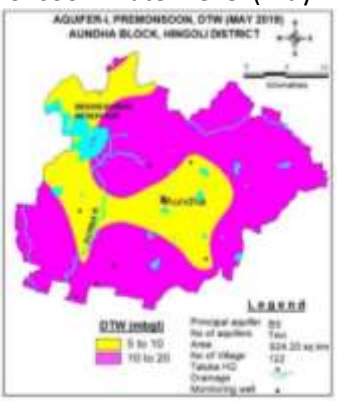
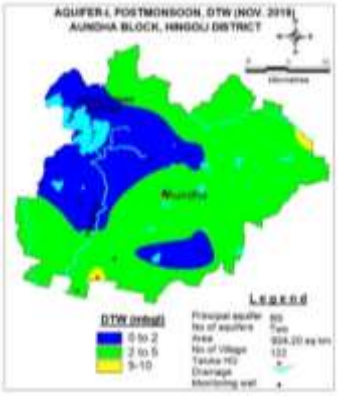
9. BLOCK WISE AQUIFER MAPS AND MANAGEMENT PLAN

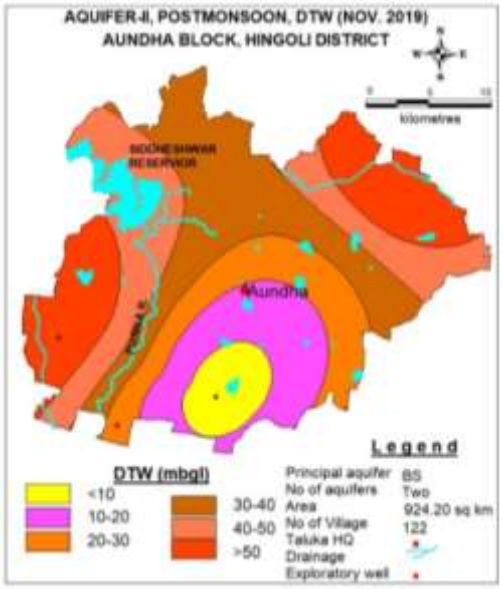
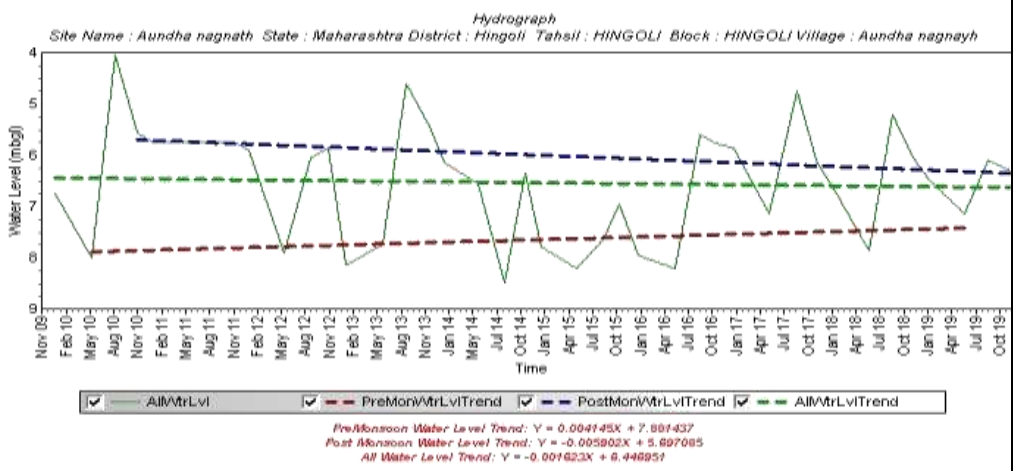
1. AUNDHA (NAGNATH) BLOCK
2. BASMATH BLOCK
3. HINGOLI BLOCK
4. KALMNURI BLOCK
5. SENGAON BLOCK

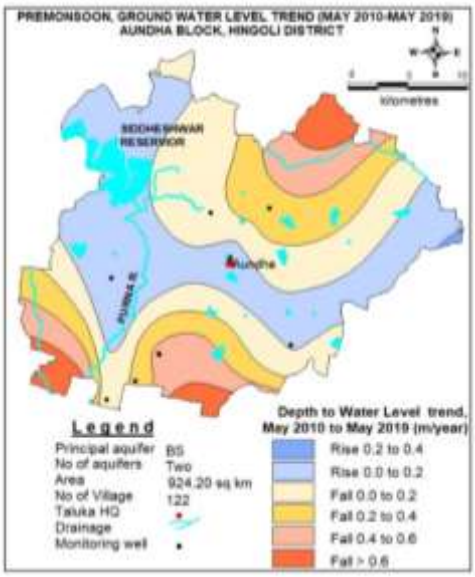
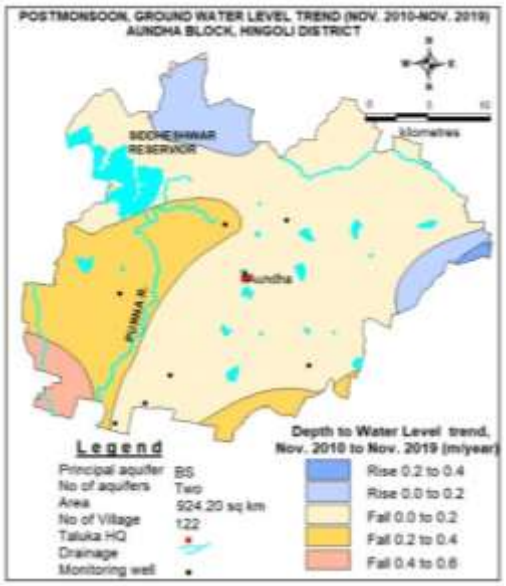
9.1 AUNDHA (NAGNATH) BLOCK

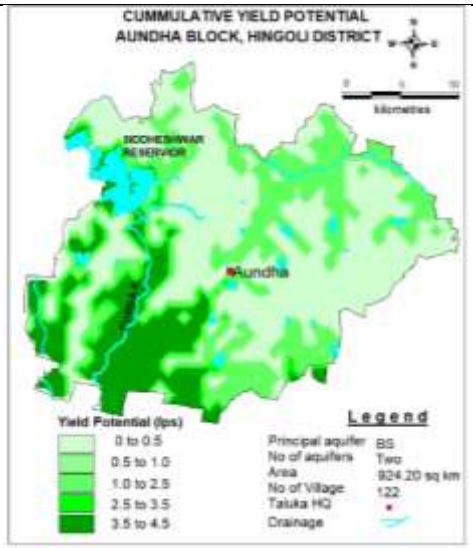
1. SALIENT FEATURES		
1.1 Introduction		
Block Name	AUNDHA (NAGNATH)	
Geographical Area (Sq. km.)	924.20 Sq. km.	
Hilly Area (Sq. km.)	104.59 Sq. km.	
Poor Ground Quality Area (Sq. km.)	Nil	
Population (2011)	1,81,148	
Climate	Sub-Tropical	
1.2 Rainfall Analysis		
Normal Rainfall	911.5 mm	
Annual Rainfall (2019)	877.5 mm	
Decadal Average Annual Rainfall (2010-19)	878.8 mm	
Long Term Rainfall Analysis (1998-2019)	Rising Trend 1.25 mm/year Probability of Normal and Excess Rainfall- 59% & 27%. Probability of Drought-: 14 % Moderate	
Rainfall Trend Analysis (1998 to 2019)		
EQUATION OF TREND LINE: Y = *1.2572x + 837.54*		
1.3. Geomorphology, Soil & Geology		
Geomorphic Unit	Plateau (Slightly to Moderately dissected) and Plateau weathered with 1-5 m weathered thickness	
Soil	Clayey soil (Shallow to Very deep 10 to >100 cm depth), Clay loamy, Sandy clay loam and Gravelly clay Soil	
Geology	Alluvium (Purna Alluvium) Age: Recent to Sub Recent Deccan Traps (Basalt) Age: Late Cretaceous to Eocene	
1.4. Hydrology & Drainage		
Drainage	Purna and Kayadhu Rivers; tributary of Godavari river	
Hydrology *(Reference year: June 2018*	Major project	Completed: 01; Purna Project generating a gross irrigation Potential of 2630 ha in Aundha (Nagnath) block, Gross Storage Capacity of 1185 MCM (including Aundha,

(wrd.maharashtra.gov.in)		Basmath and Kalmnuri blocks) and Live Storage Capacity of 891 MCM (including Aundha, Basmath and Kalmnuri blocks) Ongoing: Nil
	Medium project	Completed: Nil Ongoing: Nil
	Minor Irrigation Project (>250 Ha)	Completed: 09; Minor projects generating a gross irrigation potential of 3892 ha. Ongoing: Nil
	Irrigation Project (<250 Ha)	Completed: 12; Through minor irrigation project and KT weirs generating a gross irrigation Potential of 331 ha. Ongoing: Nil

1.5. Land Use, Agriculture, Irrigation & Cropping Pattern			
Geographical Area		924.20 Sq. km.	
Forest Area		54.32 Sq. km.	
Cultivable Area		744.44. km.	
Net Sown Area		652.60 Sq. km.	
Double Cropped Area		33.54 Sq. km.	
Area under Irrigation	Surface Water	23.00 Sq. km.	
	Ground Water	8.00 Sq. km.	
Principal Crops *(Reference year 2018)*		Crop Type	Area (Sq. km.)
		Oil Seeds	326.07
		Pulses	206.46
		Cereals	89.08
		Cotton	77.70
Horticultural Crops		Citrus fruits	1.80
		Mango	1.50
		Banana	0.90
		Others	0.65
1.6. Water Level Behaviour			
1.6.1. Aquifer-I/Shallow Aquifer			
Pre-Monsoon Water Level (May 2018)  WL> 10 mbgl 554.20 sq. km.		Post-Monsoon Water Level (Nov. 2019)  WL>5 mbgl 314.60 sq. km.	

Pre-Monsoon (May-2019)	Post-Monsoon (November-2019)
Water levels less than 10 mbgl are observed in north western and central part of the block whereas water levels in the range of 10 to 20 mbgl are observed almost over the entire block covering 554.20 sq. km. area of the block.	Water levels less than 2 mbgl are observed in western part and isolated patch in southern of the block; water levels in the range of 2 to 5 mbgl are observed in major part of the block whereas water level more than 5 mbgl is observed as isolated patches in southern and eastern peripheral parts of block covering about 7 sq. km. area of the block.
1.6.2. Aquifer-I/Deeper Aquifer	
Post-Monsoon Water Level (Nov. 2019) Water level <20 mbgl is observed in small part in southern part of the block. Water level between 20-30 mbgl is observed as southern half of the block; more than 30 mbgl has been observed in major part of the block western, northern and eastern parts of the block and cover about 544.03 sq. km. area of the block.	
1.7. Hydrographs: 	
Hydrograph shows Pre-monsoon rising water level trend @0.049 m/year and Post monsoon falling water level trend @0.070 m/year	
1.8. Water Level Trend (2010-19)	
Pre-Monsoon trend Rising 0.0048 to 0.1666 m/year Falling 0.1169 to 0.4523 m/year	Post-Monsoon trend Falling 0.0712 to 0.2454 m/year
Pre-Monsoon Water Level Trend (2010-19)	Post-Monsoon Water Level Trend (2010-19)

 Declining trend @>0.2 m/year 269.10 sq. km.	 Declining trend @>0.2 m/year 203 sq. km.
Major part of the block shows declining trend while rising trend up to 0.2 m/year has been observed as continuous patch from east to west in the block. Declining water level trend >0.2 m/year has been observed in north eastern, eastern and southern parts of the block covering about 269.10 sq. km. (32.85%) area of the block.	Major part of the block shows declining trend up to 0.2 m/year while rising trend up to 0.2 m/year has been observed in northern part of the block. Declining trend > 0.2 m/year has been observed in the southern and western parts of the block covering about 203 sq.km. (25%) area.
2. Ground Water Issues	
Declining water level Trend: - Premonsoon (2010-19), decline in water level trend more than 0.2 m/year is observed in about 269.10 sq. km. covering about 33 % area of the block. Postmonsoon (2010-19), decline in water level trend more than 0.2 m/year is observed in about 203 sq. km. covering about 25% area of the block. Low yielding Aquifer resulting poor sustainability: - Limited extent of porous and pervious zone because of predominance of secondary porosity that has evolved from prevailing erratic joint pattern and also absence of primary porosity results in poor sustainability of the aquifers. About 51 % area of the block has low yield potential (< 1 lps) and can sustain pumping only for 1 to 1.5 hrs.	

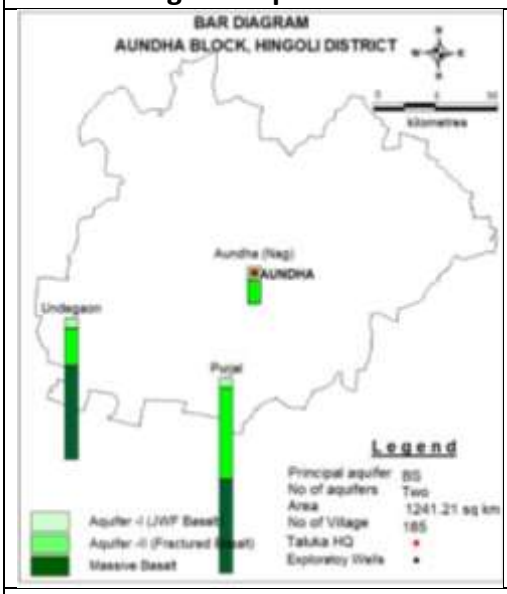


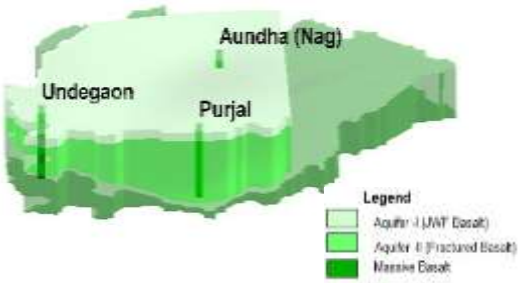
Ground Water Quality:
Fluoride contamination: In deeper aquifer Fluoride contamination is found in Purjal (F=4.0) and Undegaon (F=3.4) villages.

3. AQUIFER DISPOSITION

3.1. Number of Aquifers	**Basalt –Aquifer-I, Aquifer-II**

3.2. Lithological disposition





3.3. Cross Section

Section AA’

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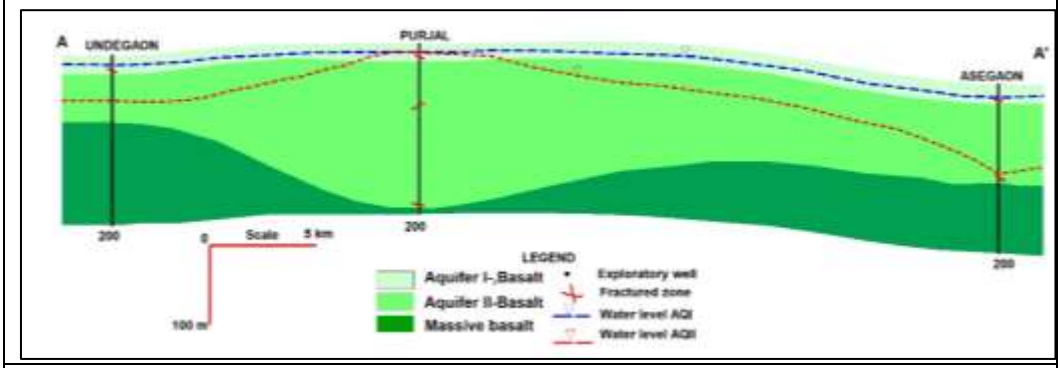
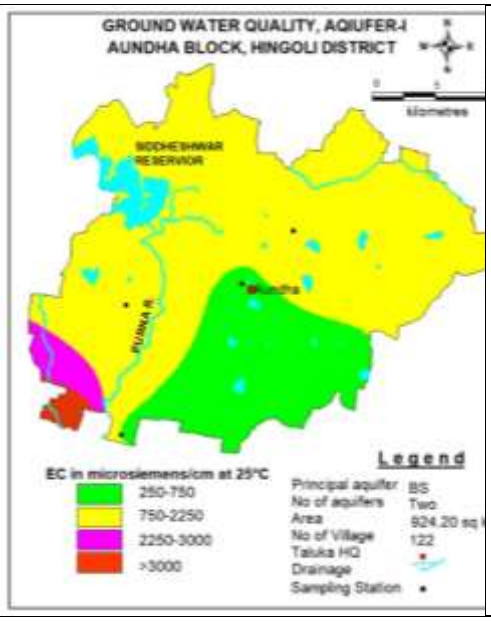
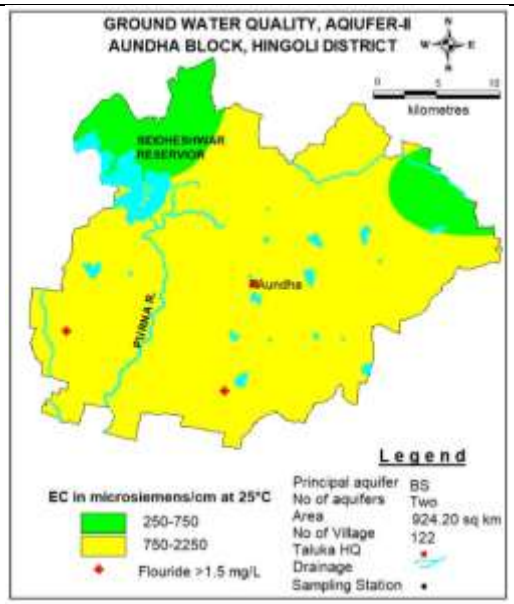


3.4. Basic Aquifer Characteristics		
Major Aquifers	Basalt (Deccan Traps)	
Type of Aquifer (Phreatic/Semi confined/Confined)	Aquifer-I (Phreatic)	Aquifer-II (Semi confined/confined)
Depth to bottom of Aquifer (mbgl)	8.5 to 18	65 to 196
Zones/Fractures encountered (mbgl)	up to 18	up to 196
Granular/Weathered/Fractured rocks thickness (m)	8 to 14	1 to 7
SWL (mbgl)	1 to 13.7	6.53 to 55.5
Specific yield/ Storativity (S)	0.019 to 0.028	*0.00003 -0.00005
Transmissivity (T)	*30 - 50 m^2/day	0.51 to 15.17 m^2/day
Yield	up to 200 m^3/day	up to 2.5 lps
Sustainability	2 to 5 hrs	1 to 3 hrs
Suitability for drinking/ irrigation	Suitable for both (except Nitrate affected village for drinking)	Suitable for both (except fluoride affected villages for drinking)
* values taken from Risod block, Washim District.		
4. GROUND WATER QUALITY		
4.1 Aquifer-I/ Shallow Aquifer		
EC up to 750 µS/cm is observed in northern and north western part of the block; EC value between 750 to 2250 µS/cm is observed in major part of the block whereas EC more than 2250 µS/cm has been observed in southwestern parts of the block. Ground water is suitable for all purposes in major part of the block except 9 villages that are affected by Nitrate contamination and village Sawangi Bk. (F=1.6 mg/L) which is affected by Fluoride contamination.		
4.2 Aquifer II/Deeper Aquifer		
EC up to 2250 µS/cm is observed in entire block Ground water is suitable for all purposes.		
Phreatic Aquifer (Aquifer-I)	Semi confined/Confined Aquifer (Aquifer II)	





5. GROUND WATER RESOURCE	
5.1 Aquifer-I/ Shallow Aquifer	
Ground Water Recharge Worthy Area (Sq. km.)	819.61
Total Annual Ground Water Recharge (MCM)	157.87
Natural Discharge (MCM)	8.39
Net Annual Ground Water Availability (MCM)	149.47
Existing Gross Ground Water Draft for irrigation (MCM)	65.73
Existing Gross Ground Water Draft for domestic and industrial water supply (MCM)	6.52
Existing Gross Ground Water Draft for All uses (MCM)	72.25
Provision for domestic and industrial requirement supply to 2025 (MCM)	14.68
Net Ground Water Availability for future irrigation development (MCM)	68.54
Stage of Ground Water Development (%)	48.34
Category	SAFE

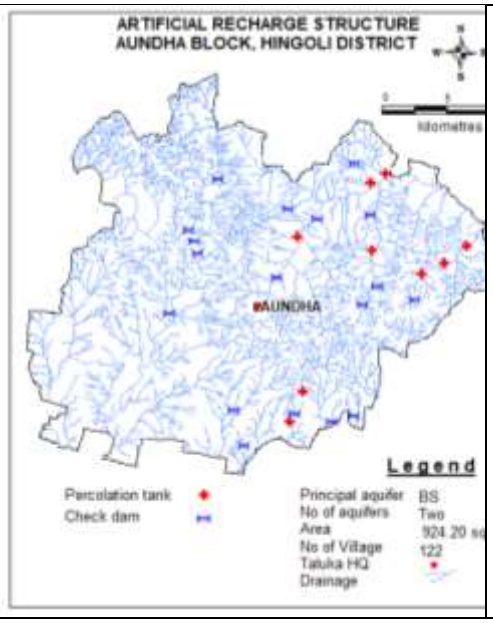
5.2 Aquifer-II/Deeper Aquifer

Semi confined/Confined Aquifer (Basalt)

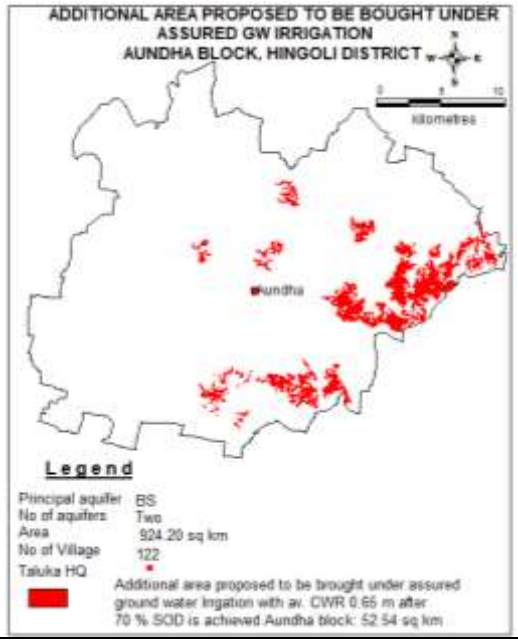
Total Area (Sq. km.)	Mean aquifer thickness (m)	Av. Sy/Storativity	Av Piezometric Head (m)	Resources above confining layer (MCM)	Resource within confining Aquifer (MCM)
924.2	3.75	0.002/0.0000145	76	1.018	6.93

6.0. GROUND WATER RESOURCE MANAGEMENT		
Available Resource (MCM)	149.47	
Gross Annual Draft (MCM)	72.25	
6.1. Supply Side Management		
SUPPLY (MCM)		
Agricultural Supply -GW	65.73	
Agricultural Supply -SW	14.95	
Domestic Supply - GW	6.52	
Domestic Supply - SW	1.63	
Total Supply	88.83	
Area of Block (Sq. km.)	924.2	
Area suitable for Artificial recharge (Sq. km.)	128.17	
Type of Formation	Hard Rock	Soft Rock
Area feasible for Artificial Recharge (WL >5mbgl) (Sq. km.)	128.17	-
Volume of Unsaturated Zone (MCM)	256.34	-
Average Specific Yield	0.02	-
Volume of Sub Surface Storage Space available for Artificial Recharge (MCM)	5.13	-
Surplus water Available (MCM)	2.87	
Proposed Structures	Percolation Tank (Av. Gross Capacity-100 TCM*2 fillings = 200 TCM)	Check Dam (Av. Gross Capacity-10 TCM * 3 fillings = 30 TCM)
Number of Structures	10	29
Volume of Water expected to be conserved / recharged @ 75% efficiency (MCM)	2.15	
Proposed Structures		
RTRWH Structures – Urban Areas		
Households to be covered (25% with 50 m^2area)	35,075	
Total RWH potential (MCM)	1.4889	
Rainwater harvested / recharged @ 80% runoff co-efficient	1.911 Economically not viable & Not Recommended	
6.2. Demand Side Management		
Micro irrigation techniques		
Cotton area proposed for drip irrigation (sq. km.)	1	
Volume of Water Saving by use of drip (MCM), Surface Flooding req- 0.815 m. Drip Req. – 0.55, WUE- 0.26 m	0.26	
Proposed Cropping Pattern change		
Irrigated area under Water Intensive Crop (ha)	Not proposed	
Water Saving by Change in Cropping Pattern	Nil	

Alternate Sources	Nil
6.3. EXPECTED BENEFITS	
Net Ground Water Availability (MCM)	149.48
Additional GW resources available after Supply side interventions (MCM)	2.15
Ground Water Availability after Supply side intervention	151.63
Existing Ground Water Draft for All Uses (MCM)	72.25
GW draft after Demand Side Interventions (MCM)	71.99
Present stage of Ground Water Development (%)	48.34
Expected Stage of Ground Water Development after interventions (%)	47.48
Other Interventions Proposed, if any	
Alternate Water Sources Available	Nil
Recommendation	
Ground water development is recommended to bring the stage of ground water development from 47.61% to 70%	
6.4. DEVELOPMENT PLAN	
Volume of water available for GWD to 70% (MCM)	34.15
Proposed Number of DW (@ 1.5 ham for 90% of GWR Available for development)	2049
Proposed Number of BW (@ 1 ham for 10% of GWR Available for development)	342
Additional Area to be brought under assured GW irrigation with av. CWR of 0.65 m (sq. km.)	52.54
Regulatory Measures	60 m
Supply Side Interventions	Demand Side Interventions
Proposed locations for AR structures	Cotton Crop Area proposed for drip Irrigation



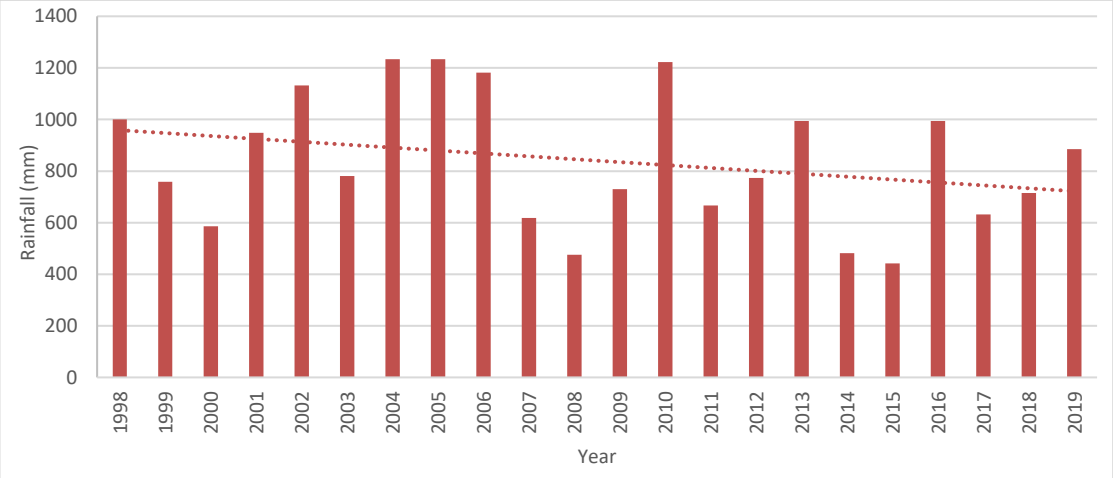
Expected Benefits: ADDITIONAL AREA PROPOSED TO BE BOUGHT UNDER ASSURED GW IRRIGATION



9.2 BASMATH BLOCK

1. SALIENT FEATURES	
1.1 Introduction	
Block Name	**BASMATH**
Geographical Area (Sq. km.)	764.36 Sq. km.
Hilly Area (Sq. km.)	Nil
Poor Ground Quality Area (Sq. km.)	Nil
Population (2011)	2,90,970
Climate	Sub-Tropical
1.2 Rainfall Analysis	
Normal Rainfall	1040.9 mm
Annual Rainfall (2019)	884.6 mm
Decadal Average Annual Rainfall (2010-19)	780.63 mm
Long Term Rainfall Analysis (1998-2019)	Declining Trend 11.26 mm/year. Probability of Normal and Excess Rainfall: - 50% & 23%. Probability of Drought: 27% Moderate Drought

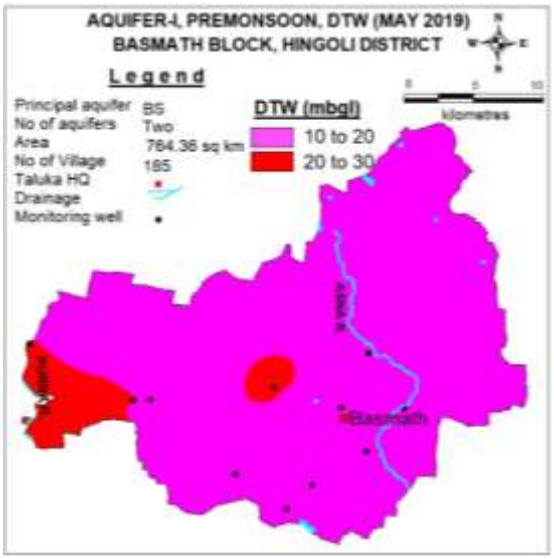
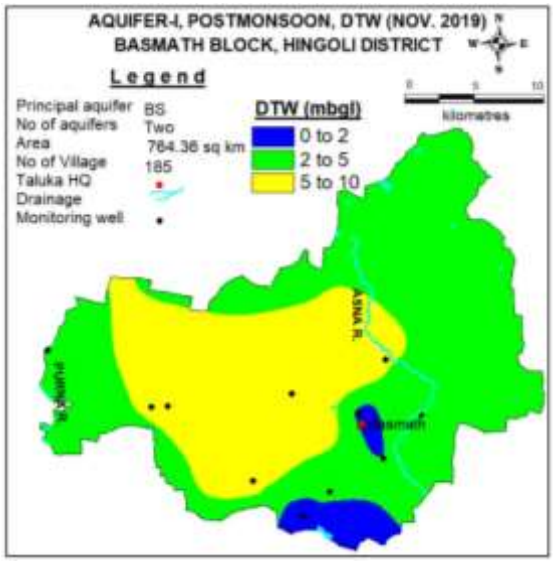
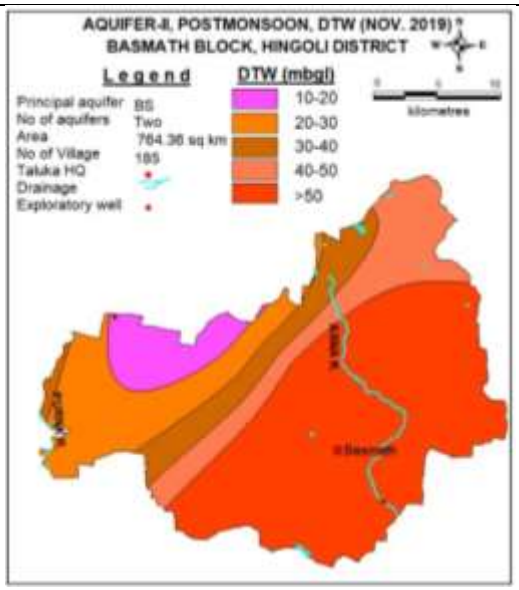
Rainfall Trend Analysis (1998 to 2019)

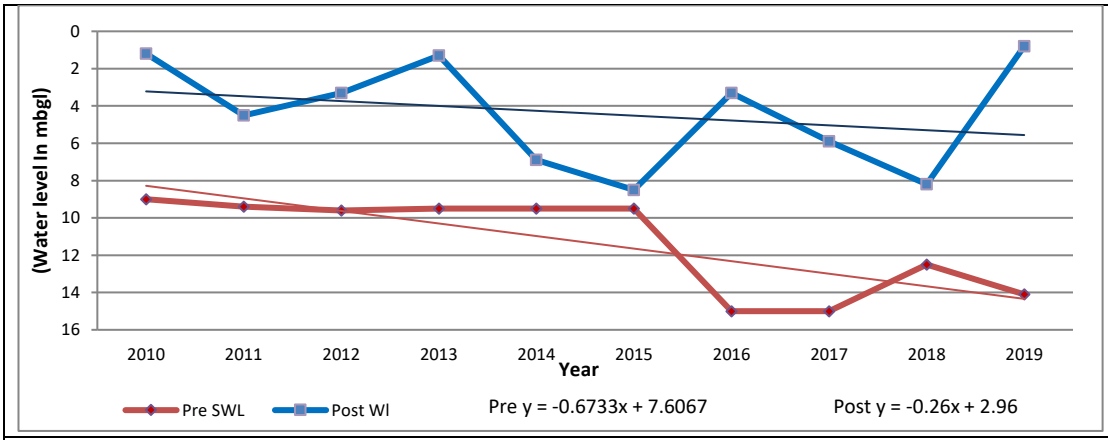


EQUATION OF TREND LINE: Y = -11.264x + 969.8

1.3. Geomorphology, Soil & Geology	
Geomorphic Unit	Plateau Weathered-Canal Command (PLC), Plateau weathered with 1 to 2 m weathered thickness, Plateau Undissected & Slightly Dissected 0 to 1 m weathered thickness and, Plateau Moderately Dissected (PLM)
Soil	Clayey soil (shallow to very deep; 10 to >100 cm depth), Gravelly clay, Gravelly clay loam, Gravelly sandy loam, Clay loam, Sandy clay loam soils.
Geology	Alluvium (Purna Alluvium) Age: Recent to Sub Recent Deccan Traps (Basalt) Age: Late Cretaceous to Eocene
1.4. Hydrology & Drainage	

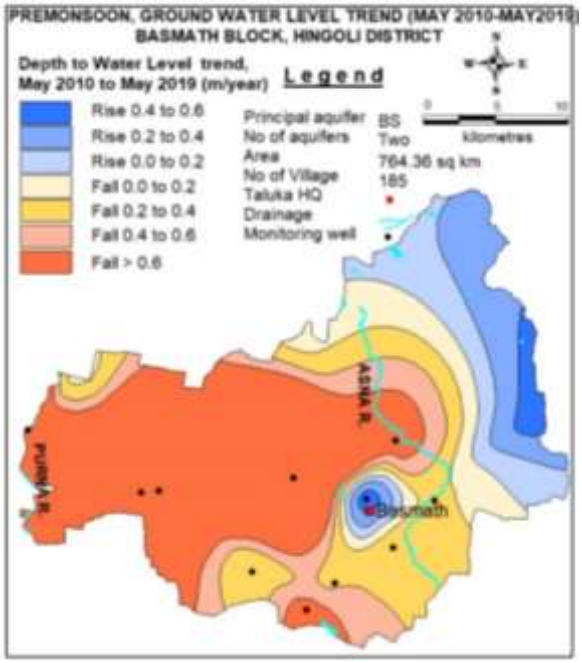
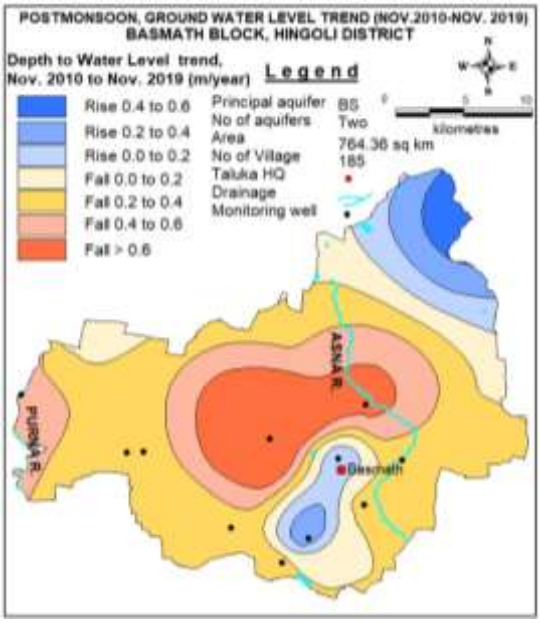
Drainage	Asna and Purna rivers; tributary of Godavari River	
Hydrology ***(Reference year: June 2018)***	Major project	**Completed:** 02; 1. Upper Penganga Project; generating a gross irrigation Potential of 7006 ha in Basmath block Gross Storage Capacity of 1279.90 MCM (Basmath and, Kalmnuri blocks) and Live Storage Capacity of 964.10 MCM (Basmath and Kalmnuri blocks). 2. Purna Siddheswar Project; generating a gross irrigation Potential of 19851 ha in Basmath block Gross Storage Capacity of 1185 MCM (Aundha, Basmath and, Kalmnuri blocks) and Live Storage Capacity of 891 MCM (Aundha, Basmath and Kalmnuri blocks). **Ongoing:** Nil
	Medium project	**Completed:** Nil **Ongoing:** Nil
	Irrigation Project (>250 Ha)	**Completed:** 01 irrigation project; generating a gross irrigation Potential of 44 ha. **Ongoing:** Nil
	Irrigation Project (<250 Ha)	**Completed: 08** Through completed KT weirs generating a gross irrigation Potential of 156 ha. **Ongoing:** Nil
1.5. Land Use, Agriculture, Irrigation & Cropping Pattern		
Geographical Area	764.36 Sq. km.	
Forest Area	33.73 Sq. km.	
Cultivable Area	784.88 Sq. km.	
Net Sown Area	784.88 Sq. km.	
Double Cropped Area	390.55 Sq. km.	
Area under Irrigation – Surface Water	86.84 Sq. km.	
Area under Irrigation – Ground Water	55.81 Sq. km.	
Principal Crops *(Reference year 2018)*	**Crop Type**	**Area (Sq. km.)**
	Oil Seeds	308.76
	Pulses	263.05
	Cereals	243.56
	Cotton	195.16
Horticultural Crops	Banana	4.89
	Citrus fruits	3.12
	Others	0.45
1.6. Water Level Behaviour		
1.6.1. Aquifer-I/Shallow Aquifer		
Pre-Monsoon (May-2019)		**Post-Monsoon (November-2019)**

Water levels less than 10 mbgl has been observed in major part of the block whereas more than 20 mbgl water levels are observed in western part and isolated patch in central part covering about 64.69 sq. km. area.	Water levels less than 2 mbgl have been observed in isolated patches in southern part of the block; water levels between 2 to 5 mbgl have been observed in major part of the block while more than 5 mbgl have been observed in major part of western half of the block and covering about 314.60 sq. km. area.
Pre-Monsoon Water Level (May 2019)  **WL>20 mbgl 64.69 sq. km.**	**Post-Monsoon Water Level (Nov. 2019)**  **WL>5 mbgl 314.60 sq. km.**
1.6.2. Aquifer-I/Deeper Aquifer	
Post-Monsoon Water Level (Nov. 2019) Water level <30 mbgl has been observed in small part in northern part of the block and covering about 199 sq km area of the block while water level more than 30 mbgl has been observed in major part of the block and covering about 696 sq. km. area of the block.	 **WL>30 mbgl 696 sq. km.**
1.7. Hydrographs: **Site Name: Loni Bk State: Maharashtra District: Hingoli Tehsil: Basmath Block: Basmath Village: Basmath**	



Hydrograph shows declining water level trend @ 0.6733 m/year during Pre-monsoon and @ 0.26 m/year during post monsoon.

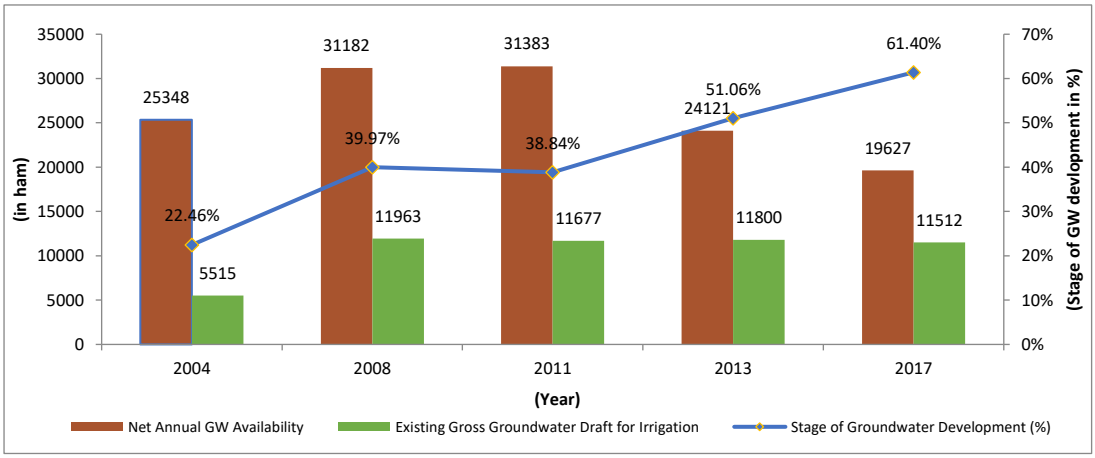
1.8. Water Level Trend (2010-19)

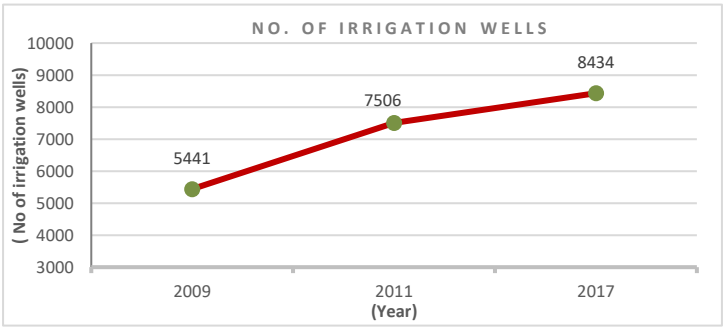
Pre-Monsoon trend	**Post-Monsoon trend**
Rising 0.4733 m/year Falling 0.2309 to 1.9524 m/year	Rising 0.1118 to 0.3148 m/year Falling 0.2587 to 0.9375 m/year
Major part of the block shows declining trend more than 0.2 m/year covering about 629 sq. km. area while rise in water level trend more than 0.2 m/year has been observed in eastern peripheral part and isolated patch in south central part of the block. Declining trend up to 0.2 m/year has been observed in eastern part and isolated path in south central part the block.	Major part of the block shows declining trend more than 0.2 m/year covering about 649 sq. km. area while rise in water level more than 0.2 m/year has been observed in eastern part and isolated patch in southern part of the block. Declining trend up to 0.2 m/ year has been observed in northern, eastern and southern part the block.
Pre-Monsoon Water Level Trend (2010-19)	**Post-Monsoon Water Level Trend (2010-19)**
	
Declining trend @>0.2 m/year 629 sq. km.	**Declining trend @>0.2 m/year 649 sq. km.**

2. Ground Water Issues

Increase in stage of ground water development: -

Despite being in Safe category, the stage of ground water development has continuously and sharply increased from 2004 (22.46%) to 2013 (61.40%). Further, the draft for irrigation and number of irrigation wells have also increased from 55.15 to 115.12 MCM and 5441 to 8434 wells implying increased utilization of ground water resources in agriculture sector.



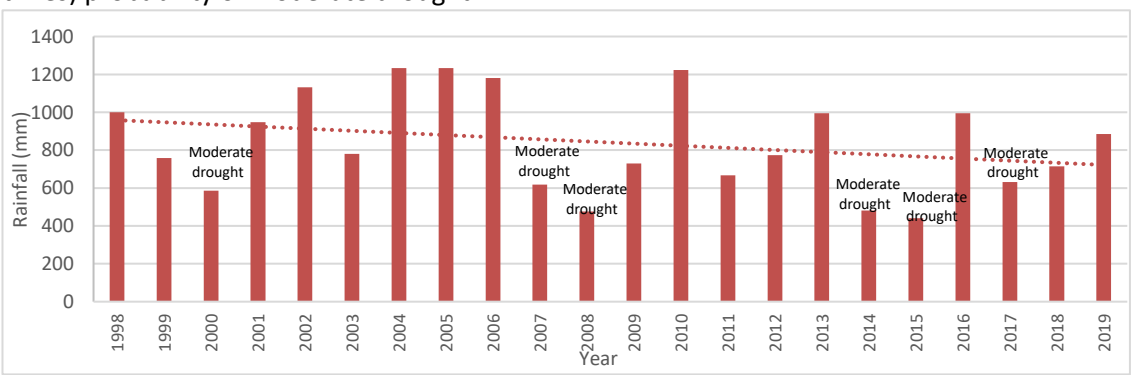


Declining water level Trend and Deeper Water level: -

- Premonsoon water level trend (2010-19), decline in water level trend more than 0.2 m/year is observed in 70 % area of the block.
- Postmonsoon water level trend (2010-19), decline in water level more than 0.2 m/year is observed in 73 % area of the block.
- During Premonsoon (2019), Deeper water level i.e., more than 20 mbgl is observed in 64.69 sq. km. area of the block.

Low Rainfall and Drought Prone Area: -

Based on the rainfall data of 1998-2019 period; the average rainfall for the period is 840.25 mm. In addition, the long-term rainfall analysis indicates a falling trend @ 11.26 mm/ year with 27% (6 times) probability of moderate drought.



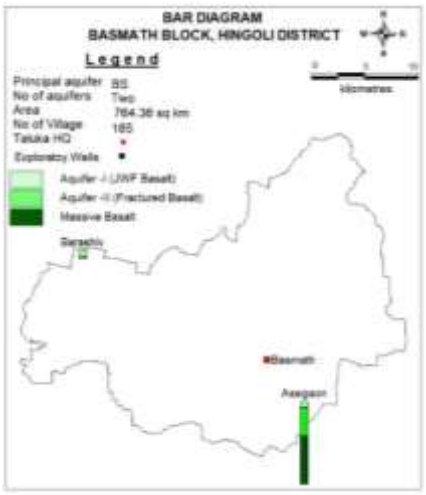
Ground Water Quality: -

Nitrate Contamination: In shallow aquifer, out of 13 samples, 9 samples i.e., 69% samples are showing nitrate contamination; i.e., more than 45 mg/L whereas in deeper Aquifer, out of 1 sample i.e., Asegaon village is showing nitrate contamination (NO_3 >48 mg/L).

3. AQUIFER DISPOSITION

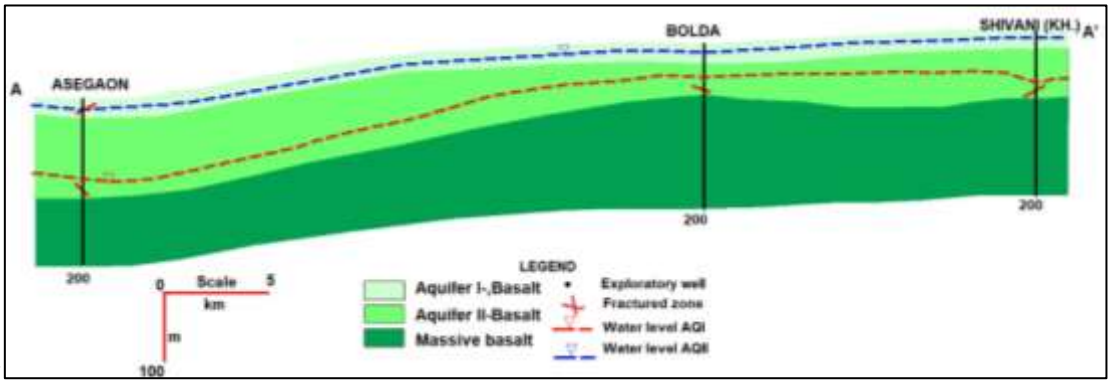
3.1. Number of Aquifers	**Basalt –Aquifer-I, Aquifer-II**

3.2. Lithological disposition



3.3. Cross Section

Section AA'

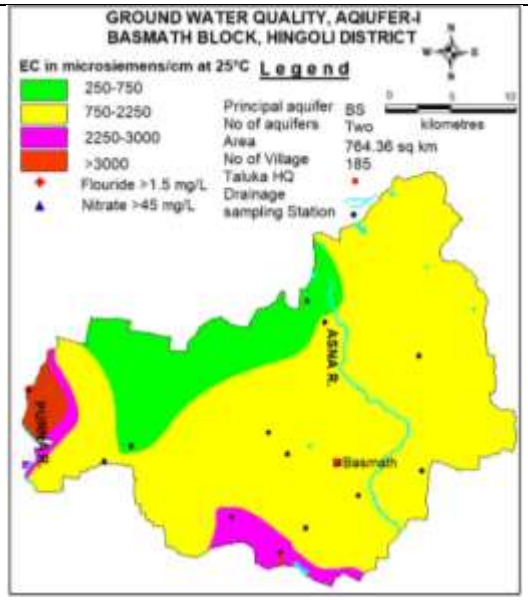


3.4. Basic Aquifer Characteristics

Major Aquifers	**Basalt (Deccan Traps)**	
Type of Aquifer (Phreatic/Semi confined/Confined)	Aquifer-I (Phreatic)	Aquifer-II (Semi confined/confined)
Depth to bottom of Aquifer (mbgl)	10 to 22	65 to 119
Zones/Fractures encountered (mbgl)	up to 22	up to 119
Granular/Weathered/Fractured rocks thickness (m)	8 to 15	1 to 3
SWL (mbgl)	0.8 to 20.9	112.4
Specific yield/Storativity (S)	0.019 to 0.028	*0.00003 -0.00005
Transmissivity (T)	*30 - 50 m^2/day	0.51 to 15.17 m^2/day
Yield	up to 100 m^3/day	up to 2.5 lps
Sustainability	2 to 4 hrs	1 to 3 hrs

Suitability for drinking/ irrigation	Suitable for both (except Nitrate and Fluoride affected villages for drinking)	Suitable for both (except Nitrate and Fluoride affected villages for drinking)
* values taken from Risod block, Washim District.		

4. GROUND WATER QUALITY



EC > 2250 µS/cm covering 60.65 sq. km.

4.1 Aquifer-I/ Shallow Aquifer

EC up to 750 µS/cm is observed in northern part of the block; EC values between 750 to 2250 µS/cm are observed in major part of the block whereas EC more than 2250 µS/cm has been observed in southern and western parts of the block. Ground water is suitable for all purposes in major part of the block except 9 villages that are affected by Nitrate contamination and village Sawangi Bk. (F=1.6 mg/L) which is affected by Fluoride contamination.

4.2 Aquifer II/Deeper Aquifer

EC up to 2250 µS/cm is observed in entire block. Ground water is suitable for all purposes.

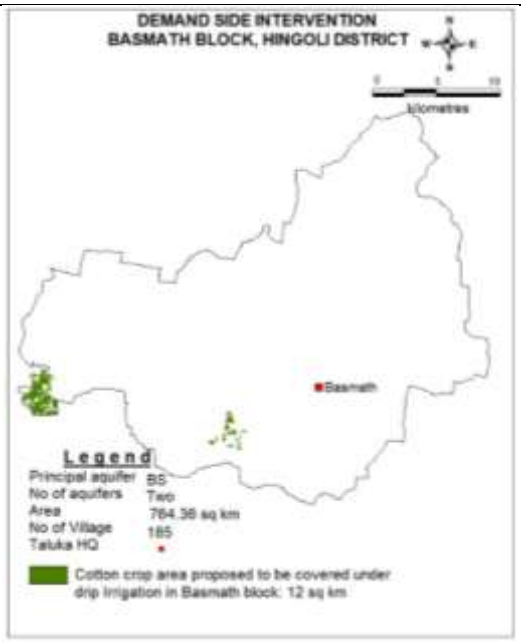
5. GROUND WATER RESOURCE

5.1 Aquifer-I/ Shallow Aquifer

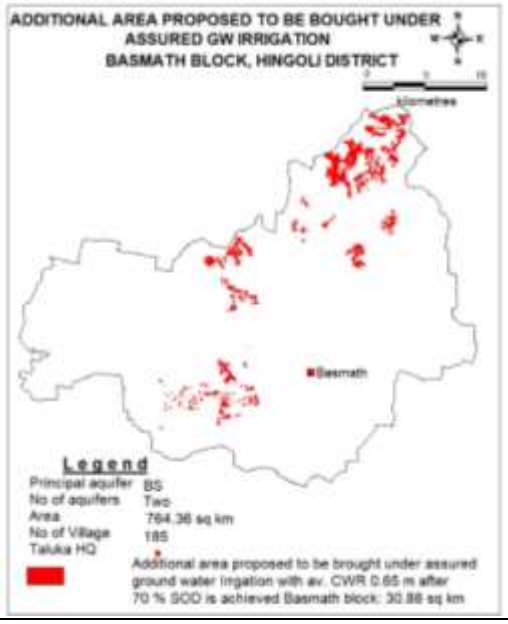
Ground Water Recharge Worthy Area (Sq. km.)	764.36
Total Annual Ground Water Recharge (MCM)	206.59
Natural Discharge (MCM)	10.32
Net Annual Ground Water Availability (MCM)	196.27
Existing Gross Ground Water Draft for irrigation (MCM)	115.12
Existing Gross Ground Water Draft for domestic and industrial water supply (MCM)	5.38
Existing Gross Ground Water Draft for All uses (MCM)	120.50
Provision for domestic and industrial requirement supply to 2025(MCM)	15.55
Net Ground Water Availability for future irrigation development (MCM)	64.34

Stage of Ground Water Development (%)			**61.40**		
Category			**SAFE**		
5.2 Aquifer-II/Deeper Aquifer					
Semi confined/Confined Aquifer **(Basalt)**					
Total Area (Sq. km.)	Mean aquifer thickness (m)	Av. Sy/Storativity	Av. Piezometric Head (m)	Resources above confining layer (MCM)	Resource within confining Aquifer (MCM)
764.36	3.00	0.002/0.0000145	4	0.044	4.59
6.0. GROUND WATER RESOURCE MANAGEMENT					
Available Resource (MCM)			196.27		
Gross Annual Draft (MCM)			120.50		
6.1. Supply Side Management					
SUPPLY (MCM)					
Agricultural Supply -GW			115.12		
Agricultural Supply -SW			56.44		
Domestic Supply - GW			5.37		
Domestic Supply - SW			1.34		
Total Supply			**178.28**		
Area of Block (Sq. km.)			764.36		
Area suitable for Artificial recharge (Sq. km.)			5.31		
Type of Formation			Hard Rock		Soft Rock
Area feasible for Artificial Recharge (WL >5mbgl) (Sq. km.)			5.31		-
Volume of Unsaturated Zone (MCM)			10.62		-
Average Specific Yield			0.02		-
Volume of Sub Surface Storage Space available for Artificial Recharge (MCM)			0.212		-
Surplus water Available (MCM)			0.12		-
Proposed Structures			Percolation Tank (Av. Gross Capacity-100 TCM*2 fillings = 200 TCM)		Check Dam (Av. Gross Capacity-10 TCM * 3 fillings = 30 TCM)
Number of Structures			0		4
Volume of Water expected to be conserved / recharged @ 75% efficiency (MCM)			0		0.09
Proposed Structures					
RTRWH Structures – Urban Areas					
Households to be covered (25% with 50 m^2area)			55,184		
Total RWH potential (MCM)			2.1687		
Rainwater harvested / recharged @ 80% runoff co-efficient			1.7350 Economically not viable & Not Recommended		
6.2. Demand Side Management					

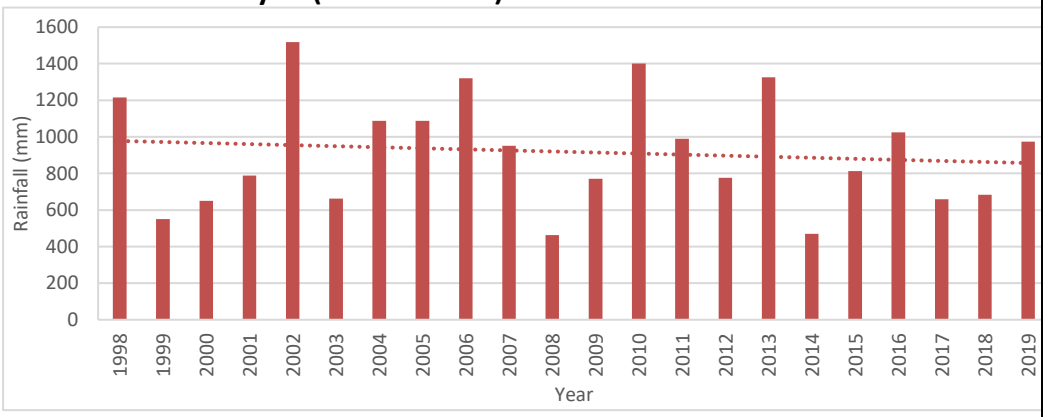
Micro irrigation techniques	
Cotton crop area proposed for drip irrigation (sq. km.)	12
Volume of Water Saving by use of drip (MCM), Surface Flooding req- 0.815 m. Drip Req. – 0.55, WUE- 0.26 m	3.12
Proposed Cropping Pattern change	
Irrigated area under Water Intensive Crop (ha)	Not proposed
Water Saving by Change in Cropping Pattern	Nil
Alternate Sources	Nil
6.3. EXPECTED BENEFITS	
Net Ground Water Availability (MCM)	196.27
Additional GW resources available after Supply side interventions (MCM)	0.09
Ground Water Availability after Supply side intervention	196.36
Existing Ground Water Draft for All Uses (MCM)	120.50
GW draft after Demand Side Interventions (MCM)	117.38
Present stage of Ground Water Development (%)	61.40
Expected Stage of Ground Water Development after interventions (%)	59.78
Other Interventions Proposed, if any	
Alternate Water Sources Available	Nil
Recommendation	
Ground water development is recommended to bring the stage of ground water development from 59.78% to 70%	
6.4. DEVELOPMENT PLAN	
Volume of water available for GWD to 70% (MCM)	20.07
Proposed Number of DW (@ 1.5 ham for 90% of GWR Available for development)	1204
Proposed Number of BW (@ 1 ham for 10% of GWR Available for development)	201
Additional Area to be brought under assured GW irrigation with av. CWR of 0.65 m (sq. km.)	30.88
Regulatory Measures	**60 m**
Supply Side Interventions	Demand Side Interventions
Proposed locations for AR structures	**Cotton crop Areas proposed for drip Irrigation**



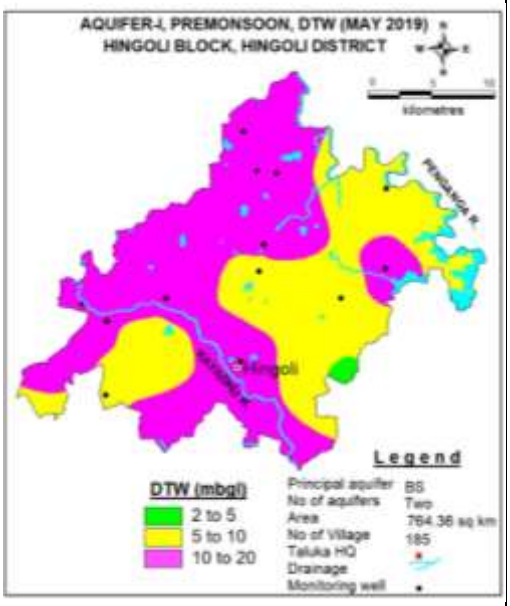
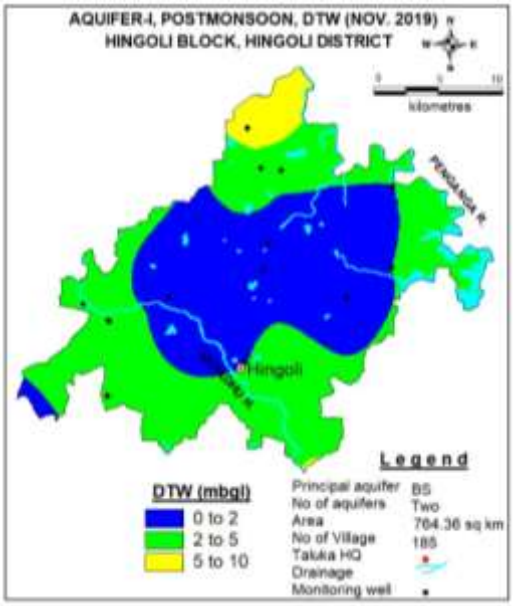
Expected Benefits: Additional area proposed to be bought under assured ground water irrigation



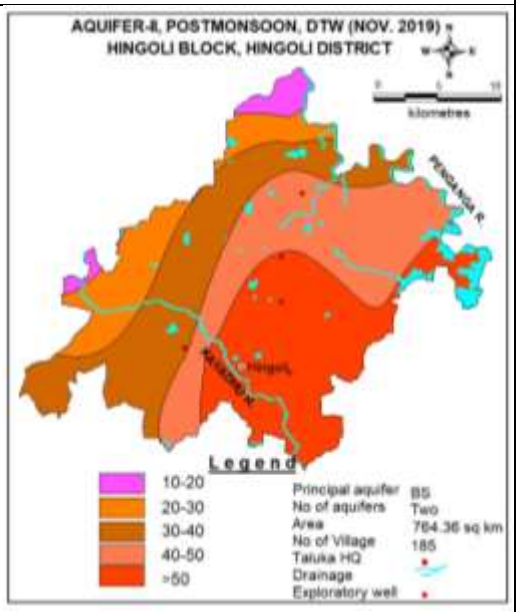
9.3 HINGOLI BLOCK

1. SALIENT FEATURES	
1.1 Introduction	
Block Name	**HINGOLI**
Geographical Area (Sq. km.)	948.32 Sq. km.
Hilly Area (Sq. km.)	Nil
Poor Ground Quality Area (Sq. km.)	Nil
Population (2011)	269546
Climate	Sub-Tropical
1.2 Rainfall Analysis	
Normal Rainfall	946.6 mm
Annual Rainfall (2019)	973.6 mm
Decadal Average Annual Rainfall (2010-19)	911.43 mm
Long Term Rainfall Analysis (1998-2019)	Declining Trend 2.80 mm/year. Probability of Normal and Excess Rainfall - 45% & 23%. Probability of Droughts-: 32% Moderate
Rainfall Trend Analysis (1998 to 2019)	
	
EQUATION OF TREND LINE: y = -5.7539x + 983.39	
1.3. Geomorphology, Soil & Geology	
Geomorphic Unit	Plateau Undissected and Slightly Dissected 0 to 1 m weathered thickness, Plateau Moderately dissected, Plateau Weathered with 1 to 5 m weathered thickness and Escarpment Slope and Butte
Soil	Clayey soil (shallow to very deep; 10 to >100 cm), Sandy clay loam, Gravelly clay loam, Gravelly clay and Silty Clay and Clay loam soils.
Geology	Deccan Traps (Basalt) Age: Late Cretaceous to Eocene
1.4. Hydrology & Drainage	

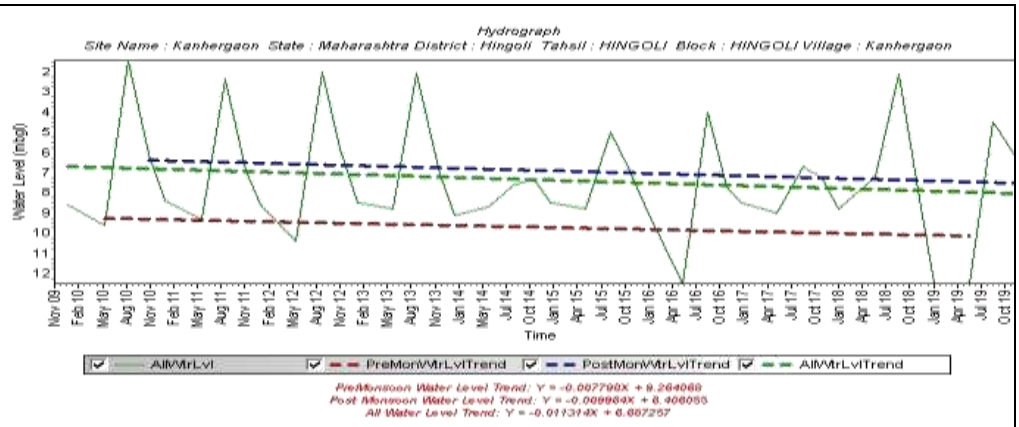
Drainage	Kayadhu and Penganga Rivers; tributaries of Godavari river	
Hydrology *(Reference Year: June 2018)*	Major project	Nil
	Medium project	**Completed**: Nil **Ongoing: Nil**
	Irrigation Project (>250 Ha.)	**Completed**: 11; Through completed minor and KT weir projects generating a gross irrigation Potential of 6731 ha. **Ongoing:** Nil
	Irrigation Project (<250 Ha.)	**Completed:** Through completed KT weir project generating a gross irrigation Potential of 846 ha. **Ongoing:** Nil
1.5. Land Use, Agriculture, Irrigation & Cropping Pattern		
Geographical Area	948.32 Sq. km.	
Forest Area	27.39 Sq. km.	
Cultivable Area	789.22 Sq. km.	
Net Sown Area	789.22 Sq. km.	
Double Cropped Area	161.47 Sq. km.	
Area under Irrigation – Surface Water	35.00 Sq. km.	
Area under Irrigation – Ground Water	9.75 Sq. km.	
Principal Crops *(Reference year 2018)*	**Crop Type**	**Area (Sq. km.)**
	Oil Seeds	597.62
	Pulses	233.13
	Cereals	62.79
	Cotton	27.09
	Sugarcane	0.08
Horticultural Crops	Citrus fruits	2.30
	Mango	0.79
	Others	0.24
1.6. Water Level Behaviour		
1.6.1. Aquifer-I/Shallow Aquifer		
Pre-Monsoon (May-2019)		**Post-Monsoon (November-2019)**

Pre-Monsoon Water Level (May 2019)	Post-Monsoon Water Level (Nov. 2019)
	
WL>10 mbgl 550 sq. km.	**WL>5 mbgl 43.41 sq. km.**
Water level less than 10 mbgl have been observed in eastern half and small part in western part of the block. Water level between 10 to 20 mbgl have been observed in major part of the block covering about 550 sq. km. area.	Water levels less than 5 mbgl have been observed in major part of the block. Water levels between 5 to 10 mbgl have been observed as small patch in northern part of the block covering about 43.41 sq. km. area.

1.6.2. Aquifer-I/Deeper Aquifer

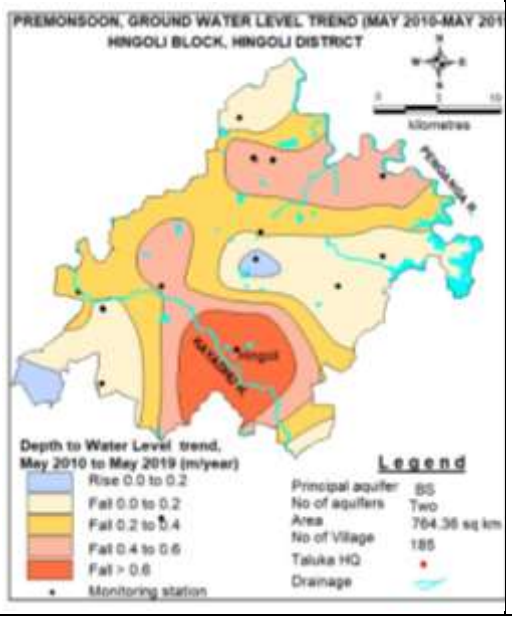
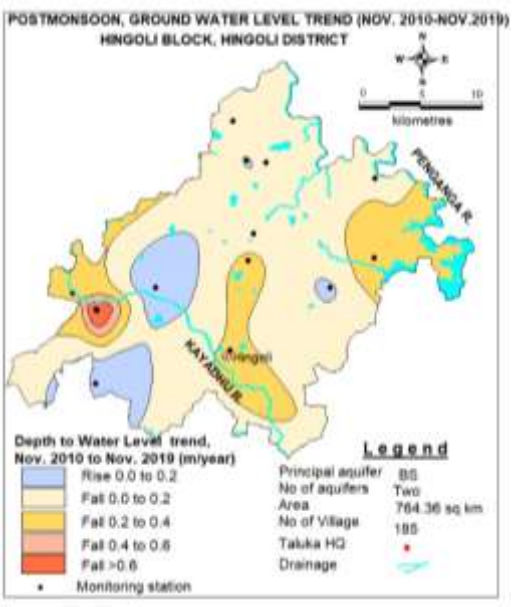
Post-Monsoon Water Level (Nov. 2019)	
Water level <20 mbgl is observed in small part in northern and western peripheral part of the block. Water level between 20-30 mbgl is observed as northern part of the block; more than 30 mbgl has been observed in major part of the block and cover about 801 sq. km. area of the block.	
	WL>30 mbgl 801 sq. km.

1.7. Hydrographs:



Hydrograph shows Pre-monsoon declining water level trend @ 0.0934 m/year and Post monsoon declining water level trend @ 0.1195 m/year

1.8. Water Level Trend (2010-19)

Pre-Monsoon trend	**Post-Monsoon trend**
Rising 0.0781 m/year Falling 0.0030 to 0.8787 m/year	Rising 0.0017 to 0.1296 m/year Falling 0.066 to 0.7877 m/year
Major part of the block shows declining trend more than 0.2 m/year and covering about 634 sq. km. area while declining trend up to 0.2 m/year have been observed in eastern half and western part of the block. Rising trend up to 0.2 m/year has been observed in south western part and isolated patch in central part of block.	Major part of the block shows declining trend up to 0.2 m/year while rising trend up to 0.2 m/year has been observed in western part of block. Declining trend >0.2 m/year has been observed in eastern, western and southern parts of the block and cover 225 sq. km. area.
Pre-Monsoon Water Level Trend (2010-19)	**Post-Monsoon Water Level Trend (2010-19)**
	

Declining trend @>0.2 m/year 634 sq. km.	**Declining trend @>0.2 m/year 225 sq. km.**

2. Ground Water Issues

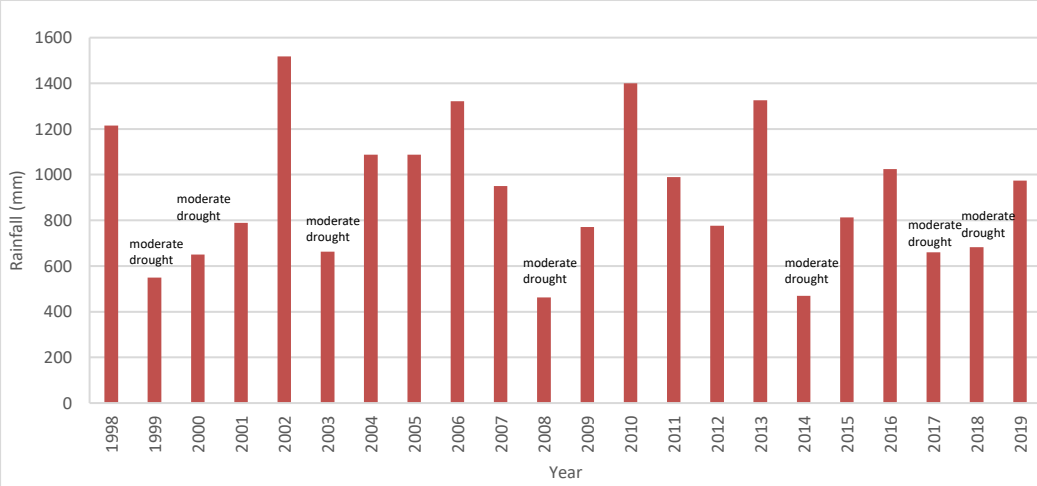
Declining water level Trend: -

During Premonsoon period (2010-19), the decline in water level more than 0.2 m/year is observed in about 634 sq. km. covering 67 % area of the block.

During Postmonsoon period (2010-19), the decline in water level more than 0.2 m/year is observed in about 225 sq. km. covering 24% area of the block.

Low rainfall and Drought:

Based on the rainfall analysis for the period 1998-2019; the average rainfall for the period 1998 to 2019 is 917.21 mm. Also, the long-term rainfall analysis indicates a falling trend @ 5.75 mm/ year with 32% probability of moderate drought.



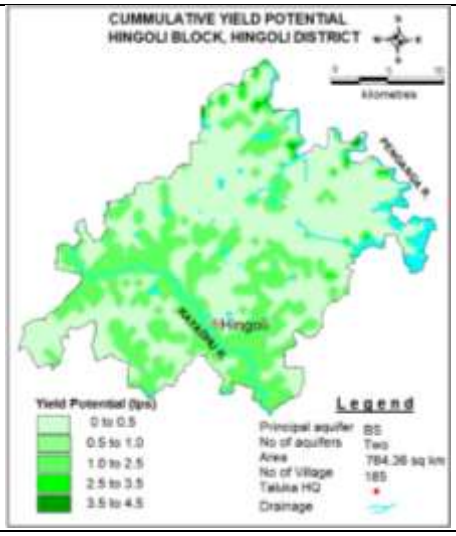
Ground Water Quality: -

Nitrate Contamination: In deeper aquifer, out of 11 samples, 2 samples i.e., 18% samples show nitrate contamination.

Fluoride contamination: In Deeper aquifer, out of 11 samples, 3 samples (Belura, Sawarkheda, Deulgaon Rama) i.e., 27% samples shows fluoride contamination.

Low yielding Aquifer resulting poor sustainability: -

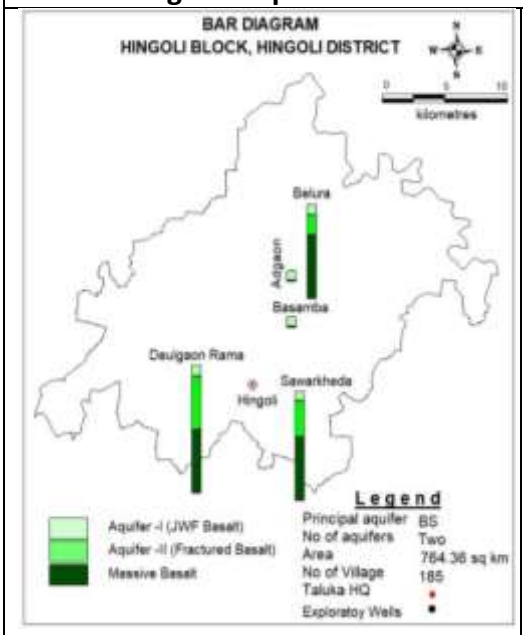
Limited extent of porous and pervious zone because of predominance of secondary porosity that has evolved from prevailing erratic joint pattern and also absence of primary porosity results in poor sustainability of the aquifers. About 67 % area of the block has low yield potential (< 1 lps) and can sustain pumping only for 1 to 1.5 hrs.

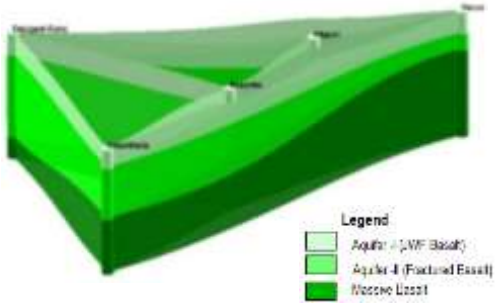


3. AQUIFER DISPOSITION

3.1. Number of Aquifers	• Basalt –Aquifer-I, Aquifer-II

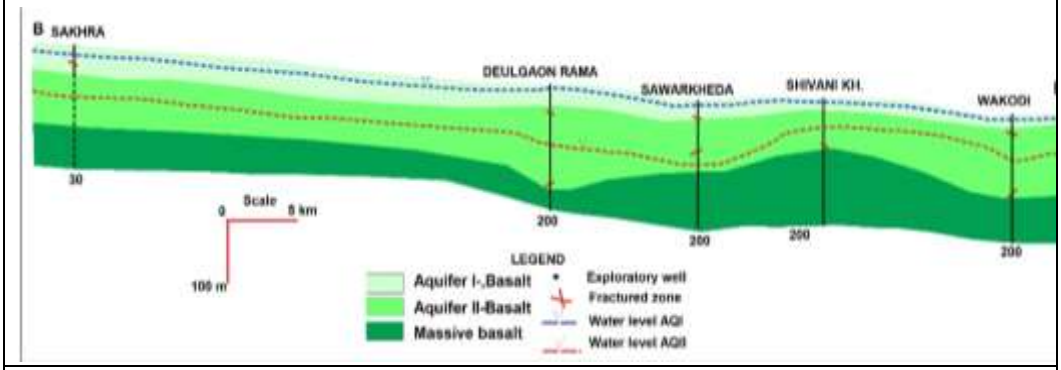
3.2. Lithological disposition





3.3. Cross Section

Section AA'

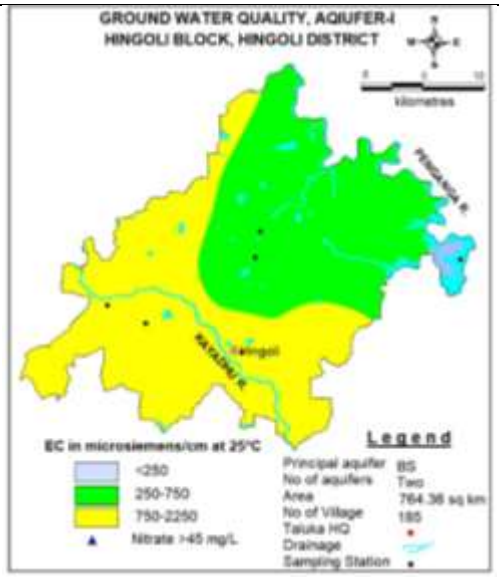
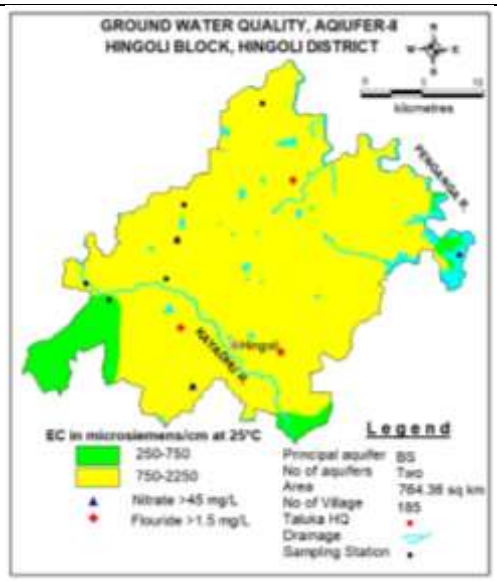


3.4. Basic Aquifer Characteristics

Major Aquifers	Basalt (Deccan Traps)

Type of Aquifer (Phreatic/Semi confined/Confined)	Aquifer-I (Phreatic)	Aquifer-II (Semiconfined/confined)
Depth to bottom of Aquifer (mbgl)	6 to 18	61 to 167
Fractures encountered (mbgl)	up to 18	up to 167
Weathered/Fractured rocks thickness (m)	8 to 14	1 to 9
SWL (mbgl)	0.9 to 13.4	39.4 to 112.4
Specific yield/Storativity (S)	0.019 to 0.028	*0.00003 -0.00005
Transmissivity (T)	*30 - 50 m^2/day	0.51 to 15.17 m^2/day
Yield	up to 100 m^3/day	up to 1.25 lps
Sustainability	1 to 4 hrs	1 to 3 hrs
Suitability for drinking/ irrigation	Suitable for both (except Nitrate affected village for drinking)	Suitable for both (except Nitrate and Fluoride affected villages for drinking)
* values taken from Risod block, Washim District.		

4. GROUND WATER QUALITY

Phreatic Aquifer (Aquifer-I)	**Semi confined/Confined Aquifer (Aquifer II)**
	
EC > 750 µS/cm covering 499 sq. km.	**EC > 2250 µS/cm covering 859 sq. km.**

4.1 Aquifer-I/ Shallow Aquifer

EC up to 750 µS/cm is observed in north eastern half of the block whereas EC values between 750 to 2250 µS/cm are observed in western half of the block covering about 499.35 sq. km. area of the block. Ground water is suitable for all purposes in major part of the block except sawad village that is affected by Nitrate contamination.

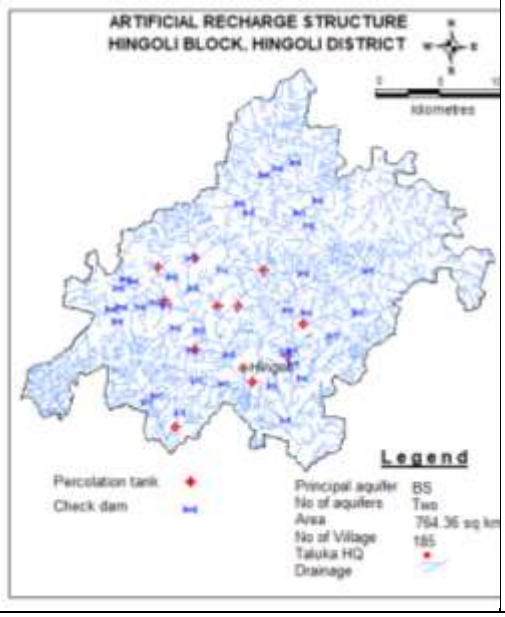
4.2 Aquifer II/Deeper Aquifer

EC up to 750 µS/cm is observed in eastern, southern and western peripheral parts of the block whereas EC values between 750 to 2250 µS/cm cover whole of the block. Ground water is suitable for all purposes except Santur Pimpari and Pangri villages that are having nitrate more than 45 mg/L and Deulgaon Rama, Sawarkheda and Belura villages that are affected by Fluoride contamination; In these villages ground water is not fit for drinking purpose without treatment.					
5. GROUND WATER RESOURCE					
5.1 Aquifer-I/ Shallow Aquifer					
Ground Water Recharge Worthy Area (Sq. km.)			948.32		
Total Annual Ground Water Recharge (MCM)			128.01		
Natural Discharge (MCM)			6.40		
Net Annual Ground Water Availability (MCM)			121.61		
Existing Gross Ground Water Draft for irrigation (MCM)			46.27		
Existing Gross Ground Water Draft for domestic and industrial water supply (MCM)			3.74		
Existing Gross Ground Water Draft for All uses (MCM)			50.02		
Provision for domestic and industrial requirement supply to 2025(MCM)			14.57		
Net Ground Water Availability for future irrigation development (MCM)			63.23		
Stage of Ground Water Development (%)			41.13		
Category			**SAFE**		
5.2 Aquifer-II/Deeper Aquifer					
Semi confined/Confined Aquifer **(Basalt)**					
Total Area (Sq. km.)	Mean aquifer thickness (m)	Av. Sy/ Storativity	Av. Piezometric Head (m)	Resources above confining layer (MCM)	Resource within confining Aquifer (MCM)
948.32	5.50	0.002/0.0000145	11.5	0.158	10.43
6.0. GROUND WATER RESOURCE MANAGEMENT					
Available Resource (MCM)			121.61		
Gross Annual Draft (MCM)			50.02		

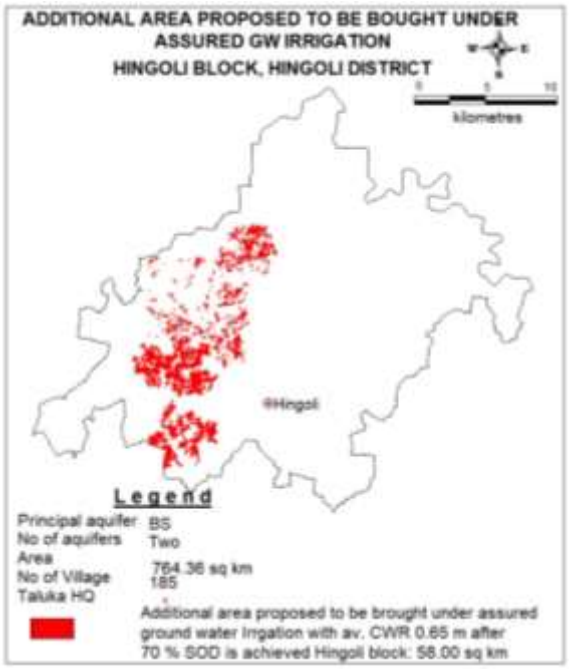
6.1. Supply Side Management		
SUPPLY (MCM)		
Agricultural Supply -GW	46.27	
Agricultural Supply -SW	22.75	
Domestic Supply - GW	3.74	
Domestic Supply - SW	0.94	
Total Supply	**73.70**	
Area of Block (Sq. km.)	948.32	
Area suitable for Artificial recharge (Sq. km.)	217.45	
Type of Formation	Hard Rock	Soft Rock
Area feasible for Artificial Recharge (WL >5mbgl) (Sq. km.)	217.45	-
Volume of Unsaturated Zone (MCM)	434.9	-
Average Specific Yield	0.02	-
Volume of Sub Surface Storage Space available for Artificial Recharge (MCM)	8.69	-
Surplus water Available (MCM)	4.86	-
Proposed Structures	Percolation Tank (Av. Gross Capacity-100 TCM*2 fillings = 200 TCM)	Check Dam (Av. Gross Capacity-10 TCM * 3 fillings = 30 TCM)
Number of Structures	17	49
Volume of Water expected to be conserved / recharged @ 75% efficiency (MCM)	2.55	1.10
Proposed Structures		
RTRWH Structures – Urban Areas		
Households to be covered (25% with 50 m^2area)	52,669	
Total RWH potential (MCM)	2.457	
Rainwater harvested / recharged @ 80% runoff co-efficient	1.965 Economically not viable & Not Recommended	
6.2. Demand Side Management		
Micro irrigation techniques		
Sugarcane crop area proposed for drip irrigation (sq. km.)	0.08	

Volume of Water Saving by use of drip (MCM) Surface Flooding req- 2.45 m. Drip Req. -1.88, WUE- 0.57 m	0.05
Proposed Cropping Pattern change	
Irrigated area under Water Intensive Crop (ha)	Not proposed
Water Saving by Change in Cropping Pattern	Nil
Alternate Sources	Nil
6.3. EXPECTED BENEFITS	
Net Ground Water Availability (MCM)	121.61
Additional GW resources available after Supply side interventions (MCM)	3.63
Ground Water Availability after Supply side intervention	125.24
Existing Ground Water Draft for All Uses (MCM)	50.02
GW draft after Demand Side Interventions (MCM)	49.97
Present stage of Ground Water Development (%)	41.13
Expected Stage of Ground Water Development after interventions (%)	39.90
Other Interventions Proposed, if any	
Alternate Water Sources Available	Nil
Recommendation	
Ground water development is recommended to bring the stage of ground water development from 39.90 % to 70%	
6.4. Development Plan	
Volume of water available for GWD to 70% (MCM)	37.70
Proposed Number of DW (@ 1.5 ham for 90% of GWR Available for development)	2262
Proposed Number of BW (@ 1 ham for 10% of GWR Available for development)	377
Additional Area to be brought under assured GW irrigation with av. CWR of 0.65 m (sq. km.)	58.0

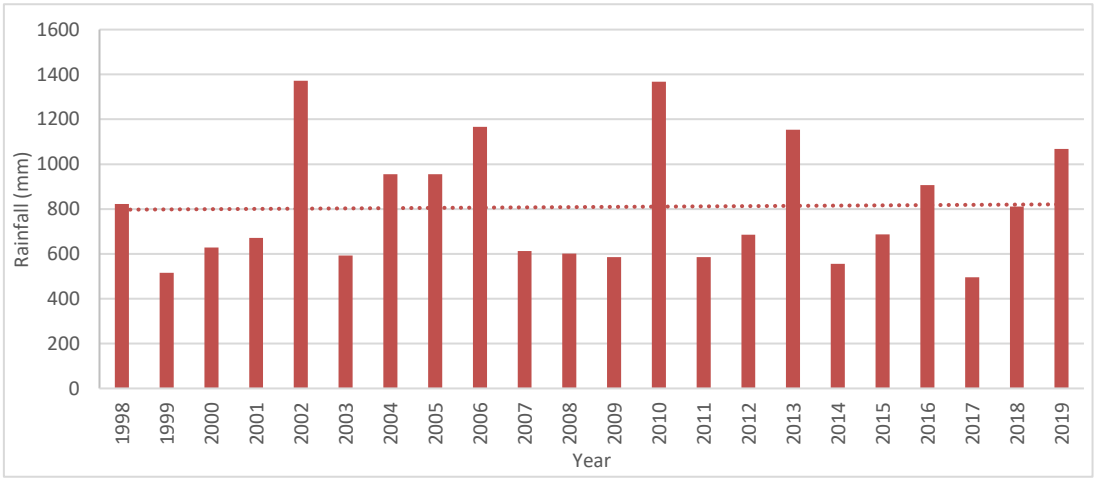
Regulatory Measures	60m
Supply Side Interventions	Demand Side Interventions
Proposed locations for AR structures	Sugarcane crop Area proposed for drip Irrigation



Expected Benefits: ADDITIONAL AREA PROPOSED TO BE BOUGHT UNDER ASSURED GW IRRIGATION



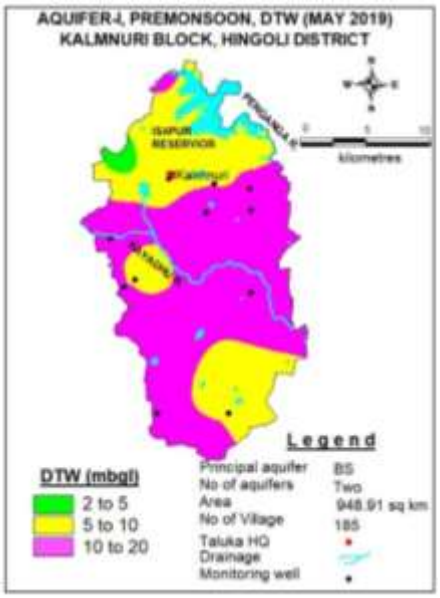
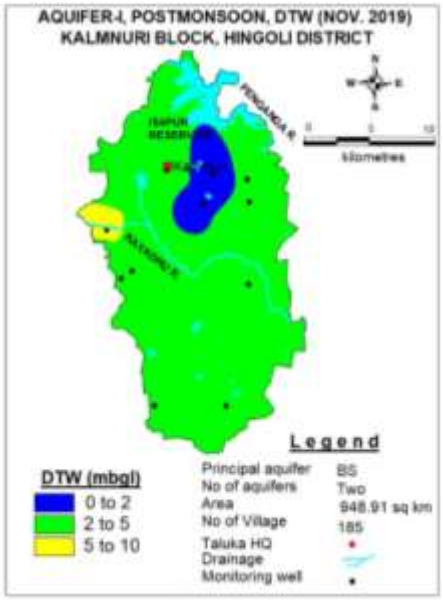
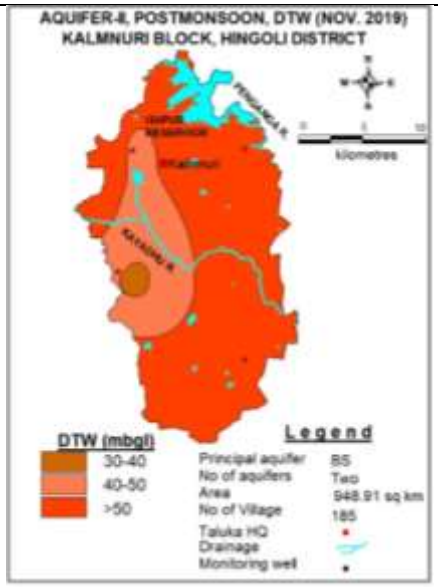
9.4 KALMNURI BLOCK

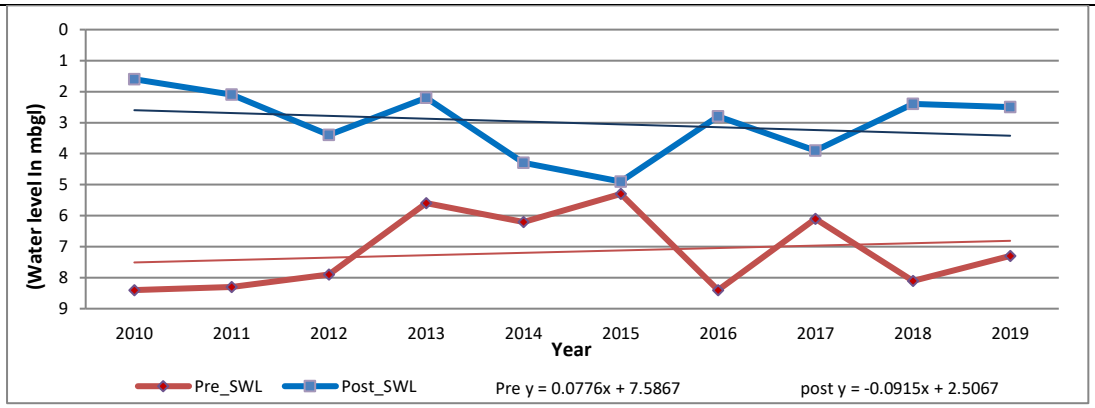
SALIENT FEATURES		
1.1 Introduction		
Block Name	**KALMNURI**	
Geographical Area (Sq. km.)	948.91 Sq. km.	
Hilly Area (Sq. km.)	Nil	
Poor Ground Quality Area (Sq. Km.)	Nil	
Population (2011)	2,31,559	
Climate	Sub-Tropical	
1.2 Rainfall Analysis		
Normal Rainfall	983.7 mm	
Annual Rainfall (2019)	1068.4 mm	
Decadal Average Annual Rainfall (2010-19)	831.8 mm	
Long Term Rainfall Analysis (1998-2019)	Rising Trend 1.131 mm/year. Probability of Normal and Excess Rainfall- 45% & 23%. Probability of Droughts-: 32% Moderate Drought	
Rainfall Trend Analysis (1998 to 2019)  **EQUATION OF TREND LINE: y = 1.131x + 795.94**		
1.3. Geomorphology, Soil & Geology		
Geomorphic Unit	Plateau weathered Canal Command, Plateau Undissected and Slightly Dissected 0 to 1 m weathered thickness, Plateau Weathered with 1 to 5 m weathered thickness, and Escarpment Slope	
Soil	Clayey soil (shallow to very deep; 10 to >100 cm depth), Gravel sandy loam and Gravel clay loam soils.	
Geology	Deccan Traps (Basalt) Age: Late Cretaceous to Eocene	
1.4. Hydrology & Drainage		
Drainage	Kayadhu and Penganga Rivers	
Hydrology *(Reference Year: June 2018)*	Major project	**Completed:** 02; 1.Upper Penganga Project; generating a gross irrigation Potential of 10496 ha in Kalmnuri

		block Gross Storage Capacity of 1279.90 MCM (Basmath and Kalmnuri blocks) and Live Storage Capacity of 964.10 MCM (Basmath and Kalmnuri blocks). 2. Purna Siddheswar Project; generating a gross irrigation Potential of 177 ha in Kalmnuri block Gross Storage Capacity of 1185 MCM (Aundha, Basmath and, Kalmnuri blocks) and Live Storage Capacity of 891 MCM (Aundha, Basmath and Kalmnuri blocks). **Ongoing:** Nil
	Medium project	**Completed:** Nil **Ongoing:** Nil
	Irrigation Project (>250 Ha.)	**Completed:** 05; minor irrigation projects generating a gross irrigation Potential of 2504 ha. **Ongoing:** Nil
	Irrigation Project (<250 Ha.)	**Completed: 15;** Through completed KT weir irrigation projects generating a gross irrigation Potential of 569 ha. **Ongoing:** Nil

1.5. Land Use, Agriculture, Irrigation & Cropping Pattern			
Geographical Area		948.91 Sq. km.	
Forest Area		36.16 Sq. km.	
Cultivable Area		733.59 Sq. km.	
Net Sown Area		733.59 Sq. km.	
Double Cropped Area		246.89 Sq. km.	
Area under Irrigation	Surface Water	5.30 Sq. km.	
	Ground Water	19.00 Sq. km.	
Principal Crops *(Reference year 2018)*		Crop Type	Area (Sq. km.)
		Oil Seeds	434.01
		Pulses	245.19
		Cereals	118.95
		Cotton	102.31
		Sugarcane	16.95
Horticultural Crops		Banana	14.20
		Citrus fruits	1.83
		Mango	0.55
		Others	1.55

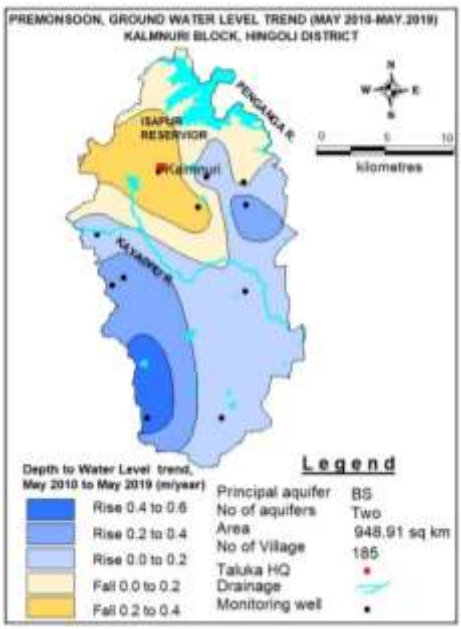
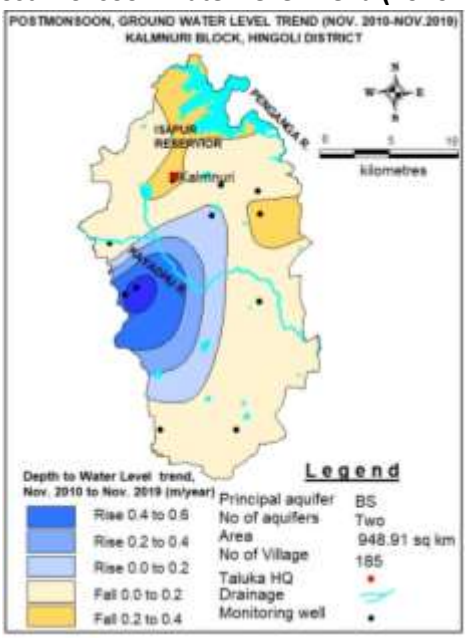
1.6. Water Level Behaviour	
1.6.1. Aquifer-I/Shallow Aquifer	
Pre-Monsoon (May-2019)	**Post-Monsoon (November-2019)**
Water levels less than 10 mbgl have been observed in northern and southern parts of the block and isolated patch in west central	Water level <2 mbgl has been observed in isolated patch in northern part of the block;

part of the block. Water levels between 10 to 20 mbgl have been observed in major part of the block covering about 566 sq. km. area.	water level between 2 to 5 mbgl has been observed in major part of the block whereas more than 5 mbgl has been observed as isolated patch in western part of the block covering about 20.67 sq. km. area.
Pre-Monsoon Water Level (May 2019)  **WL>10 mbgl 566 sq. km.**	**Post-Monsoon Water Level (Nov. 2019)**  **WL>5 mbgl 20.67 sq. km.**
1.6.2. Aquifer-I/Deeper Aquifer	
Post-Monsoon Water Level (Nov. 2019) Water level <40 mbgl is observed in small isolated patch in western part of the block. Water Level more than 40 mbgl has been observed in major part of the block and cover about 934 sq. km. area of the block.	 **WL>40 mbgl 934 sq. km.**
1.7. Hydrographs: **Site Name: Bhategaon State: Maharashtra District: Hingoli Tehsil: Kalmnuri Block: Kalmnuri Village: Bhategaon**	



Hydrograph shows Pre-monsoon rising water level trend @ 0.0776 m/year and Post monsoon declining water level trend @ 0.0915 m/year

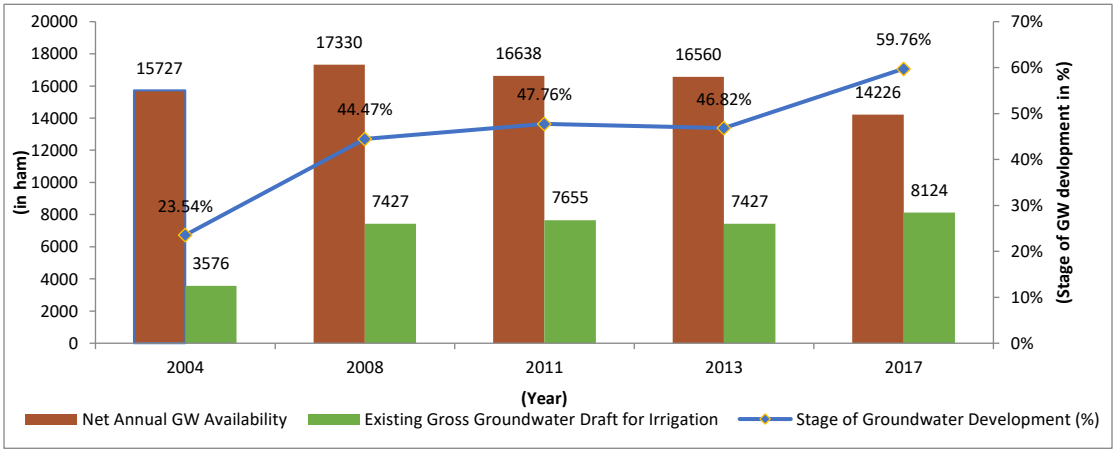
1.8. Water Level Trend (2010-19)

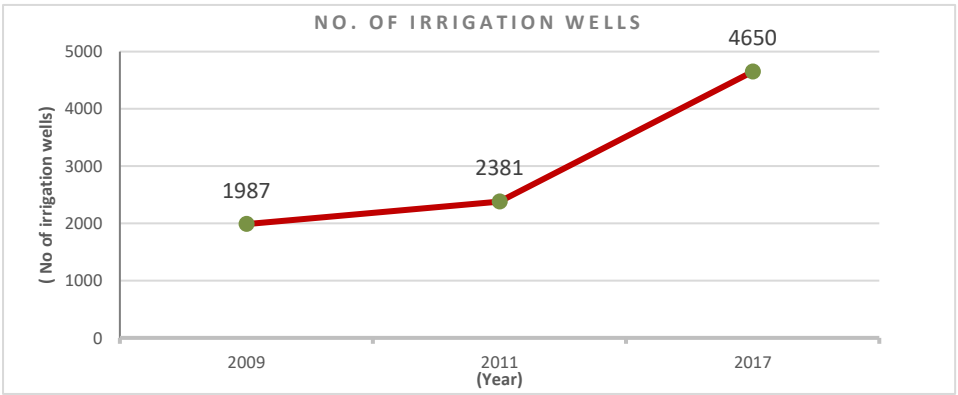
Pre-Monsoon trend	Post-Monsoon trend
Rising 0.018 to 0.5145 m/year Falling 0.02 to 0.3632 m/year	Falling 0.0381 to 0.6385 m/year Falling 0.0963 to 0.2393 m/year
Major part of the block shows rising trend covering about 610 sq km area while decline in water levels has been observed in northern half of the block and cover about 338 sq. km. area. Decline in water level >0.2 m/year has been observed in northern part of the block and cover about 126 sq km area.	Declining water level trend up to 0.2 m/year has been observed in major part of the block while declining trend > 0.2 m/year has been observed in northern and eastern parts of the block and cover 136 sq. km. area. Rising water level trend has been observed in western and west central part of the block.
Pre-Monsoon Water Level Trend (2010-19)	**Post-Monsoon Water Level Trend (2010-19)**
	
Declining trend @>0.2 m/year 126 sq. km.	**Declining trend @>0.2 m/year 136 sq. km.**

2. Ground Water Issues

Increase in stage of ground water development: -

The stage of ground water development has increased from 2004 to 2013 from 23.54% to 59.76% in Kalmnuri block. Further, the draft for irrigation has also increased from 35.76 MCM to 81.24 MCM in the block.





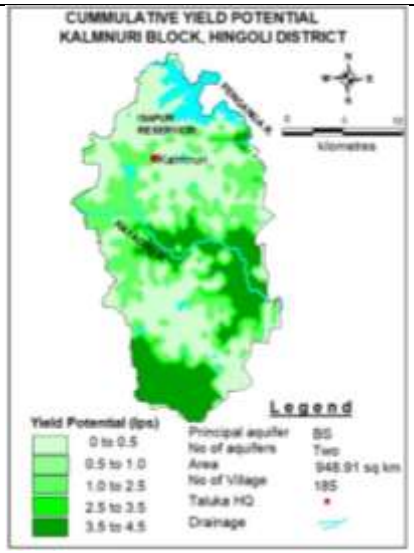
Declining water level Trend:

Premonsoon (2010-19): The decline in water level trend more than 0.2 m/year is observed in 126 sq. km. area covering 13% area of the block.

Premonsoon (2010-19): The decline in water level trend more than 0.2 m/year is observed in 136 sq. km. area covering 14% area of the block.

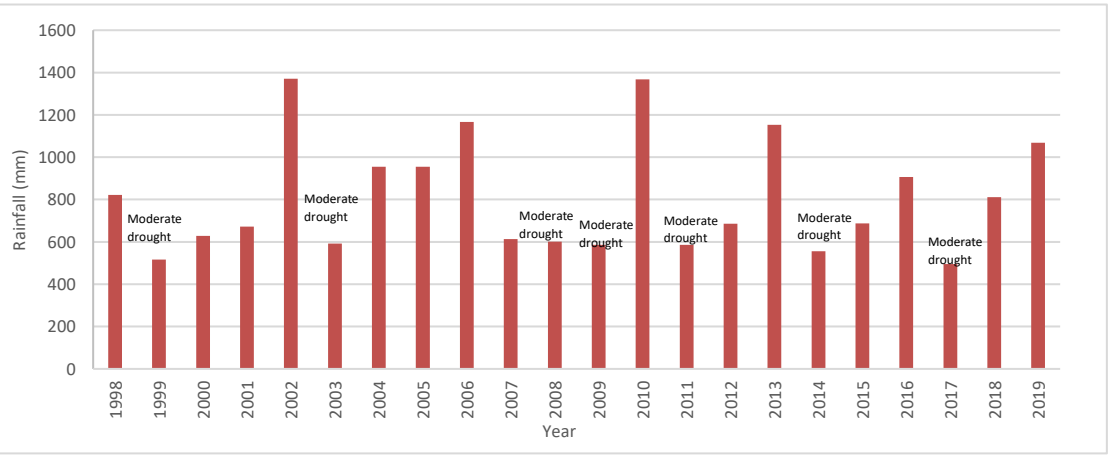
Low yielding Aquifer resulting poor sustainability:

Limited extent of porous and pervious zone, because of predominance of secondary porosity that has evolved from prevailing erratic joint pattern and also absence of primary porosity, results in poor sustainability of the aquifers. 48% area of the block has low yield potential (< 1 lps) and can sustain pumping only for 1-1.5 hrs.



Moderate Droughts:

Based on the rainfall analysis for the period 1998-2019; the average rainfall for the period 1998 to 2019 is 808.9 mm and the block experienced 7 times (32%) moderate droughts.

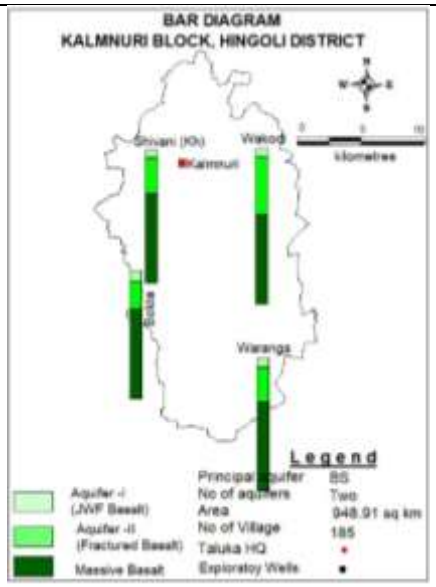


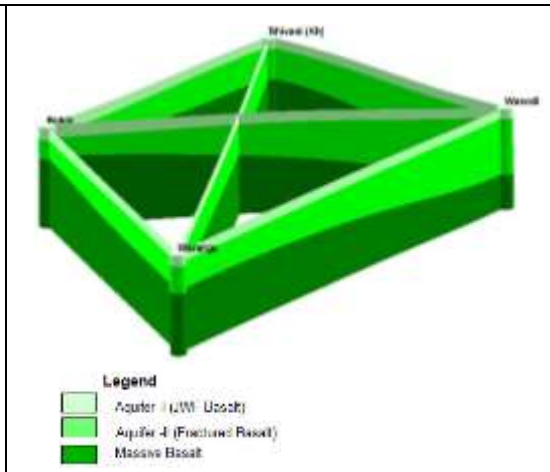
Ground Water Quality:

Nitrate Contamination: In shallow aquifer, out of 9 samples 1 sample i.e., 11% samples show nitrate contamination whereas in deeper aquifer, out of 22 samples 2 samples i.e., 9% of samples are also showing nitrate contamination (NO_3 >45 mg/L).

Fluoride contamination: In shallow aquifer, Fluoride contamination is found in Umra village (F=2.3 mg/L) whereas in deeper aquifer, out of 22 samples 4 samples i.e., 18% of samples are also showing Fluoride contamination (F >1.5mg/L).

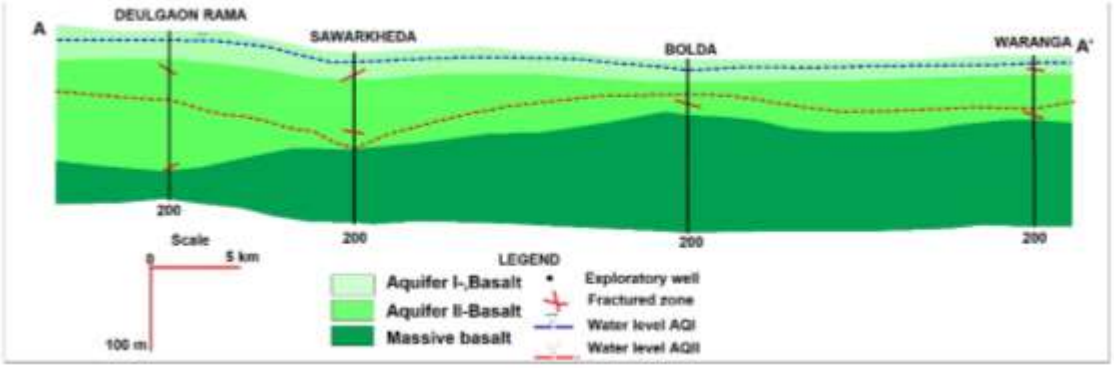
3. AQUIFER DISPOSITION	
3.1. Number of Aquifers	Basalt –Aquifer-I, Aquifer-II
3.2. Lithological disposition	





3.3. Cross Section

Section AA'



3.4. Basic Aquifer Characteristics

Major Aquifers	Basalt (Deccan Traps)	
Type of Aquifer (Phreatic/Semi confined/Confined)	Aquifer-I (Phreatic)	Aquifer-II (Semi confined /confined)
Depth to bottom of Aquifer (mbgl)	8 to 18	63 to 131
Fractures encountered (mbgl)	up to 18	up to 131
Weathered/Fractured rocks thickness (m)	8 to 15	2 to 4
SWL (mbgl)	0.2 to 12.9	40 to 66
Yield	up to 100 m^3/day	up to 2.5 lps
Specific yield/Storativity (S)	0.019 to 0.028	*0.00003 -0.00005
Transmissivity (T)	*30 - 50 m^2/day	0.51 to 15.17 m^2/day
Sustainability	1 to 4 hrs	1 to 3 hrs
Suitability for drinking/ irrigation	Suitable for both (except Nitrate and Fluoride affected villages for drinking)	Suitable for both (except Nitrate and fluoride affected villages for drinking)

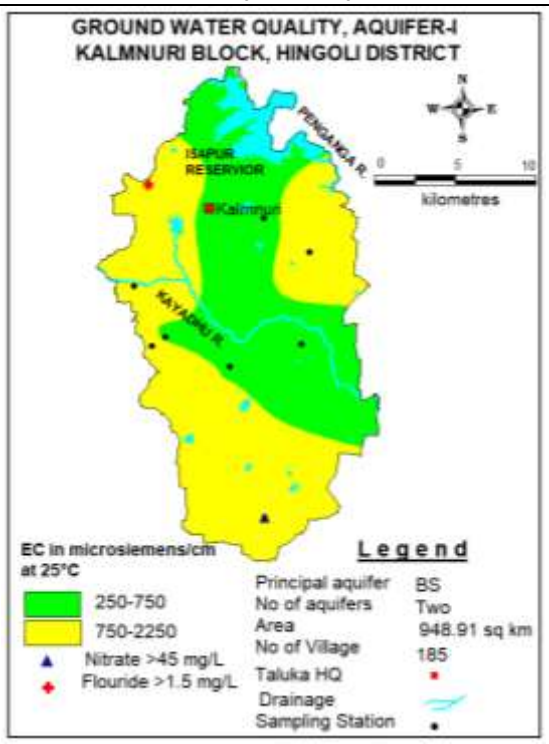
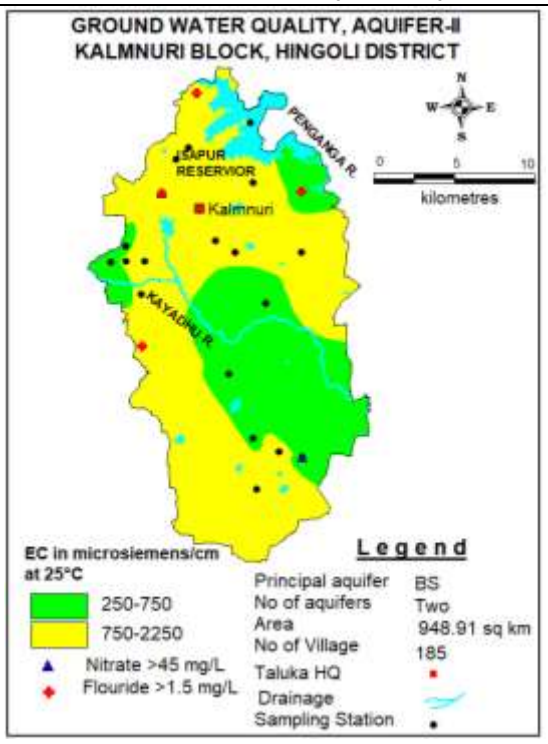
4. GROUND WATER QUALITY

4.1 Aquifer-I/ Shallow Aquifer

EC up to 750 µS/cm is observed as continuous patch from north to east while EC values between 750 to 2250 µS/cm are observed in major part of the block. Ground water is suitable for all purposes in major part of the block except Dongarkhada village that is affected by Nitrate contamination and village Umara is affected by Fluoride contamination (F=2.3 mg/L).

4.2 Aquifer II/Deeper Aquifer

EC up to 750 µS/cm is observed in east central, eastern and western parts of the block while EC values between 750 to 2250 µS/cm are found in major part of the block. Ground water is suitable for all purposes except Shivani and Waranga villages that are having nitrate more than 45 mg/L and Morwad, Wakodi, Shivani and Bolda villages are affected by Fluoride contamination (F>1.5 mg/L). These villages are not fit for drinking purpose without treatment.

Phreatic Aquifer (Aquifer-I)	Semi confined/Confined Aquifer (Aquifer II)
	

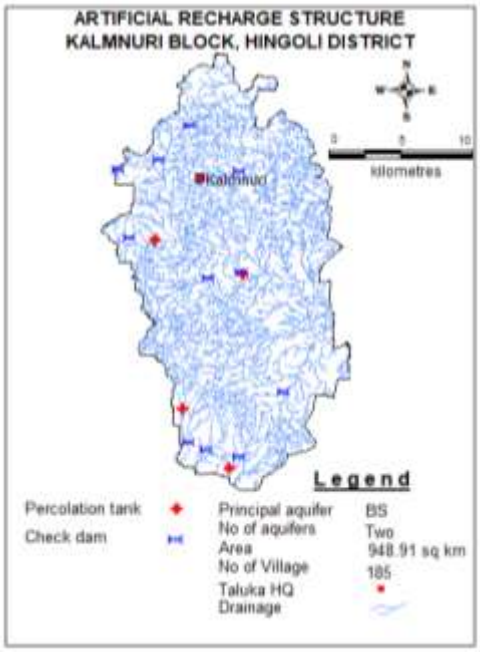
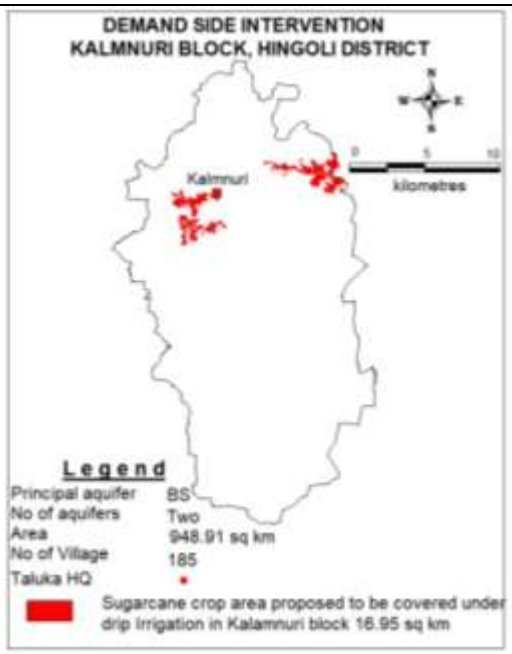
5. GROUND WATER RESOURCE

5.1 Aquifer-I/ Shallow Aquifer

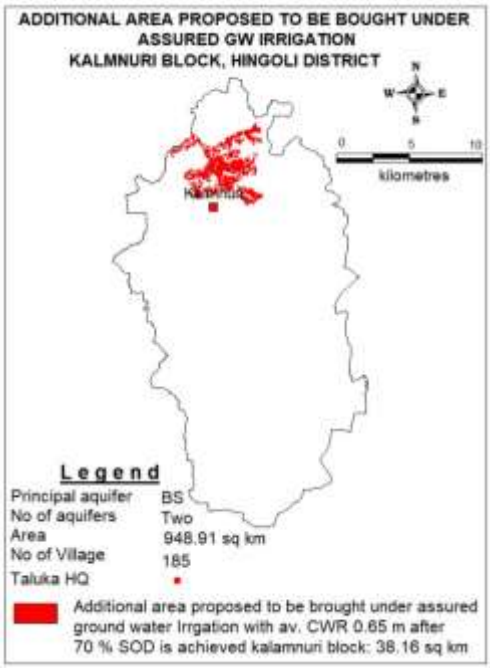
Ground Water Recharge Worthy Area (Sq. km.)	948.91
Total Annual Ground Water Recharge (MCM)	149.74
Natural Discharge (MCM)	7.48
Net Annual Ground Water Availability (MCM)	142.26
Existing Gross Ground Water Draft for irrigation (MCM)	81.24
Existing Gross Ground Water Draft for domestic and industrial water supply (MCM)	3.77
Existing Gross Ground Water Draft for All uses (MCM)	85.02
Provision for domestic and industrial requirement supply to 2025(MCM)	12.22

Net Ground Water Availability for future irrigation development (MCM)			48.30		
Stage of Ground Water Development (%)			59.76		
Category			**SAFE**		
5.2 Aquifer-II/Deeper Aquifer					
Semi confined/Confined Aquifer (Basalt)					
Total Area (Sq. km.)	Mean aquifer thickness (m)	Av (Sy/S)	Av. Piezometric Head (m)	Resources above confining layer (MCM)	Resource within confining Aquifer (MCM)
948.91	3.00	0.002/0.0000145	20.5	0.282	5.69
6.0. GROUND WATER RESOURCE MANAGEMENT					
Available Resource (MCM)			142.26		
Gross Annual Draft (MCM)			85.02		
6.1. Supply Side Management					
SUPPLY (MCM)					
Agricultural Supply -GW			81.24		
Agricultural Supply -SW			3.44		
Domestic Supply - GW			3.77		
Domestic Supply - SW			0.94		
Total Supply			**89.39**		
Area of Block (Sq. km.)			948.91		
Area suitable for Artificial recharge (Sq. km.)			49.66		
Type of Formation			Hard Rock	Soft Rock	
Area feasible for Artificial Recharge (WL >5mbgl) (Sq. km.)			49.66	-	
Volume of Unsaturated Zone (MCM)			99.32	-	
Average Specific Yield			0.02	-	
Volume of Sub Surface Storage Space available for Artificial Recharge (MCM)			10.20	-	
Surplus water Available (MCM)			1.11	-	
Proposed Structures			Percolation Tank (Av. Gross Capacity-100 TCM*2 fillings = 200 TCM)	Check Dam (Av. Gross Capacity-10 TCM * 3 fillings = 30 TCM)	
Number of Structures			4	11	
Volume of Water expected to be conserved / recharged @ 75% efficiency (MCM)			0.6	0.24	
Proposed Structures					
RTRWH Structures – Urban Areas					
Households to be covered (25% with 50 m^2area)			45,176		
Total RWH potential (MCM)			1.9087		

Rainwater harvested / recharged @ 80% runoff co-efficient	1.5269 Economically not viable & Not Recommended
6.2. Demand Side Management	
Micro irrigation techniques	
Sugarcane crop area proposed for drip irrigation (sq. km.)	16.95
Volume of Water Saving by use of drip (MCM) Surface Flooding req- 2.45 m. Drip Req. -1.88, WUE- 0.57 m	9.66
Proposed Cropping Pattern change	
Irrigated area under Water Intensive Crop (ha)	Not proposed
Water Saving by Change in Cropping Pattern	Nil
Alternate Sources	Nil
6.3. EXPECTED BENEFITS	
Net Ground Water Availability (MCM)	142.26
Additional GW resources available after Supply side interventions (MCM)	0.83
Ground Water Availability after Supply side intervention	143.09
Existing Ground Water Draft for All Uses (MCM)	85.02
GW draft after Demand Side Interventions (MCM)	75.36
Present stage of Ground Water Development (%)	59.76
Expected Stage of Ground Water Development after interventions (%)	52.67
Other Interventions Proposed, if any	
Alternate Water Sources Available	Nil
Recommendation	
Ground water development is recommended to bring the stage of ground water development from 52.67 % to 70%	
6.4. Development Plan	
Volume of water available for GWD to 70% (MCM)	24.80
Proposed Number of DW (@ 1.5 ham for 90% of GWR Available for development)	1488
Proposed Number of BW (@ 1 ham for 10% of GWR Available for development)	248
Additional Area to be brought under assured GW irrigation with av. CWR of 0.65 m (sq. km.)	38.16
Regulatory Measures	**60 m**
Supply Side Interventions	**Demand Side Interventions**

Proposed locations for AR structures	Sugarcane Crop Area proposed for drip Irrigation
	

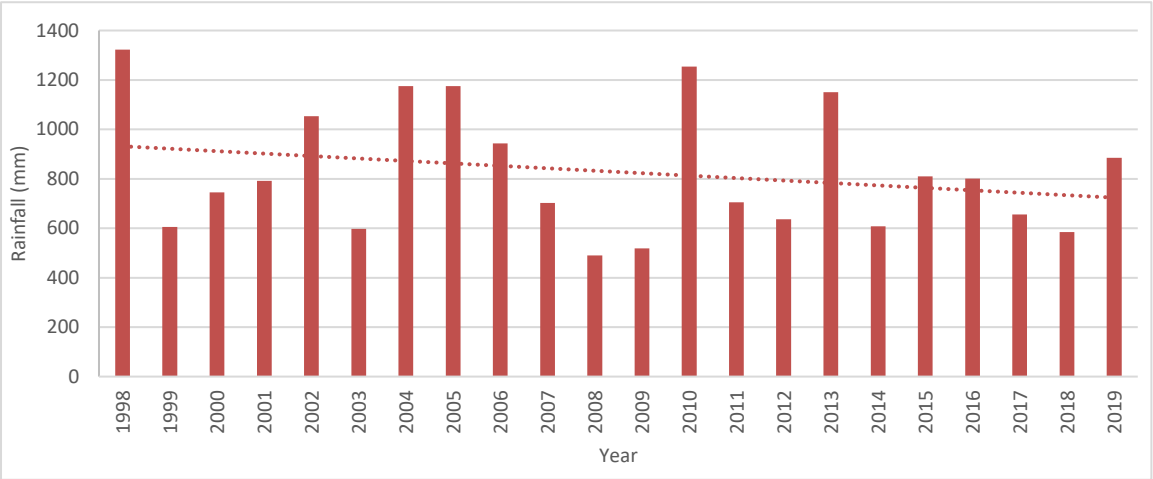
Expected Benefits: ADDITIONAL AREA PROPOSED TO BE BOUGHT UNDER ASSURED GW IRRIGATION



9.5 SENGAON BLOCK

1. SALIENT FEATURES		
1.1 Introduction		
Block Name	**SENGAON**	
Geographical Area (Sq. km.)	1241.21 Sq. km.	
Hilly Area (Sq. km.)	60.00 Sq. km.	
Poor Ground Quality Area (Sq. km.)	Nil	
Population (2011)	2,04,122	
Climate	Sub-Tropical	
1.2 Rainfall Analysis		
Normal Rainfall	898.9 mm	
Annual Rainfall (2019)	885.1 mm	
Decadal Average Annual Rainfall (2010-19)	808.8 mm	
Long Term Rainfall Analysis (1998-2019)	Declining Trend 9.90 mm/year Probability of Normal and Excess Rainfall - 46% & 27% Probability of Drought -: 27% Moderate Drought	

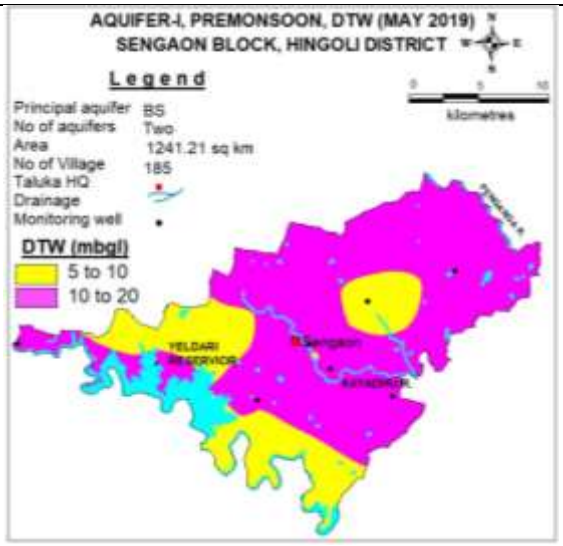
Rainfall Trend Analysis (1998 to 2019)



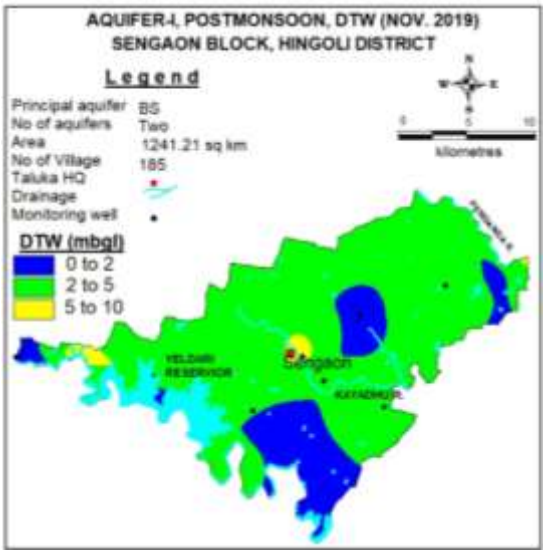
EQUATION OF TREND LINE: y = -9.9011x + 941.61

1.3. Geomorphology, Soil & Geology		
Geomorphic Unit	Plateau Undissected and Slightly Dissected 0 to 1 m weathered thickness, Plateau weathered with 1 to 5 m weathered thickness, Escarpment Slope and Butte	
Soil	Clayey soil (shallow to very deep; 10 to >100 cm depth), Clay loam, Sandy clay loam, Gravelly sandy loam, Gravelly Clay loam and Silty Clay soils.	
Geology	Deccan Traps (Basalt) Age: Late Cretaceous to Eocene	
1.4. Hydrology & Drainage		
Drainage	Kayadhu and Penganga Rivers	
Hydrology (*Reference Year: June 2018)*	Major project	**Completed:** Nil **Ongoing:** Nil

		Medium project	**Completed:** Nil **Ongoing:** Nil
		Irrigation Project (>250 Ha)	**Completed:** 07 irrigation projects; generating a gross irrigation Potential of 2522 ha. **Ongoing:** Nil
		Irrigation Project (<250 Ha)	**Completed:** 53; irrigation projects generating a gross irrigation Potential of 1455 ha. **Ongoing:** Nil
1.5. Land Use, Agriculture, Irrigation & Cropping Pattern			
Geographical Area		1241.21 Sq. km.	
Forest Area		62.13 Sq. km.	
Cultivable Area		917.94 Sq. km.	
Net Sown Area		917.94 Sq. km.	
Double Cropped Area		201.33 Sq. km.	
Area under Irrigation	Surface Water	3.40 Sq. km.	
	Ground Water	38.00 Sq. km.	
Principal Crops *(Reference year 2018)*		**Crop Type**	**Area (Sq. km.)**
		Oil Seeds	632.53
		Pulses	339.18
		Cereals	70.10
		Cotton	44.97
		Sugarcane	0.11
Horticultural Crops		Citrus fruits	0.70
		Mango	0.20
		Others	0.30
1.6. Water Level Behaviour			
1.6.1. Aquifer-I/Shallow Aquifer			
Pre-Monsoon (May-2019)		**Post-Monsoon (November-2019)**	
Water levels less than 10 mbgl have been observed in western and isolated patch in central part of the block; Water levels between 10 to 20 mbgl have been observed in major part of the block and cover about 822.7 sq. km. area.		Water levels less than 5 mbgl have been observed in major part of the block; Water levels between 5 to 10 mbgl have been observed in isolated patches in central and western parts of the block and cover about 20.38 sq. km. area.	
Pre-Monsoon Water Level (May 2019)		**Post-Monsoon Water Level (Nov. 2019)**	



WL>10 mbgl 822.7 sq. km.

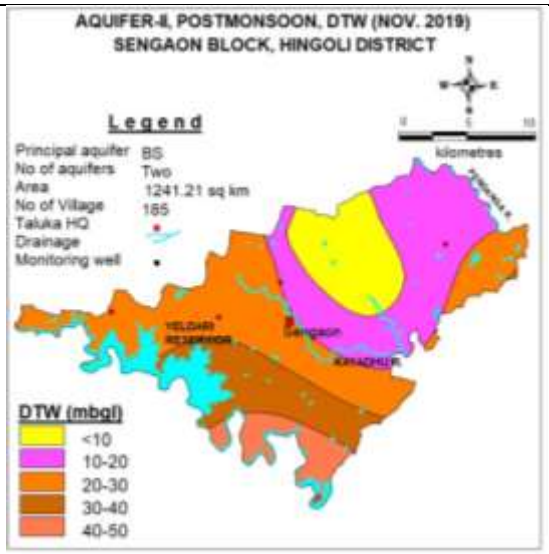


WL>5 mbgl 305.95 sq. km.

1.6.2. Aquifer-I/Deeper Aquifer

Post-Monsoon Water Level (Nov. 2019)

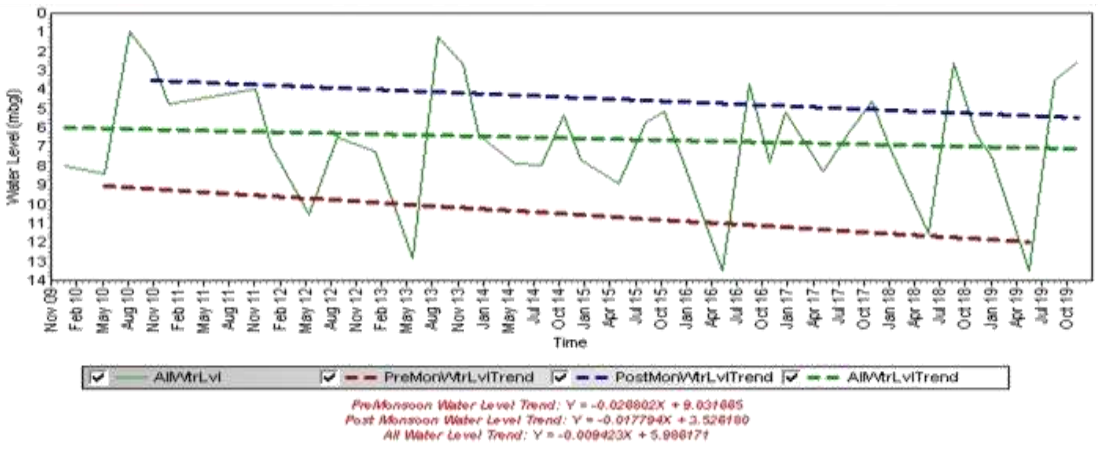
Water level <20 mbgl is observed in north eastern part of the block. Water level between 20-30 mbgl is observed in central and eastern parts of the block; more than 30 mbgl has been observed in southern part of the block and cover about 259 sq. km. area of the block.



WL>30 mbgl 259 sq. km.

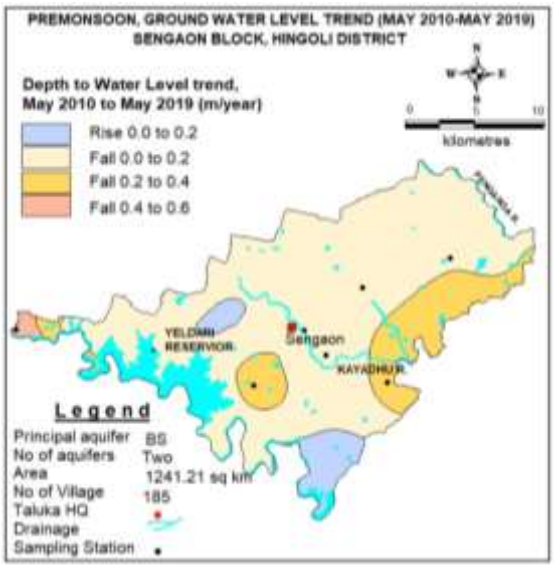
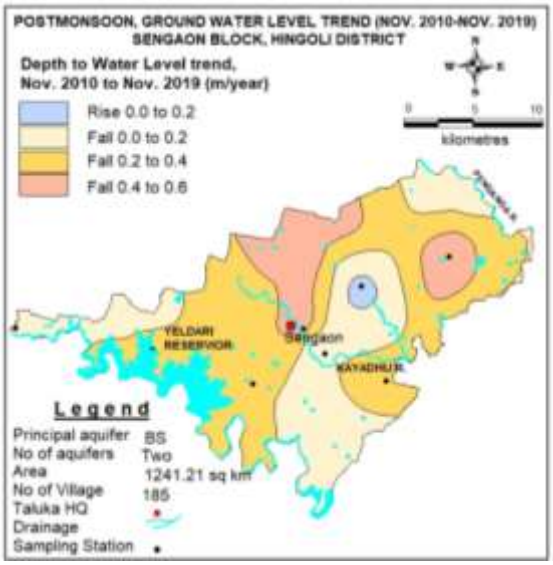
1.7. Hydrographs:

Site Name: Hatta, State: Maharashtra District :Hingoli Tehsil: Hingoli Block: Hingoli Village: Hatta



Hydrograph shows Pre-monsoon falling water level trend @ 0.321 m/year and Post monsoon falling water level trend @ 0.213 m/year

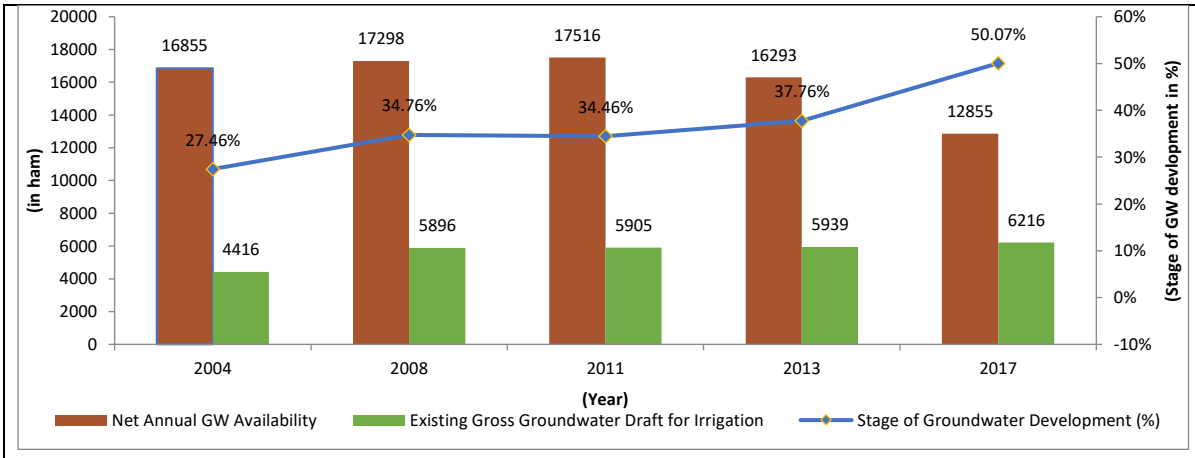
1.8. Water Level Trend (2010-19)

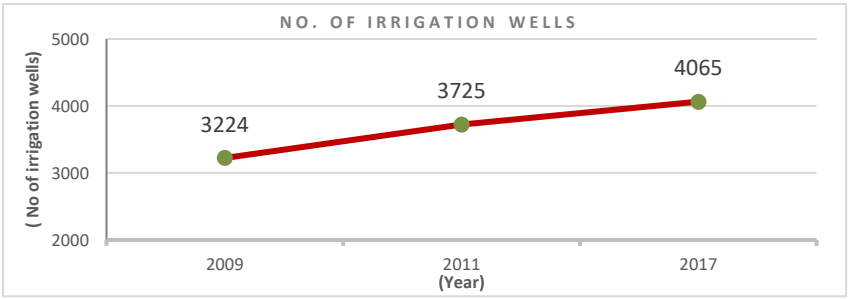
Pre-Monsoon trend	**Post-Monsoon trend**
Rising 0.0048 to 0.1145 m/year Falling 0.0066 to 0.5063 m/year	Rising 0.0321 m/year Falling 0.060 to 0.5142 m/year
Major part of the block shows declining trend up to 0.2 m/year while rise in water level up to 0.2 m/year has been observed in southern and isolated patch in west central parts of the block. Declining trend more than 0.2 m/ Year has been observed in eastern and western parts and isolated patch in central part of the block and cover about 181 sq. km. area.	Declining water level trend up to 0.2 m/year has been observed in northern and southern parts of the block while rise in water level up to 0.2 m/year has been observed in isolated patch in central part of the block. Declining trend > 0.2 m/year has been observed in major part of the block and cover 748 sq. km. area.
Pre-Monsoon Water Level Trend (2010-19)  **Declining trend @>0.2 m/year 181.42 sq. km.**	**Post-Monsoon Water Level Trend (2010-19)**  **Declining trend @>0.2 m/year 748 sq. km.**

2. Ground Water Issues

Increased Stage of Ground Water:

The stage of ground water development has continuously increased from 27.46% (2004) to 50.07% (2017). Further, the draft for irrigation and number of irrigation wells have also increased from 44.16 MCM to 62.16 MCM and 3224 to 4065 wells implying increased utilization of ground water resources in agriculture sector.



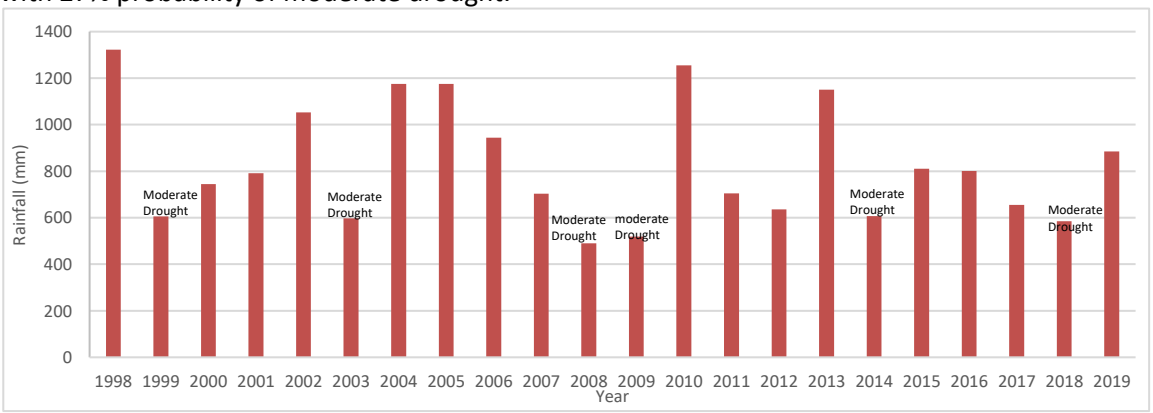


Declining water level Trend : -

- Premonsoon (2010-19): decline in water level trend more than 0.2 m/year is observed in about 181 sq. km. covering about 16 % area of the block.
- Postmonsoon (2010-19): decline in water level trend more than 0.2 m/year is observed in about 748 sq. km. covering about 66 % area of the block.

Low rainfall and Drought: -

- Based on the rainfall analysis for the period 1998-2019; the average rainfall for the period 1998 to 2019 is 827.7 mm. In addition, the long-term rainfall analysis indicates a falling trend @ 9.9 mm/ year with 27% probability of moderate drought.

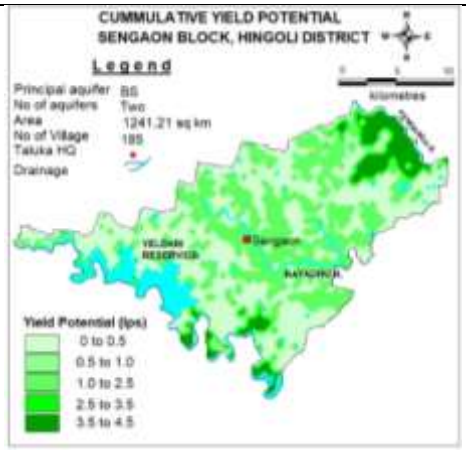


Ground Water Quality: -

Nitrate Contamination: In shallow aquifer, out of 8 samples 3 samples i.e., 38% samples show nitrate contamination.

Low yielding Aquifer resulting poor sustainability:

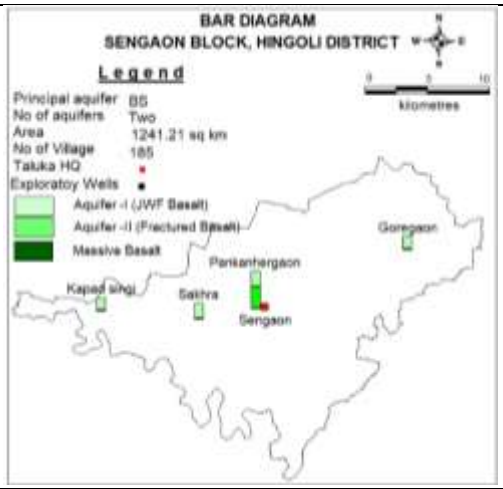
Limited extent of porous and pervious zone, because of predominance of secondary porosity that has evolved from prevailing erratic joint pattern and also absence of primary porosity, results in poor sustainability of the aquifers. Major part of the block (86% area) has low yield potential (< 1 lps) and can sustain pumping only for 1-1.5 hrs.

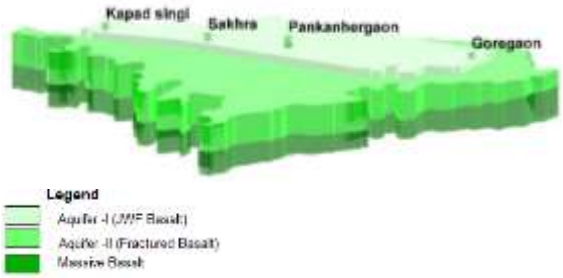


3. AQUIFER DISPOSITION

3.1. Number of Aquifers	Basalt –Aquifer-I, Aquifer-II

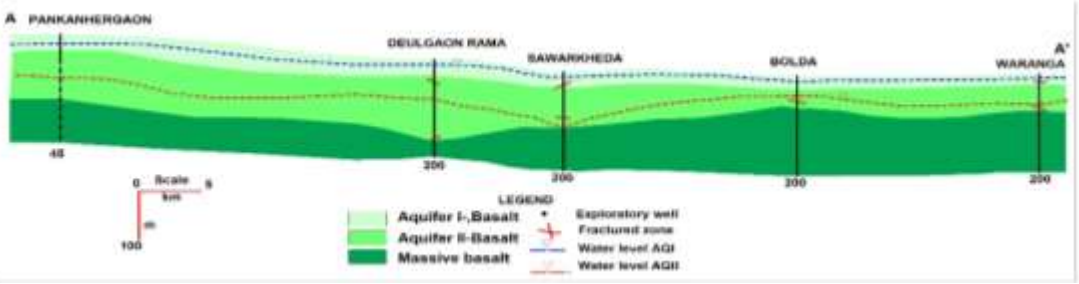
3.2. Lithological disposition





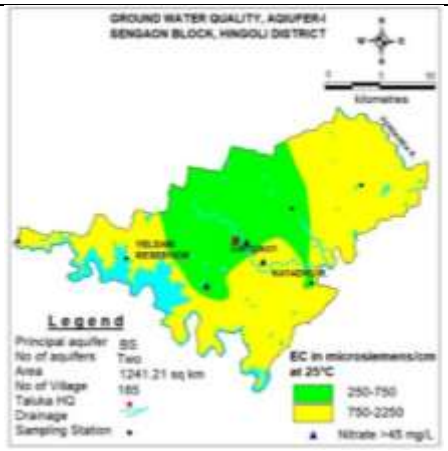
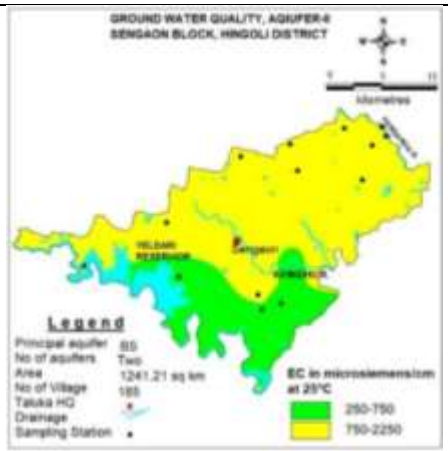
3.3. Cross Section

Section AA'



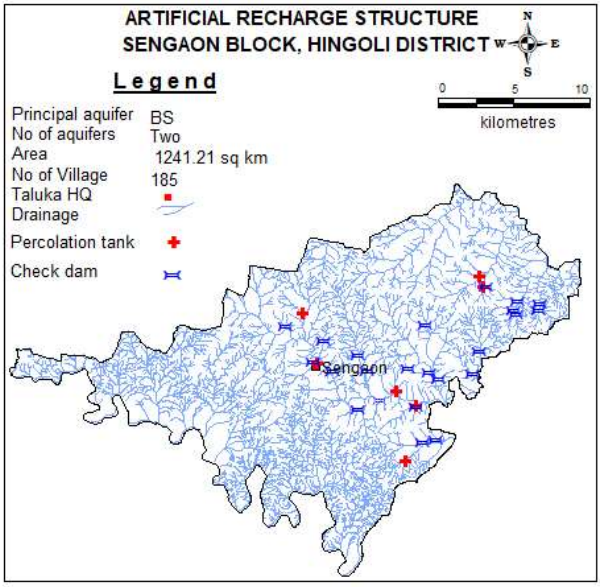
3.4. Basic Aquifer Characteristics

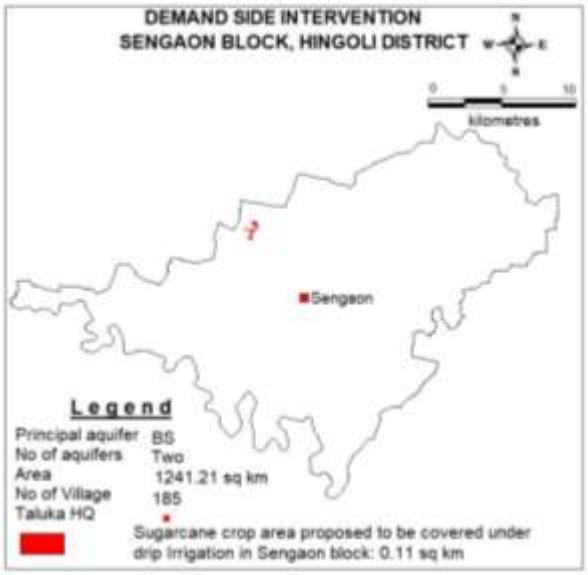
Major Aquifers	**Basalt (Deccan Traps)**	
Type of Aquifer (Phreatic/Semi confined/Confined)	Aquifer-I (Phreatic)	Aquifer-II (Semi confined /confined)
Depth to bottom of Aquifer (mbgl)	8.6 to 18	60 to 129
Fractures/Granular zones encountered (mbgl)	up to 18	up to 129
Granular /Weathered/Fractured rocks thickness (m)	8 to 14	1 to 3
SWL (mbgl)	0.3 to 15.1	4 to 26

Specific yield/Storativity (S)	0.019 to 0.028	*0.00003 -0.00005
Transmissivity (T)	*30 - 50 m^2/day	0.51 to 15.17 m^2/day
Yield	up to 100 m^3/day	up to 2.5 lps
Sustainability	2 to 4 hrs	1 to 3 hrs
Suitability for drinking/ irrigation	Suitable for both (except Nitrate affected villages for drinking)	Suitable for both (drinking and irrigation)
	* values taken from Risod block, Washim District.	
4. GROUND WATER QUALITY		
Phreatic Aquifer (Aquifer-I)	**Semi confined/Confined Aquifer (Aquifer II)**	
4.1 Aquifer-I/ Shallow Aquifer		
EC up to 750 µS/cm is observed in northern part of the block and EC values between 750 to 2250 µS/cm are observed in major part of the block. Ground water is suitable for all purposes in major part of the block except Songaon, Kutha and Hutta villages that are affected by nitrate contamination and in these villages ground water is not suitable for drinking purpose without treatment.		
4.2 Aquifer II/Deeper Aquifer		
EC up to 750 µS/cm is observed in southern part of the block and EC values between 750 to 2250 µS/cm are observed in major part of the block and Ground water is suitable for all purposes.		
		
5. GROUND WATER RESOURCE		
5.1 Aquifer-I/ Shallow Aquifer		
Ground Water Recharge Worthy Area (Sq. km.)	1181.21	
Total Annual Ground Water Recharge (MCM)	135.31	
Natural Discharge (MCM)	6.76	
Net Annual Ground Water Availability (MCM)	128.55	
Existing Gross Ground Water Draft for irrigation (MCM)	62.15	
Existing Gross Ground Water Draft for domestic and industrial water supply (MCM)	2.20	
Existing Gross Ground Water Draft for All uses (MCM)	64.36	
Provision for domestic and industrial requirement supply to 2025(MCM)	17.04	
Net Ground Water Availability for future irrigation development (MCM)	49.13	

Stage of Ground Water Development (%)			50.07		
Category			**SAFE**		
5.2 Aquifer-II/Deeper Aquifer					
Semi confined/Confined Aquifer (Basalt)					
Total Area (Sq. km.)	Mean aquifer thickness (m)	Av. (S/Sy)	Av. Piezometric Head (m)	Resources above confining layer (MCM)	Resource within confining Aquifer (MCM)
1241.21	4.00	0.002/0.0000145	55.5	0.999	9.93
6.0. GROUND WATER RESOURCE MANAGEMENT					
Available Resource (MCM)			128.55		
Gross Annual Draft (MCM)			64.36		
6.1. Supply Side Management					
SUPPLY (MCM)					
Agricultural Supply -GW			62.15		
Agricultural Supply -SW			2.21		
Domestic Supply - GW			2.2		
Domestic Supply - SW			0.55		
Total Supply			**67.12**		
Area of Block (Sq. km.)			1241.21		
Area suitable for Artificial recharge (Sq. km.)			124.20		
Type of Formation			**Hard Rock**		
Area feasible for Artificial Recharge (WL >5mbgl) (Sq. km.)			124.20		
Volume of Unsaturated Zone (MCM)			248.4		
Average Specific Yield			0.02		
Volume of Sub Surface Storage Space available for Artificial Recharge (MCM)			4.968		
Surplus water Available (MCM)			2.78		
Proposed Structures			Percolation Tank (Av. Gross Capacity-100 TCM*2 fillings = 200 TCM)	Check Dam (Av. Gross Capacity-10 TCM * 3 fillings = 30 TCM)	
Number of Structures			10	28	
Volume of Water expected to be conserved / recharged @ 75% efficiency (MCM)			1.5	0.59	
Proposed Structures					
RTRWH Structures – Urban Areas					
Households to be covered (25% with 50 m^2area)			40,764		
Total RWH potential (MCM)			1.6509		
Rainwater harvested / recharged @ 80% runoff co-efficient			1.32 Economically not viable & Not Recommended		
6.2. Demand Side Management					
Micro irrigation techniques					

Sugarcane crop area proposed for drip irrigation (sq. km.)	0.11
Volume of Water Saving by use of drip (MCM) Surface Flooding req- 2.45 m. Drip Req. – 1.88, WUE- 0.57 m	0.06
Proposed Cropping Pattern change	
Irrigated area under Water Intensive Crop (ha)	Not proposed
Water Saving by Change in Cropping Pattern	Nil
Alternate Sources	Nil
6.3. EXPECTED BENEFITS	
Net Ground Water Availability (MCM)	128.55
Additional GW resources available after Supply side interventions (MCM)	2.1
Ground Water Availability after Supply side intervention	130.64
Existing Ground Water Draft for All Uses (MCM)	64.36
GW draft after Demand Side Interventions (MCM)	64.30
Present stage of Ground Water Development (%)	50.07
Expected Stage of Ground Water Development after interventions (%)	49.22
Other Interventions Proposed, if any	
Alternate Water Sources Available	Nil
Recommendation	
Ground water development is recommended to bring the stage of ground water development from 49.22% to 70%	
6.4. Development Plan	
Volume of water available for GWD to 70% (MCM)	27.15
Proposed Number of DW (@ 1.5 ham for 90% of GWR Available for development)	1629
Proposed Number of BW (@ 1 ham for 10% of GWR Available for development)	271
Additional Area to be brought under assured GW irrigation with av. CWR of 0.65 m (sq. km.)	41.77
Regulatory Measures	**60 m**
Supply Side Interventions	**Demand Side Interventions**
Proposed locations for AR structures	**Sugarcane Crop Area proposed for drip Irrigation**





***EXPECTED BENEFITS*: ADDITIONAL AREA PROPOSED TO BE BOUGHT UNDER ASSURED GW IRRIGATION**

10. ANNEXURE

ANNEXURES

Annexure I: Salient Features of Ground Water Exploration (CGWB), Hingoli District

S. No.	Taluka	Formation	Wells			Depth	SWL	Discharge (lps)	Zones (mbgl)
			EW	OW	Pz	(mbgl)	(mbgl)		
1	Hingoli	Basalt	3	0	1	30- 200.2	3.8-112.4	0.14-3.77	29-31.50, 34-35, 40-47,56-61, 74-76.50,79-81, 164-167
2	Aundha (Nagnath)	Basalt	2	0	1	50- 200.2	3.1-55.5	0.14-0.99	17-18,21-22, 68-72,141-143,195-196
3	Kalmnuri	Basalt	4	0	0	200.2	49-66.4	0.07-3.12	16-18,44-48,59-63, 74-76,128-130.50
4	Basmath	Basalt	1	0	1	30- 200.2	112.4	0.38	16-18,116-119
Total			10	0	3	30-200.2	3.1 to 112.4	0.14 to 3.77	16-196

Annexure II: Details of GW exploration under of Hingoli district

Sl. No	Agency	Block	Village	Type of Well	Topo sheet	Latitude	Longitude	Altitude (mamsl)	Year	Depth drilled (mbgl)	Depth of casing (mbgl)	Aquifer zones encountered (mbgl)	Aquifer	SWL (mbgl)	Discharge (lps)	DD(m)	Transmissivity (m^2/day)
1	CGWB	Hingoli	Belura	EW	56E/1	19.872	77.204	513	2004-05	200.2	5.4	34-35, 56-61	F VB & MB	43.5	0.99	35.47	2.15
2	CGWB	Hingoli	Deulgaon Rama	EW	56E/2	19.727	77.087	472	2004-05	200.2	5.5	40 -47, 164 -167	F VB	39.4	3.77	-	
3	CGWB	Hingoli	Sawarkheda	EW	56E/2	19.704	77.191	444	2004-05	200.2	22.25	29 -31.5, 74 -76.5	F VB	112.4	1.73	-	
4	CGWB	Kalmnuri	Shivani (Kh)	EW	56E/6	19.685	77.280	450	2004-05	200.2	5.4	79 -81	VB	49	0.07	-	
5	CGWB	Kalmnuri	Wakodi	EW	56E/6	19.687	77.420	423	2004-05	200.2	5.5	44 -48, 128 -130.5	F VB	61.4	0.38	-	
6	CGWB	Kalmnuri	Waranga	EW	56E/7	19.436	77.422	442	2004-05	200.2	5.5	16 -18, 74 -76	F VB	66.4	0.38	-	
7	CGWB	Kalmnuri	Bolda	EW	56E/6	19.5408	77.261	436	2004-05	200.2	5.5	59-63	F MB	40.39	3.12	19.75	15.17
8	CGWB	Aundha	Purjal	EW	56E/3	19.4533	77.0177	414	2004-05	200.2	5.4	17 -18, 68 -72, 195 -196, 141 -143	W V & F MB	6.53	0.99	46.8	0.51
9	CGWB	Aundha	Undegaon	EW	56A/14	19.500	76.886	400	2004-05	200.2	11.4	21 -22	F VB	55.5	0.14	-	
10	CGWB	Basmath	Asegaon	EW	56B/9	19.275	77.201	367	2004-05	200.2	5.5	16 -18, 116 -119	F V & MB	112.4	0.38	-	
11	CGWB	Hingoli	Basamba	Pz	56E/1	19.770	77.183	463	1997-98	30	5.5	6.2-9.2	FMB	3.8	0.14	-	
12	CGWB	Aundha	Aundha	Pz	56E/4	19.541	77.041	470	1997-98	50	30	21-29.50, 45-48	WF &FMB	3.1	traces	-	
13	CGWB	Basmath	Barashiv	Pz	56A/15	19.433	76.958	408	1997-98	30	3.35	-	-	-	-	-	
14	GSDA	Sengaon	Pankanhergaon	Pz	56A/13	19.875	76.833	522	2000	45	12	9-10.50	WFB	10.25	traces	-	
15	GSDA	Sengaon	Kapad singi	Pz	56A/9	19.841	76.630	516	2000	30	6.1	25-27	WFB	25	0.07	-	
16	GSDA	Hingoli	Adgaon	Pz	56E/6	19.812	77.183	503.15	2000	30	6.1	10-11.50	WFB	11		-	
17	GSDA	Sengaon	Sakhra	Pz	56A/13	19.835	76.758	535.1	2000	30	6.1	18-21	WFB	18		-	
18	GSDA	Sengaon	Goregaon	Pz	56E/1	19.918	77.031	506	2000	26	5	11.50-12	FMB	4.6	0.11	-	

Annexure III: Water level Data of monitoring wells in Hingoli District

S. No.	Block	Village	Agency	Latitude	Longitude	Elevation (amsl)	DTW (mbgl)	
							May-19	Nov-19
1	Hingoli	Kanhergaon	CGWB	19.933	77.150	509	12.5	6.2
2	Hingoli	Narsi	CGWB	19.754	77.014	467	10.5	-
3	Basmath	Babulgaon	CGWB	19.267	77.133	401	10	2.7
4	Sengaon	Hatta	CGWB	19.767	76.800	508	13.5	2.55
5	Aundha	Aundha Nagnath	CGWB	19.542	77.042	469	7.15	6.3
6	Aundha	Barashiv-1 (Jawla bazar)	CGWB	19.439	76.958	405	10.8	5.95
7	Basmath	Chondi Amba-1	CGWB	19.433	77.150	412	10.4	-
8	Basmath	Aral-1	CGWB	19.333	76.983	392	20.7	6.4
9	Kalmnuri	Kalmnuri-1 (Morwadi)	CGWB	19.667	77.317	462	8.29	3.85
10	Aundha	Hivra	CGWB	19.637	77.083	458.9	13.7	3.1
11	Kalmnuri	Umara	CGWB	19.693	77.258	465.3	3.95	2.7
12	Kalmnuri	Dongarkada	CGWB	19.378	77.375	394.3	11.4	2.4
13	Basmath	Chikhli	CGWB	19.321	76.960	399.8	20.84	3.35
14	Basmath	Palasgaon	CGWB	19.313	77.233	395.8	15.5	-
15	Basmath	Kautha-Khudnapur	CGWB	19.362	77.190	391.1	18	3.45
16	Basmath	Kurundha	CGWB	19.406	77.231	394.3	14.9	2.9
17	Kalmnuri	Bolda	CGWB	19.548	77.275	433.7	7.4	4.1
18	Sengaon	Khutha	CGWB	19.828	76.859	503.7	13.9	5.35
19	Sengaon	Jambharun-Rodge	CGWB	19.771	76.957	493.7	15.5	3.65
20	Hingoli	Sawad	CGWB	19.737	77.061	471.3	5.2	-
21	Hingoli	Adgaon	CGWB	19.896	77.164	512.1	13	3.55
22	Kalmnuri	Salwa	CGWB	19.608	77.384	436	12	2.5
23	Kalmnuri	Balapur Akhada-1	CGWB	19.542	77.411	430	11.15	2.6
24	Kalmnuri	Tavha	CGWB	19.521	77.340	436.3	11.35	4
25	Hingoli	Hingoli-1	CGWB	19.709	77.154	452	11.3	3.5
26	Basmath	Vai Gorakhnath	CGWB	19.450	77.138	420.4	12.65	4.7
27	Basmath	Basmat Shivar	CGWB	19.326	77.126	407.7	12.8	7.1
28	Sengaon	Sengaon	CGWB	19.801	76.885	499.1	14.8	2.05
29	Basmath	Loni Bk	GSDA	19.248	77.112	396	14.1	0.8
30	Basmath	Hayat Nagar	GSDA	19.275	77.069	403	11.1	5.5
31	Basmath	Takalgaon	GSDA	19.293	77.179	375.9	16.5	2
32	Basmath	Malota	GSDA	19.327	77.211	381	16.1	2.6
33	Basmath	Basmath	GSDA	19.328	77.158	396.3	13.9	1.8
34	Basmath	Aral	GSDA	19.334	76.997	387	15.7	9
35	Basmath	Khandegaon	GSDA	19.344	77.101	401.4	20.9	8
36	Basmath	Borala	GSDA	19.371	77.181	391	17.6	7
37	Basmath	Sawangi bk	GSDA	19.378	76.896	388	20.2	4.2
38	Kalmnuri	Redgaon	GSDA	19.392	77.303	393	11.4	2.7
39	Kalmnuri	Bhategaon	GSDA	19.392	77.391	406.7	7.3	2.5
40	Aundha	Tapowan	GSDA	19.424	76.933	392	11.4	4
41	Aundha	Jawala Bazar II	GSDA	19.461	76.979	403.7	12.8	2.2
42	Aundha	Shiradh Shahapur	GSDA	19.469	77.095	433.3	9.7	1.7
43	Aundha	Salna	GSDA	19.525	76.938	401	9.2	1.6
44	Kalmnuri	Akhada Balapur	GSDA	19.533	77.419	424.9	11.7	3
45	Kalmnuri	Bolda	GSDA	19.540	77.261	435	11.1	2.6
46	Aundha	Aundha	GSDA	19.542	77.042	469	9.1	1.8
47	Aundha	Ajanwada	GSDA	19.579	77.025	489	13.4	1
48	Aundha	Suregaon	GSDA	19.583	77.076	455.2	9.6	1.8
49	Kalmnuri	Nandapur	GSDA	19.597	77.243	437	12.9	5.2
50	Kalmnuri	Arati	GSDA	19.627	77.363	449.4	12.8	0.5
51	Kalmnuri	Tuppa	GSDA	19.629	77.419	444	11.8	2.5

S. No.	Block	Village	Agency	Latitude	Longitude	Elevation (amsl)	DTW (mbgl)	
							May-19	Nov-19
52	Sengaon	Pimpri Lingi	GSDA	19.639	76.893	411	8.1	0.9
53	Kalmnuri	Shivani bk	GSDA	19.655	77.417	438.7	10.1	2.6
54	Kalmnuri	Bibgavhan	GSDA	19.661	77.373	479	9.9	0.2
55	Hingoli	Karanjala	GSDA	19.685	77.013	482	9.4	2.8
56	Hingoli	Hingoli	GSDA	19.717	77.147	466.7	13.4	1.5
57	Sengaon	Limbala Tanda	GSDA	19.739	76.769	455.3	9.3	2.8
58	Sengaon	Hatta II	GSDA	19.754	76.800	502	9.85	1.3
59	Hingoli	Narsi namdeo	GSDA	19.755	77.013	469	11.7	4.3
60	Hingoli	Sarkali	GSDA	19.771	76.989	470	11.2	3.3
61	Hingoli	Idoli	GSDA	19.776	77.073	460	13.4	1.2
62	Hingoli	Chincholi Rumna	GSDA	19.776	77.248	495	8.2	0.9
63	Sengaon	Sonesangvi	GSDA	19.786	76.685	469.1	11.2	1.9
64	Hingoli	Gadibori	GSDA	19.799	77.377	441	8.6	2.5
65	Hingoli	Kalgaon	GSDA	19.801	77.166	480.3	5.3	1.6
66	Hingoli	Limbi	GSDA	19.804	77.293	472.7	11.2	2
67	Sengaon	Khadki	GSDA	19.806	76.681	467.8	10.9	2.6
68	Hingoli	Malhiwara	GSDA	19.827	77.171	528	12.3	1.5
69	Sengaon	Ban	GSDA	19.829	76.519	484	11.4	0.3
70	Sengaon	Dhanora Bk	GSDA	19.829	76.596	466	10.3	6
71	Sengaon	Sakhara	GSDA	19.838	76.767	536	9	2.3
72	Sengaon	Kapadsingi	GSDA	19.841	76.648	482	8.2	3.2
73	Sengaon	Ajegaon	GSDA	19.875	76.928	504	9	1.5
74	Hingoli	Bhatsawangi Tanda	GSDA	19.879	77.293	450.3	8.4	2
75	Hingoli	Adgaon	GSDA	19.894	77.183	504	11.1	2.3
76	Sengaon	Sawana	GSDA	19.925	77.086	483.3	10.1	1.8
77	Sengaon	Goregaon II	GSDA	19.925	77.031	507.9	10.5	4.2
78	Sengaon	Shegaon II	GSDA	19.946	76.838	555	13.4	3.5
79	Sengaon	Bhagwati	GSDA	19.996	77.040	489.7	-	3
80	Sengaon	Kolsa	CGWB	19.817	76.867	496	9	4.2

Annexure IV: long term ground Water trend (2010-2019)

S.No.	Block	Village	Agency	Depth of Well	Premonsoon trend (m/year)		Postmonsoon trend (m/year)	
					Rise	Fall	Rise	Fall
1	Aundha	Aundha (Nagnath)	CGWB	8.5	0.0502	-	-	-0.0712
2	Aundha	Barashiv-1	CGWB	14	-	-0.2240	-	-0.1676
3	Aundha	Tapowan	GSDA	11.5	-	-0.1170	-	-0.1839
4	Aundha	Jawala Bazar I	GSDA	11	-	-0.4524	-	-0.1429
5	Aundha	Shiradh Shahapur	GSDA	10.1	0.0048	-	-	-0.1630
6	Aundha	Salna	GSDA	10.1	0.1667	-	-	-0.2455
7	Aundha	Ajanwada	GSDA	14.9	-	-0.1561	-	-0.2248
8	Aundha	Suregaon	GSDA	9.6	-	-0.3291	-	-0.1182
9	Basmath	Babulgaon	CGWB	10	-	-0.3652	0.3149	-
10	Basmath	Aral-1	CGWB	17.65	-	-1.5270	-	-0.2675
11	Basmath	Loni Bk	GSDA	15	-	-0.6733	-	-0.2600
12	Basmath	Hayat Nagar	GSDA	11.3	-	-0.2309	-	-0.3436
13	Basmath	Takalgaon	GSDA	17.6	-	-0.3539	-	-0.2588
14	Basmath	Malota	GSDA	17.3	-	-0.2418	-	-0.3109
15	Basmath	Basmath	GSDA	16.9	0.4733	-	0.1118	-
16	Basmath	Khandegaon	GSDA	22.1	-	-1.9524	-	-0.9376
17	Basmath	Borala	GSDA	21.1	-	-0.7061	-	-0.6455
18	Basmath	Sawangi bk	GSDA	25.1	-	-1.0761	-	-0.5434
19	Hingoli	Kanhergaon	CGWB	12.5	-	-0.0938	-	-0.1190
20	Hingoli	Narsi	CGWB	10.5	-	-0.1096	-	-0.7877
21	Hingoli	Adgaon	CGWB	13	-	-0.6036	0.0018	-
22	Hingoli	Karanjala	GSDA	9.4	-	-0.0030	0.1297	-
23	Hingoli	Hingoli	GSDA	15.1	-	-0.8788	-	-0.2094
24	Hingoli	Sarkali	GSDA	11.2	-	-0.3067	-	-0.2909
25	Hingoli	Idoli	GSDA	14.2	-	-0.4109	0.0970	-
26	Hingoli	Chincholi Rumna	GSDA	9.5	-	-0.0218	0.0088	-
27	Hingoli	Gadibori	GSDA	9.7	-	-0.0612	-	-0.2655
28	Hingoli	Kalgaon	GSDA	5.8	0.0782	-	-	-0.2442
29	Hingoli	Limbi	GSDA	12.7	-	-0.0303	-	-0.3679
30	Hingoli	Malhiwara	GSDA	12.3	-	-0.2121	-	-0.0661
31	Hingoli	Bhatsawangi Tanda	GSDA	9.5	-	-0.5109	-	-0.1721
32	Kalmnuri	Kalmnuri-1	CGWB	8.3	-	-0.3632	-	-0.2092
33	Kalmnuri	Bolda	CGWB	9.8	0.2946	-	0.6386	-
34	Kalmnuri	Redgaon	GSDA	13.2	0.5145	-	-	-0.0964
35	Kalmnuri	Bhategaon	GSDA	8.4	0.0788	-	-	-0.0976
36	Kalmnuri	Akhada Balapur	GSDA	11.7	0.0182	-	-	-0.1218
37	Kalmnuri	Nandapur	GSDA	13.5	0.0821	-	-	-0.1830
38	Kalmnuri	Arati	GSDA	17	-	-0.2636	0.0382	-
39	Kalmnuri	Tuppa	GSDA	12.6	0.3158	-	-	-0.2394
40	Kalmnuri	Shivani bk	GSDA	11	-	-0.0200	-	-0.1727
41	Kalmnuri	Bibgavhan	GSDA	10.8	0.0764	-	-	-0.1158
42	Sengaon	Hatta	CGWB	13.5	-	-0.3259	-	-0.2136
43	Sengaon	Khutha	CGWB	15	-	-0.0938	-	-0.4429
44	Sengaon	Pimpri Lingi	GSDA	9.9	0.1145	-	-	-0.1303
45	Sengaon	Limbala Tanda	GSDA	9.45	-	-0.0339	-	-0.3000
46	Sengaon	Sonesangvi	GSDA	11.2	-	-0.1833	-	-0.2430
47	Sengaon	Khadki	GSDA	12.5	-	-0.0067	-	-0.2873
48	Sengaon	Ban	GSDA	15.3	-	-0.5064	-	-0.1261
49	Sengaon	Dhanora Bk	GSDA	10.3	-	-0.1102	-	-0.1830
50	Sengaon	Sakhara	GSDA	9	0.0048	-	-	-0.2612
51	Sengaon	Kapadsingi	GSDA	8.6	-	-0.0400	-	-0.1279

S.No.	Block	Village	Agency	Depth of Well	Premonsoon trend (m/year)		Postmonsoon trend (m/year)	
					Rise	Fall	Rise	Fall
52	Sengaon	Ajegaon	GSDA	9	-	-0.1242	0.0321	-
53	Sengaon	Goregaon I	GSDA	11.5	-	-0.1935	-	-0.5107
54	Sengaon	Sawana	GSDA	10.1	-	-0.1103	-	-0.3115
55	Sengaon	Shegaon I	GSDA	12.75	-	-0.0208	-	-0.5143
56	Sengaon	Bhagwati	GSDA	10.5	-	-0.1650	-	-0.0606
57	Sengaon	Kolsa	CGWB	9	-	-0.0219	-	-0.1942

Annexure V: Results of Chemical analysis of ground water samples, Shallow aquifers (May 2019)

S.No.	Block	Village	Agency	Source	pH	EC	TDS	TH	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	F	iron	SAR	RSC
						µs/cm	Mg/L														
1	Basmath	Vai Gorakhnath	CGWB	DW	8.1	615	326	260	45	35	17	1.7	0	178	34	54	92.00	0.26	-	0.47	-2.22
2	Sengaon	Hatta	CGWB	DW	7.4	732	384	362	100	27	23	0.9	0	303	21	42	80.00	0.28	-	0.53	-2.24
3	Basmath	Chondi Amba-1	CGWB	DW	7.7	774	407	342	92	27	28	6.9	0	303	46	53	50.00	0.32	-	0.65	-1.83
4	Basmath	Babulgaon	CGWB	DW	7.6	1118	548	505	155	28	35	2.3	0	309	93	79	92.00	0.33	-	0.68	-5.00
5	Sengaon	Jambharun-Rodge	CGWB	DW	7.6	744	396	347	53	51	29	3.5	0	226	81	75	7.00	1.20	-	0.69	-3.15
6	Kalmnuri	Balapur Akhada-1	CGWB	DW	7.4	314	167	102	33	5	16	5.8	0	137	14	24	4.00	0.28	-	0.70	0.21
7	Kalmnuri	Toha	CGWB	DW	8.2	738	394	316	37	53	35	2.4	0	280	48	64	19.00	0.52	-	0.87	-1.66
8	Kalmnuri	Dongarkada	CGWB	DW	7.5	1223	642	525	45	98	50	0.9	0	309	103	134	68.00	0.28	-	0.95	-5.28
9	Basmath	Aral-1	CGWB	DW	8.1	726	381	311	57	40	38	2.3	0	178	58	56	92.00	0.35	-	0.95	-3.24
10	Basmath	Palasgaon	CGWB	DW	7.7	805	422	321	22	63	50	4.0	0	250	48	69	86.00	0.43	-	1.23	-2.23
11	Sengaon	Khutha	CGWB	DW	8.1	497	263	173	35	21	38	1.2	0	155	34	39	78.00	0.61	-	1.27	-0.90
12	Hingoli	Hingoli-1	CGWB	DW	7.9	971	508	347	43	57	60	1.9	0	416	63	80	16.00	1.30	-	1.42	-0.02
13	Aundha	Aundha Nagnath	CGWB	DW	8.2	706	320	235	45	29	52	23.4	0	226	68	52	22.00	0.15	-	1.49	-0.94
14	Kalmnuri	Bolda	CGWB	DW	7.6	654	346	235	41	32	62	1.4	0	357	19	45	16.00	0.42	-	1.76	1.20
15	Basmath	Basmat Shivar	CGWB	DW	7.7	1636	867	571	102	75	121	2.5	0	232	172	196	150.00	0.45	-	2.22	-7.51
16	Kalmnuri	Umara	CGWB	DW	8.3	987	518	352	57	50	101	4.2	0	398	88	114	38.00	2.30	-	2.35	-0.43
17	Hingoli	Sawad	CGWB	DW	8	1005	532	321	53	45	106	2.9	0	262	76	146	88.00	0.57	-	2.60	-2.07
18	Aundha	Songaon	CGWB	DW	7.8	987	523	316	78	29	107	1.6	0	404	43	156	46.00	0.66	-	2.63	0.34
19	Basmath	Kurundha	CGWB	DW	8	1070	598	265	51	33	107	3.5	0	297	115	75	62.00	0.55	-	2.87	-0.38
20	Basmath	Chikhli	CGWB	DW	7.7	786	412	179	47	15	101	3.7	0	315	34	35	88.00	0.52	-	3.28	1.62
21	Basmath	Lon Bk.	GSDA	DW	7.2	3000	1950	520	109	100	-	-	-	-	580	51	42.22	0.43	0.20	-	-
22	Basmath	Hayatnagar	GSDA	DW	7.2	2300	1500	540	78	112	-	-	-	-	400	10	38.76	0.31	0.06	-	-
23	Basmath	Khandegaon	GSDA	DW	7.8	973	632	472	157	77	-	-	-	-	220	27	41.17	0.61	0.14	-	-
24	Basmath	Takalgaon	GSDA	DW	7.9	805	523	400	83	77	-	-	-	-	184	22	39.71	0.46	0.30	-	-
25	Basmath	Sawangi Bk.	GSDA	DW	7.0	4380	2840	664	240	96	-	-	-	-	576	398	70.81	1.57	1.23	-	-
26	Hingoli	Gadibori	GSDA	DW	7.7	233	151	212	41	42	-	-	-	-	174	25	18.42	0.23	0.02	-	-
27	Hingoli	Narsi Namdeo	GSDA	DW	8.5	1032	671	164	38	31	-	-	-	-	71	7	43.92	0.46	0.34	-	-
28	Hingoli	Kalgaon	GSDA	DW	8.3	503	327	84	18	16	-	-	-	-	106	25	1.83	1.14	0.24	-	-
29	Hingoli	Malhiwara	GSDA	DW	8.2	501	325	76	29	11	-	-	-	-	41	17	34.78	0.49	0.42	-	-

S.No.	Block	Village	Agency	Source	pH	EC	TDS	TH	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	F	iron	SAR	RSC
						µs/cm	Mg/L														
30	Aundha	Salna	GSDA	DW	7.5	1023	660	344	96	60	-	-	-	-	150	21	7.46	0.53	0.48	-	-
31	Aundha	Suregaon	GSDA	DW	8.3	1046	679	172	48	30	-	-	-	-	158	31	11.73	0.42	0.02	-	-
32	Aundha	Tapowan	GSDA	DW	8.3	746	484	216	80	33	-	-	-	-	120	19	37.62	1.09	0.05	-	-
33	Kalmnuri	Bolda	GSDA	DW	7.7	1430	930	360	96	64	-	-	-	-	205	15	35.41	0.78	0.11	-	-
34	Kalmnuri	Bibgavhan	GSDA	DW	7.9	459	298	242	78	40	-	-	-	-	63	8	4.83	0.05	0.09	-	-
35	Kalmnuri	Tuppa	GSDA	DW	7.8	1327	863	323	47	67	-	-	-	-	208	26	33.48	0.04	0.13	-	-
36	Kalmnuri	Nandapur	GSDA	DW	7.9	1456	947	500	56	108	-	-	-	-	160	18	34.95	0.28	0.15	-	-
37	Sengaon	Ban	GSDA	DW	8.2	1004	929	510	93	99	-	-	-	-	65	55	44.91	0.19	0.06	-	-
38	Sengaon	Khadaki	GSDA	DW	8.1	839	753	178	86	22	-	-	-	-	41	7	37.41	0.26	0.98	-	-
39	Sengaon	Ajegaon	GSDA	DW	7.8	642	417	162	98	16	-	-	-	-	24	15	41.27	0.64	0.04	-	-
40	Sengaon	Goregaon	GSDA	DW	8.1	1410	916	118	99	5	-	-	-	-	111	44	36.76	0.19	0.66	-	-

Annexure VI: Results of Chemical analysis of ground water samples, deeper aquifers

S. No.	Block	Village	Agency	District	Type	pH	EC	TDS	TH	Ca	Mg	Na	K	CO3	HCO_3	Cl	SO^4	NO_3	F	Iron	SAR	RSC
							µs/cm	Mg/L														
1	Hingoli	Belura	CGWB	Hingoli	EW	7.5	1440	898	160	58	4	249	4	Nil	92	241	249	38.00	8.90	-	8.52	-1.69
2	Hingoli	Deulgaon Rama	CGWB	Hingoli	EW	7.6	2200	1362	165	62	2	426	4	Nil	49	521	305	7.00	10.70	-	14.50	-2.50
3	Hingoli	Sawarkheda	CGWB	Hingoli	EW	7.6	1700	1042	280	98	8	260	4	Nil	73	376	244	7.00	9.20	-	6.78	-4.40
4	Kalmnuri	Shivani (Kh)	CGWB	Hingoli	EW	7.8	900	542	150	42	11	136	3	Nil	232	92	81	57.00	5.22	-	4.82	0.80
5	Kalmnuri	Wakodi	CGWB	Hingoli	EW	7.8	550	331	30	10	1	109	3	Nil	201	60	1	42.00	4.52	-	8.78	2.69
6	Kalmnuri	Waranga	CGWB	Hingoli	EW	7.7	590	343	180	50	13	52	0.8	Nil	189	50	21	60.00	1.30	-	1.69	-0.50
7	Kalmnuri	Bolda	CGWB	Hingoli	EW	8	830	476	140	22	21	124	2	Nil	214	113	63	18.00	6.88	-	4.53	0.71
8	Aundha	Purjal	CGWB	Hingoli	EW	8	1080	648	180	48	15	164	2	Nil	214	142	149	12.00	8.52	-	5.29	-0.09
9	Aundha	Undegaon	CGWB	Hingoli	EW	7.8	910	532	70	22	4	175	3	Nil	299	78	87	11.00	3.54	-	9.00	3.50
10	Basmath	Asegaon	CGWB	Hingoli	EW	7.7	740	452	65	2	140	2	2	Nil	146	117	46	48.00	2.53	-	0.04	1.09
11	Sengaon	Bhandari	GSDA	Hingoli	BW	8.2	409	266	68	26	10	-	-	-	-	48	6	13.74	0.88	0.32	-	-
12	Sengaon	Garkheda	GSDA	Hingoli	BW	8.0	998	650	90	62	7	-	-	-	-	125	13	5.37	0.91	0.23	-	-
13	Sengaon	Gondala	GSDA	Hingoli	BW	8.2	660	429	334	94	58	-	-	-	-	61	14	8.76	0.68	0.59	-	-
14	Sengaon	Goregaon	GSDA	Hingoli	BW	8.5	1350	877	82	67	4	-	-	-	-	79	29	40.18	0.37	0.13	-	-
15	Sengaon	Gugulpimpri	GSDA	Hingoli	BW	8.4	2121	1378	64	46	4	-	-	-	-	79	33	13.28	0.94	0.48	-	-
16	Sengaon	Kadoli	GSDA	Hingoli	BW	7.7	2054	1335	182	45	33	-	-	-	-	114	39	5.32	0.59	0.34	-	-
17	Sengaon	Kahakar Bk	GSDA	Hingoli	BW	8.4	890	579	104	55	11	-	-	-	-	115	35	39.49	0.49	0.54	-	-
18	Sengaon	Kelsula	GSDA	Hingoli	BW	7.9	1443	938	64	98	8	-	-	-	-	172	26	6.16	0.90	0.26	-	-
19	Sengaon	Khudaj	GSDA	Hingoli	BW	7.9	404	263	348	90	63	-	-	-	-	32	14	3.52	0.59	0.33	-	-
20	Sengaon	Lingdari	GSDA	Hingoli	BW	8.2	918	597	188	114	18	-	-	-	-	112	18	11.58	0.79	0.48	-	-
21	Sengaon	Ridhora	GSDA	Hingoli	BW	8.1	695	452	82	45	9	-	-	-	-	76	34	35.52	0.89	0.37	-	-
22	Sengaon	Salegaon	GSDA	Hingoli	BW	7.4	889	578	94	53	10	-	-	-	-	64	25	14.18	0.17	0.70	-	-
23	Sengaon	Segaon	GSDA	Hingoli	BW	7.3	1179	766	142	62	99	-	-	-	-	72	30	10.18	0.80	0.91	-	-
24	Sengaon	Tapowan	GSDA	Hingoli	BW	8.0	1196	777	164	34	32	-	-	-	-	103	15	8.29	0.83	0.06	-	-
25	Sengaon	Walana	GSDA	Hingoli	BW	8.3	1445	993	402	78	79	-	-	-	-	78	46	10.94	0.67	0.71	-	-
26	Kalmnuri	Masod	GSDA	Hingoli	BW	7.7	993	645	280	64	52	-	-	-	-	145	29	30.50	0.35	0.02	-	-
27	Kalmnuri	Morgavhan	GSDA	Hingoli	BW	7.8	1009	655	300	112	46	-	-	-	-	120	32	28.66	1.09	0.11	-	-
28	Kalmnuri	Morwad	GSDA	Hingoli	BW	7.9	1724	1121	337	71	65	-	-	-	-	238	20	27.49	1.71	0.02	-	-
29	Kalmnuri	Nandapur	GSDA	Hingoli	BW	7.6	773	502	280	32	60	-	-	-	-	70	6	33.57	0.01	0.03	-	-

S. No.	Block	Village	Agency	District	Type	pH	EC	TDS	TH	Ca	Mg	Na	K	CO3	HCO_3	Cl	SO^4	NO_3	F	Iron	SAR	RSC
							µs/cm	Mg/L														
30	Kalmnuri	Palodi	GSDA	Hingoli	BW	7.8	778	506	100	32	17	-	-	-	-	70	7	8.95	0.99	0.02	-	-
31	Kalmnuri	Pardi	GSDA	Hingoli	BW	7.7	837	544	280	48	56	-	-	-	-	110	10	36.28	0.74	0.19	-	-
32	Kalmnuri	Ramwadi	GSDA	Hingoli	BW	7.8	775	504	190	80	27	-	-	-	-	60	7	27.12	1.17	0.02	-	-
33	Kalmnuri	Renapur	GSDA	Hingoli	BW	7.8	630	410	200	48	37	-	-	-	-	100	6	34.33	0.37	0.09	-	-
34	Kalmnuri	Sawangi	GSDA	Hingoli	BW	7.5	829	539	150	96	13	-	-	-	-	80	12	26.64	0.86	0.04	-	-
35	Kalmnuri	Sodegaon	GSDA	Hingoli	BW	7.8	1670	1086	440	80	87	-	-	-	-	230	25	34.65	0.54	0.01	-	-
36	Kalmnuri	Sukalivir	GSDA	Hingoli	BW	7.9	1869	1215	301	48	61	-	-	-	-	130	43	31.52	1.49	0.02	-	-
37	Kalmnuri	Takalgavhan	GSDA	Hingoli	BW	7.7	633	412	280	80	49	-	-	-	-	70	5	34.44	0.15	0.10	-	-
38	Kalmnuri	Tondapur	GSDA	Hingoli	BW	7.8	1119	727	220	64	38	-	-	-	-	130	75	27.79	0.53	0.02	-	-
39	Kalmnuri	Tovha	GSDA	Hingoli	BW	7.8	734	477	200	64	33	-	-	-	-	50	7	28.78	0.69	0.02	-	-
40	Kalmnuri	Tuppa	GSDA	Hingoli	BW	7.9	1135	738	160	62	24	-	-	-	-	131	26	33.75	0.03	0.21	-	-
41	Kalmnuri	Umardarawadi	GSDA	Hingoli	BW	7.8	523	340	304	72	56	-	-	-	-	45	12	29.03	0.23	1.88	-	-
42	Kalmnuri	Wai	GSDA	Hingoli	BW	7.9	1471	956	560	56	122	-	-	-	-	255	17	35.91	0.01	0.02	-	-
43	Kalmnuri	Yelki	GSDA	Hingoli	BW	8.0	418	272	150	86	15	-	-	-	-	80	121	30.66	0.02	0.43	-	-
44	Hingoli	Chorjawala	GSDA	Hingoli	BW	8.4	1157	752	300	64	57	-	-	-	-	65	56	18.78	0.23	0.07	-	-
45	Hingoli	Gadibori	GSDA	Hingoli	BW	8.4	618	401	188	90	24	-	-	-	-	268	26	27.23	0.84	0.22	-	-
46	Hingoli	Idoli	GSDA	Hingoli	BW	8.0	1601	1040	220	32	46	-	-	-	-	48	90	24.36	1.28	0.19	-	-
47	Hingoli	Kanadkheda Bk.	GSDA	Hingoli	BW	7.7	1204	782	80	64	4	-	-	-	-	80	31	42.56	0.89	0.50	-	-
48	Hingoli	Narsi Namdeo	GSDA	Hingoli	BW	8.5	712	462	222	46	43	-	-	-	-	64	49	38.45	0.45	0.17	-	-
49	Hingoli	Pangri	GSDA	Hingoli	BW	8.2	1211	787	264	61	49	-	-	-	-	251	32	47.55	1.03	0.44	-	-
50	Hingoli	Santuk Pimpari	GSDA	Hingoli	BW	8.0	842	547	226	56	41	-	-	-	-	28	94	47.12	0.42	0.04	-	-
51	Hingoli	Sarkali	GSDA	Hingoli	BW	7.9	910	591	320	50	66	-	-	-	-	35	76	31.30	0.13	1.14	-	-

Annexure VII: Location of proposed Percolation tanks in Hingoli district

S.No.	Village	Taluka
1	Takalgavhan Tarf Shahapur	Aundha
2	Mahalajgaon	Aundha
3	Lakh	Aundha
4	Sirala Tanda (n.v.)	Aundha
5	Turk Pimpari	Aundha
6	Tamtitanda (n.v.)	Aundha
7	Pimpaldari Tarf Nandapur	Aundha
8	Tembhurdara	Aundha
9	Rajdari	Aundha
10	Jalaldhaba	Aundha
11	Bhandegaon	Hingoli
12	Deulgaon Rama	Hingoli
13	Basamba	Hingoli
14	Kharbi	Hingoli
15	Idoli	Hingoli
16	Chikhalwadi	Hingoli
17	Borala	Hingoli
18	Sawa	Hingoli
19	Pangri	Hingoli
20	Rajwadi	Hingoli
21	Digras	Hingoli
22	Kalgaon	Hingoli

S.No.	Village	Taluka
23	HINGOLI	Hingoli
24	Bhogaon	Hingoli
25	Bori Shikari	Hingoli
26	Parola	Hingoli
27	Parda	Hingoli
28	Kasabe Dhawanda	Kalmnuri
29	Nandapur	Kalmnuri
30	Krishnapur Tarf Jawala	Kalmnuri
31	Kanosa	Kalmnuri
32	Kolsa	Sengaon
33	Bramhapuri	Sengaon
34	Pusegaon	Sengaon
35	Pankanhergaon	Sengaon
36	Jamrun Bk	Sengaon
37	Goregaon	Sengaon
38	Jamthi Bk	Sengaon
39	Watkali	Sengaon
40	Sengaon	Sengaon
41	Makodiwadi	Sengaon
42	Belkheda	Sengaon
43	Sabalkheda	Sengaon
44	Sinagi Naga	Sengaon

Note: Construction of AR structures may be taken up at these sites after field checks/verification only

Annexure VIII: Location of proposed check dam in Hingoli district

S. No.	Village	Taluka
1	Lohara Bk	Aundha
2	Ranjala	Aundha
3	Umra	Aundha
4	Asonda	Aundha
5	Purjal	Aundha
6	Sawar Kheda	Aundha
7	Tamtitanda (n.v.)	Aundha
8	Dharkheda	Aundha
9	Yehalegaon	Aundha
10	Shirad Shahapur	Aundha
11	Shingi	Aundha
12	Kundkar Pimpri	Aundha
13	Aundha	Aundha
14	Dughala	Aundha
15	Matha	Aundha
16	Bramhanwada Pr.aundha	Aundha
17	Dhar	Aundha
18	Murtijapur Sawangi	Aundha
19	Suregaon	Aundha
20	Kondasi Bk	Aundha
21	Asola Traf Aundha	Aundha
22	Pota Kh.	Aundha
23	Perjabad	Aundha
24	Chincholi Nikoba	Aundha
25	Pardi[sawali]	Aundha
26	Keli	Aundha
27	Gojegaon	Aundha
28	Wadad	Aundha
29	Ajalsonda	Aundha
30	Undegaon	Aundha
31	Hiradgaon	Basmath
32	Phata	Basmath
33	Dhanora	Basmath
34	Korta	Basmath
35	Rajawadi	Basmath
36	Khandala	Hingoli
37	Chinchala	Hingoli
38	Ghota	Hingoli

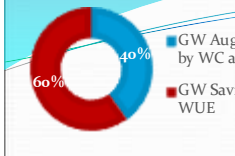
S. No.	Village	Taluka
39	Dhotarwadi	Hingoli
40	Pimparkhed	Hingoli
41	Pedgaon	Hingoli
42	Rajwadi	Hingoli
43	Basamba	Hingoli
44	Bori Shikari	Hingoli
45	Durgdhamni	Hingoli
46	Belura	Hingoli
47	Idoli	Hingoli
48	Sawad	Hingoli
49	Deulgaon Rama	Hingoli
50	Pangri	Hingoli
51	Hiradi	Hingoli
52	Bhingi	Hingoli
53	Amla	Hingoli
54	Kalkondi	Hingoli
55	Satamba	Hingoli
56	Santuk Pimpari	Hingoli
57	Bhirda	Hingoli
58	Bondala	Hingoli
59	Navalgavhan	Hingoli
60	Warud Gawali	Hingoli
61	Lohagaon	Hingoli
62	Dugheri	Hingoli
63	Sasewadi	Hingoli
64	Kesapur	Hingoli
65	Isapur	Hingoli
66	HINGOLI	Hingoli
67	Pimplekhuta	Hingoli
68	Chikhalwadi	Hingoli
69	Ekamba	Hingoli
70	Incha	Hingoli
71	Kadti	Hingoli
72	Raholi Kh.	Hingoli
73	Jambwadi	Hingoli
74	Narsi	Hingoli
75	Wadad	Hingoli
76	Dategaon	Hingoli
77	Digras	Hingoli
78	Sirsam Kh	Hingoli

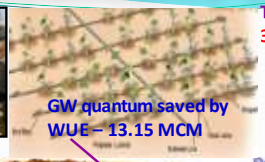
S. No.	Village	Taluka
79	Balsond	Hingoli
80	Khambala	Hingoli
81	Kharbi	Hingoli
82	Sawa	Hingoli
83	Digraswani	Hingoli
84	Kanka	Hingoli
85	Mauja	Hingoli
86	Girgaon	Kalmnuri
87	Tondapur	Kalmnuri
88	Bibthar	Kalmnuri
89	Hatmali	Kalmnuri
90	Ramwadi	Kalmnuri
91	Kalamkonda Bk.	Kalmnuri
92	Dongarkada	Kalmnuri
93	Wadgaon Tarf Jawala	Kalmnuri
94	Devdari	Kalmnuri
95	Kanjara	Kalmnuri
96	Kasabe Dhawanda	Kalmnuri
97	Goregaon	Sengaon
98	Deulgaon Jahagir	Sengaon
99	Warud Saman	Sengaon
100	Warud Kaji	Sengaon
101	Jawala Bk.	Sengaon
102	Chondi Kh	Sengaon
103	Umra	Sengaon
104	Jamrun Bk	Sengaon
105	Babhulgaon	Sengaon
106	Bramhanwada	Sengaon
107	Jamthi Bk	Sengaon
108	Chondi Bk	Sengaon
109	Belkheda	Sengaon
110	Shivni Bk	Sengaon
111	Ridhora	Sengaon
112	Sawarkheda	Sengaon
113	Kolsa	Sengaon
114	Sinagi Naga	Sengaon
115	Sengaon	Sengaon
116	Palshi	Sengaon
117	Watkali	Sengaon
118	Kawatha Bk.	Sengaon
119	Sapatgaon	Sengaon

S. No.	Village	Taluka
120	Ajegaon	Sengaon
121	Sinagikhamba	Sengaon
122	Suldali Kh	Sengaon
123	Hatala	Sengaon
124	Shindephal	Sengaon

Note: Construction of AR structures may be taken up at these sites after field checks/verification only

PROPOSED MANAGEMENT PLAN

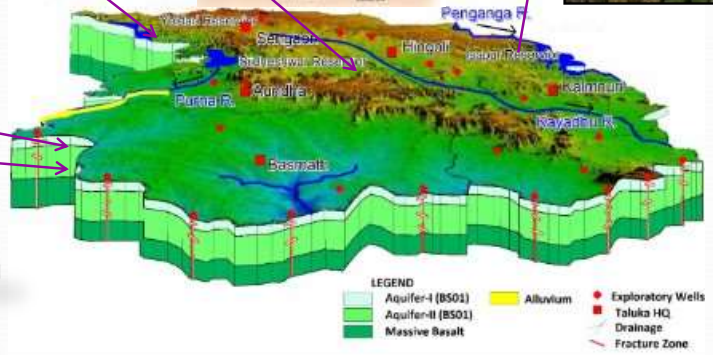




Total Draft – 392.15 MCM

Aquifer I Resources – Dy- 738.17 MCM

Aquifer II Resources – 37.57 MCM



GW SENAREO AFTER IMPLEMENTING

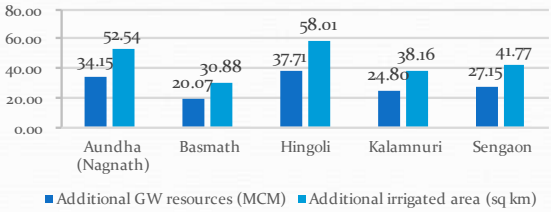
A. Artificial Recharge

GWA 738.17 + 8.81 MCM by AR = 746.99 MCM

B. WUE- 13.15 MCM

GW AVAILABLE FOR DEVELOPMENT PLAN

After SOD of 70% =143.89 MCM



PROBABLE BENEFITS AFTER IMPLEMENTING AR & WUE MEASURES

- Additional GW Resources by Supply side AR = 8.81 MCM
- Water saving through adopting (Micro Irrigation) = 13.15 MCM
- Balance GWR available for Development after SOD 70% – 143.89 MCM
- Assured GW Irrigation in ADDITIONAL 221.36 sq km area
- Even after above, SOD will be 70% (safe category)
- Increase in GW Availability & Sustainability