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Central Ground Water Board
Department of Water Resources, River
Development and Ganga Rejuvenation,
Ministry of Jal Shakti
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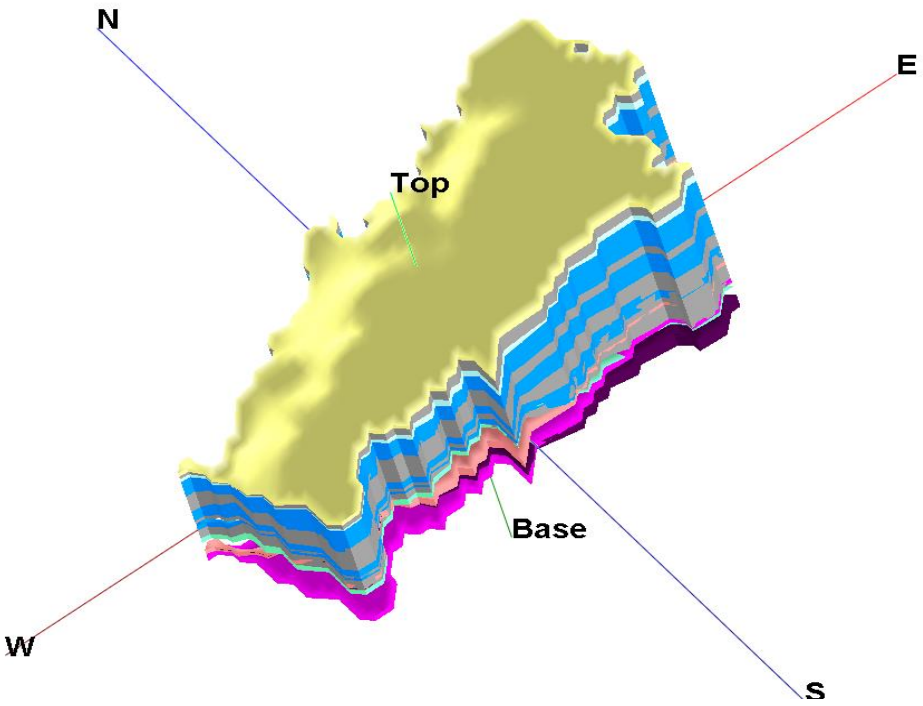
AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

HOSHANGABAD DISTRICT
MADHYA PRADESH

उत्तर मध्य क्षेत्र, भोपाल
North Central Region, Bhopal

Aquifer Mapping and Ground Water Management plan of Hoshangabad District, Madhya Pradesh



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Preface

'Aquifer mapping' is a holistic approach for aquifer-based groundwater management. It may not be construed as aquifer geometry mapping only. In a broader perspective it can be defined as understanding the aquifers, ascertaining and establishing their quantity and quality sustainability through multi-disciplinary scientific approach integrating the techniques of geology, remote sensing, hydrogeology, geophysics, borehole drilling, hydrochemistry, hydrology, hydrometeorology, mathematical modelling, agriculture and soil science, water treatment and remediation, economics and social and environmental sciences. Under the project on National Aquifer Mapping (NAQUIM to formulate sustainable aquier management plan, Central Ground Water Board (CGWB), North Central Region, Bhopal has taken up Hoshanagabad district to prepare the 3-Dimensional Model and 2-Dimensional Aquifer Maps for the entire district and formulate Block-wise Aquifer Management Plan.

The geographical area of the district is **6704.00** Sq. Km. ana recharge worthy area is 5583 sq.km It is divided into, seven administrative blocks viz Hoshangabad, Kesla, Babai, Pipariya, Bankhedi, Sohagpur and Seoni-malawa. Hoshagabad district is underlain by various geological formations, forming different types of aquifers in the area. Main geological; units of the area are Archaean, Vindhyan, Deccan traps, Gondwanas and alluvium.

The pre-monsoon depth to Water levels ranges from a minimum of 3.19 meters below ground level (mbgl) in Kesla block to a maximum of 15.57mbgl in Pipariya Block of Hoshanagabad district. The post-monsoon depth to Water levels ranges from a minimum of 1.31 m below ground level to a maximum of 14.9 m bgl both in Pipariya block.

The number of artificial recharge structure has been proposed based on the basis of sub-surface storage under supply side Management plan prepared under NAQUIM of all the Block of HoshanagabadDistrict, a total number of 371 Percolation Tanks, 742 Recharge Shafts/Tube wells and 693 Nala Bunds/Check Dams and 1103 Village Pond Cement Plugs have been proposed.

Results of these comprehensive studies will contribute significantly to ground water sustainable management tools. It will not only enhance the long-term aquifer monitoring networks and but would also help in building the conceptual and quantitative regional ground-water-flow models for planners, policy makers and other stakeholders. I would like to place on record my appreciation for ***Naresh Kumar Jatav, Scientist-B*** to compile this report. I fondly hope that this report will serve as a valuable guide for sustainable development of ground water in the Hoshangabad District, Madhya Pradesh

Rana Chatterjee
(Regional Director)

Chapter -1
Introduction

1.1 Background of Aquifer Mapping

Aquifer mapping is a holistic approach for aquifer-based groundwater management. It may not be construed as aquifer geometry mapping only. In a broader perspective it can be defined as understanding the aquifers, ascertaining and establishing their quantity and quality sustainability through multi-disciplinary scientific approach integrating the techniques of geology, remote sensing, hydrogeology, geophysics, borehole drilling, hydrochemistry, hydrology, hydrometeorology, mathematical modelling, agriculture and soil science, water treatment and remediation, economics and social and environmental sciences. Out of these the Geophysical technique will help as a strong tool to identify the aquifer geometry precisely.

1.2 Scope of Study

At present a generalized picture of aquifer-dispositions and their characteristics are known from the existing hydrogeological and surface geophysical data, the borehole lithological and geophysical logs and the aquifer performance tests conducted by CGWB and other central and state agencies. But it is not enough to prepare aquifer maps because of the inadequate density of data vis-à-vis geological heterogeneities. The extrapolation and interpolation within the existing boreholes may not yield accurate information on aquifer disposition unless they are tied up further by close-grid geophysical measurements conducted in between. This has necessitated in a systematic mapping of aquifers. Further hydro-geological investigation either by geophysical technique or by exploration is proposed for the aquifer mapping. It is to provide adequate and precise subsurface information in terms of aquifer lithology and geometry leading to 3-dimensional aquifer dispositions. Also, it is to establish the most appropriate technique or combination of techniques for identifying the aquifers in different hydrogeological terrains.

1.3 Objectives

The objective of applying the hydrogeological and geophysical techniques is to provide more adequate and more precise (reduced uncertainty and ambiguity) information on aquifers – shallow and deep including dry and saturated zones with their geometry at reasonable scale (1: 50,000) in the area.

The tentative depth of the hydrogeological and geophysical exploration will be 200 m in hard rock area. However, the depth of exploration may vary depending on the geological conditions and requirements. Additional exploratory wells shall be drilled for validations of aquifer parameter estimations where borehole data are not available.

The information thus generated through additional drilling of boreholes shall be used for refinement of hydrogeological data base in terms of aquifer characterization, yield capacity, chemical quality, selecting areas for artificial recharge and sustainability under varied future demand scenario leading to preparations of aquifer-management plans and recommendations to mitigate mining of aquifer.

1.4 Approach and Methodology

The aquifer mapping study in this report has been compiled on the basis of existing data that were assembled, analyzed and interpreted from available sources. The collected data was further prepared to generate regional hydrogeological maps, thematic maps, water quality maps, cross-sections, 2-D and 3-D aquifer dispositions and potentiometric maps eventually to define the aquifer geometry, type of aquifers, ground water regime behavior, hydraulic characteristics and geochemistry of multi-layered aquifer systems on 1:50000 scale. To achieve the objectives, the following approach and methods have been adopted and stepwise details have been shown in the **Fig 1.1.**

- Data compilation
- Data gap analysis
- Data generation
- Preparation of block-wise aquifer maps and management plan

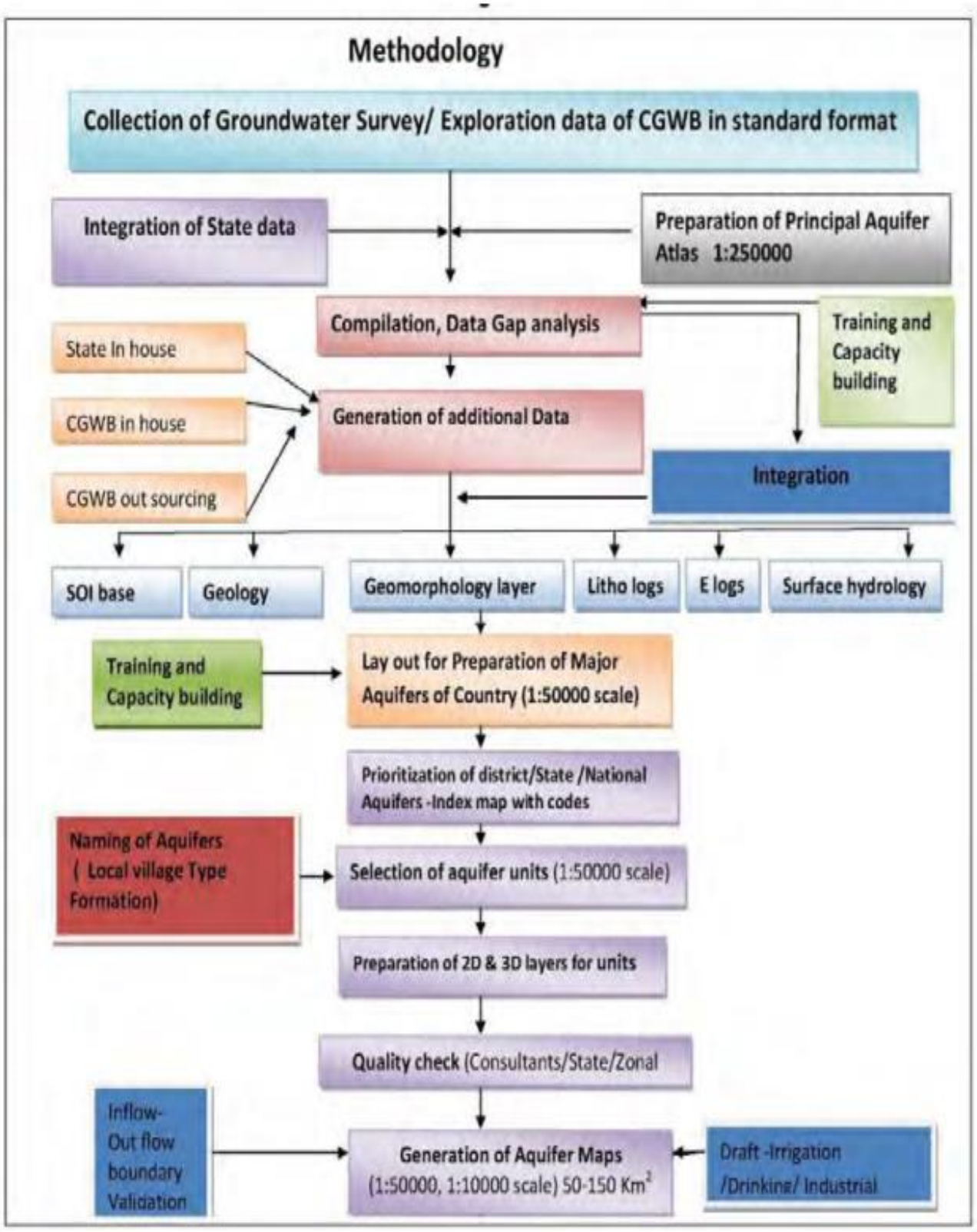

Fig:1.1 Flow Chart of Methodology

1.5 Study Area

Hoshangabad district has predominantly an agriculturally based economy. It is situated in the eastern part of Madhya Pradesh. Prior to 1998-99 District Harda was a part of Hoshangabad District. After the division of the district, the present area of the district at present remains 6704 Sq. Km. It is surrounded by Sehore and Raisen districts in the North, Narsinghpur district in the east, Chhindwara district in the south west Betul in the south and Harda district in the west. Hoshangabad district lies between north latitudes 22° 15' and 23° 00' and east longitudes 77º 15' and 78° 42' in part of survey of India toposheet Nos, 55F & 55J. Hoshangabad is the district headquarter and Itarsi, Sohagpur, Piparia, Pachmarhi and Bankheri are some of the major towns. Itarsi is a very important railway Junction lying on Delhi-Chennai, Delhi-Bangalore and Patna-Mumbai railway routes. National Highway No. 69 and State Highway No. 21 and 22 pass through the district. The villages in the district are approachable by fair weather motor abletract**.**

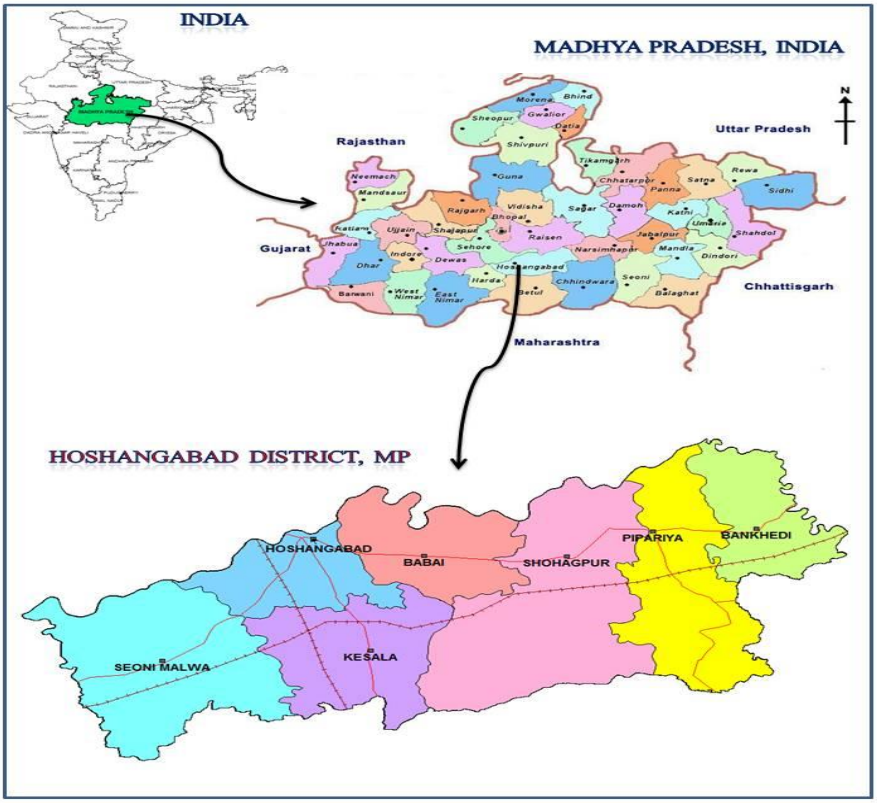

Fig:1.2 Administrative Map

The district is divided into seven Tehsils and seven development Blocks, namely Bankhedi Block, Pipariya Block, Sohagpur Block, Babai Block, Hoshangabad Block, Kesla Block (Itarsi Tehsil) and Seoni Malwa Block. **(Fig-1.2 & 1.3).** The total population of the district is 10,84,265 persons.Detailed administrative divisions of the district are given in **Table-1.1.**

The district is divided in to seven development blocks (Seoni-Malwa, Kesla, Hoshangabad, Babai,Sohagpur,Pipariyaand Bankhedi)

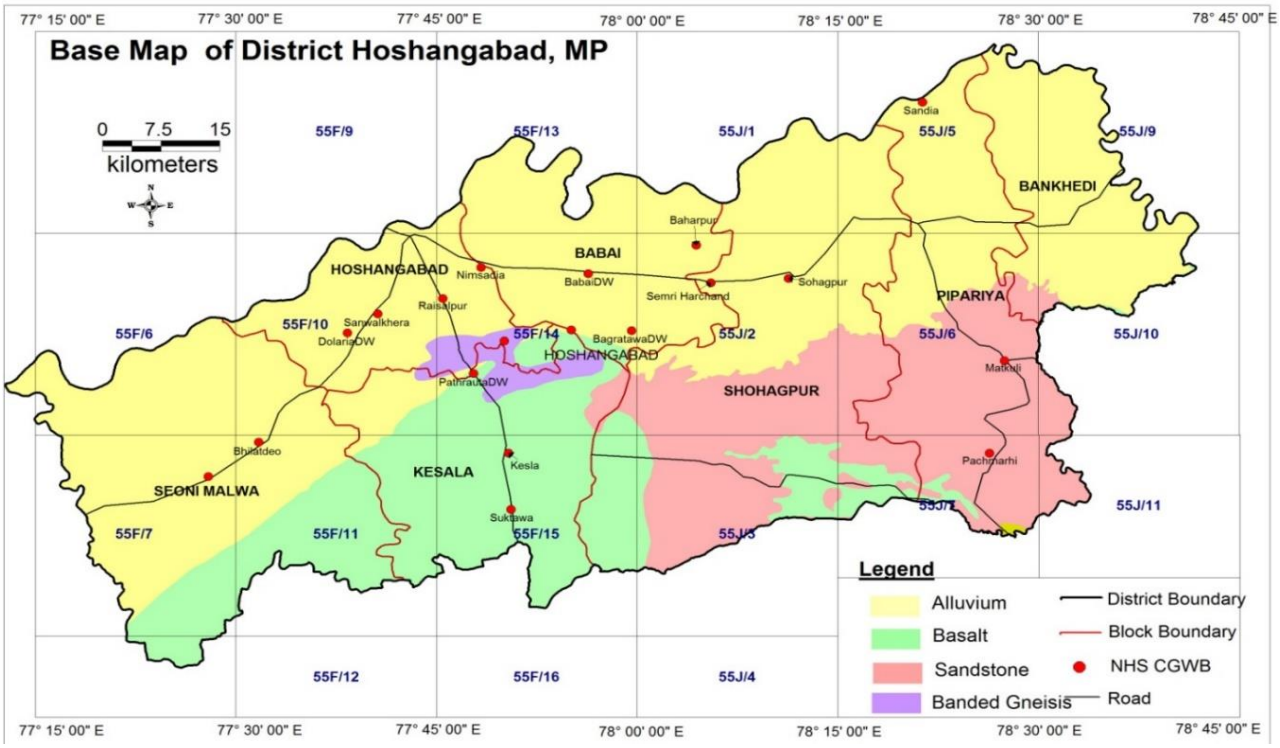

Fig:1.3 Base Map of Hoshangabad District

Table – 1.1: Administrative Units of Hoshangabad district

S.No.	Block	Geographical Area (Sq Km)	Hilly area	Recharge Area (Sq Km)
1	**Seoni-Malwa**	1375	36	1339
2	**Kesla**	883	70	813
3	**Hoshangabad**	669	95	574
4	**Babai,**	892	0	892
5	**Sohagpur**	1113	679	434
6	**Pipariya**	983	120	863
7	**Bankhedi**	789	120	669
8	**DISTRICT**	**6704.00**	**1120.00**	**5583.00**

1.6 Rainfall and Climate

Rainfall

The climate of Hoshangabad district is characterized by a hot summer and general dryness except during the south west monsoon season. The year may be divided into four seasons. The cold season, December to February is followed by the hot season from March to about the middle of June. The period from the middle of June to September is the southwest monsoon season. October and November form the post monsoon or transition period.

The normal rainfall of Hoshangabad district is 1225.9 mm. It receives maximum rainfall during southwest monsoon period. About 92.8% of the annual rainfall received during monsoon seasons and only 7.2 % of the annual rainfalls take place during October to May period. The surplus water for groundwater recharge is available only during the southwest monsoon period. The maximum rainfall received in district at Pachmarhii.e. 2122 mm and minimum at Hoshangabad i.e. 1302.3 mm.

Temperature

Hoshangabad district can be classified into three major seasons. Summer, Winter and Monsoonand monthly maximum and minimum average temperature of ten years (2000-2011) are shown in Table No-1.2

Table at a glance reveals that May is hottest month (42.30°c) and December is the coldest month (7.20) During the summer months (Feb.to May) the mean temperatures varies from 19.98ºc to 33.06°c. During rainy months (June to September). The maximum temperaturevaries from 34.50ºc (July) to 28.75°c (August)whereas, the minimum temperature varies from 24.12ºc to 22.8°c. During winter the maximum temperature falls down from 31.60ºc and then rises to 26.06°c (January). The minimum temperature varies from 16.23ºc (October) to 7.20°c (December).**Fig 1.4** presents the histogram of 10 yrs average temprature.

Table-1.2 Maximum and Minimum average temperature of ten year (2000-2011) in Hoshangabad District

S.No.	Month	Maximum	Minimum Tem	Difference
1	January	26.06	10.6	15.46
2	February	27.27	11.15	16.12
3	March	34.44	16.76	17.68
4	April	37.94	21.99	15.95
5	May	42.3	23.83	18.47
6	June	30.14	24.12	6.02
7	July	34.5	23.72	10.78
8	August	28.75	22.95	5.8

S.No.	Month	Maximum	Minimum Tem	Difference
9	September	30.14	22.81	7.33
10	October	31.6	16.32	15.28
11	November	24.32	11.13	13.19
12	December	22.6	7.2	15.4

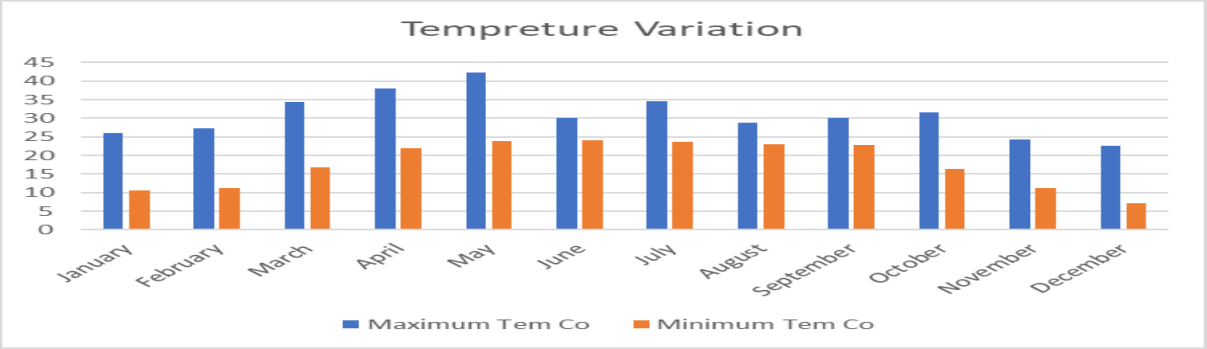

Fig-1.4 Histogram of Ten years average temperature

Humidity

The computed values for monthly and annual mean relativehumidity in the morning and evening hours in percentage based on data from 1960-75 at Hoshangabad observatory.

The **table 1.3** indicates thatthe relative humidity during monsoon period is highest ranging from 60-80%. It is higher during hours almost throughout the year.

Table-1.3 Relative humidity in Hoshangabad

S. No.	Month	RH in % (Morning)	RH in % in (Evening)
1	January	64.9	43.3
2	February	57.6	32.10
3	March	43.3	22.9
4	April	43.0	18.1
5	May	32.0	20.3
6	June	59.6	47.3
7	July	85.4	75.3
8	August	86.7	80.3
9	September	77.3	69.0
10	October	77.1	50.3
11	November	64.7	46.2
12	December	69.5	49.6

Wind Velocity

The monthly seasonal and annual mean daily wind velocity at 08.30 hours and 17.30 hours recorded for the period 1960-1975 at Hoshangabad station are given in **table 1.4**. It is seen from the table that the wind velocity is highest during the month of June both during morning and evening hours. It is also observed that during the evening hours the wind velocity is always high.

Table -1.4: Mean Wind Velocity in Hoshangabad District

S.No.	Month	0.83 hrs	17:30 hrs
1	January	4.20	4.17
2	February	3.30	4.33
3	March	3.63	5.33
4	April	4.60	6.56
5	May	5.84	7.71
6	June	6.84	8.26
7	July	5.46	7.71
8	August	4.89	6.36
9	September	3.90	5.91
10	October	2.55	3.76
11	November	2.94	3.56
12	December	3.61	4.11
13	Annual	4.32	5.65

Evaporation and evapotranspiration:

The area receives rainfall of the order of the order of 1160mm during the monsoon. Studies carried out by the Narmada Project indicate that out of 1160mm of monsoon rainfall, about 465mm is evapotranspiration losses during the monsoon. Of the remaining 695mm, a part goes off as surface run-off and only a part is available for soil saturation, sub surface flow and recharge to the groundwater body.

1.7 Physiography/DEM:

The study area isbounded by Satpura ranges in south and by Narmada river in the north. The area slopes North West toward the Narmada River. The slope is generally steep at the foothills of Satpura but moderate to gentle toward Narmada River. The altitude of the land surface is maximum

at Dhupgarh, near Panchmari (1350 m above mean sea level) and minimum at Mahendgaon (253.5 m above mean sea level) in Harda Tehsil.

The famous Adamgarh hill which stands out in the valley portion near Hoshangabad is known from historic Stone Age. Another hill which stands out in the valley portion is near Chautalali village close to Narmada River. A large number of North westerly flowing tributaries originating from thesatpura join the Narmada along the left bank.

The area may be divided into three zones on the basis of the physiography (i) The Satpura ranges in the south, (ii) An alluvial plain in the middle and (iii) Badland topography zone confined to the vicinity of Narmada River. The maximum width of the valley between Satpura and Narmada River is about 30 kms. Detailed Digital Elevation Map of the district are shown in **Fig:1.5**.

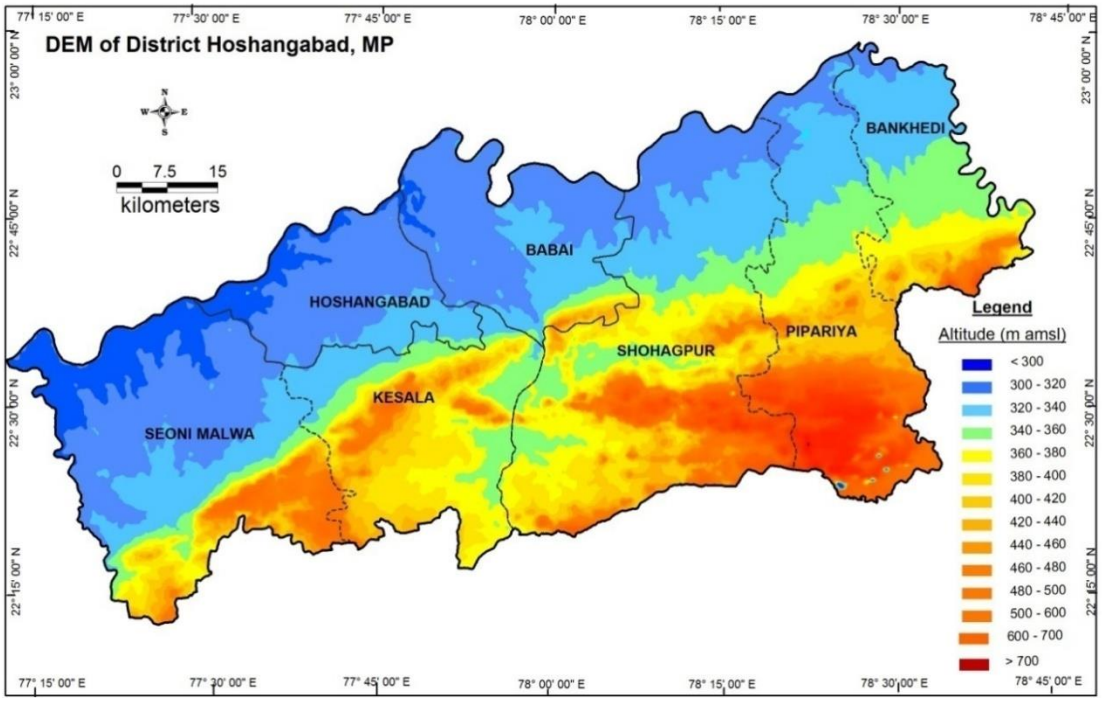

Fig:1.5. Digital Elevation Map

1.8 Geomorphology

The study area is bounded by Satpura ranges in south and by Narmada River in the north. The area slopes north west toward the Narmada River. The slope is generally step at the foothills of Satpura but moderate to gentle towards Narmada River. The land surface attains a maximum altitude of 1352 m above mean sea level at Dhupgarh (77° 22’30”: 22° 27’ 00”), near Pachmarhi

and minimum altitude of 270 m above mean sea level at confluence of Ganjal river with the Narmada (77° 12'30": 22° 33' 30"). The area may be divided into three zones on the basis of the Physiography (1) the Satpura range in the south, (2) An alluvial plain in the middle and (3) Badland topography zone confined to the vicinity of Narmada River. The maximum width of the valley between Satpura and Narmada River is about 30 kms. (**Fig:1.6)**

The famous adamgarh hill, which stands out in the valley portion near Hoshangabad, is known from history stone age. Another hill, which stands out in the valley portion is near Chautalia village close to Narmada River. A large number of north westerly flowing tributaries originating from the Satpura join the Narmada along the left bank Soils of the area are characterized by black grey, red and yellow colours, often mixed with red and black alluvium and ferruginous red ravel or lateritic soils.

The rocks occurring in the district range in age from Palaeoproterozoic to Quaternary. The Mahakoshal Group of rocks mainly comprise quartzite, slate and phyllites. The rocks of Vindhyan Supergroup comprise Bhander Group. Bhander group consists of Lower Bhander sandstone which is fine to coarse grained and at places, pebbly and quartzitic. The Gondwana sequence belonging to the Gondwana basin of Central India, comprises of Talchir, Barakar, Motur, Bijori, Panchmari, Denwa, Bagra and Jabalpur Formations. The Talchir formation comprises tillite, diamictite, fine to medium grained sandstone and grey to olive green shales. The Barakar Formation is dominantly made up of coarse-grained feldspathic sandstone, grey shales and carbonaceous shale. Motur Formation overlies Barakar Formation with a gradational contact. It comprises coarse grained sandstone with pebbly interbands, variegated shales and clay. The Bijori Formation is exposed as a broad band of olive and buff-coloured clays and shales, alternating with massive sandstone. The Pachmarhi Formation consists of thick beds of coarse to granular, white arenite or quartzwacke, separated by lenses or thin layers of conglomerate and thin red clay bands. The Denwa Formation consists mainly of alternating bands of sandstone and red to variegated calcareous clay. The Bagra formation comprises of conglomerate, variegated shales and subordinate limestone bands. The youngest Gondwana sequence is represented by Jabalpur Formation. It consists mainly of massive sandstone alternating with white clays. Lenses of conglomerate are common. Discontinuous patchy exposures of Lameta Group are seen east of Barapura, Gotabari and Tangna. The basaltic lava flows of Deccan trap are well exposed in the southern and southwestern part of the district.

These flows, grouped under Satpura Group are mainly of Aa type and non-porphyritic to porphyritic to mega-porphyritic in nature. The thickness of individual flows varies from 15m to 47m. The Satpura Group comprises of 18 to 21 basaltic flows which are further classified in 5 Formations. Numerous dykes and sills, mostly of doleritic composition intrude the Gondwana rocks and basaltic flows. The dykes range in the length from few hundred meters to few kilometres, with width ranging from few meters to few hundred meters. Most of the dykes trend in NE-SW direction. Quaternary Narmada alluvial deposits occupy a major part of the district have been sub divided into seven litho-stratigraphic formations viz. Surajkund Formation, Beneta Formation, Hirdepur Formation, Bauras Formation and Ramgarh Formation, on the basis of lithological characters, degree of oxidation, calcification of the sediments, erosional unconformities, soil stratigraphy, morpho-stratigraphy and presence of volcanic ash.

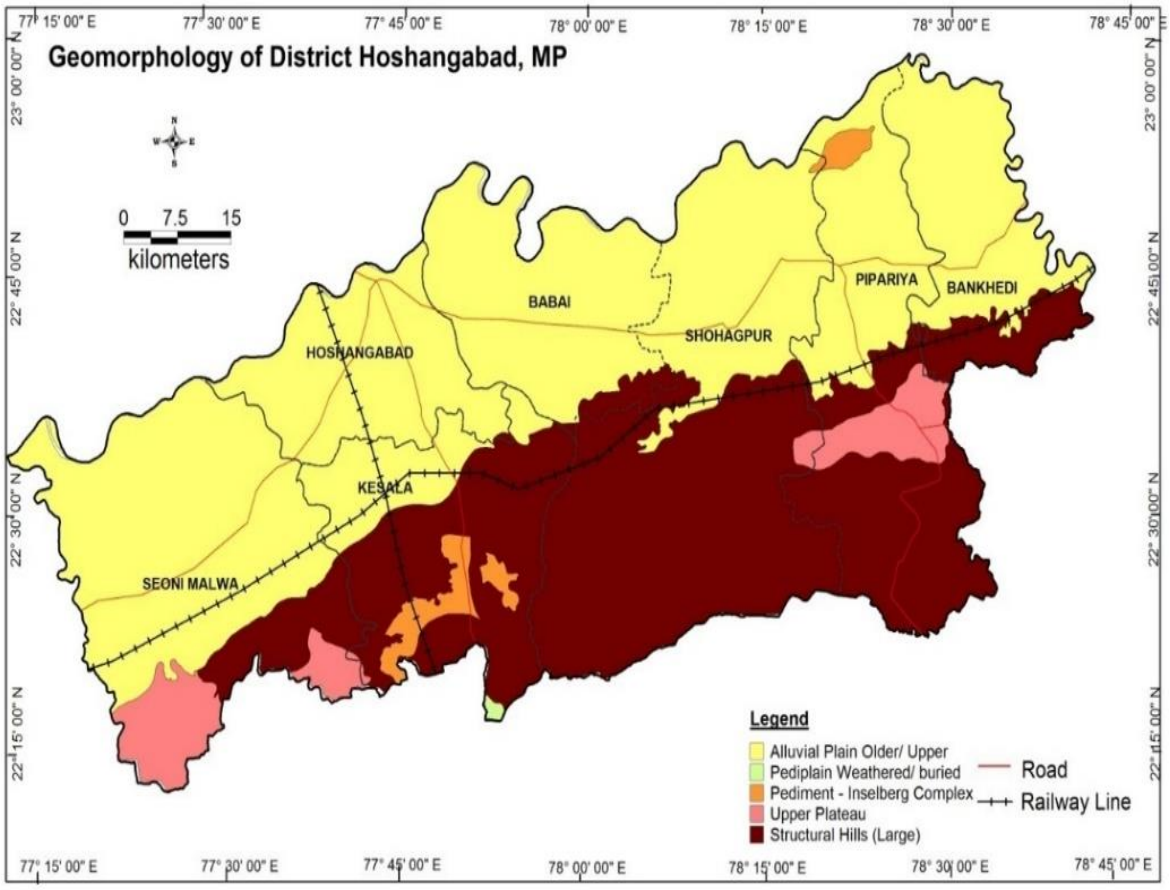

Fig 1.6 Geomorphological map of district

1.9 Soil Cover

The soil health is one of the important components of agriculture development. It determines the fertility of the soil of the district. Overall, the soils can be stated as black (64%), Red soil (15%), Sandy soil (9%), Sandy loam (9%) and others (3%). Around 510 hact area is under water logged conditions. The spatial distribution of soil health, on the basis of random sampling at all the blocks reveals that available Potash is found high in all the blocks. This district has high levels of phosphorus, medium levels of nitrogen and low levels of potassium. Potassium assists in carbon assimilation and photosynthesis process. Low Potassium levels affect adversely the leaves and thus the chlorophyll shortage and poor growth. Older leaves of potassium deficient plant give a scorched look around the edges or as if these got wilted. Also inter veinal chlorosis (yellowing between the leaf veins) can. The low proportion of organic carbon is present in all over the district. In the Pipariya and Kesla blocks amount of available nitrogen is found low. In the similar manner available nitrogen vary from low to medium in remaining blocks. The nature of phosphorous availability range between medium to high in Kesala and Pipariya blocks and rest of the blocks have medium level phosphorous availability.

The permeability of the soil is low when the clay contains montorillonite. They swell intensively when wet and shrink with deep cracks when dry. Intake of water is very rapid till the cracks disappear after complete wetting. The soils have been classified as Ustocherpts/Ustorthents/ Haplustalfs/Haplusterts as per pedological taxonomy.

The area has been divided into three zones (**Table-1.5**) on the basis of agro-climatically conditions as follows:

Table:1.5 Zones of Agro climatic conditions

Zone	Location	Soil classification
A	Area lying east of Tawa River	About 15% of the area is covered by sandy loam soil immediately on the high bank
B	Area lying between Tawa and Ganjal rivers	The soils are predominantly clayey cover
C	Area lying west of Ganjal river	The area is occupied by clayey soils and clay loam.

The permeability of the soil is low when the clay contains montmorillonite. They swell intensively when wet and shrink with deep cracks when dry. Intake of water is very rapid till the cracks disappear after complete wetting.

In Tawa command area about 80 to 85% of the area is covered by clayey loam soils. The percentage of area covered by different textural classes of soils are given in **Table 1.6** and graphically shown in **Fig:1.7.**

Table:1.6 Percentage Area of Different Textural Classes

S.No.	Textural Class	Percentage area covered
1	Clay	64.4%
2	Clay	17.8%
3	Sandy clay loam	6.4%
4	Sandy loam	4.2%
5	Others	3.0%

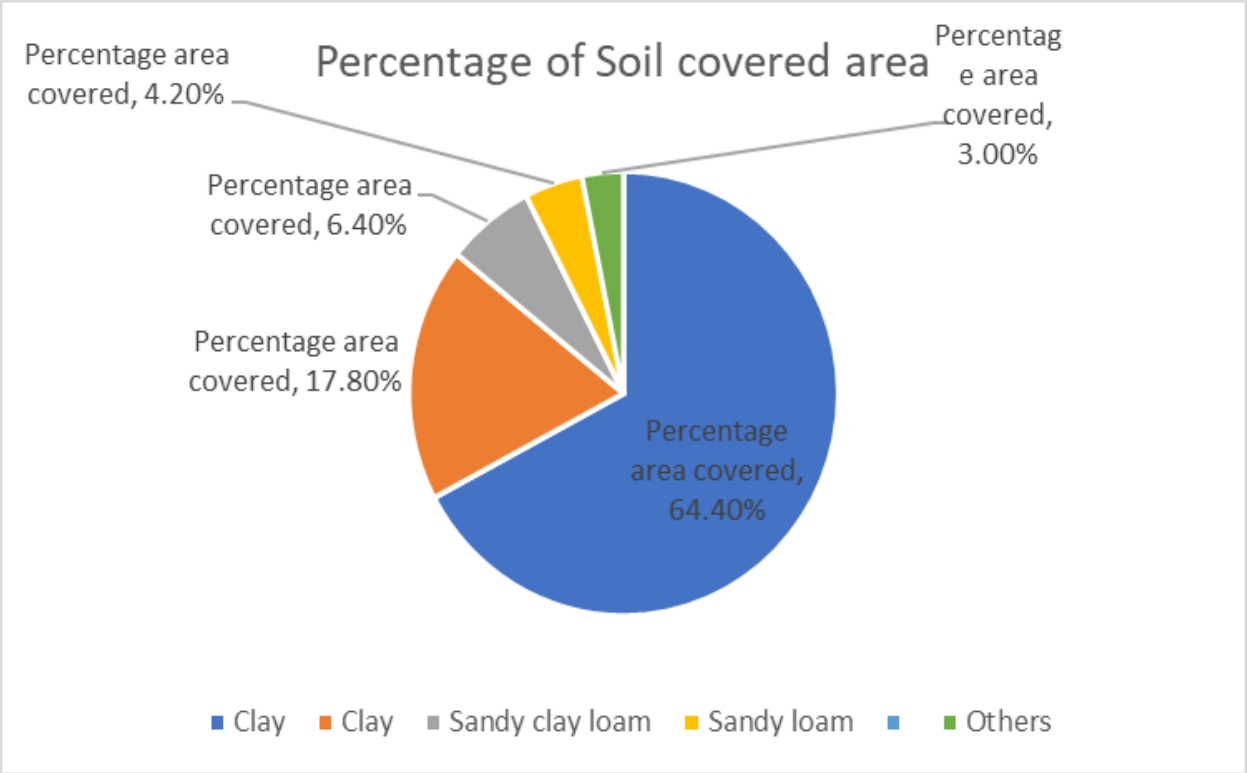

Fig:1.7 Histogram of soil percentage

1.10 Drainage

The entire district is drained by Narmada River and its tributaries. Thus, the area falls in the Narmada Basin. The river Narmada flows along the northern boundary of the district. The river Narmada originates from the Amarkantak plateau and after flowing through Hoshangabad, Mandla, Jabalpur from the north-eastern part. The Tawa River is the major tributary of the Narmada River and flows from south to north west before merging into the Narmada River. Denwa river originates from south-eastern part of the Hoshangabad district and flows district and flows from east to west direction before joining the Tawa River (south of Rainpur) where Tawa dam has been constructed. The important nalas are Keolari, Hather and Indra Nadi. The rivers draining the area in the western part are Morand, Banjal and Ajnal. The Morand river joins the Ganjal river near Chhidgaonand flows towards Narmada River. All these tributaries flow from south to north and meet Narmada River. The drainage of the district is shown in **Fig:1.8.**

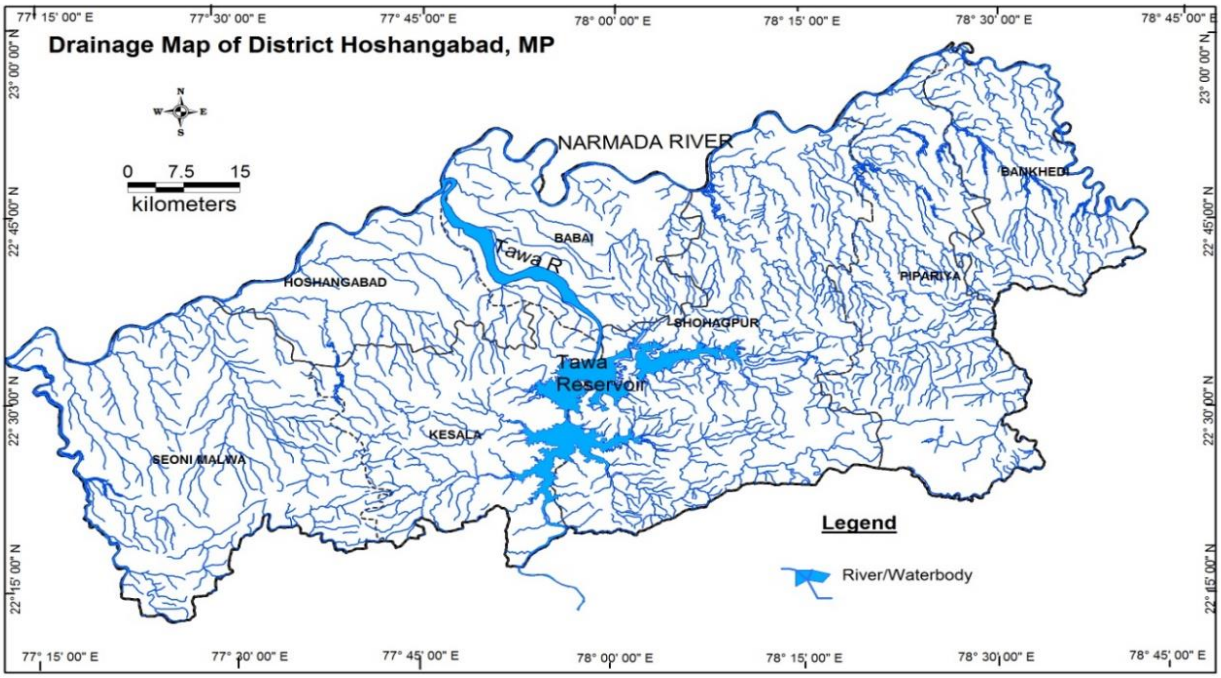

Fig:1.8. Drainage Map

1.11 Land Use, Surface Water Irrigation, and Cropping Pattern

Land use involves the management and modification of natural environment or wilderness into built environment such as settlement sand semi-natural habitats such as arable fields, pastures, and managed woods. It also has been defined as "The total of arrangements, activities, and inputs

that people undertake in a certain land cover type". The irrigation land use of Hoshangabad district can be classified as Net Sown Area (61.20%), Forest Area (16.37%), Land not available for cultivation (5.34%), Cultivable wasteland (5.07%), other uncultivated land excluding both fallow land and cultivable wasteland (2.67%). Block wise detailed of land use are given in **Table 1.7.**

Narmada River is the main river of the area which is flowing from east to west direction. Eastern boundary of the district is marked by the Dundhi river which flows almost toward north and takes westerly diversion before meeting the Narmada River. Denwa originates from the hilly range of Pachmarhi and meets with Tawa River which finally joins Narmada River. Palakmati ,Sukhri , Anjan and Ajnal

Hoshangabad district are divided in to five major units, Agricultural land, Forest land, water body, waste land and buildup land. Detailed landuse are given in **Fig:1.9**

Table 1.7: Land Use Pattern in Hoshangabad District

S. No.	Block	Number of Gram panchayat	Number of the villages covered	Total Geographical area	AreaunderAgriculture				Area under Forest	Area under Waste land	Area under other uses
					Gross Cropped Area(1)	Net Sown Area (2)	Area sown more than once (1-2)	Cropping Intensity(%)			
1	Hoshangabad	49	103	51262	46080	48575	38316	203	0	2470	101
2	Kesla	49	128	96567	32475	32475	24338	201	20224	6230	155
3	Seonimalwa	95	202	124915	76045	76045	66485	205	28694	6480	108
4	Babai	61	107	58977	42595	42595	24338	204	0	3835	120
5	Sohagpur	65	141	126819	51345	41450	23141	202	65909	6010	141
6	Pipariya	52	135	147344	40345	40345	27752	203	60503	6190	120
7	Bankhedi	53	120	62806	35615	35615	25183	201	0	3125	115
Total		**424**	**936**	**668690**	**324500**	**317100**	**229553**	**203**	**175330**	**34340**	**860**

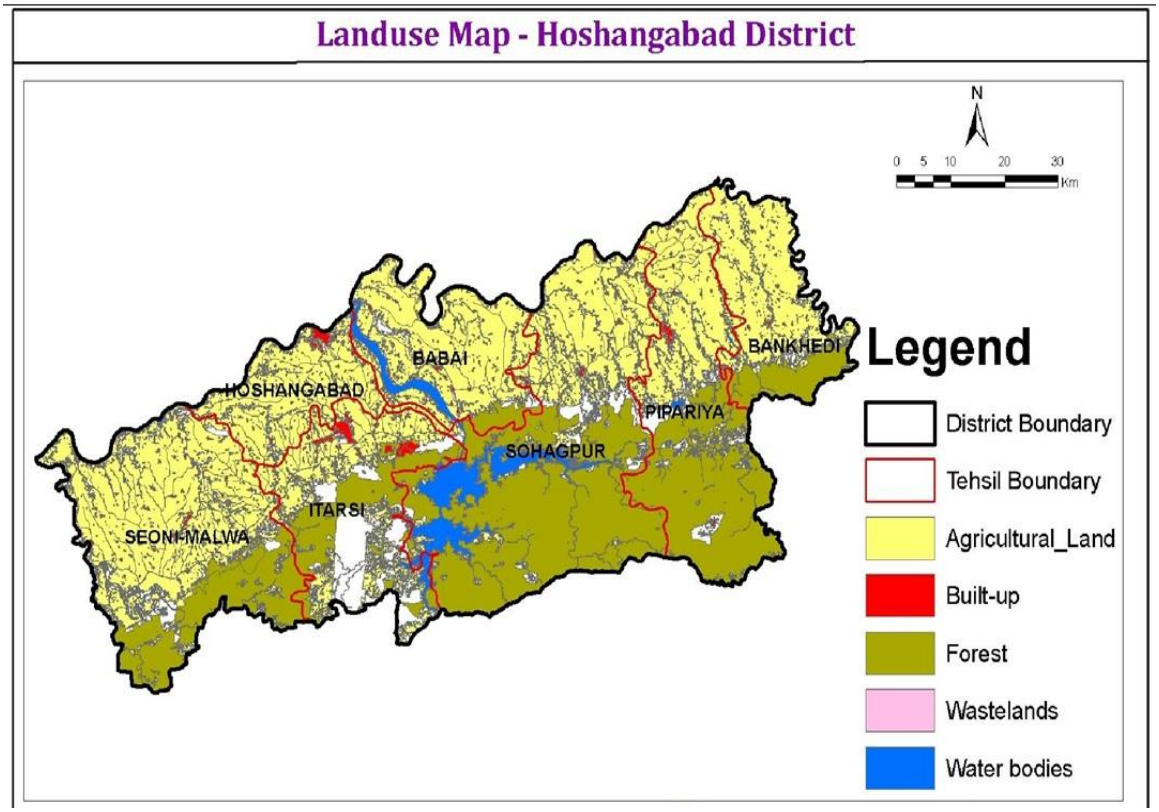

Fig:1.9: Landuse Map of Hoshangabad District

Table 1.8: Surface Water Bodies in the District Hoshangabad

S.No.	Block	No. of Water Bodies	Total Area (In Ha)
1	Hoshanagabad	3405	11250
2	Kesla	5427	10200
3	Seonimalwa	7825	14100
4	Babai	3806	12430
5	Sohagpur	3990	11550
6	Pipariya	3855	13140
7	Bankhedi	4197	12350
Total		**32505**	**85020**

Tawa dam is a major irrigation system in the study area. About 60% of the total area of Hoshangabad district is irrigated by Tawa canal system (**Fig:1.10**) The Tawa dam is constructed about 823 m. downstream of the confluence of Tawa and Denwa rivers at east longitude 77° 58'30" and north latitude 22° 33' 40". It has a Catchment area of 5982.90 Sq. Km. with 20055 ha area under submergence. The left Bank Canal starts from Ranipur and runs parralel to Narmada River course along the limits of the foot hill pediments of Satpura. This canal takes off directly from the reservoir with a head discharge of 103.06 cumecs. The first 6.44 km length is lined with thick concrete. The Handia branch canal with a head discharge of 29.9 cumecs takes off from the main

canal at 92 km point. The right bank canal is taken through a tunnel from Kamthi and runs parallel more or less to the course of Narmada River. The distributary system has been planned

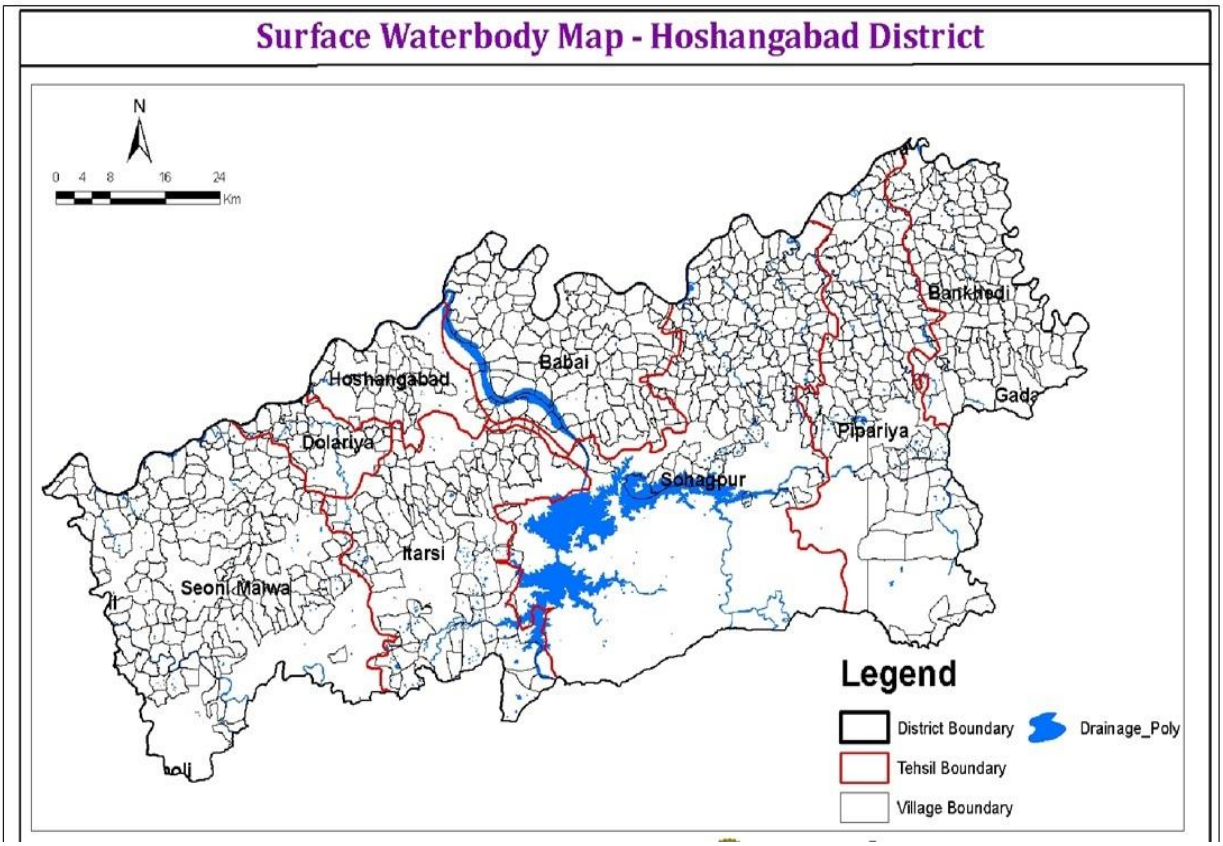

Fig:1.10 Major surface Water Body Map

along the drainage divide. Due to topographic difference between the right and left bank canal has been taken through 6 km long tunnel. Bagra branch canal and Piparia branch canals take off on either side of the pickup weir. The Bagra canal is 60 km long. The total length of distributaries and minors on the right bank is 450 km.

Many minor irrigation Schemes are also operating in the district, amongst which Dokrikhera Tank Project in Bankheri block is prominent. Dokrikhera Tank Project has a gross command area 9104 ha and culturable command area 7625 ha. The area irrigated by canals, tubewells, dugwells and tanks are tabulated below in **Table 1.9.** The crop wise irrigation is tabulated in Table 1.10

Table:1.9 Area Irrigated by different sources

IRRIGATION BY DIFFERENT SOURCES		
	Number	**Area (Sq. Km.)**
Dugwells	20303	544.53
Tube wells/Bore wells	4757	474.96
Tanks/Ponds	9	8.84
Canals (Tawa Canal Command)		1435.16
Other Sources		134.83
Net Irrigated Area		2610.22
Gross Irrigated Area		2610.22

Irrigation Projects:

Tawa dam is a major irrigation system in the study area. About 60 percent of the total area of Hoshangabad district is irrigated by Tawa canal system. The detail of Tawa dam and its main canals are shown in **Fig-1.11**. The salient features of the Tawa Irrigation Project are as follows:

Tawa Dam and Main Canal: The Tawa dam is constructed about 823m downstream of the confluence of Tawa and Denwa rivers at longitude 77º 58' 30" and East longitude 22º 33' 40" N. The network of Tawa canal, both right and left banks.

Catchment Area: 5982.90 Sq.km.

Avearge Rainfall of 58 years: 1546.13mm

Designed flood discharge : 0.308 lac cumecs.

Reservoir Data

Top Bank Level	359.664m.amsl
Maximum water level	356.692m. amsl
F.R.L.	355.397 m.
Crest Level	343.205 m. amsl
Gross storage at F.R.L.	0.231 m. ha.m
Dead storage	0.02m.ha.m
Avearge river bed level	309.677 m.amsl
Area under submergence	20,055 ha.

a) Left Bank Canal: The left bank canal starts from Ranipur and runs parallel to Narmada River course along the limits of the foot hill pediments of Satpura. This canal takes off

directly from the reservoir with a head discharge of 103.6 cumecs. The first 6.44 km length is lined with thick concrete.

The Handia branch canal with a head discharge of 29.9 cumecs takes off from the main canal at 92 Km. point.

b) Right Bank Canal: The right bank canal is taken through a tunnel from Kamthi and runs parallel more or loss to the course of Narmada River. The distributaries system has been planned along the drainage divide. Due to topographic difference between the right and left bank canal the right bank canal has been taken through 6km long tunnel. Bagra branch canal and Pipariya branch canals take off on either side of the pickup weir. The Bagra canal is 60 km long. The total length of the distributaries and minors on the right bank is 450 km.

Many Minor Irrigation Scheme are also operating in the district, amongst which Dokrikhera Tank Project in Bankheri block is prominent.

DOKRIKHERA TANK PROJECT

SALIENT FEATURES OF DOKRIKHERA RESERVOIR

1.	STATE	Madhya Pradesh
2.	DISTRICT	Hoshangabad
3.	LONGITUDE	22° 39’ 00”, 78º 22’ 00”
4.	LOCATION	Ghogra and Dabka Nalla

HYDROLOGY

1.	Catchment area up to dam site	:	31.08sq.km.
2.	Maxm Annual Rainfall (1973)	:	1767 mm.
3.	Minm Annual Rainfall (1965)	:	635 mm.
4.	Average Annual Rainfall from (1964to 90)	:	841 mm.
5.	Design flood	:	255.45 cumecs
6.	Actual observed maxm Flood at dam site	:	283.00 cumecs

RESERVOIR DATA

1.	Maximum water level	379.57 m
2.	Full reservoir level	378.66 m
3.	Maximum draw down level	362.93 m
4.	Lowest sill level	370.42 m
5.	River bed level	362.93 m
6.	Water Spread Area at FRL	352.23 Ha
7.	Gross stoarge at FRL	13.369mcm
8.	Dead storage at	

a)	L.sl	0.736 mcm
b)	At L.S.L.35 mcft	1.736 mcm
c)	Minm draw down level.	370.42
9.	Live stoarge at FRL	12.633mcm
10.	Summer stoarge at FRL	1.736 mcm
11.	Tehsil in which submergence area lies	Pipariya
12.	No. of village affected	Nil
13.	No. of Persons displaced	Nil
14.	Culturable area submerged at FRL	267.20 ha.

DAM

1)	Waste weir	
2)	Crest level of waste weir	378.66 m amsl.
3)	Length of waste weir	30.48 m.
4)	Length of dam.	1981.20 m.
5)	Top width of dam	4.00 m.
6)	Maxm length of dam	18.07 m.

CANAL SYSTEM

1.	Gross command area	9104 ha.
2.	Culturable command	7625 ha.
3.	Area to be irrigated	2672 ha.
4.	Annual irrigation	2672 ha.
5.	Intensity of irrigation	12%
6.	Existing crop practices, Proposed crop pattern and Annual irrigation	
	a) Existing	2672 ha.
	b) Proposed	2672 ha.
7.	Length of Canal	
	a) Main Canal	
	i) Left bank	18.24 km.
	ii) Right bank	12.96 km.
	b) Distributories	
	i) Taron distributories	8.48 km.
	ii) Banwari distributory	5.44 km.
	c) Minors	
	i) RBC -3 No.	3.20 km
	ii) LBC-5 No.	370.42 km.
8.	Full supply level at head of canal	
	i) RBC	370.42 m.
	ii) LBC	370.42 m.
9.	Head discharge	
	i) RBC	0.736 cumecs

ii) LBC 1.868 cumecs

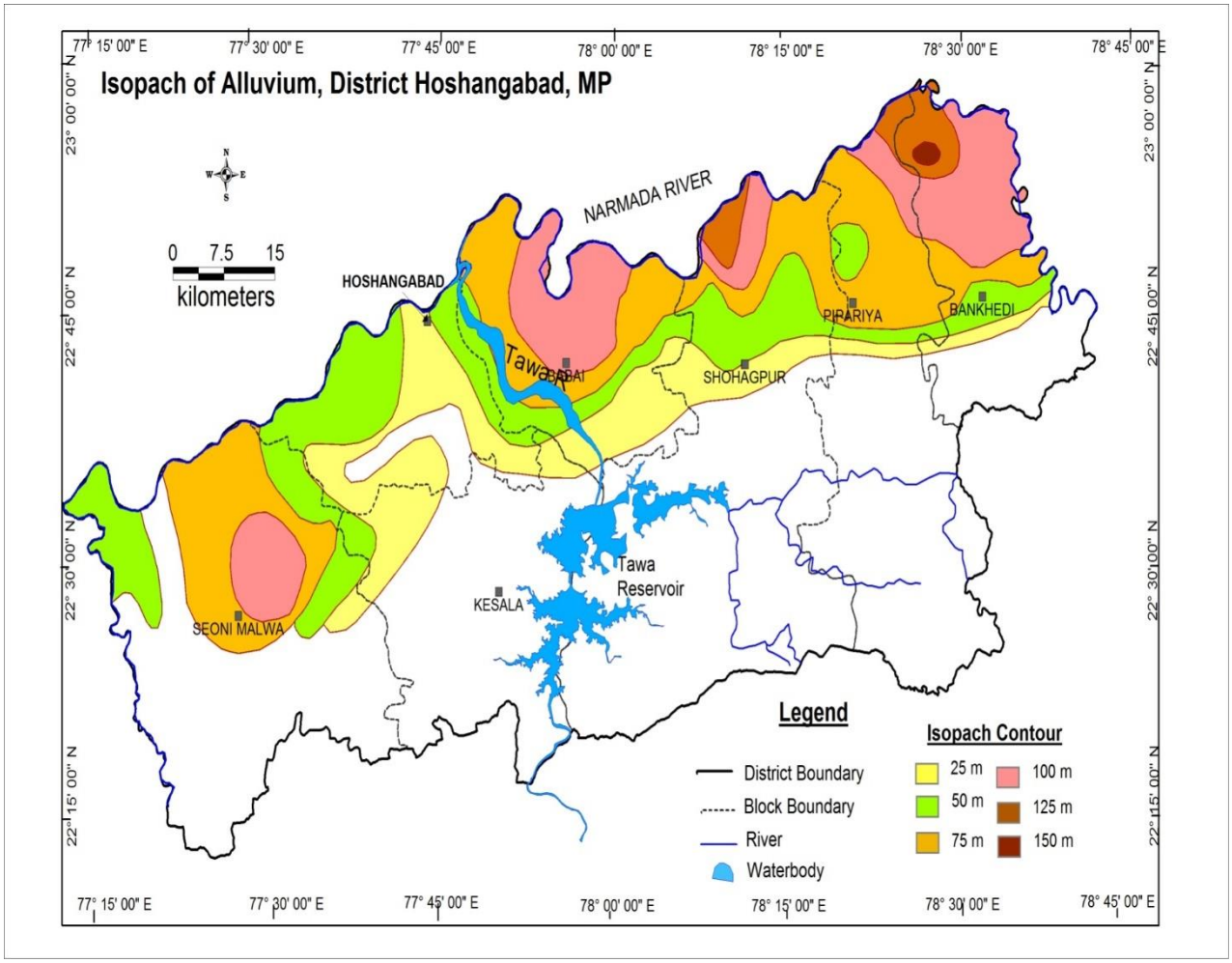

Fig. 1.11 Isopach map with tawa reservoir

Table:1.10 Irrigation Area & Crops

AREA UNDER PRINCIPAL CROPS (Sq. Km.)	
Wheat	2026.28
Paddy	140.52
Jowar	11.61
Maize	19.28
Other Grains	24.01
Gram	501.13
Tuar	121.53
Urad	1.72
Other Pulses	43.28
Soyabean	1884.95
Groundnut	0.70
Til	3.67
Other Oilseeds	6.03
Sugarcane	17.96
Cotton	0.25
Spices	15.35
Vegetables	32.02

1.12 Geology and Stratigraphy

Northern part of Hoshangabad district, adjoining the Narmada River is covered with alluvium, which makes for more than 50% of the entire district area. Deccan Traps occur as lava flows in the west central part of the district. The southern part of the area is hilly and occupied by rocks belonging to Gondwanas. Bijawars and Archean's are exposed in the western part of the district as linear ridges. Geological Map is given in **Fig:1.12**

The general geological succession (table 1.11) in the district is as follows:

Table 1.11: Geological Succession

Age	**Super Group**	**Group**	**Series**	**Formation**
Recent Pleistocene				Alluvium and soil cap Older alluvium &laterite
Upper Creataceous to	-	Deccan Trap Intertrappeans	-	Basaltic lava flows, dykes, sills
---------- Unconformity----------				
Upper Creataceous		Lametas		Sandstones, arenaceous mudsstones, Limestone
Triassic	Gondwana	Upper Gondwana Group	Jabalpur Series	Jabalpur Sandstone. Chaugan stage-
			Mahadeva series	Denwa sandstone & clay Panchmarhi stage-red & buff sandstone with red clays.Bijorisandstone & shales(micaceous)
Permian		Lower Gondwana	Damuda Series	Motursandstone(white or brownish-greenish) with
			Talchir series	TalchirBoulderr beds
---------- Unconformity----------				
Cambarian	Vindhyan (Upper)		Bhander series	Lower bander sandstone & Quartzite
---------- Unconformity----------				
Pre-cambarian	Bijawar			Dolomitic limestone and schists
---------- Unconformity----------				

Archean				Granite, Gneiss etc.

Archeans

Archeans are exposed south of Itarsi around Kesla railway station and west of Handia. Granite, gneiss is exposed around Harda Khas. Exposures of Archeans rocks are also seen at many places between the rock of Gondwanas.

Bijawars

Rocks of Bijawar group are exposed north west of Harda and south west of Harda and south west of Handia.The rock types include dolomitic crystalline limestone and quartzite.

Vindhyans

UpperVindhyans represented by Lower Bhander sandstone are exposed south of Hoshangabad in Adamgarh quarry and at the confluence of Hather nala and River Narmada, north of Misrod and Dhamasa village near Chautalai village. These sandstones are medium grained, hard, compact, red-lightpink in color and dip 12º due N. top of sandstone is buff colored and fine grained and traversed by two sets of joints, one parallel to the strike and another at right angles to it. The rocks have poor groundwater potentialas they form hills in the district. The Vindhyansandstone serves as a good building stone.

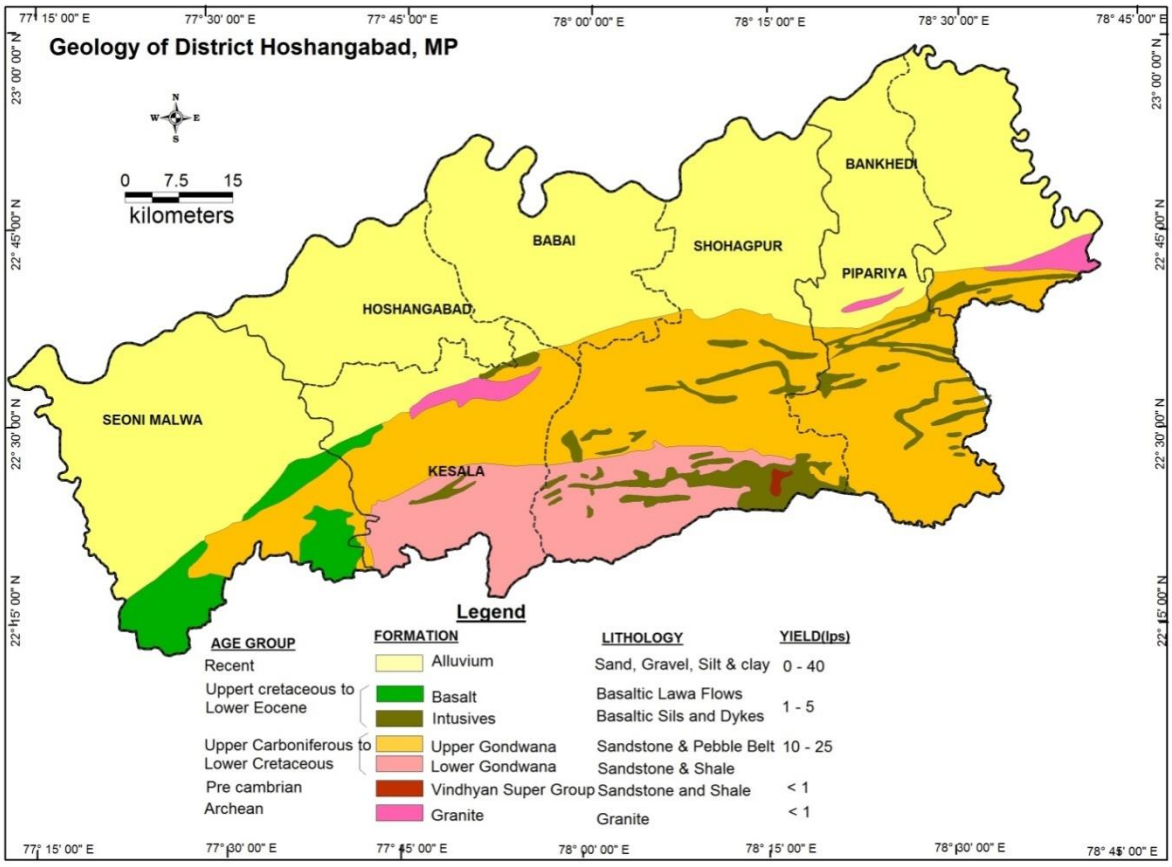

Fig:1.12. Geological Map

Gondwanas

Lower Gondwanas are well exposed in the Satpura region of the district on the sides of upper Denwa valley in the southern base of panchmari hills, north-west of Harda Khas and at the confluernce of the Anjan river and at Pathapani due north of Fatehpur (55J/ 10). The lower Gondwanas are divided into the Talchirs and the Damuda series. The Talchirs are characterised by the pebbles and boulders of varied diameters from 5 to 25cm and by green clays, shales and sandstones. The rocks of Barakar stage are coarse grained and composed of white to fawn-coloured sandstones, grits, conglomerates, shales and carbonaceous shales. The Motur stage consists of earthly white to brown. coarse, grained sandstone with lenticles of clay and shale. The rocks of bijori stage comprise micaceous flagstones, sandstones and shales.

Damuda series of the Lower Gondwanas is overlain by the rocks of the Mahdeva and Jabalpur series of Upper Gondwana system. The Mahadeva series is further divided into the Panchmari,

Denwa and the Bagra stages. The rocks of coarse-grained sandstones with thin intervening horizons of pebbles. Sometimes red to buff-colored sandstones with current bedding are also observed. The red clays Occurring east of river Denwa seem to merge in the Denwa beds. The rocks of the Denwa stage consisting of soft thick variegated, clays, mostly red to buff colored, containing calcitic nodules, with a few bands of white to yellow sandstones, lie conformably over the Panchmari s and are exposed in the Denwa and Dudhi river beds. The Bagras occur in the immediate south of Narmada valley overlaying the older rocks of upper Gondwana. They comprise conglomerates and pebble beds with occasional bands of calcareous sandstones, Variegated clays, limestones and dolerites.

The Jabalpur Series is subdivided into Chaugan and Jabalpur stages. The Jabalpurs comprise mostly soft, fine grained, occasionally pebbly sandstone with thin thin subordinate beds of conglomerates, earthly haematite, coal, carbonaceous red clays, shales and chert. A small patch occurs south east of Hoshangabad. At some places they are overlain by the lametas and/or by the Deccan Traps.

Lametas

The Lametas lie conformably over the Jabalpur and are exposed near Khatama and Kiratgarh, south east of Hoshangabad. They comprise light colored limestones, sandstones and clay/shale of fresh water origin.

Deccan Traps

The basaltic lava flows comprising the Deccan Traps overlie all the older formations in the western part of the district and in the form of Dykes/sills in the southern part of the district criss-crosssing the Gondwanas.

Alluvium and Laterite:

The Narmada valley alluvium covering more than 50% of the district area, extends from Harda in the west to much beyond the eastern boundary of the district to Jabalpur in the east, filling the faulted through of the Narmada rift valley. In general, the alluvial layer is thickest near the Narmada i.e in the North and tapering towards the foot hills of Satpura. The alluvium is encountered at Tinasri (55J/5). The alluvium is chiefly composed of reddish, brownish and yellowish clay/sandy clay with numerous inter calations of bands of sand and gravel.

A Few small outcrops of laterite are located in the vicinity of Itarsi in the form of loose ferruginous material of bricks red colur of pisolitic (gravelly) texture.

Chapter -2

Data Collection and Generation

Hydrogeological data includes quality and quality from existing data were collected and analyzed in GIS platform to validate and avoid discrepancy while preparing the aquifer mapping in the basin. The date collected from allied department such as WRD and PHED Agriculture departments and administrative department were also included in the data collection and analysis.

2.1 Groundwater exploration

The groundwater exploration was carried out CGWB, NCR down to depth of 120 mts and state departments drilled for drinking water purposes well down to depth of maximum 60 mts were collected and compiled for demarcating the aquifer system of the basin. In the study area, 79nos exploratory well drilled in Hoshangabad district under the exploratory well Programme of erstwhile Exploratory Tube-wells Organization (now Central Ground Water Board) and later during the Narmada Project. Period between 1971 to 1978 under the CGWB.

2.2 Groundwater Quality Monitoring Well

Central Ground Water Board, NCR were established 121 key observation wells to monitor the groundwater quality one time in a year of shallow aquifer. All the groundwater quality data are incorporated for analyzing the groundwater quality issues. The water samples were collected from Key observation wells in clean double stopped poly ethylene bottles from 121 different locations of Hoshangabad district during July 2018.

2.3 Groundwater Level Monitoring

Central Ground Water Board, NCR was established key wells to monitor the groundwater level four times in a year in shallow aquifer which will give clear picture about the groundwater recharge in aquifer system and WRD Govt.of Madhya Pradesh is also monitoring the groundwater level in month wise in each district of water table aquifer mainly of dug well. The fractured/Vesicularaquifer of deeper aquifer is also monitored using the bore well called piezometer. Water level of existing NHS wells is given in table 2.1.

Table: 2.1 Water Level of Existing NHS well

Block	Well Location	Type of well	Aquifer Type	Depth in m	Pre-Monsoon WL (m)	Post-Monsoon WL (m)
Kesla	Suktawa	Dug Well	Unconfined	13.5	7.32	2.48
Sohagpur	Sohagpur	Dug Well	Unconfined	10.25	9.26	7.9
Sohagpur	Semri Harchand	Dug Well	Unconfined	12	5.12	11.03
Hoshangabad	Sanwalkhera	Dug Well	Unconfined	10.55	9.13	7.65
Kesla	Sankhera	Dug Well	Unconfined	7.5	3.19	2.96
Pipariya	Sandia	Dug Well	Unconfined	20.5	15.57	14.9
Hoshangabad	Raisalpur	Dug Well	Unconfined	12.38	7.41	8.7
Kesla	Pathrauta	Dug Well	Unconfined	14.87	12.68	6.55
Pipariya	Pachmarhi	Dug Well	Unconfined	16.15	6.54	1.31
Pipariya	Matkuli	Dug Well	Unconfined	20.65	6.93	8.3
Kesla	Kesla	Dug Well	Unconfined	7.95	4.46	5.15
Kesla	Gurra New	Dug Well	Unconfined	18.65	4.66	10.95
Seoni Malwa	Bhilatdeo	Dug Well	Unconfined	16	6.91	6.64
Babai	Baharpur	Dug Well	Unconfined	12.5	8.07	10.75

Block	Well Location	Type of well	Aquifer Type	Depth in m	Pre-Monsoon WL (m)	Post-Monsoon WL (m)
Babai	Bagratawa	Dug Well	Unconfined	19.1	7.02	12.2
Babai	Babai	Dug Well	Unconfined	14	8.17	5.75

Chapter -3
Data Interpretation, Intregation and Aquifer Mapping

3.1 Groundwater Level Monitoring

Water level data, including historical data are essential for not only to know the present ground water conditions but also for forecasting future trends in response to ground water reservoir operations. Using the water level data of 33 NHS monitoring wells, 121 NQUIM key wells data of Hoshangabad districts shown in **Fig: 3.1**. Pre and post monsoon depth to water level maps are prepared on the basis of NHS and key observation wells data, presented on **Fig: 3.3, 3.4.**

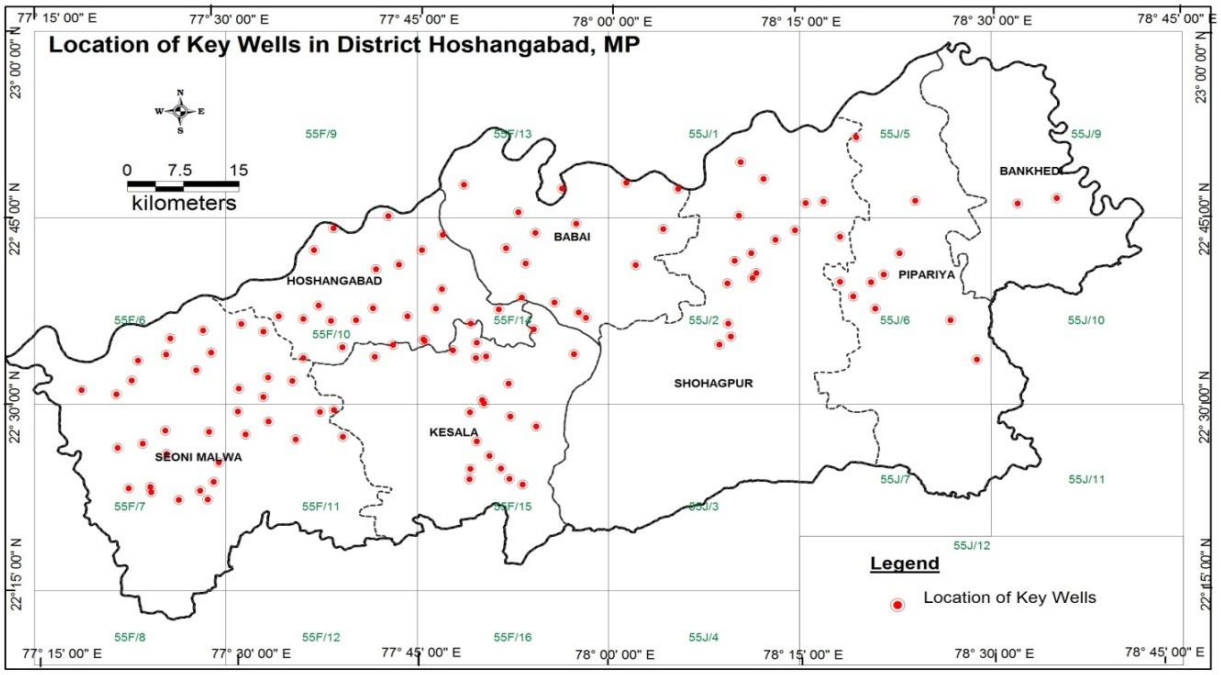

Fig 3.1: Location key observation wells

The water table contour map reveals that flow of ground water is towards NW part of the valley towards Narmada River.Detailed of water table contour and regional ground water flow direction are shown in **Fig: 3.2.**

3.2 Pre-monsoon water level (May 2021)

The pre-monsoon depth to Water levels ranges from a minimum of 3.19 meters below ground level (mbgl) in Kesla block to a maximum of 15.57 m bgl in Pipariya block of Hoshanagabaddistrict. About 19% wellsare showing water level ranges in 2-5 m bgl have been recorded in in Southern part of district. About 69 % of monitoring wells recorded water level in the range of 5-10 m bgl category, spreading in major part of area. About 12% of monitoring wells are showing water level >10 m bgl occurring in Eastern (Pipariya Block) and in pocket of Southern part district.

3.3 Post-monsoon water level (Nov 2021)

The post-monsoon depth to Water levels ranges recorded from a minimum of 1.39 meters below ground level (mbgl) and maximum of 14.19 m bgl both in Pipariya block of Hoshanagabad district. About 19% wells are showing water level ranges in 2-5 m bgl have been recorded in in Southern part of district. About 50 % of monitoring wells recorded water level in the range of 5-10 m bgl category, spreading in major part of area. About 31% of monitoring wells recorded water level >10 m bgl occurring in maximum part of the district.

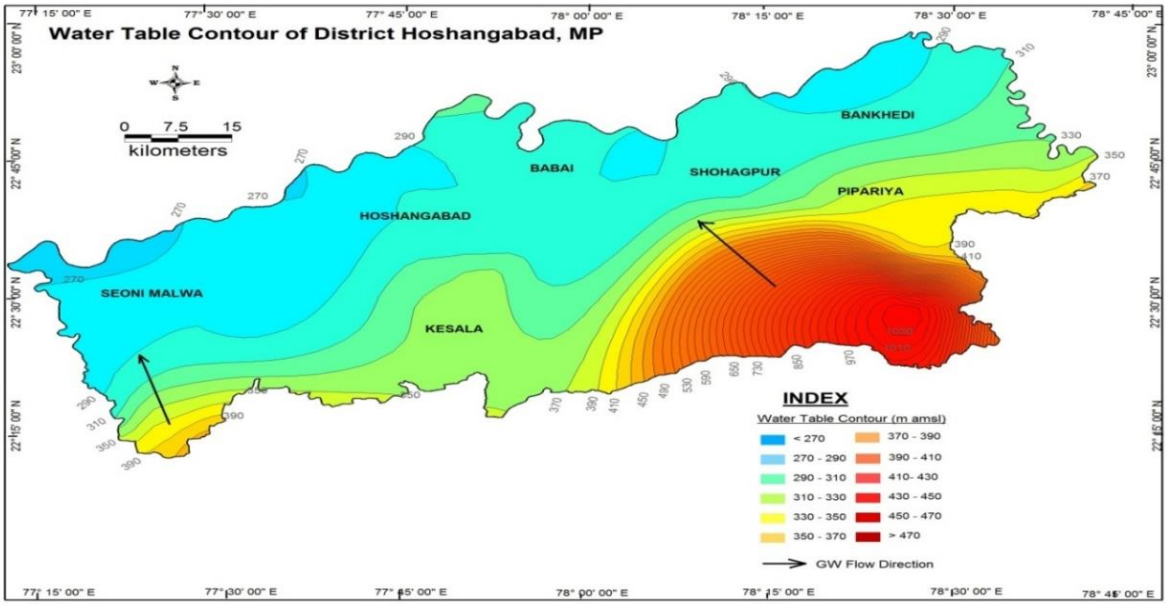

Fig.3.2 Water level contour map

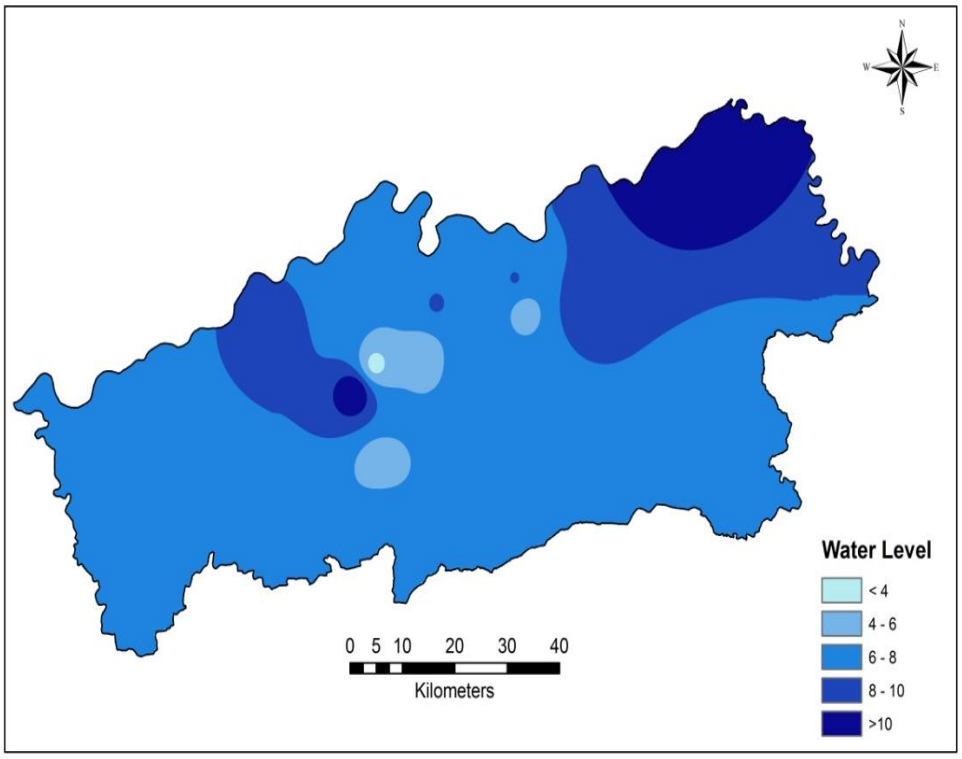

Fig: 3.3 Depth to water level pre-monsoon

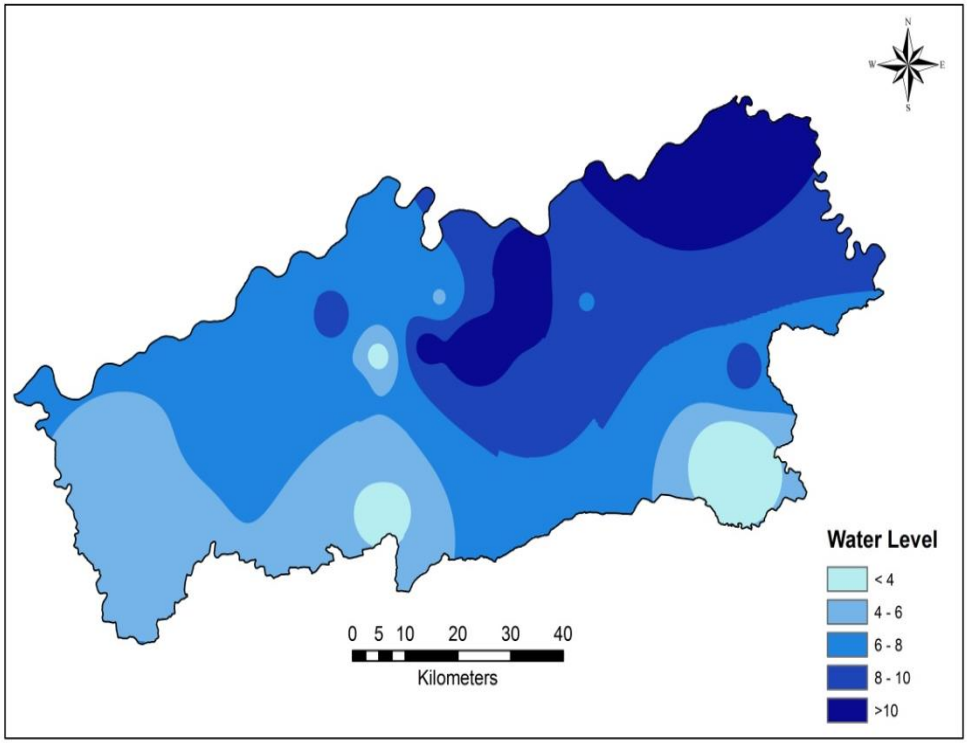

Fig: 3.4 Depth to water level post-monsoon

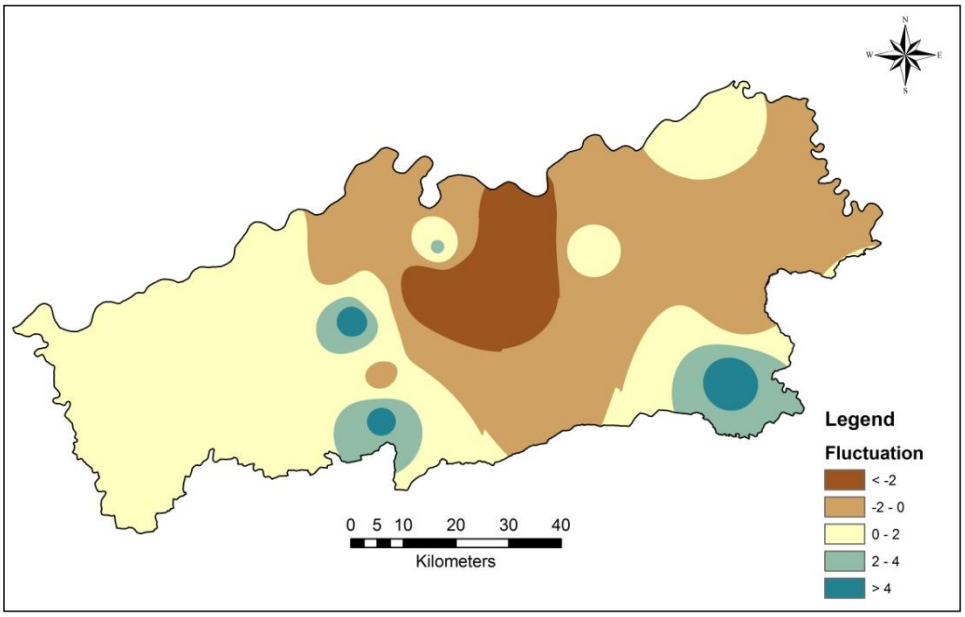

Fig: 3.5 Water Level fluctuation

3.4 Aquifer Disposition in the District

The water bearing properties of different hydrogeological units occurring in Hoshangabad District are described below.

Northern part of Hoshangabad district, adjoining the Narmada River is covered with alluvium, which makes for more than 50% of the entire district, Deccan traps occur as lava flows in the west central part of the district. The southern part of the area is hilly and occupied by rocks belonging to Gondwanas: southern part of the district around Kesla Railway station Archeans are exposed The Archaeans are exposed south of Itarsi around Kesla railway station between the rocks of Gondwana in the form of inliers they are in very small patches and no ground water structure exist in them for hydrogeological studies. In general ground water occurs in phreatic condition.

The alluvial aquifer system in the district is the most extensive i.e. Two to three granular zones comprising of fine to medium to coarse grained sand, gravel and pebbles and laterite are encountered in alluvium. The top phreatic acquifer ranges in thickness from 2 to 10m and is encountered in the depth ranges of 4 to 20mbgl. The phreatic acquifer mostly

comprises of fine to medium grained sand with inercalations of clay and silt, and at places also of coarse sand or gravel.

It appears that all the alluvial aquifer zones constitute a single acquifer system. The unconfined aquifer long the southern fringe adjacent to Gondwanas, passes laterally to the north into a number of aquifer zones separated by clay lenses or thick clay zones. The deeper aquifers are of semi-confined nature with varying potentiometric heads.

Histogram showing aquifer wise discharge is presented in **Fig:3.6.** Hydrogeology of the district is shown in **Fig: 3.7.**

Pumping tests were carried out on select dug wells to evaluate the hydraulic parameters of aquifers in the area. The results of computations are tabulated in **Table 3.1**

Table 3.1 Results of pumping test of selected dugwells

S. No.	Location	Aquifer Materials	SWL (m bgl)	Discharge in (m3/day)	Transmissivity (m2/day)	Specific yield
1	Bairagarh	Weathered Granite	8.16	727	115.66	0.05
2	Dudhkatch	Weathered Granite	10.17	596	39.51	0.17
3	Rehtakhurd	Sand and Pebbles (Alluvium clay)	6.53	691.2	420.56	0.10
4	Langha	Clay & Sand	6.53	691.2	6.47	0.025
5	Alakhari	Sand & Pebbles	4.36	517.8	34.32	0.024

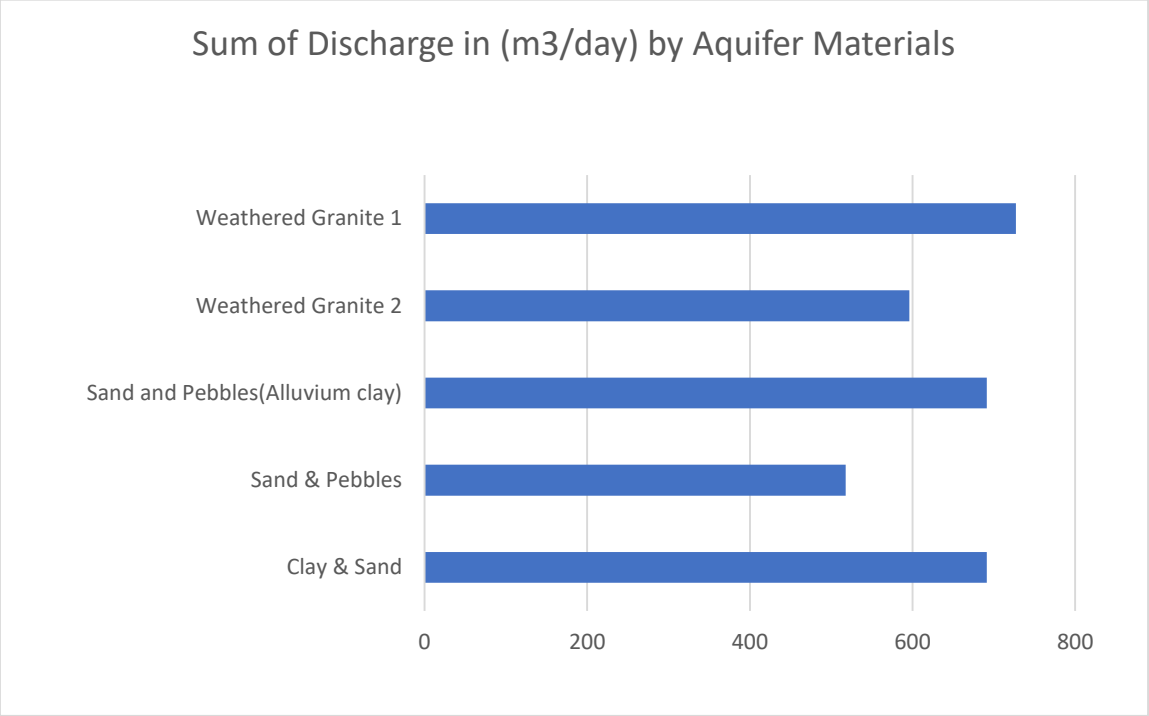

Fig:3.6 Histogram showing aquifer wise discharge

Table 3.2 Results of pumping test conducted in Borewells

S.No.	Location	Capacity m2/hr	Discharge in (m3/day)	Transmissivity (m2/day)	Specific yield
1	Amlara	2.42	6.67	13.56	0.06
2	Faridpur	224.06	18..78	7.79	0.32
3	Tugharia	20.02	32.44	12.37	0.20
4	Sountara		36.00	8.54	0.001
5	Nitya		28.00	7.84	0.0001

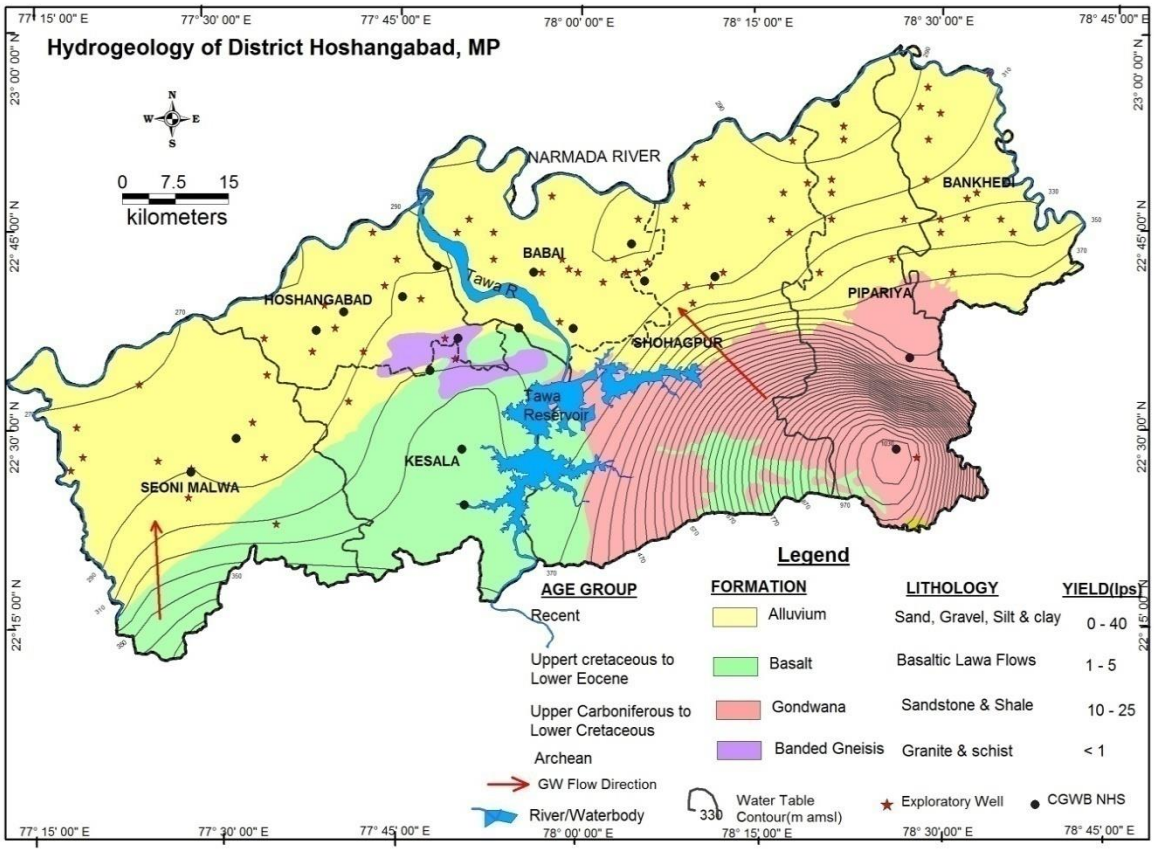

Fig:3.7. Hydrogeology Map

Hot Spring

A hot water spring occurs in the area at Anhoni (55J/5) (west of road from Pipariya to Pachmarhi). The temperature of Anhoni spring water is 41ºC. A borehole has been drilled by Geological Survey of India, Geothermal Division, Nagpur down to a depth of 250 mbgl near the spring. The water smells of sulphur and occurrence of methane gas during drilling is reported by G.S.I. staff.

3.5 2D/3D Aquifer Disposition

About 79 exploratory tube wells have been drilled in Hoshangabad district under the exploratory well programme of erstwhile Exploratory Tube-wells Organization (now Central Ground Water Board) and later during the Narmada Project. Period between 1971 to 1978 under the CGWB. Data of exploratory Borewell drilled during the Narmada Project. A fence diagram has been prepared using data of exploratory tube wells of Narmada Project to delineate the sub –surface litho-units of Hoshangabad district. The sub-surface geology based on the exploratory drilling is described below:

West of Tawa River:

In general, the bed rock in the area west of the Tawa River is the Deccan Trap (at Raisalpur, Itarsi, Pawarkhera, Bhilakheri, Tikhar, Dolaria, Khal, Palanpur, Sauntara and Paghdal) and phyllitic schist (Sausar series) with bands of quartzite at Dharamkundi and Khutwasa. At Misrod, Sandstone is encounetred. Granite is encontered at Sheopur.

The basements are deep around Dharam Kundi, Gajanpur and Nipania where these are encountered between 91 and 110mbgl. And shallow around Raisalpur, Pawarkhera, Dolaria and Tikhar occuring between 18 and 43mbgl. Gondwanas in this area are encountered only in the borehole at Sankhera.

The thickness of alluvium gradually increases from 28m at Timurni to Paghdhal to Nipania to Gajanpur to 118m at Dharamkundi from where it gradually decreases towards Bhilakheri to 45m at Sankhera.

East of Tawa River:

The basement in the form of granite at Dhana and Chanderi; Quartzite at Seoni, Shobhapur and Pachlora; hard limestone at Paladeori and Vindhyans are encountered in the boreholes at Paladeori and taron and Vindhyans are encountered in the boreholes at Chilachaun, Pachlaora at depth between 82 and 150.27mbgl. While the basement in the form of shale is encountered at Bhatwari, Managaon and Pathrai-

The basement is deep around Chaurahat, Gujjarkheri, Shobhapur and Tinsari-

Upper Gondwanas in the form of argillaceous (Denwas) and arenaceous (Bagras of Panchmarhis) semi –consolidated and relatively more compact sediments, more particularly around Dhakwara (J/5), Mokalwari (J/6), Mahuakhera and Tinsari.The Gondwana formations occuring beneath the alluvium comprise mostly thick Clays with thin granular zones in few isolated patches. The Gondwanas sediments range in thickness from 34m. at 59m. at Shobhapur.

It is observed that the Gondwanas prominently exist in the east of Tawa River. Very thick deposits of gondwanas are observed along the southern fringe of alluvium, decreasing in thickness progressively towards north. In few Isolated patches in the central parts of alluvial plain thick deposits of Gondawanas are encountered in boreholes at Chaurahat and Shobhapur where the thickness of Gondwana is 198 to 259m. respectively.

The thickness of alluvium ranges between 19m. at Pathrai to 160m. at Tinsari. Very thick alluvium was recorded in a few isolated patches around Mohansa, Bhatwari, Sirwar, Ari, Ranigohan, kapuri, Chandon Nibhora and Tinsari. It is noticed that thick deposits of Narmada alluvium exist along and at the confluence of major tributaries to Narmada River.

A north east geological section covering a distance of 22.75 km with the bore hole at Tinsiri, Chandon, kapuri, Gondalwara, Bachawani, Kalkuhi and Mhuakher. In all the borehole alluvium encountered at different depth varying from 21m (Mahukhera –BHE-73) to 159 m (Tinsiri-BHE-76) after that upper Gondwana formation encountered, in all the bore hole varying in thickness from 61-184m and the Gondwana occur just below the clay and Kanker beds with thickness increasing towards south direction. The basement formation of shale, sandstone and granite of archean age were encountered in all bore holes except Bachawani-BE-71

Geological section along with Maragaon to Pathari

A north-west geological section covering a distance of 19.75 km with boreole at Maragaon, Chaurahat, Rakh, Bamohari, Semri and Pathari. **Fig: 3.8** It is observed from this section that the alluvium thickness is more in central part in borehole drilled at Bamohri than the northern and southern borehole at maragaon and pathrai. Clay stone of 5-10 thickness is encountered in Chaurahat, Rakh and Bamohri boreholes only.

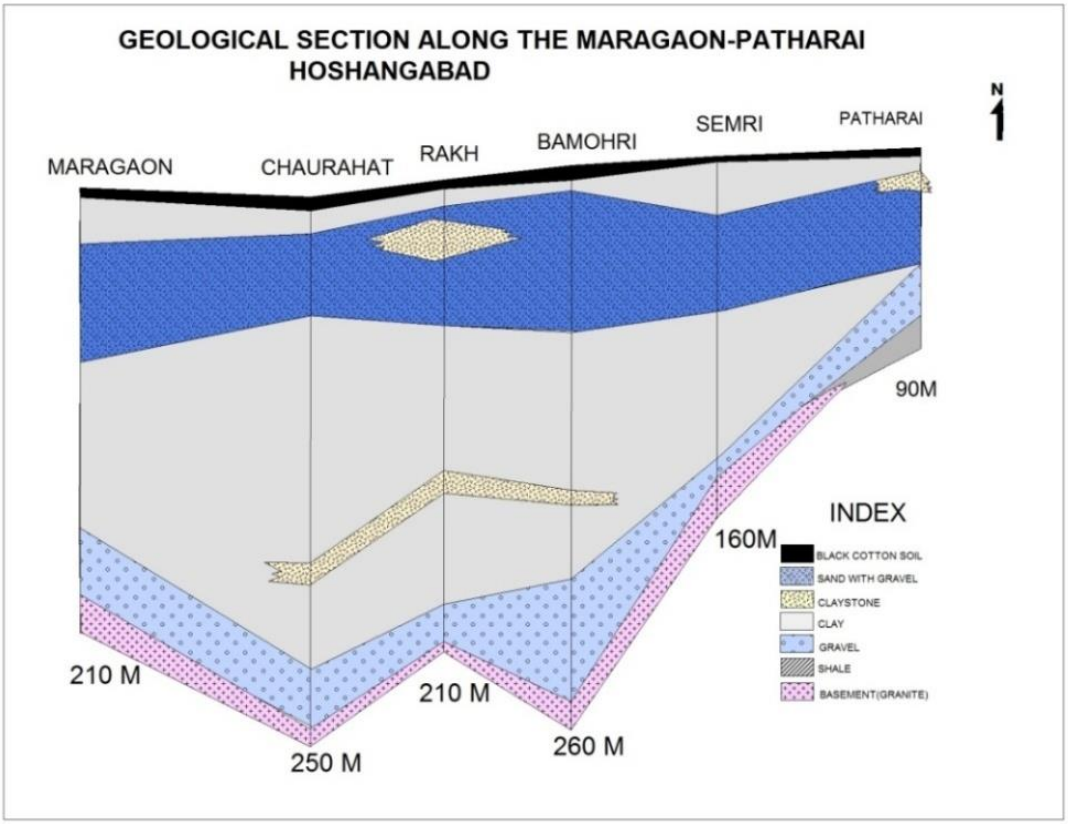

Fig. 3.8 Aquifer disposition from Maragaon to Patharai

Geological section along with Pachlora to Taron

A north- south geological section covering a distance of 38 km with boreole at Kharagon, Tonga, Untiakalan, Pachlora, Garagha, Khap [arkhera, Dhandia. Piparia and Taron. **Fig: 3.9** It is observed from this section that the alluvium thickness is increase towards Narmada River and its varies from 20-80m. Thickest Gondwana formation encountered at Piparia about 176 m bed rock of Archean age is encountered in all the boreholes except Untikaaln, whereas basalt formation encountered at depth of 44 m bgl. The fence diagram of Hosangabad distrcit is presented in Fig:3.10 and 2D & 3D maps of the study area is presented in Fig 3.11 -3.14

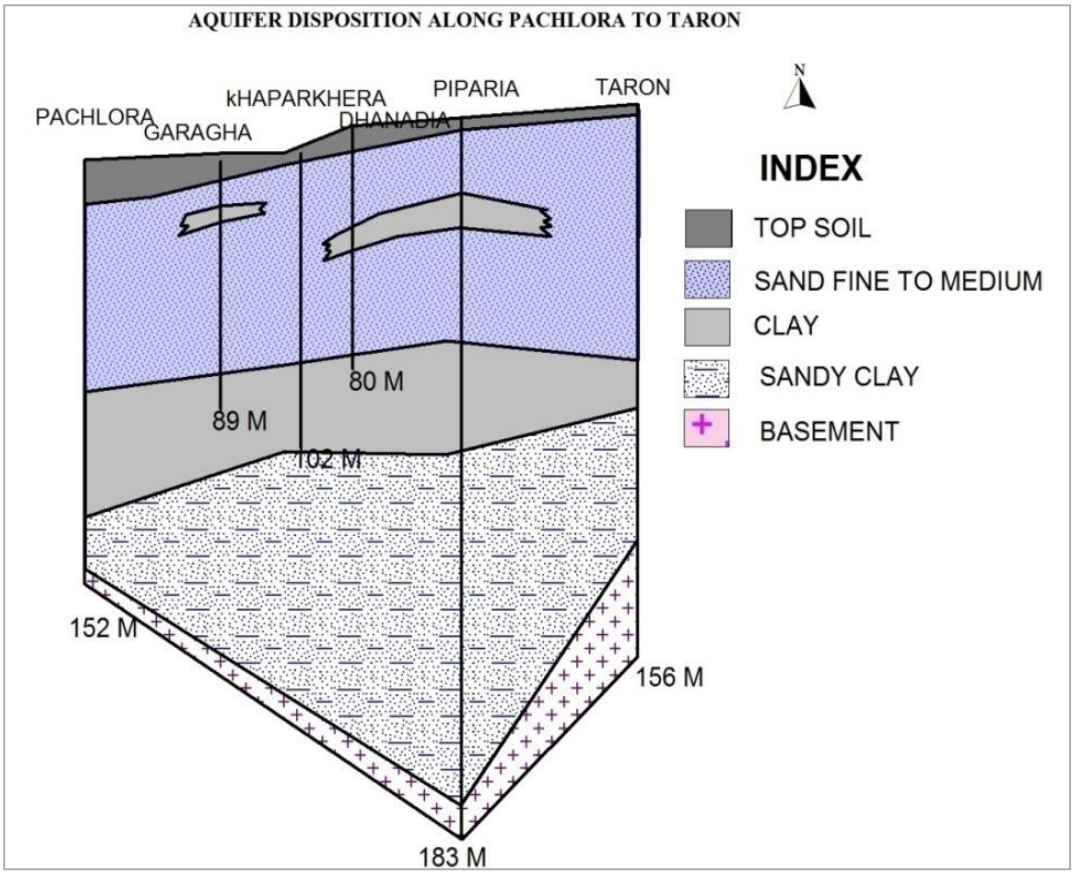

Fig 3.9

Fig:3.9 Aquifer disposition from Pachlora to Taron

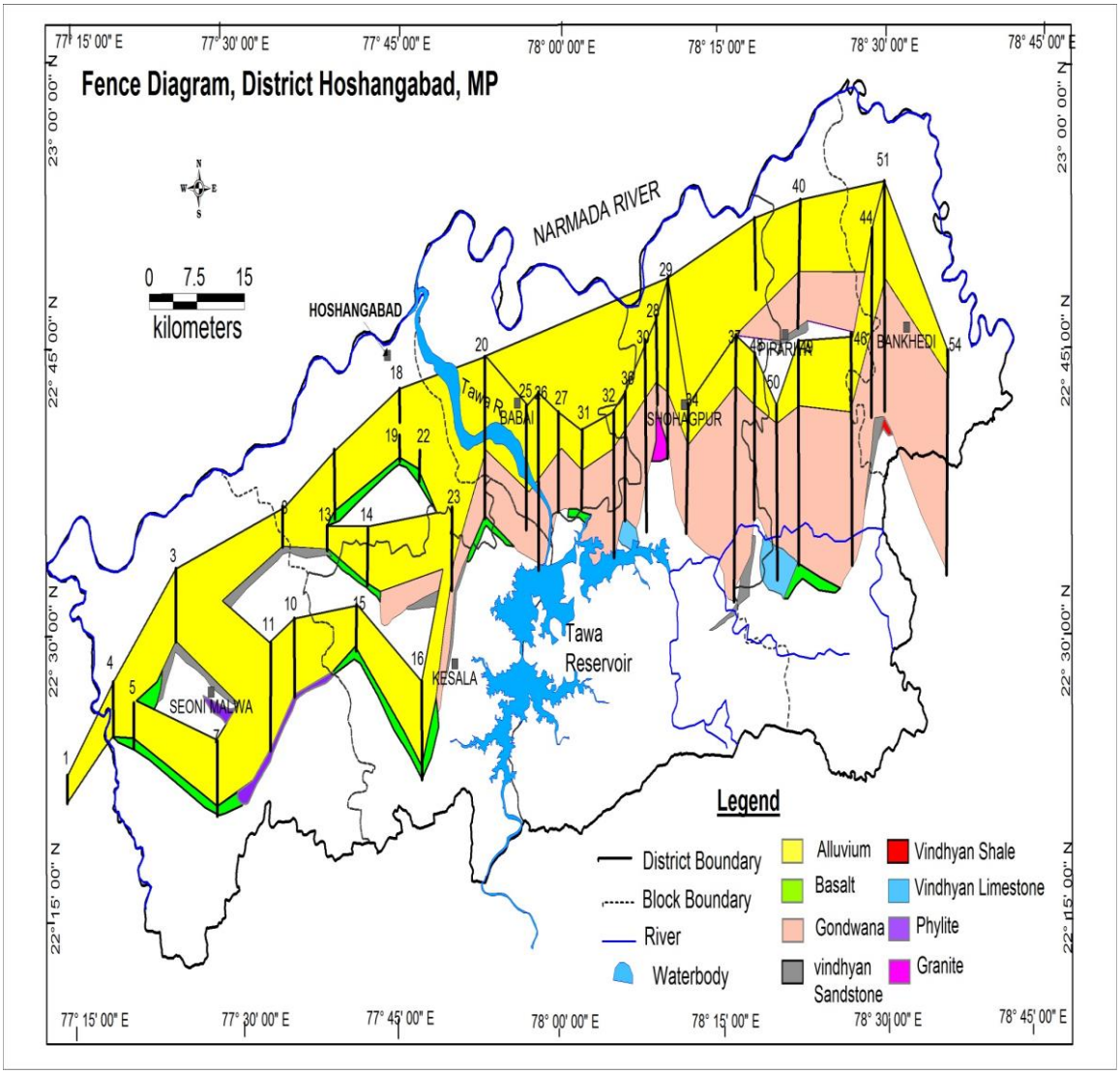

Fig: 3.10 Fence diagram of Hoshanagabad District

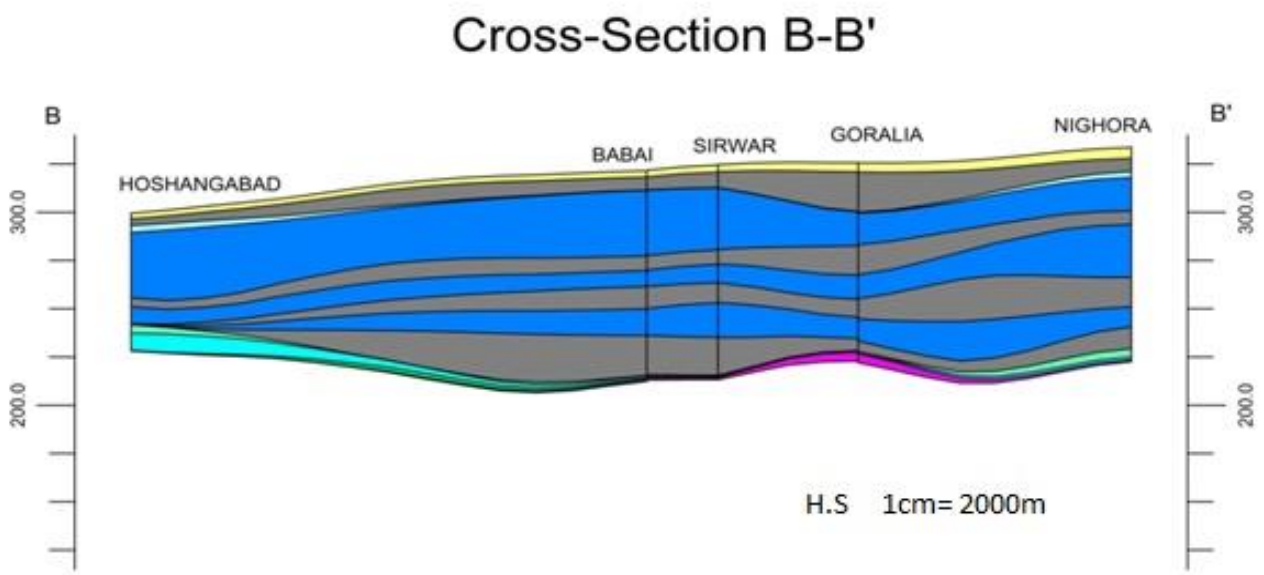

Fig: 3.11 Sub surface 2D from Hoshangabad to Nighora in the study area

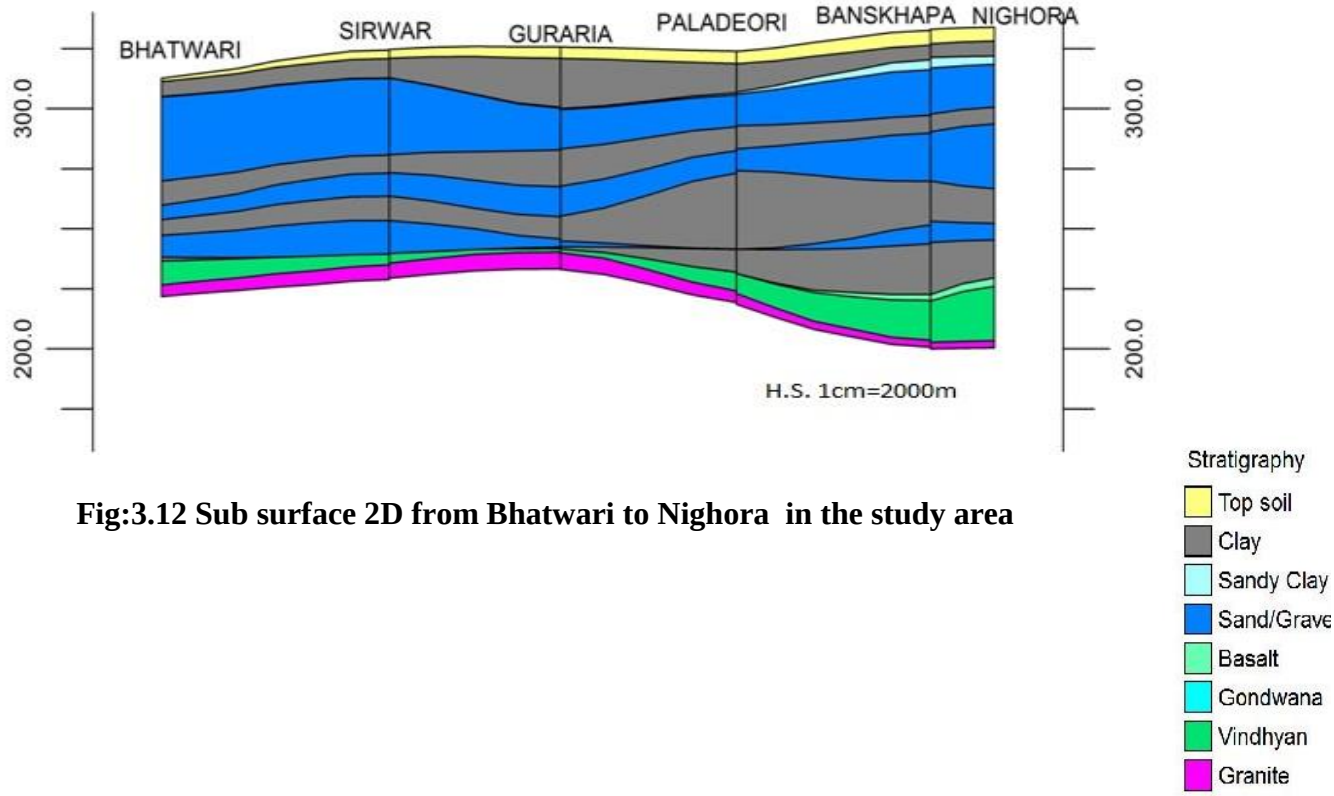

Fig:3.12 Sub surface 2D from Bhatwari to Nighora in the study area

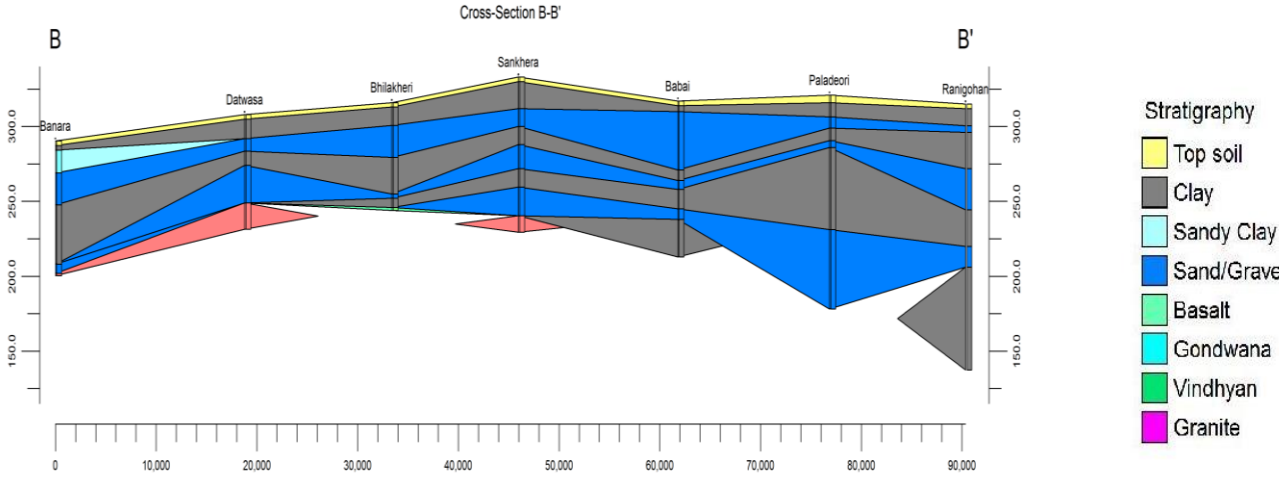

Fig:3.13 2-D Aquifer Disposition

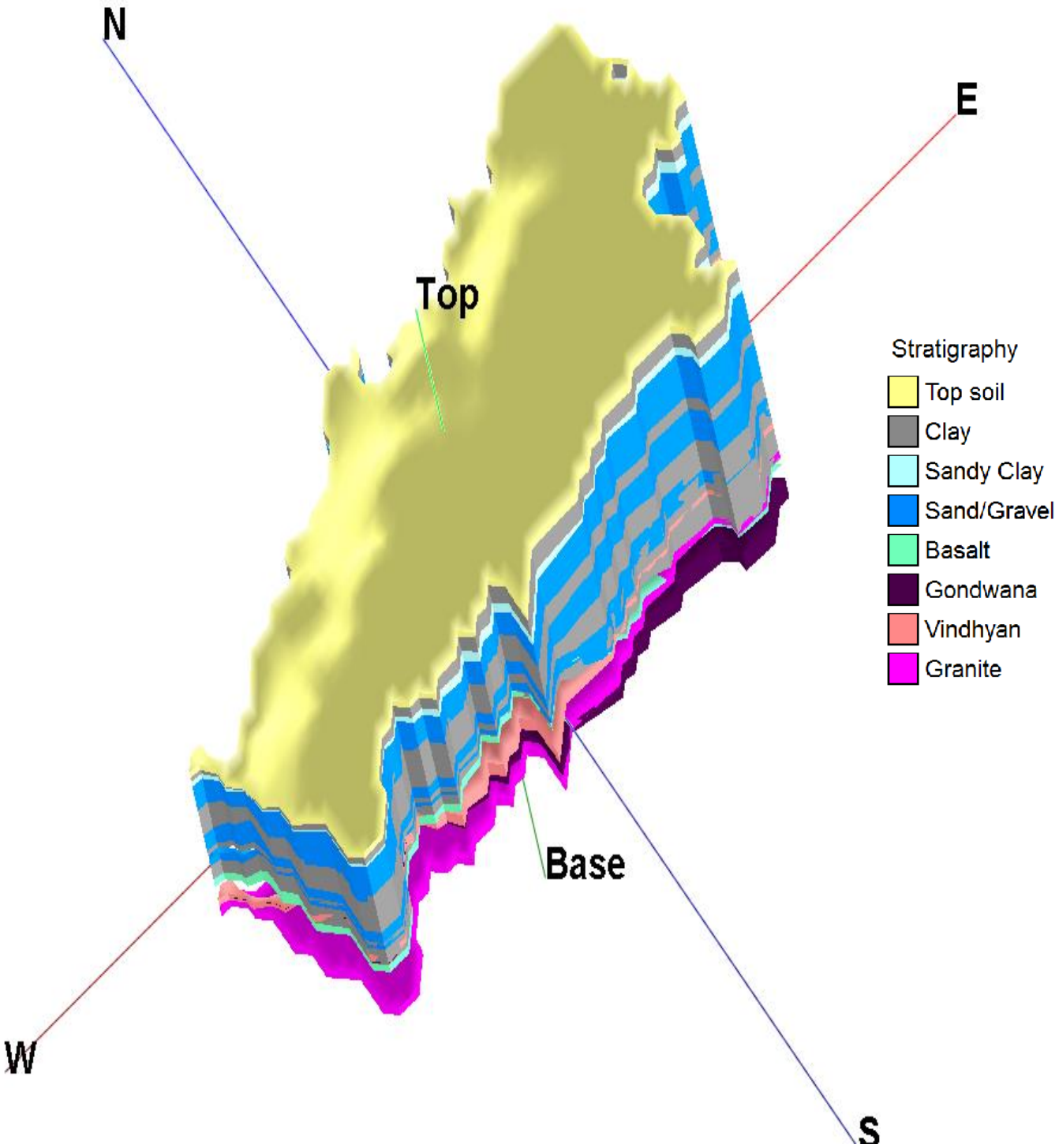

Fig 3.14 Sub Surface 3-D Lithological Model- Hoshangabad District

3.6 Ground Water Quality

The water samples were collected from Key observation wells in clean double stopped poly ethylene bottles from 121 different locations of Hoshangabad district during July 2018.

The pH of ground water of the study area ranged in between 6.81 to 7.95 at Bharlay and Khakrapuradugwellrespectively. As per BIS recommendation, 100 % water samples recorded within the permissible limit of 6.5 to 8.5.. The electrical conductivity of ground water in the district ranged between 560 to 1920 µS/cm at 25°C and the maximum EC value at Jeerawah (1750 µS/cm at 25°C). The EC values in the district have not been observed more than the 3000 µS/cm 25°C..

The fluoride concentration in the district ranged in between 0.15 to 1.85 mg/l. The BIS has set the maximum concentration of fluoride in drinking water is 1.5 mg/l as permissible limit. Six water samples of thearea have shown fluoride concentration more than 1.5 mg/l and the maximum concentration of fluoride has been recorded in the dug well of Mohgaon i.e.1.80 mg/l. In the district, nitrate concentration in ground water ranged in between 6 to 218 mg/l. The 65 % ground water samples recorded nitrate concentration within the acceptable limit of 45 mg/l and 35% water samples recorded more than 45 mg/l as per -BIS recommendation. The highest concentration of nitrate has been detected in ground water of the study area Khursipura (218 mg/l), Bhairanpura (209 mg/l), Kamti (184 mg/l) and Madiko (173 mg/l). **Table: 3.3**

Table:3.3 Detail Chemical Analysis of 121 Key observation wells

S. No.	Block	Location	Source	Lat.	Long.	pH*	EC*	CO_3*	HCO_3	Cl	SO_4*	NO_3*	F*	PO_4*	SiO_2*	TH	Ca	Mg*	Na*	K*
1	Babai	Jawali	DW	22.6882	77.8926	7.56	943	0	310	54	42	56	0.75	BDL	55	359	61	50	35	10.9
2	Babai	Bajjarwada	HP	22.7293	77.9051	7.61	888	0	401	45	14	31	0.35	BDL	25	313	40	52	50	2.6
3	Babai	SangaKheda Kala	HP	22.7935	77.8118	7.91	689	0	267	35	22	16	0.85	BDL	28	247	65	21	28	3.3
4	Babai	Khargawali	DW	22.7886	77.9404	7.35	845	0	346	17	49	32	0.55	BDL	32	328	101	18	38	3.5
5	Babai	Khidiya	HP	22.7415	77.9586	7.47	1412	0	431	149	52	25	0.60	BDL	24	616	137	66	30	2.4
6	Babai	Maragaon	HP	22.7964	78.0239	7.84	777	0	389	12	16	19	0.70	BDL	23	283	65	29	41	2.6
7	Babai	Satwasa	HP	22.7879	78.0919	7.62	923	0	358	35	27	74	0.40	BDL	42	364	77	42	38	5.1
8	Babai	Baharpur	DW	22.7342	78.0727	7.49	935	0	430	22	46	25	0.20	BDL	32	347	79	36	55	1.0
9	Babai	Anchal Kheda	DW	22.7085	77.8668	7.42	1398	0	236	300	15	0	0.35	0.2	42	550	156	39	53	13.7
10	Babai	Guradiya	DW	22.6861	78.0364	7.65	888	0	351	62	12	17	0.50	BDL	32	330	80	32	43	3.2
11	Babai	Ari	HP	22.7569	77.8832	7.87	689	0	304	27	16	22	0.65	BDL	32	268	85	14	28	2.7
12	Bankhedi	Bankhedi	HP	22.7685	78.5359	7.56	843	0	333	22	47	26	0.35	BDL	32	360	82	38	16	2.7
13	Bankhedi	Nagwada	HP	22.776	78.5869	7.50	923	0	399	20	36	32	0.85	0.2	28	390	56	61	26	3.4
14	Hoshangabad	Gwaltoli	HP	22.7517	77.7131	7.36	935	0	363	72	16	27	0.25	BDL	32	277	81	18	81	4.2
15	Hoshangabad	Palasi	HP	22.6864	77.7269	7.53	897	0	424	22	8	31	0.45	BDL	19	356	105	23	30	1.5
16	Hoshangabad	Rohna	DW	22.6806	77.6972	7.56	1412	0	599	95	35	29	0.75	0.2	18	381	107	28	137	6.2
17	Hoshangabad	Talnagri	DW	22.706	77.6159	7.51	1675	0	793	85	12	32	0.30	BDL	16	213	69	10	278	1.8
18	Hoshangabad	Randhal	DW	22.7351	77.6416	7.42	1144	0	551	32	18	53	0.35	BDL	19	297	81	23	117	3.2

Table:3.3 Detail Chemical Analysis of 121 Key observation wells

S. No.	Block	Location	Source	Lat.	Long.	pH*	EC*	CO_3*	HCO_3	Cl	SO_4*	NO_3*	F*	PO_4*	SiO_2*	TH	Ca	Mg*	Na*	K*
19	Hoshangabad	Misrod	HP	22.6173	77.5695	7.37	956	0	418	60	5	32	0.40	BDL	25	366	103	26	42	5.6
20	Hoshangabad	Bortalai	TW	22.6174	77.7383	7.42	902	0	436	15	18	28	0.15	0.2	53	297	83	22	62	1.2
21	Hoshangabad	Suparli	TW	22.6121	77.6708	7.13	985	0	478	37	12	14	0.50	0.1	25	297	83	22	78	5.5
22	Hoshangabad	Bamhori Khurd	HP	22.628	77.6931	7.78	1222	0	654	25	14	16	0.30	BDL	26	342	101	22	117	6.9
23	Hoshangabad	Dodugaon	HP	22.6139	77.602	7.54	1177	0	533	42	32	45	0.65	BDL	25	252	75	16	142	1.2
24	Hoshangabad	Chandon	HP	22.6263	77.8574	7.62	735	0	342	17	10	20	0.85	BDL	36	225	64	16	58	2.8
25	Hoshangabad	Rampur	DW	22.6426	77.8872	7.55	912	0	390	45	14	37	0.55	BDL	29	260	78	16	79	2.4
26	Hoshangabad	Pathodi	HP	22.7058	77.757	7.62	888	0	389	20	44	16	0.60	0.1	31	288	75	25	63	2.6
27	Hoshangabad	Jasalpur	HP	22.7267	77.784	7.55	912	0	346	35	56	55	0.55	BDL	28	333	105	17	52	4.8
28	Hoshangabad	Dhonkheda	HP	22.654	77.7833	7.75	977	0	411	32	32	27	0.40	BDL	27	320	44	51	65	3.4
29	Hoshangabad	Itarsi	HP	22.6275	77.7754	7.51	1089	0	453.84	24.9993	44	56	0.6	BDL	19	300	44	46.208	106	1.2
30	Kesala	Semri khurd	DW	22.576	77.6528	7.40	1152	0	484	72	12	35	0.90	0.2	24	401	111	30	66	1.5
31	Kesala	Bandri	HP	22.4917	77.642	7.48	1087	0	459	40	16	36	0.45	BDL	38	465	113	44	20	1.5
32	Kesala	Bhatti	DW	22.5789	77.7194	7.46	1489	0	531	129	82	23	0.50	BDL	42	409	99	39	148	1.5
33	Kesala	Dehri	HP	22.5862	77.7592	7.34	1157	0	500	32	42	28	0.55	0.1	36	455	113	42	45	2.7
34	Kesala	Jhujhalpur	HP	22.5846	77.7602	7.45	1088	0	531	35	23	17	0.85	BDL	26	409	119	27	55	2.1
35	Kesala	Jamai Kalan	HP	22.5615	77.8273	7.12	912	0	366	37	32	24	1.10	BDL	28	348	103	22	42	2.1
36	Kesala	Mohla	HP	22.5635	77.8406	7.20	1198	0	390	106	15	105	0.25	BDL	27	354	99	26	102	1.7
37	Kesala	Tawanagar	DW	22.5664	77.956	7.24	968	0	220	87	45	136	0.20	BDL	29	323	101	17	63	2.9

Table:3.3 Detail Chemical Analysis of 121 Key observation wells

S. No.	Block	Location	Source	Lat.	Long.	pH*	EC*	CO_3*	HCO_3	Cl	SO_4*	NO_3*	F*	PO_4*	SiO_2*	TH	Ca	Mg*	Na*	K*
38	Kesala	Saheli	DW	22.4494	77.8285	7.12	1152	0	305	129	54	67	0.30	BDL	25	444	107	43	50	3.0
39	Kesala	Khakrapura	DW	22.4299	77.8455	7.95	1712	0	714	99	88	39	0.25	BDL	31	212	71	9	287	3.1
40	Kesala	Pathrota	DW	22.5717	77.7972	7.41	1252	0	573	45	14	38	0.35	BDL	36	455	113	42	67	3.4
41	Kesala	Nagpur Kalan	HP	22.5817	77.8286	7.48	1212	0	555	40	17	51	0.40	0.1	38	384	113	25	83	9.5
42	Kesala	Dhansai	DW	22.5002	77.8381	7.46	1563	0	567	134	12	120	0.40	BDL	42	606	168	45	68	3.7
43	Kesala	Jalikheda	DW	22.5052	77.8357	7.48	1205	0	293	106	35	156	0.25	BDL	49	404	103	36	83	5.0
44	Kesala	Morpani	HP	22.4827	77.8724	7.55	1036	0	409	42	44	52	0.35	BDL	32	247	73	16	114	9.6
45	Kesala	Madiko	HP	22.4697	77.9061	7.38	687	0	24	82	24	173	0.25	BDL	52	258	59	27	24	8.8
46	Kesala	Takku	DW	22.4887	77.82	7.47	1325	0	433	153	15	56	0.20	BDL	32	414	113	32	92	9.5
47	Kesala	Bhargada	DW	22.3993	77.8716	7.12	1286	0	336	126	16	161	0.35	BDL	19	480	139	32	64	3.8
48	Kesala	Komati Raiyat	DW	22.3915	77.8885	7.49	1105	0	433	62	15	95	0.65	BDL	22	515	143	38	12	3.4
49	Kesala	Kala Akhar	DW	22.399	77.8193	7.31	586	0	214	30	14	54	0.75	BDL	29	167	36	18	47	9.0
50	Kesala	Rasalpatta	DW	22.4131	77.8605	7.68	1189	0	293	124	54	89	0.40	0.1	31	455	125	34	54	3.7
51	Kesala	Kasda Khurd	DW	22.4126	77.8203	7.56	1098	0	378	69	25	101	0.75	BDL	26	360	102	26	74	3.9
52	Kesala	Amjhira	DW	22.527	77.8705	7.93	1402	0	476	119	42	33	0.50	BDL	51	525	92	72	66	8.2
53	Kesala	Somalwara Khurd	HP	22.6078	77.8205	7.61	699	0	336	22	12	10	1.75	BDL	46	265	58	29	31	2.3
54	Kesala	Bichhua	DW	22.6357	77.9303	7.46	888	0	346	35	12	61	1.00	BDL	28	293	103	9	53	3.1
55	Kesala	Sontalai	DW	22.6225	77.9622	7.68	912	0	365	30	42	32	0.70	BDL	35	404	83	48	15	2.4

Table:3.3 Detail Chemical Analysis of 121 Key observation wells

S. No.	Block	Location	Source	Lat.	Long.	pH*	EC*	CO_3*	HCO_3	Cl	SO_4*	NO_3*	F*	PO_4*	SiO_2*	TH	Ca	Mg*	Na*	K*
56	Kesala	Kotha	DW	22.6152	77.9713	7.92	842	0	352	12	56	8	1.00	BDL	39	268	63	27	61	2.1
57	Kesala	Nandner	DW	22.6	77.9029	7.56	812	0	334	27	24	35	1.65	BDL	34	328	83	29	24	4.3
58	Pipariya	Singa Nama	DW	22.5591	78.4823	7.42	1065	0	484	67	12	8	1.25	BDL	38	351	101	24	78	1.2
59	Pipariya	Mohgaon	HP	22.612	78.4479	7.72	712	0	230	47	18	10	1.80	BDL	18	163	42	14	64	1.3
60	Pipariya	Dapka	DW	22.6629	78.3439	7.71	1103	0	581	15	9	12	0.50	BDL	26	297	73	28	108	3.5
61	Pipariya	Anhoni	Hot spring	22.6273	78.3494	7.65	945	0	424	52	22	14	1.80	BDL	17	307	75	29	67	4.5
62	Pipariya	Khursikhapa	DW	22.6439	78.3207	7.72	2310	0	545	325	42	218	1.60	BDL	28	549	135	52	265	4.5
63	Pipariya	Mohari Kalan	HP	22.6633	78.3035	7.22	1798	0	436	302	15	65	0.80	0.1	26	644	160	59	107	1.8
64	Pipariya	Kumhabar	DW	22.7241	78.3037	7.20	905	0	357	72	10	41	0.30	BDL	34	327	85	28	53	3.6
65	Pipariya	Rechheda	DW	22.7018	78.381	7.67	1175	0	454	100	25	28	0.60	BDL	26	337	95	24	105	2.9
66	Pipariya	Samnapur	HP	22.6733	78.3608	7.43	1256	0	478	80	5	89	0.45	BDL	42	396	105	33	95	3.8
67	Pipariya	Semri Kishor	HP	22.8573	78.3245	7.42	987	0	393	35	44	34	0.65	BDL	26	295	54	39	69	17.1
68	Pipariya	Rampur	HP	22.772	78.4021	7.57	742	0	339	15	28	18	0.70	BDL	32	310	64	36	18	3.2
69	Seoni Malwa	ChautalaiPahadh	HP	22.6068	77.5208	7.73	616	0	266	22	16	20	0.35	BDL	26	223	63	16	28	6.8
70	Seoni Malwa	Dhamasa	DW	22.5969	77.55	7.27	978	0	387	67	28	23	1.00	BDL	42	322	81	29	55	23.0
71	Seoni Malwa	Amupura	DW	22.611	77.6379	7.61	866	0	393	22	28	47	0.50	BDL	23	248	55	26	73	9.8
72	Seoni Malwa	Mohari	TW	22.6315	77.6219	7.41	752	0	345	12	7	52	0.35	BDL	32	297	71	29	27	1.1
73	Seoni Malwa	Ratwada	DW	22.5613	77.6022	7.62	1423	0	454	210	4	32	0.30	0.1	36	629	162	54	28	6.2

Table:3.3 Detail Chemical Analysis of 121 Key observation wells

S. No.	Block	Location	Source	Lat.	Long.	pH*	EC*	CO_3*	HCO_3	Cl	SO_4*	NO_3*	F*	PO_4*	SiO_2*	TH	Ca	Mg*	Na*	K*
74	Seoni Malwa	Khutwasa	DW	22.5305	77.5873	7.68	1123	0	490	65	22	38	0.65	BDL	25	317	69	35	103	5.3
75	Seoni Malwa	Bhaghwada	HP	22.5353	77.5556	7.21	1768	0	448	310	10	60	0.85	BDL	32	723	170	72	66	2.3
76	Seoni Malwa	Rajora Jat	DW	22.5206	77.5177	7..55	986	0	424	30	22	67	0.30	BDL	34	302	63	35	73	6.5
77	Seoni Malwa	Dharam Kundi	DW	22.509	77.55	7.33	893	0	387	60	5	41	0.29	BDL	36	356	85	35	32	4.5
78	Seoni Malwa	Khapariya	DW	22.5686	77.4815	7.31	1036	0	478	22	12	58	0.30	BDL	35	307	85	23	85	2.3
79	Seoni Malwa	Rehra	DW	22.5985	77.4711	7.52	987	0	472	17	18	35	0.45	BDL	26	302	95	16	72	3.5
80	Seoni Malwa	Harpalpur	DW	22.5451	77.4618	7.22	863	0	355	17	14	62	0.65	BDL	23	328	103	17	32	1.1
81	Seoni Malwa	Rampura	DW	22.5658	77.4226	7.29	2423	0	833	302	16	49	0.25	0.3	21	621	166	50	243	23.0
82	Seoni Malwa	Amaladadongar	DW	22.5875	77.4282	7.40	896	0	410	27	5	53	0.65	BDL	19	323	71	36	44	1.2
83	Seoni Malwa	Sahaj kui	DW	22.558	77.386	7.13	1012	0	312	99	9	76	0.25	BDL	25	444	97	49	21	1.4
84	Seoni Malwa	Guradiya	DW	22.5313	77.3776	7.42	898	0	318	50	34	50	0.35	BDL	28	374	103	28	26	2.5
85	Seoni Malwa	Chhapara Grahan	DW	22.5129	77.3575	7.82	1352	0	533	104	14	23	0.50	0.2	31	404	99	38	112	3.5
86	Seoni Malwa	Shivpur	DW	22.5185	77.3121	7.01	1502	0	367	176	85	85	0.55	BDL	42	379	87	39	125	66.0
87	Seoni Malwa	Jeerawah	DW	22.4411	77.3594	6.93	1912	0	472	186	114	135	0.85	BDL	56	374	93	34	236	30.0
88	Seoni Malwa	Bhairanpura	DW	22.4467	77.392	7.32	2287	0	533	285	52	209	0.65	BDL	18	818	228	60	124	27.0
89	Seoni Malwa	Bhadang Chikkli	DW	22.489	77.6235	7.79	1187	0	496	59	12	24	1.25	BDL	26	323	77	32	108	2.2
90	Seoni Malwa	Keolajhir	HP	22.4558	77.6536	7.20	812	0	343	35	10	46	0.30	BDL	27	343	73	39	17	1.6

Table:3.3 Detail Chemical Analysis of 121 Key observation wells

S. No.	Block	Location	Source	Lat.	Long.	pH*	EC*	CO_3*	HCO_3	Cl	SO_4*	NO_3*	F*	PO_4*	SiO_2*	TH	Ca	Mg*	Na*	K*
91	Seoni Malwa	Malapat	DW	22.4521	77.5918	7.23	642	0	276	20	32	10	0.65	BDL	33	278	63	29	15	1.9
92	Seoni Malwa	Kharda	DW	22.476	77.5563	7.21	898	0	429	30	12	31	0.55	BDL	42	318	85	26	51	5.1
93	Seoni Malwa	Gajanpur	HP	22.4587	77.5265	7.37	1289	0	551	42	63	6	0.25	0.2	26	293	63	33	152	2.2
94	Seoni Malwa	Pipaliya	HP	22.3955	77.485	7.48	1142	0	374	146	17	21	0.45	BDL	29	323	105	15	105	1.4
95	Seoni Malwa	Dhandiwada	HP	22.3715	77.4769	7.62	898	0	343	79	13	32	0.35	BDL	33	394	99	36	19	1.6
96	Seoni Malwa	Begania	HP	22.3833	77.467	7.35	636	0	245	22	35	18	0.65	BDL	45	237	65	18	28	1.6
97	Seoni Malwa	Berakhedi	DW	22.4213	77.4915	7.51	898	0	361	15	62	29	0.85	BDL	25	288	85	18	65	2.1
98	Seoni Malwa	Banapura	HP	22.4622	77.4789	7.39	912	0	398	37	26	23	0.35	BDL	36	232	63	18	92	1.4
99	Seoni Malwa	Nipaniya	DW	22.464	77.4213	7.21	1351	0	392	106	117	43	0.65	BDL	38	515	143	38	65	1.6
100	Seoni Malwa	Bharlay	DW	22.4328	77.4229	6.81	712	0	239	74	12	20	0.55	BDL	32	227	65	16	51	1.6
101	Seoni Malwa	Basaniya Kalan	HP	22.3884	77.402	7.82	645	0	282	17	47	9	0.65	BDL	26	192	42	21	56	2.1
102	Seoni Malwa	Jhinganpur	HP	22.3814	77.4029	7.93	1652	0	857	42	12	28	0.35	0.1	29	263	61	27	242	10.8
103	Seoni Malwa	Faridpur	DW	22.3866	77.3734	7.31	1058	0	306	116	18	70	0.25	BDL	35	429	105	41	35	6.7
104	Seoni Malwa	Soorajpur	DW	22.3711	77.4392	7.54	768	0	367	17	10	37	0.35	BDL	24	258	57	28	51	1.9
105	Seoni Malwa	Kahariya	HP	22.4896	77.5162	7.47	987	0	470	20	17	36	0.45	BDL	28	222	51	23	114	2.7
106	Seoni Malwa	Nayagaon	HP	22.563	77.6952	7.54	1398	0	531	92	65	20	0.40	BDL	34	404	107	33	128	2.5
107	Shohagpur	Bamari	HP	22.7329	78.2445	7.67	1178	0	411	85	36	43	0.55	BDL	28	450	102	47	51	3.0
108	Shohagpur	Ghurkheri	DW	22.7522	78.1713	7.52	857	0	418	25	12	24	0.25	BDL	23	252	83	11	75	2.5
109	Shohagpur	Gori gaon	DW	22.8241	78.1735	7.21	632	0	309	12	8	25	0.20	BDL	25	252	81	12	22	0.5

Table:3.3 Detail Chemical Analysis of 121 Key observation wells

S. No.	Block	Location	Source	Lat.	Long.	pH*	EC*	CO_3*	HCO_3	Cl	SO_4*	NO_3*	F*	PO_4*	SiO_2*	TH	Ca	Mg*	Na*	K*
110	Shohagpur	Bhiladiya	DW	22.8016	78.2036	7.29	612	0	278	17	22	27	0.45	0.2	26	223	73	10	35	0.8
111	Shohagpur	Bamori Khurd	DW	22.6918	78.1659	7.68	1075	0	424	77	15	49	0.35	BDL	42	376	79	43	61	2.1
112	Shohagpur	Nibhora	HP	22.6614	78.1561	7.78	1089	0	436	40	65	21	0.40	BDL	27	376	59	55	70	2.4
113	Shohagpur	Pathrai	HP	22.6685	78.1892	7.13	945	0	375	35	58	47	0.50	0.3	29	351	79	37	33	25.2
114	Shohagpur	Kamti	HP	22.6076	78.1577	7.60	1568	0	411	150	54	184	0.60	BDL	33	520	162	28	107	6.5
115	Shohagpur	Sarangpur (Madai)	DW	22.5791	78.1456	7.53	1602	0	526	145	45	85	0.65	BDL	25	401	55	64	174	6.9
116	Shohagpur	Teka Par	DW	22.5899	78.1607	7.92	1243	0	399	175	12	14	0.75	BDL	23	267	81	16	156	2.8
117	Shohagpur	Nayagaon	HP	22.6753	78.1943	7.64	912	0	345	30	42	40	1.00	BDL	27	272	77	19	71	5.9
118	Shohagpur	Karanpur	HP	22.72	78.2193	7.65	1206	0	375	135	24	30	0.95	BDL	29	535	123	55	22	5.7
119	Shohagpur	Shobhapur	DW	22.7711	78.2818	7.37	686	0	248	20	56	17	0.80	BDL	35	252	59	25	26	3.4
120	Shohagpur	Sohagpur	HP	22.702	78.1873	7.73	875	0	405	32	17	19	0.65	BDL	27	350	84	34	31	2.5
121	Shohagpur	Shobhapur	HP	22.7693	78.2585	7.50	723	0	321	22	24	27	0.25	BDL	29	260	78	16	38	2.6

As per the piper diagram of district, water samples is Calcium Chloride (permanent hardness) type, Calcium Bi-carbonate (temporary hardness) type, Mixed Type and Sodium Chloride types of water. Block wise Piper diagram is depicted in **Fig 3.15 – 3.17**

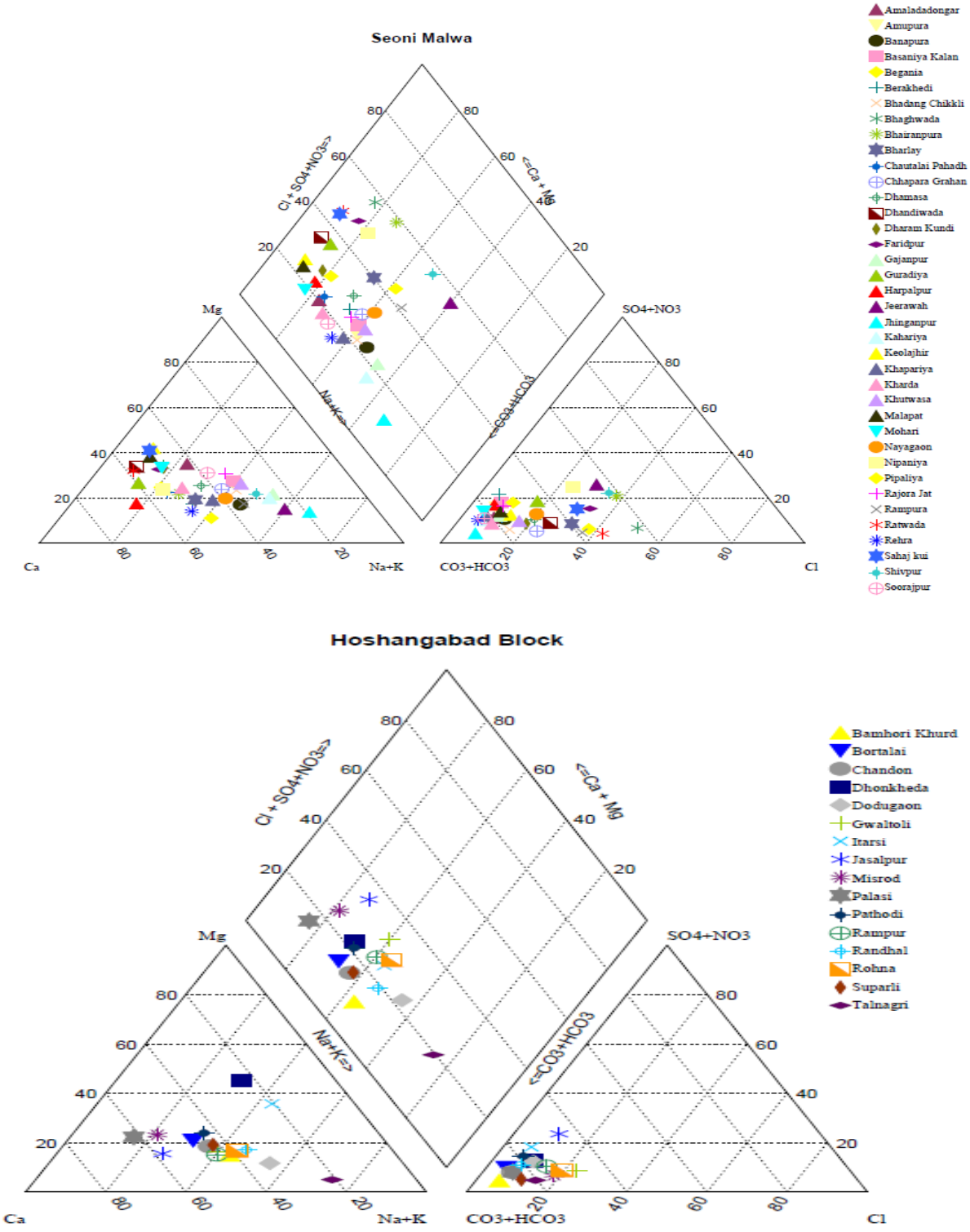

Fig:3.15 Piper diagram (Seoni Malwa and Hoshangabad block)

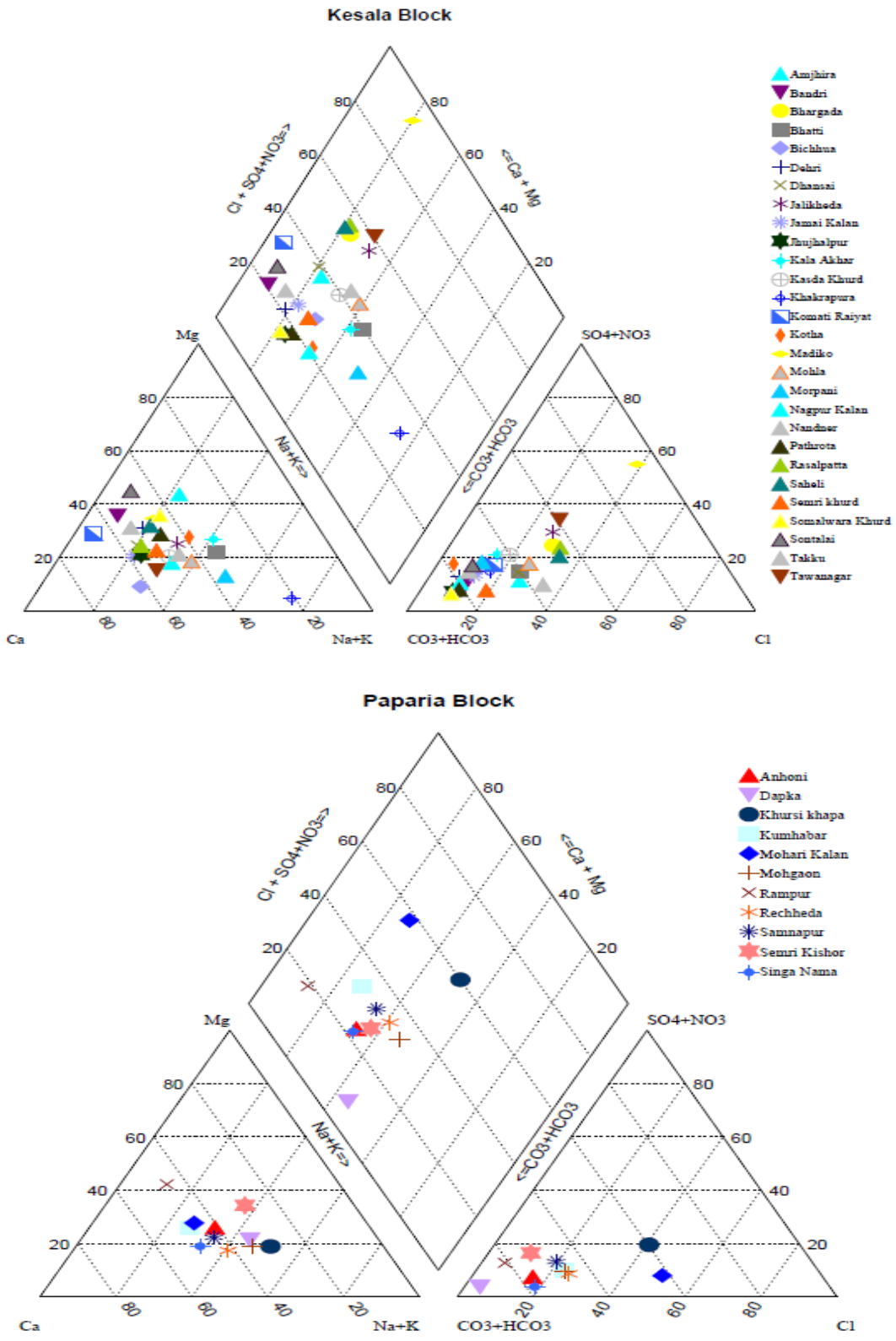

Fig: 3.16 Piper diagram (Kesala and Paparia block)

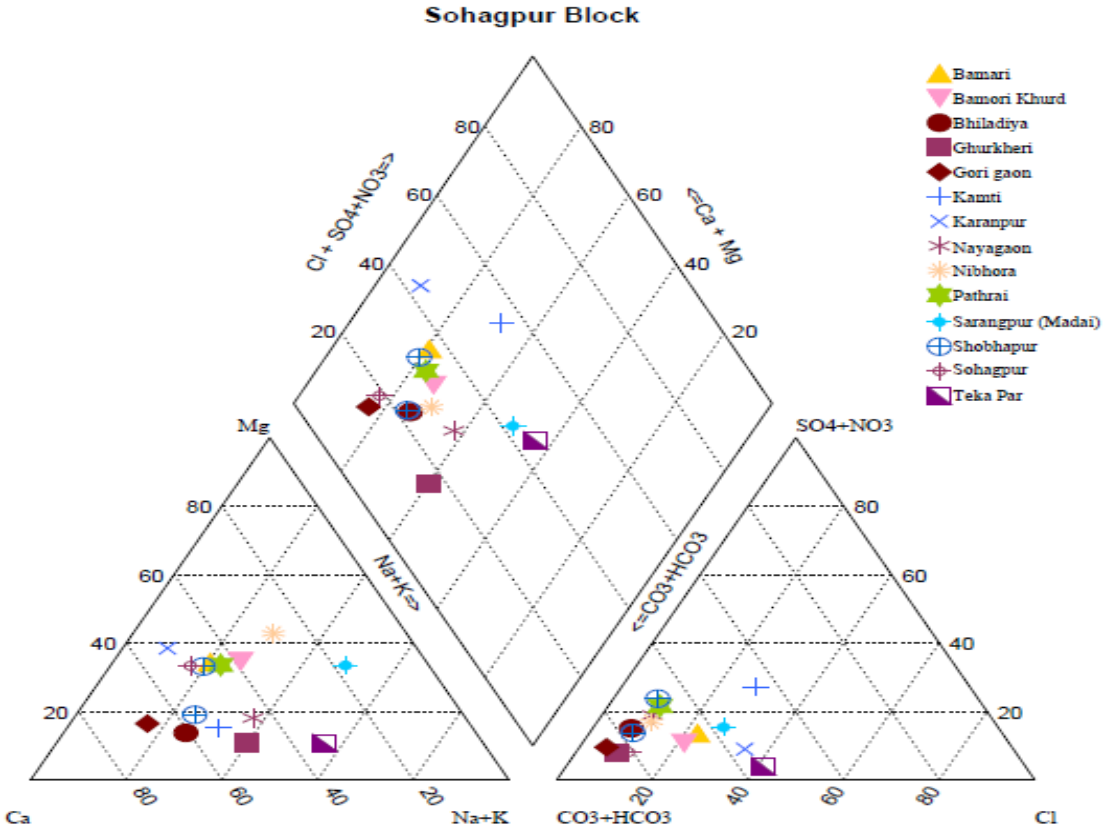

Fig 3.17 Piper diagram (Sohagpur block)

The US Salinity Diagram **(Fig:3.18)** of Hoshangabad district shows the ground water is medium toVery high salinity classes.

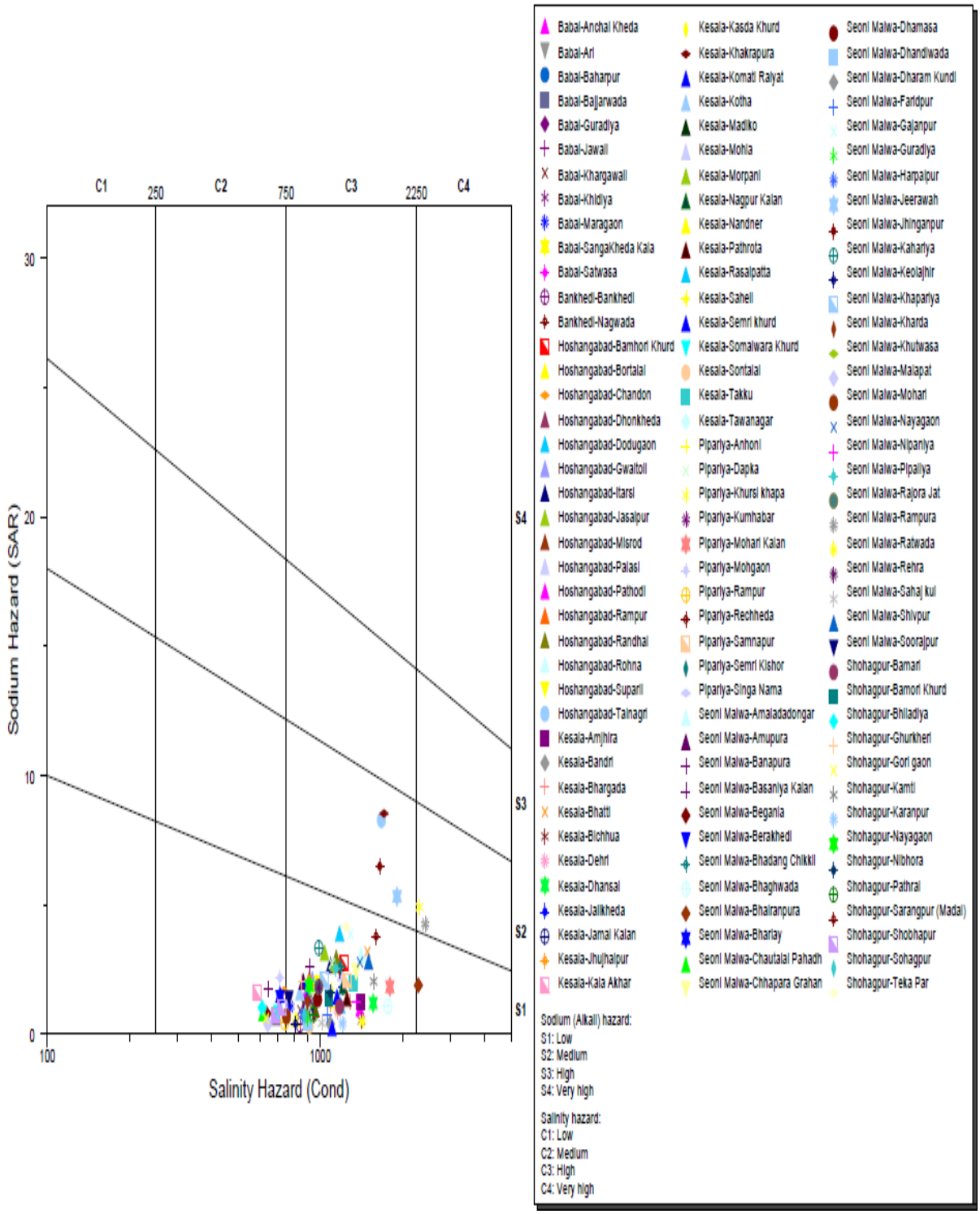

Fig:3.18 Salinity - Sodium hazards diagram

Chapter-4
Ground Water Resources

4.1 Dynamic Ground water resources

Recently dynamic ground water resources of the district have been estimated -2020on block-wise basis. Out of 6704.00 sq. km of geographical area, 5583.52 (83%) is ground water recharge worthy area and 1120.48 sq. km is forest and hilly area (17 %).

There are seven numbers of assessment units in the district which fall under command (45%) and non-command (55%) sub units. Six blocks of the district are categorized as safe blocks and Bankhedi block is categorized as semi-critical with highest stage of ground water extraction of 72.56%. The net ground water availability in the district 1950.17mcm and ground water extraction for all uses is 413.13 mcm, making stage of ground water extraction 21.18% as a whole for district. After making allocation for future domestic and industrial supply for year 2025, balance available ground water for future irrigation would be 1535.18 mcm. **Table 4.1** shows the Dynamic Ground Water Resource Assessment estimated by CGWB for the year 2017 & 2020.

Table: 4.1 Dynamic Groundwater Resources, 2017& 2020 in the Study Area in mcm

Assessment Unit/ District	Assessment Year	Non-Command (ha)	Net Annual Ground Water Availability (mcm)	Provision for domestic, and industrial requirement supply to 2025 (mcm)	Net GW Availability for future irrigation extraction (mcm)	Stage of Ground Water extraction
Hoshangabad	2017	304729	2031.37	43.48	1637.45	19
	2020	304729	1950.17	23.55	1535.18	21.18

To deal with the problem of water logging the possibilities of conjunctive use of surface water and ground water should be considered immediately to begin with all existing ground water structures should be put back to their fullest use. All the tube wells constructed in the water logged area should be run to their fullest capacity. Water from this source should be put in to distributaries and minor cutting of the supply from main canal. More number of tube wells

could be sunk in the demarcated productive areas and individual command per tube well can be made for efficient and appropriate irrigation.

Based on the hydrogeological studies the following recommendations are made for proper development and utilization of the available groundwater resources and management of ground water resources.

It is recommended that conjunctive use of surface water and ground water should be planned in the area and to begin with all existing ground water structures should be put back to their fullest use. All the tube wells constructed in the area should be run to their fullest capacity. More number of tube wells could be sunk in the demarcated productive areas and individual command per tube well can be made for efficient and appropriate irrigation. Water of canals be made available to tail-end reaches and areas with less groundwater potential and canal command may be extended further.

As per GWR estimation 2020 Net Groundwater Availability for future irrigation extraction is 1535.18 MCM. to achieve optimum utilization of presently available ground water resources in Hoshangabad district, a total of about 81160 dug wells and about 22629 tube wells are feasible. The construction of these structures can be taken up over a span of ten years so that the development takes place in a phased manner and the additional power requirement for irrigation can also be met with suitably.

Table:4.2 Blockwise Dynamic Ground water resource 2020– Hoshangabad District

S. No.	Assessment Unit Name	Recharge from Rainfall-Monsoon Season (Ham)	Recharge from Other Sources-Monsoon Season (Ham)	Recharge from Rainfall-Non Monsoon Season (Ham)	Recharge from Other Sources- Non Monsoon Season (Ham)	Total Annual Ground Water Recharge (Ham)	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)
1	Sohagpur	7975.22	886.73	0	4860.32	13722.27	686.12	13036.15
2	Seoni Malwa	27481.23	3095.58	0	18118.8	48695.61	3266.42	45429.19
3	Babai	25696.38	1463.92	0	10591.45	37751.75	1887.59	35864.16
4	Hoshangabad	16371.85	4026.45	0	22259.22	42657.52	2132.87	40524.65
5	Bankhedi	17868.47	471.96	0	2831.76	21172.19	1058.61	20113.58
6	Pipariya	20486.1	473.3	0	1987.02	22946.42	2035.21	20911.21
7	Kesla	13400.06	1031.36	0	5716.21	20147.63	1007.38	19140.25
8	District Total	129279.31	11449.3	0	66364.78	207093.39	12074.2	195019.19

Table 4.3 Total Ground water extraction

Assessment Unit Name	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Industrial Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization
Sohagpur	3841.34	0.00	308.18	4149.52	334.80	8860.01	31.83	safe
Seoni Malwa	3548.88	0.00	415.85	3964.72	451.77	41428.55	8.73	safe
Babai	2576.45	0.00	290.98	2867.42	316.11	32971.61	8.00	safe
Hoshangabad	3798.90	0.00	247.79	4046.69	269.20	36456.55	9.99	safe
Bankhedi	14364.00	0.00	310.91	14674.92	337.77	5411.80	72.96	semi_critical
Pipariya	7407.94	0.00	324.08	7732.01	352.08	13151.20	36.98	safe
Kesla	3607.20	0.00	270.69	3877.89	294.07	15238.98	20.26	safe
District Total	39144.71	0.00	2168.49	41313.17	2355.80	153518.70	21.18	

Table: 4.4 Salient features of GW resources of the Hoshangabad District

District	Blocks Name	Type of rock formation	Recharge worthy area in hect	Areal extent (in hectares)						
				Total Geographical Area	Hilly Area	Ground Water Recharge Worthy Area			Shallow Water Table Area	Flood Prone Area
						Command area	Non-command area	Poor ground water quality area		
Hoshangabad	Babai	Alluvium	89200	89200	0	89200	0	0	0	0
Hoshangabad	Bankhedi	Alluvium	66900	78900	12000	0	66900	0	0	0
Hoshangabad	Hoshangaba	Alluvium	57400	66900	9500	57400	0	0	0	0
Hoshangabad	Kesla	Gonwana sandstone,	81255	88300	7045	16570	64685	0	0	0
Hoshangabad	Pipariya	Alluvium, Gonwana	86300	98300	12000	17000	69300	0	0	0
Hoshangabad	Seoni Malwa	Alluvium, Deccan trap basalt	133907	137500	3593	58080	75827	0	0	0
Hoshangabad	Sohagpur	Gonwana sandstone,	43390	111300	67910	15373	28017	0	0	0
DISTRICT TOTAL			**558352**	**670400**	**11204**	**253623**	**304729**	**0**	**0**	**0**

Chapter-5

Ground Water Related Issues

Hydrogeological studies were carried out in entire Hoshangabad district with a view to study

- The change in ground water regime, caused by the surface water irrigation in the Tawa Canal Command area and the effects of ground water development in the Command and out –side the command area;
- To assess the present hydrogeological scenario
- To study all problems related to ground water (especially water-logging problem in the Tawa Canal Command water and suggest remedial measures;
- To assess the future prospects of ground water development in the area.
- Decline water level in Bankhedi and Pipariya blocks.

Over all Hoshangabad district comes under safe category from ground water development point of view. Due to easy availability of surface water for irrigation, after the construction of major irrigation Tawa project (1975), the development of ground water for irrigation has been negligible in the area falling under the Tawa Command Project. The ground water development is confined only in non-command are in the district i.e. in Bankhedi block and parts of Pipariya block. Ground water being the main source of irrigation is groundwater and water level in both blocks area declining.

- **Water Logging in Tawa Canal Command Area**

Since the commencement of canal irrigation in the area, the heavy import of water from surface water irrigation system to the ground water reservoirs, and practically no draft of water from the ground water system to Tawa Canal command area has resulted in rise in water level leading in water logging conditions.

A general rise in phreatic water level has been recorded in the command area. The rise in water level has especially affected the low-lying areas of many villages and villages which already has shallow water table conditions even before the commencement of canal irrigation and rise in water level after monsoon has rendered almost 250 sq.km. of land water logged. Water levels of the range of 0.3 to 2 mbgl have been recorded at Nitaya, Raisalpur, Byawara, Rampur, Panjra (55F/14), Kharar, Rawan Pipal, Agra Kalan, Baikheri, Bamhori (55F/10) and

in low lying areas around Muhuakhera, Gurari. It is seen that even during the pre-monsoon period, shallow water levels i.e. water logging conditions are seen in small patches around Pipaliya, Bawariabapu, Kharar, Chiidgaon, Basna, Jirahaber, Rawan Pipal, Bara kalan tec. Villages (55F/7) in Seoni Malwa block and also around Jaisalpur, Nitaya, Panjarakhurd, Byawara, Raisalpur, Sankhera, Rampur (55 F/14) Dasaniya and Devri (55F/15) villages.

The Tawa reservoir is constructed in the Gondwana which has a hydraulic continuity with the alluvial aquifers and seepage from the reservoir has also causes rise to water table/piezometric head in the right bank command areas lying in the north of reservoir.

The water table gradient in the command area has become steeper as a result of seepage from canals. This has resulted in increased base flow in canals/rivers, making them perennial.

The natural drainage in the area has been severely affected due to land shaping for command area development.

Some stretches of nalas have become choked due to heavy growth of Ipomia, stopping the base flow thus compounding the problems of water logging.

- **Hydrogeological Scenario in the area outside the Tawa command in the district (Water table depleted area)**

In the non-command area of the district i.e. in Bankhedi block and parts of Pipariya block ground water being the main source of irrigation ground water and it is also observed that the water level is declining in both the block.

Phreatic aquifer is hardly able to meet the needs of irrigation. The dug wells as well as bore wells in a large area are drying up by April. Since the water availability and potential of deeper aquifer were very good and sufficient to meet the irrigation demands in past, the number of tube wells in this area is increasing at a fast rate and dug wells are being converted into dug-cum-bore wells. Thus now it is the deeper aquifers, which are being exploited for meeting the irrigation demands.

The decline in water level in non-command area can be attributed to two main factors.

- Below normal rainfall in the non-command area over the past years.
- Heavy draft of ground water in the area to meet the irrigation demands.

- Tributaries of Narmada River are also gradually become a seasonal river. Pasa river is also gradually drying up.

Chapter-6

Ground Water Management Strategies

Groundwater has been contributing more to agricultural wealth than surface irrigation since ages. Tube wells are now the largest source of irrigation in the country. Since this sector has almost no dependence on the government, it is growing at a rapid rate and it is estimated that one million wells are added every year (Shah and Deb, 2004). Being an individually managed source, ground water irrigation is also a more efficient form of irrigation, with crop yields per cubic meter of water being 1.2 to 3 times higher than surface irrigation. However, since this sector has grown through investment by individual farmers, with little state involvement compared to canal irrigation, government support for understanding this sector and improving its performance is negligible. The major issues for the future growth of groundwater irrigation are declining resource base, demand driven growth, and a lack of policy and regulatory framework. Since groundwater extraction is primarily driven by the needs of the population and the density of farmer population and not the quality of resource, groundwater irrigation is scaling up even in such hard rock areas causing irreversible depletion of the resource base (Shah and Deb, 2004).To warrant the current situation effective groundwater management strategies needs to be evolved.

6.1 Supply Side Management

Artificial recharge to ground water is one of the most efficient, scientifically proven and cost-effective technology to mitigate the problems of over exploitation of ground water resources specially in Bankhedi and pipariya blocks of Hoshangabad district. The artificial recharge techniques simultaneously rejuvenate the depleted ground water storage, reduces the ground water quality problems and also improves the sustainability of wells in the affected areas.

The supply side management plan for Hoshangabaddistrict has been formulated using the basic concepts of hydrogeology. Sub-surface storage is calculated by multiplying the total area with the respective specific yield (considering the variable lithology) and the unsaturated zone thickness obtained by subtracting 3 mts from the post-monsoon water level. The volume of ground water recharge generated through pre-existing rain water harvesting/water conservation structures is subtracted from the sub-surface storage to assess the available storage potential. Thus, the surface water requirement to completely saturate the sub-surface storage is obtained

by multiplying a factor of 1.33 to available storage potential. A runoff coefficient factor of 0.20 has been considered for Hoshangabad district to calculate the total surface water runoff, 30% of which accounts to the non-committed runoff which is available to sustain the proposed artificial recharge structures. Further, the number of structures has been calculated by allotting 35%, 20% and 35% of non-committed runoff to Percolation tanks, Recharge shafts/Tube wells and Nala bunds/Check dams/Cement Plugs respectively. The remaining runoff is considered to restore the pre-existing village tanks, ponds and water conservation structures.

6.2 Block Wise Management Strategies

The dynamic resource estimation presented here is taken from 2017 dynamic groundwater resources of Madhya Pradesh where resource was estimated Block wise.

Table 6.1 Salient features of GW resource of Hoshangabad Block

Assessment Unit / District	Command / Non-Command	Net Ground Water Availability for Future Irrigation extraction in Ham	Stage of Ground Water extraction in %
Hoshangabad	Command	36456.55	9.99
	Block Total	36456.55	9.99

As per dynamic ground water resource estimation (2020) of the study area, Existing total Ground Water extraction for Irrigation in 38 mcm and stage of extraction is only 9.99% (Table 6.1). The area is having balance net ground water availability for future irrigation is 364 mcm. If an irrigation plan is made to develop 60% of the balance dynamic ground water resources available, then 218 mcm of groundwater resources will be available in the study area for the future irrigation uses.

As per agriculture and Irrigation data 2014-15 net sown area in the study area is 43054ha and cropping intensity is 189%. As per recent cropping pattern of the study area, some area still remains fallow in between Kharif and Rabicrops. A management plan has been envisaged to use this fallow land for increasing cropping intensity by utilizing the huge available groundwater resources. Basic aim is to increase the gross cropped area from 43054 ha to 100000 ha and thereby increase in cropping intensity up to 235%. To use the groundwater for irrigation, purpose a cropping plan has been designed for the district by using CROPWAT model developed by FAO. A suitable cropping plan for the block is prepared **(table 6.2).**

Crop-wise and month-wise irrigation water requirement (Precipitation deficit) has been estimated by using CROPWAT tool after giving necessary meteorological, soil, crop plan inputs and the same has been shown in **Table 6.3** Crop-wise and month-wise Irrigation water requirement in ham has been further calculated in **Table 6.5.**

Table-6.2. Proposed cropping pattern for Hoshangabad Block

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CROPPING PATTERN DATA

(File: C:\ProgramData\CROPWAT\data\sessions\hoshangabad final.PAT)

Cropping pattern name: hoshangabad final

No.	Crop file	Crop name	Planting date	Harvest date	Area %
1	...a\CROPWAT\data\cr	Spring Wheat	10/10	16/02	15
2	...a\CROPWAT\data\cr	Spring Wheat	15/10	21/02	10
3	...a\CROPWAT\data\cr	Spring Wheat	25/10	03/03	10
4	...\CROPWAT\data\cro	Soybean	20/07	12/10	10
5	...\CROPWAT\data\cro	Soybean	25/07	17/10	10
6	...\CROPWAT\data\cro	Soybean	20/07	12/10	10
7	...Data\CROPWAT\data	Rice	10/07	06/11	10
8	...Data\CROPWAT\data	Rice	20/07	16/11	10
9	...a\CROPWAT\data\cr	Pulses	10/11	27/02	5
10	...\CROPWAT\data\cro	Potato	15/11	24/03	5
11	...CROPWAT\data\crop	Small Vegetables	20/03	22/06	5

Source: CROPWAT

Table-6.3: - Recent Crop-wise and month and year wise precipitation deficit (mm) using CROPWAT 8 for Hoshangabad Block

Crops	Area in %	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Spring Wheat	15	70.7	22.5	0	0	0	0	0	0	0	14.8	36.2	80.3
2. Spring Wheat	10	75.5	35.1	0	0	0	0	0	0	0	11.5	28.2	76.6
3. Spring Wheat	10	79.1	64.4	2.7	0	0	0	0	0	0	5.1	18.3	63.9
4. Soybean	10	0	0	0	0	0	0	1.7	0	0	3.7	0	0
5. Soybean	10	0	0	0	0	0	0	0	0	0	0	0	0
6. Soybean	10	0	0	0	0	0	0	1.4	0	1	12.2	0	0
7. Rice	10	0	0	0	0	0	106	90	0	3.7	98	17.5	0
8. Rice	10	0	0	0	0	0	91.3	88.6	0	3.7	101.5	46.6	0
9. Pulses	5	79.6	68.2	0	0	0	0	0	0	0	0	18.8	56.7
10. Potato	5	77.8	100.4	84.9	0	0	0	0	0	0	0	18.7	45.3
11. Small Vegetables	5	70.4	68.2	0	0	0	0	0	0	0	0	19	55.1
Total	100	453.1	358.8	87.6	0	0	197.3	181.7	0	8.4	246.8	203.3	377.9
Irrigated area (% of total area)		55	15	0	0	20	40	0	30	75	75	55	55

Table -6.4: -Recent Irrigation water requirement (ham) for Hoshangabad Block

Crops	Area in Ha	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total in Ham
1. Spring Wheat	12233.85	864.99	275.25	0	0	0	0	0	0	0	181.08	442.86	982.37	2746.49
2. Spring Wheat	8155.9	615.75	286.29	0	0	0	0	0	0	0	93.79	229.99	624.74	1850.57
3. Spring Wheat	8155.9	645.19	525.23	22.09	0	0	0	0	0	0	41.59	149.25	521.16	1904.40
4. Soybean	8155.9	0	0	0	0	0	0	13.86	0	0	30.17	0	0	44.0418
5. Soybean	8155.9	0	0	0	0	0	0	0	0	0	0	0	0	0
6. Soybean	8155.9	0	0	0	0	0	0	11.41	0	8.15	99.50	0	0	119.076
7. Rice	8155.9	0	0	0	0	0	864.52	734.03	0	30.83	799.27	142.72	0	2570.73
8. Rice	8155.9	0	0	0	0	0	744.67	722.74	0	30.18	827.82	380.06	0	2705.31
9. Pulses	4077.95	324.62	278.19	0	0	0	0	0	0	0	0	76.665	231.21	910.606
10. Potato	4077.95	317.21	409.48	346.55	0	0	0	0	0	0	0	76.257	184.73	1333.89
11. Small	4077.95	287.08	278.19	0	0	0	0	0	0	0	0	77.481	224.69	867.379
Total	81559	3054.345	2052.2235	368.28	0	0	1609.10	1481.97	0	68.56	2073.22	1575.35	2768.9	15052.5

Table -6.5: Proposed Crop-wise and month and year wise precipitation deficit (mm) using CROPWAT 8 for Hoshangabad Block

Proposed Cropping Pattern													
Crops	**Area in %**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1. Spring Wheat	10	70.7	22.5	0	0	0	0	0	0	0	14.8	36.2	80.3
2. Spring Wheat	10	75.5	35.1	0	0	0	0	0	0	0	11.5	28.2	76.6
3. Spring Wheat	10	79.1	64.4	2.7	0	0	0	0	0	0	5.1	18.3	63.9
4. Soybean	10	0	0	0	0	0	0	1.4	0	1	12.2	0	0
5. Soybean	10	0	0	0	0	0	0	0	0	1.9	27.5	0	0
6. Soybean	5	0	0	0	0	0	0	1.4	0	1	12.2	0	0
7. Rice	8	0	0	0	0	0	106	90	0	3.7	98	17.5	0
8. Rice	8	0	0	0	0	0	91.3	88.6	0	3.7	101.5	46.6	0
9. Pulses	5	79.6	68.2	0	0	0	0	0	0	0	0	18.8	56.7
10. Potato	5	77.8	100.4	84.9	0	0	0	0	0	0	0	18.7	45.3
11. Small Vegetables	9	0	0	37.6	128.1	198.6	74.2	0	0	0	0	0	0
12. Small Vegetables	10	0	0	6.7	117.2	189.8	77.8	8.1	0	0	0	0	0
Total	100	382.7	290.6	131.9	245.3	388.4	349.3	189.5	0	11.3	282.8	184.3	322.8
Irrigated area (% of total area)		40	40	34	19	19	35	41	0	41	71	56	40

Table -6.6: Future Monthly and Yearly Irrigation water requirement (ham) for Hoshangabad Block

Crops	Area in Ha	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total Water Requirement
1. Spring Wheat	10000	707.00	225.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	148.00	362.00	803.00	2245.00
2. Spring Wheat	10000	755.00	351.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	115.00	282.00	766.00	2269.00
3. Spring Wheat	10000	791.00	644.00	27.00	0.00	0.00	0.00	0.00	0.00	0.00	51.00	183.00	639.00	2335.00
4. Soybean	10000	0.00	0.00	0.00	0.00	0.00	0.00	14.00	0.00	10.00	122.00	0.00	0.00	146.00
5. Soybean	10000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.00	275.00	0.00	0.00	294.00
6. Soybean	5000	0.00	0.00	0.00	0.00	0.00	0.00	7.00	0.00	5.00	61.00	0.00	0.00	73.00
7. Rice	8000	0.00	0.00	0.00	0.00	0.00	848.00	720.00	0.00	29.60	784.00	140.00	0.00	2521.60
8. Rice	8000	0.00	0.00	0.00	0.00	0.00	730.40	708.80	0.00	29.60	812.00	372.80	0.00	2653.60
9. Pulses	5000	398.00	341.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	94.00	283.50	1116.50
10. Potato	5000	389.00	502.00	424.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	93.50	226.50	1635.50
11. Small Vegetables	9000	0.00	0.00	338.40	1152.90	1787.40	667.80	0.00	0.00	0.00	0.00	0.00	0.00	3946.50
12. Small Vegetables	10000	0.00	0.00	67.00	1172.00	1898.00	778.00	81.00	0.00	0.00	0.00	0.00	0.00	3996.00
Total	100000	3040.00	2063.00	856.90	2324.90	3685.40	3024.20	1530.80	0.00	93.20	2368.00	1527.30	2718.00	23231.70

The gross irrigation requirement, calculated using 'CROPWAT' software, of the study area with the recommended cropping plan calculated as 232 MCM**.** As available groundwater resource is 355 MCM therefore, above-mentioned cropping plan can be safely implemented for the area.

Table 6.7: Dynamic and stastic Ground water resources of Hoshangabad Block

Block	**Hoshangabad**
Shallow Aquifer	
Dynamic Resources (MCM)	355.00
Instorage Resources (MCM)	82.66
Total Resources (MCM)	437.66
Irrigation extraction (MCM)	38.00
Surface water irrigation (MCM)	127.00
Domestic+Industries extraction (MCM)	2.36
Deeper Aquifer	
Static Resources (MCM)	275.52
Total GW Resources (MCM)	672.82
Gross Ground Water extraction (MCM)	167.36

Table: 6.8 Management Plan for Artificial Recharge Structures in Hoshanagabad Block, Hoshangabad District

Block	Rainfall (m)	Area (Sq Km)	Area suitable for recharge (Sq Km)	Average post-monsoon water level (m)	Unsaturated zone (m)	Average SP Yield (%)	Sub-surface storage (mcm)	Surface water required (mcm)	Surface water (Run-off) available (mcm)	Non-committed Run-off (mcm)	Percolation tank	Recharge shaft/ Tube well	NB/ CD/ CP	No of Villages
Hoshangabad	1.226	669	574	3.5	0.5	0.02	5	6.11	134	40.14	2	12	43	57

Table: 6.9 Change in Stage of groundwater extraction in Hoshangabad Block, Hoshangabad district after adoption of cropping pattern

S.No.	Block	Surface water use for irrigation mcm	GWR for Future irrigation mcm	GW required for implementation of proposed cropping pattern mcm	Stage of GW Extraction before implementation	Stage of GW Extraction after implementation
1	Hoshangabad	127	353	105	9.99	29.75

Management plan for Seoni –Malwa block

The dynamic resource estimation presented here is taken from 2020 dynamic groundwater resources of Madhya Pradesh where resource was estimated Block wise.

Table: 6.10 Salient features of GW resource of Seoni-Malwa Block

Assessment Unit	Command / Non Command	Net Ground Water Availability for Future Irrigation extraction in Ham	Exiting Gross ground water extraction for Irrigation (ham)	Stage of Ground Water extraction in %
Seoni-Malwa	Block Total	36907	3548	8.73

As per dynamic ground water resource estimation (2020) of the study area, Existing Total Ground Water extraction for Irrigation in 35.48 mcm and stage of extraction is only 8.73% (Table 6.10). The area is having balance net ground water availability for future irrigation is 414 mcm. If an irrigation plan is made to develop 60% of the balance dynamic ground water resources available, then 248 mcm of groundwater resources will be available in the study area for the future irrigation uses and total command area of the block is 27639 ha, surface water can also use for irrigation for implementation of proposed cropping pattern.

As per agriculture and Irrigation data 2014-15 net sown area in the study area is 43054ha and cropping intensity is 100 %. As per recent cropping pattern of the study area, some area still remains fallow in between Kharif and Rabi crops. A management plan has been envisaged to use this fallow land for increasing cropping intensity by utilizing the huge available groundwater resources. Basic aim is to increase the gross cropped area from 71500 ha to 143000 ha and thereby increase in cropping intensity up to 200%. To use the groundwater for irrigation, purpose a cropping plan has been designed for the district by using CROPWAT model developed by FAO. A suitable cropping plan for the block is prepared and Present cropping pattern, proposed cropping pattern, and targeted increase in cropping intensity were shown in below Tables.

Crop-wise and month-wise irrigation water requirement (Precipitation deficit) has been estimated from CROPWAT after giving necessary meteorological, soil, crop plan inputs and the same has been shown in Table 6.11 Crop-wise and month-wise Irrigation water requirement in ham has been further calculated in Table 6.12

Table: 6.11 Proposed Cropping pattern for Seoni-Malwa Block

CROPPING PATTERN DATA

(File: C:\ProgramData\CROPWAT\data\sessions\seoni malwa.PAT)

Cropping pattern name: Seoni-Malwa

No.	Crop file	Crop name	Planting date	Harvest date	Area %
1	...a\CROPWAT\data\cr	Spring Wheat	10/10	16/02	10
2	...a\CROPWAT\data\cr	Spring Wheat	15/10	21/02	15
3	...a\CROPWAT\data\cr	Spring Wheat	10/11	19/03	15
4	...Data\CROPWAT\data	Rice	05/07	01/11	10
5	...Data\CROPWAT\data	Rice	15/07	11/11	10
6	...Data\CROPWAT\data	Rice	20/07	16/11	5
7	...\CROPWAT\data\cro	Soybean	10/07	02/10	10
8	...\CROPWAT\data\cro	Soybean	25/10	17/01	10
9	...a\CROPWAT\data\cr	Pulses	10/11	27/02	5
10	...a\CROPWAT\data\cr	Pulses	20/11	09/03	5
11	...CROPWAT\data\crop	Small Vegetables	15/11	17/02	5

Source: CROPWAT

Table: 6.12 Proposed Crop-wise and month and year wise precipitation deficit (mm) using CROPWAT 8 for Seoni-Malwa Block														
Crops	**Area (%)**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
1. Spring Wheat	10	70.7	22.5	0	0	0	0	0	0	0	14.8	36.2	80.3	224.5
2. Spring Wheat	15	75.5	35.1	0	0	0	0	0	0	0	11.5	28.2	76.6	226.9
3. Spring Wheat	15	77	94.4	38.2	0	0	0	0	0	0	0	12.6	33.4	255.6
4. Rice	10	0	0	0	0	0	203.4	0	0	3.7	95.6	3.3	0	306
5. Rice	10	0	0	0	0	0	91.5	90	0	3.7	100	31.8	0	317
6. Rice	5	0	0	0	0	0	91.3	88.6	0	3.7	101.5	46.6	0	331.7
7. Soybean	10	0	0	0	0	0	0	1.7	0	0	3.7	0	0	5.4
8. Soybean	10	25.1	0	0	0	0	0	0	0	0	7.6	56.7	82.6	172
9. Pulses	5	79.6	68.2	0	0	0	0	0	0	0	0	18.8	56.7	223.3
10. Pulses	5	77.8	92.2	16	0	0	0	0	0	0	0	9.6	39.5	235.1
11. Small Vegetables	5	71.1	50.1	0	0	0	0	0	0	0	0	27.9	58.7	207.8
Total	**100**	**476.8**	**362.5**	**54.2**	**0**	**0**	**386.2**	**180.3**	**0**	**11.1**	**334.7**	**271.7**	**427.8**	**2505.3**

Table: 6.13 Future Monthly and Yearly Irrigation water requirement (ham) for Seoni Malwa Block														
Crops	**Area in Ha**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
1. Spring Wheat	14300	1011.01	321.75	0	0	0	0	0	0	0	211.6	517.66	1148.29	3210.35
2. Spring Wheat	21450	1619.475	752.895	0	0	0	0	0	0	0	246.7	604.89	1643.07	4867.005
3. Spring Wheat	21450	1651.65	2024.88	819.39	0	0	0	0	0	0	0	270.27	716.43	5482.62
4. Rice	14300	0	0	0	0	0	2909	0	0	52.91	1367	47.19	0	4375.8
5. Rice	14300	0	0	0	0	0	1308	1287	0	52.91	1430	454.74	0	4533.1
6. Rice	7150	0	0	0	0	0	652.8	633.49	0	26.46	725.7	333.19	0	2371.655
7. Soybean	14300	0	0	0	0	0	0	24.31	0	0	52.91	0	0	77.22
8. Soybean	14300	358.93	0	0	0	0	0	0	0	0	108.7	810.81	1181.18	2459.6
9. Pulses	7150	569.14	487.63	0	0	0	0	0	0	0	0	134.42	405.405	1596.595
10. Pulses	7150	556.27	659.23	114.4	0	0	0	0	0	0	0	68.64	282.425	1680.965
11. Small Vegetables	7150	508.365	358.215	0	0	0	0	0	0	0	0	199.485	419.705	1485.77
Total	143000	6274.84	4604.6	933.79	0	0	4870	1944.8	0	132.3	4143	3441.295	5796.51	32140.68

The gross irrigation requirement, calculated using 'CROPWAT' software, of the study area with the recommended cropping plan calculated as 321 MCM. As available groundwater resource is 370 MCM therefore, above-mentioned cropping plan can be safely implemented for the area.

Table: 6.14 Dynamic and static Ground water resources of Seoni Malwa Block

Block	**Seonimalwa**
Shallow Aquifer	
Dynamic Resources (MCM)	370.00
Instorage Resources (MCM)	111.40
Total Resources (MCM)	481.40
Irrigation extraction (MCM)	35.00
Surface water irrigation (MCM)	161.00
Domestic+Industries extraction (MCM)	3.95
Deeper Aquifer	
Static Resources (MCM)	535.60
Total GW Resources (MCM)	978.05
Gross Ground Water extraction (MCM)	199.95

Table: 6.15 Management Plan for Artificial Recharge Structures in Seoni-Malwa Block, Hoshangabad District

Block	Rainfall (m)	Area (Sq Km)	Area suitable for recharge (Sq Km)	Average post-monsoon water level (m)	Unsaturated zone (m)	Average SP Yield (%)	Sub-surface storage (mcm)	Surface water required (mcm)	Surface water (Run-off) available (mcm)	Non-committed Run-off (mcm)	Percolation tank	Recharge shaft/ Tube well	NB/ CD/ CP	No of Villages
Seoni Malwa	1.226	1375	1339	4.45	1.45	0.02	31	41.32	275	82.5	12	83	289	132

Table: 6.16 Change in Stage of groundwater extraction in Seoni- Malwa Block, Hoshangabad district after adoption of cropping pattern

S.No.	Block	Surface water use for irrigation mcm	GWR for Future irrigation mcm	GR required for implementation of proposed cropping pattern mcm	Stage of GW Extraction before implementation	Stage of GW Extraction after implementation
1	Seoni-Malwa	161	370	160	8.73	43.24

Table: 6.17 Salient features of GW resource of the Babai Block

Assessment Unit	Command / Non-Command	Net Ground Water Availability for Future Irrigation extraction in Ham	Exiting Gross ground water extraction for Irrigation (ham)	Stage of Ground Water extraction in %
Babai	Block Total	32971	2576.45	8.73

As per dynamic ground water resource estimation 2020 of the study area, Existing total Ground Water extraction for Irrigation in 26 mcm and stage of extraction is only 8.73 % (Table: 6.15). The area is having balance net ground water availability for future irrigation is 329 mcm. If an irrigation plan is made to develop 60% of the balance dynamic ground water resources available, then 197 mcm of groundwater resources will be available in the study area for the future irrigation uses.

As per agriculture and Irrigation data 2014-15 net sown area in the study area is 46400 ha and cropping intensity is 100 %. A management plan has been envisaged to use this fallow land and double cropping pattern for increasing cropping intensity by utilizing the huge available groundwater resources. Basic aim is to increase the gross cropped area from 46400 ha to 92800 ha and thereby increase in cropping intensity up to 200%. To use the groundwater for irrigation, purpose a cropping plan has been designed for the block by using CROPWAT model developed by FAO. A suitable cropping plan for the block is prepared and Present cropping pattern, proposed cropping pattern, and targeted increase in cropping intensity are shown in Table 6.18, 6.19 and 6.20.

Crop-wise and month-wise irrigation water requirement (Precipitation deficit) has been estimated from CROPWAT after giving necessary meteorological, soil, crop plan inputs and the same has been shown in Table 6.16 Crop-wise and month-wise Irrigation water requirement in ham has been further calculated in Table 6.17.

Table: 6.18 Proposed Cropping pattern for Babai Block

CROPPING PATTERN DATA
(File: untitled)

Cropping pattern name:

No.	Crop file	Crop name	Planting date	Harvest date	Area %
1	...\CROPWAT\data\cro	Soybean	15/07	07/10	10
2	...\CROPWAT\data\cro	Soybean	20/07	12/10	10
3	...\CROPWAT\data\cro	Soybean	30/07	22/10	10
4	...a\CROPWAT\data\cr	Spring Wheat	10/10	16/02	10
5	...a\CROPWAT\data\cr	Spring Wheat	15/10	21/02	10
6	...a\CROPWAT\data\cr	Spring Wheat	25/10	03/03	10
7	...Data\CROPWAT\data	Rice	15/07	11/11	10
8	...Data\CROPWAT\data	Rice	20/07	16/11	10
9	...a\CROPWAT\data\cr	Pulses	10/11	27/02	5
10	...a\CROPWAT\data\cr	Pulses	25/11	14/03	5
11	...CROPWAT\data\crop	Small Vegetables	20/12	24/03	5
12	...CROPWAT\data\crop	Small Vegetables	10/04	13/07	5

Source: CROPWAT

Table: 6.19 Proposed Crop-wise and month and year wise precipitation deficit (mm) using CROPWAT 8 for Babai Block														
Crops	**Area %**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
1. Spring Wheat	10	70.7	22.5	0	0	0	0	0	0	0	14.8	36.2	80.3	224.5
2. Spring Wheat	10	75.5	35.1	0	0	0	0	0	0	0	11.5	28.2	76.6	226.9
3. Spring Wheat	10	79.1	64.4	2.7	0	0	0	0	0	0	5.1	18.3	63.9	233.5
4. Soybean	10	0	0	0	0	0	0	1.4	0	1	12.2	0	0	14.6
5. Soybean	10	0	0	0	0	0	0	0	0	1.9	27.5	0	0	29.4
6. Soybean	10	0	0	0	0	0	0	1.4	0	1	12.2	0	0	14.6
7. Rice	10	0	0	0	0	0	106	90	0	3.7	98	17.5	0	315.2
8. Rice	5	0	0	0	0	0	91.3	88.6	0	3.7	101.5	46.6	0	331.7
9. Pulses	5	79.6	68.2	0	0	0	0	0	0	0	0	18.8	56.7	223.3
10. Potato	5	77.8	100.4	84.9	0	0	0	0	0	0	0	18.7	45.3	327.1
11. Small Vegetables	5	0	0	37.6	128.1	198.6	74.2	0	0	0	0	0	0	438.5
12. Small Vegetables	10	0	0	6.7	117.2	189.8	77.8	8.1	0	0	0	0	0	399.6
Total	100	383	290.6	131.9	245.3	388.4	349	190	0	11.3	282.8	184.3	322.8	2778.9

Table: 6.20 Future Monthly and Yearly Irrigation water requirement (ham) for Babai Block

Crops	Area in Ha	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1. Spring Wheat	9280	656.096	208.8	0	0	0	0	0	0	0	137.344	335.936	745.184	2083.36
2. Spring Wheat	9280	700.64	325.728	0	0	0	0	0	0	0	106.72	261.696	710.848	2105.632
3. Spring Wheat	9280	734.048	597.632	25.056	0	0	0	0	0	0	47.328	169.824	592.992	2166.88
4. Soybean	9280	0	0	0	0	0	0	12.992	0	9.28	113.216	0	0	135.488
5. Soybean	9280	0	0	0	0	0	0	0	0	17.632	255.2	0	0	272.832
6. Soybean	9280	0	0	0	0	0	0	12.992	0	9.28	113.216	0	0	135.488
7. Rice	9280	0	0	0	0	0	983.68	835.2	0	34.336	909.44	162.4	0	2925.056
8. Rice	4640	0	0	0	0	0	423.632	411.104	0	17.168	470.96	216.224	0	1539.088
9. Pulses	4640	369.344	316.448	0	0	0	0	0	0	0	0	87.232	263.088	1036.112
10. Potato	4640	360.992	465.856	393.936	0	0	0	0	0	0	0	86.768	210.192	1517.744
11. Small Vegetables	4640	0	0	174.464	594.384	921.504	344.288	0	0	0	0	0	0	2034.64
12. Small Vegetables	9280	0	0	62.176	1087.616	1761.344	721.984	75.168	0	0	0	0	0	3708.288
Total	**92800**	**2821.12**	**1914.464**	**655.632**	**1682**	**2682.848**	**2473.584**	**1347.456**	**0**	**87.696**	**2153.424**	**1320.08**	**2522.304**	**19660.608**

The gross irrigation requirement, calculated using 'CROPWAT' software, of the study area with the recommended cropping plan calculated as 196 **MCM and as per ground water resource estimation** available groundwater resource is **292 MCM** therefore, above-mentioned cropping plan can be safely implemented for the area for utilizing huge GWR.

Table: 6.21 Dynamic and static Ground water resources of Babai Block

Block	**Babai**
Shallow Aquifer	
Dynamic Resources (MCM)	292.00
Instorage Resources (MCM)	262.60
Total Resources (MCM)	554.60
Irrigation extraction (MCM)	26.00
Surface water irrigation (MCM)	32.00
Domestic+Industries extraction (MCM)	2.80
Deeper Aquifer	
Static Resources (MCM)	413.89
Total GW Resources (MCM)	939.69
Gross Ground Water extraction (MCM)	60.80

Table: 6.22 Management Plan for Artificial Recharge Structures in Babai Block, Hoshangabad District

Block	Rainfall (m)	Area (Sq Km)	Area suitable for recharge (Sq Km)	Average post-monsoon water level (m)	Unsaturated zone (m)	Average SP Yield (%)	Sub-surface storage (mcm)	Surface water required (mcm)	Surface water (Run-off) available (mcm)	Non-committed Run-off (mcm)	Percolation tank	Recharge shaft/ Tube well	NB/ CD/ CP	No of Villages
Babai	1.226	892	892	9.2	6.2	0.02	88	117.69	178	53.52	118	412	824	177

Table: 6.23 Stage of groundwater extraction after implementation of management plan in Babai Block, Hoshangabad district

S. No.	Block	Surface water use for irrigation mcm	GWR for Future irrigation mcm	GR required for implementation of proposed cropping pattern mcm	Stage of GW Extraction before implementation	Stage of GW Extraction after implementation
3	Babai	32	292	164	8	56.16

Table: 6.24 Salient features of GW resource of the pipariya Block

Assessment Unit	Command / Non Command	Net Ground Water Availability for Future Irrigation extraction in Ham	Exiting Gross ground water extraction for Irrigation (ham)	Stage of Ground Water extraction in %
Pipariya	Block Total	13151	7408	36.98

As per dynamic ground water resource estimation (2020) of the study area, Existing total Ground Water extraction for Irrigation in 74 mcm and stage of extraction is only 37 % (Table:6.20). The area is having balance net ground water availability for future irrigation is 131 mcm. If an irrigation plan is made to develop 60% of the balance dynamic ground water resources available and 78 mcm of groundwater resources will be available in the study area for the future irrigation uses.

As per agriculture and Irrigation data 2014-15 net sown area in the study area is 46400 ha and cropping intensity is 100 %. A management plan has been envisaged to use this fallow land and double cropping pattern for increasing cropping intensity by utilizing the huge available groundwater resources. Basic aim is to increase the gross cropped area from 35000 ha to 70000 ha and thereby increase in cropping intensity up to 200%. To use the groundwater for irrigation purpose a cropping plan has been designed for the block by using CROPWAT model developed by FAO. A suitable cropping plan for the block is prepared and Present cropping pattern, proposed cropping pattern, and targeted increase in cropping intensity were shown in Table 2,3,&4.

Crop-wise and month-wise irrigation water requirement (Precipitation deficit) has been estimated from CROPWAT after giving necessary meteorological, soil, crop plan inputs. Crop-wise and month-wise Irrigation water requirement in ham has been further calculated in Table 6.18.

Table-6.25 Proposed Cropping pattern for Pipariya Block

CROPPING PATTERN DATA
(File: untitled)

Cropping pattern name:

No.	Crop file	Crop name	Planting date	Harvest date	Area %
1	...\CROPWAT\data\cro	Soybean	15/07	07/10	10
2	...\CROPWAT\data\cro	Soybean	20/07	12/10	10
3	...\CROPWAT\data\cro	Soybean	30/07	22/10	10
4	...a\CROPWAT\data\cr	Spring Wheat	10/10	16/02	10
5	...a\CROPWAT\data\cr	Spring Wheat	15/10	21/02	10
6	...a\CROPWAT\data\cr	Spring Wheat	25/10	03/03	10
7	...Data\CROPWAT\data	Rice	15/07	11/11	10
8	...Data\CROPWAT\data	Rice	20/07	16/11	10
9	...a\CROPWAT\data\cr	Pulses	10/11	27/02	5
10	...a\CROPWAT\data\cr	Pulses	25/11	14/03	5
11	...CROPWAT\data\crop	Small Vegetables	20/12	24/03	5
12	...CROPWAT\data\crop	Small Vegetables	10/04	13/07	5

Source: CROPWAT

Table: 6.26 Proposed Crop-wise and month and year wise precipitation deficit (mm) using CROPWAT 8 for pipariya Block														
Crops	**Area**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
1. Spring Wheat	10	70.7	22.5	0	0	0	0	0	0	0	14.8	36.2	80.3	224.5
2. Spring Wheat	10	75.5	35.1	0	0	0	0	0	0	0	11.5	28.2	76.6	226.9
3. Spring Wheat	10	79.1	64.4	2.7	0	0	0	0	0	0	5.1	18.3	63.9	233.5
4. Soybean	10	0	0	0	0	0	0	1.4	0	1	12.2	0	0	14.6
5. Soybean	10	0	0	0	0	0	0	0	0	1.9	27.5	0	0	29.4
6. Soybean	10	0	0	0	0	0	0	1.4	0	1	12.2	0	0	14.6
7. Rice	10	0	0	0	0	0	106	90	0	3.7	98	17.5	0	315.2
8. Rice	10	0	0	0	0	0	91.3	88.6	0	3.7	101.5	46.6	0	331.7
9. Pulses	5	79.6	68.2	0	0	0	0	0	0	0	0	18.8	56.7	223.3
10. Potato	5	77.8	100.4	84.9	0	0	0	0	0	0	0	18.7	45.3	327.1
11. Small Vegetables	5	0	0	37.6	128.1	198.6	74.2	0	0	0	0	0	0	438.5
12. Small Vegetables	5	0	0	6.7	117.2	189.8	77.8	8.1	0	0	0	0	0	399.6
Total	100	382.7	290.6	131.9	245.3	388.4	349.3	189.5	0	11.3	282.8	184.3	322.8	2778.9

Table: 6.27 Future Monthly and Yearly Irrigation water requirement (ham) for Piparia Block

Crops	Area in Ha	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1. Spring Wheat	7000	494.9	157.5	0	0	0	0	0	0	0	103.6	253.4	562.1	1571.5
2. Spring Wheat	7000	528.5	245.7	0	0	0	0	0	0	0	80.5	197.4	536.2	1588.3
3. Spring Wheat	7000	553.7	450.8	18.9	0	0	0	0	0	0	35.7	128.1	447.3	1634.5
4. Soybean	7000	0	0	0	0	0	0	9.8	0	7	85.4	0	0	102.2
5. Soybean	7000	0	0	0	0	0	0	0	0	13.3	192.5	0	0	205.8
6. Soybean	7000	0	0	0	0	0	0	9.8	0	7	85.4	0	0	102.2
7. Rice	7000	0	0	0	0	0	742	630	0	25.9	686	122.5	0	2206.4
8. Rice	7000	0	0	0	0	0	639.1	620.2	0	25.9	710.5	326.2	0	2321.9
9. Pulses	3500	278.6	238.7	0	0	0	0	0	0	0	0	65.8	198.45	781.55
10. Potato	3500	272.3	351.4	297.15	0	0	0	0	0	0	0	65.45	158.55	1144.85
11. Small Vegetables	3500	0	0	131.6	448.35	695.1	259.7	0	0	0	0	0	0	1534.75
12. Small Vegetables	3500	0	0	23.45	410.2	664.3	272.3	28.35	0	0	0	0	0	1398.6
Total	70000	2128	1444.1	471.1	858.55	1359.4	1913.1	1298.15	0	79.1	1979.6	1158.85	1902.6	14592.55

The gross irrigation requirement, calculated using 'CROPWAT' software, of the study area with the recommended cropping plan calculated as 146 **MCM and as per ground water resource estimation** available groundwater resource is 118 **MCM** and command area irrigation by canal and other surface water therefore, above-mentioned cropping plan can be safely implemented for the area. Artificial recharge structures are also to be proposed to recharge the ground water, Tentative location of AR structures are shown in **Fig: 6.1.**

Table: 6.28 Dynamic and static Ground water resources of Pipariya Block

Block	**Pipariya**
Shallow Aquifer	
Dynamic Resources (MCM)	118.00
Instorage Resources (MCM)	133.94
Total Resources (MCM)	2105.07
Irrigation extraction (MCM)	73.00
Surface water irrigation extraction (MCM)	65.00
Domestic+Industries extraction (MCM)	3.07
Deeper Aquifer	
Static Resources (MCM)	1736.82
Total GW Resources (MCM)	1912.68
Gross Ground Water extraction (MCM)	141.07

Table: 6.29 Management Plan for Artificial Recharge Structures in Pipariya Block, Hoshangabad District

Block	Rainfall (m)	Area (Sq Km)	Area suitable for recharge (Sq Km)	Average post-monsoon water level (m)	Unsaturated zone (m)	Average SP Yield (%)	Sub-surface storage (mcm)	Surface water required (mcm)	Surface water (Run-off) available (mcm)	Non-committed Run-off (mcm)	Percolation tank	Recharge shaft/ Tube well	NB/ CD/ CP	No of Villages
Pipariya	1.226	983	863	7.9	4.9	0.02	68	89.99	197	58.98	27	180	630	156

Table: 6.30 Change in Stage of groundwater extraction in Pipariya Block, Hoshangabad district after adoption of Above cropping pattern

S. No.	Block	Surface water use for irrigation mcm	GWR for Future irrigation mcm	GWR required for implementation of proposed cropping pattern mcm	Stage of GW Extraction before implementation	Stage of GW Extraction after implementation
1	Pipariya	65	118	81	36	68.64

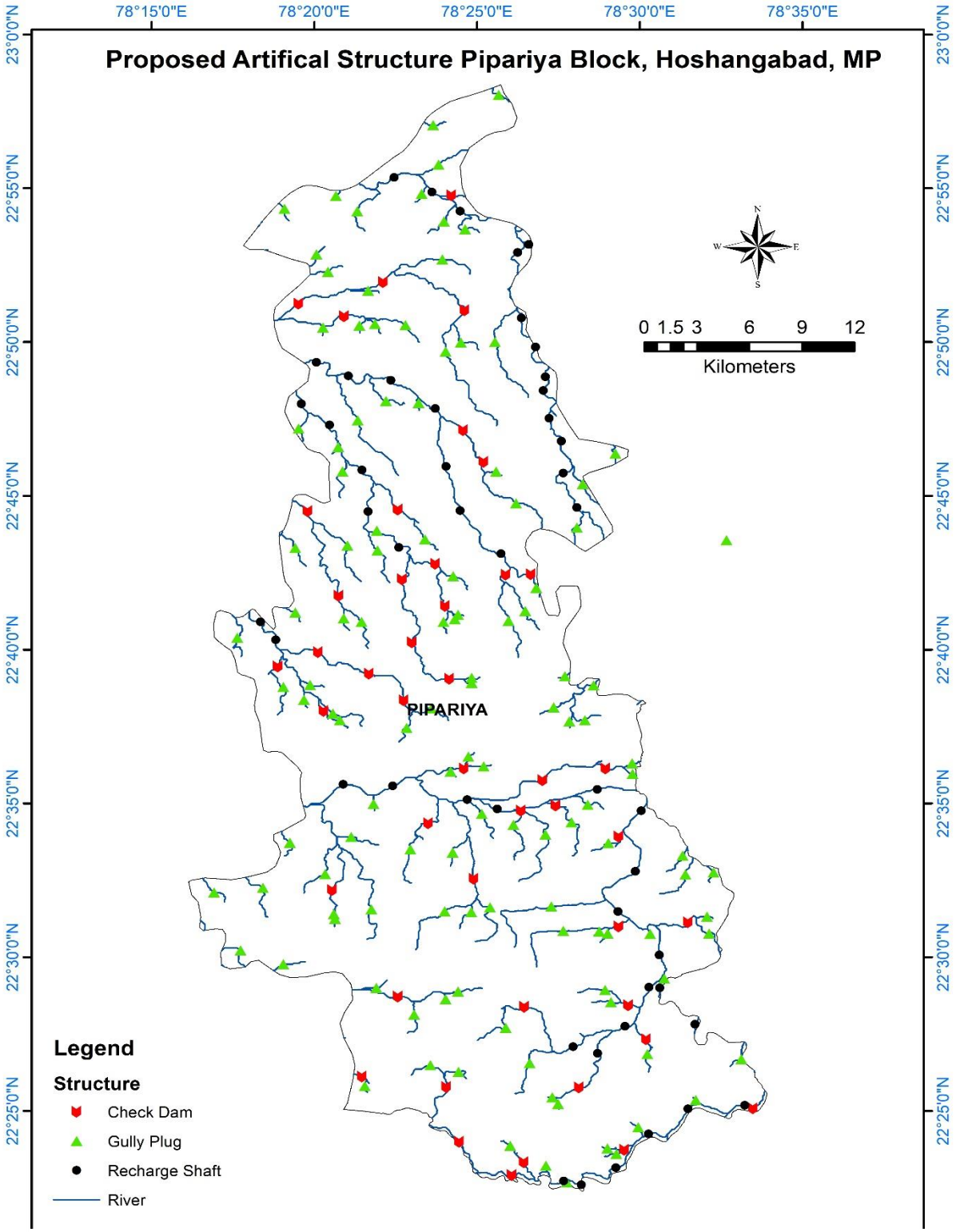

Fig: 6.1 Tentative Location of AR Structures in Pipariya block

Table: 6.31 Salient features of GW resource of the Sohagpur Block

Assessment Unit	Command / Non Command	Net Ground Water Availability for Future Irrigation extraction in Ham	Exiting Gross ground water extraction for Irrigation (ham)	Stage of Ground Water extraction in %
Sohagpur	Block Total	8860	3841	31.83

As per dynamic ground water resource estimation (2020) of the study area, Existing total Ground Water extraction for Irrigation in 38 mcm and stage of extraction is only 32% (Table: 6.31). The area is having balance net ground water availability for future irrigation is 88mcm. If an irrigation plan is made to develop 60% of the balance dynamic ground water resources available, then 53 mcm of groundwater resources will be available in the study area for the future irrigation uses.

As per agriculture and Irrigation data 2014-15 net sown area in the study area is 31000 ha and cropping intensity is 98 %. A management plan has been envisaged to use this fallow land and double cropping pattern for increasing cropping intensity by utilizing the huge available groundwater resources. Basic aim is to increase the gross cropped area from 31000 ha to 40000 ha and thereby increase in cropping intensity up to 130 %. To use the groundwater for irrigation, purpose a cropping plan has been designed for the block by using CROPWAT model developed by FAO. A suitable cropping plan for the block is prepared (table 6.32).

Crop-wise and month-wise irrigation water requirement (Precipitation deficit) has been estimated from CROPWAT after giving necessary meteorological, soil, crop plan inputs and the same has been shown in Table:6.33. Crop-wise and month-wise Irrigation water requirement in ham has been further calculated in Table: 6.34

Table: 6.32 Proposed Cropping pattern for Sohagpur Block

CROPPING PATTERN DATA
(File: untitled)

Cropping pattern name:

No.	Crop file	Crop name	Planting date	Harvest date	Area %
1	...\CROPWAT\data\cro	Soybean	15/07	07/10	10
2	...\CROPWAT\data\cro	Soybean	20/07	12/10	10
3	...\CROPWAT\data\cro	Soybean	30/07	22/10	10
4	...a\CROPWAT\data\cr	Spring Wheat	10/10	16/02	10
5	...a\CROPWAT\data\cr	Spring Wheat	15/10	21/02	10
6	...a\CROPWAT\data\cr	Spring Wheat	25/10	03/03	10
7	...Data\CROPWAT\data	Rice	15/07	11/11	10
8	...Data\CROPWAT\data	Rice	20/07	16/11	10
9	...a\CROPWAT\data\cr	Pulses	10/11	27/02	5
10	...a\CROPWAT\data\cr	Pulses	25/11	14/03	5
11	...CROPWAT\data\crop	Small Vegetables	20/12	24/03	5
12	...CROPWAT\data\crop	Small Vegetables	10/04	13/07	5

Source: CROPWAT

Table: 6.33 Proposed Crop-wise and month and year wise precipitation deficit (mm) using CROPWAT 8 for Sohagpur Block

Crops	Area %	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1. Spring Wheat	10	70.7	22.5	0	0	0	0	0	0	0	14.8	36.2	80.3	224.5
2. Spring Wheat	10	75.5	35.1	0	0	0	0	0	0	0	11.5	28.2	76.6	226.9
3. Spring Wheat	10	79.1	64.4	2.7	0	0	0	0	0	0	5.1	18.3	63.9	233.5
4. Soybean	10	0	0	0	0	0	0	1.4	0	1	12.2	0	0	14.6
5. Soybean	10	0	0	0	0	0	0	0	0	1.9	27.5	0	0	29.4
6. Soybean	10	0	0	0	0	0	0	1.4	0	1	12.2	0	0	14.6
7. Rice	10	0	0	0	0	0	106	90	0	3.7	98	17.5	0	315.2
8. Rice	5	0	0	0	0	0	91.3	88.6	0	3.7	101.5	46.6	0	331.7
9. Pulses	5	79.6	68.2	0	0	0	0	0	0	0	0	18.8	56.7	223.3
10. Potato	5	77.8	100.4	84.9	0	0	0	0	0	0	0	18.7	45.3	327.1
11. Small Vegetables	5	0	0	37.6	128.1	198.6	74.2	0	0	0	0	0	0	438.5
12. Small Vegetables	10	0	0	6.7	117.2	189.8	77.8	8.1	0	0	0	0	0	399.6
Total	100	383	290.6	131.9	245.3	388.4	349	190	0	11.3	282.8	184.3	322.8	2778.9

Table: 6.34 Future Monthly and Yearly Irrigation water requirement (ham) for Sohagpur Block

Crops	Area in Ha	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1. Spring Wheat	4000	282.8	90	0	0	0	0	0	0	0	59.2	144.8	321.2	898
2. Spring Wheat	4000	302	140.4	0	0	0	0	0	0	0	46	112.8	306.4	907.6
3. Spring Wheat	4000	316.4	257.6	10.8	0	0	0	0	0	0	20.4	73.2	255.6	934
4. Soybean	4000	0	0	0	0	0	0	5.6	0	4	48.8	0	0	58.4
5. Soybean	4000	0	0	0	0	0	0	0	0	7.6	110	0	0	117.6
6. Soybean	4000	0	0	0	0	0	0	5.6	0	4	48.8	0	0	58.4
7. Rice	4000	0	0	0	0	0	424	360	0	14.8	392	70	0	1260.8
8. Rice	2000	0	0	0	0	0	182.6	177.2	0	7.4	203	93.2	0	663.4
9. Pulses	2000	159.2	136.4	0	0	0	0	0	0	0	0	37.6	113.4	446.6
10. Potato	2000	155.6	200.8	169.8	0	0	0	0	0	0	0	37.4	90.6	654.2
11. Small Vegetables	2000	0	0	75.2	256.2	397.2	148.4	0	0	0	0	0	0	877
12. Small Vegetables	4000	0	0	26.8	468.8	759.2	311.2	32.4	0	0	0	0	0	1598.4
Total	40000	1216	825.2	282.6	725	1156.4	1066.2	580.8	0	37.8	928.2	569	1087.2	8474.4

The gross irrigation requirement, calculated using 'CROPWAT' software, of the study area with the recommended cropping plan calculated as 85**MCM and as per ground water resource estimation** available groundwater resource is 93 **MCM** therefore, above-mentioned cropping plan can be safely implemented for the area for utilizing huge GWR.

Table: 6.35 Dynamic and static Ground water resources of Sohagpur Block

Block	**Sohagpur**
Shallow Aquifer	
Dynamic Resources (MCM)	93.00
Instorage Resources (MCM)	165.27
Total Resources (MCM)	258.27
Irrigation extraction(MCM)	36.00
Surface water irrigation extraction (MCM)	55.00
Domestic+Industries extraction (MCM)	2.93
Deeper Aquifer	
Static Resources (MCM)	173.60
Total GW Resources (MCM)	392.94
Gross Ground Water extraction (MCM)	93.93

Table: 6.36 Management Plan for Artificial Recharge Structures in Sohagpur Block, Hoshangabad District

Block	Rainfall (m)	Area (Sq Km)	Area suitable for recharge (Sq Km)	Average post-monsoon water level (m)	Unsaturated zone (m)	Average SP Yield (%)	Sub-surface storage (mcm)	Surface water required (mcm)	Surface water (Run-off) available (mcm)	Non-committed Run-off (mcm)	Percolation tank	Recharge shaft/ Tube well	NB/ CD/ CP	No of Villages
Sohangpur	1.226	1113	434	3.44	0.44	0.02	3	4.06	223	66.78	1	8	28	181

Table: 6.37 Stage of groundwater extraction after adoption of cropping pattern in Sohagpur Block, Hoshangabad district

S. No.	Block	Surface water use for irrigation mcm	GWR for Future irrigation mcm	GR required for implementation of proposed cropping pattern mcm	Stage of GW Extraction before implementation	Stage of GW Extraction after implementation
5	Sohagpur	55	93	38	31	41

Table: 6.38 Salient features of GW resource of the Kesla Block

Assessment Unit	Command / Non Command	Net Ground Water Availability for Future Irrigation extraction in Ham	Exiting Gross ground water extraction for Irrigation (ham)	Stage of Ground Water extraction in %
Kesla	Block Total	15238	3607	21

As per dynamic ground water resource estimation (2020) of the study area, Existing total Ground Water extraction for Irrigation in 36 mcm and stage of extraction is only 21% **Table: 6.38**. The area is having balance net ground water availability for future irrigation is 152 mcm. If an irrigation plan is made to develop 60% of the balance dynamic ground water resources available, then 91 mcm of groundwater resources will be available in the study area for the future irrigation uses.

As per agriculture and Irrigation data 2014-15 net sown area in the study area is 25000 ha and cropping intensity is 98 %. A management plan has been envisaged to use this fallow land and double cropping pattern for increasing cropping intensity by utilizing the huge available groundwater resources. Basic aim is to increase the gross cropped area from 25000 ha to 50000 ha and thereby increase in cropping intensity up to 200 %. To use the groundwater for irrigation, purpose a cropping plan has been designed for the block by using CROPWAT model developed by FAO. A suitable cropping plan for the block is prepared (table 6.39).

Crop-wise and month-wise irrigation water requirement (Precipitation deficit) has been estimated from CROPWAT after giving necessary meteorological, soil, crop plan inputs and the same has been shown in Table: 6.40. Crop-wise and month-wise Irrigation water requirement in ham has been further calculated in Table: 6.41.

Table: 6.39 Proposed Cropping pattern for Kesla Blocks

CROPPING PATTERN DATA
(File: untitled)

Cropping pattern name:

No.	Crop file	Crop name	Planting date	Harvest date	Area %
1	...\CROPWAT\data\cro	Soybean	15/07	07/10	10
2	...\CROPWAT\data\cro	Soybean	20/07	12/10	10
3	...\CROPWAT\data\cro	Soybean	30/07	22/10	10
4	...a\CROPWAT\data\cr	Spring Wheat	10/10	16/02	10
5	...a\CROPWAT\data\cr	Spring Wheat	15/10	21/02	10
6	...a\CROPWAT\data\cr	Spring Wheat	25/10	03/03	10
7	...Data\CROPWAT\data	Rice	15/07	11/11	10
8	...Data\CROPWAT\data	Rice	20/07	16/11	10
9	...a\CROPWAT\data\cr	Pulses	10/11	27/02	5
10	...a\CROPWAT\data\cr	Pulses	25/11	14/03	5
11	...CROPWAT\data\crop	Small Vegetables	20/12	24/03	5
12	...CROPWAT\data\crop	Small Vegetables	10/04	13/07	5

Source: CROPWAT

Table: 6.40 Proposed Crop-wise and month and year wise precipitation deficit (mm) using CROPWAT 8 for Kesla Block

Crops	Area %	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1. Spring Wheat	10	70.7	22.5	0	0	0	0	0	0	0	14.8	36.2	80.3	224.5
2. Spring Wheat	10	75.5	35.1	0	0	0	0	0	0	0	11.5	28.2	76.6	226.9
3. Spring Wheat	10	79.1	64.4	2.7	0	0	0	0	0	0	5.1	18.3	63.9	233.5
4. Soybean	10	0	0	0	0	0	0	1.4	0	1	12.2	0	0	14.6
5. Soybean	10	0	0	0	0	0	0	0	0	1.9	27.5	0	0	29.4
6. Soybean	10	0	0	0	0	0	0	1.4	0	1	12.2	0	0	14.6
7. Rice	10	0	0	0	0	0	106	90	0	3.7	98	17.5	0	315.2
8. Rice	5	0	0	0	0	0	91.3	88.6	0	3.7	101.5	46.6	0	331.7
9. Pulses	5	79.6	68.2	0	0	0	0	0	0	0	0	18.8	56.7	223.3
10. Potato	5	77.8	100.4	84.9	0	0	0	0	0	0	0	18.7	45.3	327.1
11. Small Vegetables	5	0	0	37.6	128.1	198.6	74.2	0	0	0	0	0	0	438.5
12. Small Vegetables	10	0	0	6.7	117.2	189.8	77.8	8.1	0	0	0	0	0	399.6
Total	100	383	290.6	131.9	245.3	388.4	349	190	0	11.3	282.8	184.3	322.8	2778.9

Table: 6.41 Future Monthly and Yearly Irrigation water requirement (ham) for Kesla Block

Crops	Area in Ha	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1. Spring Wheat	5000	353.5	112.5	0	0	0	0	0	0	0	74	181	401.5	1122.5
2. Spring Wheat	5000	377.5	175.5	0	0	0	0	0	0	0	57.5	141	383	1134.5
3. Spring Wheat	5000	395.5	322	13.5	0	0	0	0	0	0	25.5	91.5	319.5	1167.5
4. Soybean	5000	0	0	0	0	0	0	7	0	5	61	0	0	73
5. Soybean	5000	0	0	0	0	0	0	0	0	9.5	137.5	0	0	147
6. Soybean	5000	0	0	0	0	0	0	7	0	5	61	0	0	73
7. Rice	5000	0	0	0	0	0	530	450	0	18.5	490	87.5	0	1576
8. Rice	2500	0	0	0	0	0	228.25	221.5	0	9.25	253.75	116.5	0	829.25
9. Pulses	2500	199	170.5	0	0	0	0	0	0	0	0	47	141.75	558.25
10. Potato	2500	194.5	251	212.25	0	0	0	0	0	0	0	46.75	113.25	817.75
11. Small Vegetables	2500	0	0	94	320.25	496.5	185.5	0	0	0	0	0	0	1096.25
12. Small Vegetables	5000	0	0	33.5	586	949	389	40.5	0	0	0	0	0	1998
Total	50000	1520	1031.5	353.25	906.25	1445.5	1332.75	726	0	47.25	1160.25	711.25	1359	10593

Table: 6.42 Management Plan for Artificial Recharge Structures in Kesla Block, Hoshangabad District

Block	Rainfall (m)	Area (Sq Km)	Area suitable for recharge (Sq Km)	Average post-monsoon water level (m)	Unsaturated zone (m)	Average SP Yield (%)	Sub-surface storage (mcm)	Surface water required (mcm)	Surface water (Run-off) available (mcm)	Non-committed Run-off (mcm)	Percolation tank	Recharge shaft/ Tube well	NB/ CD/ CP	No of Villages
Kesla	1.226	883	813	5.13	2.13	0.02	28	36.85	177	52.98	11	74	258	179

The gross irrigation requirement, calculated using 'CROPWAT' software, of the study area with the recommended cropping plan calculated as 106 **MCM and as per ground water resource estimation** available groundwater resource is 152 **MCM** therefore, above-mentioned cropping plan can be safely implemented for the area for utilizing GWR.

Table: 6.43 Dynamic and static Ground water resources of Kesla Block

Block	Kesla
Shallow Aquifer	
Dynamic Resources (MCM)	152.00
Instorage Resources (MCM)	221.14
Total Resources (MCM)	**373.14**
Irrigation Draft(MCM)	38.00
Surface water Irrigation draft (MCM)	61.00
Domestic+IndustriesDraft(MCM)	2.57
Deeper Aquifer	

Static Resources (MCM)	338.21
Total GW Resources (MCM)	670.77
Gross Ground Water Draft (MCM)	99.00

Table: 6.44 Change in Stage of groundwater extraction in Kesla Block, Hoshangabad district after adoption of cropping pattern

S. No.	Block	Surface water use for irrigation mcm	GWR for Future irrigation mcm	GW required for implementation of proposed cropping pattern mcm	Stage of GW Extraction before implementation	Stage of GW Extraction after implementation
1	Kesla	61	152	45	20	29.61

Management plan of Bankhedi Block-

The dynamic resource estimation presented here is taken from 2017dynamic groundwater resources of Madhya Pradesh where resource was estimated Block wise.

Table: 6.45 Salient features of GW resource of the Bankhedi Block

Assessment Unit	Command / Non Command	Net Ground Water Availability for Future Irrigation extraction in Ham	Exiting Gross ground water extraction for Irrigation (ham)	Stage of Ground Water extraction in %
Bankhedi	Block Total	5411	14364	72.96

Table: 6.46 Dynamic and static Ground water resources of Bankhedi Block

Block	Bankhedi
Shallow Aquifer	
Dynamic Resources (MCM)	69.00
Instorage Resources (MCM)	21.41
Total Resources (MCM)	90.41
Irrigation extraction (MCM)	153.00
Surface water irrigation extraction (MCM)	0.00
Domestic+Industries extraction (MCM)	0.98
Deeper Aquifer	
Static Resources (MCM)	192.67
Total GW Resources (MCM)	129.10
Gross Ground Water extraction (MCM)	153.98

A water crisis looms in some villages and Borewells located in Pipariya and Bankhedi blocks are drying up gradually. Some Borewell already dried up two-three years ago. The Artificial recharge structures are to be proposed in the both the block to recharge the ground water.

Watershed development: being most economical method of recharging rain water into the ground, the conservation of rain water, soil and vegetation by watershed based interventions will improve sustainable stream flows to provide value added surface irrigation. Watershed management in the upper most forest catchment is the highly prioritized starting point for integrated development of resources from ridge to valley. Thus, Watershed management, development of surface water resources, reviving of traditional dug-wells and tanks,

desilting ponds, command area development and efficient micro irrigation systems should get high priority.

The artificial recharge to ground water aims at augmentation of ground water reservoir by modifying the natural movement of surface water through suitable artificial recharge /RWH and water conservation structures. Artificial recharge structures are also to be proposed to recharge the ground water, Tentative location of AR structures are shown in **Fig: 6.2.**

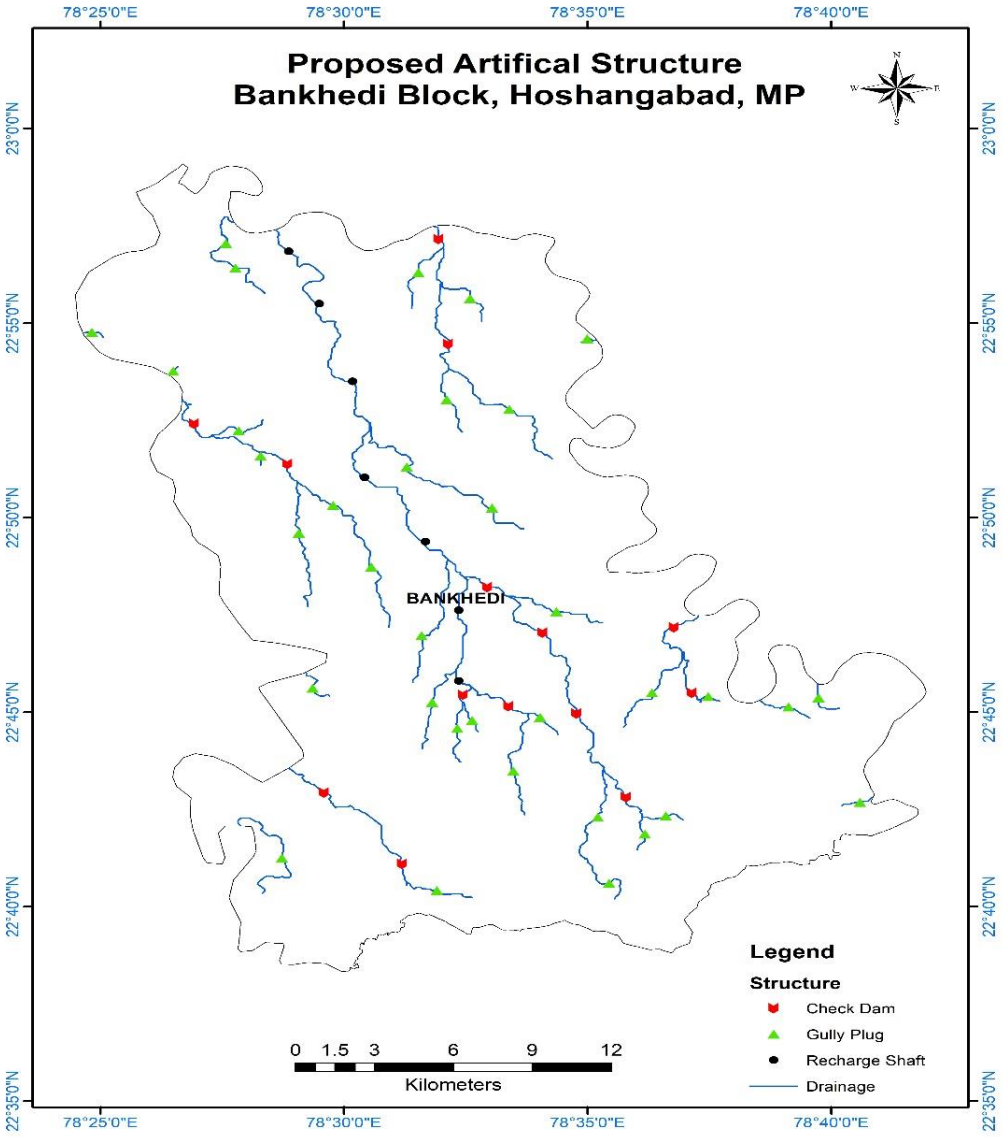

Fig:6.2 Tentative location of AR structures in Bankhedi block

Table: 6.47 Management Plan for Artificial Recharge Structures in Bankhedi Block, Hoshangabad District

Block	Rainfall (m)	Area (Sq Km)	Area suitable for recharge (Sq Km)	Average post-monsoon water level (m)	Unsaturated zone (m)	Average SP Yield (%)	Sub-surface storage (mcm)	Surface water required (mcm)	Surface water (Run-off) available (mcm)	Non-committed Run-off (mcm)	Percolation tank	Recharge shaft/ Tube well	NB/ CD/ CP	No of Villages
Bankhedi	1.226	789	669	8.26	5.26	0.02	56	74.88	158	47.34	22	150	524	221

Table: 6.48 Change in Stage of groundwater extraction in Bankhedi Block, Hoshangabad district after adoption of cropping pattern

S. No.	Block	Surface water use for irrigation mcm	GWR for Future irrigation mcm	GR required for implementation of proposed cropping pattern mcm	Stage of GW Extraction before implementation	Stage of GW Extraction after implementation
7	Bankhedi	0	75	52	72.96	69.33

Table: 6.49 Ground water Management of Hoshangabad district

Block	Rainfall (m)	Area (Sq Km)	Area suitable for recharge (Sq Km)	Average post-monsoon water level (m)	Unsaturated zone (m)	Average SP Yield (%)	Sub-surface storage (mcm)	Surface water required (mcm)	Surface water (Run-off) available (mcm)	Non-committed Run-off (mcm)	Percolation tank	Recharge shaft/ Tube well	NB/ CD/ CP	No of Villages
Babai	1.226	892	892	9.2	6.20	0.02	88	117.69	178	53.52	118	412	824	177
Bankhedi	1.226	789	669	8.26	5.26	0.02	56	74.88	158	47.34	22	150	524	221
Hoshangabad	1.226	669	574	3.5	0.50	0.02	5	6.11	134	40.14	2	12	43	57
Kesla	1.226	883	813	5.13	2.13	0.02	28	36.85	177	52.98	11	74	258	179
Pipariya	1.226	983	863	7.9	4.90	0.02	68	89.99	197	58.98	27	180	630	156
Seoni Malwa	1.226	1375	1339	4.45	1.45	0.02	31	41.32	275	82.50	12	83	289	132
Sohangpur	1.226	1113	434	3.44	0.44	0.02	3	4.06	223	66.78	1	8	28	181
TOTAL		6704	5584	41.88	20.88		279	370.89	1341	402.24	371	742	693	1103

Chapter 7

Conclusions and Recommendations

Hoshangabad district comes under safe category from ground water extraction point of view. Due to easy availability of surface water for irrigation, after the construction of major irrigation Tawa project (1975), the extraction of ground water for irrigation has been negligible in the area falling under the Tawa Command Project. The ground water extraction is confined only in non-command are in the district i.e. in Bankhedi block and parts of Pipariya block. Ground water being the main source of irrigation, ground water level in declining.

In the non-command area of the district i.e. in Bankhedi and parts of Pipariya blocks ground water being the main source of irrigation, ground water level in declining. Phreatic aquifer is hardly able to meet the needs of irrigation. The dug wells in a large area dry up by April. Since the water availability and potential of deeper aquifer is very good and sufficient to meet the irrigation demands at present, the number of tube wells in this area is increasing at a fast rate and dug wells are being converted into dug-cum-bore wells. Thus, now it is the deeper aquifers, which are being exploited for meeting the irrigation demands.

The decline in water level in non-command area can be attributed to two main factors.

1. Below normal rainfall in the non-command area over the past years.
2. Heavy extraction of ground water in the area to meet the irrigation demands

- Water Logging in Tawa Canal Command Area. Since the commencement of canal irrigation in the area, the heavy import of water from surface water irrigation system to the ground water reservoirs, and practically no draft of water from the ground water system to Tawa Canal command area has resulted in rise in water level leading in water logging conditions.
- It is proposed to switching from a low water demand crop to a high-water consuming crop such as rice especially in tawa command area, so that water level in and around

water logged area may be decline as well as stage of GW extraction may also be improved.

- Artificial recharge to ground water is one of the most efficient, scientifically proven and cost-effective technology to mitigate the problems of depleting ground water particularly in Bankhedi and pipariya blocks of Hoshangabad district. It may be rejuvenating the depleted ground water storage, reduces the ground water quality problems and also improves the sustainability of wells in the affected areas.
- The number of artificial recharge structure has been proposed based on the basis of sub-surface storage. It may be differ from the field condition as well as changes in dynamic Ground water resources.

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7ANNEXURE

DETAILS OF KEY WELLS

Block	Location	Lat	Long	Altitude (m)	Geology	Depth of well (m)	Diameter (m)	Casing Length (m)	MP (m)	SWL July-18 mbgl	SWL Feb-19 mbgl	WL Fluctuations
Babai	Bajjarwada	22.73	77.91	317	Alluvium, Black and Siyari soil	13.60	1.90	13.60	0.74	(12.40) Dry	Dry	
Babai	SangaKheda Kala	22.79	77.81	306	Alluvium, Balck and Siyari soil	9.60	4.00	9.60	1.68	9.55	Dry	
Babai	Khargawali	22.79	77.94	300	Alluvium, Black and Siyari soil	9.60	4.00	9.60	1.68	(9.20)Dry	Dry	
Babai	Khidiya	22.74	77.96	314	Alluvium, black soil	15.35	3.50	15.35	0.38	15.50	Dry	
Babai	Maragaon	22.80	78.02	321	Aluvium, black soil	16.30	3.00	16.30	1.50	(15.50) Dry	Dry	
Babai	Satwasa	22.79	78.09	327	Alluvium, black & yellow soil	16.10	2.90	16.10	1	(15.80) Dry	Dry	
Babai	Baharpur	22.73	78.07	332	Alluvium, Black soil	10.00	2.50	10.00	0.80	6.15	9.00	-2.85
Babai	Anchal Kheda	22.71	77.87	319	Black soil	8.80	1.55	8.80	0.91	8.25	7.38	0.87
Babai	Guradiya	22.69	78.04	325	Black, red, yellow soil	12.00	2.60	12.00	0.8	5.05	3.25	1.80
Babni	Ari	22.76	77.88	324	Alluvium, Black and Siyari soil	11.50	3.10	11.50	0.50	(10.70) Dry	Dry	
Bankhedi	Bankhedi	22.77	78.54	364	Alluvium, black, red soil	12.70	6.00	12.70	1.10	(13.30) Dry	Dry	
Bankhedi	Nagwada	22.78	78.59	361	Alluvium, black and red soil	11.80	2.00	11.80	0.94	(11.30) Dry	Dry	

Hoshangabad	Gwaltoli	22.75	77.71	309	Alluvium	17.63	2.66	17.63	0.88	(18.60) Dry	Dry	
Hoshangabad	Palasi	22.69	77.73	307	Alluvium	9.84	3.00	9.84	1.25	9.70	Dry	
Hoshangabad	Rohna	22.68	77.70	305	Alluvium	9.60	3.05	9.60	1.20	7.30	9.46	-2.16
Hoshangabad	Talnagri	22.71	77.62	311	Alluvium, Yellow soil	25.20	1.20	25.20	0.60	19.30	19.20	0.10
Hoshangabad	Randhal	22.74	77.64	308	Alluvium	24.90	1.30	24.90	0.34	18.00	18.40	-0.40
Hoshangabad	Misrod	22.62	77.57	296	Alluvium	10.45	3.00	10.45	0.65	(10.50) Dry	Dry	#VALUE!
Hoshangabad	Bortalai	22.62	77.74	320	Alluvium,Black soil	8.10	1.82	8.10	0.50	Filled Up	Dry	
Hoshangabad	Suparli	22.61	77.67	321	Alluvium,Black soil	8.73	0.90	8.73	0.65	(8.90)Dry	Dry	
Hoshangabad	Bamhori Khurd	22.63	77.69	314	Alluvium	4.50	1.25	4.50	0.74	4.35	4.18	0.17
Hoshangabad	Dodugaon	22.61	77.60	311	Alluvium, Black soil	9.13	2.00	9.13	0.80	8.10	8.80	-0.70
Hoshangabad	Chandon	22.63	77.86	326	Black and Siyari soil	8.70	2.74	8.70	1.10	7.10	Dry	
Hoshangabad	Rampur	22.64	77.89	326	Black Soil	10.60	2.60	10.60	0.54	7.50	10.40	-2.90
Hoshangabad	Pathodi	22.71	77.76	308	Alluvium, Black and Siyari soil	6.60	1.24	6.60	0.66	5.50	Dry	
Hoshangabad	Jasalpur	22.73	77.78	306	Alluvium, Black soil	6.80	2.15 side	6.80	0.55	6.15	Dry	
Hoshangabad	Dhonkheda	22.65	77.78	312	Black soil	10.30	3.90	10.30	0.87	8.7	Dry	
Itarsi	Itarsi	22.63	77.78	329	Black soil	26.00	2.90	26.00	0.62	12.60	12.20	0.40

Kesala	Semri khurd	22.58	77.65	320	Alluvium, Black soil	19.50	2.86	19.50	0.50	8.40	11.44	-3.04
Kesala	Bandri	22.49	77.64	340	Siyari soil	9.00	2.96	9.00	0.48	(8.80)Dry	dry	
Kesala	Bhatti	22.58	77.72	332	Black soil	15.70	3.55	15.70	1.60	4.50	3.35	1.15
Kesala	Dehri	22.59	77.76	338	Alluvium, Black soil	9.50	2.28	9.50	0.90	8.45	8.03	0.42
Kesala	Jhujhalpur	22.58	77.76	332	Black soil	9.42	1.70	9.42	0.44	(9.40)Dry	9.05	
Kesala	Jamai Kalan	22.56	77.83	363	Black soil	13.45	2.03	13.45	0.60	(10.70) Dry	Dry	
Kesala	Mohla	22.56	77.84	362	Balck and Siyari soil	10.45	2.35	10.45	0.55	(10.30) Dry	Dry	
Kesala	Tawanagar	22.57	77.96	369	Muram Soil	19.60	3.80	19.60	0.68	5.35	2.80	2.55
Kesala	Saheli	22.45	77.83	377		12.35	4.92	12.35	0.34	4.80	5.20	-0.40
Kesala	Khakrapura	22.43	77.85	386	Black Soil	16.45	3.23	16.45	0.68	13.50	12.40	1.10
Kesala	Pathrota	22.57	77.80	356	Black Soil	7.50	2.00	7.50	0.90	(7.40)Dry	Dry	
Kesala	Nagpur Kalan	22.58	77.83	346	Siyari soil	13.20	2.82	13.20	0.95	14.00	Dry	
Kesala	Dhansai	22.50	77.84	377	Black soil	9.20	3.15	9.20	0.95	7.80	7.45	0.35
Kesala	Jalikheda	22.51	77.84	387	Siyari Soil	9.54	3.60	9.54	0.95	5.20	6.40	-1.20
Kesala	Morpani	22.48	77.87	360	Basalt,Siyari Soil	10.30	2.45	10.30	1.26	7.30	8.20	-0.90
Kesala	Madiko	22.47	77.91	371	Basalt,Black, Red Soil	10.20	5.60	3.80	0.94	6.00	8.10	-2.10

Kesala	Takku	22.49	77.82	403	Basalt,Black and Red soil mix	7.65	2.10	7.65	0.60	5.45	6.80	-1.35
Kesala	Bhargada	22.40	77.87	359	Basalt, Black soil	6.47	1.80	6.47	0.26	3.80	2.90	0.90
Kesala	Komati Raiyat	22.39	77.89	368	Basalt, Black and Siyari soil	17.00	2.60	17.00	1.00	15.70	8.50	7.20
Kesala	Kala Akhar	22.40	77.82	373	Basalt, Black and Siyari soil	9.94	2.50	9.94	1.34	9.40	9.50	-0.10
Kesla	Rasalpatta	22.41	77.86	361	Basalt, Reddish soil	7.70	2.50	7.70	0.68	5.40	3.30	2.10
Kesla	Kasda Khurd	22.41	77.82	380	Siyari soil	7.20	2.80	7.20	0.75	5.80	5.53	0.27
Kesla	Amjhira	22.53	77.87	373	Black soil	8.12	3.86	4.64	1.05	3.90	6.90	-3.00
Kesla	Somalwara Khurd	22.61	77.82	342	Black soil	8.36	1.60	8.36	1.73	5.90	8.20	-2.30
Kesla	Bichhua	22.64	77.93	316	Siyari and Black soil	9.25	3.70	3.70	0.75	6.70	9.10	-2.40
Kesla	Sontalai	22.62	77.96	319	Black and Sugari soil	15.38	2.55	15.38	1.06	12.10	14.49	-2.39
Kesla	Kotha	22.62	77.97	321	Black Soil	15.95	2.50	15.95	0.70	7.60	12.10	-4.50
Kesla	Nandner	22.60	77.90	337	Siyari soil	16.10	3.60	16.10	0.40	11.00	9.70	1.30
Pipariya	Singa Nama	22.56	78.48	424	Vindhyan Sanstone	5.87	3.75	5.87	0.96	3.60	4.66	-1.06
Pipariya	Mohgaon	22.61	78.45	410		9.14	3.60	8.00	GL	5.30	8.00	-2.70
Pipariya	Dapka	22.66	78.34	355	-	5.52	3.70	5.00	0.92	4.25	4.63	-0.38
Pipariya	Anhoni	22.63	78.35	386		3.30	2.20	1.95	0.60	1.90	1.95	-0.05

Pipariya	Khursikhapa	22.64	78.32	396		8.50	2.70	6.40	0.50	8.50	6.40	2.10
Pipariya	Mohari Kalan	22.66	78.30	355		9.32	3.74	9.32	1.10	(9.55)Dry	Dry	
Pipariya	Kumhabar	22.72	78.30	341	Black soil	10.30	1.82	10.30	0.34	9.00	10.20	-1.20
Pipariya	Rechheda	22.70	78.38	353		10.70	2.45	10.70	0.51	10.10	10.50	-0.40
Pipariya	Samnapur	22.67	78.36	363		8.78	1.95	8.78	1.25	(9.50)Dry	Dry	
Pipariya	Semri Kishor	22.86	78.32	315	Alluvium, Black & Yellow soil	12.00	2.50	12.00	0.65	(11.50) Dry	Dry	
Pipariya	Rampur	22.77	78.40	344	Black soil	10.20	2.00	10.20	0.85	8.20	6.40	1.80
Seoni Malwa	ChautalaiPahadh	22.61	77.52	308	Alluvium,Black soil	15.74	2.3 square side	15.74	0.85	(15.90) Dry	Dry	
Seoni Malwa	Dhamasa	22.60	77.55	312	Alluvium,Siyari soil	13.68	1.72	13.68	0.65	10.90	16.50	-5.60
Seoni Malwa	Amupura	22.61	77.64	305	Alluvium,Black soil	25.60	1.10	25.60	0.40	8.40	20.63	-12.23
Seoni Malwa	Mohari	22.63	77.62	312	Alluvium, Siyari soil	11.00	3.20	11.00	0.85	10.90	Dry	
Seoni Malwa	Ratwada	22.56	77.60	316	Alluvium, Black soil	11.70	3.15	11.70	0.65	6.15	11.60	-5.45
Seoni Malwa	Khutwasa	22.53	77.59	313	Alluvium, Black soil	11.20	3.85	11.20	0.52	1.40	2.95	-1.55
Seoni Malwa	Bhaghwada	22.54	77.56	308	Alluvium (Yellow, Black, Siyari soil	7.36	0.93	7.36	0.40	5.30	Dry	
Seoni Malwa	Rajora Jat	22.52	77.52	308	Undulatory terrain, Black soil	10.55	0.90	10.55	GL	10.40	10.10	0.30

Seoni Malwa	Dharam Kundi	22.51	77.55	318	Alluvium, Black soil	9.20	3.30	9.20	0.40	2.90	7.20	-4.30
Seoni Malwa	Khapariya	22.57	77.48	302	Alluvium, Domat Soil	13.20	0.70	13.20	0.60	12.50	12.15	0.35
Seoni Malwa	Rehra	22.60	77.47	294	Alluvium, Black soil	8.10	2.20	8.10	1.40	7.70	7.98	-0.28
Seoni Malwa	Harpalpur	22.55	77.46	309	Alluvium, Black soil	20.00	4.16	20.00	0.47	5.60	8.30	-2.70
Seoni Malwa	Rampura	22.57	77.42	306	Alluvium, Black soil	10.10	2.56	10.10	0.90	5.45	8.76	-3.31
Seoni Malwa	Amaladadongar	22.59	77.43	293	Alluvium, Black soil	10.80	1.58	10.80	1.36	13.45	Dry	
Seoni Malwa	Sahaj kui	22.56	77.39	296	Alluvium, Black soil	13.60	2.38	13.60	0.82	10.20	9.95	0.25
Seoni Malwa	Guradiya	22.53	77.38	306	Alluvium, Black soil	9.70	1.21	9.70	0.59	4.60	5.64	-1.04
Seoni Malwa	Chhapara Grahan	22.51	77.36	306	Alluvium, Black soil	8.15	3.56	8.15	1.10	4.00	6.30	-2.30
Seoni Malwa	Shivpur	22.52	77.31	306	Alluvium, Black soil	10.29	2.75	10.29	0.80	5.00	4.80	0.20
Seoni Malwa	Jirahaber	22.44	77.36	306	Alluvium, Black soil	9.60	2.72	9.60	0.55	7.30	9.20	-1.90
Seoni Malwa	Bhairanpura	22.45	77.39	311	Black soil	21.21	3.20	21.21	GL	3.70	4.50	-0.80
Seoni Malwa	Bhadang Chikkli	22.49	77.62	331	Black soil	7.18	1.73	7.18	0.58	3.00	6.56	-3.56
Seoni Malwa	Keolajhir	22.46	77.65	357	Siyari soil	10.50	3.10	10.50	GL	9.30	9.30	0.00
Seoni Malwa	Malapat	22.45	77.59	330	Black Soil	8.95	5.00	8.95	0.94	5.40	7.80	-2.40
Seoni Malwa	Kharda	22.48	77.56	324	Black soil	7.20	2.35	7.20	0.44	4.30	6.70	-2.40

Seoni Malwa	Gajanpur	22.46	77.53	320	Black soil	9.80	2.00	9.80	0.90	1.60	4.70	-3.10
Seoni Malwa	Pipaliya	22.40	77.48	338	Black soil	10.00	2.52	10.00	0.24	5.90	9.20	-3.30
Seoni Malwa	Dhandiwada	22.37	77.48	335	Black and Red soil	10.90	2.80	10.90	GL	(11.20) Dry	Dry	
Seoni Malwa	Begania	22.38	77.47	326	Black Soil	12.65	2.00	12.65	1.00	12.40	Dry	
Seoni Malwa	Berakhedi	22.42	77.49	316	Alluvium, Black soil	6.85	1.23	6.85	0.50	1.65	6.20	-4.55
Seoni Malwa	Banapura	22.46	77.48	320	Alluvium, Black soil	12.20	1.22	12.20	0.82	9.00	Dry	
Seoni Malwa	Nipaniya	22.46	77.42	314	Alluvium, Black soil	15.70	2.60	15.70	1.40	5.60	3.60	2.00
Seoni Malwa	Bharlay	22.43	77.42	323	Alluvium, Black soil	14.70	3.00	14.70	0.70	13.30	12.80	0.50
Seoni Malwa	Basaniya Kalan	22.39	77.40	318	Black soil	7.53	3.43	7.53	1.46	7.60	Dry	
Seoni Malwa	Jhinganpur	22.38	77.40	334	Black and Yellow Soil	16.20	1.88	6.20	GL	16.20	15.90	0.30
Seoni Malwa	Faridpur	22.39	77.37	324	Black Soil	9.40	4.00	7.30	0.73	8.60	8.90	-0.30
Seoni Malwa	Soorajpur	22.37	77.44	343	Black soil	18.20	2.90	18.20	0.47	20.00	17.10	2.90
Seoni Malwa	Kahariya	22.49	77.52	313	Black soil	8.00	0.80	8.00	GL	8.00	Dry	
Seoni Malwa	Nayagaon	22.56	77.70	326	Black soil	7.00	3.60	7.00	0.46	2.90	3.50	-0.60
Shohagapur	Bamari	22.73	78.24	327	Alluvium, Black soil	8.70	2.73	8.70	0.42	8.4	Dry	
Shohagpur	Ghurkheri	22.75	78.17	336	Alluvium	28.40	4.00	16.00	0.51	7.70	16.30	-8.60

Shohagpur	Gori gaon	22.82	78.17	322	Alluvium	9.40	3.20	9.40	1.27	(9.15)Dry	Dry	
Shohagpur	Bhiladiya	22.80	78.20	328	Alluvium	10.80	3.00	10.80	0.79	(10.70) Dry	Dry	
Shohagpur	Bamori Khurd	22.69	78.17		Alluvium, Black soil	11.10	2.40	11.10	BGL	6.95	6.75	0.20
Shohagpur	Nibhora	22.66	78.16		Alluvium	6.12	2.32	6.12	0.42	4.15	Dry	
Shohagpur	Pathrai	22.67	78.19	335	Alluvium, Black soil	9.95	2.55	9.95	1.10	Dry	Dry	
Shohagpur	Kamti	22.61	78.16	380	Alluvium, Black soil	14.50	2.04	14.50	1.6	10.50	14.20	-3.70
Shohagpur	Sarangpur (Madai)	22.58	78.15	361	Black soil	15.10	1.82	15.10	0.83	7.70	8.36	-0.66
Shohagpur	Teka Par	22.59	78.16	370	Alluvium, Black & Red soil	10.30	2.80	10.30	0.35 BGL	9.15	8.10	1.05
Shohagpur	Nayagaon	22.68	78.19	345	Alluvium, Black & Red soil	14.00	2.10	14.00	0.50	13.5	Dry	
Shohagpur	Karanpur	22.72	78.22	341	Alluvium, Black soil	11.00	3.00	11.00	0.99	6.00	7.83	-1.83
Shohagpur	Shobhapur	22.77	78.28	304	Alluvium, Black soil	9.05	1.64	9.05	0.70	8.80	8.80	0.00
Shohagpur	Sohagpur	22.70	78.19	339	Black soil	8.30	2.68	8.30	1.3	(8.20)Dry	Dry	
Shohagpur	Shobhapur	22.77	78.26	331	Alluvium	8.60	1.88	8.60	0.73	(8.55)Dry	Dry	

Block	Location	Lat	Long	Altitude (m)	Geology	Depth of well (m)	Diameter (m)	Casing Length (m)	MP (m)	SWL July-18 mbgl	SWL Feb-19mbgl	WL Fluctuations
Babai	Bajjarwada	22.73	77.91	317	Alluvium, Black and Siyari soil	13.60	1.90	13.60	0.74	(12.40)Dry	Dry	
Babai	SangaKheda Kala	22.79	77.81	306	Alluvium, Balck and Siyari soil	9.60	4.00	9.60	1.68	9.55	Dry	
Babai	Khargawali	22.79	77.94	300	Alluvium, Black and Siyari soil	9.60	4.00	9.60	1.68	(9.20)Dry	Dry	
Babai	Khidiya	22.74	77.96	314	Alluvium, black soil	15.35	3.50	15.35	0.38	15.50	Dry	
Babai	Maragaon	22.80	78.02	321	Aluvium, black soil	16.30	3.00	16.30	1.50	(15.50)Dry	Dry	
Babai	Satwasa	22.79	78.09	327	Alluvium, black & yellow soil	16.10	2.90	16.10	1	(15.80)Dry	Dry	
Babai	Baharpur	22.73	78.07	332	Alluvium, Black soil	10.00	2.50	10.00	0.80	6.15	9.00	-2.85
Babai	Anchal Kheda	22.71	77.87	319	Black soil	8.80	1.55	8.80	0.91	8.25	7.38	0.87
Babai	Guradiya	22.69	78.04	325	Black, red, yellow soil	12.00	2.60	12.00	0.8	5.05	3.25	1.80
Babni	Ari	22.76	77.88	324	Alluvium, Black and Siyari soil	11.50	3.10	11.50	0.50	(10.70)Dry	Dry	
Bankhedi	Bankhedi	22.77	78.54	364	Alluvium, black, red soil	12.70	6.00	12.70	1.10	(13.30)Dry	Dry	
Bankhedi	Nagwada	22.78	78.59	361	Alluvium, black and red soil	11.80	2.00	11.80	0.94	(11.30)Dry	Dry	
Hoshangabad	Gwaltoli	22.75	77.71	309	Alluvium	17.63	2.66	17.63	0.88	(18.60)Dry	Dry	
Hoshangabad	Palasi	22.69	77.73	307	Alluvium	9.84	3.00	9.84	1.25	9.70	Dry	
Hoshangabad	Rohna	22.68	77.70	305	Alluvium	9.60	3.05	9.60	1.20	7.30	9.46	-2.16
Hoshangabad	Talnagri	22.71	77.62	311	Alluvium, Yellow soil	25.20	1.20	25.20	0.60	19.30	19.20	0.10

Hoshangabad	Randhal	22.74	77.64	308	Alluvium	24.90	1.30	24.90	0.34	18.00	18.40	-0.40
Hoshangabad	Misrod	22.62	77.57	296	Alluvium	10.45	3.00	10.45	0.65	(10.50)Dry	Dry	#VALUE!
Hoshangabad	Bortalai	22.62	77.74	320	Alluvium,Black soil	8.10	1.82	8.10	0.50	Filled Up	Dry	
Hoshangabad	Suparli	22.61	77.67	321	Alluvium,Black soil	8.73	0.90	8.73	0.65	(8.90)Dry	Dry	
Hoshangabad	Bamhori Khurd	22.63	77.69	314	Alluvium	4.50	1.25	4.50	0.74	4.35	4.18	0.17
Hoshangabad	Dodugaon	22.61	77.60	311	Alluvium, Black soil	9.13	2.00	9.13	0.80	8.10	8.80	-0.70
Hoshangabad	Chandon	22.63	77.86	326	Black and Siyari soil	8.70	2.74	8.70	1.10	7.10	Dry	
Hoshangabad	Rampur	22.64	77.89	326	Black Soil	10.60	2.60	10.60	0.54	7.50	10.40	-2.90
Hoshangabad	Pathodi	22.71	77.76	308	Alluvium, Black and Siyari soil	6.60	1.24	6.60	0.66	5.50	Dry	
Hoshangabad	Jasalpur	22.73	77.78	306	Alluvium, Black soil	6.80	2.15 side	6.80	0.55	6.15	Dry	
Hoshangabad	Dhonkheda	22.65	77.78	312	Black soil	10.30	3.90	10.30	0.87	8.7	Dry	
Itarsi	Itarsi	22.63	77.78	329	Black soil	26.00	2.90	26.00	0.62	12.60	12.20	0.40
Kesala	Semri khurd	22.58	77.65	320	Alluvium, Black soil	19.50	2.86	19.50	0.50	8.40	11.44	-3.04
Kesala	Bandri	22.49	77.64	340	Siyari soil	9.00	2.96	9.00	0.48	(8.80)Dry	dry	
Kesala	Bhatti	22.58	77.72	332	Black soil	15.70	3.55	15.70	1.60	4.50	3.35	1.15
Kesala	Dehri	22.59	77.76	338	Alluvium, Black soil	9.50	2.28	9.50	0.90	8.45	8.03	0.42
Kesala	Jhujhalpur	22.58	77.76	332	Black soil	9.42	1.70	9.42	0.44	(9.40)Dry	9.05	
Kesala	Jamai Kalan	22.56	77.83	363	Black soil	13.45	2.03	13.45	0.60	(10.70)Dry	Dry	
Kesala	Mohla	22.56	77.84	362	Balck and Siyari soil	10.45	2.35	10.45	0.55	(10.30)Dry	Dry	
Kesala	Tawanagar	22.57	77.96	369	Muram Soil	19.60	3.80	19.60	0.68	5.35	2.80	2.55

Kesala	Saheli	22.45	77.83	377		12.35	4.92	12.35	0.34	4.80	5.20	-0.40
Kesala	Khakrapura	22.43	77.85	386	Black Soil	16.45	3.23	16.45	0.68	13.50	12.40	1.10
Kesala	Pathrota	22.57	77.80	356	Black Soil	7.50	2.00	7.50	0.90	(7.40)Dry	Dry	
Kesala	Nagpur Kalan	22.58	77.83	346	Siyari soil	13.20	2.82	13.20	0.95	14.00	Dry	
Kesala	Dhansai	22.50	77.84	377	Black soil	9.20	3.15	9.20	0.95	7.80	7.45	0.35
Kesala	Jalikheda	22.51	77.84	387	Siyari Soil	9.54	3.60	9.54	0.95	5.20	6.40	-1.20
Kesala	Morpani	22.48	77.87	360	Basalt,Siyari Soil	10.30	2.45	10.30	1.26	7.30	8.20	-0.90
Kesala	Madiko	22.47	77.91	371	Basalt,Black, Red Soil	10.20	5.60	3.80	0.94	6.00	8.10	-2.10
Kesala	Takku	22.49	77.82	403	Basalt,Black and Red soil mix	7.65	2.10	7.65	0.60	5.45	6.80	-1.35
Kesala	Bhargada	22.40	77.87	359	Basalt, Black soil	6.47	1.80	6.47	0.26	3.80	2.90	0.90
Kesala	Komati Raiyat	22.39	77.89	368	Basalt, Black and Siyari soil	17.00	2.60	17.00	1.00	15.70	8.50	7.20
Kesala	Kala Akhar	22.40	77.82	373	Basalt, Black and Siyari soil	9.94	2.50	9.94	1.34	9.40	9.50	-0.10
Kesla	Rasalpatta	22.41	77.86	361	Basalt, Reddish soil	7.70	2.50	7.70	0.68	5.40	3.30	2.10
Kesla	Kasda Khurd	22.41	77.82	380	Siyari soil	7.20	2.80	7.20	0.75	5.80	5.53	0.27
Kesla	Amjhira	22.53	77.87	373	Black soil	8.12	3.86	4.64	1.05	3.90	6.90	-3.00
Kesla	Somalwara Khurd	22.61	77.82	342	Black soil	8.36	1.60	8.36	1.73	5.90	8.20	-2.30
Kesla	Bichhua	22.64	77.93	316	Siyari and Black soil	9.25	3.70	3.70	0.75	6.70	9.10	-2.40
Kesla	Sontalai	22.62	77.96	319	Black and Sugari soil	15.38	2.55	15.38	1.06	12.10	14.49	-2.39
Kesla	Kotha	22.62	77.97	321	Black Soil	15.95	2.50	15.95	0.70	7.60	12.10	-4.50
Kesla	Nandner	22.60	77.90	337	Siyari soil	16.10	3.60	16.10	0.40	11.00	9.70	1.30

Pipariya	Singa Nama	22.56	78.48	424	Vindhyan Sanstone	5.87	3.75	5.87	0.96	3.60	4.66	-1.06
Pipariya	Mohgaon	22.61	78.45	410		9.14	3.60	8.00	GL	5.30	8.00	-2.70
Pipariya	Dapka	22.66	78.34	355	-	5.52	3.70	5.00	0.92	4.25	4.63	-0.38
Pipariya	Anhoni	22.63	78.35	386		3.30	2.20	1.95	0.60	1.90	1.95	-0.05
Pipariya	Khursikhapa	22.64	78.32	396		8.50	2.70	6.40	0.50	8.50	6.40	2.10
Pipariya	Mohari Kalan	22.66	78.30	355		9.32	3.74	9.32	1.10	(9.55)Dry	Dry	
Pipariya	Kumhabar	22.72	78.30	341	Black soil	10.30	1.82	10.30	0.34	9.00	10.20	-1.20
Pipariya	Rechheda	22.70	78.38	353		10.70	2.45	10.70	0.51	10.10	10.50	-0.40
Pipariya	Samnapur	22.67	78.36	363		8.78	1.95	8.78	1.25	(9.50)Dry	Dry	
Pipariya	Semri Kishor	22.86	78.32	315	Alluvium, Black & Yellow soil	12.00	2.50	12.00	0.65	(11.50)Dry	Dry	
Pipariya	Rampur	22.77	78.40	344	Black soil	10.20	2.00	10.20	0.85	8.20	6.40	1.80
Seoni Malwa	ChautalaiPahadh	22.61	77.52	308	Alluvium,Black soil	15.74	2.3 square side	15.74	0.85	(15.90)Dry	Dry	
Seoni Malwa	Dhamasa	22.60	77.55	312	Alluvium,Siyari soil	13.68	1.72	13.68	0.65	10.90	16.50	-5.60
Seoni Malwa	Amupura	22.61	77.64	305	Alluvium,Black soil	25.60	1.10	25.60	0.40	8.40	20.63	-12.23
Seoni Malwa	Mohari	22.63	77.62	312	Alluvium, Siyari soil	11.00	3.20	11.00	0.85	10.90	Dry	
Seoni Malwa	Ratwada	22.56	77.60	316	Alluvium, Black soil	11.70	3.15	11.70	0.65	6.15	11.60	-5.45
Seoni Malwa	Khutwasa	22.53	77.59	313	Alluvium, Black soil	11.20	3.85	11.20	0.52	1.40	2.95	-1.55
Seoni Malwa	Bhaghwada	22.54	77.56	308	Alluvium (Yellow, Black, Siyari soil	7.36	0.93	7.36	0.40	5.30	Dry	

Seoni Malwa	Rajora Jat	22.52	77.52	308	Undulatory terrain, Black soil	10.55	0.90	10.55	GL	10.40	10.10	0.30
Seoni Malwa	Dharam Kundi	22.51	77.55	318	Alluvium, Black soil	9.20	3.30	9.20	0.40	2.90	7.20	-4.30
Seoni Malwa	Khapariya	22.57	77.48	302	Alluvium, Domat Soil	13.20	0.70	13.20	0.60	12.50	12.15	0.35
Seoni Malwa	Rehra	22.60	77.47	294	Alluvium, Black soil	8.10	2.20	8.10	1.40	7.70	7.98	-0.28
Seoni Malwa	Harpalpur	22.55	77.46	309	Alluvium, Black soil	20.00	4.16	20.00	0.47	5.60	8.30	-2.70
Seoni Malwa	Rampura	22.57	77.42	306	Alluvium, Black soil	10.10	2.56	10.10	0.90	5.45	8.76	-3.31
Seoni Malwa	Amaladadongar	22.59	77.43	293	Alluvium, Black soil	10.80	1.58	10.80	1.36	13.45	Dry	
Seoni Malwa	Sahaj kui	22.56	77.39	296	Alluvium, Black soil	13.60	2.38	13.60	0.82	10.20	9.95	0.25
Seoni Malwa	Guradiya	22.53	77.38	306	Alluvium, Black soil	9.70	1.21	9.70	0.59	4.60	5.64	-1.04
Seoni Malwa	Chhapara Grahan	22.51	77.36	306	Alluvium, Black soil	8.15	3.56	8.15	1.10	4.00	6.30	-2.30
Seoni Malwa	Shivpur	22.52	77.31	306	Alluvium, Black soil	10.29	2.75	10.29	0.80	5.00	4.80	0.20
Seoni Malwa	Jirahaber	22.44	77.36	306	Alluvium, Black soil	9.60	2.72	9.60	0.55	7.30	9.20	-1.90
Seoni Malwa	Bhairanpura	22.45	77.39	311	Black soil	21.21	3.20	21.21	GL	3.70	4.50	-0.80
Seoni Malwa	Bhadang Chikkli	22.49	77.62	331	Black soil	7.18	1.73	7.18	0.58	3.00	6.56	-3.56
Seoni Malwa	Keolajhir	22.46	77.65	357	Siyari soil	10.50	3.10	10.50	GL	9.30	9.30	0.00
Seoni Malwa	Malapat	22.45	77.59	330	Black Soil	8.95	5.00	8.95	0.94	5.40	7.80	-2.40
Seoni Malwa	Kharda	22.48	77.56	324	Black soil	7.20	2.35	7.20	0.44	4.30	6.70	-2.40
Seoni Malwa	Gajanpur	22.46	77.53	320	Black soil	9.80	2.00	9.80	0.90	1.60	4.70	-3.10

Seoni Malwa	Pipaliya	22.40	77.48	338	Black soil	10.00	2.52	10.00	0.24	5.90	9.20	-3.30
Seoni Malwa	Dhandiwada	22.37	77.48	335	Black and Red soil	10.90	2.80	10.90	GL	(11.20)Dry	Dry	
Seoni Malwa	Begania	22.38	77.47	326	Black Soil	12.65	2.00	12.65	1.00	12.40	Dry	
Seoni Malwa	Berakhedi	22.42	77.49	316	Alluvium, Black soil	6.85	1.23	6.85	0.50	1.65	6.20	-4.55
Seoni Malwa	Banapura	22.46	77.48	320	Alluvium, Black soil	12.20	1.22	12.20	0.82	9.00	Dry	
Seoni Malwa	Nipaniya	22.46	77.42	314	Alluvium, Black soil	15.70	2.60	15.70	1.40	5.60	3.60	2.00
Seoni Malwa	Bharlay	22.43	77.42	323	Alluvium, Black soil	14.70	3.00	14.70	0.70	13.30	12.80	0.50
Seoni Malwa	Basaniya Kalan	22.39	77.40	318	Black soil	7.53	3.43	7.53	1.46	7.60	Dry	
Seoni Malwa	Jhinganpur	22.38	77.40	334	Black and Yellow Soil	16.20	1.88	6.20	GL	16.20	15.90	0.30
Seoni Malwa	Faridpur	22.39	77.37	324	Black Soil	9.40	4.00	7.30	0.73	8.60	8.90	-0.30
Seoni Malwa	Soorajpur	22.37	77.44	343	Black soil	18.20	2.90	18.20	0.47	20.00	17.10	2.90
Seoni Malwa	Kahariya	22.49	77.52	313	Black soil	8.00	0.80	8.00	GL	8.00	Dry	
Seoni Malwa	Nayagaon	22.56	77.70	326	Black soil	7.00	3.60	7.00	0.46	2.90	3.50	-0.60
Shohagapur	Bamari	22.73	78.24	327	Alluvium, Black soil	8.70	2.73	8.70	0.42	8.4	Dry	
Shohagpur	Ghurkheri	22.75	78.17	336	Alluvium	28.40	4.00	16.00	0.51	7.70	16.30	-8.60
Shohagpur	Gori gaon	22.82	78.17	322	Alluvium	9.40	3.20	9.40	1.27	(9.15)Dry	Dry	
Shohagpur	Bhiladiya	22.80	78.20	328	Alluvium	10.80	3.00	10.80	0.79	(10.70)Dry	Dry	
Shohagpur	Bamori Khurd	22.69	78.17		Alluvium, Black soil	11.10	2.40	11.10	BGL	6.95	6.75	0.20
Shohagpur	Nibhora	22.66	78.16		Alluvium	6.12	2.32	6.12	0.42	4.15	Dry	
Shohagpur	Pathrai	22.67	78.19	335	Alluvium, Black soil	9.95	2.55	9.95	1.10	Dry	Dry	

Shohagpur	Kamti	22.61	78.16	380	Alluvium, Black soil	14.50	2.04	14.50	1.6	10.50	14.20	-3.70
Shohagpur	Sarangpur (Madai)	22.58	78.15	361	Black soil	15.10	1.82	15.10	0.83	7.70	8.36	-0.66
Shohagpur	Teka Par	22.59	78.16	370	Alluvium, Black & Red soil	10.30	2.80	10.30	0.35 BGL	9.15	8.10	1.05
Shohagpur	Nayagaon	22.68	78.19	345	Alluvium, Black & Red soil	14.00	2.10	14.00	0.50	13.5	Dry	
Shohagpur	Karanpur	22.72	78.22	341	Alluvium, Black soil	11.00	3.00	11.00	0.99	6.00	7.83	-1.83
Shohagpur	Shobhapur	22.77	78.28	304	Alluvium, Black soil	9.05	1.64	9.05	0.70	8.80	8.80	0.00
Shohagpur	Sohagpur	22.70	78.19	339	Black soil	8.30	2.68	8.30	1.3	(8.20)Dry	Dry	