केन्द्रीय भूमि जल बोर्ड

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विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

Balaghat District
Madhya Pradesh

उत्तर मध्य क्षेत्र, भोपाल

North Central Region, Bhopal

Central Ground Water Board

Department of Water Resources, River Development & Ganga Rejuvenation
Ministry of Jal Shakti
Government of India

Aquifer Mapping and Ground Water Management Plan of Balaghat District, Madhya Pradesh

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NORTH CENTRAL REGION
BHOPAL
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PREFACE

Aquifer mapping is as a multi-disciplinary scientific process, wherein a combination of geological, geophysical, hydrogeological and geochemical studies is applied to characterize the quantity, quality and sustainability of ground water. Systematic aquifer mapping is a procedure to improve our understanding of the hydrogeological framework of aquifer system.

Under the project on National Aquifer Mapping (NAQUIM) in XII & XIII Plan to formulate sustainable aquifer management plan, Central Ground Water Board (CGWB), North Central Region, Bhopal has taken up Balaghat district to prepare the 3-Dimensional Model and 2-Dimensional Aquifer Maps for the entire district and formulate Block-wise Aquifer Management Plan.

Balaghat district occupies an area of 9229 sq. km out of which the ground water recharge worthy area is 8918 sq. km. and the rest is covered by hilly and forest area. The major rivers flowing through the area includes the river Wein Ganga River and its tributaries Bagh, Banjar, Shisire, Sod and Tumnar. The major part of the district is covered by the by Archean granite gneisses/schist. As per the Dynamic Ground Water Resource Assessment Report (2020), the net ground water availability in the district 780 MCM and ground water draft for all uses is 161 MCM, resulting the stage of ground water development to be 21 % as a whole for district. The Balaghat district falls under safe category. After the implemented of project interventions in the report, the stage of development is expected to improve by 38 % i.e. from 21% to 59% for the Balaghat district.

Balaghat district comprises of ten blocks namely Baihar, Balaghat, Birsa, Katangi, Khairlanji, Kirnapur, Lanji, Lalburra, Paraswada and Waraseoni. Based on the available data and the earlier hydrogeological studies taken up in the district, an attempt has been made in this report to compile all relevant information, such as hydrogeological, agriculture, irrigation, land use, rain fall, chemical quality of water and other collateral data.

Before finalization of this report a three tier evaluation mechanism is adopted presentations were made at Regional level & State level Coordination Committee ,then the revised presentation were made before the Member and finally it was presented to National Level Expert Committee , after all corrections this report is prepared. 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 of the untiring efforts of **Mr Sumanta Kumar Mohanta**, Scientist-B for preparing the Aquifer maps and Management plan and compiling this informative report. I fondly hope that this report will serve as a valuable guide for sustainable development of Ground Water in the Balaghat district, Madhya Pradesh.

(**Rana Chatterjee**)
Regional Director

PART-I: DISTRICT WISE TECHNICAL REPORT

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CHAPTER-1

I. INTRODUCTION

National project on Aquifer Mapping (NAQUIM) had been taken up by CGWB to carry out detailed hydrogeological investigation on Toposheet scale of 1:50,000. Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical analyses is applied to characterize the quantity, quality and sustainability of ground water in aquifers.

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

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

1.1 Objective and Scope

Aquifer mapping includes ground water conservation, harvesting and protocols of managing groundwater. The activities under NAQUIM are aimed at:

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

This clear demarcation of aquifers and their potential will help the agencies involved in water supply in ascertaining, how much volume of water is under their control. The robust and implementable ground water management plan will provide a road map to systematically manage the ground water resources for equitable distribution across the spectrum.

The NAQUIM report explains the aquifer geometry, type of aquifers, ground water regime behaviors, hydraulic characteristics and geochemistry of Multi-layered aquifer systems on 1:50,000 scale. The data generation will require sincere effort in organizing the field work by involving central, state agencies and creation of aquifer unit wise resource centre with local community participation in data collection and implementation of the aquifer management plan.

1.2 Approach and Methodology

National Aquifer Mapping Programme basically aims at characterizing the geometry, parameters, behavior of ground water levels and status of ground water development in various aquifer systems to facilitate Major Aquifers planning of their sustainable management. The major activities involved in this process include compilation of existing data, identification of data gaps and generation of data for filling data gaps and preparation of aquifer maps. The overall methodology of aquifer mapping is presented once the maps are prepared, plans for sustainable management of ground water resources in the aquifers mapped shall be formulated and implemented through participatory approach involving all stakeholders. It is worthwhile to mention upfront, that aquifer mapping is not simply creation of aquifer maps. It is a process for visioning how India's groundwater resources will be managed not just in the next 5-10 years, but for the next 50 years, primarily through the active participation of its citizens. Aquifer mapping will lead to strategic plans for ensuring sustainable, equitable and efficient use of India's groundwater resources for many years to come. The action plan adopted for Aquifer mapping is given in the fig 1.1 as below.

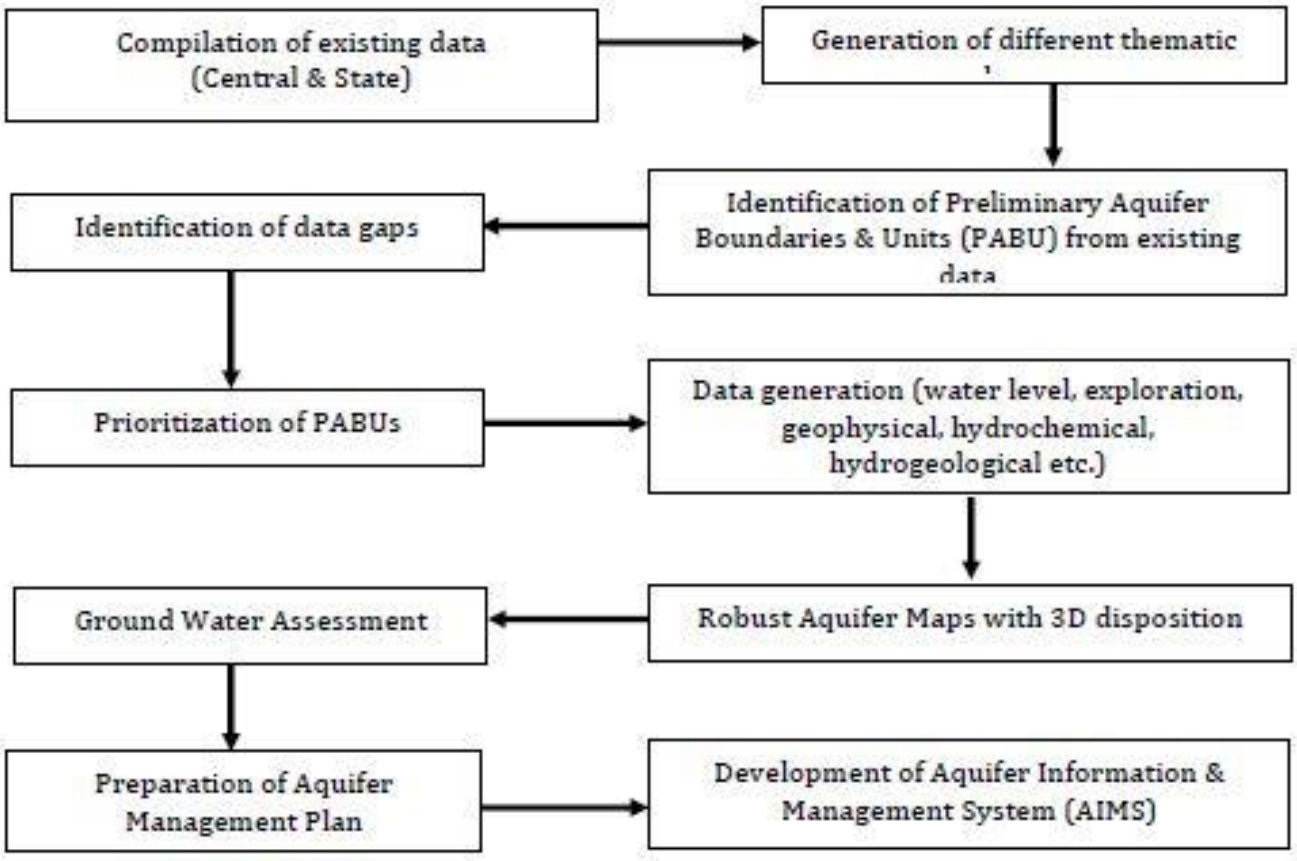


Figure –1.1: Approach and Methodology

1.3 Study area

The Balaghat District lies in the Southern part of Madhya Pradesh state are located in the southern part of Jabalpur division. It occupies the south eastern portion of the satpura range and the upper valley of the Wainganga River. The district extends from 21º19' to 22º24' north latitudes and 79º31' to 81º3' east longitude falling in Survey of India Toposheet number **64B, C, 55N** and **55O**. The total area of the district is 9245 Sq Km. Balaghat district is bounded by Mandla district of Madhya Pradesh to north, Dindori district to the north west, Rajnathgaon district of Chhattisgarh State to east, Gondiya and Bhandara district of Maharastra State to the south, and Seoni district of Madhya Pradesh to the west. The index map demarcating the study area is shown in the **figure-1.2.**

Balaghat consists of ten developmental blocks (Fig-1.3): Balaghat, Lalbarra, Waraseoni, Katangi, Khairlanji, Lanji, Kirnapur, Baihar, Birsa and Paraswada. Tehsil in the district is eleven i.e. Balaghat, Lalbarra, Waraseoni, Katangi, Tirodi, Khairlanji, Lanji, Kirnapur, Baihar,Birsa and Paraswada.

The district has a total population of 1701698 out of which the Schedule casts comprise 130220 (7.65%), Schedule Tribes 349463 (20.53%), other backward and general castes 1183048. According to census 2011 of the total population, there are 842178 males and 859520 females, Sex ratio - 1000:1021, which is highest in MP.

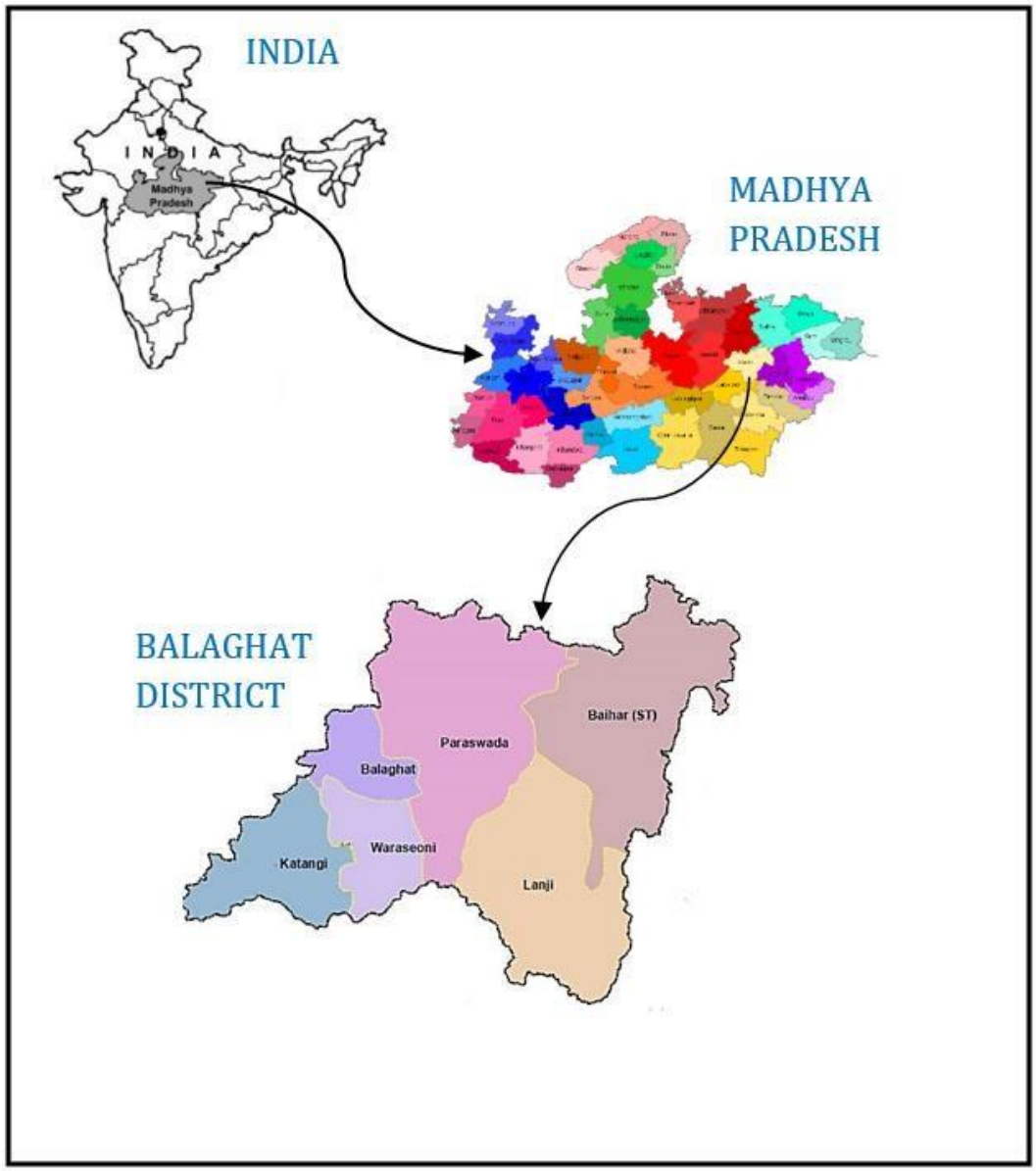


Fig 1.2: Index Map of Balaghat, MP

1.4 Administrative Setup: The District is divided into 10 Tehsils and 10 Blocks. The block wise geographical area of the district is shown in the table-1.1

Table-1.1: Administrative setup of Balaghat district, MP

S. No.	Blocks	Area Sq. Km
1	Baihar	1291.6
2	Balaghat	1222.19
3	Birsa	1415.43
4	Katangi	697.79
5	Khairlanji	487.88
6	Kirnapur	810.4
7	Lalburra	715.92
8	Lanji	871.26
9	Paraswada	1240.5
10	Waraseoni	476.03

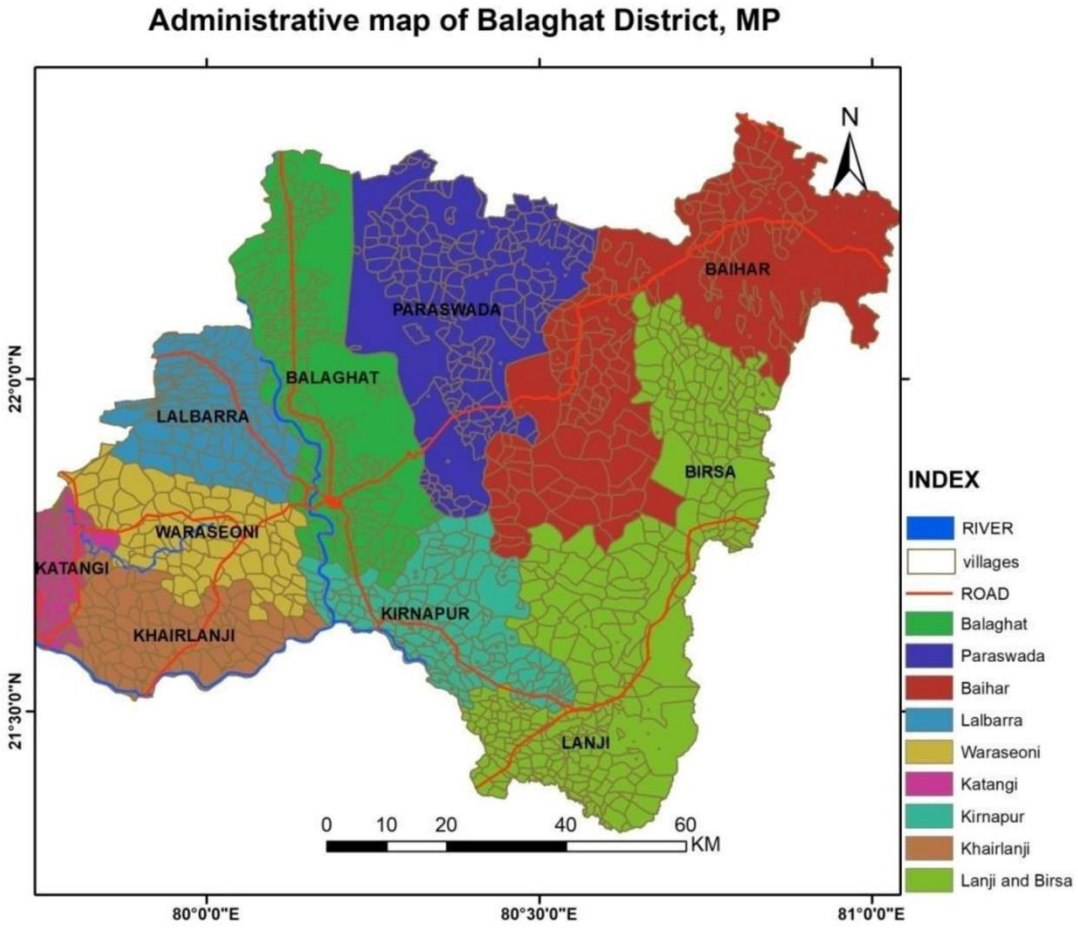


Fig1.3: Administrative Map of Balaghat, MP

1.5 Demography

As per 2011 census, the district has a total population of 3055925 (Table-1.2), out of which the Schedule casts comprise 124693 (4.08%), Schedule Tribes 300689(9.83%), other backward and general castes 1084763. According to census 2011 of the total population, there are 842178 males and 859520 females.

Table-1.2: Block wise Population Detail of Balaghat District, MP

S. No.	Blocks	Male	Female	SC	ST	GEN/OBC	TOTAL
1	Baihar	140250	144102	8570	158506	117276	284352
2	Balaghat	133692	135660	22609	38967	207776	221233
3	Birsa	63228	65206	3043	70765	54626	363990
4	Katangi	89980	92015	24214	31215	126566	294416
5	Khairlanji	72616	74592	13887	10936	122385	351780
6	Kirnapur	87123	88767	14103	13795	147992	341920
7	Lalburra	84860	86100	11559	23323	136078	375248
8	Lanji	93283	94341	11598	35133	140893	216052
9	Paraswada	53067	54959	4163	56491	47372	352582
10	Waraseoni	87307	88984	19517	20064	136710	538704

1.6 Climate and Rainfall

The Climate of Balaghat District is sub- tropical characterized by a hot summer and general dryness except during the southwest 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. October and November form the post monsoon or transition period.

The normal annual rainfall of Balaghat district is 1168.12 mm (Table-1.3). Balaghat District received maximum rainfall during southwest monsoon period i.e. June to September. Thus, surplus water for ground water recharge is available only during the southwest monsoon period.

The normal maximum temperature recorded during the month of May is 43^0C and minimum during the month of December is 8^0C. The normal annual means maximum and minimum temperatures of Balaghat district are 32^0C & 8^0C respectively. The rainfall comparison of the district is shown in the figure-1.4.

During the southwest monsoon season the relative humidity ranges between 70-75%. In the rest of the year it is drier. The driest part of the year is the summer season, when relative humidity is less 34%. May is the driest month of the year.

The wind velocity is higher during the pre-monsoon period as compared to post monsoon period. The maximum wind velocity 7.7 km/hr observed during the month of June and minimum 3.9 km/hr during the month of December.

Table-1.3: Annual Rainfall Data - 2016-2020(mm)

Year	Jan Rainfall (mm)	Feb Rainfall (mm)	Mar Rainfall (mm)	Apr Rainfall (mm)	May Rainfall (mm)	Jun Rainfall (mm)	Jul Rainfall (mm)	Aug Rainfall (mm)	Sept Rainfall (mm)	Oct Rainfall (mm)	Nov Rainfall (mm)	Dec Rainfall (mm)
2016	3.7	3.8	12.3	0.2	3.4	74.1	380.7	347	170.3	15.8	0	0
2017	7.7	2.8	0.9	0	7.3	105.8	290.4	263.6	187.5	49.4	0	0
2018	0	23.3	0.1	9.6	2	142.8	407.9	330.7	101.4	5.2	0	16.3
2019	28.6	18	17.9	0.4	0	35.1	353.6	447.1	448.4	20.4	1.5	7.3
2020	102.7	27.2	60.1	7.1	11.4	168	238.2	661.2	130.1	77.1	12.2	1

(Source: Indian Meteorological Department)

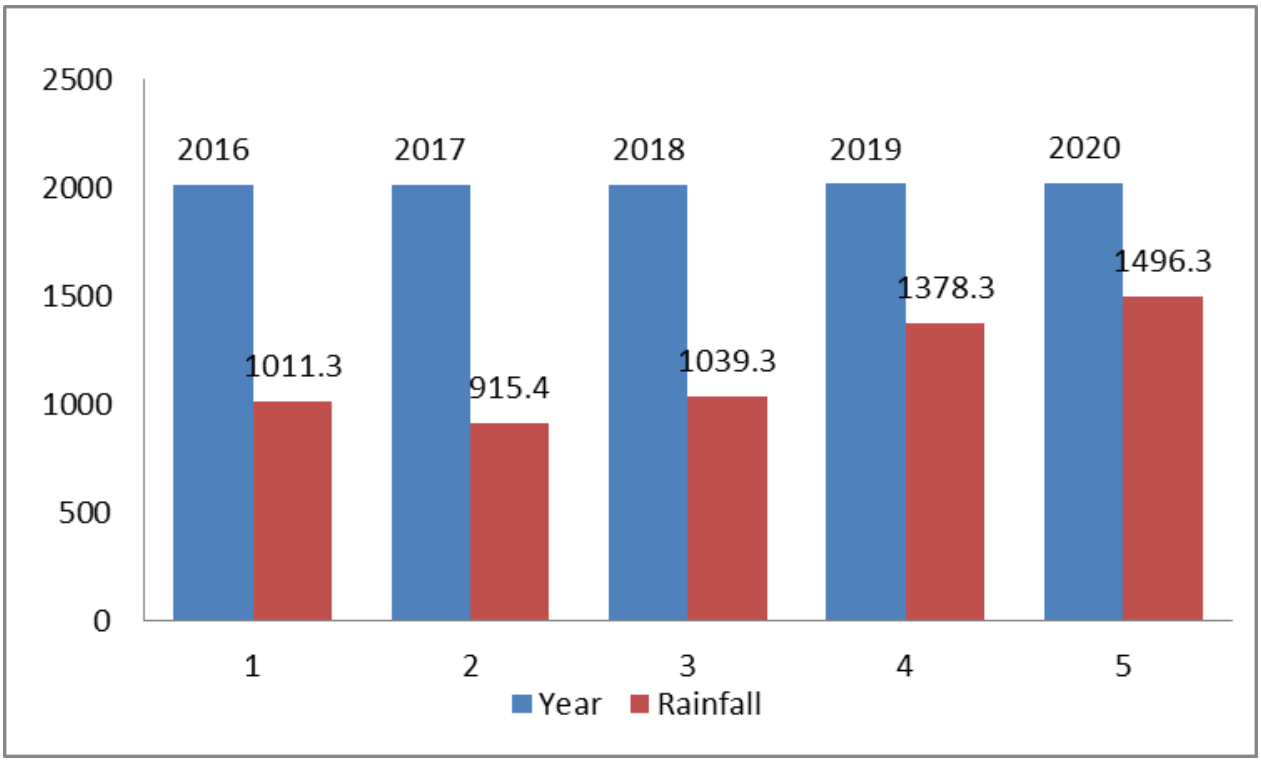


Fig-1.4: Rainfall comparison (2016-2020)

1.7 Physiography

The District of Balaghat is having unique physiographic setup. The district comprises of alluvial plains, intermontane valleys, denudational hills, Pedi plains & pediment structural hills (Fig-1.5). WainGanga, Bagh, Banjar, Shisire, Sod, tumnar along with their tributaries form Wain Ganga & Narmada river basins. The pattern of drainage on the whole is dendritic.

The Geomorphological map explains the geo-environment, geo-engineering, geohazards, mineral and ground water exploration and also interdisciplinary themes like soil, land use / land cover and forest, etc. Geomorphology plays an important role in various fields of planning. One of the major themes is the irrigation development wherein the geomorphological guides are used as one of the indicator zone for site selection. The understanding of subsurface geology is a primary requirement for planning exploration and exploitation strategies. The basement structure highs manifest itself on the surface as geomorphic anomaly like annular drainage pattern, radial pattern, sudden change in the river course etc.

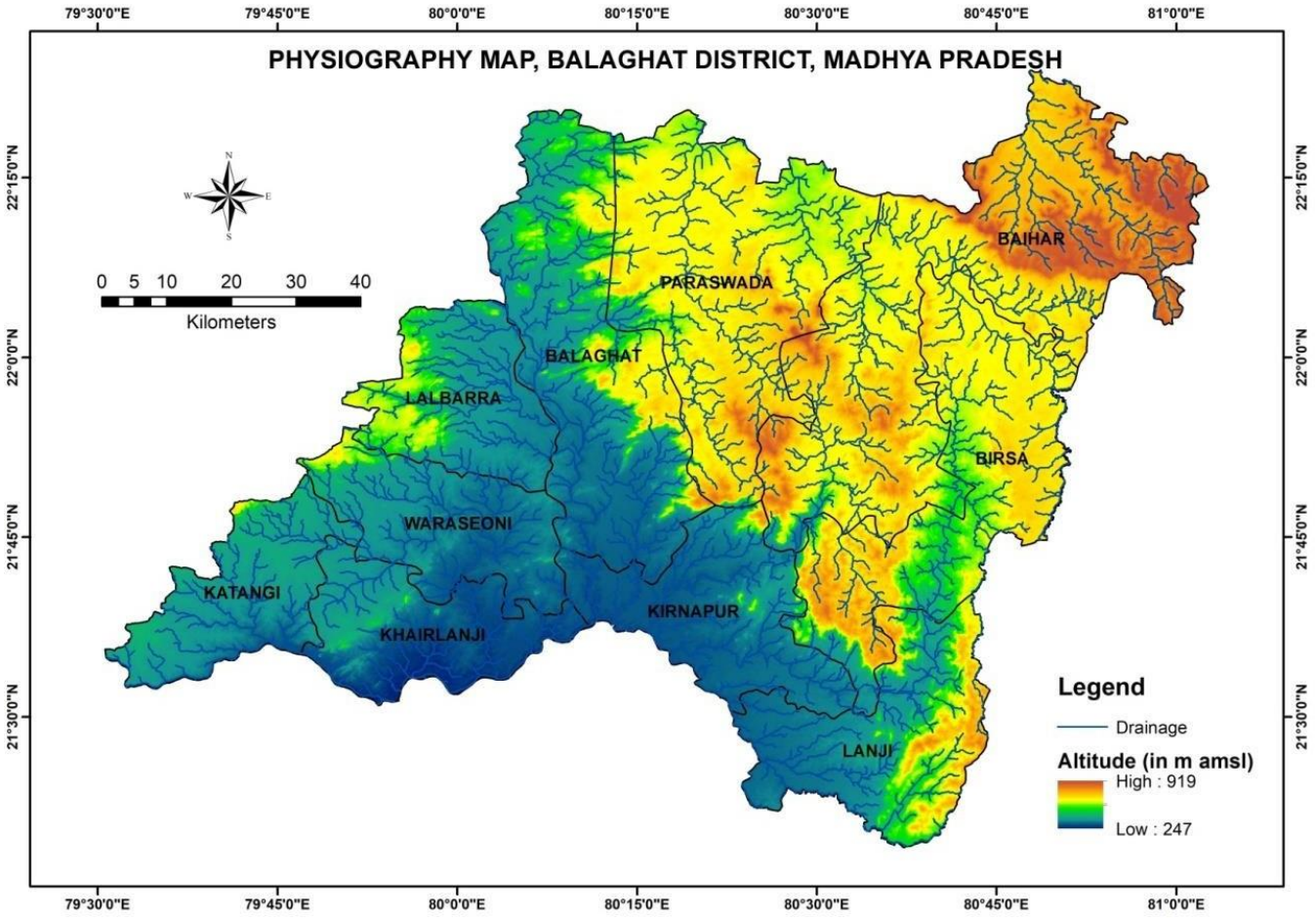


Fig.1.5: Physiography Map of Balaghat, MP

The alluvial soil cover **(Fig-1.6)** is also developed along the Bagh, Son and Deo rivers, which are major tributaries of Wainganga in Godavari drainage system **(Fig-1.7)**. The thickness of alluvium varies from 1.5m. to 10.5m.

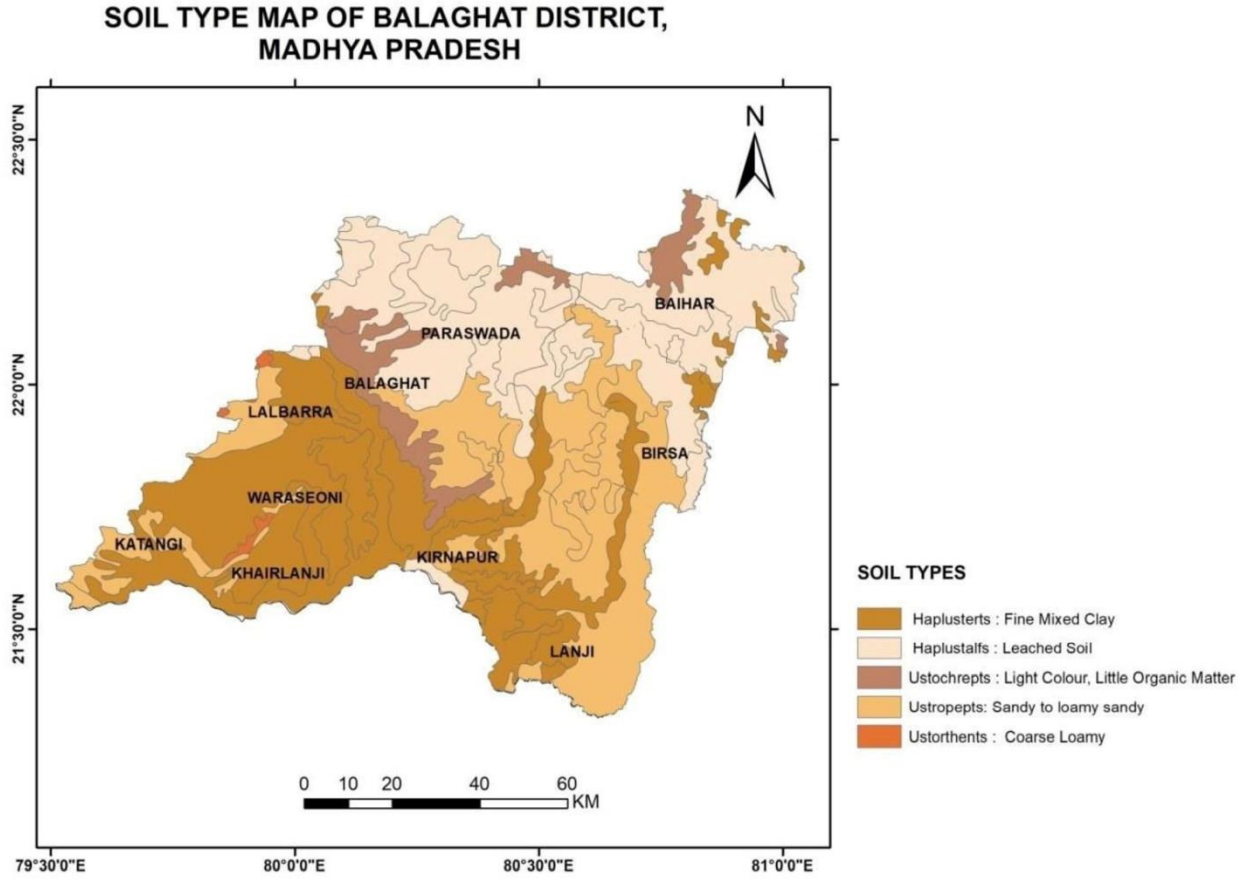


Fig-1.6:- Soil type map of Balaghat district, MP

1.7.1 Drainage

In geomorphology, a drainage system is the pattern formed by the streams, rivers, and lakes in a particular drainage basin. The drainage in the area is controlled by Wain Ganga, Bagh, Banjar, Shisire, Sod, Tumnar along with their tributaries **(fig-1.7).** They are governed by the topography of the land, whether a particular region is dominated by hard or soft rocks and the gradient of the land. Geomorphologists and hydrologists often view streams as being part of drainage basins. A drainage basin is the topographic region from which a stream receives runoff, through flow, and groundwater flow. Drainage basins are divided from each other by topographic barriers called a watershed. A watershed represents all of the stream tributaries that flow to some location along the stream channel. The number, size, and shape of the drainage basins found vary from one place to another.

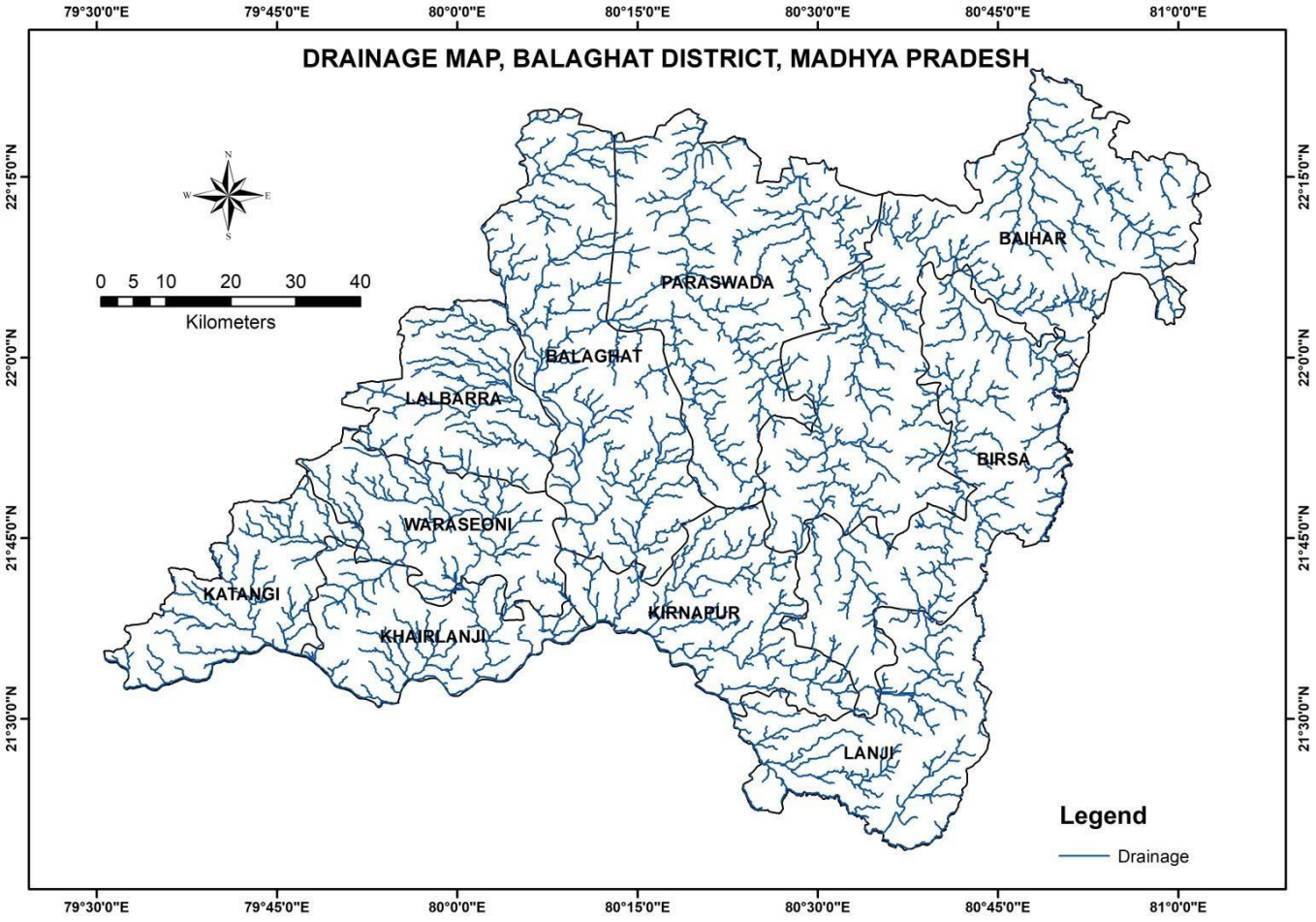


Figure1.7: Drainage Map of Balaghat District, MP

1.7.2 Land Uses

Land use denotes how humans use the biophysical or ecological properties of land. Land use include the modification and/or management of land for agriculture, settlements, forestry and other uses including those that exclude humans from land, as in the designation of nature reserves for conservation.

The major Land use in this district is forest land covers more than 50% of the geographical area. This is followed by net sown area which covers around 33% of the geographical area. Waste land and others including water bodies and built up area covers 14% of the geo- graphical area of the Balaghat district. The block wise landuse / landcover distribution in Balaghat district is shown in the **table-1.4** and **table-1.5** and landuse / landcover map is shown in the **fig-1.8** and **fig-1.9**.

Balaghat district comprises of 10 development blocks, 690 panchayats and 1312 villages. Total geographical area of the district is 924500 Hectare, of which the gross cropped area is 431080 Hectare, of which the net sown area is 301811 Hectare and more than once crop area is 125269 Hectare. Average crop intensity of whole district is 143% of the whole geographical area.

Table-1.4: Block wise Landuse / Land cover Distribution in Balaghat District, MP

Sl No	Name of Block	No of the Gram Panchayat	No of the Villages Covered	Total Geographical Area(Ha)	Area under Agriculture				Area under Forest (Ha)	Area under Wasteland(Ha)	Area under Other uses
					Gross Cropped Area (1) (Ha)	Net sown Area (2) (Ha)	Area sown more than once (1-2)	Cropping Intensity (%)			
1	Balaghat	77	162	122219	46605	29090	17515	160	78308	2346	12475
2	Kirnapur	83	148	81040	48429	30560	17869	158	36451	2438	11591
3	Lanji	77	157	87126	46407	29278	17129	159	48299	1761	7788
4	Lalburra	77	106	71592	42846	27900	14946	154	29380	1904	12408
5	Waraseoni	60	80	47603	43080	28239	14841	153	8119	326	10919
6	Khairlanji	62	84	48788	40394	29114	11280	139	7293	1019	11362
7	Katangi	81	138	69779	39781	28740	11041	138	26036	2078	12925
8	Paraswara	57	155	125650	36073	27986	8087	129	84111	6845	6708
9	Baihar	55	113	129160	33915	24919	8996	136	84131	9066	11044
10	Birsa	61	169	141543	53550	45985	7565	116	83938	5058	6562
	Total	**690**	**1312**	**924500**	**431080**	**301811**	**129269**	**143**	**486066**	**32841**	**103782**

Source: DAP, PPR, Land Use Plan

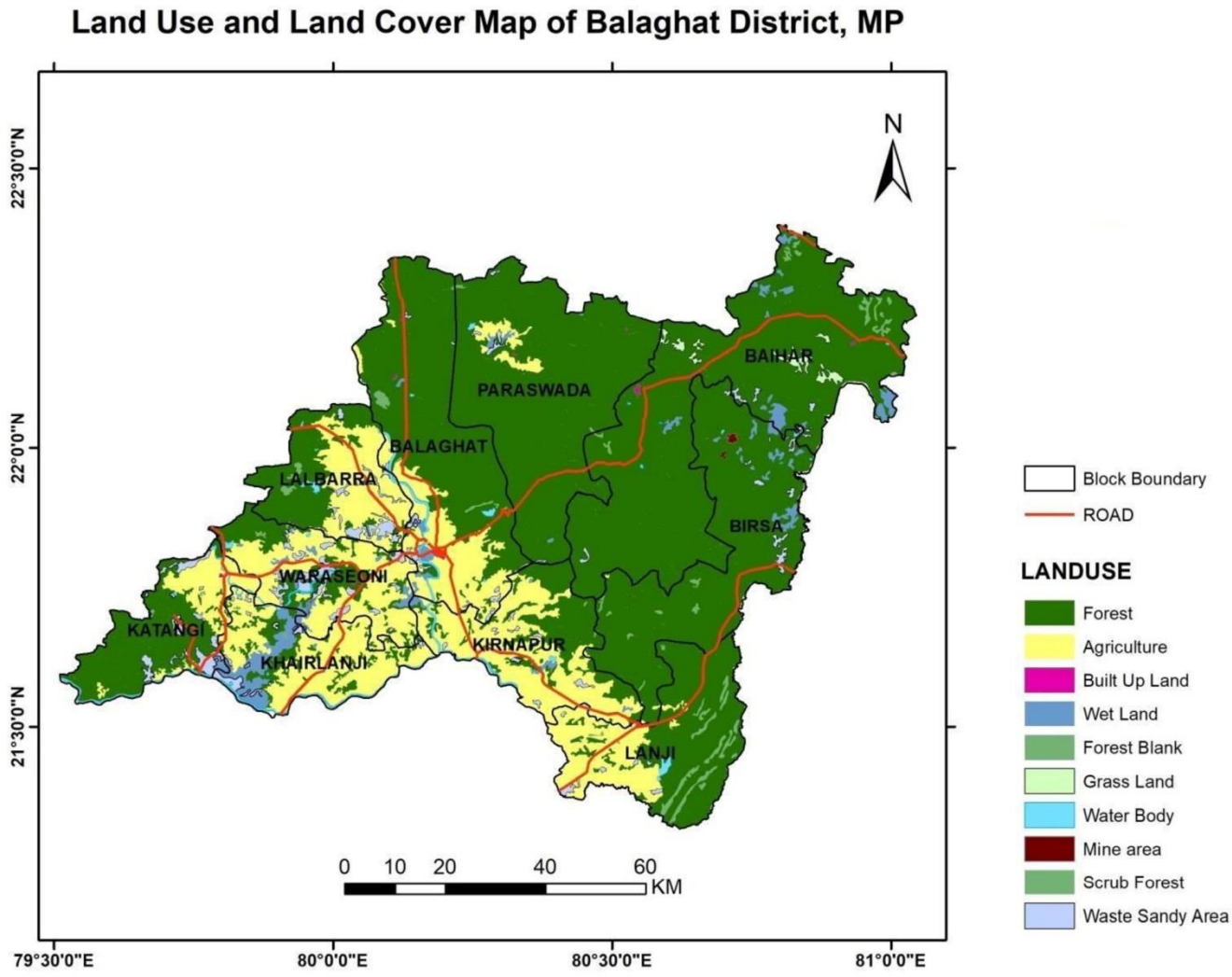
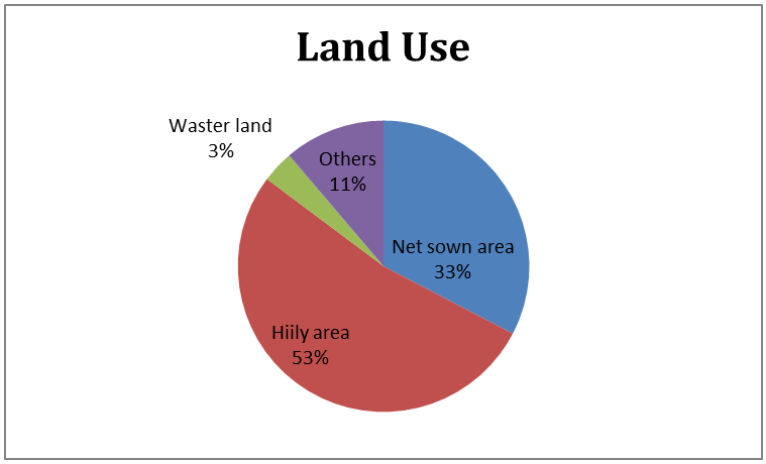


Figure –1.8: Landuse / Land cover Map of Balaghat District, MP

Table-1.4(a): Land Use (in Ha)

Net sown area(Ha)	Hiily area(Ha)	Waster land(Ha)	Others(Ha)	Total(Ha)
301811	486061	32841	103782	924495



Source- DIP, Balaghat

Fig.1.9: Land use Pie Chart.

1.8 Agriculture

As already pointed out, that agriculture is the main livelihood of the people in Balaghat district. Cereals is the principal crop grown in this district, followed by other pulses, oilseeds, rice, vegetables, spices and sugarcane. Cereals are major crop of Balaghat district. It is cultivated in 2701.26 Sq.km under rain fed and311.9 Sq.km under irrigated condition. Pulses, Oil seeds, Fibre, rice, Sugarcane are other crops grown in kharif season and Wheat and Mustard are major crops of Rabi season in the district.

The climate of the district is congenial for successful cultivation for oilseed, pulses, cereals in kharif and wheat, sugarcane in rabi are grown predominantly in the district. The Ground water source (Open Well, bore well) based irrigation caters to the major area. The block wise agricultural statistics for Balaghat district is shown below:

Crop Irrigation Status of Baihar Block

Sl No	Name of Block	Crop Type	Kharif (Area in Sq. km)			Rabi (Area in sq km)			Summer Crop (Area in Sq km)			Horticulture and Plantation Crops (Area in Sq km)		
			Kharif(Areain Sq. km)	Rain fed (Area in Sq. km	Total(Area in Sq. km)	Irrigated (Area in Sq. km)	rain fed (Area in Sq. km)	Total (Area in Sq.	Irrigated (Area in Sq. km)	rain fed (Area in Sq. km)	Total(Area in Sq. km)	Irrigated (Area in Sq. km)	rain fed (Area in Sq. km)	Total (Area in Sq. km)
1	Baihar	A) Cereals	27.03	154.39	181.42	1.6	27.4	29	0.61	0	0.61	0	0	0
2		B) Coarse Cereals	0	36.72	36.72	0	0	0	0	0	0	0	0	0
3		C) Pulses	0	17.85	17.85	0.9	19.13	20.03	0.2	0	0.2	0	0	0
4		D) Oil Seeds	0	12.98	12.98	1.75	27.96	29.71	0	0	0	0	0	0
5		E) Fibre	0	2	2	0	0	0	0	0	0	0	0	0
6		F) Any Other Crops..Sugarcane	0	0	0	0.2	0	0.2	0	0	0	10.41	0	10.41
Total			**27.03**	**221.96**	**248.99**	**4.45**	**74.49**	**78.94**	**0.81**	**0**	**0.81**	**10.41**	**0**	**10.41**
Source: Department of Agriculture, Agriculture Statistic of State, Agristat														

Crop Irrigation Status of Balaghat Block

Sl No	Name of Block	Crop Type	Kharif(Area in Sq. km)			Rabi(Area in sq km)			Summer Crop(Area in Sq km)			Horticulture and Plantation Crops (Area in Sq km)		
			Kharif(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km)	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)
1	Balaghat	A) Cereals	154.59	113.47	268.06	10.47	40.53	51	16.45	0	16.45	0	0	0
2		B) Coarse Cereals	0	1.73	1.73	0	0	0	0	0	0	0	0	0
3		C) Pulses	0	17.94	17.94	14.5	50.79	65.29	0.95	0	0.95	0	0	0
4		D) Oil Seeds	0	2.62	2.62	2.51	27.85	30.36	0.05	0	0.05	0	0	0
5		E) Fibre	0	0.2	0.2	16 0	0	0	0	0	0	0	0	0
6		F) Any Other Crops..Sugarcane	0	0	0	0.35	0	35	0	0	0	11.05	0	11.05
Total			**154.59**	**135.96**	**290.55**	**27.83**	**119.17**	**147**	**17.45**	**0**	**17.45**	**11.05**	**0**	**11.05**
Source: Department of Agriculture, Agriculture Statistic of State, Agristat														

Crop Irrigation Status of Birsa Block

Sl no	Name of Block	Crop Type	Kharif(Area in Sq. km)			Rabi(Area in sq km)			Summer Crop(Area in Sq km)			Horticulture and Plantation Crops (Area in Sq km)		
			Kharif(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km)	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)
1	Birsa	A) Cereals	53.98	328.52	382.5	1.93	16.07	18	0.39	0	0.39	0	0	0
2		B) Coarse Cereals	0	64.5	64.5	0	0	0	0	0	0	0	0	0
3		C) Pulses	0	9	9	1	16.07	17.07	0.29	0	0.29	0	0	0
4		D) Oil Seeds	0	3.55	3.55	1	27.7	28.7	0	0	0	0	0	0
5		E) Fibre	0	0.1	0.1	0	0	0	0	0	0	0	0	0
6		F) Any Other Crops..Sugarcane	0	0	0	0.2	0	0.2	0	0	0	11.2	0	11.2
Total			**53.98**	**405.67**	**459.65**	**4.13**	**59.84**	**63.97**	**0.68**	**0**	**0.68**	**11.2**	**0**	**11.2**
Source: Department of Agriculture, Agriculture Statistic of State, Agristat														

Crop Irrigation Status of Katangi Block

Sl No	Name of Block	Crop Type	Kharif(Area in Sq. km)			Rabi(Area in sq km)			Summer Crop(Area in Sq km)			Horticulture and Plantation Crops (Area in Sq km)		
			Kharif (Area)in Sq. km)	Rain fed(Area in Sq. km	Total (Area in Sq. km)	Irrigated(Area in Sq. km)	Rain fed(Area in Sq. km)	Total (Area in Sq. km)	Irrigated(Area in Sq. km)	Rain fed(Area in Sq. km	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rain fed(Area in Sq. km	Total(Area in Sq. km)
1	Katangi	A) Cereals	219.59	51.37	270.96	15.48	0.52	16	13.05	0	13.05	0	0	0
2		B) Coarse Cereals	0	1.8	1.8	0	0	0	0	0	0	0	0	0
3		C) Pulses	0	6.2	6.2	9	31.34	40.34	0	0	0	0	0	0
4		D) Oil Seeds	0	2.15	2.15	4.47	27.74	32.21	0.7	0	70	0	0	0
5		E) Fibre	0	0.06	0.06	0	0	0	0	0	0	0	0	0
6		F) Any Other Crops. Sugarcane	0	0	0	6.23	0	6.23	0	0	0	8.11	0	8.11
Total			**219.59**	**61.58**	**281.17**	**35.18**	**59.6**	**94.78**	**13.75**	**0**	**13.75**	**8.11**	**0**	**8.11**
Source: Department of Agriculture, Agriculture Statistic of State, Agristat														

Crop Irrigation Status of Kirnapur Block

Sl No	Name of Block	Crop Type	Kharif(Area in Sq. km)			Rabi(Area in sq km)			Summer Crop(Area in Sq km)			Horticulture and Plantation Crops (Area in Sq km)		
			Kharif(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km)	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)
1	Kirnapur	A) Cereals	136.59	152.41	289	5.01	30.99	36	25.78	0	25.78	0	0	0
2		B) Coarse Cereals	0	0.52	0.52	0	0	0	0	0	0	0	0	0
3		C) Pulses	0	13.32	13.32	13.15	65.81	78.96	0.35	0	0.35	0	0	0
4		D) Oil Seeds	0	1.47	1.47	1.6	28.49	30.09	0	0	0	0	0	0
5		E) Fibre	0	0.44	0.44	0	0	0	0	0	0	0	0	0
6		F) Any Other Crops..Sugarcane	0	0	0	0.85	0	0.85	0	0	0	7.51	0	7.51
Total			**136.59**	**168.16**	**304.75**	**20.61**	**125.29**	**145.9**	**26.13**	**0**	**26.13**	**7.51**	**0**	**7.51**
Source: Department of Agriculture, Agriculture Statistic of State, Agristat														

Crop Irrigation Status of Khairlanji Block

Sl No	Name of Block	Crop Type	Kharif(Area in Sq. km)			Rabi(Area in sq km)			Summer Crop(Area in Sq km)			Horticulture and Plantation Crops (Area in Sq km)		
			Kharif(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km)	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)
1	Khairlanji	A) Cereals	156.79	116.19	272.98	9.56	6.44	16	12.84	0	12.84	0	0	0
2		B) Coarse Cereals	0	0.31	0.31	0	0	0	0	0	0	0	0	0
3		C) Pulses	0	9.18	9.18	8.5	38.45	46.95	0.7	0	70	0	0	0
4		D) Oil Seeds	0	1.44	1.44	1.5	26.52	28.02	0.2	0	20	0	0	0
5		E) Fibre	0	0.43	0.43	0	0	0	0	0	0	0	0	0
6		F) Any Other Crops..Sugarcane	0	0	0	6.8	0	6.8	0	0	0	8.09	0	8.09
Total			**156.79**	**127.55**	**284.34**	**26.36**	**71.41**	**97.77**	**13.74**	**0**	**13.74**	**8.09**	**0**	**8.09**
Source: Department of Agriculture, Agriculture Statistic of State, Agristat														

Crop Irrigation Status of Lanji Block

Sl No	Name of Block	Crop Type	Kharif(Area in Sq. km)			Rabi(Area in sq km)			Summer Crop(Area in Sq km)			Horticulture and Plantation Crops (Area in Sq km)		
			Kharif(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km)	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)
1	Lanji	A) Cereals	152.09	126.68	278.77	18.74	23.16	41.9	26.85	0	26.85	0	0	0
2		B) Coarse Cereals	0	1.26	1.26	0	0	0	0	0	0	0	0	0
3		C) Pulses	0	7.45	7.45	17.4	47.42	64.82	0.26	0	26	0	0	0
4		D) Oil Seeds	0	2.9	2.9	1.75	29.21	30.96	0	0	0	0	0	0
5		E) Fibre	0	0.25	0.25	0	0	0	0	0	0	0	0	0
6		F) Any Other Crops..Sugarcane	0	0	0	2.15	0	2.15	0	0	0	6.5	0	6.5
		Total	**152.09**	**138.54**	**290.63**	**40.04**	**99.79**	**139.83**	**27.11**	**0**	**27.11**	**6.5**	**0**	**6.5**
Source: Department of Agriculture, Agriculture Statistic of State, Agristat														

Crop Irrigation Status of Lalburra Block

Sl No	Name of Block	Crop Type	Kharif(Area in Sq. km)			Rabi(Area in sq km)			Summer Crop(Area in Sq km)			Horticulture and Plantation Crops (Area in Sq km)		
			Kharif(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km)	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)
1	Lalburra	A) Cereals	236.29	32.55	268.84	18.14	23.36	41.5	12.74	0	12.74	0	0	0
2		B) Coarse Cereals	0	0.3	0.3	0	0	0	0	0	0	0	0	0
3		C) Pulses	0	7.65	7.65	16.75	43.09	59.84	0.95	0	0.95	0	0	0
4		D) Oil Seeds	0	2.06	2.06	3.15	27.21	30.36	0.05	0	5	0	0	0
5		E) Fibre	0	0.13	0.13	0	0	0	0	0	0	0	0	0
6		F) Any Other Crops..Sugarcane	0	0	0	0.02	0	2	0	0	0	4.02	0	4.02
Total			**236.29**	**42.69**	**278.98**	**38.06**	**93.66**	**131.72**	**13.74**	**0**	**13.74**	**4.02**	**0**	**4.02**
Source: Department of Agriculture, Agriculture Statistic of State, Agristat														

Crop Irrigation Status of Paraswada Block

Sl No	Name of Block	Crop Type	Kharif(Area in Sq. km)			Rabi(Area in sq km)			Summer Crop(Area in Sq km)			Horticulture and Plantation Crops (Area in Sq km)		
			Kharif(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km)	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)
1	Paraswada	A) Cereals	36.37	177.38	213.75	5.5	19.5	25	2.38	0	2.38	0	0	0
2		B) Coarse Cereals	0	48.38	48.38	0	0	0	0	0	0	0	0	0
3		C) Pulses	0	14.73	14.73	2.5	14.15	16.65	0.36	0	0.36	0	0	0
4		D) Oil Seeds	0	2.9	2.9	0.72	28.85	29.57	0	0	0	0	0	0
5		E) Fibre	0	0.08	0.08	0	0	0	0	0	0	0	0	0
6		F) Any Other Crops..Sugarcane	0	0	0	0.02	0	2	0	0	0	6.91	0	6.91
Total			**36.37**	**243.47**	**279.84**	**8.74**	**62.5**	**71.24**	**2.74**	**0**	**2.74**	**6.91**	**0**	**6.91**
Source: Department of Agriculture, Agriculture Statistic of State, Agristat														

Crop Irrigation Status of Waraseoni Block

Sl No	Name of Block	Crop Type	Kharif(Area in Sq. km)			Rabi(Area in sq km)			Summer Crop(Area in Sq km)			Horticulture and Plantation Crops (Area in Sq km)		
			Kharif(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km)	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)
1	Waraseoni	A) Cereals	260.26	14.72	274.98	21.46	16.04	37.5	14.56	0	14.56	0	0	0
2		B) Coarse Cereals	0	0.24	0.24	0	0	0	0	0	0	0	0	0
3		C) Pulses	0	4.81	4.81	13.6	37.34	50.94	0.95	0	0.95	0	0	0
4		D) Oil Seeds	0	1.77	1.77	2.1	29.42	31.52	0.1	0	0.1	0	0	0
5		E) Fibre	0	0.35	0.35	0	0	0	0	0	0	0	0	0
6		F) Any Other Crops..Sugarcane	0	0	0	0.24	0	0.24	0	0	0	12.84	0	12.84
Total			**260.26**	**21.89**	**282.15**	**37.4**	**82.8**	**120.2**	**15.61**	**0**	**15.61**	**12.84**	**0**	**12.84**
Source: Department of Agriculture, Agriculture Statistic of State, Agristat														

Crop Irrigation Status of Balaghat District

Sl No	Name of District	Crop Type	Kharif(Area in Sq. km)			Rabi(Area in sq km)			Summer Crop(Area in Sq km)			Horticulture and Plantation		
			Kharif(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km)	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)	Irrigated(Area in Sq. km)	Rainfed(Area in Sq. km	Total(Area in Sq. km)
1	Balaghat	A) Cereals	1433.58	1267.68	2701.26	107.89	204.01	311.9	125.65	0	125.65	0	0	0
2		B) Coarse Cereals	0	155.76	155.76	0	0	0	0	0	0	0	0	0
3		C) Pulses	0	108.13	108.13	97.3	363.59	460.89	5.01	0	5.01	0	0	0
4		D) Oil Seeds	0	33.84	33.84	20.55	280.95	301.5	1.1	0	1.1	0	0	0
5		E) Fibre	0	2.06	2.06	0	0	0	0	0	0	0	0	0
6		F) Any Other Crops..Sugarcane	0	0	0	17.06	0	17.06	0	0	0	86.64	0	86.64
Total			**1433.58**	**1567.47**	**3001.05**	**242.8**	**848.55**	**1091.35**	**131.76**	**0**	**131.76**	**86.64**	**0**	**86.64**
Source: Department of Agriculture, Agriculture Statistic of State, Agristat														

1.9 Geology

Geologically Balaghat M.P. has the older rocks of Precambrian and Archean age. A good amount of work has been carried out during the 18^{th} and 19^{th} century in the search of manganese ore deposits in Central India by the team of geologists of British Geological Survey. The controversial nature of the rocks of Balaghat area was studied in great details by the officers of the Geological Survey of India, State Directorate of Geology and Mining, Scientists of Universities and Research Organizations.

In this area, the rocks belonging to the Tirodi- Sausar –Chilpi Group and Bharweli Group are found. Amgaon granite/ Migmatites and Nandgaon volcanics are found in the south eastern part of Balaghat District, M.P. The Regional trend of the low grade metamorphic rocks is exposed in the ENE-WSW, with a doubly plunging syncline trending between Waraseoni in the west to Mukki in the east. The rocks of Chilpi Ghats Group nowhere comes in contact with the Manganese Belt and it is separated by interfering gneissic country through which a major ductile mylonite zone , termed as 'Central Indian Suture' passes in this area. The manganese bearing rocks of Tirodi-Sausar Group and Bharweli- Ukwa group are exposed to the north of this so called Central Indian Suture (CIS). The metamorphosed rocks of Chilpi group are confined to thesouthern and south –eastern part of the Balaghat District **(Fig 2.0).**

Earliest account of the rocks of Bharweli- Ukwa belt in Balaghat district had been given by Bose (1888-1889) who investigated this area. He had described mica- phyllite, sericite-schist, sandstone-quartzite and jaspery quartzite associated with manganese ores within the Chilpi Ghat Series. The ore bed was assumed to be marking the base of the series, overlying the massive gneiss, weathering like gritstone with a denudational unconformity (Table- 1.5).

TABLE-1.5- Geological succession of Balaghat district, MP

REGIONAL STRATIGRAPHY OF BALAGHAT AREA

(after BOSE 1889 in FERMOR1909) CHILPI GHAT SERIES

Metamorphic and crystalline series(=Baihar gneiss by Bose)
Intrusive granite (=Chauria Gneiss)
(=Bundelkhand granite by Bose)
Older metamorphics

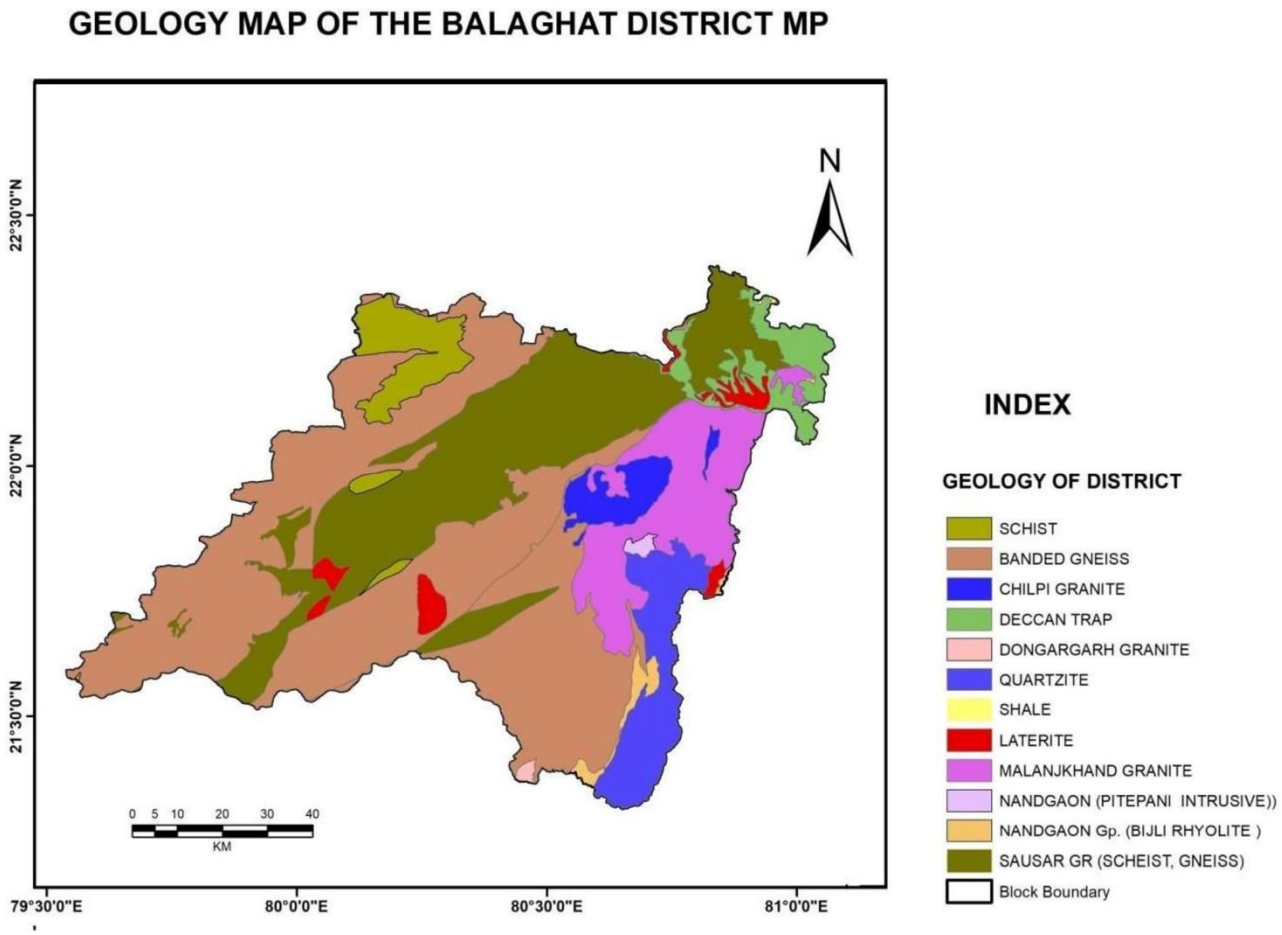


Fig-2.0: Geological map of the Balaghat District

1.9.1 MAJOR LITHOLOGY

Mica Schist:

These rocks are exposed in Bharweli mine area trending ENE-WSW. The sericite schist is fine to medium grained. It is greenish to dark greyish black in colour. Some carbonaceous matter is identifiable. Sericite schist grades into medium grained mica schist towards the northern part of study area. The mica schist is fine to medium grained and is grey to brownish grey in colour. Sericite schist and mica schist bands gradually merge into one another.

The sericite schist is fine grained and it contains quartz, flakes of sericite and muscovite. The dimensionally oriented flakes of sericite, quartz and occasionally muscovite define the schistosity. Extensive crushing and granulation has taken place with subsequent shearing and faulting. Quartz mica schist is medium grained, containing essentially quartz muscovite and biotite with occasional development of garnet. Garnet is syntectonic.

Granites

In the Balaghat area the granites are intruded in the form of batholith in the existing metasedimentary rocks, which have transformed to granite gneiss. The large outcrops of the granites are exposed in Lamta -Charegaon -Nagarwada area, continued up to Malanjkhand-Lanji-Amagaon area. In the Lalburra-Tirodi-Barghat (Seoni) area, pink fine-grained varieties of granite with biotite gneiss and granite gneiss are exposed. The exposure of the granitic rocks in the study area is less. Either they are covered by alluvium or by dense reserve forest and so, much of the work is based on the regional studies.

Following varieties of granites have been identified in the area.
1. Fine grained grey granites

2. Fine grained pink granites

Granite gneiss

These rocks are exposed in the south of Bharwelli Group, along Wainganga river valley in Balaghat area. The biotite hornblende rich granite rock shows gneissose structure. Coloured mineral show parallelism in different patterns such a streaky, curly and contorted type. They are medium to coarse grained, non-porphyritic rocks, pink grey in colour consisting of microcline, plagioclase quartz and biotite. The important accessories are zircon, sphene, fluorite, apatite, ilmenite, and magnetite. The texture is granoblastic. Microcline shows cross-hatched twins both coarse and fine in nature. Small inclusions of plagioclase with crenulated margin also occur in the microcline. The oligoclase is protruded into microcline and shows a more acid margin against microcline, which is probably of later origin. Quartz is allotriomorphic and forms lenticular patch with irregular margin. A fine grained specimen shows replacement of oligoclase by quartz, gradually working its way along twin planes. Subhedral biotite flakes do not show any orientation. These are highly pleochroic in nature. It is unoriented and is in Subhedral flakes. Biotite is sometimes seen with muscovite which is because of its vermicular habit. The hornblende is also strongly/ feebly pleochroic and occurs as small Subhedral grains. Sphene, apatite and zircon form small Subhedral crystals, which are distributed irregularly in the thin sections.

The granite gneiss-foliated varieties are also exposed at Shankar Ghat, near the Road Bridge to Seoni. Mineralogically, the rocks are similar to above. Biotite forms evenly distributed wavy, discontinuous streaks. Quartz and feldspar are lenticular in between streaks. The rock is cut by coarse-grained thin pegmatite vein, obliquely across the gneissic foliation. Microcline is last to crystallize, but in some sections the oligoclase has inclusions of microcline in optical continuity with the larger pieces of microcline or have crenulated margin against microcline. The quartz has grown at the expense of the granitic material, i.e., quartz, feldspar and biotite. The larger quartz grains show undulose extinction, but they include small quartz grains which are unstrained. Quartz has corroded the plagioclase along twin planes.

Alluvium:

The Wainganga River and its tributaries have a thick cover of alluvium, where the main paddy fields are situated. The area has detritus soil derived from weathering of rocks, which is constantly washed down from the hill slopes by torrential rains and are admixed with the alluvial materials in the plains. The alluvial soil cover is also developed along the Bagh, Son and Deo rivers, which are major tributaries of Wainganga in Godavari drainage system **(Fig-1.7)**. The thickness of alluvium varies from 1.5m. to 10.5m.

CHAPTER-2

II. DATA COLLECTION AND GENERATION

2.1 Data Collection and Compilation

The data collection and compilation for various components was carried out as given below.

- Hydrogeological Data – Current and historical water levels along with water level trend data of monitoring wells representing Aquifer-I (Shallow aquifer) of CGWB. The weathered zone thickness (aquifer-I), lithological details of deeper aquifers (aquifer- II) of exploratory wells were also collected and compiled.

- Hydro chemical Data - Ground water quality data of monitoring wells of CGWB representing shallow aquifer and data from exploratory wells representing deeper aquifer.

- Exploratory Drilling – Ground water exploration data of exploratory wells of CGWB.

- Hydro meteorological Data - Long term rainfall data for the whole district and for each block from Indian meteorological Department and Water Resource Department.

- Cropping Pattern Data – Data on prevailing cropping pattern from District Irrigation Plan, Balaghat district.

- For data generation 41 no's of key wells have been established throughout the district and collected water sample.

2.2 Ground Water Exploration

Central Ground Water Board, has not taken up any exploratory drilling in Balaghat district so for. The state agencies and private drilling agencies have constructed some shallow as well as deep tube wells. However, Central Ground Water Board has constructed 5 piezometers at different places under hydrology project in parts of study area. In addition to this, 41 nos of key wells were established in Balaghat district excluding forest area **(Fig-2.1)**. The details of piezometers and Key wells are given in **Annexure-I.**

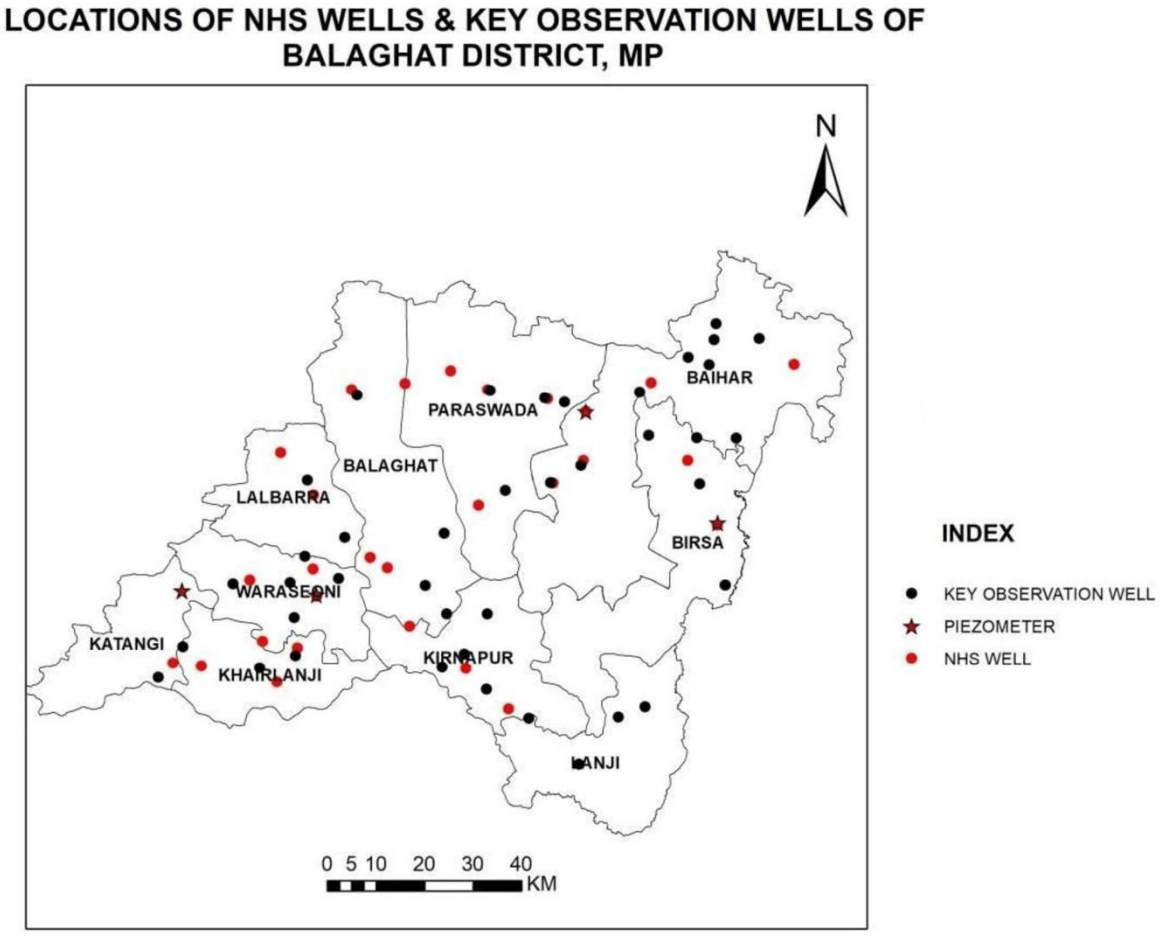


Fig-2.1: Locations of Piezometers, key wells and NHS wells in Balaghat, MP

2.3 Ground Water Monitoring Wells

Central Ground Water Board has been carrying out water level monitoring through ground water monitoring wells since last two decades. The water levels of the monitoring wells are being monitored four times in a year during the month January, May, August and November. The locations of monitoring wells are shown in **Fig. 2.1 and table-2.1 & 2.2.**

Table. 2.1:- Location details of key wells

Sl No	District	Locations	Source	Long	Lat	Depth(m)	Weathering thickness(m)
1	Balaghat	Linga	HP	80.25391	21.77994	65	33
3	Balaghat	Khursuni	DW	80.29358	21.72763	20	20
4	Balaghat	Bhalwa	HP	80.36865	21.72773	100	30
5	Balaghat	Chhotapala	HP	80.32559	21.65288	83	30
6	Balaghat	Binora	DW	80.36673	21.5874	100	28
7	Balaghat	Benegaon	Bore	80.44574	21.53376	50	30
8	Balaghat	Lohara	Bore	80.53837	21.44996	100	30
9	Balaghat	Keratola	HP	80.66111	21.555	105	30
10	Balaghat	Khandwa	Bore	80.6116	21.53553	116	35
11	Balaghat	Paraswada	Bore	80.28509	21.62844	30	20
12	Balaghat	Kaydi	HP	80.09305	21.79298	100	25
13	Balaghat	Kabuliwara	HP	80.01087	21.72047	65	30
14	Balaghat	Sonjhara	HP	80.01302	21.64961	85	33
15	Balaghat	Saleteka	HP	79.94709	21.62682	100	30
16	Balaghat	Bonkata	HP	79.75906	21.60999	110	35
17	Balaghat	Paraswadaghat	HP	79.80452	21.66632	150	20
18	Balaghat	Serpar	HP	79.89732	21.78287	180	20
19	Balaghat	Saongi	HP	80.00318	21.7856	100	32
20	Balaghat	Nayatola	HP	80.03107	21.83425	120	35
21	Balaghat	Pathersahi	HP	80.03505	21.97455	100	20
22	Balaghat	Birsola	HP	80.10475	21.86903	100	30
23	Balaghat	Pipartola	HP	80.28837	21.87706	85	80
24	Balaghat	Chiklaghodi	Bore	80.4019	21.95615	80	30
25	Balaghat	Samnapur	HP	80.48612	21.97024	83	20
26	Balaghat	Ramatola	Bore	80.54184	22.00241	52	30
27	Balaghat	Sakrai Tola	HP	80.65059	22.13721	100	10
28	Balaghat	Khursipar	HP	80.74069	22.20172	60	10
29	Balaghat	Gaddi	HP	80.78856	22.23419	80	20
30	Balaghat	Jobati Tola	Bore	80.8726	22.23686	50	10
31	Balaghat	Brahman Tola	HP	80.7924	22.26429	70	20
32	Balaghat	Nabalpur	HP	80.77963	22.18824	100	30
33	Balaghat	Mohgaon	Bore	80.66772	22.05749	60	20
34	Balaghat	Palera	HP	80.75653	22.05299	60	30
35	Balaghat	Mundai	HP	80.82948	22.05256	100	35
36	Balaghat	Salghat	HP	80.76173	21.96791	60	30
37	Balaghat	Saletekri	HP	80.80892	21.78116	100	60
38	Balaghat	Singhodi	HP	80.51153	22.11878	130	30
39	Balaghat	Khurmundi	HP	80.47527	22.1261	130	30
40	Balaghat	Bagholi	HP	80.37359	22.1399	50	50
41	Balaghat	Bondua	HP	80.12726	22.1318	65	20

Table.2.2:- Location details of Monitoring wells

LATITUDE	LONGITUDE	SITE_TYPE	DISTRICT_NAME	BLOCK_NAME	VILLAGE_NAME	DEPTH
22°6'15" N	80°33'5" E	Bore Well	BALAGHAT	BAIHAR	Baihar	58.2
22°6'15" N	80°33'5" E	Dug Well	BALAGHAT	BAIHAR	Baihar	16.1
22°11'0" N	80°42'50" E	Dug Well	BALAGHAT	BAIHAR	Bhaisanghat	7.5
22°14'9" N	80°52'15" E	Dug Well	BALAGHAT	BAIHAR	Jawaditula	10
21°55'48" N	80°21'7" E	Dug Well	BALAGHAT	BAIHAR	Laugur	12
22°3'7" N	80°40'50" E	Dug Well	BALAGHAT	BAIHAR	Mohagaon	10.91
22°9'15" N	80°40'20" E	Dug Well	BALAGHAT	BAIHAR	Mukki	9.5
22°0'42" N	80°32'47" E	Dug Well	BALAGHAT	BAIHAR	Parsatola	12
21°58'10" N	80°29'25" E	Dug Well	BALAGHAT	BAIHAR	Samnapur	13.65
22°11'20" N	80°56'13" E	Dug Well	BALAGHAT	BAIHAR	Supkhar	13.9
21°48'46" N	80°11'1" E	Dug Well	BALAGHAT	BALAGHAT	Balaghat	11.2
22°8'30" N	80°7'30" E	Dug Well	BALAGHAT	BALAGHAT	Lamta	12.6
21°57'56" N	80°7'30" E	Dug Well	BALAGHAT	BALAGHAT	Magardarta	10
21°42'18" N	80°13'30" E	Dug Well	BALAGHAT	BALAGHAT	Saleteka New	15.4
22°0'40" N	80°44'23" E	Dug Well	BALAGHAT	BIRSA	Birsa	9.9
21°53'47" N	80°47'43" E	Bore Well	BALAGHAT	BIRSA	Damoh	33.15
21°53'47" N	80°47'43" E	Dug Well	BALAGHAT	BIRSA	Damoh	11
21°46'50" N	80°48'36" E	Dug Well	BALAGHAT	BIRSA	Saletekhri	12.05
21°46'15" N	79°48'12" E	Dug Well	BALAGHAT	KATANGI	Katangi	7.75
21°46'15" N	79°48'12" E	Bore Well	BALAGHAT	KATANGI	Katangi-D	59.82
21°46'15" N	79°48'12" E	Bore Well	BALAGHAT	KATANGI	Katangi-S	20.94
21°42'50" N	79°47'50" E	Dug Well	BALAGHAT	KATANGI	Katedhara	8.5
21°36'20" N	79°45'45" E	Dug Well	BALAGHAT	KHAIRLANJI	Bonkatta	9.75
21°38'10" N	79°47'10" E	Dug Well	BALAGHAT	KHAIRLANJI	Garraghoda	17.43
21°36'4" N	79°58'45" E	Dug Well	BALAGHAT	KHAIRLANJI	Khairlanji	9.1
21°37'50" N	79°50'20" E	Dug Well	BALAGHAT	KHAIRLANJI	Miragpur	11.02
21°39'52" N	80°1'2" E	Dug Well	BALAGHAT	KHAIRLANJI	Rampalli	9.66
21°33'5" N	80°24'30" E	Dug Well	BALAGHAT	KIRNAPUR	Bhanegaon	14.5
21°37'35" N	80°19'43" E	Dug Well	BALAGHAT	KIRNAPUR	Kirnapur	11.3
21°37'50" N	80°15'0" E	Dug Well	BALAGHAT	KIRNAPUR	Rajegaon	13.8
22°1'33" N	79°59'8" E	Dug Well	BALAGHAT	LALBARRA	Kanjai	10
21°56'51" N	80°2'48" E	Dug Well	BALAGHAT	LALBARRA	Katang Tola	9
21°23'52" N	80°37'37" E	Dug Well	BALAGHAT	LANJI	Baghatola	10
21°37'25" N	80°39'35" E	Dug Well	BALAGHAT	LANJI	Deverbeli	10
22°8'30" N	80°22'10" E	Dug Well	BALAGHAT	PARASWADA	Bagholi	8.5
22°7'30" N	80°28'50" E	Dug Well	BALAGHAT	PARASWADA	Khurmundi	10.9
22°10'35" N	80°18'3" E	Dug Well	BALAGHAT	PARASWADA	Paraswara	9.35
22°9'10" N	80°13'0" E	Dug Well	BALAGHAT	PARASWADA	Rangpatbaba	9
21°40'35" N	79°57'8" E	Dug Well	BALAGHAT	WARASEONI	Amai	9.1
21°49'55" N	80°9'6" E	Dug Well	BALAGHAT	WARASEONI	Kanki	11.7
21°47'25" N	79°55'43" E	Dug Well	BALAGHAT	WARASEONI	Kochwahi	7.3
21°48'38" N	80°2'45" E	Dug Well	BALAGHAT	WARASEONI	Newargaon	10.6
21°45'48" N	80°3'7" E	Bore Well	BALAGHAT	WARASEONI	Waraseoni	44.95
21°45'48" N	80°3'7" E	Dug Well	BALAGHAT	WARASEONI	Waraseoni	10.99

2.4: Ground Water Quality

The suitability of ground water for drinking/irrigation/industrial purposes is determined keeping in view the effects of various chemical constituents present in water on the growth of human being, animals and various plants and also on industrial requirement. Though many ions are very essential for the growth of plants and human body but when present in excess, have an adverse effect on health and growth. For assessment of ground water quality, samples from 38 wells (shallow dug wells representing phreatic aquifer) have been collected during premonsoon. Similarly for Aquifer – II, the ground water quality data of 38 key wells have been collected. The details of shallow dug wells and key wells are given in **table-2.1** and **2.2** and water quality details of the key wells are attached in **annexure-III.**

CHAPTER-3

III. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

The data collected and generated on various parameters viz., water levels, water quality, exploration, aquifer parameters, hydrology, hydrometeorology, irrigation were integrated. Based on this the various aquifer characteristic maps on hydrogeology, aquifer wise water level scenario both current and long term scenarios, aquifer wise ground water quality, 2-D and 3-D sub surface disposition of aquifers by drawing fence and lithological sections, aquifer wise yield potential, aquifer wise resources, aquifer maps were generated and as discussed in details.

3.1 HYDROGEOLOGY

The occurrence and movement of ground water in hard rock areas is widely controlled by the secondary porosity present in them like joints, fractures, weathering etc. The district is mainly occupied by Precambrian rocks & alluvium. The weathering of Archean rocks ranges from 0.50 mbgl to 20.00 mbgl. The weaker zones in Deccan traps are also developed at the contacts of two consecutive lava flows, which facilitate downward movement of ground water. In Vesicular basalts the voids provide more space for the accumulation of ground water. The water bearing properties of these formations varied widely depending upon their lithological properties and structural control. The hydrogeological map of Balaghat district is shown in the **fig-3.1**.

3.2 WATER BEARING FORMATIONS

The Ground Water occurs under water table and semi confined to confined conditions in all formations of the area. Topographic depressions, nature and extent of weathering, presence of joints and fractures play an important role in the occurrence and movement of ground water. The area occupied by Archean rocks is mostly undulating. The ground water in these rocks occurs under unconfined conditions, which is widely controlled by the weathering of the rocks, presence of joints, fracture and lineament in them.

The area occupied by Deccan trappean rocks, where ground water occurs under phreatic conditions in the weaker zones of weathered, vesicular, fractured and jointed parts of the flows. The sheet joints, basal parts of flows and inter-connection of joints and fractures controls the horizontal as well as vertical movement of ground water. The plateau like topography plays an important role in occurrence and movement of ground water. Under semi-confined conditions the ground water occurs at the contacts of two flows and at the contact of trappean rocks with Archean basement.

3.3 HYDROGEOLOGICAL DATA COLLECTION

Groundwater is the principal source of irrigation in the district. Map (fig-3.1) showing geology, hydrogeology, water table and location of national hydrograph stations of Balaghat district.

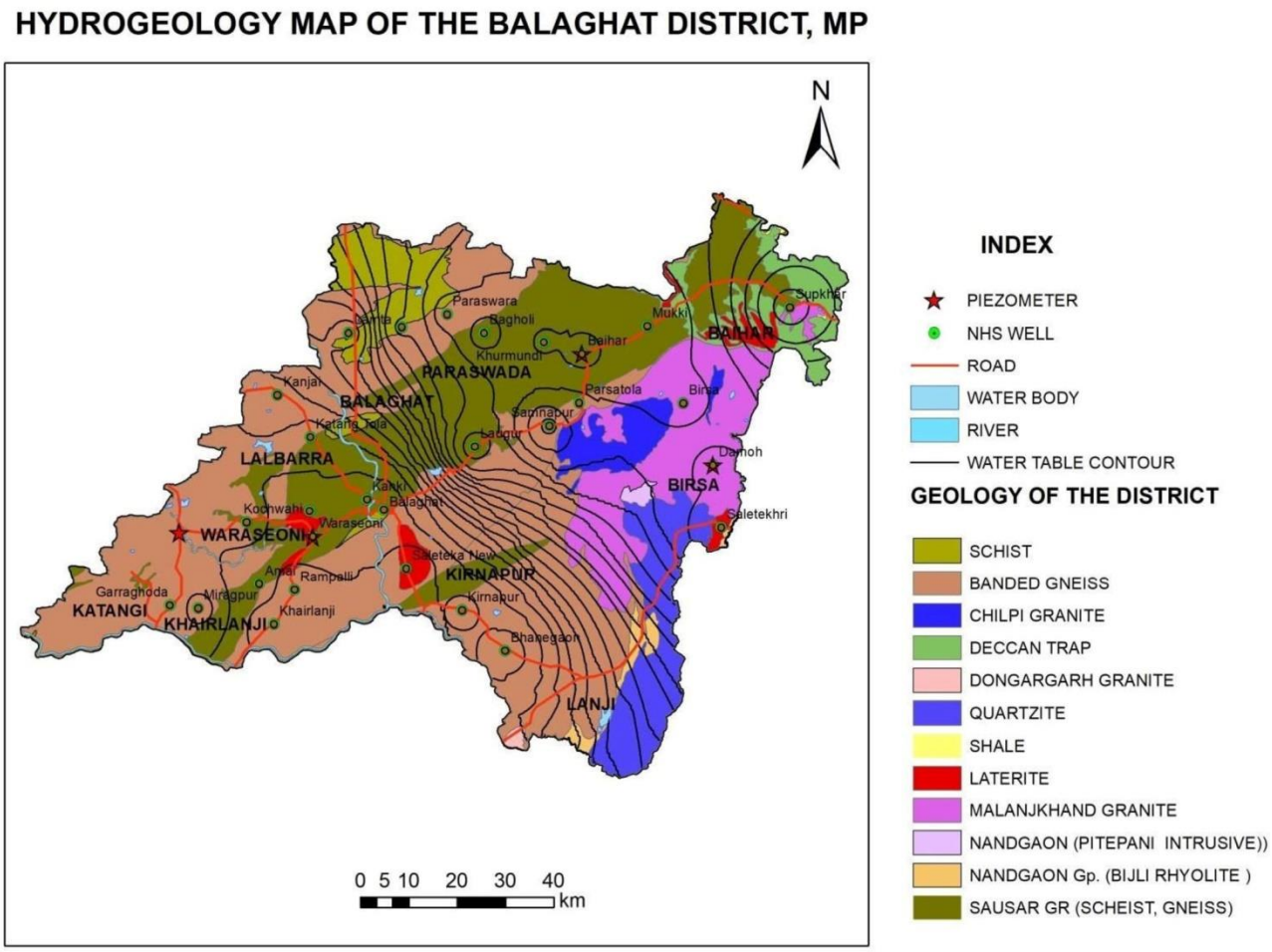


Fig-3.1: Hydrogeological Map of the Balaghat District

3.4 GROUND WATER LEVELS

The present depth to water level scenario of shallow aquifer was generated by utilizing water Level data of 36 monitoring wells representing shallow aquifer as well as deep aquifer.

3.4.1 Pre-monsoon Ground Water Level

A perusal of the pre-monsoon ground water (2021) reveals that in a major part of the district, the ground water levels are between 1.65-14.2 mbgl, in 77.77% area water level is between 3 & 19m **(fig-3.2** and **table-3.1)**. Deeper Ground water levels > 11 m bgl are found in parts of Baihar and Balaghat blocks. Shallower water levels of < 3 mbgl are found in Waraseoni & Kirnapur blocks.

Table-3.1: Premonsoon water level of 2021

DISTRICT_NAME	BLOCK_NAME	VILLAGE_NAME	SITE_NAME	DEPTH	WLS_WTR_LEVEL
BALAGHAT	WARASEONI	Newargaon	Newargaon	10.6	1.65
BALAGHAT	WARASEONI	Waraseoni	Waraseoni1	10.99	2.34
BALAGHAT	KIRNAPUR	Kirnapur	Kirnapur	11.3	2.7
BALAGHAT	BAIHAR	Parsatola	Parsatola	12	2.75
BALAGHAT	PARASWADA	Bagholi	Bagholi	8.5	2.88
BALAGHAT	BAIHAR	Jawaditula	Jawaditula	10	3
BALAGHAT	LALBARRA	Katang Tola	Katang Tola	9	3
BALAGHAT	WARASEONI	Kochwahi	Kochwahi	7.3	3.13
BALAGHAT	BIRSA	Damoh	Damoh2	11	3.3
BALAGHAT	WARASEONI	Amai	Amai	9.1	3.3
BALAGHAT	WARASEONI	Kanki	Kanki	11.7	3.5
BALAGHAT	KHAIRLANJI	Miragpur	Miragpur	11.02	3.7
BALAGHAT	KHAIRLANJI	Khairlanji	Khairlanji	9.1	3.9
BALAGHAT	BIRSA	Damoh	Damoh(S)	33.15	4.21
BALAGHAT	BIRSA	Saletekhri	Saletekhri	12.05	4.55
BALAGHAT	BAIHAR	Baihar	Baihar1	16.1	4.75
BALAGHAT	PARASWADA	Khurmundi	Khurmundi	10.9	4.75
BALAGHAT	BAIHAR	Supkhar	Supkhar	13.9	4.94
BALAGHAT	KHAIRLANJI	Garraghoda	Garraghoda	17.43	5.18
BALAGHAT	LALBARRA	Kanjai	Kanjai	10	5.2
BALAGHAT	PARASWADA	Rangpatbaba	Rangpatbab a	9	5.6
BALAGHAT	BIRSA	Birsa	Birsa	9.9	5.95
BALAGHAT	BAIHAR	Mukki	Mukki	9.5	6.82
BALAGHAT	BALAGHAT	Balaghat	Balaghat	11.2	6.9
BALAGHAT	KATANGI	Katedhara	Katedhara	8.5	7.5
BALAGHAT	KHAIRLANJI	Rampalli	Rampalli	9.66	7.5
BALAGHAT	BALAGHAT	Lamta	Lamta1	12.6	7.6
BALAGHAT	PARASWADA	Paraswara	Paraswara	9.35	7.65
BALAGHAT	KATANGI	Katangi-S	Katangi-S	20.94	8.1
BALAGHAT	BAIHAR	Samnapur	Samnapur	13.65	8.4
BALAGHAT	WARASEONI	Waraseoni	Warase-oni(S)	44.95	9.34
BALAGHAT	KIRNAPUR	Bhanegaon	Bhanegaon	14.5	9.4
BALAGHAT	BAIHAR	Baihar	Baihar(D)	58.2	9.89
BALAGHAT	BAIHAR	Laugur	Laugur	12	11
BALAGHAT	BALAGHAT	Saleteka New	Saleteka New	15.4	14.2

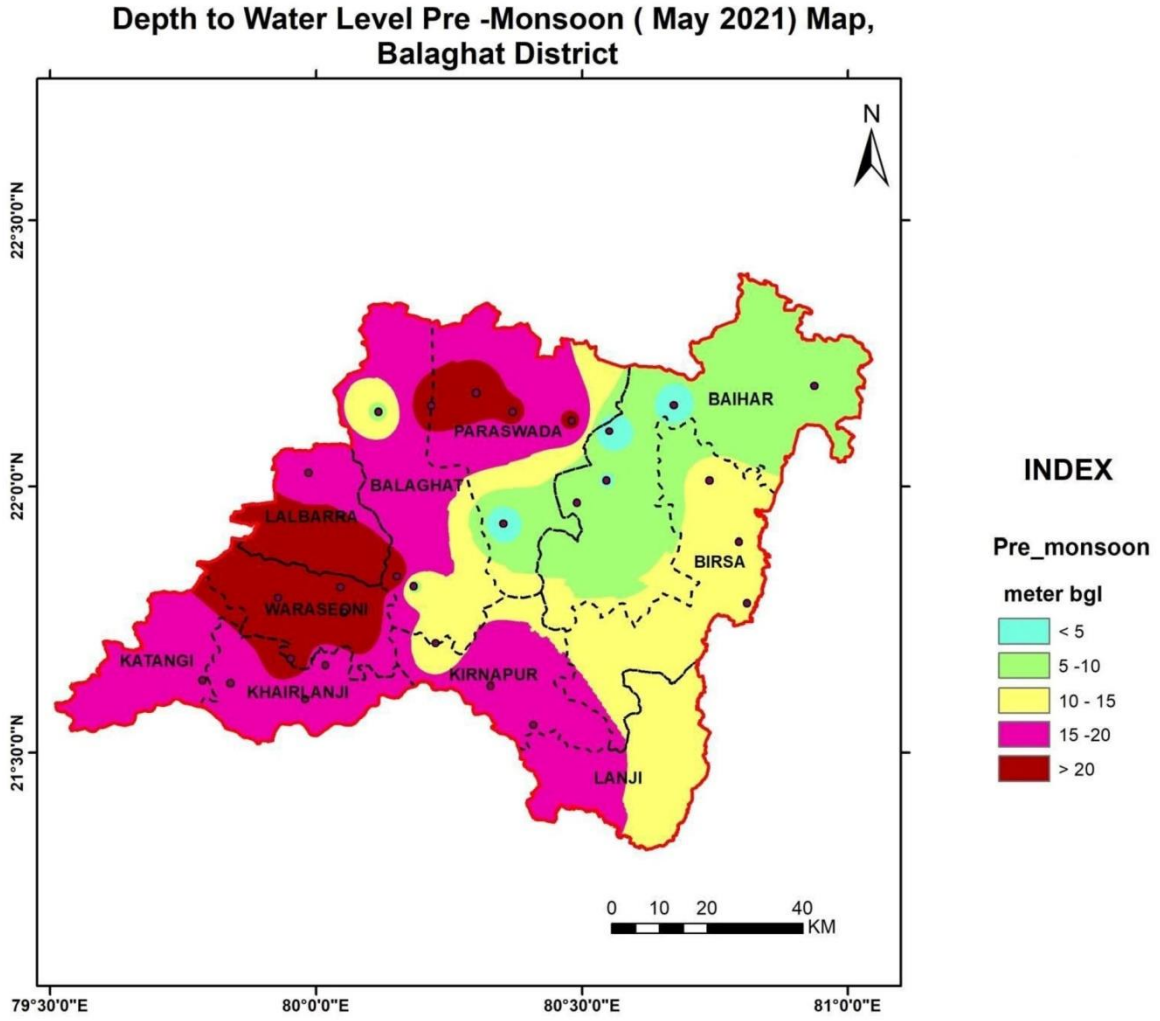


Fig-3.2: Pre-monsoon (May 2021) Depth to Water Level of Shallow Aquifer.

3.4.2 Post –monsoon Ground Water Level

During the post monsoon period (2021), ground water levels, in about 69% area of the district are between 2& 5 m bgl. Shallower water levels of 1-2m bgl are observed in parts of Baihar, Paraswada and Khairlanji Blocks. Deeper water levels of 9-13 m bgl are observed in isolated patch in Balaghat and Kirnapur Blocks **(fig-3.3).**

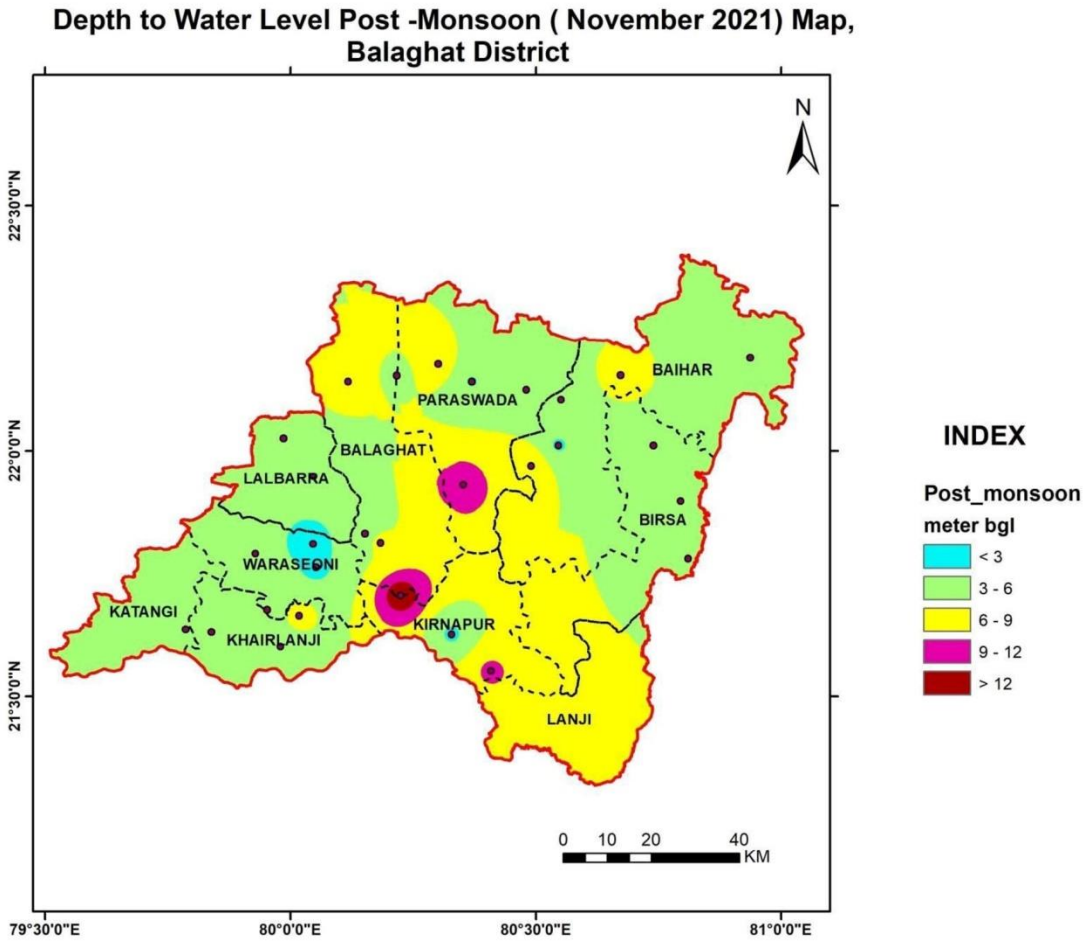


Fig-3.3: Post monsoon (November 2021) Depth to Water Level of Shallow Aquifer, Balaghat district, MP

3.4.3 Long Term Water Level Trend

The long term water level trend (pre monsoon 2012-2021) indicates that 68% wells showing a rising trend between 0.0304 & 0.3816 m/yr whereas 32% showing a decline of 0.1127 m. Hence the Ground Water development is very less in the district. The premonsoon and post-monsoon trend of the district is given in **annexure IV**.

3.4.4 Water level Fluctuation

The water level measured during pre and post monsoon period (2021) was used to compute the seasonal fluctuation. The analysis of water level fluctuation data indicated that minimum water level fluctuation was observed at Waraseoni (0.02m) while maximum water level fluctuation was observed at Lagur (6.77 m) **(fig-3.4)**. The water level fluctuations were grouped under three categories i.e., less, moderate and high and the % of wells in each category was analyzed (**Table 3.2**).

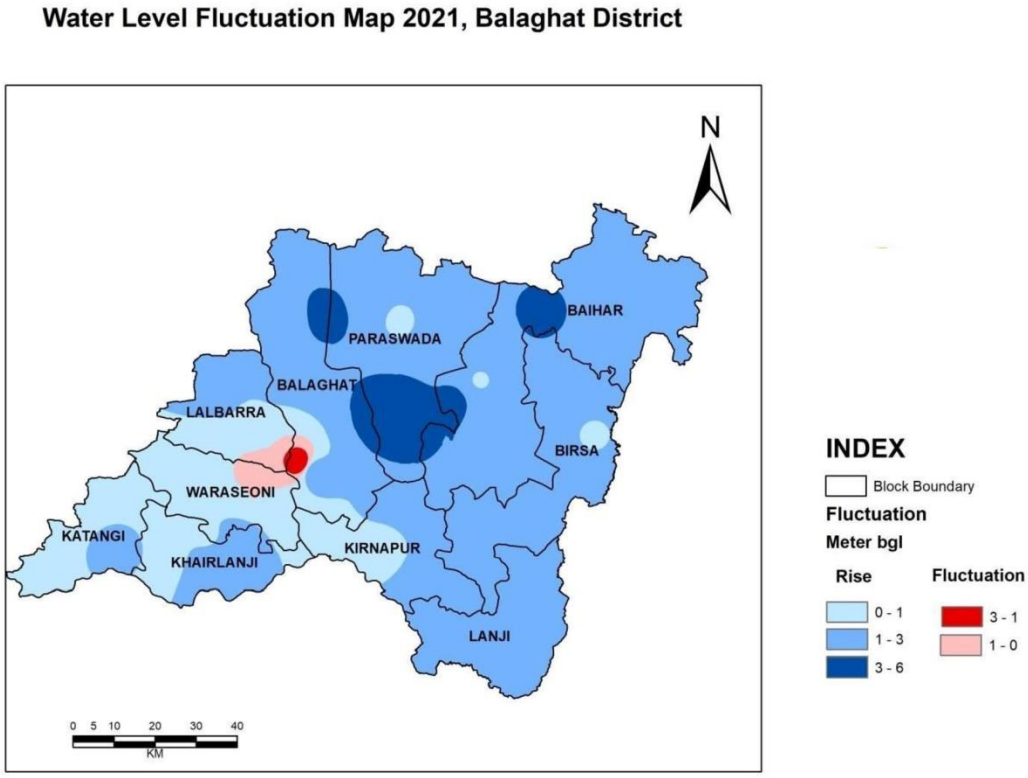


Fig-3.4: Water Level Fluctuation map of Balaghat district, MP

Table-3.2: Analysis of Water Level Fluctuation.

S. No.	Category	Fluctuation Range	% of Wells
1.	Less water level fluctuation	0 to 2 m	48%
2.	Moderate water level fluctuation	2 to 5 m	45%
3.	High water level fluctuation	>5 m	7%

The analysis indicates that majority of the wells (48%) are falling in low fluctuation range indicating aquifer storage is not fluctuating much, whereas moderate water level fluctuation are observed in 45% wells and high water level fluctuation were observed in 7% wells. The seasonal fluctuation map is presented in **Fig. 3.4**.

3.5 GROUND WATER QUALITY

3.5.1 Hydro chemical scenario of Balaghat District

The water samples were collected from National Hydrograph Stations in clean double stoppered poly ethylene bottles from 38 different locations of Balaghat district during May 2020. The water quality details of Balaghat district is given in table-3.3.

3.5.2 Quality of Ground Water for Drinking Purpose:

The ground water samples from Balaghat district have varied range of pH from 6.71 to 7.85. As per BIS (IS 10500:2012) recommendation, all the water samples have pH recorded within the permissible limits of 6.5 to 8.5, the maximum pH recorded in the water sample of Khairlanji (7.85). The pH of ground water can be assessed as neutral to slightly alkaline in nature. The electrical conductivity of ground water samples in Balaghat district varies from 285 to 1760 µS/cm at 25°C. In the district, 28 locations of sample shows EC less than 1000 µS/cm; 8 locations of sample shows EC in between 1000 to 1500 µS/cm and 2 locations of sample shows EC more than 1500 µS/cm from Newargaon (1500) and Miragpur (1760 µS/cm) villages. So, overall ground water quality of Balaghat district is good to saline in nature in few pockets of the districts.

The fluoride concentration in Balaghat district lies in between 0.011 to 1.22 mg/l, which represent that all the samples are within the permissible limit i.e. 1.5 mg/l of BIS standard. The maximum concentration of fluoride has been observed in the dug well of Rangpatbaba village i.e. 1.22 mg/l. The nitrate concentration (fig-3.9) in the Balaghat districts ranges in between 3 to 165 mg/l. In the district, 26.3% samples have nitrate concentration more than the acceptable limit of 45 mg/l, while rest 73.7% samples have concentration less than acceptable limit. Highest concentration of nitrate has been recorded in the village of Miragpur (165 mg/l).

The total hardness in the ground water of the districts ranges between 95 to 695 mg/l. In the district, all the ground water samples recorded total hardness less than BIS permissible limit of 600 mg/l except the ground water of Miragpur village (695 mg/l) i.e. maximum concentration of total hardness.

Piper diagram (fig-3.6) has three parts: a Cation triangle, an Anion triangle, and a Central diamond shaped field. In Cation triangle, the relative percentages of the major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) are plotted. In Anion triangle the major anions ($HCO_3^{-}+CO_3^{2-}$, SO_4^{2-}, Cl^{-}) are plotted. These points are then projected to the central diamond shaped field.

In the district; piper diagram shows that the samples are Calcium-Bicarbonate type (temporary hardness); Mixed type and Calcium chloride type (permanent hardness) types of water. The electrical conductivity diagram is also shown in the fig-3.8.

3.5.3 Quality of Ground Water for Irrigation Purpose:

The classification of water for irrigation purpose, it is assumed that the water will be used for irrigation purpose based upon its soil texture, infiltration rate, drainage and climate. The chemical data of all the water samples from Balaghat district is plotted on U.S. Salinity Laboratory diagram (fig-3.7). and Piper Diagram (fig-3.6).

The USSL diagram shows that the districts falls under C_2-S_1 Class (Medium Salinity & Low Sodium); C_3-S_1 Class (High Salinity & Low Sodium). The ground water of the district may be used for irrigation with proper soil management.

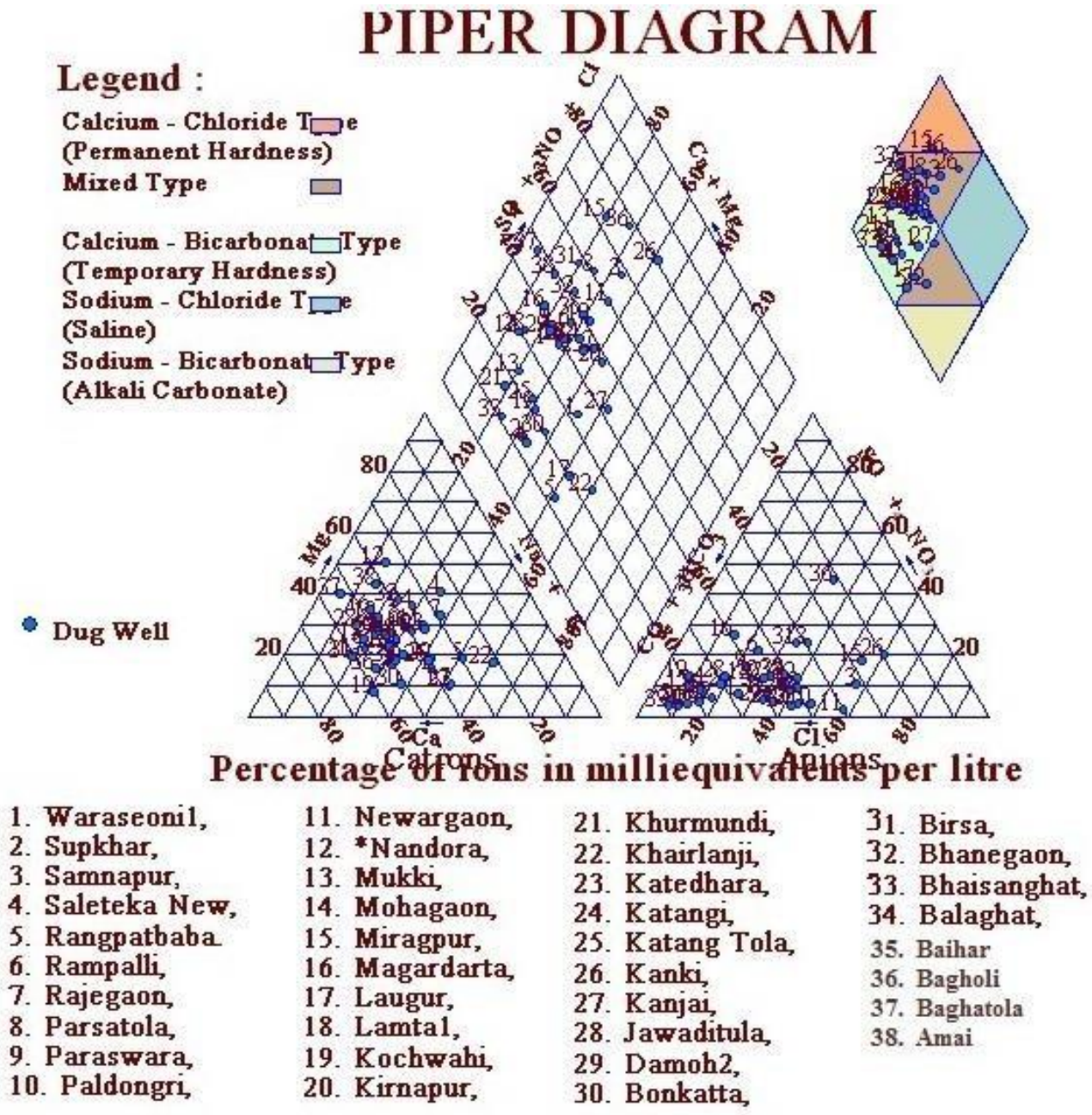
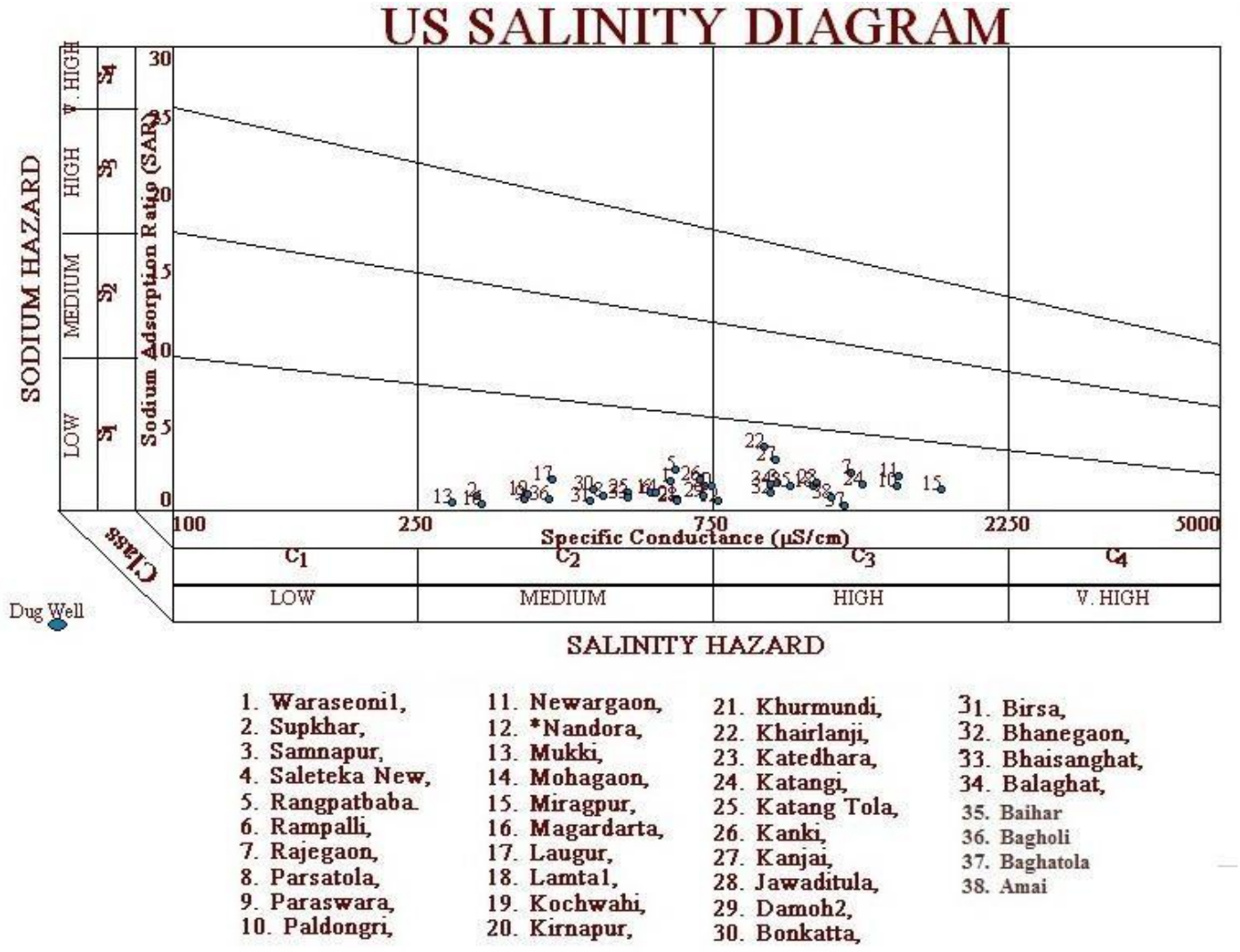


Fig3.6: Piper Diagram representing classification of water samples collected from National Hydrograph Stations, Balaghat District, Madhya Pradesh



1. Waraseoni1,
2. Supkhar,
3. Samnapur,
4. Saleteka New,
5. Rangpatbaba.
6. Rampalli,
7. Rajegaon,
8. Parsatola,
9. Paraswara,
10. Paldongri,
11. Newargaon,
12. *Nandora,
13. Mukki,
14. Mohagaon,
15. Miragpur,
16. Magardarta,
17. Laugur,
18. Lamta1,
19. Kochwahi,
20. Kirnapur,
21. Khurmundi,
22. Khairlanji,
23. Katedhara,
24. Katangi,
25. Katang Tola,
26. Kanki,
27. Kanjai,
28. Jawaditula,
29. Damoh2,
30. Bonkatta,
31. Birsa,
32. Bhanegaon,
33. Bhaisanghat,
34. Balaghat,
35. Baihar
36. Bagholi
37. Baghatola
38. Amai

Fig-3.7: US Salinity Diagram for water samples collected from National Hydrograph Stations of Balaghat District, Madhya Pradesh

Table:3.3 Chemical Quality of Ground Water for Shallow Aquifer

S. No.	District	Block	Location	Lat.	Long.	pH	EC	CO_3	HCO_3	Cl	SO_4	NO_3	F	PO_4	SiO_2	TH	Ca	Mg	Na	K	TDS
						at 25°C	S/cmat 25°C	mg/l													
1	Balaghat	Waraseoni	Amai	21.676	79.952	7.46	1172	0	342	142	15	78	1.06	0.06	31	490	96	61	39	1	762
2	Balaghat	Lanji	Baghatola	21.398	80.627	7.53	1233	0	378	192	12	15	0.10	0.04	30	570	130	60	17	1	801
3	Balaghat	Paraswada	Bagholi	22.142	80.369	6.71	408	0	49	47	14	87	0.01	0.08	21	140	44	7	20	9	265
4	Balaghat	Baihar	Baihar1	22.104	80.551	7.35	1007	0	275	137	15	35	0.17	0.06	32	350	90	30	66	3	655
5	Balaghat	Balaghat	Balaghat	21.813	80.184	7.42	935	0	293	135	10	6	0.10	0.12	31	310	90	21	67	4	608
6	Balaghat	Baihar	Bhaisanghat	22.183	80.714	7.41	549	0	287	15	7	3	0.22	0.29	72	205	52	18	28	1	357
7	Balaghat	Kirnapur	Bhanegaon	21.551	80.408	7.37	932	0	250	122	18	44	0.13	0.07	40	350	70	43	49	1	606
8	Balaghat	Birsa	Birsa	22.011	80.740	7.34	478	0	116	55	14	50	0.13	0.28	63	185	56	11	20	2	311
9	Balaghat	Khairlanji	Bonkatta	21.606	79.763	7.37	482	0	226	27	8	4	0.34	0.43	19	145	48	6	38	5	313
10	Balaghat	Birsa	Damoh2	21.896	80.795	7.63	727	0	250	80	11	9	0.09	0.33	28	275	72	23	35	5	473
11	Balaghat	Baihar	Jawaditula	22.236	80.871	7.48	660	0	250	42	13	32	0.05	0.09	41	270	70	23	21	5	429
12	Balaghat	Lalbarra	Kanjai	22.026	79.986	7.36	953	0	323	100	17	49	0.64	0.12	43	225	70	12	111	4	619
13	Balaghat	Waraseoni	Kanki	21.832	80.152	7.09	720	0	79	150	12	70	0.08	0.06	25	205	56	16	65	5	468
14	Balaghat	Lalbarra	Katang Tola	21.948	80.047	7.63	550	0	244	27	14	9	0.40	0.07	28	190	52	15	35	1	358
15	Balaghat	Katangi	Katangi	21.771	79.803	7.36	1314	0	445	165	9	25	0.60	0.07	36	465	92	57	84	1	854
16	Balaghat	Katangi	Katedhara	21.714	79.797	7.54	1109	0	348	120	14	66	0.28	0.06	30	350	78	38	75	25	721
17	Balaghat	Khairlanji	Khairlanji	21.601	79.979	7.85	912	0	403	60	15	13	1.20	0.10	23	175	38	19	125	2	593
18	Balaghat	Paraswada	Khurmundi	22.125	80.481	7.66	658	0	323	30	9	5	0.07	0.39	18	260	78	16	25	5	428
19	Balaghat	Kirnapur	Kirnapur	21.626	80.329	7.31	749	0	232	105	12	25	0.11	0.08	32	210	56	17	51	36	487
20	Balaghat	Waraseoni	Kochwahi	21.790	79.929	7.41	378	0	171	12	20	3	0.18	0.05	45	125	44	4	26	1	246
21	Balaghat	Balaghat	Lamta1	22.142	80.125	7.43	1095	0	365	127	12	34	0.06	0.08	29	385	104	30	70	2	712
22	Balaghat	Baihar	Laugur	21.930	80.352	7.20	413	0	182	15	14	5	0.13	0.28	23	95	30	5	45	5	268
23	Balaghat	Balaghat	Magardarta	21.966	80.125	7.13	319	0	115	17	9	42	0.02	0.07	31	130	30	13	10	4	207
24	Balaghat	Khairlanji	Miragpur	21.631	79.839	7.15	1760	0	267	327	16	165	0.80	0.07	1	695	190	54	79	2	1144
25	Balaghat	Baihar	Mohagaon	22.052	80.681	7.41	608	0	213	55	5	38	0.24	0.06	43	215	54	19	36	3	395

26	Balaghat	Baihar	Mukki	22.154	80.672	7.33	285	0	122	15	2	10	0.06	0.17	38	110	26	11	11	4	185
27	Balaghat	Lanji	Nandora	21.515	80.618	7.58	770	0	322	52	9	38	0.03	0.07	10	325	54	46	24	1	501
28	Balaghat	Waraseoni	Newargaon	21.811	80.046	7.62	1500	0	352	300	14	5	0.56	0.06	38	485	106	54	109	15	975
29	Balaghat	Lanji	Paldongri	21.471	80.488	7.48	1495	0	419	247	22	7	0.31	1.24	24	495	116	50	78	57	972
30	Balaghat	Paraswada	Paraswara	22.176	80.301	7.44	374	0	128	30	8	26	0.25	0.17	35	140	40	10	18	1	243
31	Balaghat	Baihar	Parsatola	22.012	80.546	6.95	500	0	115	65	17	51	0.04	0.07	37	180	46	16	28	1	325
32	Balaghat	Kirnapur	Rajegaon	21.631	80.250	7.33	1263	0	389	167	13	66	0.16	0.05	40	385	72	50	109	1	821
33	Balaghat	Khairlanji	Rampalli	21.664	80.017	7.45	599	0	188	50	18	54	0.05	0.06	27	210	48	22	36	2	389
34	Balaghat	Paraswada	Rangpatba-ba	22.153	80.217	7.46	655	0	316	17	12	4	1.22	0.09	56	155	38	15	75	1	426
35	Balaghat	Balaghat	Saleteka new	21.705	80.225	7.61	730	0	371	27	7	6	0.20	0.06	43	235	36	35	56	2	475
36	Balaghat	Baihar	Samnapur	21.969	80.490	7.09	955	0	170	182	19	34	0.17	0.09	58	310	86	23	73	1	621
37	Balaghat	Baihar	Supkhar	22.189	80.937	7.45	313	0	146	10	3	3	0.09	0.07	26	100	30	6	21	2	203
38	Balaghat	Waraseoni	Waraseoni1	21.763	80.052	7.26	645	0	243	55	12	11	0.10	0.62	18	175	50	12	57	12	419

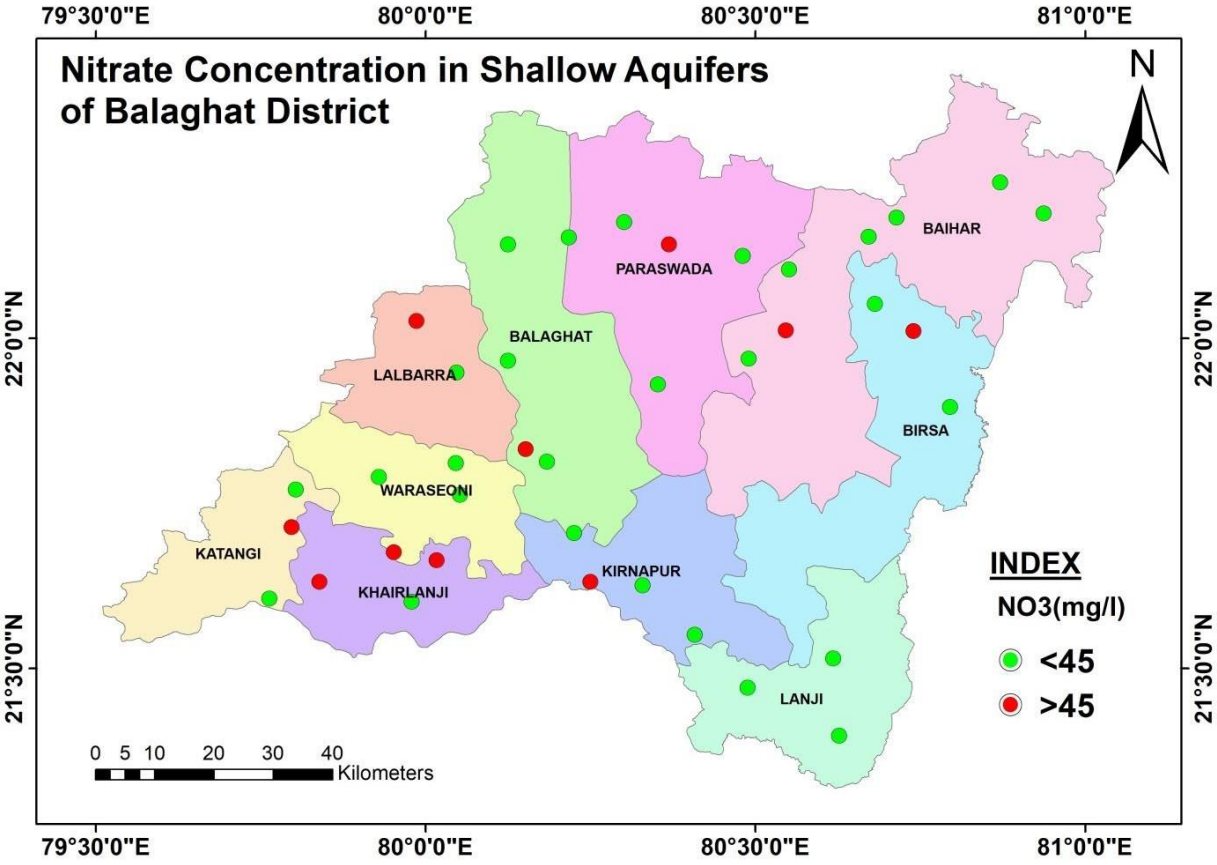


Fig-3.8: Electrical Conductivity of Aquifer-I (Shallow Aquifer).

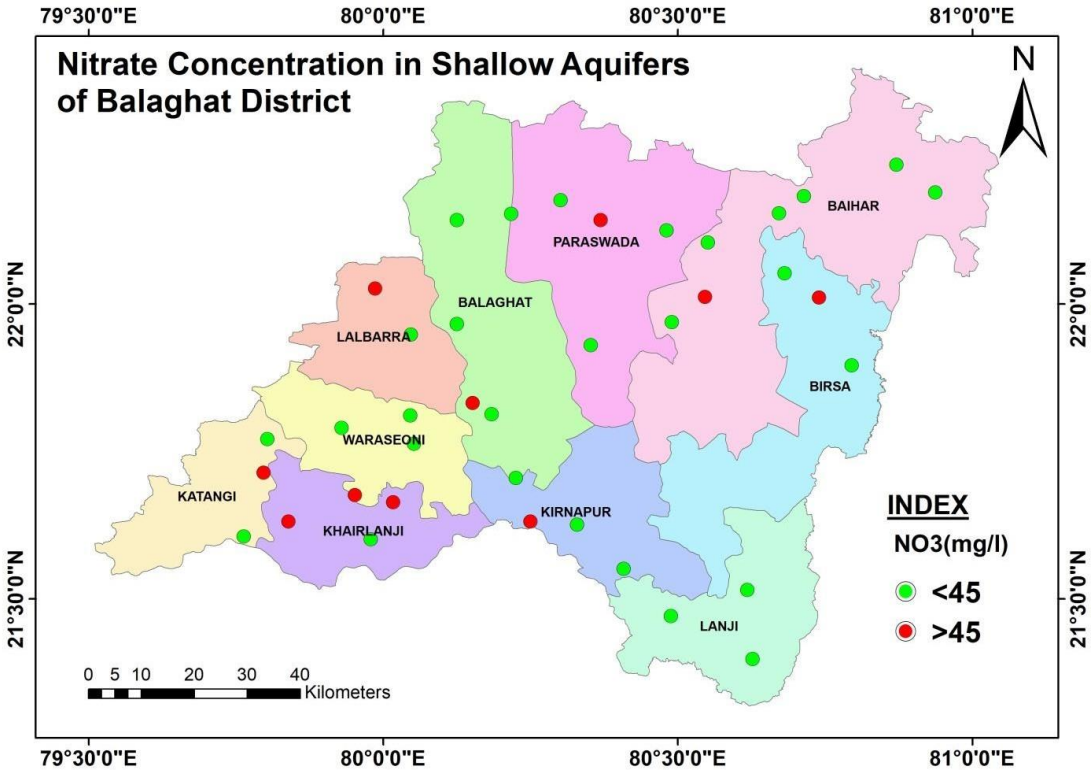


Fig-3.9: Nitrate of Aquifer-I (Shallow Aquifer)

3.6- 3-D and 2-D Aquifer Disposition

The data generated from ground water monitoring wells, micro level hydrogeological inventories, exploratory and observation wells, various thematic layers was utilized to decipher the aquifer disposition of the area. This particularly includes the information on geometry of aquifers and hydrogeological information of these aquifers. In the area the two aquifer systems has been deciphered as listed below:

a. **Aquifer –I (Shallow Aquifer)**
b. **Aquifer – II (Deeper Aquifer)**

3.6.1 Fence Diagram and 3D model

As the area is covered with hard rocks, the thickness of the aquifers is limited. The weathered formations generally form the shallow aquifer, which are extends maximum up to the depth of 30m. The fractured /jointed Banded Gneiss and Schist form deep aquifer. The fence diagram indicating the disposition of various aquifers is presented in **Fig.3.11** and 3-D representation is presented in **Fig. 3.10**. The disposition of Aquifer-I and Aquifer-II and other geological units can be observed in the Fence and 3D diagram.

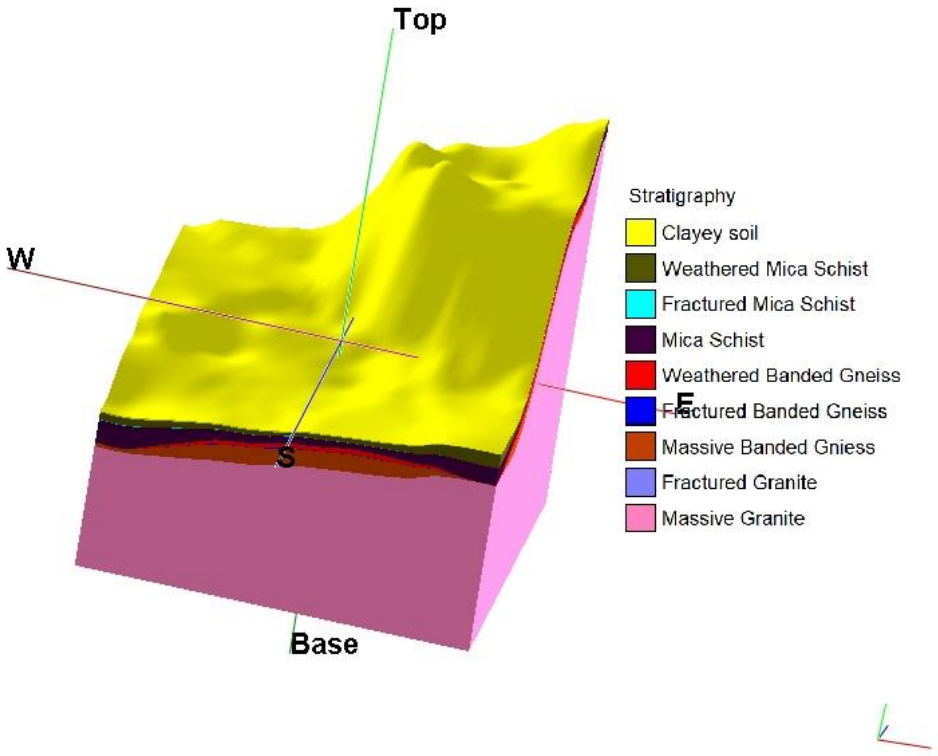


Fig.3.10: 3-D disposition of Aquifers.

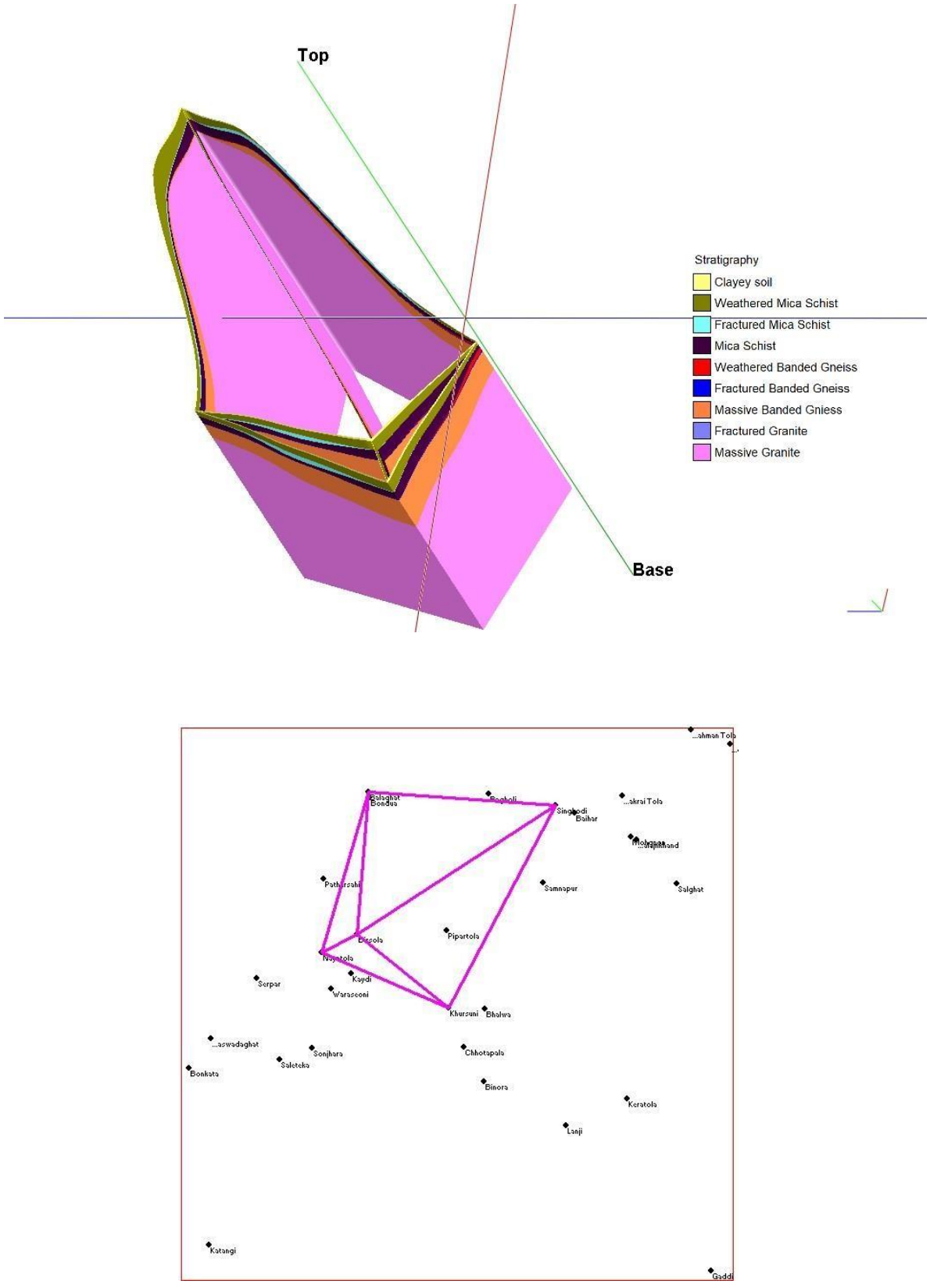


Fig:-3.11(b): Fence diagram of north Balaghat

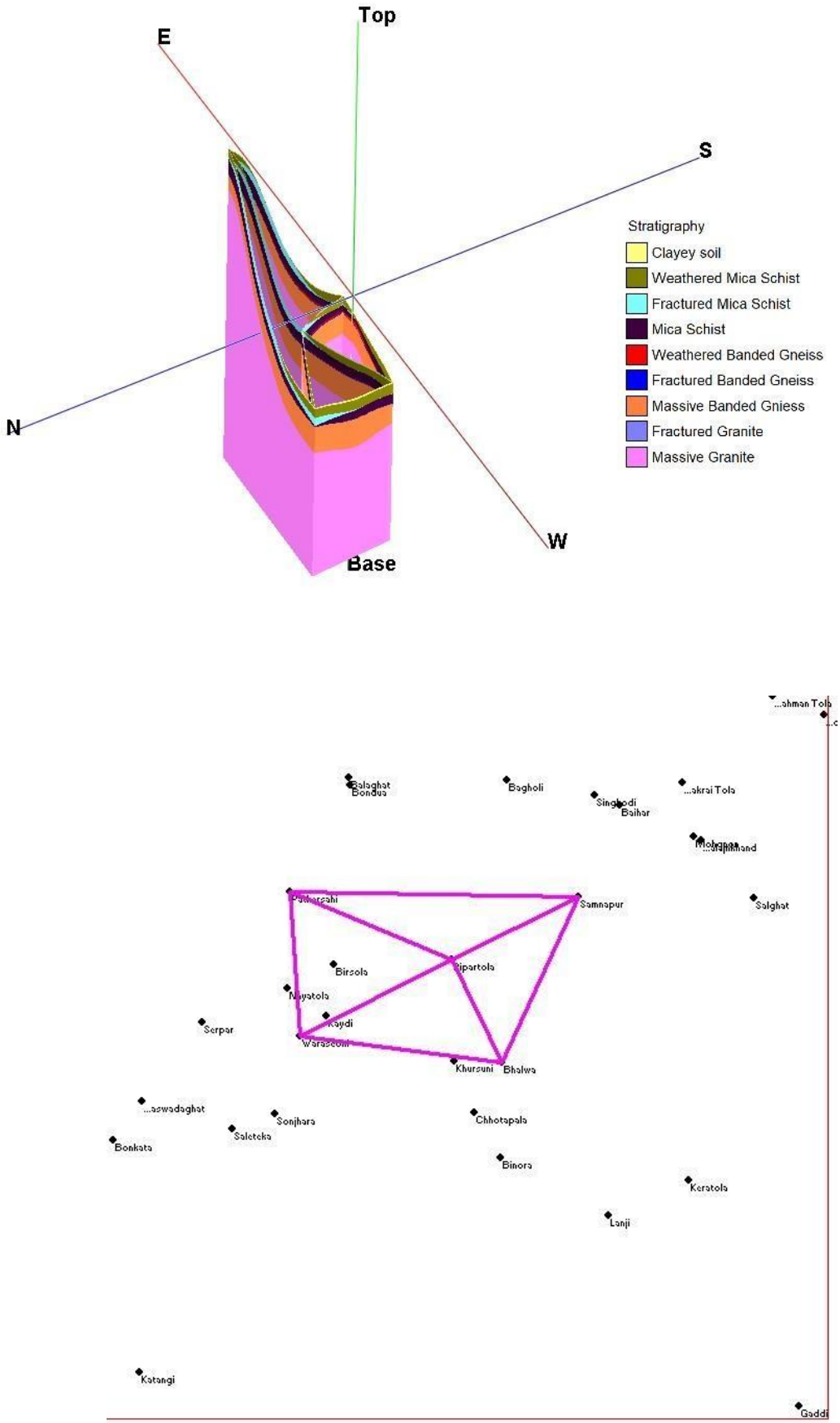


Fig-3.11(a): Fence diagram of Middle Balaghat

3.7 Hydrogeological Cross Sections

To study the aquifer disposition in detail, various hydrogeological cross section indicating aquifer geometry has been prepared viz. A-A' **(fig-3.12)** representing north west – North east direction and B-B' representing north – North East direction.

3.7.1 Hydrogeological Cross Section A-A'

Hydrogeological cross section A-A' (**Fig.3.12**) represents north west – North east direction and data of the wells i.e Bonkatta, Paraswadaghat, Serpar, Pathersahi and Balaghat has been utilised of Balaghat Block.

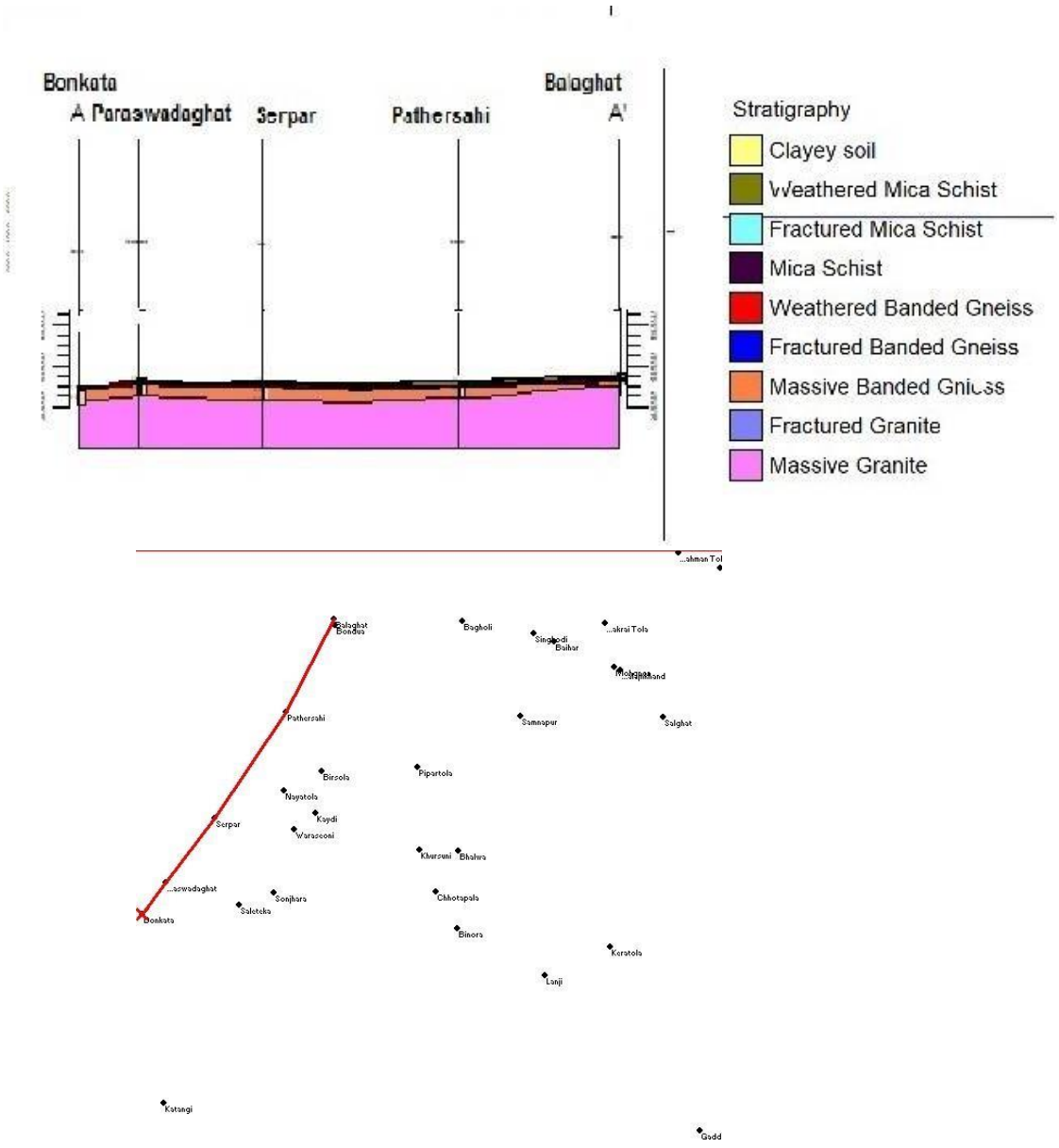


Fig. 3.12: Hydrogeological Cross Section A-A'.

3.7 Hydrogeological Cross Sections

To study the aquifer disposition in detail, various hydrogeological cross section indicating aquifer geometry has been prepared viz. B-B' **(fig-3.13)** representing north west – North east direction and B-B' representing north – North East direction.

3.7.1 Hydrogeological Cross Section B-B'

Hydrogeological cross section B-B' (**Fig.3.12**) represents north west – North east direction and data of the wells i.e Bonkatta, Paraswadaghat, Serpar, Pathersahi and Balaghat has been utilised of Balaghat Block.

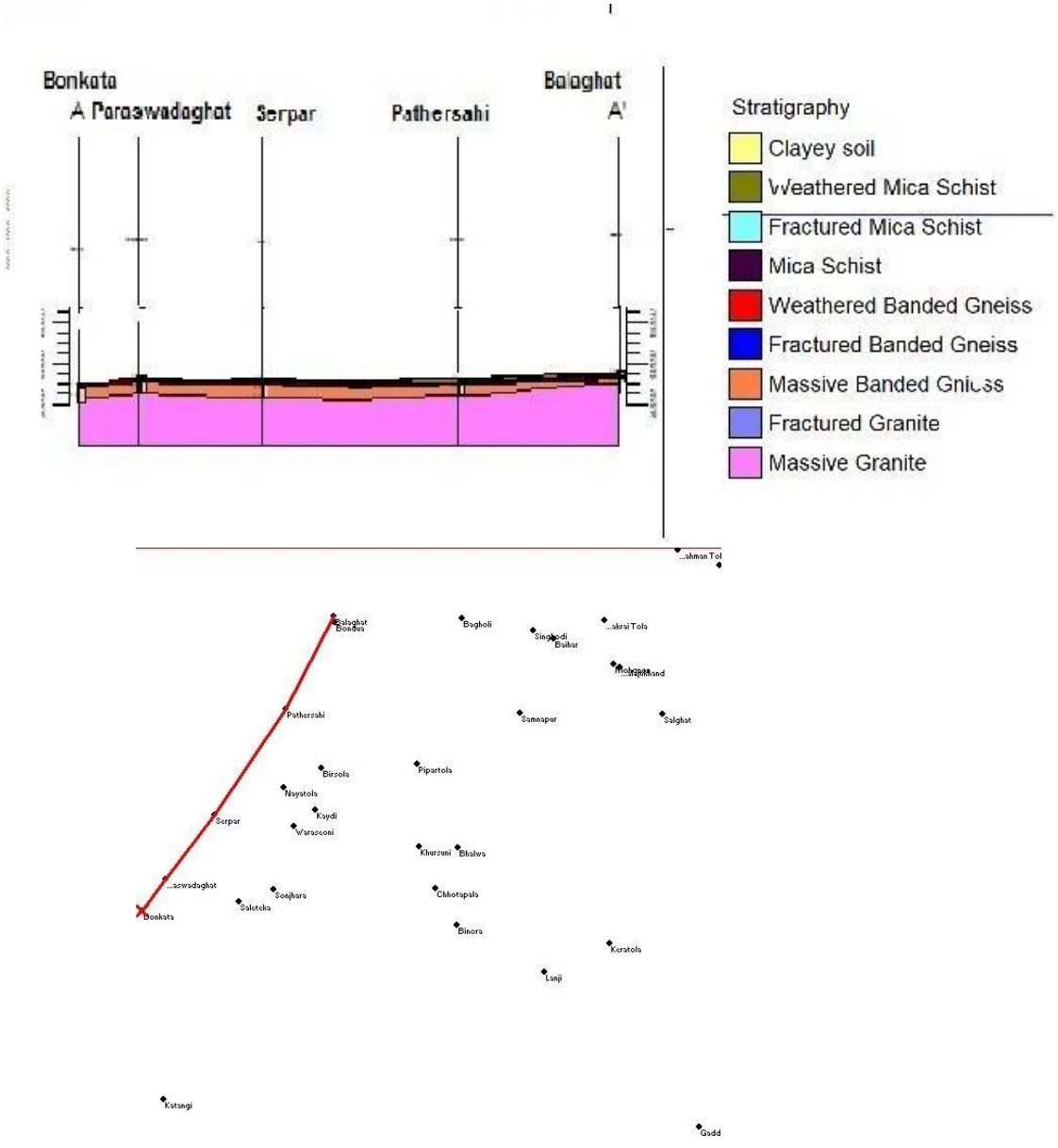


Fig. 3.13: Hydrogeological Cross Section B-B'.

3.8 Aquifer Parameters

The Ground Water occurs under water table and semi confined to confined conditions in all formations of the area. Topographic depressions, nature and extent of weathering, presence of joints and fractures play an important role in the occurrence and movement of ground water. The area occupied by Archean rocks is mostly undulating. The ground water in these rocks occurs under unconfined conditions, which is widely controlled by the weathering of the rocks, presence of joints, fracture and lineament in them.

The area occupied by Deccan trappean rocks, where ground water occurs under phreatic conditions in the weaker zones of weathered, vesicular, fractured and jointed parts of the flows. The sheet joints, basal parts of flows and inter-connection of joints and fractures controls the horizontal as well as vertical movement of ground water. The plateau like topography plays an important role in occurrence and movement of groundwater.

Under semi-confined conditions the ground water occurs at the contacts of two flows and at the contact of trappean rocks with Archean basement. Based on the ground water exploration and key well established in the Balaghat district, the following two types of aquifers can be demarcated and the details are given in **table-3.4.**

Table 3.4: Aquifer Parameters.

Major Aquifer	**Alluvium & Fractured Schist/Gneiss**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Schist/ Gneiss	Jointed / Fractured Gneiss/Schist
Depth of Occurrence (mbgl)	1 to 30	30 to 200
SWL (mbgl)	3-7	7-10
Weathered thickness (m)	2 -50	0.5 to 3
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	Upto 2 lps	Upto 4 lps
Suitability for drinking/ irrigation	Suitable for both drinking and agriculture, except high Nitrate at places	Suitable for both drinking and agriculture, except high Nitrate and Fluoride at places

CHAPTER-4
IV. GROUND WATER RESOURCES

The ground water resources have been assessed for two types of aquifer existing in the area i.e., Aquifer-I and Aquifer-II. The details of the assessment are discussed below.

4.1 Ground Water Resources

The ground water resource assessment has been carried out for Balaghat district and the salient features of the resources are given in **Table 4.1, 4.2 and 4.3.**

As per **Table 4.1**, out of the total 922900 ha area, recharge worthy areas is 891793 ha, command areas is 101503 ha and non-command areas 790290 ha, whereas 31107 ha area is not worthy for recharge on account of its hilly nature.

Table 4.1: Ground Water Recharge worthy Areas for Resource Estimation (2020)

District	Predominant Formation	Total Geo-graphical Area (ha)	Hilly Area (ha)	Recharge worthy area in ha	Ground Water Recharge Worthy Area	
					Command area (ha)	Non-command area (ha)
Balaghat	Granitoid, Banded Gneiss, Schist, Decan Trap	922900	31107	891793	101503	790290

4.1.1 Recharge Component

During the monsoon season, the rainfall recharge is the main recharge parameter, which is estimated as the sum total of the change in storage and gross draft. The change in storage is computed by multiplying groundwater level fluctuation between pre and post monsoon periods with the area of assessment and specific yield. Monsoon recharge can be expressed as:-

$R = h \times Sy \times A + DG$ Where,

h = rise in water level in the monsoon season, Sy = specific yield

A = area for computation of recharge, DG = gross ground water draft

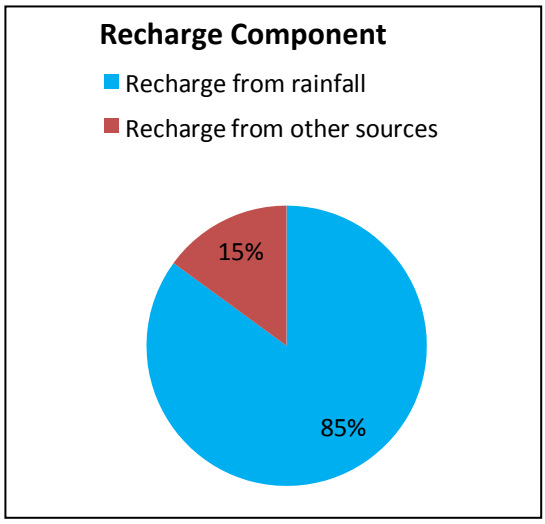
The monsoon ground water recharge has two components- rainfall recharge and recharge from other sources. The other sources of groundwater recharge during monsoon season include seepage from canals, surface water irrigation, tanks and ponds, ground water irrigation, and water conservation structures.

During the non-monsoon season, rainfall recharge is computed by using Rainfall Infiltration Factor (RIF) method. Recharge from other sources is then added to get total non-monsoon recharge.

The season wise assessment of recharge from various components such as rainfall and other sources was done and presented in **Table-4.2** and pie chart for Recharge component and histogram for Ground Water availability is shown in **fig-4.1**.

Table:-4.2 GW Recharge from various component (2020)

District	Recharge from rain-fall during monsoon season (ham)	Recharge from other sources during monsoon season (ham)	Recharge from rain-fall during non-monsoon season (ham)	Recharge from other sources during non-monsoon season (ham)	Total Annual Ground Water Recharge (ham)	Natural discharge (ham)	Annual Extractable Ground Water Resources (ham)
Balaghat	81686.5	1957.93	290.51	2791.18	86726.12	8672.64	78053.48



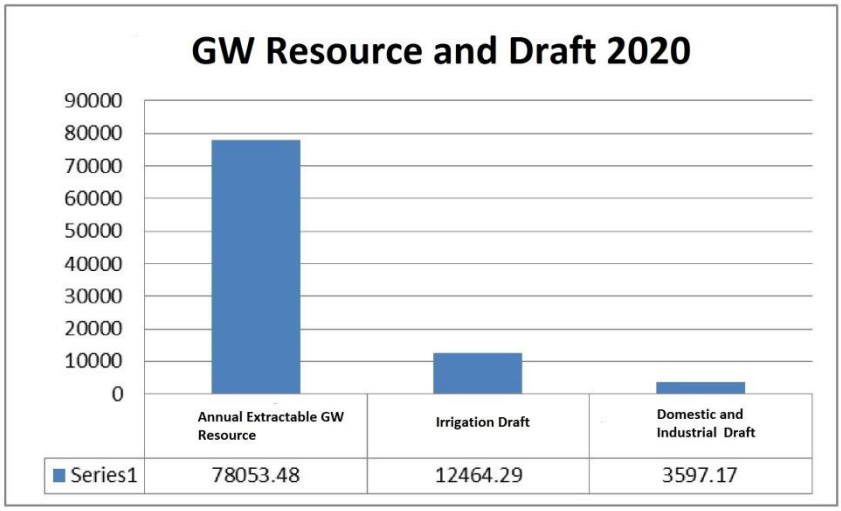


Fig.4.1: Recharge from various sources.

The utilization of available ground water resources for various purposes is provided in **Table 4.3**. The annual gross draft for all uses is estimated at 16061.44 ham with irrigation sector being the major consumer having a draft of 12464.29 ham and ground wateravailable for future use is 61699.41 ham. The stage of ground water extraction is 20.58% and hence all blocks come under safe category.

Table:-4.3 Dynamic Ground water Resource as on March 2020

Assessment Unit Name	Assessment Unit Type	Total Area of Assessment Unit (Ha)	Recharge Worthy Area(Ha)	Annual Extractable Ground Water Resource (Ham)	Ground Water Extraction for Irrigation Use(Ham)	Ground Water Extraction for Domestic and Industrial Use (Ham)	Total Extraction (Ham)	AnnualGW Allocation for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (Over-Exploited/ Critical/ Semi critical / Safe/ Saline)
PARASWADA	BLOCK	124050	116750	9616.31	108	265.53	373.53	287.13	9221.18	3.88	safe
LANGI	BLOCK	86826	85596	7131.95	1119.59	427.86	1547.45	462.67	5549.69	21.69	safe
KATANGI	BLOCK	69779	67679	7090.49	2723.37	407.66	3131.02	440.83	3926.3	44.15	safe
KIRNAPUR	BLOCK	81040	76240	6608.63	1573.2	432.34	2005.55	467.52	4567.91	30.34	safe
BAIHER	BLOCK	129160	127451	10284.68	171	261.22	432.23	282.48	9831.2	4.2	safe
LALBURRA	BLOCK	71592	70232	6125.3	1728.66	420.22	2148.89	454.41	3942.23	35.08	safe
KHAIRLANGI	BLOCK	48788	45388	3987.15	1734.33	361.84	2096.18	391.28	1861.53	52.57	safe
WARASEONI	BLOCK	47603	44403	4624.91	1484.24	252.69	1736.94	273.26	2867.41	37.55	safe
BALAGHAT	BLOCK	122219	121956	11381.76	1705.6	454.96	2160.55	491.97	9184.2	18.98	safe
BIRSA	BLOCK	141543	135798	11202.3	116.3	312.79	429.1	338.23	10747.76	3.83	safe

As a part of NAQUIM project 2020-21, groundwater resources of dynamic and static aquifers were calculated using water level fluctuation methods draft is calculated using unit draft method for each block in Balaghat district as given in the **tables 4.4-4.6** below.

Table: -4.4 In-storage Ground Water Resource of Shallow Aquifer in Balaghat district

		Baihar	Balaghat	Birsa	Kirnapur	Khairlanji	Lanji	Paraswada	Katangi	Lalbarra	Waraseoni
Recharge worthy Area	Sq km	1274.5	1219.56	1357.98	762.4	453.88	855.96	1167.5	676.79	702.32	444.03
Premonsoon (average) depth to water level	m	7.02	9.35	7.12	9.52	5.19	7.56	6.74	6.11	6.03	5.71
Av. depth of Dug well	m	12.48	12.44	10.94	11.92	11.28	12.04	9.42	8.14	9.56	10.44
Specific yield(Sy)%	Fraction	0.008	0.008	0.008	0.008	0.002	0.0095	0.008	0.003	0.009	0.003
Saturated thickness of aquifer (ST)	m	5.46	3.08	3.82	2.4	6.08	4.48	2.68	2.03	3.52	4.72
Resource (A * Sy * ST)	MCM	55.69	30.12	41.51	14.6	5.59	36.48	25.05	4.14	22.31	6.30

Table 4.5: In-storage Ground Water Resources of Deeper Aquifer in Balaghat district

		Baihar	Balaghat	Birsa	Katangi	Khairlanji	Kirnapur	Lalburra	Lanji	Paraswada	Waraseoni
Recharge worthy Area	Sq km	1274.51	1219.56	1358	6767.9	4538.8	7624	7023.2	8589.6	1167.5	4440.3
Thickness of fracture in deeper aquifer(2% of 170m)	m	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Specific yield(Sy)%	Fraction	0.008	0.008	0.008	0.003	0.002	0.008	0.009	0.0095	0.008	0.003
Resource (A * Sy * ST)	MCM	35.69	34.14	38.02	107.85	180.02	325.90	613.79	1119.73	2059.43	3792.96

Table 4.6: Ground water Resources of Balaghat district

	Baihar	Balaghat	Birsa	Katangi	Khairlanji	Kirnapur	Lalburra	Lanji	Paraswada	Waraseoni
Shallow Aquifer										
Dynamic Resources (MCM)	102.85	113.82	112.02	70.90	40	66.08	61.25	71.31	96.16	46.24
In-storage Resources (MCM)	55.69	30.117	41.51	14.64	5.52	36.43	25.06	4.14	22.30	6.29
Total Resources (MCM)	**158.54**	**143.93**	**153.53**	**85.54**	**45.39**	**102.52**	**86.31**	**75.46**	**118.46**	**52.54**
Irrigation Draft	1.71	17.05	1.16	27.23	17	15.73	17.28	11.19	1.08	14.84
Domestic+Industries Draft	2.61	4.550	3.12	4.27	4	4.32	4.20	4.27	2.65	2.52
Total GW Draft (MCM)	4.32	21.60	4.29	31.51	20.96	20.05	21.48	15.47	3.73	17.36
Deeper Aquifer										
Static Resources (MCM)	**35.69**	**34.14**	**38.02**	**107.85**	**180.02**	**325.90**	**613.79**	**1119.73**	**2059.43**	**3792.96**
GW Draft (MCM	3.00	45.70	8.30	11.76	4.75	15.20	45.45	90.20	0.00	72.84
Total GW Resources (MCM)	194.23	178.08	191.56	193.40	225.42	428.43	700.11	1195.19	2177.90	3845.51
Gross Ground Water Draft (MCM)	7.32	67.30	12.59	43.27	25.71	35.25	66.93	105.67	3.73	90.20

CHAPTER-5
V. GROUND WATER RELATED ISSUES

In the district there are some Groundwater issues which are described both in quantity and quality wise as follows.

5.1 -Low Ground Water Potential / Limited Aquifer Thickness / Sustainability

The district is covered mostly with hard rock i.e. Schist and Banded Gneiss and Achaean Granitoid. These hard rocks don't have primary porosity and are impermeable. So they can form aquifers only when they are weathered, fractured and jointed. So the depth of weathering in shallow aquifer and aquifer thickness in deeper aquifers are limited. Sustainability of both the aquifers is limited.

5.2 Inferior Ground Water Quality

The maximum concentration of fluoride has been observed in the dug well of Rangpatbaba village i.e. 1.22 mg/l. The nitrate concentration in the Balaghat districts ranges in between 3 to 165 mg/l. In the district, 26.3% samples have nitrate concentration more thanthe acceptable limit of 45 mg/l, while rest 73.7% samples have concentration less than acceptable limit. Highest concentration of nitrate has been recorded in the village of Miragpur (165 mg/l).

The details about groundwater quality of both shallow and deep aquifers have been already discussed in **Chapter-3**.

CHAPTER-6

VI. GROUND WATER MANAGEMENT STRATEGIES

As discussed in previous chapter, there are some groundwater related issues owing to many socio-economic and hydrogeological reasons. The groundwater management plan for Balaghat district has been made keeping in view the area specific details and includes the strategies like enhancing the ground water draft through the construction of new bore wells and dug wells etc and proper study for tracing of the lineaments which are to be recharged artificially.

6.1. Ground Water Development plan

An Aquifer Management Plan for Balaghat district in the State has been prepared block wise for enhancing the ground water utilization in the district as the present stage of extraction is meagerly 21% only. Each plan discusses the broad framework of ground water situation in the block, status of water availability and exiting draft of the District. It is proposed to increase the overall Stage of Ground Water Extraction to about 59% in the district after suitable management interventions.

In Balaghat district, after 2020 water resource assessment all blocks are under safe category. Ten blocks i.e., Baihar, Balaghat, Birsa, Katangi, Khairlanji, Kirnapur, Lalburra, Lanji, Paraswada and Waraseoni blocks are having less than 60% stage of groundwater development. Adoption of suitable water abstraction structures in Baihar, Balaghat, Birsa, Katangi, Khairlanji, Kirnapur, Lalburra, Lanji, Paraswada and Waraseoni blocks will increase the draft and stage of groundwater extraction reached up to 59% **(Table-6.1).** Since the district is covered with hard rocks, the potential aquifer zones are very limited. However, the areas with higher intensity of lineaments as shown in figure **(Fig-6.1)** can be demarked for ground water extraction.

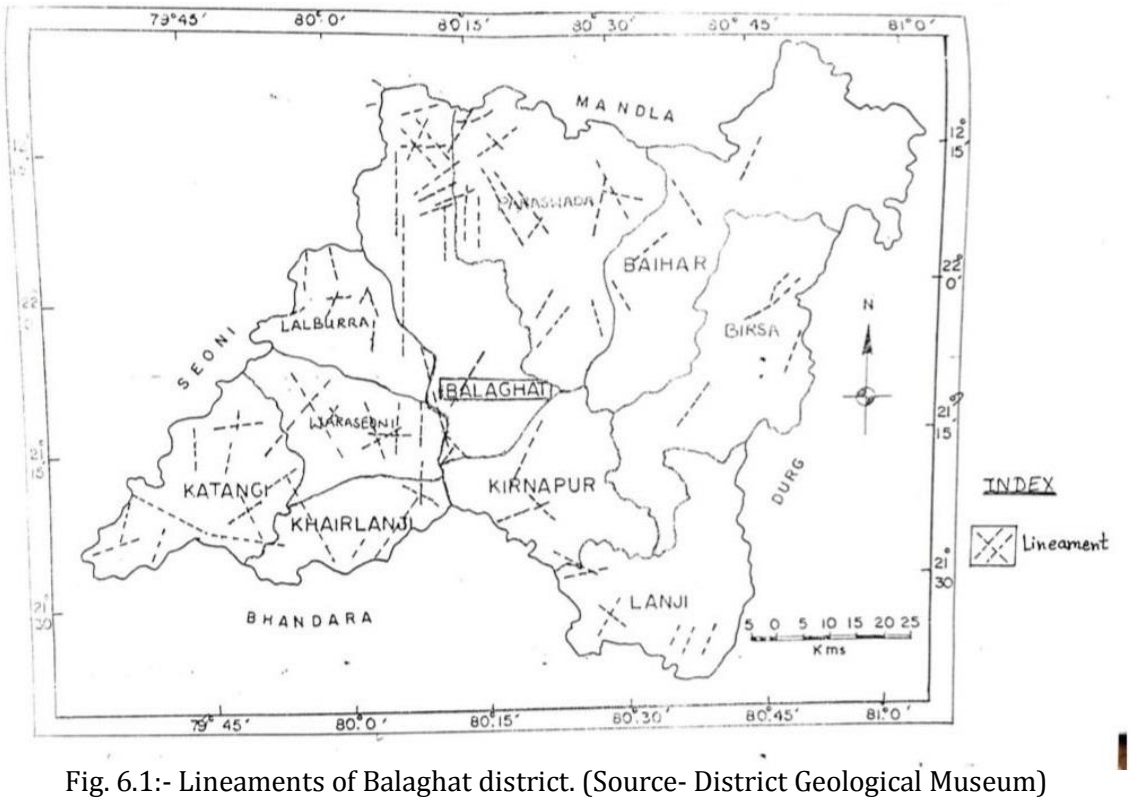


Fig. 6.1:- Lineaments of Balaghat district. (Source- District Geological Museum)

6.2 Solution for Fluoride Contamination in groundwater

As a part of the management strategies, solution for fluoride contamination is as given below.

1. Artificial recharge of wells contaminated with Fluoride and dilution: this is the most effective and simplest method for getting fluoride free water from deep bore wells. Due to shallow water levels and unavailability of subsurface storage, it is not possible to recharge the shallow aquifers. However, deep aquifers can be recharged through existing bore wells/hand pumps etc.

2. Lowering of well assembly **(Fig-6.2):** Another method for obtaining fluoride free water from affected wells is lowering of assembly for sealing the contaminated zone thereby tapping only the available fresh water zone above or below fluoride affected aquifer.

3. Chemical treatment known as Nalgonda technique in which contaminated water is mixed with alum, lime and bleaching powder.

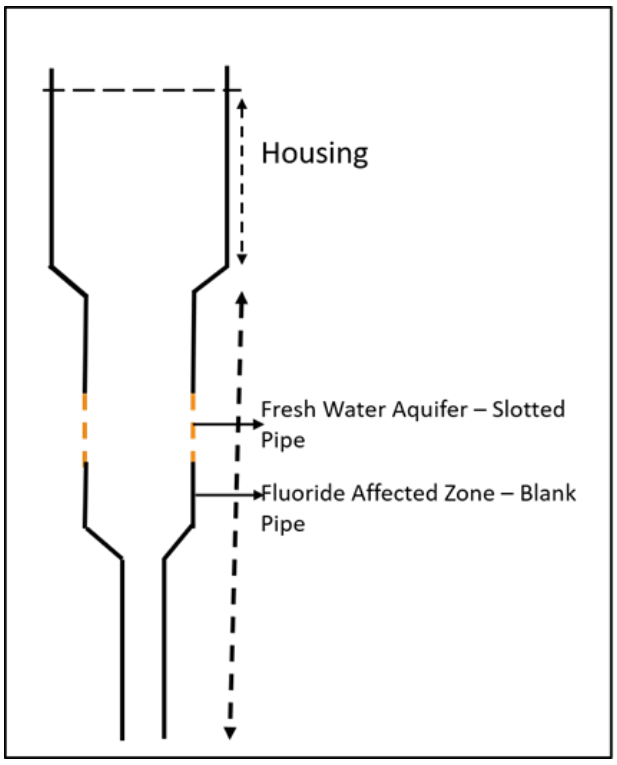


Fig.6.2: Well Assembly for fluoride contaminated well

Table 6.1:- Ground Water Management plan

Block	Annual Extractable GW resource (MCM)	Gross Draft (MCM)	Stage of GW Extraction (%)	Additonal draft Proposed (MCM)	Gross Draft(MCM)	Net Extractable GW resource after utilising additional draft(MCM)	Stage of GW Extraction (%)after intervention	Unit Draft (Non-monsoon) (MCM)		Proposed abstraction structures	
								Dugwell	Bore Well	Dug well	Bore well
Baihar	102.85	4.32	4.20	34.97	39.29	67.88	57.88	0.25	0.1	49	52
Balaghat	113.82	21.61	18.98	28.45	50.06	85.36	58.64	0.31	0.695	32	6
Birsa	112.02	4.29	3.83	33.61	37.90	78.42	48.33	0.35	0.6	34	8
Katangi	70.9	31.31	44.16	7.09	38.40	63.81	60.18	0.62	0.55	4	2
Khairlanji	39.87	20.96	52.57	3.19	24.15	36.68	65.84	0.36	0.69	3	1
Kirnapur	66.080	20.050	30.300	13.22	33.27	52.86	62.93	0.3	0.69	15	3
Lalburra	61.250	21.480	35.080	9.19	30.67	52.06	58.91	0.62	0.59	5	2
Lanji	71.310	15.470	21.700	17.83	33.30	53.48	62.26	0.36	0.79	17	3
Paraswada	96.160	3.730	3.800	32.69	36.42	63.47	57.39	0.42	0.64	27	8
Waraseoni	46.240	17.360	37.560	6.94	24.30	39.30	61.82	0.69	0.6	4	2
Total	**780.50**	**160.58**	**20.57**	**187.17**	**347.75**	**593.33**	**59.00**	**4.28**	**5.945**	**190**	**88**

PART-II: BLOCK WISE AQUIFER MANAGEMENT PLANS

1. AQUIFER MAPS AND MANAGEMENT PLAN OF BALAGHAT BLOCK

1. 1 SALIENT INFORMATION			
Block	**BALAGHAT**		
Area		Sq Km	1222.19
Population (2011 CENSUS)			269352
Normal Rain-fall(2017-20)		millimeter	1168.12
Land use and Agriculture	Principal crops		Wheat, rice, vegetables, fruits, Cereals, Fibre, Pulses, Oil seeds, Sugarcane
	Gross cropped area	Sq Km	466.05
	Net sown area		290.90
	Area sown more than once		175.15
	Cropping intensity	%	160
	Area under forest	Sq Km	783.08
	Area under Waste land		24.46
Data Utilized	Monitoring Wells for Water Level		Dw-4 , Pz-1
	Monitoring Wells for Quality		Dw-4
Water level behavior	Pre-monsoon WL	meter	9.35
	Post-monsoon WL		6.59
	Pre-monsoon WL Trend	(m /yr.)	Rising 0.0732
	Post-monsoon WL Trend		Rising 0.767

1.2 AQUIFER DISPOSITION		
Major Aquifer	**Banded Gneiss**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Gneiss	Jointed / Fractured Banded Gneiss
Depth of Occurrence (mbgl)	1 to 30	30 to 200
SWL (mbgl)	9.56	9.56
Weathered thickness (m)	0.00-20.00	2.0-3.0
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield (M^3/day)	20-40	150-1123
Transmissivity (m^2/day)	-	

As the area is covered with hard rocks, the thickness of the aquifers is limited. The weathered formations generally form the shallow aquifer, which are extends maximum up to the depth of 20 m. The fractured /jointed Banded Gneiss form the deeper aquifer.

1.3 GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION AND OTHER ISSUES

DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Banded Gneiss	
	Recharge worthy area	Sq Km	1357.98
	Command area		188.9
	Non-Command area		1030.66
	Recharge From Rain Fall During Monsoon Season	MCM	119.4225
	Recharge From other sources During Monsoon Season		2.7582
	Recharge From Rain Fall During Non-Monsoon Season		0.4247
	Recharge From other sources During non-Monsoon Season		3.8586
	Total Recharge		126.464
	Annual Extractable Groundwater Recharge		113.82
	Existing Gross Ground Water Draft for Irrigation		17.056
	Existing Gross Ground Water Draft for Industrial Water Supply		0
	Existing Gross Ground Water Draft for Domestic Water Supply		4.550
	Existing Gross Ground Water Draft for All Uses		21.606
	Annual GW Allocation for Domestic Use ason 2025		4.9197
	Net Ground Water Availability for Future Development		91.842
	Stage of Ground Water Extraction	**%**	18.98
	Category		**SAFE**
Static Resource Of Shallow Aquifer		MCM	30.117
Static Resource Of Deep Aquifer			34.148

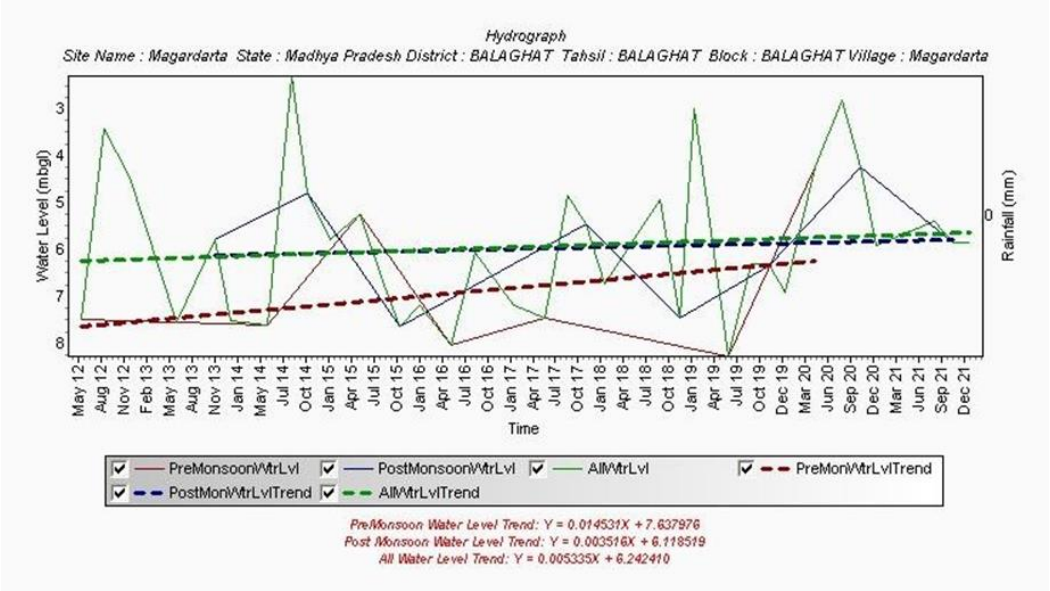


Fig.1.1: Hydrograph (2012-21), Village- Magardarta, Block- Balaghat District.

1.3.1 Ground Water Related Issues	
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High runoff	As the block is covered with hard Banded Gneiss there is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

Based on available datas the management plan of Balaghat district has been prepared which is given as follows in the table below-

Block	**Annual Extractable GW resource (MCM)**	**Gross Draft (MCM)**	**Stage of GW Extraction (%)**	**Additonal draft Proposed (MCM)**	**Gross Draft(MCM)**	**Net Extractable GW resource after utilising additional draft(MCM)**	**Stage of GW Extraction (%)after intervention**	**Unit Draft (Non-monsoon) (MCM)**		**Proposed abstraction structures**	
								Dugwell	**Bore Well**	**Dug well**	**Bore well**
Balaghat	113.82	21.61	18.98	28.45	50.06	85.36	58.64	0.31	0.695	32	6

2. AQUIFER MAPS AND MANAGEMENT PLAN OF BAIHAR BLOCK

2. 1 SALIENT INFORMATION			
Block	**Baihar**		
Area		Sq Km	1291.60
Population (2011 CENSUS)			**155718**
Normal Rain-fall(2015-19)		millimeter	1168.12
Land use and Agriculture	Principal crops		Wheat, rice, vegetables, fruits, Cereals, Fibre, Pulses, Oil seeds, Sugarcane
	Gross cropped area	Sq Km	339.15
	Net sown area		249.19
	Area sown more than once		89.96
	Cropping intensity	%	136
	Area under forest	Sq Km	841.31
	Area under Waste land		90.66
Data Utilized	Monitoring Wells for Water Level		DW-9 , Pz-2
	Monitoring Wells for Quality		Dw-9
Water level behavior	Pre-monsoon WL	meter	7.023
	Post-monsoon WL		3.55
	Pre-monsoon WL Trend	(m /yr)	Rising 0.25104
	Post-monsoon WL Trend		Rising 0.04446

2.2 AQUIFER DISPOSITION		
Major Aquifer	**Mica Schist/ Banded Gneiss**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Schist/Gneiss	Jointed / Fractured Schist or Gneiss
Depth of Occurrence (mbgl)	1 to 30	30-200
SWL (mbgl)	5.95	9.89
Weathered thickness (m)	0-25	2 -3
Fractures encountered (mbgl)	Upto 20	Upto 60
Yield	20-40	150-1123
Transmissivity (m^2/day)	-	

As the area is covered with hard rocks, the thickness of the aquifers is limited. The weathered formations generally form the shallow aquifer, which are extends maximum up to the depth of 25 m. The fractured /jointed Schist or Gneiss forms the deeper aquifer.

2.3 GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION AND OTHER ISSUES

DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Mica Schist, Banded Gneiss	
	Recharge worthy area	Sq Km	1274.51
	Command area		0
	Non-Command area		1274.91
	Recharge From Rain Fall During Monsoon Season	MCM	112.4662
	Recharge From other sources During Monsoon Season		0.6374
	Recharge From Rain Fall During Non-Monsoon Season		0.40
	Recharge From other sources During non-Monsoon Season		0.7707
	Total Recharge		114.2743
	Annual Extractable Groundwater Recharge		102.8468
	Existing Gross Ground Water Draft for Irrigation		1.71
	Existing Gross Ground Water Draft for Industrial Water Supply		0
	Existing Gross Ground Water Draft for Domestic Water Supply		2.61
	Existing Gross Ground Water Draft for All Uses		4.32
	Annual GW Allocation for Domestic Use ason 2025		2.8248
	Net Ground Water Availability for Future Irrigation Development		98.312
	Stage of Ground Water Extraction	**%**	4.20
	Category		**Safe**
Static Resource Of Shallow Aquifer		MCM	55.69
Static Resource Of Deep Aquifer			35.69

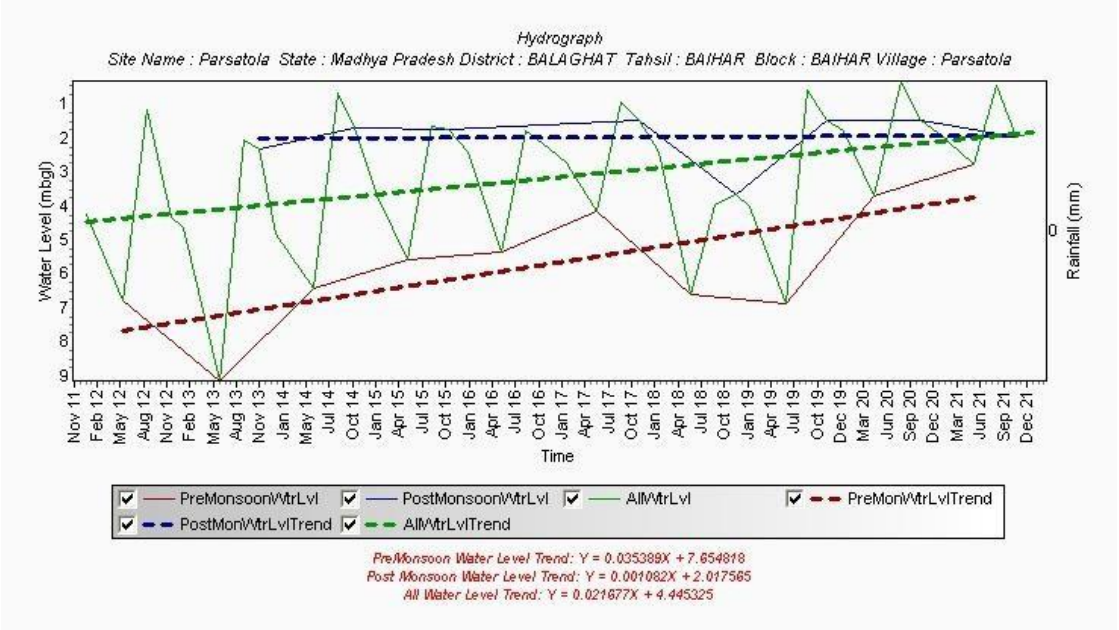


Fig.2.1: Hydrograph (2011-21), Village- Parsatola, Block- Baihar, Balaghat District.

2.3.1 Ground Water Related Issues	
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High runoff	As the block is covered with Mica Schist and Banded Gneiss there is restricted depth of weathering (< 25 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the Aquifers are limited.

Based on available datas the management plan of Baihar district has been prepared which is given as follows in the table below

Block	**Annual Extractable GW resource (MCM)**	**Gross Draft (MCM)**	**Stage of GW Extraction (%)**	**Additonal draft Proposed (MCM)**	**Gross Draft(MCM)**	**Net Extractable GW resource after utilising additional draft(MCM)**	**Stage of GW Extraction (%)after intervention**	**Unit Draft (Non-monsoon) (MCM)**		**Proposed abstraction structures**	
								Dugwell	**Bore Well**	**Dug well**	**Bore well**
Baihar	102.85	4.32	4.20	34.97	39.29	67.88	57.88	0.25	0.1	49	52

3.AQUIFER MAPS AND MANAGEMENT PLAN OF BIRSA BLOCK

3. 1 SALIENT INFORMATION			
Block	**Birsa**		
Area		Sq Km	1415.43
Population (2011 CENSUS)			128634
Normal Rain-fall(2017-20		millimeter	1168.12
Land use and Agriculture	Principal crops		Wheat, rice, vegetables, fruits, Cereals, Fibre, Pulses, Oil seeds, Sugarcane
	Gross cropped area	Sq Km	535.5
	Net sown area		459.85
	Area sown more than once		75.65
	Cropping intensity	%	1.16
	Area under forest	Sq Km	839.38
	Area under Waste land		50.58
Data Utilized	Monitoring Wells for Water Level		Dw-3 , Pz-1
	Monitoring Wells for Quality		Dw-3
Water level behavior	Pre-monsoon WL	meter	7.12
	Post-monsoon WL		3.79
	Pre-monsoon WL Trend	(m /yr)	Falling- 0.09999
	Post-monsoon WL Trend		Rising- 0.01673

3.2 AQUIFER DISPOSITION		
Major Aquifer	**Alluvium/Basalt**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Gneiss/ Granite	Jointed / Fractured Gneiss or Granite
Depth of Occurrence (mbgl)	1 to 30	30 to 200
SWL (mbgl)	4.6	4.21
Weathered thickness (m)	2 to 20	0.50 to 3
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

As the area is covered with hard rocks, the thickness of the aquifers is limited. The weathered formations generally form the shallow aquifer, which are extends maximum up to the depth of 20 m. The fractured /jointed Granite form the deeper aquifer.

3.3 GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION AND OTHER ISSUES

DYNAMIC GROUNDWA-TER RE-SOURCES 2020	Type of Rock formation	Granite	
	Recharge worthy area	Sq Km	1357.98
	Command area		0
	Non-Command area		1357.98
	Recharge From Rain Fall During Monsoon Season	MCM	122.4336
	Recharge From other sources During Monsoon Season		0.883
	Recharge From Rain Fall During Non-Monsoon Season		0.4354
	Recharge From other sources During non-Monsoon Season		0.718
	Total Recharge		124.47
	Annual Extractable Groundwater Recharge		112.023
	Existing Gross Ground Water Draft for Irrigation		1.163
	Existing Gross Ground Water Draft for Indus-trial Water Supply		00
	Existing Gross Ground Water Draft for Domes-tic Water Supply		3.128
	Existing Gross Ground Water Draft for All Uses		4.291
	Annual GW Allocation for Domestic Use ason 2025		3.3823
	Net Ground Water Availability for Future Irrigation Development		107.4776
	Stage of Ground Water Extraction	**%**	3.83
	Category		**SAFE**
Static Resource Of Shallow Aquifer		MCM	41.514
Static Resource Of Deep Aquifer			38.023

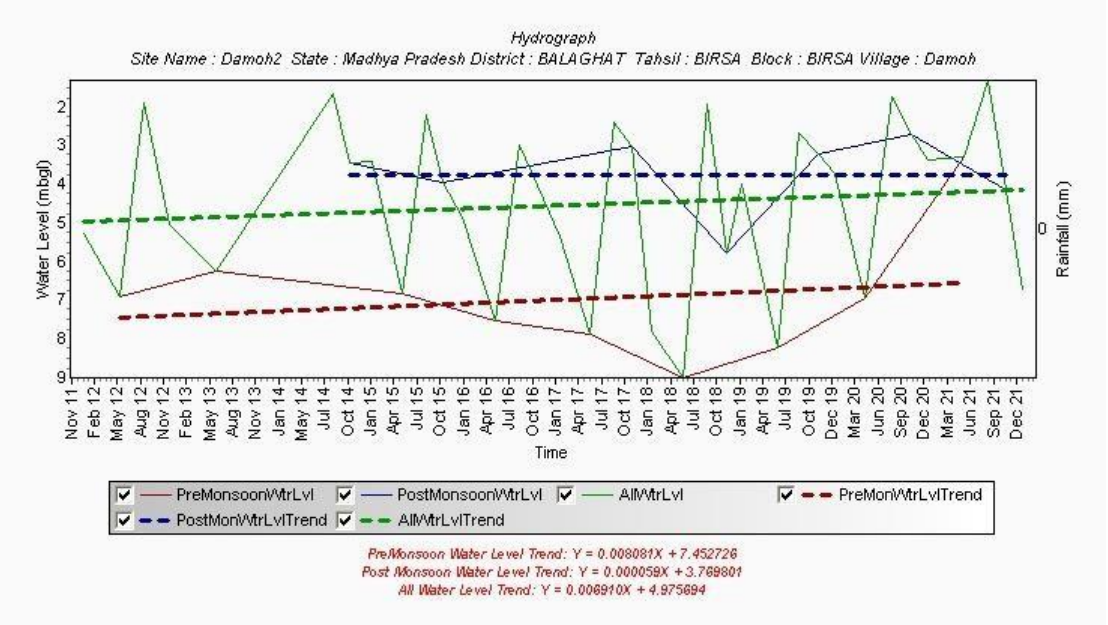


Fig.3.1: Hydrograph (2011-2021), Village-Damoh, Block- Birsa, Balaghat District.

3.3.1 Ground Water Related Issues	
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and Highrunoff	As the block is covered with alluvium and hard Malajhkhand Granite there is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer- II. Sustainability of both the aquifers is limited.

Based on available datas the management plan of Birsa district has been prepared which is given as follows in the table below

Block	**Annual Extractable GW resource (MCM)**	**Gross Draft (MCM)**	**Stage of GW Extraction (%)**	**Additonal draft Proposed (MCM)**	**Gross Draft(MCM)**	**Net Extractable GW resource after utilising additional draft(MCM)**	**Stage of GW Extraction (%)after intervention**	**Unit Draft (Non-monsoon) (MCM)**		**Proposed abstraction structures**	
								Dugwell	**Bore Well**	**Dug well**	**Bore well**
Birsa	112.02	4.29	3.83	33.61	37.90	78.42	48.33	0.35	0.6	34	8

4. AQUIFER MAPS AND MANAGEMENT PLAN OF KATANGI BLOCK

4. 1 SALIENT INFORMATION			
Block	**Katangi**		
Area		Sq Km	697.79
Population (2011 CENSUS)			181995
Normal Rain-fall(2016-20)		millimeter	1168.12
Land use and Agriculture	Principal crops		Wheat, rice, vegetables, fruits, Cereals, Fibre, Pulses, Oil seeds, Sugarcane
	Gross cropped area	Sq Km	397.81
	Net sown area		287.4
	Area sown more than once		110.41
	Cropping intensity	%	138
	Area under forest	Sq Km	260.36
	Area under Waste land		20.78
Data Utilized	Monitoring Wells for Water Level		Dw-2, Pz-2
	Monitoring Wells for Quality		Dw-2
Water level behavior	Pre-monsoon WL	meter	6.015
	Post-monsoon WL		2.656
	Pre-monsoon WL Trend	(m /yr)	Fall -0.5896
	Post-monsoon WL Trend		Fall -0.250116

4.2 AQUIFER DISPOSITION		
Major Aquifer	**Schist/Gneiss**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Schist	Jointed / Fractured Schist or Gneiss
Depth of Occurrence (mbgl)	1 to 30	30-200
SWL (mbgl)	7.5	8.1
Weathered thickness (m)	0-20	0.50 to 1
Fractures encountered (mbgl)	Upto 30	59-60
Yield	-	
Transmissivity (m^2/day)	-	

As the area is covered with hard rocks, the thickness of the aquifers is limited. The weathered formations generally form the shallow aquifer, which are extends maximum up to the depth of 20 m. The fractured /jointed Schist or Gneiss form the deeper aquifer.

4.3 GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION AND OTHER ISSUES

DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Schist / Gneiss	
	Recharge worthy area	Sq Km	676.79
	Command area		114.42
	Non-Command area		562.37
	Recharge From Rain Fall During Monsoon Season	MCM	69.917
	Recharge From other sources During Monsoon Season		28.854
	Recharge From Rain Fall During Non-Monsoon Season		0.2486
	Recharge From other sources During non-Monsoon Season		5.7323
	Total Recharge		78.7833
	Annual Extractable Groundwater Recharge		70.9049
	Existing Gross Ground Water Draft for Irrigation		27.234
	Existing Gross Ground Water Draft for Industrial Water Supply		0
	Existing Gross Ground Water Draft for Domestic Water Supply		4.279
	Existing Gross Ground Water Draft for All Uses		31.512
	Annual GW Allocation for Domestic Use as on 2025		4.4083
	Net Ground Water Availability for Future Irrigation Development		39.263
	Stage of Ground Water Extraction	**%**	44.16
	Category		**Safe**
Static Resource Of Shallow Aquifer		MCM	14.641
Static Resource Of Deep Aquifer			107.857

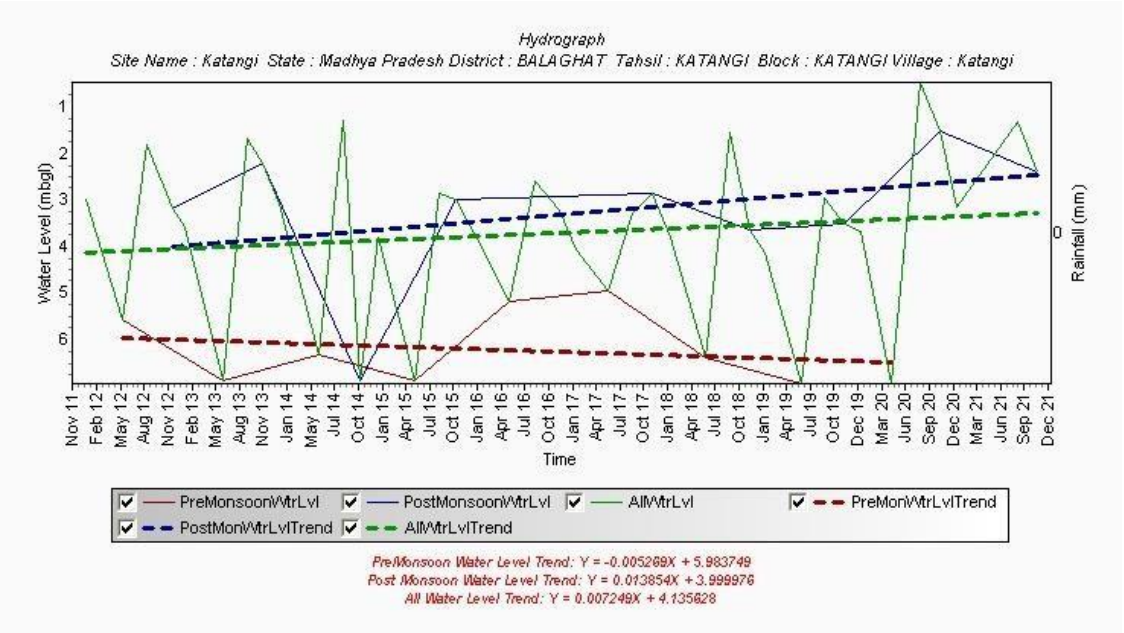


Fig.4.1: Hydrograph (2011-21), Village- Katangi, Block- Katangi, Balaghat District.

4.3.1 Ground Water Related Issues	
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High runoff	As the block is covered with hard Banded Gneiss or Schist there is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

Based on available datas the management plan of Katangi district has been prepared which is given as follows in the table below

Block	**Annual Extractable GW resource (MCM)**	**Gross Draft (MCM)**	**Stage of GW Extraction (%)**	**Additonal draft Proposed (MCM)**	**Gross Draft(MCM)**	**Net Extractable GW resource after utilising additional draft(MCM)**	**Stage of GW Extraction (%)after intervention**	**Unit Draft (Non-monsoon) (MCM)**		**Proposed abstraction structures**	
								Dugwell	**Bore Well**	**Dug well**	**Bore well**
Katangi	70.9	31.31	44.16	7.09	38.40	63.81	60.18	0.62	0.55	4	2

5. AQUIFER MAPPING AND MANAGEMENT PLAN OF KIRNAPUR BLOCK

5. 1 SALIENT INFORMATION			
Block	**Kirnapur**		
Area		Sq Km	810.40
Population (2011 CENSUS)			**175890**
Normal Rain-fall(2015-2019)		millimeter	1168.12
Land use and Agriculture	Principal crops		Wheat, rice, vegetables, fruits, Cereals, Fibre, Pulses, Oil seeds, Sugarcane
	Gross cropped area	Sq Km	484.29
	Net sown area		305.6
	Area sown more than once		178.69
	Cropping intensity	%	158
	Area under forest	Sq Km	364.51
	Area under Waste land		24.35
Data Utilised	Monitoring Wells for Water Level		Dw-3 , Pz-0
	Monitoring Wells for Quality		Dw-3
Water level behavior	Pre-monsoon WL	meter	9.523
	Post-monsoon WL		6.637
	Pre-monsoon WL Trend	(m /yr)	Rising 0.0333
	Post-monsoon WL Trend		Falling -0.53904

5.2 AQUIFER DISPOSITION		
Major Aquifer	**Basalt /Granitoids**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Schist or Gneiss	Jointed / Fractured Schist or Gneiss
Depth of Occurrence (mbgl)	1 to 30	30-200
SWL (mbgl)	6.05	6.05
Weathered thickness (m)	0-15	0.50 to 1
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

As the area is covered with hard rocks, the thickness of the aquifers is limited. The weathered formations generally form the shallow aquifer, which are extends maximum up to the depth of 20 m. The fractured /jointed Gneiss form the deeper aquifer.

5.3 GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION AND OTHER ISSUES

DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Schist, Gneiss	
	Recharge worthy area	Sq Km	719.15
	Command area		109.19
	Non-Command area		609.96
	Recharge From Rain Fall During Monsoon Season	MCM	6836.46
	Recharge From other sources During Monsoon Season		1.6561
	Recharge From Rain Fall During Non-Monsoon Season		0.2431
	Recharge From other sources During non-Monsoon Season		3.1655
	Total Recharge		73.4293
	Annual Extractable Groundwater Recharge		66.0863
	Existing Gross Ground Water Draft for Irrigation		15.732
	Existing Gross Ground Water Draft for Industrial Water Supply		0.0
	Existing Gross Ground Water Draft for Domestic Water Supply		4.323476
	Existing Gross Ground Water Draft for All Uses		20.0555
	Annual GW Allocation for Domestic Use as on 2025		4.6752
	Net Ground Water Availability for Future Irrigation Development		45.6791
	Stage of Ground Water Extraction	**%**	30.35
	Category		**Safe**
Static Resource Of Shallow Aquifer		MCM	36.439
Static Resource Of Deep Aquifer			325.909

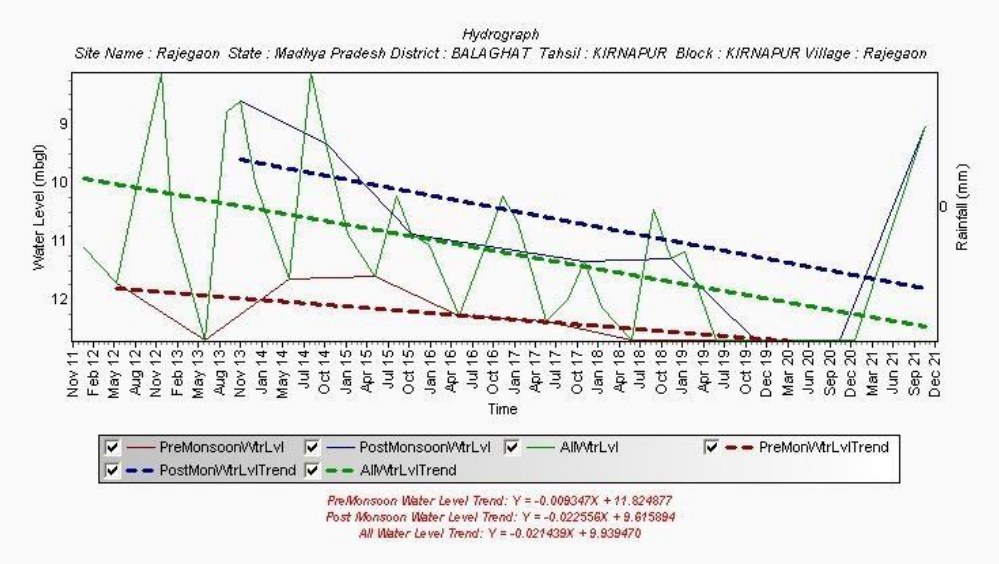


Fig.5.1: Hydrograph (2008-19), Village- Rajegaon, Block- Kirnapur, Barwani District.

5.3.1 Ground Water Related Issues	
Declining water level	Declining water level observed both in pre in some parts of the block(**Fig.5.1**)
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High run-off	As the block is covered with hard Banded Gneiss is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

Based on available datas the management plan of Kirnapur district has been prepared which is given as follows in the table below

Block	**Annual Extractable GW resource (MCM)**	**Gross Draft (MCM)**	**Stage of GW Extraction (%)**	**Additonal draft Proposed (MCM)**	**Gross Draft(MCM)**	**Net Extractable GW resource after utilising additional draft(MCM)**	**Stage of GW Extraction (%)after intervention**	**Unit Draft (Non-monsoon) (MCM)**		**Proposed abstraction structures**	
								Dugwell	**Bore Well**	**Dug well**	**Bore well**
Kirnapur	66.080	20.050	30.300	13.22	33.27	52.86	62.93	0.3	0.69	15	3

6. AQUIFER MAPS AND MANAGEMENT PLAN OF KHAIRLANJI BLOCK

6. 1 SALIENT INFORMATION			
Block	**Khairlanji**		
Area		Sq Km	487.88
Population (2011 CENSUS)			147208
Normal Rain-fall(2017-21)		millimeter	1168.12
Land use and Agriculture	Principal crops		Wheat, rice, vegetables, fruits, Cereals, Fibre, Pulses, Oil seeds, Sugarcane
	Gross cropped area	Sq Km	403.94
	Net sown area		291.14
	Area sown more than once		112.8
	Cropping intensity	%	139
	Area under forest	Sq Km	72.93
	Area under Waste land		10.19
Data Utilised	Monitoring Wells for Water Level		Dw-5
	Monitoring Wells for Quality		Dw-5
Water level behavior	Pre-monsoon WL	meter	5.19
	Post-monsoon WL		3.35
	Pre-monsoon WL Trend	(m /yr)	Falling- 0.0024
	Post-monsoon WL Trend		Falling- 0.02937

6.2 AQUIFER DISPOSITION		
Major Aquifer	**Basalt**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Schist/ Gneiss	Jointed / Fractured Gneiss
Depth of Occurrence (mbgl)	0-20	20-200
SWL (mbgl)	5.07	5.07
Weathered thickness (m)	0-20	0.50 to 2
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

As the area is covered with hard rocks, the thickness of the aquifers is limited. The weathered formations generally form the shallow aquifer, which are extends maximum up to the depth of 12 m. The fractured /jointed Schist or Gneiss form the deeper aquifer.

6.3 GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION AND OTHER ISSUES

DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Schist, Gneiss	
	Recharge worthy area	Sq Km	453.88
	Command area		136.58
	Non-Command area		317.30
	Recharge From Rain Fall During Monsoon Season	MCM	38.9968
	Recharge From other sources During Monsoon Season		1.738
	Recharge From Rain Fall During Non-Monsoon Season		13.87
	Recharge From other sources During non-Monsoon Season		3.4281
	Total Recharge		44.3016
	Annual Extractable Groundwater Recharge		39.8715
	Existing Gross Ground Water Draft for Irrigation		17.3433
	Existing Gross Ground Water Draft for Industrial Water Supply		0.0
	Existing Gross Ground Water Draft for Domestic Water Supply		3.618449
	Existing Gross Ground Water Draft for All Uses		20.9618
	Annual GW Allocation for Domestic Use ason 2025		3.9128
	Net Ground Water Availability for Future Irrigation Development		18.6153
	Stage of Ground Water Extraction	**%**	52.57
	Category		**Safe**
Static Resource Of Shallow Aquifer		MCM	5.528
Static Resource Of Deep Aquifer			180.029

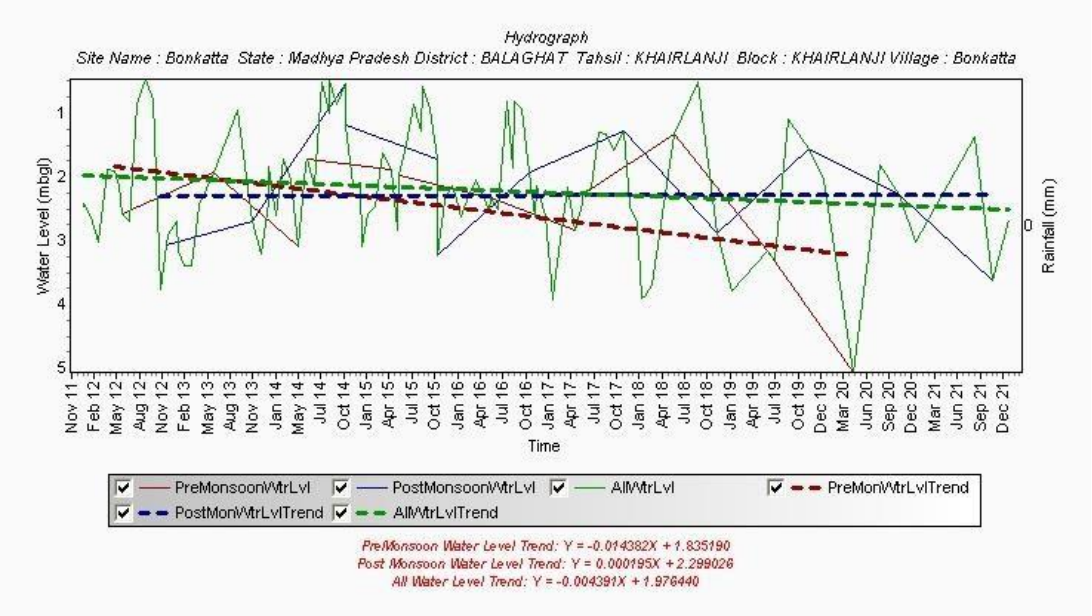


Fig.6.1: Hydrograph (2011-21), Village-Bonkatta, Block- Khairlanji, Balaghat District.

6.3.1 Ground Water Related Issues	
Declining water level	Declining water level observed both in pre in some parts of the block(**Fig.6.1**)
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High run-off	As the block is covered with hard Banded Gneiss is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

Based on available datas the management plan of Khairlanji district has been prepared which is given as follows in the table below

Block	**Annual Extractable GW resource (MCM)**	**Gross Draft (MCM)**	**Stage of GW Extraction (%)**	**Additonal draft Proposed (MCM)**	**Gross Draft(MCM)**	**Net Extractable GW resource after utilising additional draft(MCM)**	**Stage of GW Extraction (%)after intervention**	**Unit Draft (Non-monsoon) (MCM)**		**Proposed abstraction structures**	
								Dugwell	**Bore Well**	**Dug well**	**Bore well**
Khairlanji	39.87	20.96	52.57	3.19	24.15	36.68	65.84	0.36	0.69	3	1

7. AQUIFER MAPS AND MANAGEMENT PLAN OF LANJI BLOCK

7. 1 SALIENT INFORMATION			
Block	**Lanji**		
Area		Sq Km	343
Population (2011 CENSUS)			**187624**
Normal Rain-fall(2017-21)		millimeter	1168.12
Land use and Agriculture	Principal crops		Wheat, rice, vegetables, fruits, Cereals, Fibre, Pulses, Oil seeds, Sugarcane
	Gross cropped area	Sq Km	464.07
	Net sown area		292.78
	Area sown more than once		171.29
	Cropping intensity	%	159
	Area under forest	Sq Km	482.99
	Area under Waste land		17.61
Data Utilised	Monitoring Wells for Water Level		DW-1 PZ-1,
	Monitoring Wells for Quality		Dw-4
Water level behavior	Pre-monsoon WL	meter	4.5652
	Post-monsoon WL		4.465
	Pre-monsoon WL Trend	(m /yr)	Falling - 0.61426
	Post-monsoon WL Trend		Falling -1.208628

7.2 AQUIFER DISPOSITION		
Major Aquifer	**Fractured Schist/ Fractured Gneiss**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Schist, Gneiss	Jointed / Fractured Banded Gneiss
Depth of Occurrence (mbgl)	1 to 30	30-200
SWL (mbgl)	7.56	7.63
Weathered thickness (m)	0-25	0.5-1
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

As the area is covered with hard rocks, the thickness of the aquifers is limited. The weathered formations generally form the shallow aquifer, which are extends maximum up to the depth of 12 m. The fractured /jointed Schist or Gneiss form the deeper aquifer.

7.3 GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION AND OTHER ISSUES

DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Schist or Gneiss	
	Recharge worthy area	Sq Km	787.47
	Command area		92.75
	Non-Command area		694.72
	Recharge From Rain Fall During Monsoon Season	MCM	71.11
	Recharge From other sources During Monsoon Season		5.53
	Recharge From Rain Fall During Non-Monsoon Season		00
	Recharge From other sources During non-Monsoon Season		19.33
	Total Recharge		95.99
	Annual Extractable Groundwater Recharge		86.81
	Existing Gross Ground Water Draft for Irrigation		42.90
	Existing Gross Ground Water Draft for Industrial Water Supply		0.0
	Existing Gross Ground Water Draft for Domestic Water Supply		8.62
	Existing Gross Ground Water Draft for All Uses		51.53
	Annual GW Allocation for Domestic Use as on 2025		9.66
	Net Ground Water Availability for Future Irrigation Development		24.57
	Stage of Ground Water Extraction	**%**	59.36
	Category		**Safe**
Static Resource Of Shallow Aquifer		MCM	4.141
Static Resource Of Deep Aquifer			1119.733

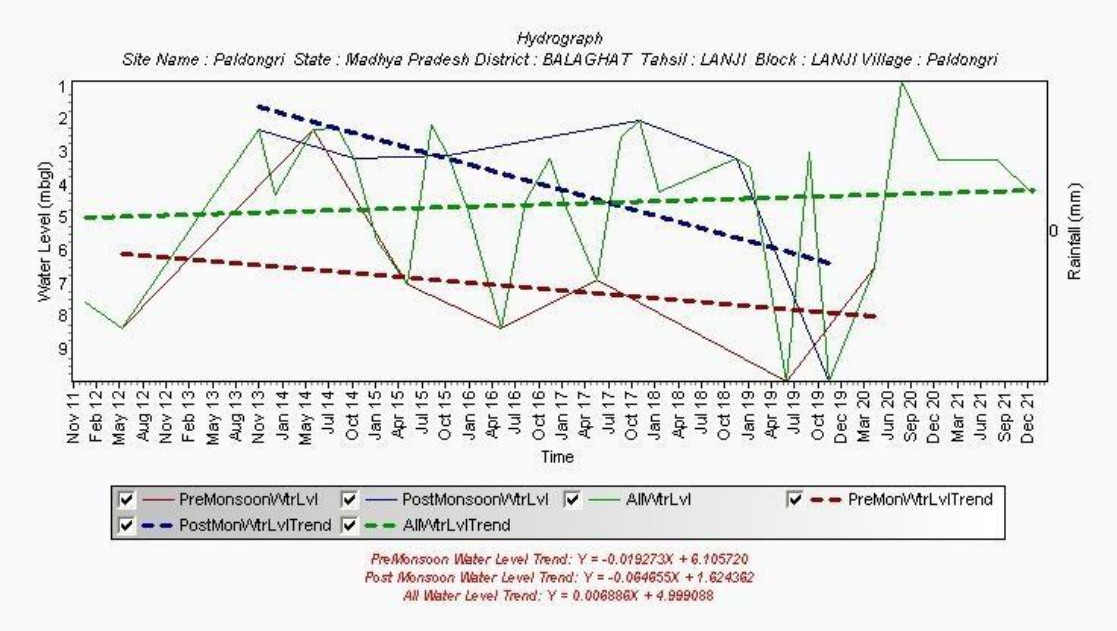


Fig.7.1: Hydrograph (2011-21), Village-Paldongri, Block- Lanji, Balaghat District.

7.3.1 Ground Water Related Issues	
Declining water level	Declining water level observed both in pre and post-monsoon in major part of the block(**Fig.7.1**)
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High run-off	As the block is covered with Schist or Gneiss is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

Based on available datas the management plan of Lanji district has been prepared which is given as follows in the table below

Block	**Annual Extractable GW resource (MCM)**	**Gross Draft (MCM)**	**Stage of GW Extraction (%)**	**Additonal draft Proposed (MCM)**	**Gross Draft(MCM)**	**Net Extractable GW resource after utilising additional draft(MCM)**	**Stage of GW Extraction (%)after intervention**	**Unit Draft (Non-monsoon) (MCM)**		**Proposed abstraction structures**	
								Dugwell	**Bore Well**	**Dug well**	**Bore well**
Lanji	71.310	15.470	21.700	17.83	33.30	53.48	62.26	0.36	0.79	17	3

8. AQUIFER MAPS AND MANAGEMENT PLAN OF LALBURRA BLOCK

8. 1 SALIENT INFORMATION			
Block	**Lalburra**		
Area		Sq Km	343
Population (2011 CENSUS)			**170960**
Normal Rain-fall(2017-21)		millimeter	1168.12
Land use and Agriculture	Principal crops		Wheat, rice, vegetables, fruits, Cereals, Fibre, Pulses, Oil seeds, Sugarcane
	Gross cropped area	Sq Km	428.46
	Net sown area		279.00
	Area sown more than once		149.46
	Cropping intensity	%	154
	Area under forest	Sq Km	293.80
	Area under Waste land		19.04
Data Utilized	Monitoring Wells for Water Level		DW-2
	Monitoring Wells for Quality		Dw-2
Water level behavior	Pre-monsoon WL	meter	6.037
	Post-monsoon WL		2.7535
	Pre-monsoon WL Trend	(m /yr)	Rising 0.404148
	Post-monsoon WL Trend		Rising 0.147006

8.2 AQUIFER DISPOSITION		
Major Aquifer	Schist or Gneiss	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Schist	Jointed / Fractured Gneiss
Depth of Occurrence (mbgl)	1 to 30	30-200
SWL (mbgl)	4.1	4.1
Weathered thickness (m)	0-15	1-2
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

As the area is covered with hard rocks, the thickness of the aquifers is limited. The weathered formations generally form the shallow aquifer, which are extends maximum up to the depth of 30 m. The fractured /jointed Schist or Gneiss form the deeper aquifer.

8.3 GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION AND OTHER ISSUES

DYNAMIC GROUNDWA-TER RE-SOURCES 2020	Type of Rock formation	Schist or Gneiss	
	Recharge worthy area	Sq Km	787.47
	Command area		92.75
	Non-Command area		694.72
	Recharge From Rain Fall During Monsoon Season	MCM	71.11
	Recharge From other sources During Monsoon Season		5.53
	Recharge From Rain Fall During Non-Monsoon Season		00
	Recharge From other sources During non-Monsoon Season		19.33
	Total Recharge		95.99
	Annual Extractable Groundwater Recharge		86.81
	Existing Gross Ground Water Draft for Irrigation		42.90
	Existing Gross Ground Water Draft for Indus-trial Water Supply		0.0
	Existing Gross Ground Water Draft for Domestic Water Supply		8.62
	Existing Gross Ground Water Draft for All Uses		51.53
	Annual GW Allocation for for Domestic Use as on 2025		9.66
	Net Ground Water Avail-ability for Future Irrigation Development		24.57
	Stage of Ground Water Extraction	**%**	59.36
	Category		**Safe**
Static Resource Of Shallow Aquifer		MCM	25.065
Static Resource Of Deep Aquifer			613.795

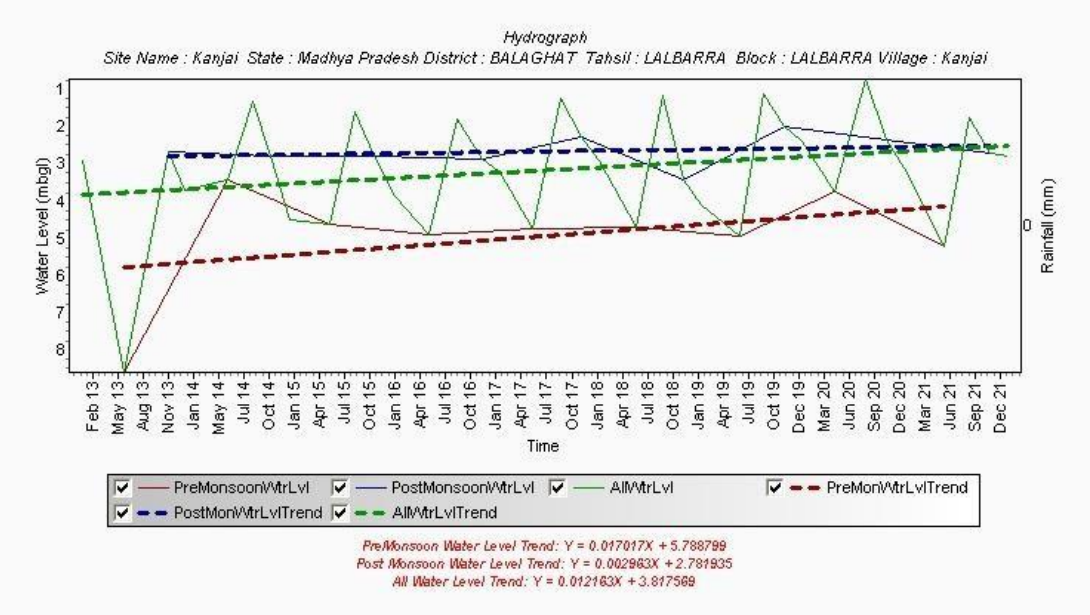


Fig.8.1: Hydrograph (2013-21), Village-Kanjai, Block- Lalbarra, Balaghat District.

8.3.1 Ground Water Related Issues	
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High run-off	As the block is covered with hard Schist or Gneiss is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

Based on available datas the management plan of Lalburra district has been prepared which is given as follows in the table below

Block	**Annual Extractable GW resource (MCM)**	**Gross Draft (MCM)**	**Stage of GW Extraction (%)**	**Additonal draft Proposed (MCM)**	**Gross Draft(MCM)**	**Net Extractable GW resource after utilising additional draft(MCM)**	**Stage of GW Extraction (%)after intervention**	**Unit Draft (Non-monsoon) (MCM)**		**Proposed abstraction structures**	
								Dugwell	**Bore Well**	**Dug well**	**Bore well**
Lalburra	61.250	21.480	35.080	9.19	30.67	52.06	58.91	0.62	0.59	5	2

9. AQUIFER MAPS AND MANAGEMENT PLAN OF PARASWADA BLOCK

9. 1 SALIENT INFORMATION			
Block	**Paraswada**		
Area		Sq Km	343
Population (2011 CENSUS)			**108026**
Normal Rain-fall(2017-21)		millimeter	1168.12
Land use and Agriculture	Principal crops		Wheat, rice, vegetables, fruits, Cereals, Fibre, Pulses, Oil seeds, Sugarcane
	Gross cropped area	Sq Km	360.73
	Net sown area		279.86
	Area sown more than once		80.87
	Cropping intensity	%	129
	Area under forest	Sq Km	841.11
	Area under Waste land		68.45
Data Utilised	Monitoring Wells for Water Level		DW-4
	Monitoring Wells for Quality		Dw-4
Water level behavior	Pre-monsoon WL	meter	6.744
	Post-monsoon WL		2.854
	Pre-monsoon WL Trend	(m /yr)	Rising 0.1753
	Post-monsoon WL Trend		Rising 0.0539

9.2 AQUIFER DISPOSITION		
Major Aquifer	Mica Schist	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Mica Schist	Jointed / Fractured Mica Schist
Depth of Occurrence (mbgl)	1 to 30	30-200
SWL (mbgl)	5.22	5.22
Weathered thickness (m)	0-50	0.2
Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

As the area is covered with hard rocks, the thickness of the aquifers is limited. The weathered formations generally form the shallow aquifer, which are extends maximum up to the depth of 30 m. The fractured /jointed Mica Schist form the deeper aquifer.

9.3 GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION AND OTHER ISSUES

DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Mica Schist	
	Recharge worthy area	Sq Km	787.47
	Command area		92.75
	Non-Command area		694.72
	Recharge From Rain Fall During Monsoon Season	MCM	71.11
	Recharge From other sources During Monsoon Season		5.53
	Recharge From Rain Fall During Non-Monsoon Season		00
	Recharge From other sources During non-Monsoon Season		19.33
	Total Recharge		95.99
	Annual Extractable Groundwater Recharge		86.81
	Existing Gross Ground Water Draft for Irrigation		42.90
	Existing Gross Ground Water Draft for Industrial Water Supply		0.0
	Existing Gross Ground Water Draft for Domestic Water Supply		8.62
	Existing Gross Ground Water Draft for All Uses		51.53
	Annual GW Allocation for Domestic Use as on 2025		9.66
	Net Ground Water Availability for Future Irrigation Development		24.57
	Stage of Ground Water Extraction	**%**	59.36
	Category		**Safe**
Static Resource Of Shallow Aquifer		MCM	22.306
Static Resource Of Deep Aquifer			2059.438

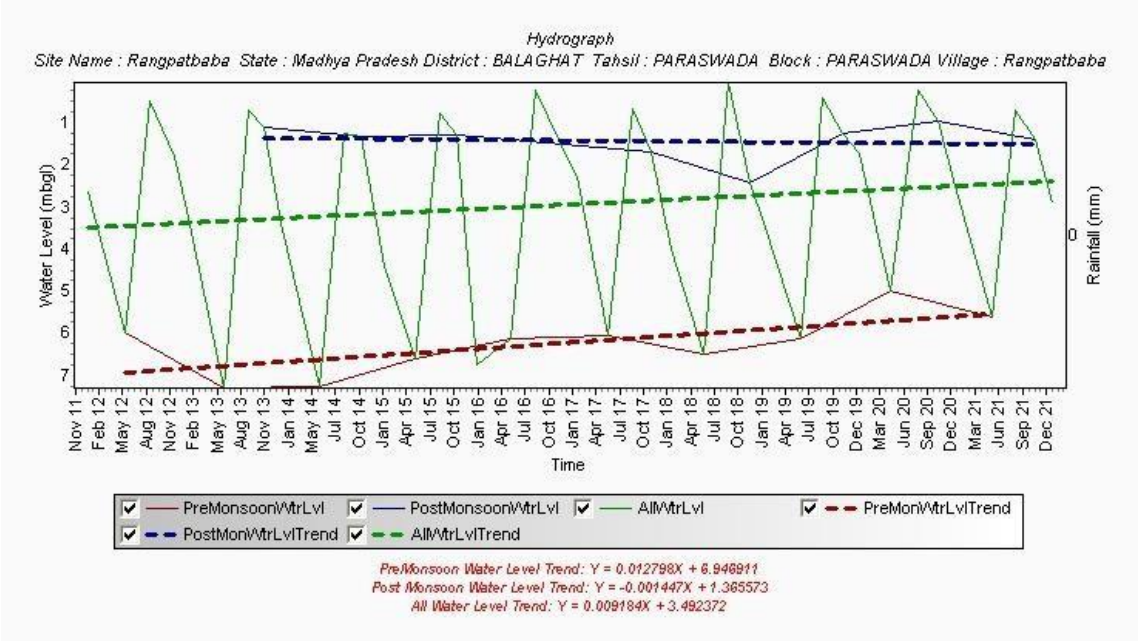


Fig.9.1: Hydrograph (2011-21), Village-Rangpatbaba, Block- Paraswada, Balaghat District.

9.3.1 Ground Water Related Issues	
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High run-off	As the block is covered with hard Deccan trap bas Mica Schist is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

Based on available datas the management plan of Paraswada district has been prepared which is given as follows in the table below

Block	**Annual Extractable GW resource (MCM)**	**Gross Draft (MCM)**	**Stage of GW Extraction (%)**	**Additonal draft Proposed (MCM)**	**Gross Draft(MCM)**	**Net Extractable GW resource after utilising additional draft(MCM)**	**Stage of GW Extraction (%)after intervention**	**Unit Draft (Non-monsoon) (MCM)**		**Proposed abstraction structures**	
								Dugwell	**Bore Well**	**Dug well**	**Bore well**
Paras wada	96.160	3.730	3.800	32.69	36.42	63.47	57.39	0.42	0.64	27	8

10.AQUIFER MAPS AND MANAGEMENT PLAN OF WARASEONI BLOCK

10. 1 SALIENT INFORMATION			
Block	**Waraseoni**		
Area		Sq Km	476.03
Population (2011 CENSUS)			**176291**
Normal Rain-fall(2017-21)		millimeter	1168.12
Land use and Agriculture	Principal crops		Wheat, rice, vegetables, fruits, Cereals, Fibre, Pulses, Oil seeds, Sugarcane
	Gross cropped area	Sq Km	430.80
	Net sown area		282.39
	Area sown more than once		148.41
	Cropping intensity	%	153
	Area under forest	Sq Km	81.19
	Area under Waste land		3.26
Data Utilised	Monitoring Wells for Water Level		DW-5 , PZ-1
	Monitoring Wells for Quality		Dw-5
Water level behavior	Pre-monsoon WL	meter	5.71
	Post-monsoon WL		3.0
	Pre-monsoon WL Trend	(m /yr)	Rising 0.03226
	Post-monsoon WL Trend		Rising 0.002538

10.2 AQUIFER DISPOSITION		
Major Aquifer	**Schist / Gneiss**	
Type of Aquifer	Aquifer-I	Aquifer-II
Formation	Weathered Schist	Jointed / Fractured Schist or Gneiss
Depth of Occurrence (mbgl)	1 to 30	30-200
SWL (mbgl)	2.78	9.34
Weathered / Fractured rocks thickness (m)	0-20	0.5-1
1Fractures encountered (mbgl)	Upto 30	Upto 200
Yield	-	
Transmissivity (m^2/day)	-	

As the area is covered with hard rocks, the thickness of the aquifers is limited. The weathered formations generally form the shallow aquifer, which are extends maximum up to the depth of 20 m. The fractured /jointed Schist and Gneiss form the deeper aquifer.

10.3 GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION AND OTHER ISSUES

DYNAMIC GROUNDWATER RESOURCES 2020	Type of Rock formation	Mica Schist and Gneiss	
	Recharge worthy area	Sq Km	444.03
	Command area		152.32
	Non-Command area		291.71
	Recharge From Rain Fall During Monsoon Season	MCM	45.8713
	Recharge From other sources During Monsoon Season		2.4494
	Recharge From Rain Fall During Non-Monsoon Season		0.1632
	Recharge From other sources During non-Monsoon Season		2.904
	Total Recharge		51.3879
	Annual Extractable Groundwater Recharge		46.2491
	Existing Gross Ground Water Draft for Irrigation		14.8424
	Existing Gross Ground Water Draft for Industrial Water Supply		0
	Existing Gross Ground Water Draft for Domestic Water Supply		2.526997
	Existing Gross Ground Water Draft for All Uses		17.3694
	Annual GW Allocation for Domestic Use ason 2025		2.7326
	Net Ground Water Availability for Future Irrigation Development		28.6741
	Stage of Ground Water Extraction	**%**	37.56
	Category		**Safe**
Static Resource Of Shallow Aquifer		MCM	6.299
Static Resource Of Deep Aquifer			3792.966

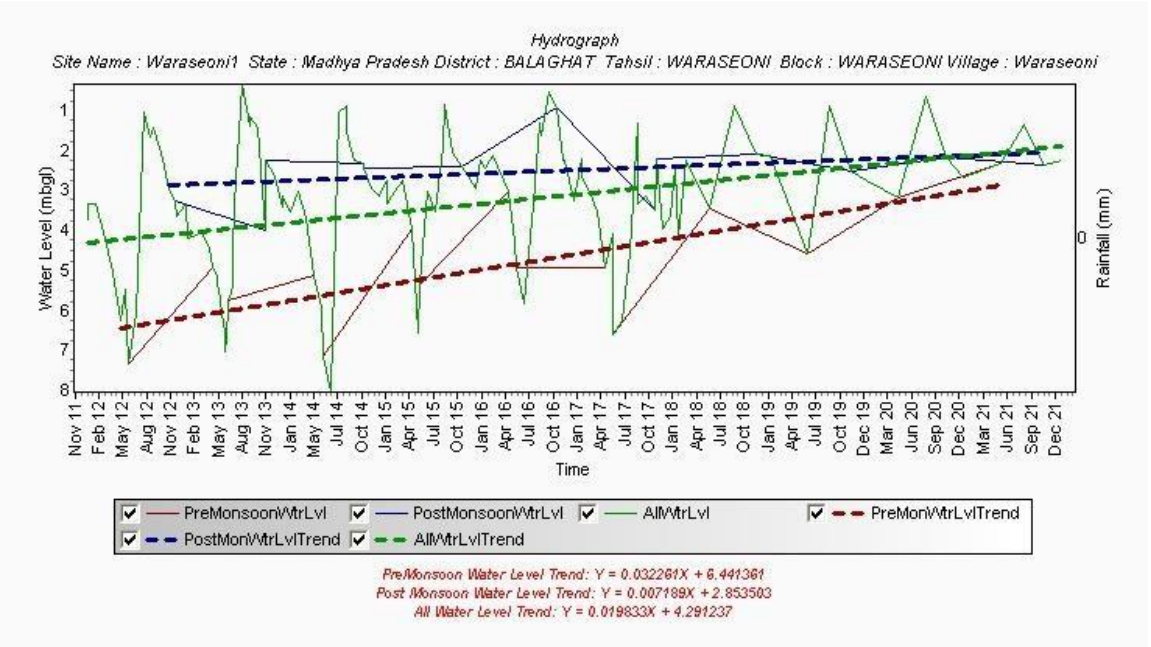


Fig.10.1: Hydrograph (2011-21), Village- Waraseoni, Block- Waraseoni, Balaghat District.

1.3.1 Ground Water Related Issues	
Low Ground Water Potential / Limited Aquifer Thickness / Low Sustainability and High run-off	As the block is covered with hard Banded Gneiss basalt is restricted depth of weathering (< 20 m) in Aquifer-I and limited aquifer thickness in Aquifer-II. Sustainability of both the aquifers is limited.

Based on available datas the management plan of Waraseoni district has been prepared which is given as follows in the table below-

Block	**Annual Extractable GW resource (MCM)**	**Gross Draft (MCM)**	**Stage of GW Extraction (%)**	**Additonal draft Proposed (MCM)**	**Gross Draft(MCM)**	**Net Extractable GW resource after utilising additional draft(MCM)**	**Stage of GW Extraction (%)after intervention**	**Unit Draft (Non-monsoon) (MCM)**		**Proposed abstraction structures**	
								Dugwell	**Bore Well**	**Dug well**	**Bore well**
Waraseoni	46.240	17.360	37.560	6.94	24.30	39.30	61.82	0.69	0.6	4	2

CONCLUSION & RECOMMENDATIONS

- A thorough study was carried out based on data gap analysis, data generated in-house; data acquired from State Govt. departments and GIS maps prepared for various themes. All the available data was brought on GIS platform and an integrated approach was adopted for preparation of aquifer maps and aquifer management plans of Balaghat district.
- The study area is spanning over 9229 sq.km, out of which 311.07 sq.km is hilly area and area suitable for recharge is 8917.9 sq.km.
- The entire district is drained by Wein Ganga River and its tributaries as well as the tributaries of Narmada river. Thus the area falls in the Wein Ganga Basin and Narmada basin. The tributaries are Bagh, Banjar, Shisire, Sod and Tumnar.
- The pre-monsoon depth to water levels during May 2021 ranged between 1.65 to 16.59 mbgl and the post-monsoon depth to water levels during Nov. 2021 ranged between 1.18 to 13.29 mbgl.
- Electrical conductivity of ground water ranged between 285 to 1760 µS/cm at 25°C, pH ranged in between 6.71 to 7.85, fluoride concentration is within permissible limit. Nitrate concentration ranged in between 3 to 165mg/l. Total hardness ranged in between 95 to 695 mg/l.
- During monsoon season recharge from rainfall contributes maximum component (81686.5 ham) and recharge from other sources is 1957.93 ham, whereas during non-monsoon season, recharge from rainfall is 2791.18 ham and the re- charge from other sources is 8672.612 ham.
- The net dynamic ground water resource available is 78053.48 ham. The annual gross draft for all uses is estimated as 16061 ham with irrigation sector being the major consumer having a draft of 12464ham, resulting the stage of ground water development to be 20.50 % as a whole for district. The Balaghat district falls under safe category.
- The Block constitute 10 blocks and all are fall under safe category with stage of GW Extraction as follows: (Baihar-4.2%), (Balaghat-18.98%), (Birsa-3.83%), (Katangi-44.16%), (Khairlanji-52.57%), (Kirnapur-30.35%), (Lalbarra-35.080), (Lanji-21.7) (Paraswada-3.88), (Waraseoni-37.56)and overall Balaghat district comes under safe category with very low stage of GW Extraction (20.5%).

- As per the Management plan prepared under NAQUIM of all the Block of Balaghat District, it is proposed to enhance the Stage of Ground Water Extraction for all the blocks upto around 60%. Accordingly, it is suggested that to increase the GW draft by harnessing about 30% of Extractable Ground Water Resources in Birsa block, 25% increase in Balaghat and Lanji Blocks, 15% increase in Waraseoni and Lalburra, 10% in Katangi block and 8% in Khairlanji block of net GW available (780.5348 mcm) i.e. created additional irrigated area by GW of 667.90 Sq. km and the stage of GW Extraction of Balaghat district after increase in draft will be estimated about 58.63% and of block (Baihar-57.9%), (Birsa-48.3%), (Katangi-60.2%), (Khairlanji-65.8%), (Kirnapur- 62.9%), (Lalbarra-58.9), (Lanji-62.2),(Paraswada-57.4), (Waraseoni- 61.8).

- Since data gap is prevailed in Balaghat district, it is recommended to construct new Exploratory wells throughout the district for better understanding the Hydrogeological scenario of the area and for better implementation of the management plan.
- Defluoridation techniques like NalaGonda method, membrane filtration, Ion exchange technique, activated alumina technique may be adopted in fluoride contaminated area of the district. In addition to this while constructing deeper wells, the zone with Fluoride contamination should be sealed and Fluoride free zones to be taken into use.

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Annexure-I (Details of Existed wells and key wells)

Block	Locations	Long	Lat	RL	Depth	Weathering thickness
Baihar	Baihar	80.5513889	22.10417	555	54.9	
Baihar	Samnapur	80.486118	21.9702	626.8	83	20
Baihar	Sakrai Tola	80.65059	22.1372	552.3	100	10
Baihar	Jobati Tola	80.872599	22.2369	677.2	50	10
Baihar	Brahman Tola	80.792396	22.2643	651.7	70	20
Baihar	Gaddi	80.8336111	21.225	342	54.9	35
Balaghat	Khursuni	80.293584	21.7276	311	65	20
Balaghat	Pipartola	80.288367	21.8771	324	85	80
Balaghat	Bondua	80.127259	22.1318	348.4	65	20
Balaghat	Balaghat	80.125	22.14167	358	54.55	15.4
Birasa	Mohgaon	80.66772	22.0575	592	60	20
Birasa	Salghat	80.761732	21.9679	590.2	60	30
Birasa	malajhkhand	80.6805556	22.05194	574	30.32	14.6
Katangi	Bonkata	79.759058	21.61	296.3	110	30
Katangi	Katangi	79.8033333	21.27083	263	59.82	25
Khairlanji	Sonjhara	80.01302	21.6496	286.9	85	33
Khairlanji	Saleteka	79.947086	21.6268	294.9	100	30
Khairlanji	Paraswadaghat	79.80452	21.6663	339.5	150	20
Kirnapur	Bhalwa	80.368649	21.7277	306.3	100	30
Kirnapur	Chhotapala	80.32559	21.6529	303.3	83	30
Kirnapur	Binora	80.36673	21.5874	296.8	100	28
Lalbarra	Nayatola	80.031068	21.8343	311.9	120	35
Lalbarra	Pathersahi	80.03505	21.9746	334.4	100	20
Lalbarra	Birsola	80.10475	21.869	317.3	100	30
Lanji	Keratola	80.66111	21.555	330.7	105	30
Lanji	Khandwa	80.611599	21.5355	329.8	116	35
Lanji	Lanji	80.5361111	21.50417	318	60.16	10
Paraswada	Chiklaghodi	80.401903	21.9561	618.5	80	30
Paraswada	Singhodi	80.511533	22.1188	553	130	30
Paraswada	Bagholi	80.373589	22.1399	601.8	50	50
Waraseoni	Kaydi	80.09305	21.793	322.7	100	25
Waraseoni	Kabuliwara	80.010871	21.7205	296.7	65	30
Waraseoni	Serpar	79.89732	21.7829	330.2	180	20
Waraseoni	Waraseoni	80.0519444	21.76333	310	36.5	30

ANNEXURE-II (Pre-monsoon and Post -Monsoon Water level datas)

S No	Block	Village	Pre-Monsoon (mbgl)	Post-Monsoon (mbgl)	Seasonal Fluctuation (m)
1	BAIHAR	Baihar	9.89	5.7	4.19
2	BAIHAR	Baihar	4.75	2.94	1.81
3	BAIHAR	Jawaditula	3	1.23	1.77
4	BAIHAR	Laugur	11	4.23	6.77
5	BAIHAR	Mukki	6.82	3.04	3.78
6	BAIHAR	Parsatola	2.75	1.97	0.78
7	BAIHAR	Samnapur	8.4	4.74	3.66
8	BAIHAR	Supkhar	4.94	2.78	2.16
9	BALAGHAT	Balaghat	6.9	3.92	2.98
10	BALAGHAT	Lamta	7.6	5.32	2.28
11	BALAGHAT	Saleteka New	14.2	13.29	0.91
12	BIRSA	Birsa	5.95	3.33	2.62
13	BIRSA	Damoh	4.21	2.74	1.47
15	BIRSA	Saletekhri	4.55	3.37	1.18
16	KATANGI	Katangi-S	8.1	3.75	4.35
17	KATANGI	Katedhara	7.5	3.7	3.8
18	KHAIRLANJI	Garraghoda	5.18	3.79	1.39
19	KHAIRLANJI	Khairlanji	3.9	1.75	2.15
20	KHAIRLANJI	Miragpur	3.7	3.22	0.48
21	KHAIRLANJI	Rampalli	7.5	5.33	2.17
22	KIRNAPUR	Bhanegaon	9.4	7.53	1.87
23	KIRNAPUR	Kirnapur	2.7	2.17	0.53
24	LALBARRA	Kanjai	5.2	2.69	2.51
25	LALBARRA	Katang Tola	3	2.01	0.99
26	PARASWADA	Bagholi	2.88	2.53	0.35
27	PARASWADA	Khurmundi	4.75	2.55	2.2
28	PARASWADA	Paraswara	7.65	5.44	2.21
29	PARASWADA	Rangpatbaba	5.6	1.39	4.21
30	WARASEONI	Amai	3.3	2.46	0.84
32	WARASEONI	Kochwahi	3.13	2.14	0.99
34	WARASEONI	Waraseoni	9.34	5.14	4.2

ANNEXURE-III (Water Quality details)

Parameters					pH	EC	HCO_3	Cl	SO_4	NO_3	F	PO_4	SiO_2	TH	Ca	Mg	Na	K	TDS
S. No.	Location	Source	Lat.	Long.	at 25°C	µS/cm at 25°C													
1	Linga	HP	21.7799	80.2539	7.51	1935	671	262	20	98	0.21	BDL	23	600	110	79	205	3.7	1258
2	Khursuni	DW	21.7276	80.2936	6.72	246	49	22	25	11	0.05	0.1	25	55	16	4	25	1.2	160
3	Bhalwa	HP	21.7277	80.3686	7.24	974	311	120	15	41	0.06	BDL	32	335	94	24	65	1.2	633
4	Chhotapala	HP	21.6529	80.3256	7.68	451	159	45	10	16	0.19	0.2	43	180	50	13	18	2.1	293
5	Binora	DW	21.5874	80.3667	7.64	712	366	22	8	10	0.18	BDL	22	210	70	9	65	1.1	463
6	Benegaon	Bore	21.5338	80.4457	7.94	640	305	35	5	8	0.11	0	27	245	68	18	32	1.9	416
7	Lohara	Bore	21.4500	80.5384	7.85	737	366	45	8	9	0.26	BDL	32	230	60	19	70	2.3	479
8	Keratola	HP	21.5550	80.6611	7.65	384	201	10	5	4	0.24	BDL	25	140	42	9	22	1.8	250
9	Khandwa	Bore	21.5355	80.6116	7.35	478	220	25	6	5	0.12	BDL	32	175	42	17	23	2.5	311
10	Paraswada	Bore	21.6284	80.2851	7.45	780	311	75	4	16	0.16	BDL	43	260	80	15	55	1.8	507
11	Kaydi	HP	21.7930	80.0931	6.40	101	31	12	3	2	0.04	BDL	38	30	8	2	8	1.1	66
12	Kabuliwara	HP	21.7205	80.0109	7.74	1647	311	370	20	6	0.40	0.1	22	650	176	51	75	1.6	1071
13	Sonjhara	HP	21.6496	80.0130	7.58	1572	494	240	5	32	0.42	BDL	30	495	170	17	130	1.9	1022
14	Saleteka	HP	21.6268	79.9471	7.47	1997	531	305	6	125	0.33	BDL	28	625	222	17	165	2.4	1298
15	Bonkata	HP	21.6100	79.7591	7.12	1067	250	160	38	43	0.44	BDL	30	365	88	35	72	2	694
16	Paraswadaghat	HP	21.6663	79.8045	7.65	1493	336	250	38	75	0.37	BDL	42	500	166	21	108	4.9	970
17	Serpar	HP	21.7829	79.8973	7.73	1420	750	52	10	4	1.42	BDL	25	280	110	1	195	1.6	923
18	Saongi	HP	21.7856	80.0032	7.92	872	427	32	15	8	1.14	BDL	25	295	60	35	54.9	5	567
19	Nayatola	HP	21.8343	80.0311	8.04	1078	482	87	10	9	0.98	0.1	22	285	52	38	115	4.9	701
20	Pathersahi	HP	21.9746	80.0351	7.43	1074	378	115	12	49	0.66	BDL	26	340	112	15	80	15.1	698
21	Birsola	HP	21.8690	80.1048	7.95	753	305	65	5	27	0.57	BDL	32	250	76	15	52	5.8	489
22	Pipartola	HP	21.8771	80.2884	7.25	239	104	12	6	3	0.16	BDL	25	75	18	7	16	2.6	155
23	Chiklaghodi	Bore	21.9561	80.4019	7.5	315	146	15	5	10	0.2	BDL	36	110	36	5	20	2.1	205
24	Sarnnapur	HP	21.9702	80.4861	7.54	251	85	12	12	17	0.41	BDL	37	85	26	5	12	3.1	163
25	Ramatola	Bore	22.0024	80.5418	7.37	640	317	32	5	4	0.07	BDL	38	240	90	4	35	1.6	416
26	Sakrai Tola	HP	22.1372	80.6506	7.89	272	122	15	6	2	0.3	BDL	39	65	16	6	30	2.2	177
27	Khursipar	HP	22.2017	80.7407	7.28	361	140	15	8	27	0.03	BDL	40	145	42	10	9.4	1.4	235

Parameters					pH	EC	HCO_3	Cl	SO_4	NO_3	F	PO_4	SiO_2	TH	Ca	Mg	Na	K	TDS
S. No.	Location	Source	Lat.	Long.	at 25°C	µS/cm at 25°C													
28	Gaddi	HP	22.2342	80.7886	7.61	767	146	107	60	55	0.27	BDL	41	295	86	19	39	0.7	499
29	Jobati Tola	Bore	22.2369	80.8726	8.27	731	329	47	10	11	0.27	BDL	42	135	38	10	100	6.1	475
30	Brahman Tola	HP	22.2643	80.7924	7.04	408	67	40	28	70	0.03	BDL	43	145	38	12	25	2.9	265
31	Nabalpur	HP	22.1882	80.7796	7.82	874	293	97	10	50	0.18	BDL	44	320	100	17	46	8.3	568
32	Mohgaon	Bore	22.0575	80.6677	7.05	731	171	87	27	79	0.27	BDL	45	245	62	22	52	2.4	475
33	Palera	HP	22.0530	80.7565	7.54	646	238	50	10	46	0.06	BDL	46	250	74	16	30	2.8	420
34	Mundai	HP	22.0526	80.8295	7.1	768	268	95	5	20	0.06	BDL	47	290	82	21	40	3.5	499
35	Salghat	HP	21.9679	80.7617	7.34	357	122	25	8	31	0.1	BDL	48	115	38	5	25	1.9	232
36	Saletekri	HP	21.7812	80.8089	7.77	362	189	10	5	4	0.05	BDL	49	115	22	15	28	1.9	235
37	Singhodi	HP	22.1188	80.5115	7.26	715	220	115	8	2	0.43	BDL	50	205	64	11	66	5	465
38	Khurmundi	HP	22.1261	80.4753	7.27	763	201	77	20	91	0.07	BDL	51	275	100	6	43	4.3	496
39	Bagholi	HP	22.1399	80.3736	7.25	275	110	22	4	12	0.14	BDL	52	80	24	5	24	2.9	179
40	Bondua	HP	22.1318	80.1273	7.18	1065	207	135	72	104	0.15	BDL	53	270	106	1	110	14	692

ANNEXURE-IV (Ground Water Trend)

BLOCK_NAME	SITE_NAME	Premonsoon_trend (m/yr)_2012-21	Postmonsoon trend (m/year)_2012-21
WARASEONI	Amai	0.211884	-0.020844
LANJI	Baghatola	-0.97854	-0.443808
PARASWADA	Bagholi	0.303216	0.079416
BAIHAR	Baihar(D)	0.030432	-0.171732
BAIHAR	Baihar1	0.035916	-0.105756
BALAGHAT	Balaghat	0.434724	0.05904
BAIHAR	Bhaisanghat	0.179016	-0.0093
KIRNAPUR	Bhanegaon	-0.147552	-0.211968
BIRSA	Birsa	0.079476	-0.08772
KHAIRLANJI	Bonkatta	-0.170124	0.002316
BIRSA	Damoh(S)	0.043332	-0.03252
BIRSA	Damoh2	0.09558	0.00072
KHAIRLANJI	Garraghoda	0.244428	0.088332
BAIHAR	Jawaditula	0.65544	0.162396
LALBARRA	Kanjai	0.201264	0.035052
WARASEONI	Kanki	0.577704	-0.246732
LALBARRA	Katang Tola	0.607032	0.25896
KATANGI	Katangi	-0.062316	0.16386
KATANGI	Katangi-D	-1.675524	-0.242652
KATANGI	Katangi-S	-0.556068	-0.247128
KATANGI	Katedhara	-0.064644	0.075804
KHAIRLANJI	Khairlanji	0.379704	0.178788
PARASWADA	Khurmundi	0.521916	0.099384
KIRNAPUR	Kirnapur	0.35802	-0.060288
WARASEONI	Kochwahi	0.215652	0.057528
BALAGHAT	Lamta(S)	-0.234312	0.306192
BALAGHAT	Lamta1	0.16656	0.19968
BAIHAR	Laugur	0.587496	0.59232
BALAGHAT	Magardarta	0.171888	0.041592
KHAIRLANJI	Miragpur	-0.215604	-0.074208
BAIHAR	Mohagaon	0.093204	0.098988
BAIHAR	Mukki	0.021516	-0.05334
WARASEONI	Newargaon	0.584172	0.048948
LANJI	Paldongri	-0.22794	-0.76482
BAIHAR	Parsatola	0.418572	0.012816
KIRNAPUR	Rajegaon	-0.110556	-0.266784
KHAIRLANJI	Rampalli	-0.226068	-0.048336
PARASWADA	Rangpatbaba	0.15138	-0.0171
BALAGHAT	Saleteka New	-0.172668	-0.222756
BIRSA	Saletekhri	0.181608	0.186444
BAIHAR	Samnapur	0.03594	0.022296
BAIHAR	Supkhar	0.452868	-0.104088

ANNEXURE-V (Lithologs)

Bore	depth1	depth2	Geology
Baihar	0.00	0.50	Clayey soil
Baihar	0.50	25	Weathered Mica Schist
Baihar	25.00	25	Fractured Mica Schist
Baihar	25	54.90	Mica Schist
Samnapur	0	1.5	Clayey soil
Samnapur	1.50	20.00	Weathered Mica Schist
Samnapur	20	52	Mica Schist
Samnapur	52.00	83.00	Massive Banded Gniess
Sakrai Tola	0.00	2.50	Clayey soil
Sakrai Tola	2.50	10.00	Weathered Mica Schist
Sakrai Tola	10.00	35.00	Mica Schist
Sakrai Tola	35.00	100.00	Fractured Granite
Jobati Tola	0.00	1.50	Clayey soil
Jobati Tola	1.50	10.00	Weathered Mica Schist
Jobati Tola	10.00	30.00	Mica Schist
Brahman Tola	0	2.5	Clayey soil
Brahman Tola	2.5	20.00	Weathered Mica Schist
Brahman Tola	20	32.00	Mica Schist
Brahman Tola	32	50.00	Massive Banded Gniess
Gaddi	0.00	0.50	Clayey soil
Gaddi	0.50	25	Weathered Mica Schist
Gaddi	25	54.90	Mica Schist
Balaghat	0	0.50	Clayey soil
Balaghat	0.5	15.40	Weathered Mica Schist
Balaghat	15.4	15.40	Fractured Mica Schist
Balaghat	15.4	23.00	Mica Schist
Balaghat	23	23.00	Weathered Banded Gneiss
Balaghat	23	25.00	Fractured Banded Gneiss
Balaghat	25	54.55	Massive Banded Gniess
Balaghat	54.55	54.55	Fractured Granite
Balaghat	54.55	54.55	Massive Granite
Khursuni	0	1.50	Clayey soil
Khursuni	1.5	1.50	Weathered Mica Schist
Khursuni	1.5	1.50	Fractured Mica Schist
Khursuni	1.5	1.50	Mica Schist
Khursuni	1.5	10.00	Weathered Banded Gneiss
Khursuni	10	12.00	Fractured Banded Gneiss
Khursuni	50	50.00	Massive Granite
Pipartola	0	2.50	Clayey soil
Pipartola	2.5	10.00	Weathered Mica Schist
Pipartola	10	30.00	Mica Schist
Pipartola	30	32.00	Fractured Banded Gneiss
Pipartola	32	80.00	Massive Banded Gniess

Bondua	0	4.00	Clayey soil	
Bondua	4	10.00	Weathered Mica Schist	
Bondua	10	30.00	Mica Schist	
Bondua	30	31.00	Fractured Banded Gneiss	
Bondua	31	60.00	Massive Banded Gniess	
malajhkhand	0	3.15	Clayey soil	
malajhkhand	3.15	3.15	Mica Schist	
malajhkhand	3.15	14.60	Weathered Banded Gneiss	
malajhkhand	14.6	15.20	Fractured Banded Gneiss	
malajhkhand	15.2	20.00	Massive Banded Gniess	
malajhkhand	20	30.32	Massive Granite	
Mohgaon	0	5.00	Clayey soil	
Mohgaon	5	20.00	Weathered Banded Gneiss	
Mohgaon	20	22.00	Fractured Banded Gneiss	
Mohgaon	22	30.00	Massive Banded Gniess	
Mohgaon	30	32.00	Fractured Granite	
Mohgaon	32	60.00	Massive Granite	
Salghat	0	2.50	Clayey soil	
Salghat	2.5	23.00	Weathered Banded Gneiss	
Salghat	23	25.00	Fractured Banded Gneiss	
Salghat	25	35.00	Massive Banded Gniess	
Salghat	35	37.00	Fractured Granite	
Salghat	37	60.00	Massive Granite	
Katangi	0	2.50	Clayey soil	
Katangi	2.5	15.50	Weathered Mica Schist	
Katangi	15.5	16.50	Fractured Mica Schist	
Katangi	16.5	59.82	Mica Schist	
Bonkata	0	1.50	Clayey soil	
Bonkata	1.5	5.00	Weathered Mica Schist	
Bonkata	5	18.00	Weathered Banded Gneiss	
Bonkata	18	19.00	Fractured Banded Gneiss	
Bonkata	19	80.00	Massive Banded Gniess	
Sonjhara	0	3.50	Clayey soil	
Sonjhara	3.5	5.50	Weathered Mica Schist	
Sonjhara	5.5	20.00	Weathered Banded Gneiss	
Sonjhara	20	22.00	Fractured Banded Gneiss	
Sonjhara	22	60.00	Massive Banded Gniess	
Saleteka	0	2.50	Clayey soil	
Saleteka	2.5	15.00	Weathered Mica Schist	
Saleteka	15	15.50	Fractured Mica Schist	
Saleteka	15.5	25.00	Mica Schist	
Saleteka	25	60.00	Massive Banded Gniess	
Paraswadaghat	0	3.50	Clayey soil	
Paraswadaghat	3.5	4.50	Weathered Mica Schist	
Paraswadaghat	4.5	4.50	Fractured Mica Schist	
Paraswadaghat	4.5	4.50	Mica Schist	
Paraswadaghat	4.5	25.00	Weathered Banded Gneiss	
Paraswadaghat	25	27.00	Fractured Banded Gneiss	
Paraswadaghat	27	80.00	Massive Banded Gniess	
Bhalwa	0	1.50	Clayey soil	

Bhalwa	1.5	20.00	Weathered Mica Schist
Bhalwa	20	22.00	Fractured Mica Schist
Bhalwa	22	35.00	Mica Schist
Bhalwa	35	36.00	Fractured Banded Gneiss
Bhalwa	36	80.00	Massive Banded Gniess
Chhotapala	0	2.50	Clayey soil
Chhotapala	2.5	20.00	Weathered Mica Schist
Chhotapala	20	22.00	Fractured Mica Schist
Chhotapala	22	60.00	Mica Schist
Chhotapala	60	80.00	Massive Banded Gniess
Binora	0	2.50	Clayey soil
Binora	2.5	20.00	Weathered Banded Gneiss
Binora	20	22.00	Fractured Banded Gneiss
Binora	20	60.00	Massive Banded Gniess
Nayatola	0	4.50	Clayey soil
Nayatola	4.5	25.00	Weathered Mica Schist
Nayatola	25	26.00	Fractured Mica Schist
Nayatola	26	40.00	Mica Schist
Nayatola	40	41.00	Fractured Banded Gneiss
Nayatola	41	100.00	Massive Banded Gniess
Pathersahi	0	2.50	Clayey soil
Pathersahi	2.5	20.00	Weathered Mica Schist
Pathersahi	20	22.00	Fractured Mica Schist
Pathersahi	38	90.00	Massive Banded Gniess
Birsola	0	4.50	Clayey soil
Birsola	4.5	25.00	Weathered Mica Schist
Birsola	25	50.00	Mica Schist
Birsola	50	110.00	Massive Banded Gniess
Lanji	0	2.50	Clayey soil
Lanji	2.5	10.00	Weathered Banded Gneiss
Lanji	10	50.00	Massive Banded Gniess
Keratola	0	4.50	Clayey soil
Keratola	4.5	25.00	Weathered Banded Gneiss
Keratola	25	26.00	Fractured Banded Gneiss
Keratola	26	60.00	Massive Banded Gniess
Singhodi	0	5.00	Clayey soil
Singhodi	5	25.00	Weathered Mica Schist
Singhodi	25	26.00	Fractured Mica Schist
Singhodi	26	50.00	Mica Schist
Singhodi	50	50.00	Weathered Banded Gneiss
Singhodi	50	50.00	Fractured Banded Gneiss
Singhodi	50	50.00	Massive Banded Gniess
Singhodi	50	50.00	Fractured Granite
Singhodi	50	50.00	Massive Granite
Bagholi	0	5.50	Clayey soil
Bagholi	0.5	50.00	Weathered Mica Schist
Waraseoni	0	2.50	Clayey soil
Waraseoni	2.5	30.00	Weathered Mica Schist

Waraseoni	30	50.00	Mica Schist	
Waraseoni	50	80.00	Massive Banded Gniess	
Kaydi	0	2.50	Clayey soil	
Kaydi	2.5	10.00	Weathered Mica Schist	
Kaydi	10	30.00	Mica Schist	
Kaydi	30	31.00	Fractured Banded Gneiss	
Kaydi	31	80.00	Massive Banded Gniess	
Serpar	0	4.00	Clayey soil	
Serpar	4	15.00	Weathered Mica Schist	
Serpar	15	30.00	Mica Schist	
Serpar	30	31.00	Fractured Banded Gneiss	
Serpar	31	100.00	Massive Banded Gniess	