केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

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

JHARSUGUDA DISTRICT, ODISHA

दक्षिण पूर्वी क्षेत्र, भुवनेश्वर

South Eastern Region, Bhubaneswar

AQUIFER MAPPING
&
MANAGEMENT PLAN
JHARSUGUDA DISTRICT
ODISHA

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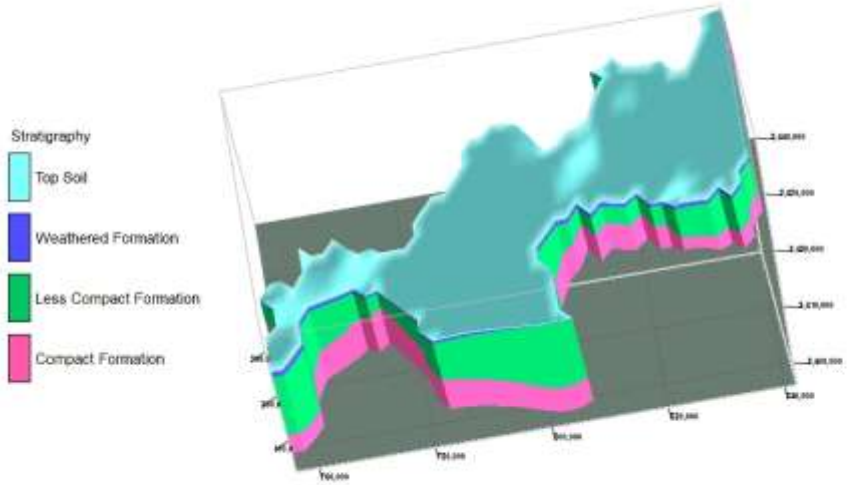
Scientist – 'B'



Central Ground Water Board
Ministry of Water Resources, River Development and Ganga Rejuvenation
Government of India
2020

FOREWORD

In recent decades groundwater has emerged as a dependable resource for assured irrigation, drinking and industrial needs worldwide. In food production and boosting up the economy of India, it has played a significant role in recent decades. It has now been quite essential to know our aquifers; the source of groundwater, its yield potential and response to the increasing demand of pumping, and the ways of its sustainable management.

Jharsuguda district, is bounded in the north by Sundergarh district, east by Sambalpur district, south by Sambalpur and Bargarh district and west by Raigarh district of Chhattisgarh State. The total geographical area is 2081.86sq. km. It is a premier mineral producing district in the state and in the country as well. The district is underlain by crystalline and sedimentary rocks belonging to Precambrian and Permo – Carboniferous age. Late sedimentaries of Recent to sub recent age developed in patches. These rocks, with their inherent properties, always constitute difficult terrains as far as groundwater prospects are concern. Unless there are some structural deformations and other geological activities perturbing the country rock, it's always difficult to get sufficient water in the secondary pores of these rocks. Though, the surface water irrigation works successfully in some parts of the district, groundwater based irrigation is yet to take up.

The present report brings forth the information available about the aquifers in the district under the National Aquifer Mapping programme of government of India. It is an excellent effort by **Sh. Tarun Mishra, Scientist-B** Central Ground Water Board, South Eastern Region, Bhubaneswar to analyse and synthesize the data and present it in a lucid way to make it quite user friendly. I am sure, the Aquifer Management Plan suggested here, will be of immense help to the Policy Makers, Planners and Researchers alike.

P K Mohapatra

Regional Director

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1. INTRODUCTION:

i. **Objectives**: To establish the disposition of aquifers up to 200-meter depth. To know the ground water quality of the shallow and deep aquifers. To calculate the ground water resources up to 100-meter depth and if feasible beyond 100-meter depth also. To prepare a comprehensive ground water management plan for the whole district.

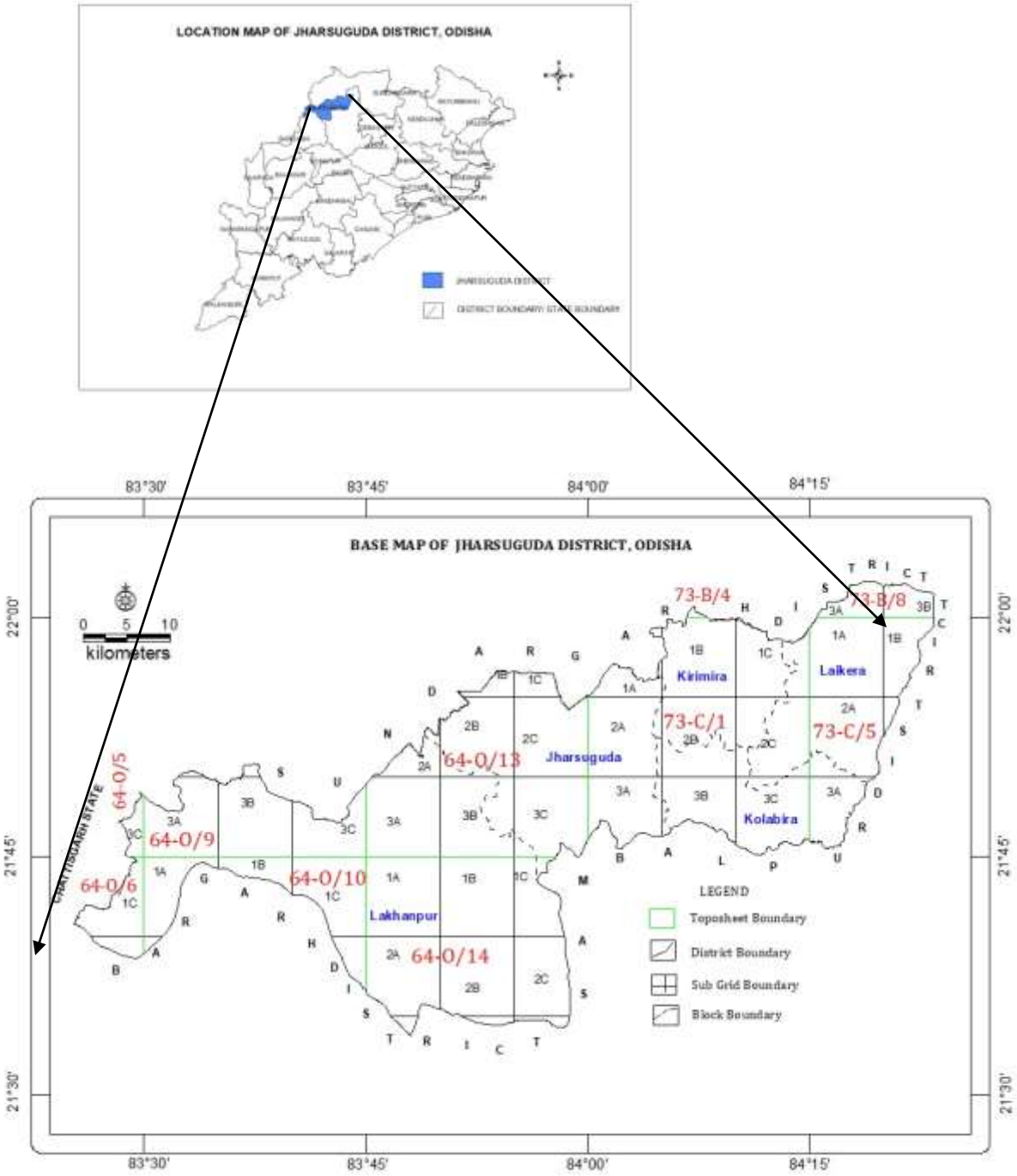
ii. **Scope of the Study**: As Jharsuguda is a mineral rich district, and lot of coal mines of MCL are located in this district and a very few hydrogeological investigations have been done during previous 20 years, there is a good scope for work regarding details of aquifer mapping in this district and as per AAP 2019-20, this district has been chosen for aquifer mapping.

iii. **Approach and Methodology**: The Jharsuguda district is falling in parts of grid/sub grid area of the Toposheet number 64 O/5, 64 O/6, 64 O/9, 64 O/10, 64 O/13, 64 O/14, 73 C/1, 73 B/4, 73 B/8, 73 C/1, 73 C/5. The data of all existing CGWB exploratory wells and NHS monitoring wells in the district are plotted on the Toposheets of 1:50000 scale with 5'X5'grid (9km x 9km). The exploration data shows that majority of tube wells falls in the Shallow aquifer (50 m depth) and Deep aquifer (from50 - 200 m depth). The grids/ formations devoid of SH/PZ/EW are identified as data gaps and these are to be filled by data generation. Similarly, data gap established for ground water key monitoring wells (for collection of water level, quality etc.) in grids/sub grids and data generated for new established key wells. Similar methodology has been adopted for VES surveys. On the basis of aquifer disposition, decadal water level declining trend areas, availability of excess future ground water resources up to the year 2025 and surplus rainfall – runoff amount, a suitable supply side and demand side management plan for the whole Jharsuguda district have been prepared.

iv. **Area details**: Jharsuguda district is bounded between the 21° 34' North and 22°02' North latitudes and also between 83°25' East and 84°23' East longitudes (Fig-1). Prior to 1993, Jharsuguda was a subdivision of Sambalpur District and was subsequently awarded the status of a new district. It is bounded in the north by Sundergarh district, east by Sambalpur district, south by Sambalpur and Bargarh district and west by Raigarh district of Chhattisgarh State. The total geographical area is 2081.86sq. km. It is divided into five administrative blocks namely Lakhanpur, Jharsuguda, Kirimira, Laikera, Kolabira. Total population of

the district is 579,505 as per 2011 census. Out of the total population 60.11% live in rural areas and rest 39.89% in urban area. The population density of the district is 274 per sq. km. The literacy rate of the district is 78.86 %. The district is well connected by rail and roads. The block headquarters are well connected by metaled roads and villages by fair weather roads. Jharsuguda district has 46588 farmers comprising of 24916 (53.48%) small farmers (SF),14203(30.49%) marginal farmers (MF) and 7469 (16.03%) big farmers (BF).

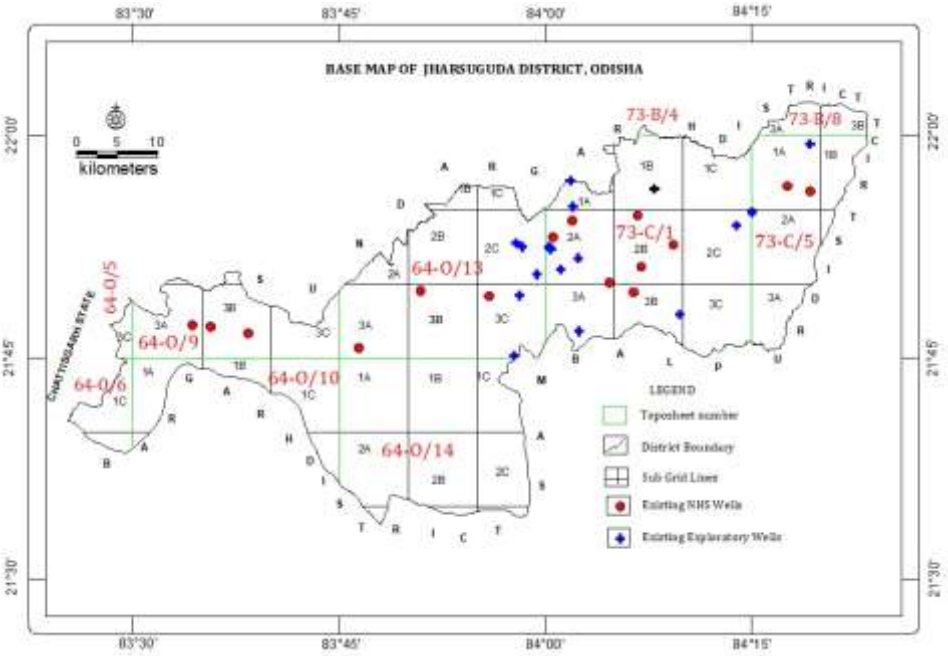
Fig.1. Location of Jharsuguda District, Odisha



v. Brief Description (Data Availability, data adequacy, data gap and data generation):

a. **Data Availability**: Status of exploratory wells (only 16) and NHS monitoring wells (only 15) are plotted in the Fig.2.

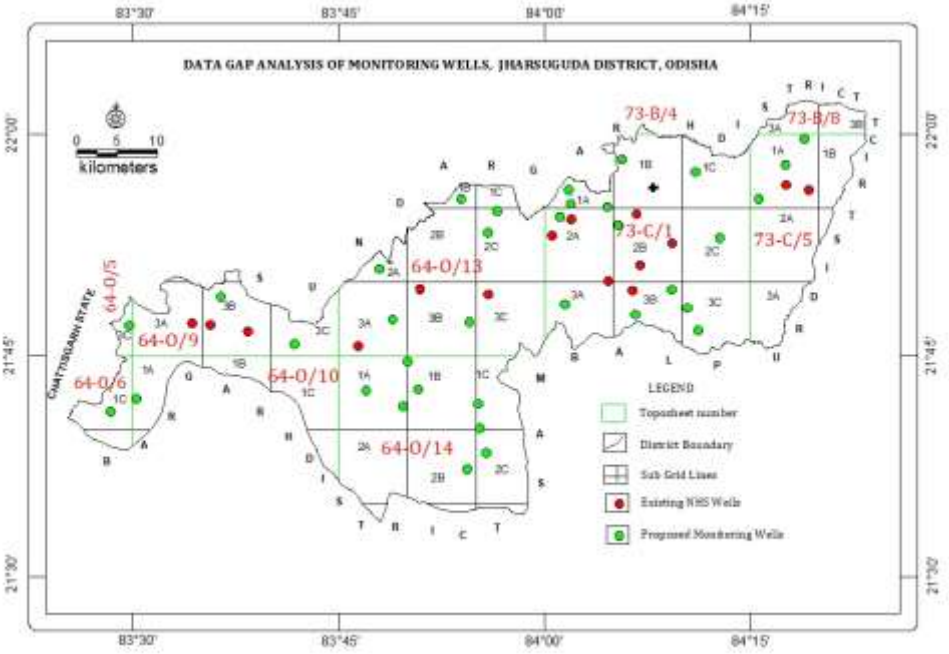
Fig.2. Availability of exploratory wells and NHS monitoring Wells, Jharsuguda District.



b. **Data Adequacy and data gap analysis**:

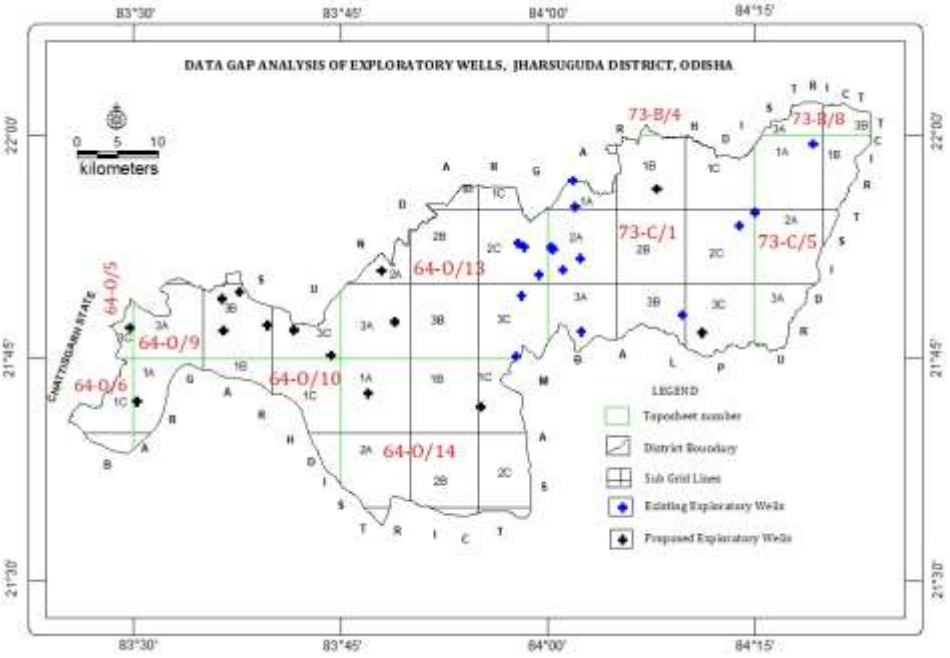
1.Monitoring Wells: On the basis of data adequacy of only 15 NHS monitoring wells data additional 36 key well have been selected to find the gap of water level monitoring and water quality analysis (Fig.3).

Fig.3. Data Gap analysis of Monitoring Wells, Jharsuguda, Odisha



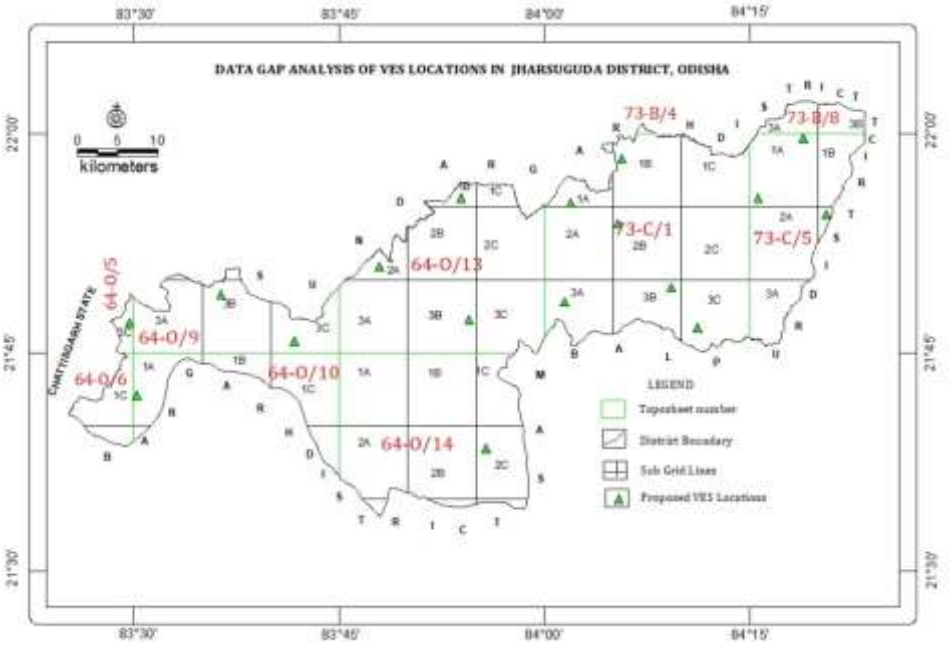
2.Exploratory Wells: On the basis of data adequacy of only 16 NHS exploratory wells data additional 14 exploratory wells (EW) have been selected to find the gap of different aquifer disposition (Fig.4).

Fig 4. Data Gap analysis of Exploratory Wells, Jharsuguda, Odisha



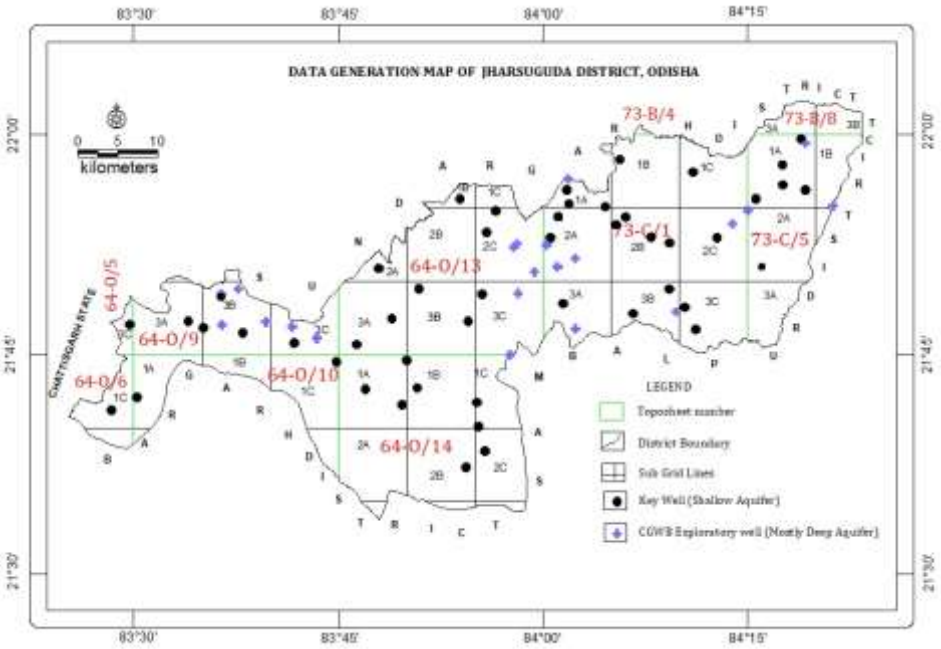
3.VES Locations: As Jharsuguda district have been devoid of any VES surveys (as per previous reports) 17 uniformly distributed VES survey locations (Fig.5) have been selected to generated data up to 200meter depth by WAPCOS. Data generation interpretations are discussed in Annexure –2.

Fig.5.Data Gap and data generation analysis of VES surveys, Jharsuguda, Odisha



c. **Data Generation**: On the basis of construction of 22 exploratory wells (as on August, 2020) a three-dimensional panel diagram and lithological sections in various directions to show the disposition of weathered zone and fractured zone have been prepared. Similarly on the basis of data obtained from key wells, NHS wells different types of water level map, decadal trend map, hydrograph, chemical quality parameters etc., are generated. Data generation points are given in Fig.6.

Fig.6. Data generation points in Jharsuguda District, Odisha.



vi. Rainfall-spatial, temporal and secular distribution:

Jharsuguda district falls under two agro ecological zones i.e (i) West Central Table Zone and (ii) North Western Plateau. Normal annual rainfall of the district is 1362.8mm with average monthly rainfall of 113.6mm & average 66 rainy days. Laikera block falls under North Western Plateau while rest of the blocks comes under West Central Table Zone. Minimum & maximum temperature of the district ranges from 26 to 40°C during summer, 16.5 to 30.2° C during winter and 25.3 to 32.5° C during rainy season. Normal Annual Rainfall is 1502mm in Jharsuguda block, 1495.9mm in Kolabira block, 1653.1mm in Laikera block, 1564mm in Kirimira block and 1269.5mm in Lakhanpur block. Average Monthly Rainfall is 125.2mm in Jharsuguda block with 68 rainy days, 124.7mm in Kolabira block with 62 rainy days, 137.8mm in Laikera block with 86 rainy days, 130.3mm in Kirimira block with 72 rainy days

and 105.8mm in Lakhanpur block with 57 rainy days as mentioned in the Table 1 hereunder;

Table 1- Year wise monthly rainfall (in mm) details of Jharsuguda District (Source- IMD website)

Year	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec	Total
2014	0	12.1	6.8	3.2	16.2	87.3	411	420.7	284.5	40	0	0.9	1283
2015	13.2	3.5	3	34	7.5	182	487	444	260.5	3.3	0	25.5	1464
2016	0.3	19.5	18.7	0.1	16	77.4	257	422	263.8	35	0	0	1110
2017	10.7	0	6	2	63.5	209	414	300	236.1	91	0.1	0	1332
2018	0	0.1	1.6	29	94.2	179	394	400.5	123.6	5.5	0	92.6	1320

Table 2: Agro Ecology, Climate in Jharsuguda District, Odisha

District	Normal Annual Rainfall (mm)	Average Monthly Rainfall (mm)	No. of Rainy Days (No.)	Average Weekly Temperature (degree Celsius)								
				Period								
				Summer (April- May)			Winter (Oct-Mar)			Rainy (June- Sept.)		
				Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
Jharsuguda	1362.80	113.60	66	26.00	40.50	33.30	16.50	30.20	23.40	25.30	32.50	28.90

Table 3: block wise rainfall distribution in Jharsuguda District

Name of the Block	Agro Ecological Zone Type	Block area (Ha)	Normal Annual Rainfall (mm)	Average Monthly Rainfall (mm)	No. of Rainy Days (No.)
Jharsuguda	West Central Table Zone	37784.40	1502.00	125.20	68
Kolarbira	West Central Table Zone	23178.60	1495.90	124.70	62
Laikera	Northwestern Plateau	36862.20	1653.10	137.80	86
Kirmira	West Central Table Zone	19079.00	1564.00	130.30	72
Lakhanpur	West Central Table Zone	113355.20	1269.50	105.80	57

Source: District irrigation plan of Jharsuguda, Odisha, PMKSY, 2016.

vii. Physiography and Geomorphology: The North –Western part of the district is mainly hilly. About 80 % of the area is characterized by isolated hillocks and rounds and undulating plains. A part of Hirakud reservoir occupying 185 sq. km is present in southern part of the district. The highest and lowest topographic

elevation of the district are 474 metre and 180 metres respectively. On the basis of RL of key wells and exploratory wells a tentative elevation contour map is shown in Fig.7. Geomorphologically this district has been divided into several units and subunits (viz., pediment, buried pediment shallow, pediment inselberg complex, valley fill, lateritic upland, denudational hill (large and small), structural hill, linear ridge/dyke, residual hill, gulley land, inselberg and structural valley). These units are shown in the Fig.8.

Fig.7. Elevation contour map, Jharsuguda District

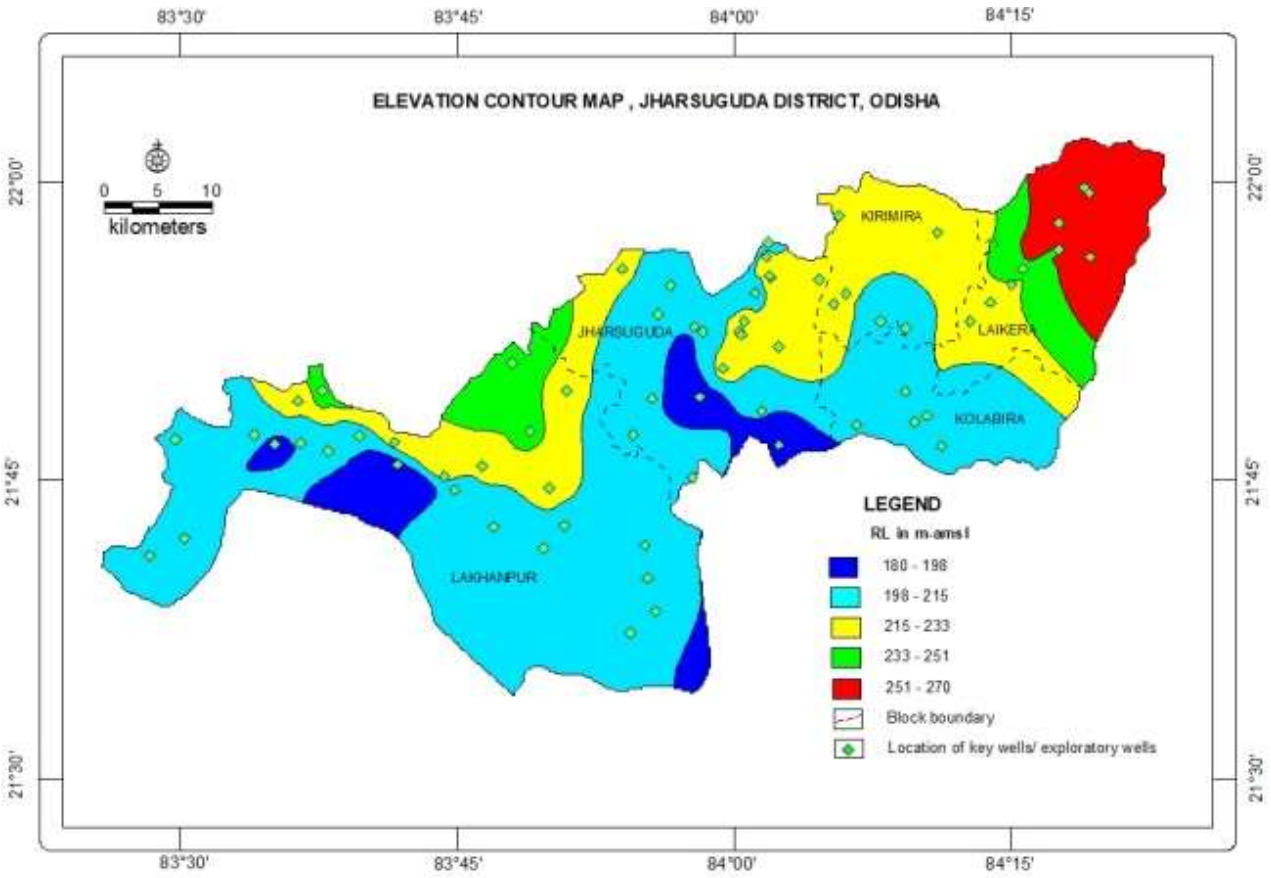


Fig.8. Geomorphology map, Jharsuguda District, Odisha

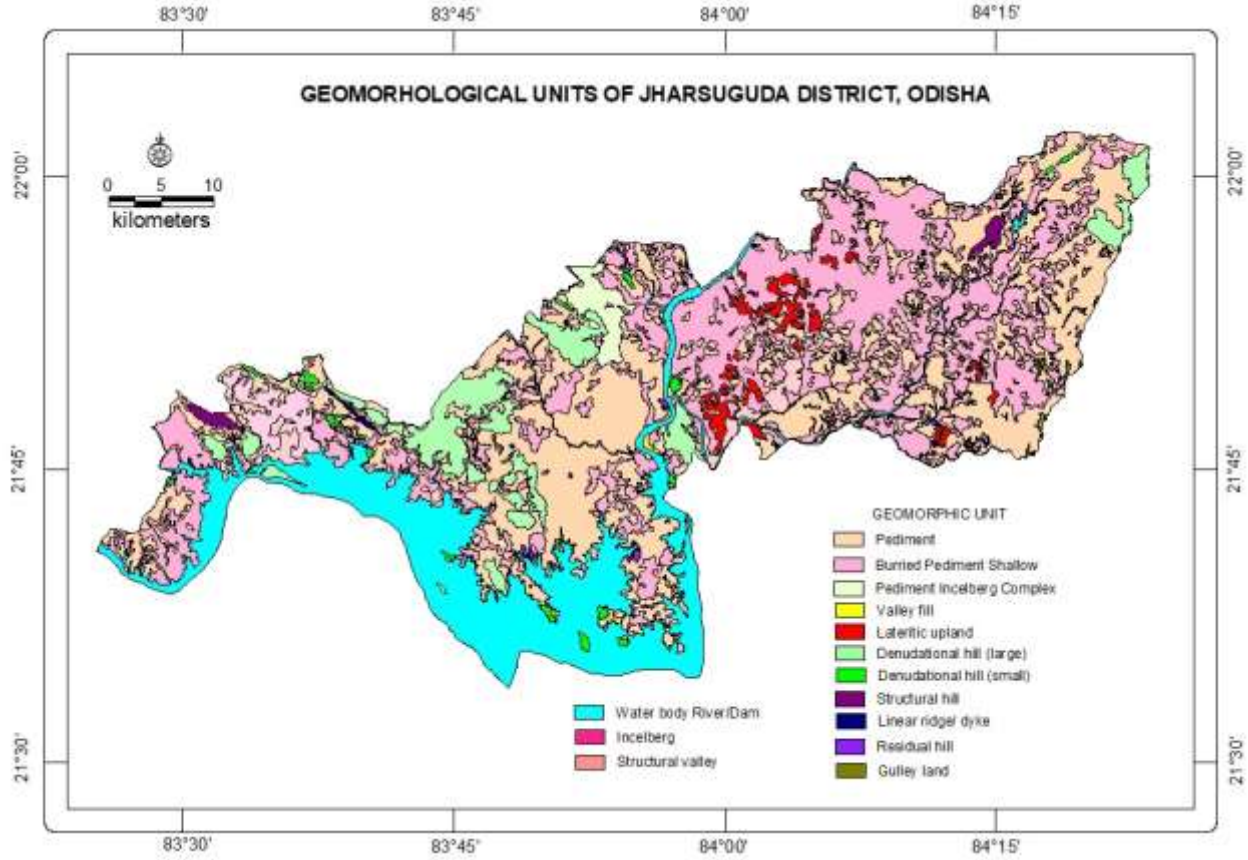
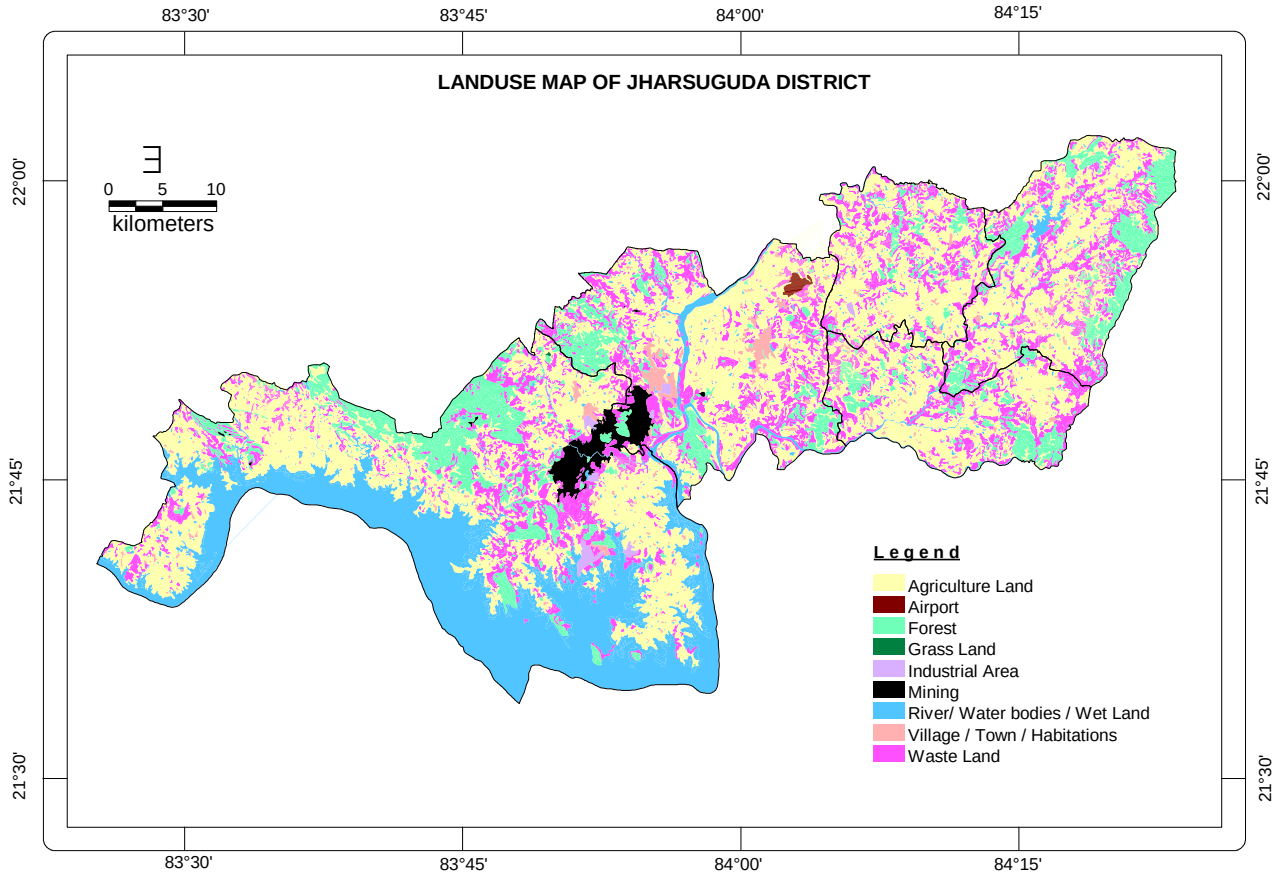


Fig.9. Land use map, Jharsuguda District, Odisha.



viii. **Land use:** The total geographical area of the district is 2081.86 sq.km out of which net sown area is 860.00 sq.km, area under forest is 203.17 sq.km and 1018.69 sq.km comes under wasteland including area under other uses (Fig.9). Gross cropped area of the district is 757.70 sq.km with 88.1% cropping intensity. Block wise details of land use pattern are mentioned in Table-4.

Table 4: Block wise Land use Pattern, Jharsuguda District, Odisha

Name of the State: Odisha							
Name of the District: Jharsuguda							*Area in Sq. Km*
S. No	Block	Total Geographical Area	Area under Agriculture			Area under Forest	Waste land & area under other uses
			Gross cropped Area	Net Sown Area	Cropping Intensity (%)		
1	Jharsuguda	407.36	186.28	194.00	96.02	55.12	158.24
2	Lakhanpur	981.97	208.58	240.00	86.91	95.14	646.83
3	Kolabira	240.46	128.96	150.00	85.97	20.69	69.77
4	Kirmira	196.06	102.19	105.00	97.32	18.02	73.04
5	Laikera	256.01	131.69	171.00	77.01	14.20	70.81
	Total:	2081.86	757.70	860.00	88.10	203.17	1018.69

Source: ***District irrigation plan of Jharsuguda, Odisha, PMKSY, 2016.***

ix. **Soil:** Major soil classes of the district are (i) Matured, Red & Lateritic soil (Alfisols), (ii) Mixed Grey soil (Inceptisols) and (iii) Unaltered soil with coarse parent materials (Entisols). These soils spread across the blocks with varying extent of area. Jharsuguda block has 16.48sq.km of Alfisols, 314.77 sq.km of Inceptisols& 23.04sq.km of Entisols. Kirimira block has 0. 82sq.kmof Alfisols, 185.87 sq.km of Inceptisols& 1.24sq.km of Entisols. Kolabira block has 14.02 sq.km of Alfisols, 206.08sq.km of Inceptisols&13.31 sq.km of Entisols. Laikera block has 78.61sq.km of Alfisols, 184.58 sq.km of Inceptisols& 22.75sq.km of Entisols, whereas Lakhanpur block has 41.86 sq.km of Alfisols, 458.72 sq.km of Inceptisols& 76.98 sq.km of Entisols (*District irrigation plan of Jharsuguda, Odisha, PMKSY, 2016*). Details of soil types are presented in Fig.10.

Fig.10. Soil distribution map, Jharsuguda District, Odisha.

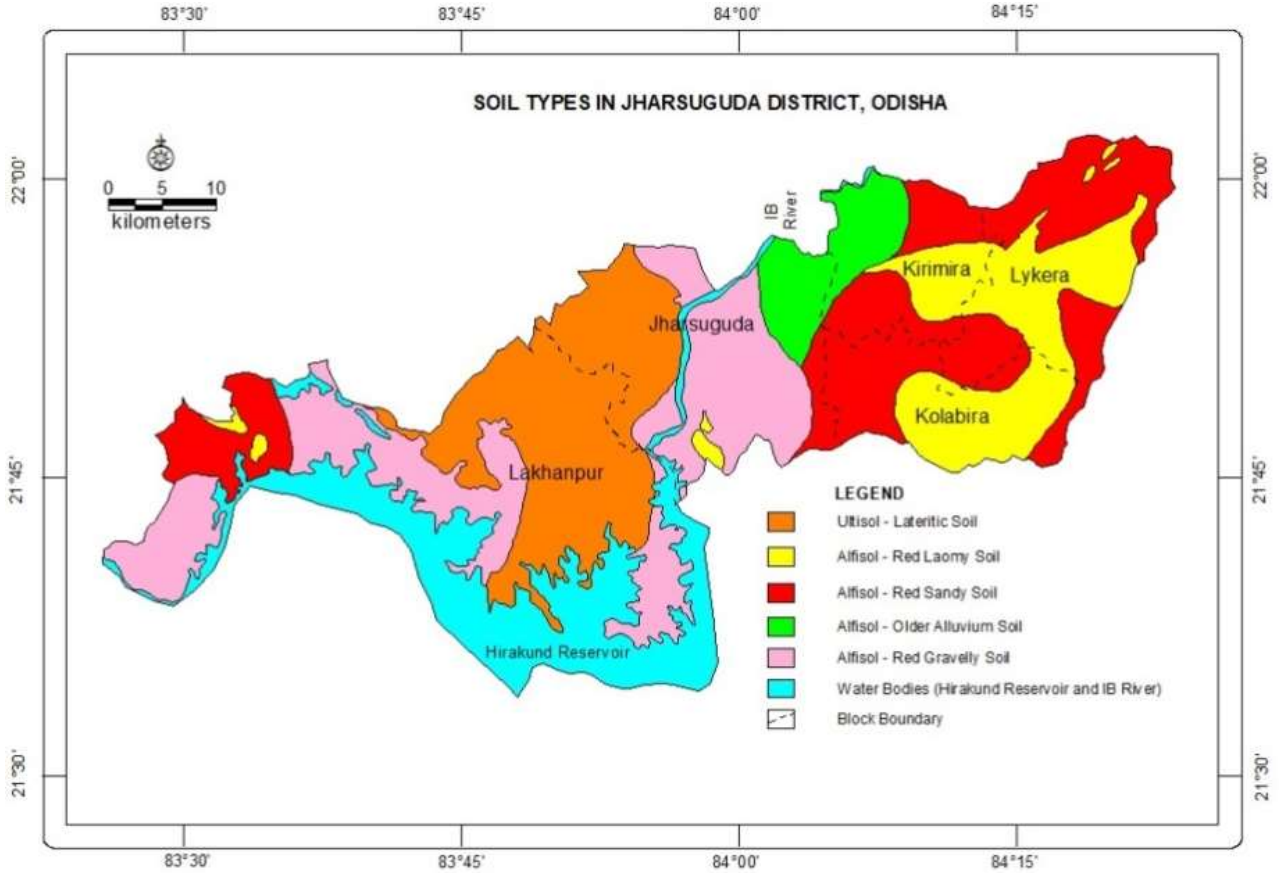
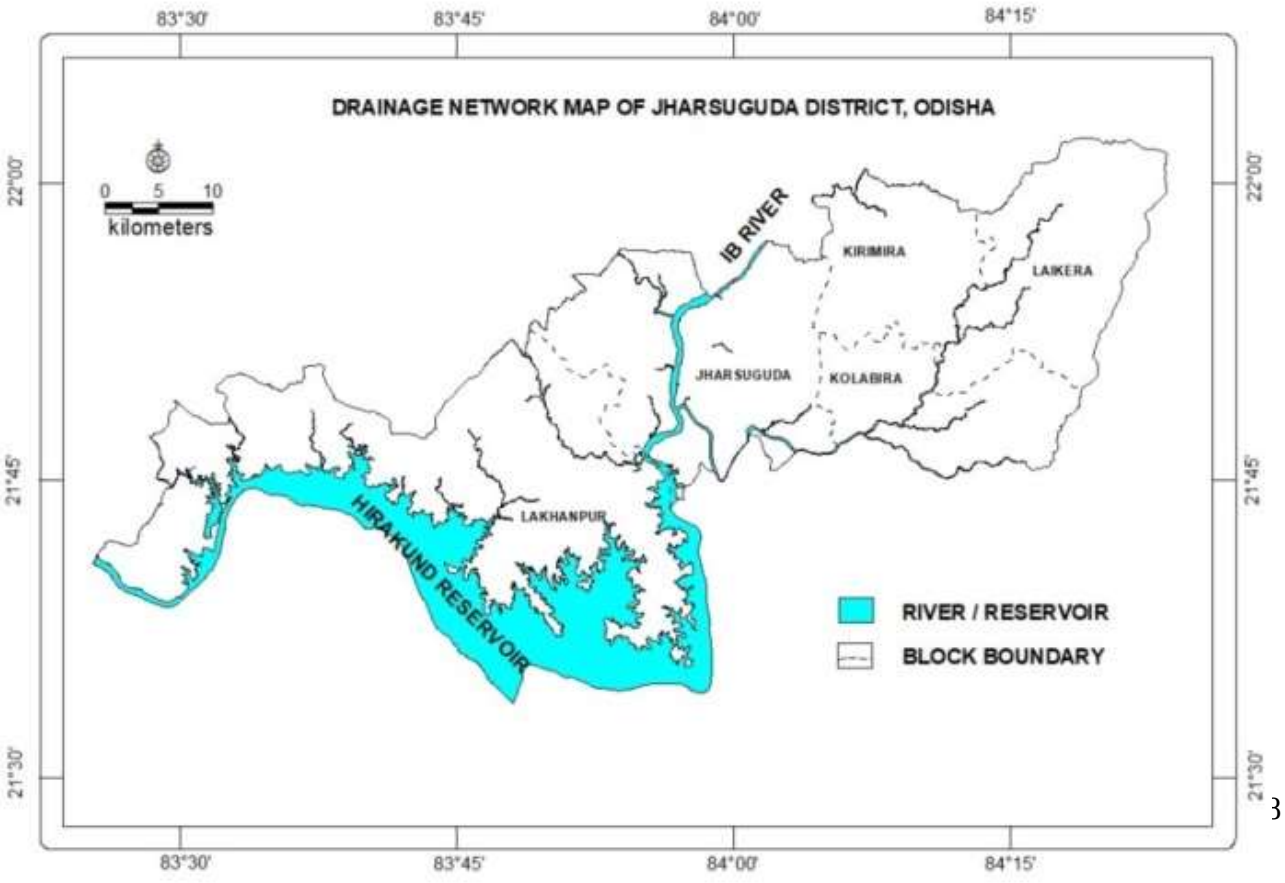


Fig.11. Drainage map, Jharsuguda District, Odisha



x. Drainage: The drainage of the district is controlled by the Mahanadi in the western part and Ib river, a tributary of the Mahanadi in the central and eastern part. The Bheden, Lilari and Basundhara nalas which join the Ib, comprise other drainage channels in the area. The drainage pattern is mainly dendritic and high drainage density is found in the western part of the district. The details of major drainages are shown in the Fig.11.

xi. Agriculture: Production& productivity of major crops like cereals, coarse cereals, pulses, oilseeds, vegetables, spices and plantation crops in different blocks in the district varies depending on the soil agro climatic condition, agronomic practices adopted & use of agri. inputs. In Jharsuguda block during Kharif, productivity of cereal crops comes to 2482 kg/ha in rainfed & 3182 kg/ha in irrigated condition while in rabi, it is 4600kg/ha in irrigated condition. Productivity of pulses comes to 450kg/ha in rainfed condition during kharif& 775 kg/ha in rainfed & 800kg/ha in irrigated condition during rabi. Productivity of oilseeds in the block show 550kg/ha in rainfed during kharif and during rabi it is 800kg/ha in rainfed& 1000kg/ha in irrigated condition. Productivity of Vegetable crops comes to 10430kg/ha in rainfed& 14600kg/ha in irrigated condition. In Lakhanpur block during Kharif, productivity of cereal crops comes to 1867 kg/ha in rainfed n& 2567 kg/ha in irrigated condition while in rabi, it is 4200kg/ha in irrigated condition. Productivity of pulses comes to 650 kg/ha in rainfed condition during kharif& 780 kg/ha in rainfed& 850kg/ha in irrigated condition during rabi. Productivity of oilseeds in the block show 550kg/ha in rainfed during kharif and during rabi it is 1200 kg/ha in irrigated condition. Productivity of Vegetable crops comes to 10430kg/ha in rainfed& 14600kg/ha in irrigated condition. In Kolabira block during Kharif, productivity of cereal crops comes to 1483 kg/ha in rainfed& 1923 kg/ha in irrigated condition while in rabi, it is 4200kg/ha in irrigated condition. Productivity of pulses comes to 625 kg/ha in rainfed condition during kharif& 750 kg/ha in rainfed& 900kg/ha in irrigated condition during rabi. Productivity of oilseeds in the block show 450kg/ha in rainfed during kharif and during rabi it is 850 kg/ha in rainfed& 900kg/ha in irrigated condition. Productivity of Vegetable crops comes to 10430kg/ha in rainfed& 14600kg/ha in irrigated condition. In Kirimira block during Kharif, productivity of cereal crops comes to 1735 kg/ha in rainfed &

2323 kg/ha in irrigated condition. Productivity of pulses comes to 450 kg/ha in rainfed condition during kharif& 650 kg/ha in rainfed& 825kg/ha in irrigated condition during rabi. Productivity of oilseeds in the block show 550kg/ha in rainfed during kharif and during rabi it is 675 kg/ha in rainfed& 900kg/ha in irrigated condition. Productivity of Vegetable crops comes to 10430kg/ha in rainfed& 14600kg/ha in irrigated condition. In Laikera block during Kharif, productivity of cereal crops comes to 1735 kg/ha in rainfed & 2235 kg/ha in irrigated condition while in rabi, it is 4220kg/ha in rainfed & 4500kg/ha in irrigated condition. Productivity of pulses comes to 600 kg/ha in rainfed condition during kharif& 700 kg/ha in rainfed& 750kg/ha in irrigated condition during rabi. Productivity of oilseeds in the block show 425kg/ha in rainfed during kharif and during rabi it is 780 kg/ha in rainfed& 840kg/ha in irrigated condition. Productivity of Vegetable crops comes to 10430kg/ha in rainfed& 10430kg/ha in irrigated condition (Source DDA and ADH, Jharsuguda).

xii. **Irrigation:** For surface irrigation, Jharsuguda district has 48 nos. of Govt. reservoirs/dams having 5380.4 Ha command area with 28 canals for 3993.6 Ha command area. The district has 1305 Nos. of community ponds with 4572.21 Ha command area. For ground water utilization, district has 867 Nos. of tube wells with 1059 Ha command area, 5436 Nos. of open wells (Govt/community) with 2058 Ha command area & 1400 Nos. of deep bore wells with 2800 Ha command area. Other sources including traditional water harvesting structures (WHS) counts to 121 Nos. with 378.31 Ha command area. Water extraction devices like electricity pumps 184 Nos.& 1551 Nos. of diesel pumps are available in the district with command area 368 Ha & 3102 Ha respectively. 185 nos. of Govt. lift irrigation points are available with 4714 Ha command area.

Table 5- Current Irrigation Potential, Jharsuguda District, Odisha.

Area in Ha

Sl. No	Block Name	Cultivated area	MIP (Major and Medium irrigation Potenial)		LIP (Lift Irrigation Potential)		Deep Bore Well		Other Sources		Other Sources Agriculture & OAIC		Total	
			Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
1	Jharsuguda	19400	312.5	425	1380	730	56	11.2	891	670	18	2.8	2657.5	1839
2	Lakhanpur	24000	1928.5	315.6	1736	958	1344	401.8	2875	2347	55	13.9	7938.5	4036.3
3	Kolabira	15000	57	11.4	610	380	150	30	965	725	8	1.2	1790	1147.6
4	Kirimira	10500	364	52.8	358	178	86	17.2	950	835	15	1.3	1773	1084.3
5	Lykera	17100	2987	389.2	400	258	1649	329.8	1885	1625	26	4.8	6947	2606.8
Total		**86000**	**5649**	**1194**	**4484**	**2504**	**3285**	**790**	**7566**	**6202**	**122**	**24**	**21106**	**10714**

Source: ***District irrigation plan of Jharsuguda, Odisha, PMKSY, 2016.***

Current irrigation potential of the district as per the above matrix comes to 21106 Ha in Kharif& 10714 Ha in Rabi out of which MIPs have the potentiality to irrigate 5649 Ha in Kharif& 1194 Ha in Rabi, LIPs can irrigate 4484 Ha in Kharif& 2504 Ha in Rabi, 3285 Ha in Kharif& 790 Ha in Rabi season can be irrigated by Deep Borewells and 7688 Ha land in Kharif& 6226 Ha land in Rabi can be irrigated by other sources. Block wise and source wise irrigation potentiality in different cropping seasons have been presented in the above matrix.

The block wise details of irrigated and unirrigated or rainfed areas are summarized in the Table-6.

Table-6. Block wise details of irrigated/ unirrigated/ rainfed areas, Jharsuguda District, Odisha.

Name of the State: Odisha				
Name of the District: Jharsuguda				
Name of the Block	Irrigated (area in Ha)		Rainfed (area in Ha)	
	Gross Irrigated Area	Net Irrigated Area	Partially irrigated / protective irrigation	Un-Irrigated or Totally Rainfed
Jharsuguda	4496.50	2657.50	0	16742.50
Lakhanpur	11974.80	7938.50	0	16061.50
Kolabira	2937.60	1790.00	0	13210.00
Kirmira	2857.30	1773.00	0	8727.00
Laikera	9553.80	6947.00	0	10153.00
Total:	31820.00	21106.00	0	64894.00

Source: District irrigation plan of Jharsuguda, Odisha, PMKSY, 2016.

Under surface irrigation, availability of water is 53.8MCM in reservoir/dams & canals, 62.1MCM in the MI tanks with 45.7MCM in kharif&16.4MCM in rabi, 84.9MCM under lift irrigation with 47.1MCM in kharif&37.7MCM in rabi and 5.9MCM in various water bodies including Rain water Harvesting with 3.8 MCM in kharif& 2.1 MCM in rabi. Availability of ground water is 32 MCM in open well with 20.6MCM in kharif& 11.4 MCM in rabi, 53.2 MCM in deep bore wells with 28 MCM in kharif& 25.2 MCM in rabi, 16.7 MCM in medium/shallow tube wells with 10.6 MCM in kharif& 6.2 MCM in rabi (Source: Department of MI, LI, Agriculture, Watershed, Jharsuguda).

xiii. Cropping pattern: In Jharsuguda district, agricultural and horticultural crops are cultivated in the total area of 75770 Ha out of which 24050 Ha irrigated

and 51720 Ha rainfed. During Kharif, 64657.4 Ha is utilised for cultivating the crops with 21106 Ha under irrigated condition and 43551.4 Ha under rainfed condition whereas during Rabi, 2944 Ha is irrigated and 8168.6 Ha is rainfed totalling to 11112.6 Ha area under rabi crops. Agricultural crops of the district include cereals, coarse cereals, pulses, oilseeds, fibre crops, etc while horticultural crops include fruit crops, vegetable crops, flowers, spices and plantation crops. Cereals are grown over 36153 Ha area with 18782 Ha irrigated and 17371 ha rainfed. Coarse cereals are cultivated in 1490 Ha area with 142.4 Ha irrigated and 1347.6 Ha rainfed. 9710 Ha comes under pulses with 675 Ha under irrigated condition and 9035 ha under rainfed condition.

Table-7. Prevailing water conservation, recharge structures, Jharsuguda District, Odisha.

DoLR-MoRD (Water shed WHS)	Unit	Jharsuguda		Kolabira		Kirmira		Laikera		Lakhanpur		Total	
		New	Renovation	New	Renovation	New	Renovation	New	Renovation	New	Renovation	New	Renovation
Check dam	No	10	0	65	22	17	2	60	4	15	11	167	39
	Area (in ha)	125.00	0	216.00	70.40	226.00	20.00	453.60	25.00	58.60	40.00	1079.20	155.40
Farm pond	No	176	27	92	32	158	79	351	60	86	55	863	253
	Area (in Ha)	704.00	298.00	368.00	32.00	632.00	93.00	1404.00	70.50	344.00	62.00	3452.00	555.50
Fishery Pond	No	133	0	73	18	8	2	68	71	58	60	340	151
	Area (in Ha)	497.42	0	273.42	17.00	29.92	5.00	254.32	65.00	216.92	86.00	1272.00	173.00
Nala Bandha	No	0	0	16	0	11	0	0	0	224	8	251	8
	Area (in Ha)	0	0	32.00	0	14.00	0	0	0	125.00	16.00	171.00	16.00
Percolations	No	81	0	30	8	78	31	5	14	66	56	260	109
	Area (in Ha)	466.00	0	62.00	8.00	196.00	77.00	13.50	66	139.00	112.00	876.50	263.00
Water Harvesting Structure	No	37	41	57	256	74	218	130	249	19	99	317	863
	Area (in Ha)	370.00	312.00	570.00	1202.00	740.00	2093.00	1300.00	908.5	190.00	340.00	3170.00	4855.50
Graded Bunding (rmt)	No	1	0	0	0	0	0	0	0	9026.00	0	9027	0
	Area (in Ha)	6.00	0	0	0	0	zg0	0	0	16.00	0	22.00	0
RMS	No	1	0	0	0	0	0	0	0	0	0	1	0
	Area (in Ha)	8.00	0	0	0	0	0	0	0	0	0	8.00	0
Field Bunding (rmt)	No	0	0	0	0	0	0	0	0	5107	0	5107	0
	Area (in Ha)	0	0	0	0	0	0	0	0	9.50	0	9.50	0
Total	**No**	**439.00**	**68**	**333**	**336**	**346**	**332**	**614**	**398**	**14601**	**289**	**16333**	**1423**
	Area (in Ha)	**2176.42**	**610**	**1521.42**	**1329.4**	**1837.92**	**2288**	**3425.42**	**1135**	**1099.02**	**656**	**10059.8**	**6018.4**

Source: District irrigation plan of Jharsuguda, Odisha, PMKSY, 2016.

xiv. Oilseeds are grown to the extent of 5083.6 Ha with 675.7 Ha irrigated and 4407.9 Ha rainfed. Fibre crops are cultivated in an area of 50 Ha under rainfed condition. About 23284 Ha of land comes under other crops out of which horticultural & plantation crops are grown in 13708 Ha with 1961.3 Ha irrigated and 11747Harainfed (Source-DDA and ADH, Jharsuguda) .

xv. **Prevailing water conservation, recharge practices etc.:** About 17756 Water Bodies have been identified in the district (16333 newly created &1423 renovated) and under PMKSY, these watersheds are being taken up for Run-off management, soil water conservation and improving soil-moisture regime (District Irrigation Plan, Jharsuguda). The details of water conservation structures and recharge structures are shown in the Table-7.

2. DATA COLLECTION AND GENERATION

i. HYDROGEOLOGY: *Previous study*

Consolidated formations

About 60% of the area in Jharsuguda District is underlain by consolidated formations comprising Precambrian metasediment of Sambalpur series, Iron ore and Gangpur series. These rocks are very hard and compact and the ground water occurs mainly in secondary porosity. Ground water occurs under semiconfined to confined conditions in fractured rocks. Granite Gneisses are the most predominant rock types usually occupying the underlying plains and topographic lows. These rocks are highly weathered and the thickness of the weathered zone usually ranges from 4.57 to 12.03 m bgl. The specific capacity of open wells varies from 5.765 to 53.001 1pm/m. Quartzite of the iron ore group are bedded, joined but having little ground water development prospects. The depth of open wells varies from 6.94 to 9.37 mbgl. The open wells are tested and its capacity was found to be 7.266 lpm/m. Mica schists have low permeability. The depth of the open wells ranges from 6.11 to 7.84 m The specific capacity of the open well tested was found to be of the order of 5.765 lpm/m.

Semi consolidated formation: Sandstones, shales, conglomerates grit etc. belonging to Talcher, Barakar and Kamthis of lower Gondwana's constitute the semi consolidated formations. The needle shales with high frequency of intersecting joints form good

aquifers. The depth of the open well varies from 6.6 to 12.5m bgl. The specific capacity was found to be 7.148 lpm/m.

Unconsolidated formation: Laterites and alluvium of sub recent to recent age constitute the unconsolidated formations. Laterites which occur in patches as capping the older formations and form a very good shallow aquifer. The coarse-grained sand with gravels and pebbles form repository of ground water which occurs under water table conditions. Alluvium forms potential shallow aquifer to be developed through dug wells.

Present Study: During the present NAQUIM study details of key wells, its depth, depth to water level (pre and post,2019), water table etc., are summarized block wise in Table-8.

Table 8a. Details of Key wells, its water level, water table (pre and post monsoon, 2019), annual fluctuation in Jharsuguda Block.

NAME OF THE LOCATION	Location	Block	Longitude	Latitude	Well depth(m)	Well.dia(m)	M.P(m)	W.L.(Pre) mbgl	W.L.(Post) mbgl	Fluctuation in meter	Water Table(m) Pre 2019	Water Table(m) Post2019
Amlipali	Backside of Sh.Ramgopal house	Jharsuguda	84.01889	21.90694	7.38	1.95	0.6	4.84	1.9	2.94	205.16	208.1
Durlaga	In the land of Sh.TarunNaik,behind Geo Tower	Jharsuguda	84.03194	21.92167	8		0.6	6.87	1.89	4.98	213.13	218.11
Talpatia	By the side of Sh.Jagannath temple	Jharsuguda	84.02944	21.9375	11	1.8	0.45	8.23	2.23	6	211.77	217.77
Talmol	In the house of Sh.SurendraNaik	Jharsuguda	84.07639	21.91861	8	2.2	0.5	7.3	1.88	5.42	222.7	228.12
Kudopali	By the RHS of the road near house of Sh. Shridhar Thakur	Jharsuguda	83.90861	21.78833	9.25	2.35	0.35	8.22	4.05	4.17	196.78	200.95
Rajpur	In front Sh.Jagannathmadir& by the side of house of Sh. Sanjib Mishra	Jharsuguda	83.93139	21.88917	9.8	3.35	0.3	4.15	2.85	1.3	195.85	197.15
Chinchida	In the plot of Sh.Laxman Mishra, by the right side of mandir	Jharsuguda	83.89861	21.9275	9.63	1.98	0	9.15	1.89	7.26	210.85	218.11
Badakhandia	In the land of Sh.Jagannath Patel	Jharsuguda	83.9425	21.91361	7.3			6.5	2.71	3.79	193.5	197.29
Jharsuguda	JhasugudaInd.Estate,inSh.Nigabananda Ashram near Labour office	Jharsuguda	84.00917	21.88333	6.15	1.35	0.5	2.75	1.55	1.2	217.25	218.45
Brajarajnagar	In Jagannath temple premises	Jharsuguda	83.92583	21.81889	7.17	1.25	0	5.93	5.7	0.23	194.07	194.3
Brundamal	By the side of house of Sh.GhanashyamChatiria, opposite Gouda SanscrutiMandap, the village is approachable from Vendanata Gate	Jharsuguda	84.025	21.80833	7.6	1.7	0.5	5.85	1.7	4.15	194.15	198.3

Table 8b. Details of Key wells, its water level, water table (pre and postmonsoon, 2019), annual fluctuation in Kirimira Block.

NAME OF THE LOCATION	Location	Block	Longitude	Latitude	Well depth(m)	Well.dia(m)	M.P(m)	W.L.(Pre)mbgl	W.L.(Post)mbgl	Fluctuation in meter	Water Table(m) Pre 2019	Water Table(m) Post2019
Dhutra	By the side of RadhakrishnaMandir	Kirimira	84.08972	21.89778	8.8	2.7	0.8	5.5	1.2	4.3	224.5	228.8
Bhalupatra	Govt well infront house of Sh.BudhaKisan	Kirimira	84.1325	21.88389	6.55	2.15	0.3	5.38	2.4	2.98	194.62	197.6
Kirmira	In Soven Memorial Panchayat College	Kirimira	84.155	21.8775	7.95	3.05	0.6	4.83	1.67	3.16	205.17	208.33
Arda	On the road infront house of Sh.AmbikaDehiria	Kirimira	84.10139	21.90667	9.05	3.2	0.7	6.4	1.6	4.8	213.6	218.4
Sulahi	Jagannath temple's well	Kirimira	84.09444	21.97194	9.4	1.7	0.65	7.85	3.2	4.65	222.15	226.8
Baghudihi	In the house of Sh.Rohit Kumar Yadav	Kirimira	84.18389	21.95778	9.15	1.4	0.4	7.2	1.55	5.65	212.8	218.45

Table 8c. Details of Key wells, its water level, water table (pre and postmonsoon, 2019), annual fluctuation in Kolabira Block.

NAME OF THE LOCATION	Location	Block	Longitude	Latitude	Well depth(m)	Well.dia(m)	M.P(m)	W.L.(Pre) mbgl	W.L.(Post) mbgl	Fluctuation in meter	Water Table(m) Pre 2019	Water Table(m) Post2019
Paramanpur	By the side of U.P.School(Old),near JagannathMandir&BinapaniYubakSangha	Kolabira	84.11056	21.79667	9.14	1.9	0.7	4.23	2	2.23	205.77	208
Raghunathpur	In Sunharipada,govt well infront house of Sh.Varun Chandra	Kolabira	84.15472	21.82472	7.95	2.6	0.6	3.73	0.81	2.92	206.27	209.19
Kolabira	Inside block office	Kolabira	84.17389	21.80417	10.57	2.4	0.75	6.85	2.05	4.8	203.15	207.95
Samasingha	In front house of Sh. PitambarRana near Gram Panchayat Office &infront of DurgaMandap	Kolabira	84.18722	21.77889	10.5	2.45	0.6	6.4	3.18	3.22	193.6	196.82

Table 8d. Details of Key wells, its water level, water table (pre and postmonsoon, 2019), annual fluctuation in Lakhanpur Block.

NAME OF THE LOCATION	Location	Block	Longitude	Latitude	Well depth (m)	Well.dia(m)	M.P(m)	W.L.(Pre) mbgl	W.L.(Post) mbgl	Fluctuation in meter	Water Table (m) Pre 2019	Water Table (m) Post 2019
Singarpur	In Jhadeswar Shiv temple	Lakhanpur	83.74778	21.74194	3.85	1.1	0	3.1	1.82	1.28	196.9	198.18
Katarbaga	By the side of the compound wall (inside) in the premises of Adarsh Primary School (covered with slab)	Lakhanpur	83.63333	21.775	6.4	2.2	0.7	5.05	1.06	3.99	194.95	198.94
Panchagaon	NHS Well	Lakhanpur	83.58528	21.78056	6.95	1.5	0.4	5.82	1.1	4.72	189.18	193.9
Bhikhampali	Inside High School Compound	Lakhanpur	83.56667	21.78833	6.05	2.15	0.75	4.41		No Value	200.59	No Value
Kadamdihi	On trijunction,on RHS of the road to village at the junction by the side of the building of Sh.Suresh Nayak	Lakhanpur	83.69611	21.76333	8.75	1.5	0.6	7.15	2.09	5.06	187.85	192.91
Machida	Near Sh.Jagannathtemple,infront of Angwanwadi Centre & by the side of Committee centre	Lakhanpur	83.60639	21.81694	9.4	3.05	0.8	8.15	1.7	6.45	211.85	218.3
Kandeikela	In the house of Sh.AlekhBarik	Lakhanpur	83.4725	21.68694	9.6	2.7	0.3	3.6	2.36	1.24	206.4	207.64
Dhulunda	In the middle of the viilage by the side of MausiMandir&infront house of Sh.ShashiBiswal	Lakhanpur	83.50389	21.70167	7.95	2.2	0.9	1.3	1.02	0.28	198.7	198.98
Kanakatura	in the house of Sh.MakardhojaSahoo, by the side of NH-49 near Balaji Petrol Pump	Lakhanpur	83.49528	21.78472	4.75	1.5	0.45	2.98	1.35	1.63	197.02	198.65

Kuraloi	on RHS of the road at trijunction, at the approach road to village Bartap&infront of Jana Seva Kendra	Lakhanpur	83.81556	21.79111	7.96	1.9	0	5.61	3.3	2.31	232.39	234.7
Grindola	In the house of Sh.HemakantaBadhei	Lakhanpur	83.79972	21.84833	8.4	2.2	0.2	7.55	4.6	2.95	242.45	245.4
Beheramal	In front Anganwadi Centre & electric substation	Lakhanpur	83.78306	21.71111	7.25	1.9	0.7	3.75	1.45	2.3	196.25	198.55
Remenda	In the premises of High School	Lakhanpur	83.82806	21.69306	6.6	1.45	0.8	2.78	2.05	0.73	197.22	197.95
Arhapada	Govt well behind Bhagabatagudi& club	Lakhanpur	83.84639	21.71222	9.95	2.15	0.8	5.95	1.92	4.03	204.05	208.08
Uburha	In the house of Smt. KhitisutarSha, infront of Uburha UP School	Lakhanpur	83.83361	21.74361	9.66	3	0.68	8.76	2.68	6.08	211.24	217.32
Kumbharabandha	Infront of Sh.JagannathMandir	Lakhanpur	83.91944	21.69583	10.28	1.5	0.7	9.4	1.58	7.82	190.6	198.42
Govindpur	Well of Raghu Panda,200m from ME School	Lakhanpur	83.92167	21.66833	10.16	1.25	0.6	4.58	6.41	-1.83	195.42	193.59
Lakhanpur	In block office	Lakhanpur	83.7725	21.76194	7.9	2	0.6	5.7	2.6	3.1	214.3	217.4
Tilia	In front of N.M.Centre&TiliaSevaSamabayaSamiti Ltd Godown	Lakhanpur	83.92944	21.64028	9	1.5	0.75	6.8	2.1	4.7	193.2	197.9
Singhaipali	In front of club at the entrance of the village,RHS of the road to village &infront house of TarunaSahoo& Hanuman mandir	Lakhanpur	83.90639	21.62194	8.9	2.75	0.55	6.05	2.3	3.75	193.95	197.7
Belpahar	In the house of Sh. KailashPradhan,near station DurgaPradhan	Lakhanpur	83.84861	21.82528	9.27	1.5	0.55	7.95	3.73	4.22	212.05	216.27

Table 8e. Details of Key wells, its water level, water table (pre and postmonsoon, 2019), annual fluctuation in Laikera Block.

NAME OF THE LOCATION	Location	Block	Longitud	Latitude	Well depth(m)	Well.dia(m)	M.P(m)	W.L.(Pre)mbgl	W.L.(Post)mbgl	Fluctuation in meter	Water Table(m) Pre 2019	Water Table(m) Post2019
Laikera	In block office, covered with slab	Laikera	84.21306	21.88333	9.9	2.7	0.9	5.3	1.8	3.5	214.7	218.2
Jhirlapali	In the house of Sh.Kalpabata Patel near overhead water tank	Laikera	85.24306	21.83444	9.58	2.35	0.7	7.42	0.93	6.49	216.58	223.07
Dimirdihi	In the house of Sh. Ramesh Patel	Laikera	84.26083	21.9275	8.35	3.65	0.35	6.56	3.13	3.43	243.44	246.87
Shahaspur	Opposite Anganwadi Centre, near Pry.School	Laikera	84.29333	21.94333	8	2.5	0.6	6	1.5	4.5	244	248.5
Ramachipidi	by the side of Club & Road	Laikera	84.29306	21.96611	9.1	1.9	0.55	8.06	2.73	5.33	251.94	257.27
Chandanimal	In Pry.School	Laikera	84.32111	21.9375	9.05	2	0.6	7.02	1.85	5.17	252.98	258.15
Kukerama	In the house of Sh. Dambarudhara Behera	Laikera	84.31611	21.99556	8.9	3.2	0.6	8.1	3.35	4.75	256.9	261.65

ii.Hydrochemical: For water sample collection from shallow aquifers (mainly weathered zone)38 number of water samples collected for basic analysis (only for major elements in mg/l) only during pre monsoon time. Apart from these 12 wells have been selected for Fe and uranium analysis. All samples are analysed in CGWB Lab.The details are summarized in Table 9.

Table-9. Chemical quality analytical results of major elements from all key wells, Jharsuguda District.

Block	VILLAGE	Long	Lat	EC µS/cm	Cl^-	NO_3^{-*}	F	TDS*	Hardness	Alkalinity	Ca^{++}	Mg^{++}	Na^+	K^+	$CO_3^=$	HCO_3^-	$SO_4^{=*}$
Jharsuguda	Brundamal	84.025	21.808	830	129	49	0.45	431	267	139	54	32	43	40.8	0	169	49
Jharsuguda	Kuraloi	83.816	21.791	170	19	3	0.1	80	69	44	16	7	4	2	0	54	5
Jharsuguda	Grindola	83.800	21.848	640	78	48	0.1	339	168	129	42	15	40	49	0	157	38
Jharsuguda	Kudopali	83.909	21.788	330	39	32	0.1	154	119	75	26	13	17	5	0	91	9
Jharsuguda	Rajpur	83.931	21.889	1370	175	46	0.62	687	455	302	48	81	99	9.1	0	368	94

Jharsuguda	Chinchida	83.899	21.928	860	87	18	0.23	444	312	208	56	42	46	10.5	0	254	78
Jharsuguda	Badakhandia	83.943	21.914	970	124	47	0.1	503	307	213	54	42	49	55	0	260	52
Jharsuguda	Jh.Ind.Estate	84.009	21.883	660	29	25	0.12	335	208	203	48	21	50	6.7	0	248	58
Jharsuguda	Amlipani	84.019	21.907	660	114	18	0.2	339	193	119	32	27	58	5.8	0	145	31
Kolabira	Paramanpur	84.111	21.797	1280	114	52	0.1	675	401	371	91	42	57	88	0	453	61
Kolabira	Raghunathpali	84.155	21.825	570	68	26	0.1	255	248	129	54	27	13	3	0	157	13
Kolabira	Kolabira	84.174	21.804	450	29	8	0.28	221	188	173	60	9	12	7.5	0	211	0
Kolabira	Samasingha	84.187	21.779	590	107	37	0.1	316	158	70	42	13	48	23	0	85	41
Kolabira	Jhirapali	85.243	21.834	1270	177	43	0.18	667	426	272	77	57	56	65	0	332	73
Lakhanpur	Kadamdihi	83.696	21.763	600	70	5	0.12	297	252	178	50	31	19	3.6	0	217	17
Lakhanpur	Machida	83.606	21.817	1260	187	43	0.28	688	327	302	46	52	82	95	0	368	46
Lakhanpur	Kandeikela	83.473	21.687	1870	352	6	0.29	981	589	322	54	110	108	83	0	393	81
Lakhanpur	Dhulunda	83.504	21.702	1840	223	38	0.33	969	520	440	107	61	115	115	0	537	85
Lakhanpur	Kanakatura	83.495	21.785	250	36	5	0.1	130	94	44	24	8	12	2.4	0	54	21
Lakhanpur	Beheramal	83.783	21.711	480	49	12	0.17	241	173	104	44	15	19	17	0	127	34
Lakhanpur	Remanda	83.828	21.693	2020	556	44	0.4	1093	703	109	123	96	136	5.7	0	133	111
Lakhanpur	Arhapada	83.846	21.712	960	141	46	0.1	477	337	188	50	52	53	20.6	0	229	49
Lakhanpur	Uburha	83.834	21.744	260	36	41	0.1	116	89	30	30	3	12	8.5	0	36	8
Lakhanpur	Kumbharabandh	83.919	21.696	1070	197	46	0.6	537	396	153	71	53	58	7.5	0	187	59
Lakhanpur	Govindpur	83.922	21.668	450	36	4	1.27	224	124	163	28	13	43	2.8	0	199	4
Lakhanpur	Tilia	83.929	21.640	550	27	1	0.44	267	218	228	54	20	24	2	0	278	3.5
Lakhanpur	Singhaipali	83.906	21.622	1270	168	46	1.18	630	475	262	62	78	70	3.3	0	320	92
Kirimira	Dhutra	84.090	21.898	1110	117	32	0.29	618	307	228	63	36	78	58	0	278	129
Kirimira	Talmol	84.076	21.919	1590	313	46	0.32	793	584	168	97	83	89	12.8	0	205	98
Kirimira	Arda	84.101	21.907	270	29	3.8	0.24	132	89	59	24	7	16	4.9	0	72	16
Kirimira	Sulahi	84.094	21.972	740	53	3	0.24	396	203	208	42	24	28	80	0	254	45
Kirimira	Durlaga	84.032	21.922	560	53	25	0.2	270	198	153	46	20	35	2.5	0	187	22
Kirimira	Talapatia	84.029	21.938	340	22	19	0.98	176	114	94	26	12	13	20	0	115	27
Kirimira	Baghudihi	84.184	21.958	890	97	42	0.13	506	178	183	48	14	77	76	0	223	85
Lykera	Laikera	84.213	21.883	1690	330	2.6	0.59	886	584	282	71	99	89	51	0	344	78
Lykera	Ramachipidi	84.293	21.966	1310	168	17	0.4	656	584	396	115	72	25	10	0	483	29
Lykera	Kukerama	84.316	21.996	1230	117	15	0.28	591	480	411	69	75	57	5.8	0	501	22
Lykera	Dimirdihi	84.261	21.928	1090	129	47	0.3	521	470	272	85	63	32	2.3	0	332	47

iii.Geophysical Study: Data generation from VES locations are explained in Annexure 2. VES results were compared with the lithologs of the nearby 3 boreholes drilled by CGWB at Machida, Jogidhipa, and Kutrapali. After Comparing the VES results with the lithologs of the nearby boreholes and local geology and hydrogeology, the resistivity characteristics of the near surface weathered rock and the underlying massive / fractured formation were presented in the table Annexure 2.

The resistivity of the top soil is varying between 14- and 235-Ohm m depending on its nature and saturation and the thickness is varying between 0.4 and 4.8 m The resistivity of weathered zone ranges from 8 to 69-ohm m depending on its nature and saturation. Occasionally, it exceeds 112 Ohm m where poor weathering is there. In general, the weathered zone is extending down to a depth of 19 m bgl. To understand the possibility of encountering thin fractured zones, the VES curves were analysed for 'current increase', 'curve break' and 'factor flat'. The depth zones with combination of all these three attributes, viz., increase in current, associated with reduced gradient in apparent resistivity trend (curve break) and horizontal flattening of factor curve were identified as indicators of the presence of fractured zones. The 3rd and / or 4th geoelectric layer with resistivities ranging between 18 and 126 Ohm infers the less compact / formation with fractures, occasionally the resistivities exceed to 435 Ohm m depending on the degree of fracturing, nature of the formation, etc. The thickness of the geoelectric layer inferred as less compact / formation with fractures is varying between10 and 71 m, occasionally exceeding to 166 m. The depth to bottom of this layer is in general varying from 17 to 84 m, occasionally exceeds to 195 m. On the basis of geoelectrical layer parameters and the fractured zone analysis a few sites are recommended for borehole drilling (Annexure-2). On the VES data a three-dimensional model has been prepared which consists of 4 layers, viz., Top soil, followed by weathered Formation, followed by less compact Formation and at the bottom Compact Formation (Fig.4d).

iv. Exploratory Drilling (Previous study): Initially exploratory drilling carried out by GSI and CMPDIL in parts of IB river coal fields has yielded good results. The bore hole drilled by GSI ranged from 504**.**45 to 725.25 m depth, which recorded free flow (06 to 4 lps) wells tapping Barakar sandstone at a depth

range from 346-375 mbgl and 264-314 mbgl. The test wells (viz., Lajkura, Parkhari in IB river coal field) drilled by CMPDIL ranges from 36.8-142 mbgl depth with varying discharge from 1.9 lps to 9.5 lps with a drawdown from 10.69-21.25 m. Transmissivity values ranges from 60 m^2/day to 114.65 m^2/day and storativity values ranges from 5.3 × 10^{-5} to 6 × 10^{-4}. As lithologs of these wells are not available these wells are not taken for preparation of cross sections and panel diagram.

The exploration carried out by the Department (CGWB) have taken into account for detailed analysis. The rock types encountered are mostly granite, granite gneiss, mica schists and sandstones, shales. The yield varies from negligible to 7 liters per second (at Sahaspur, Laikera Block). Two to three sets of saturated fractures (water bearing zones) occur in these wells and are mostly confined within a depth of 100 meters below ground level. Perusal of pumping test data shows that the specific capacity of the wells in the granite gneiss varies from 5.765 to 53.001 lpm/m and in Barakar and Kamthi Sandstones from 0.72 to 39.886 lpm/m. The specific capacity of the dug wells in alluvial formation is of the order of 61.593 lpm/m. Similarly, it is observed that the permeability value of weathered granite gneiss varies from 0.371 to 7.195m /day and in Gondwana, permeability varies from 0.256 to 8.045m/day. In contrast the permeability value of the order of 14.448 m/day is observed in the alluvial formations.

Under accelerated drilling programme during Phase I and II, 30 exploratory wells have been constructed in Jharsuguda District. The details are summarised in Table 10e. But due to nonavailability of the details tube well design, lithology, fracture zone, weathered zone these wells could not be taken into account for preparation of aquifer map.

Present Study: As on date 6 EW and 3 OW have been constructed in data gap areas of Lakhanpur Block during current AAP. Other well construction is in progress. The wells have been constructed within depth ranges from 172.2 to 202.6 mbgl and discharge varying from negligible to 9 lps. Lithologs data, discharge data, chemical quality data etc. are also collected from the Basic data reports of 16 Exploratory wells constructed in Jharsuguda District earlier. block wise details of exploratory wells are given in Table-10. Therefore, on the basis of 22 Exploratory well data composite cross section, panel diagram has been prepared.

TABLE- 10a. EXPLORATORY WELL DETAILS IN JHARSUGUDA BLOCK

Sr. No	District	Block	Location	Latitude in decimal	Longitude in decimal	Depth drilled (mbgl)	Lithology	Depth to Bed rock (mbgl) Casing Pipe Lowered	Fracture zones deciphered (mbgl)	SWL (mbgl) / Date	Discharge (lps)	NA	T (m² / day)	Toposheet No and Grid
1	**Jharsuguda**	Jharsuguda	Sarbahal	21.8441	83.9897	200	Gr. Gneiss	NA	43	NA	3.5	NA	14.37	64-O/13(2C)
2	**Jharsuguda**	-do-	Jharsuguda	21.8747	84.0046	200.00	Mica. Schist, Granite gneiss	NA	24	NA	1.50	NA	NA	73-C/1(2A)
3	**Jharsuguda**	Jharsuguda	H Katapalli	21.8749	83.9717	56.9	Gr. gneiss	17.6	19-21, 30-35	NA	1.8	NA	NA	64-O/13 (2C)
4	**Jharsuguda**	Jharsuguda	Jhanda Chack	21.8492	84.0187	150	Gr. gneiss	14.6	58-59	NA	0.4	NA	NA	73-C/1(2A)
5	**Jharsuguda**	Jharsuguda	Patrapalli	21.7525	83.9625	150	Gondwana Shale	19.5	66-68	NA	0.5	NA	NA	64-O/14 (1C)
6	**Jharsuguda**	Jharsuguda	Durlaga	21.9203	84.0334	87	Mica schist intruded by granite	25.5	46-60	NA	0.8	NA	NA	73-C/1(1A)
7	**Jharsuguda**	Jharsuguda	Singhabaga	21.8201	83.9689	150	Gondwana Shale	10.96	NA	NA	Nil	NA	NA	64-O/13 (3C)
8	**Jharsuguda**	Jharsuguda	Orissa state armed police barrack	21.8723	84.0067	105	Mica schist intruded by granite	19.2	49	NA	0.5	NA	NA	73-C/1(2A)
9	**Jharsuguda**	Jharsuguda	Ghutghuti Pata	21.8792	83.9644	51	Gondwana Siltstone, shale	NA	NA	NA	NA	NA	NA	64-O/13 (2C)
10	**Jharsuguda**	Jharsuguda	DhankerPalli	21.9494	84.0307	150	Gr. gneiss	5.6	66-69	NA	0.1	NA	NA	73-C/1(1A)
11	**Jharsuguda**	Jharsuguda	Sripura	21.7799	84.0408	151	Gr. gneiss	21.5	60-62	NA	0.8	NA	NA	73-C/1(3A)
12	**Jharsuguda**	Jharsuguda	Bhadeimunda	21.8621	84.0399	137	Gr. gneiss	18.02	18-19, 60-62	NA	Nil	NA	NA	73-C/1(2A)

TABLE 10b. EXPLORATORY WELL DETAILS IN LAKHANPUR BLOCK, JHARSUGUDA DISTRICT

Sr.No	District	Block	Location	Latitude in decimal	Longitude in decimal	Depth drilled (mbgl)	Lithology	Depth to Bed rock (mbgl) Casing Pipe Lowered	Fracture zones deciphered (mbgl)	SWL (mbgl) / Date	Discharge (lps)	Drawdown (m)	T (m²/ day)	Toposheet No and Grid
1	Jharsuguda	Lakhanpur	Kutrapali (EW)	21.7821	83.6936	184.3	Gondwana sandstone, shale	22	53.5,78.5, 184.3	15.30/17.2.20	9	9.4	18.98	64-O/9(3C)
2	Jharsuguda	Lakhanpur	Kutrapali (OW)	21.7821	83.6936	184.3	Gondwana sandstone, shale	23.8	34.8-37.9, 181.2-184.3	13.80/27.2.20	6	17.9	13.76	64-O/9(3C)
3	Jharsuguda	Lakhanpur	Kuremal (EW)	21.7872	83.6617	200.1	Gondwana shale	18	nil		Dry	NA	NA	64-O/9(3B)
4	Jharsuguda	Lakhanpur	Jogidhipa (EW)	21.8249	83.628	172.2	Gondwana sandstone, shale	18	31.7-50, 59.1-74.4, 89.6-101.8, 147.6-150.6, 162.1-172.1	7.00/16.3.20	8.409	NA	NA	64-O/9(3B)
5	Jharsuguda	Lakhanpur	Jogidhipa (OW)	21.8249	83.628	172.2	Gondwana sandstone, shale	18		7.00/19.3.20	8.409	NA	NA	64-O/9(3B)
6	Jharsuguda	Lakhanpur	Machida	21.8168	83.6065	202.6	Granite	9	No Fracture		Dry	NA	NA	64-O/9(3B)
7	Jharsuguda	Lakhanpur	Sukhadihi	21.7814	83.6083	202.6	Granite	11.6	196-198	3.9	1.2	NA	NA	64-O/9(3B)
8	Jharsuguda	Lakhanpur	Bhaurnkhol (EW)	21.7535	83.7385	196.5	Gondwana sandstone, Shale, coal and Granite	13	84	3	3.2	NA	NA	64-O/9(3C)
9	Jharsuguda	Lakhanpur	Bhaurnkhol (OW)	21.7535	83.7385	196.5	Gondwana sandstone, Shale, coal and Granite	13	84	3	2	NA	NA	64-O/9(3C)

TABLE 10c. EXPLORATORY WELL DETAILS IN KOLABIRA BLOCK, JHARSUGUDA DISTRICT

Sr.No	District	Block	Location	Latitude in decimal	Longitude in decimal	Depth drilled (mbgl)	Lithology	Depth to Bed rock (mbgl) Casing Pipe Lowered	Fracture zones deciphered (mbgl)	SWL (mbgl) / Date	Discharge (lps)	Drawdown (m)	T (m^2 / day)	Toposheet No and Grid
1	**Jharsuguda**	Kolabira	Kolabira	21.7988	84.1628	38.6	Granite gneiss	NA	NA	NA	NA	NA	NA	73-C/1(3B)

TABLE 10d. EXPLORATORY WELL DETAILS IN LAIKERA BLOCK, JHARSUGUDA DISTRICT

Sr.No	District	Block	Location	Latitude in decimal	Longitude in decimal	Depth drilled (mbgl)	Lithology	Depth to Bed rock (mbgl) Casing Pipe Lowered	Fracture zones deciphered (mbgl)	SWL (mbgl) / Date	Discharge (lps)	Drawdown (m)	T (m^2 / day)	Toposheet No and Grid
1	**Jharsuguda**	Laikera	Laikera	21.9141	84.2509	185.0	Gr.gneiss		183-184	2.77	Negligible	NA	NA	73-C/5(2A)
2	**Jharsuguda**	-do-	Sahaspur	21.991	84.321	130	Gr. gneiss	20.1	20.5-23,75-76	0.85	7	NA	NA	73-C/5(1A)
3	**Jharsuguda**	-do-	Sahaspur	21.991	84.321	166.7	--do-	23.69	49-50.5	0.82	2	NA	NA	73-C/5(1A)
4	**Jharsuguda**	-do-	Arda	21.8993	84.2318	185	-do-	4.8	NA	3.33	Negligible	NA	NA	73-C/1(2C)

Table-10e. Exploratory tube wells constructed under Accelerated Exploratory Drilling Programme (Phase I and Phase II), Jharsuguda District, Odisha

Sl No	DISTRICT	BLOCK/ Municipality (MNC)	LOCATION	DEPTH in mbgl	DISCHARGE in lps
1	JHARSUGUDA	BELPAHAR MNC	WARD NO 12	150	5
2	JHARSUGUDA	BELPAHAR MNC	WARD NO 9 HANUMAN CHHAK	150	3.5
3	JHARSUGUDA	BRAJRAJNAGAR MNC	ABHYAPUR WARD NO.3	150	2
4	JHARSUGUDA	BRAJRAJNAGAR MNC	BAHADURPADA WARDNO. 8	150	1.5
5	JHARSUGUDA	BRAJRAJNAGAR MNC	GANDHI CHHAK WARD NO. 17	150	2.5
6	JHARSUGUDA	BRAJRAJNAGAR MNC	MADHUBAN NAGAR WARD NO. 10	150	6
7	JHARSUGUDA	BRAJRAJNAGAR MNC	SANJOB WARD NO.100	146	4
8	JHARSUGUDA	JHARSUGUDA	BUROMAL	150	1
9	JHARSUGUDA	JHARSUGUDA	DEBADIHI	91.5	5
10	JHARSUGUDA	JHARSUGUDA	KABRASTAHN PARA	150	1
11	JHARSUGUDA	JHARSUGUDA	EKATALI	150	3
12	JHARSUGUDA	JHARSUGUDA	TALPATIA	97.5	4.3
13	JHARSUGUDA	JHARSUGUDA MNC	MARWADIPARA WARD NO. 3	150	1
14	JHARSUGUDA	JHARSUGUDA MNC	PANCHPARA	150	1.2
15	JHARSUGUDA	KIRMIRA	SULAHI	150	2
16	JHARSUGUDA	KOLABIRA	SODAMAL	150	1.5
17	JHARSUGUDA	LAIKERA	NIKTIMAL	150	2
18	JHARSUGUDA	LAIKERA	SALETIKRA	122	0.5
19	JHARSUGUDA	LAKHANPUR	DALGAON	150	0.5
20	JHARSUGUDA	BELPAHAR MNC	BELPAHAR WARD NO 14	137	12
21	JHARSUGUDA	BELPAHAR MNC	BELPAHAR WARD NO2	153	7
22	JHARSUGUDA	BELPAHAR MNC	BELPAHAR WARD NO3	153	1.0
23	JHARSUGUDA	BRAJRAJNAGAR MNC	NUADIHI	137	15.0(0.5 during testing)
24	JHARSUGUDA	JHARSUGUDA	RAJPUR	152	2.0
25	JHARSUGUDA	KIRIMIRA	GOURPANPALI	153	4.0
26	JHARSUGUDA	KOLABIRA	PARMANPUR	153	0.5
27	JHARSUGUDA	KOLABIRA	SAMASINGHA	137	7.0
28	JHARSUGUDA	LAIKERA	KULEMURA	153	0.5
30	JHARSUGUDA	LAKHANPUR	TILIA	153	0.5

3. DATA INTREGATION, INTERPRETATION AND AQUIFER MAPPING

A. GEOLOGY: The district is underlain by crystalline and sedimentary rocks belonging to Precambrian and Permo – Carboniferous age. Late sedimentaries of Recent to sub recent age developed in patches (Fig.12). The main rock types of the area are:

Granite gneisses: Granite gneisses are the most prominent rock types in the district generally occupying the undulating plains forming low hills and mounds represented by biotite granite gneiss, porphyritic gneiss etc.

Iron Ore Group: Iron Ore Group of metasediments comprise mainly of quartzites and occurs in the north eastern part of the district.

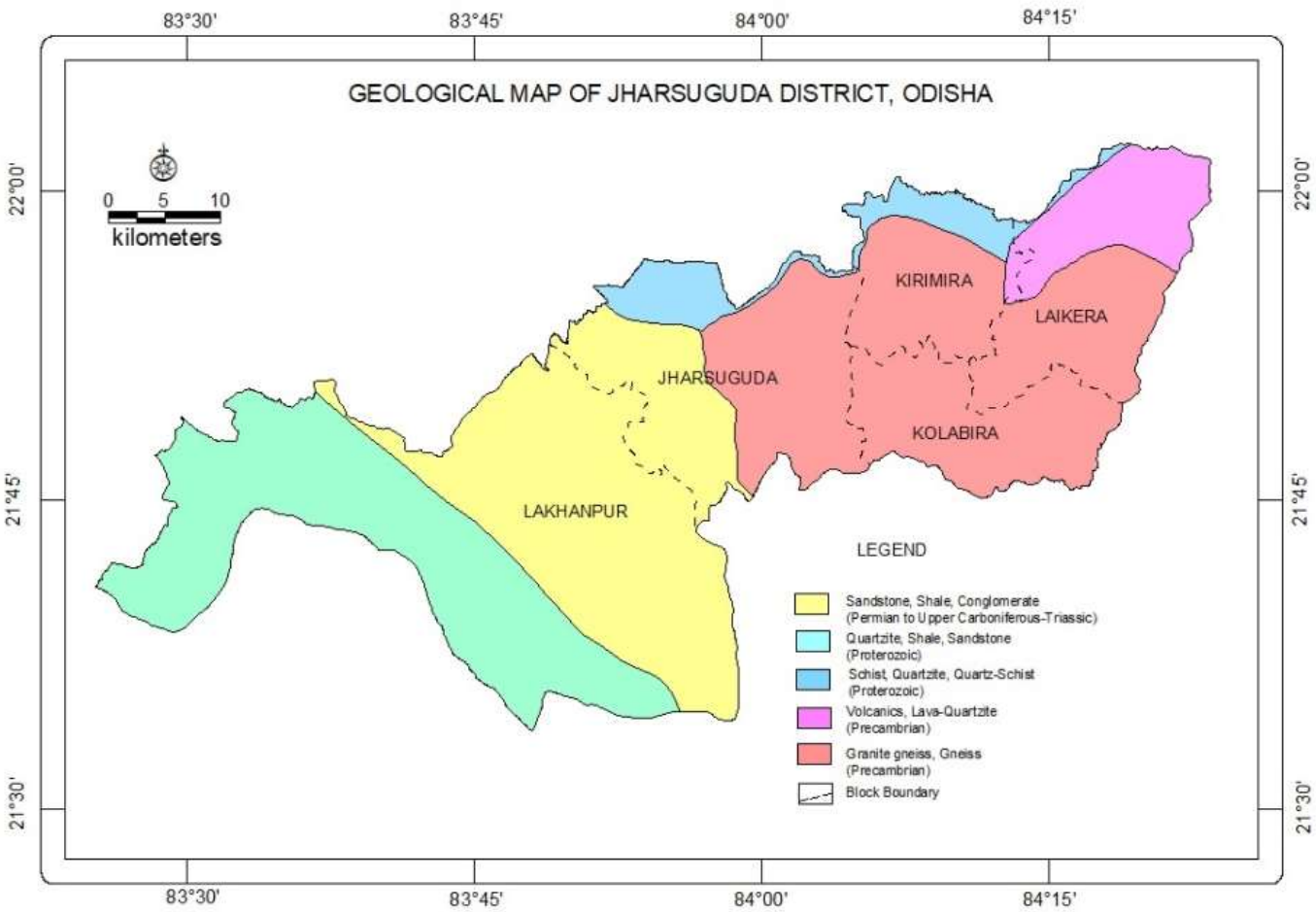
Gangpur Group: The rocks of Gangpur Group are mainly mica schists which are often traversed by pegmatites and quartz veins.

Chandrapur and Raipur Groups: Chandrapur and Raipur Group of rocks comprise of sandstones, shales, quartzites and conglomerates which occur in the western part of the district as an extension of Chhattisgarh basin**.**

Intrusive: Basic dykes (dolerite and epidiorites) are seen cutting through the gneissic rocks over considerable aerial extent.

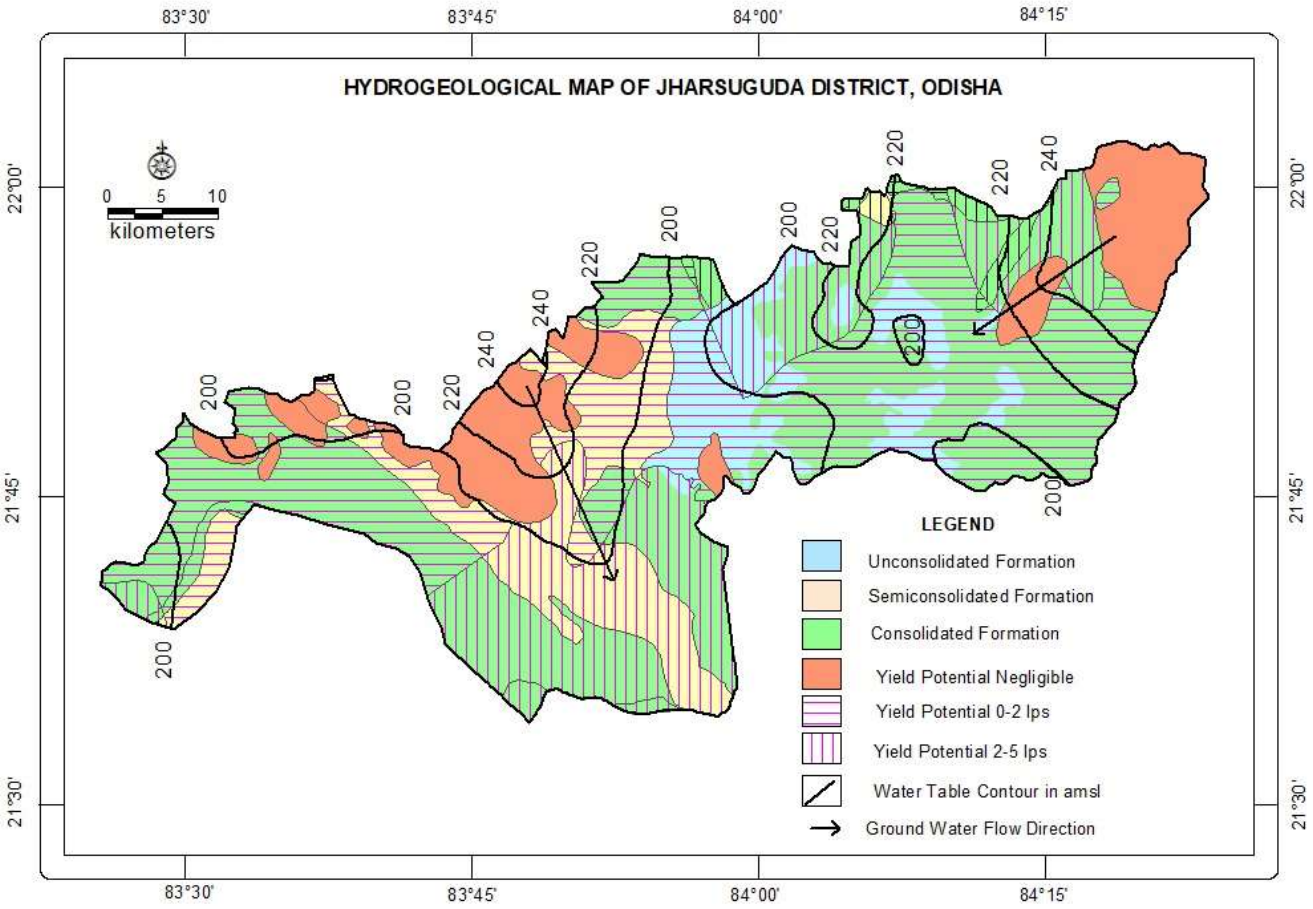
Gondwana sedimentaries: Gondwana sedimentaries comprising a thick sequence of Sandstone, shale, sandy shales and workable coal seams occur in the west central part of the district in the Ib valley. Laterites discontinuously occur as capping over older formations. Alluvium of recent to sub-recent origin occurs in small patches in the vicinity of prominent rivers.

Fig.12. Geological map of Jharsuguda District, Odisha



B. HYDROGEOLOGY: As discussed earlier the district comprises with consolidated formation, semi-consolidated formation and unconsolidated formations. The regional groundwater flow direction is from NE-SW in eastern part and NNW-SSE in the west-central part of Jharsuguda District (Fig.13).

Fig.13. Hydrogeological Map of Jharsuguda District



C. SUBSURFACE DETAILS: Hydrogeologically Jharsuguda District comprises of Recent to Subrecent alluvium, laterite, gravels, conglomerate (weathered zone) having a thickness of 10-20 meter, followed by Permo-Carboniferous Lower Gondwana Group of Sedimentary rocks (Kamthi, Barakar, Karaharbari, Talcher Formations) and then followed by basement Pre-Cambrian Granite, gneisses and Schists. Basement rocks with fractured aquifers observed mainly Jharsuguda (eastern part) Block, Kolabira, Laikera, Kirimira Blocks. Whereas Gondwana Group of rocks observed in western part of Jharsuguda Blocks and in Lakhanpur Block. Discharge of bore wells tapping mica schist fractured aquifer is very meagre (negligible to 1.5 lps). Similarly discharge of borewells tapping granite gneisses varies from 0.4 to 7 lps. But very reasonable quantities of discharge (6 to 12 lps) have been observed in villages located towards north of a NW-SE trending a regional lineament found in Lower Gondwana group of sedimentary rocks in Lakhanpur Block of Jharsuguda District. Generally, fractures are observed in shallow depth upto100 meters in Precambrian basement, except at Sukhadihi (in Lakhanpur Block), where at 196-198 mbgl depth having a fractured aquifer with discharge of 1.2 lps has been observed. But in Gondwana group of rocks fractures with good quantity discharge observed up to 184-meter depth. On the basis of lithologs three-dimensional panel diagram (Fig 14a, c) and a two-dimensional section (Fig.14b) have been drawn to know the aquifer disposition in up to 100 meter and beyond 100 meters to 200-meter depth.

Fig.14a.Three-dimensional aquifer disposition model, Jharsuguda District

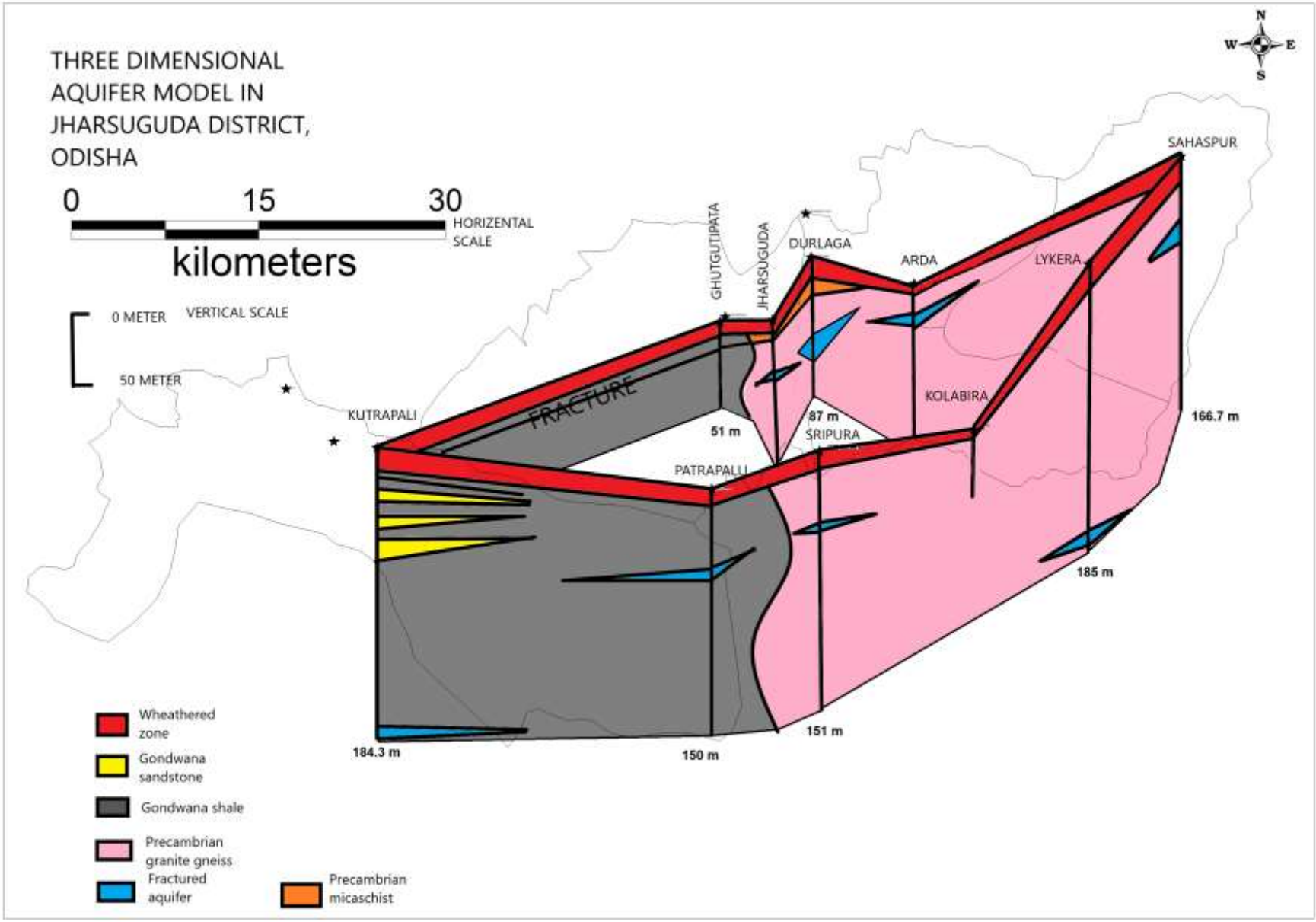


Fig.14b. Two Dimensional cross sections in various direction in Jharsuguda District, Odisha

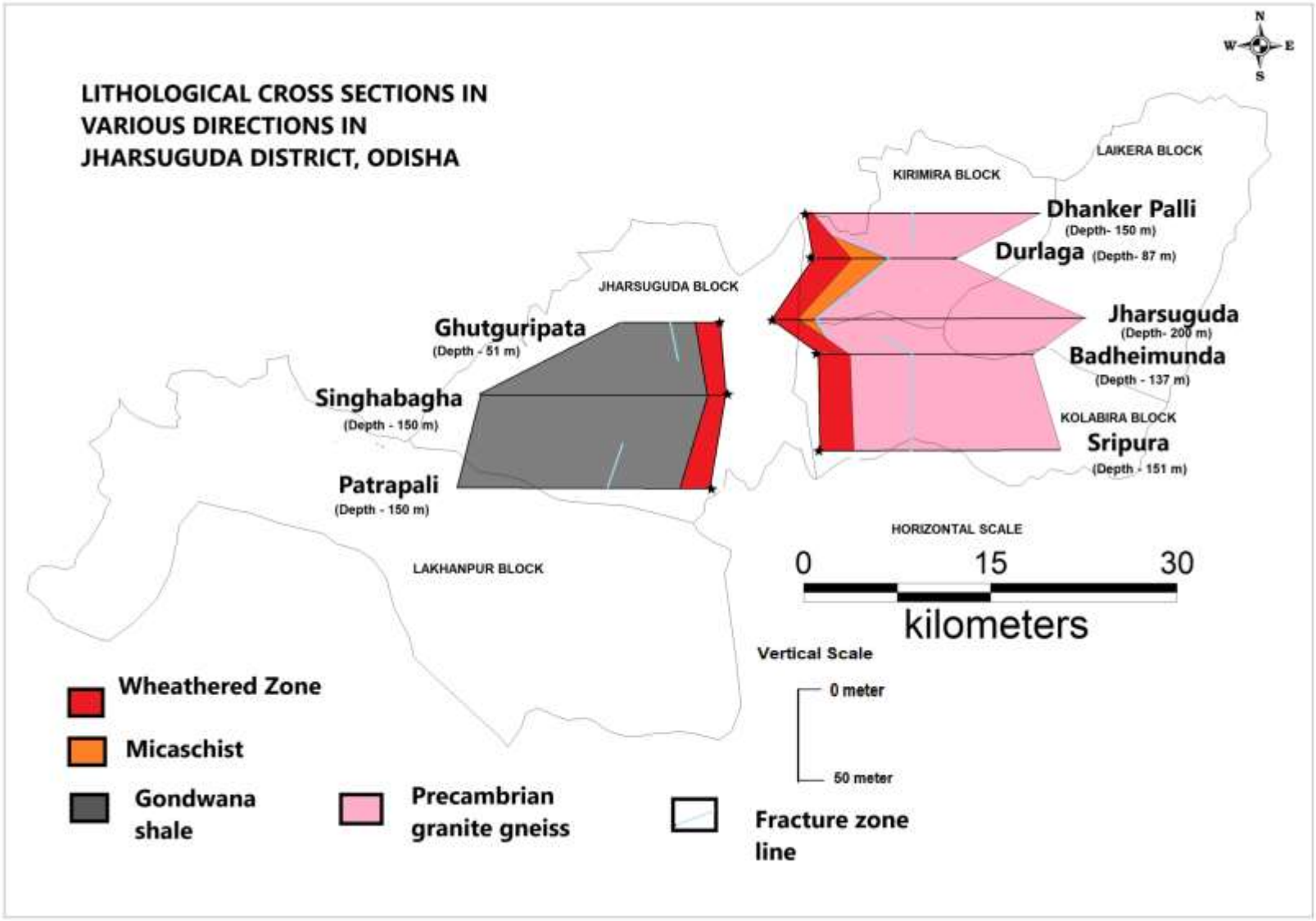


Fig.14C. Three-dimensional panel diagram showing aquifer disposition across the major lineament in western part of Lakhanpur Block, Jharsuguda District, Odisha

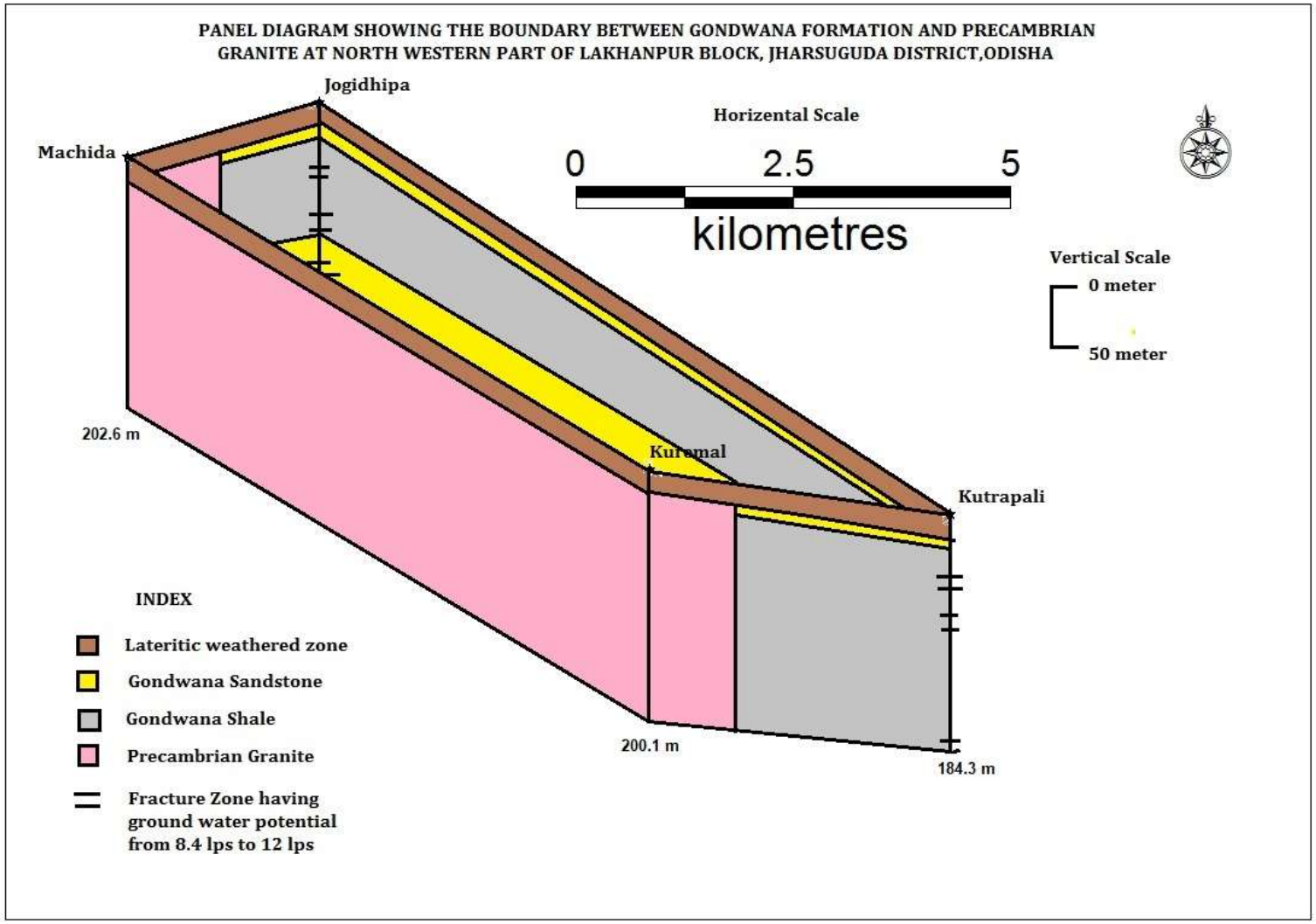
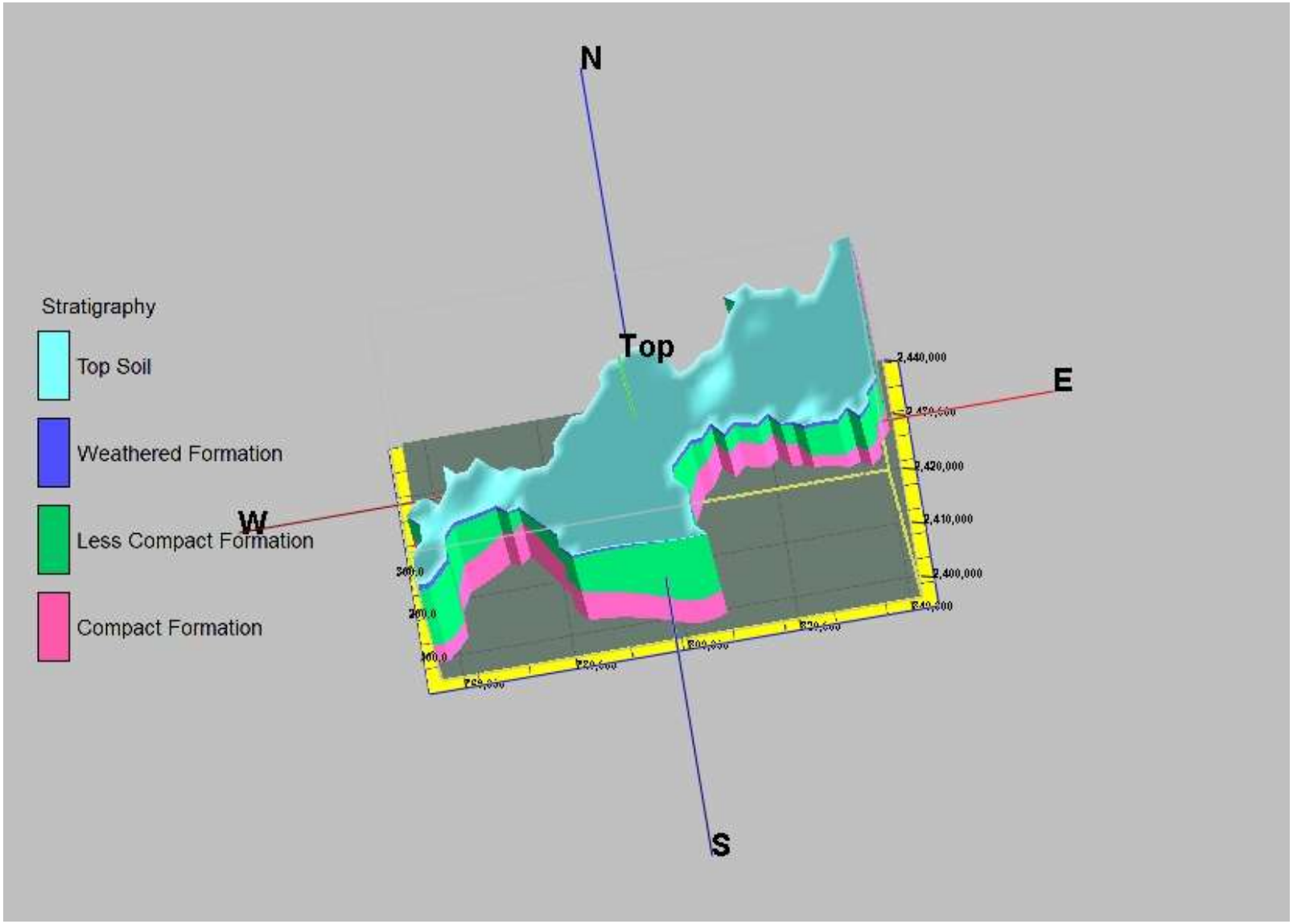


Fig.14d. Three-dimensional model on the basis of VES data, Jharsuguda District



D. AQUIFER GROUPING: On the basis of data collection of exploratory wells it has observed that 6 tube wells constructed within 100 mbgl depth and 50 tube wells constructed between 100-200 mbgl depth. Discharge of the tube wells within 100meter depth varies from 0.8-1.8 lps and discharge of the tube wells constructed between 100 to 200 meter depth varies from 0.5 – 15 lps. But as per weathered zone and fracture zone details aquifer grouping is summarized in the table below:

Table 11: Aquifer Grouping in Jharsuguda District, Odisha

Aquifer Group		Depth Range (mbgl)		Thickness (m)	
		From	To	Min	Max
Aquifer I (Within 100 m)	(Weathered Zone)	4.8	25.5	3.2*	23.9*
	(Fracture Zone)	18	101.8	1	18.3
Aquifer II (100-200 m) (Fracture zone)		147.6	198	1	9.3

Depth of mean water level, i.e., 1.6 mbgl will be considered as depth of unsaturated zone. Hence it will be subtracted from the total depth of weathered zone.

E. WATER LEVEL, WATER TABLE, DECEDAL TREND AND HYDROGRAPH: Pre-Monsoon Depth to Water Level of shallow aquifer (mainly weathered zone) in the district during 2019 ranges from 1.3 mbgl to 9.4mbgl (Fig.15a). Post monsoon Depth to Water Level during 2019 ranges from 0.81mbgl to 6.41mbgl (Fig.15b). Annual water level fluctuation (Fig. 15c) varies from 0.23 to 7.8 m rising. Only one well located near coal mines are having 1.82 m falling water level fluctuation. This may be due to heavy ground water dewatering from the coal mines located near Belpahar. Similarly, pre monsoon water table varies from 187.85 m amsl to 256.9 m amsl (Fig.15d) and post monsoon water table varies from 192.91 – 261.65 m amsl (Fig. 15e). Long Term water level trend in 10 yrs. (2009-2019) in m/yr. 0.0549 m to 0.2226 m rise in 28.56% well, 1.88 m to 9.14 m falling in 52.38 % well (Pre-monsoon). 42.85% of wells show rise in 0.0056 m to 0.1864 m, 0.6327m to 5.09 m 57.14% of wells show fall (Post monsoon) (Fig.16a, b). Few hydrographs are also shown in the Fig.17.

Fig.15a. Depth to water level map (Pre monsoon, 2019), Jharsuguda District

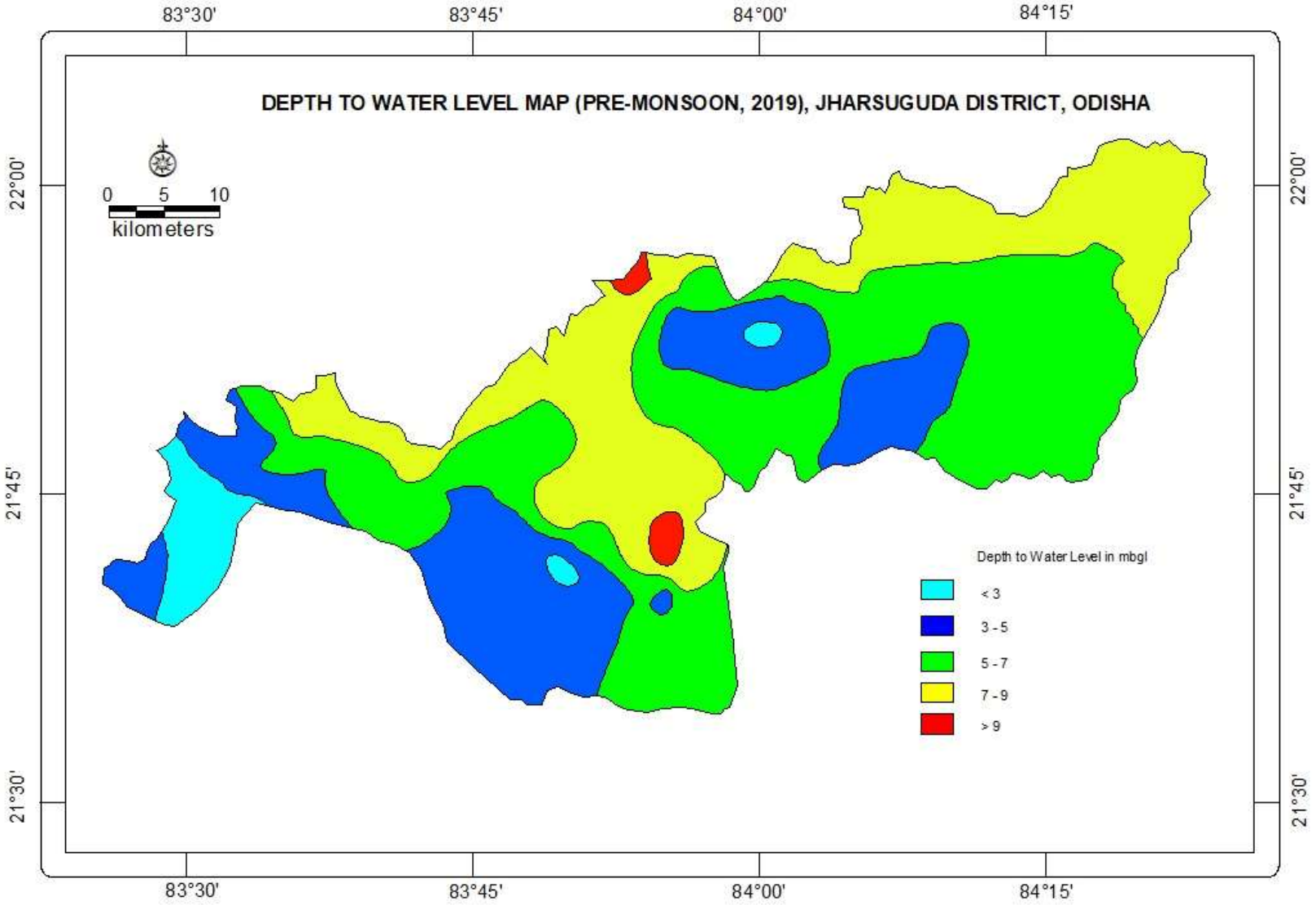


Fig.15b. Depth to water level map (Post monsoon, 2019), Jharsuguda District

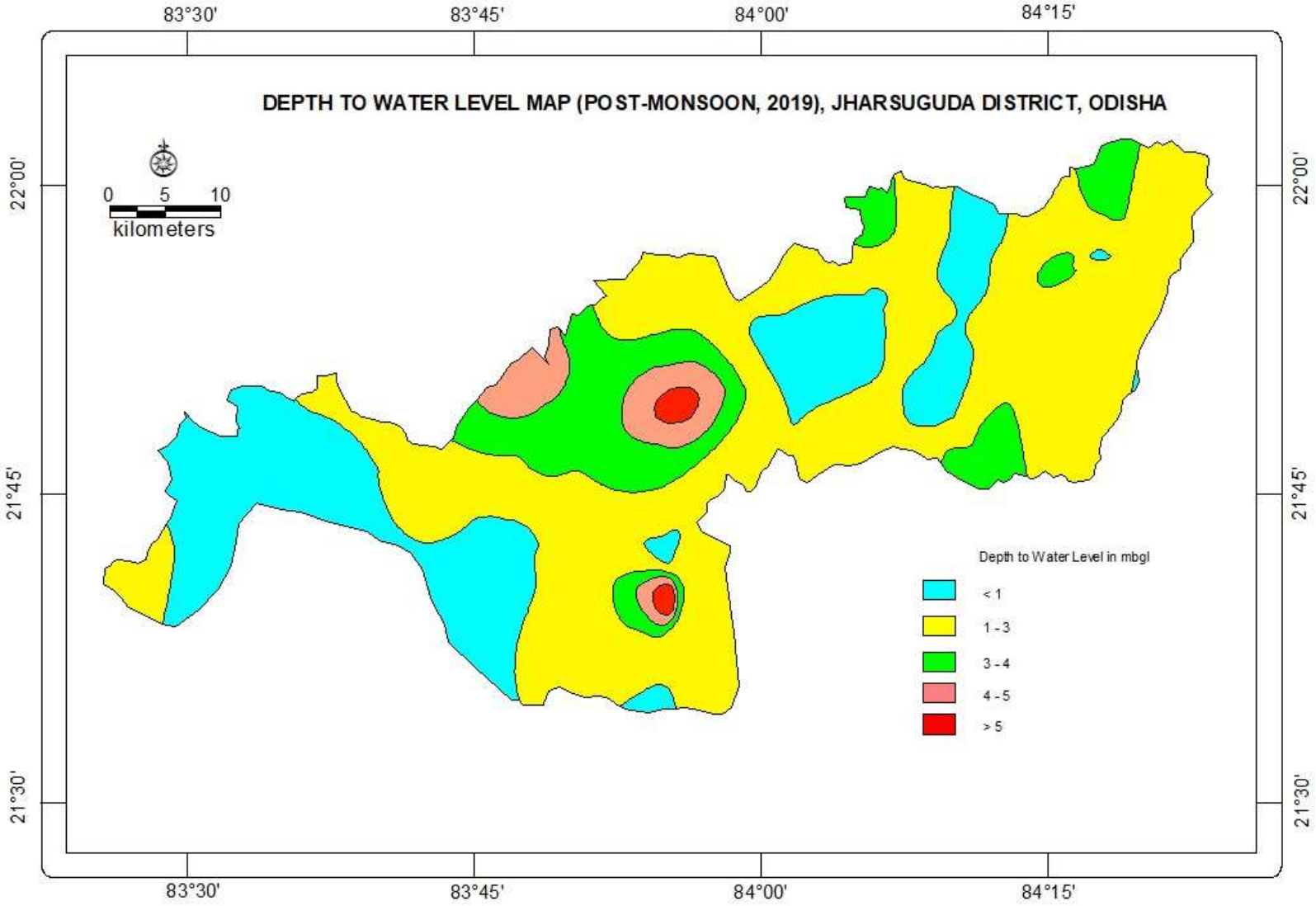


Fig.15c. Annual water level fluctuation (Pre, Post, 2019), Jharsuguda District

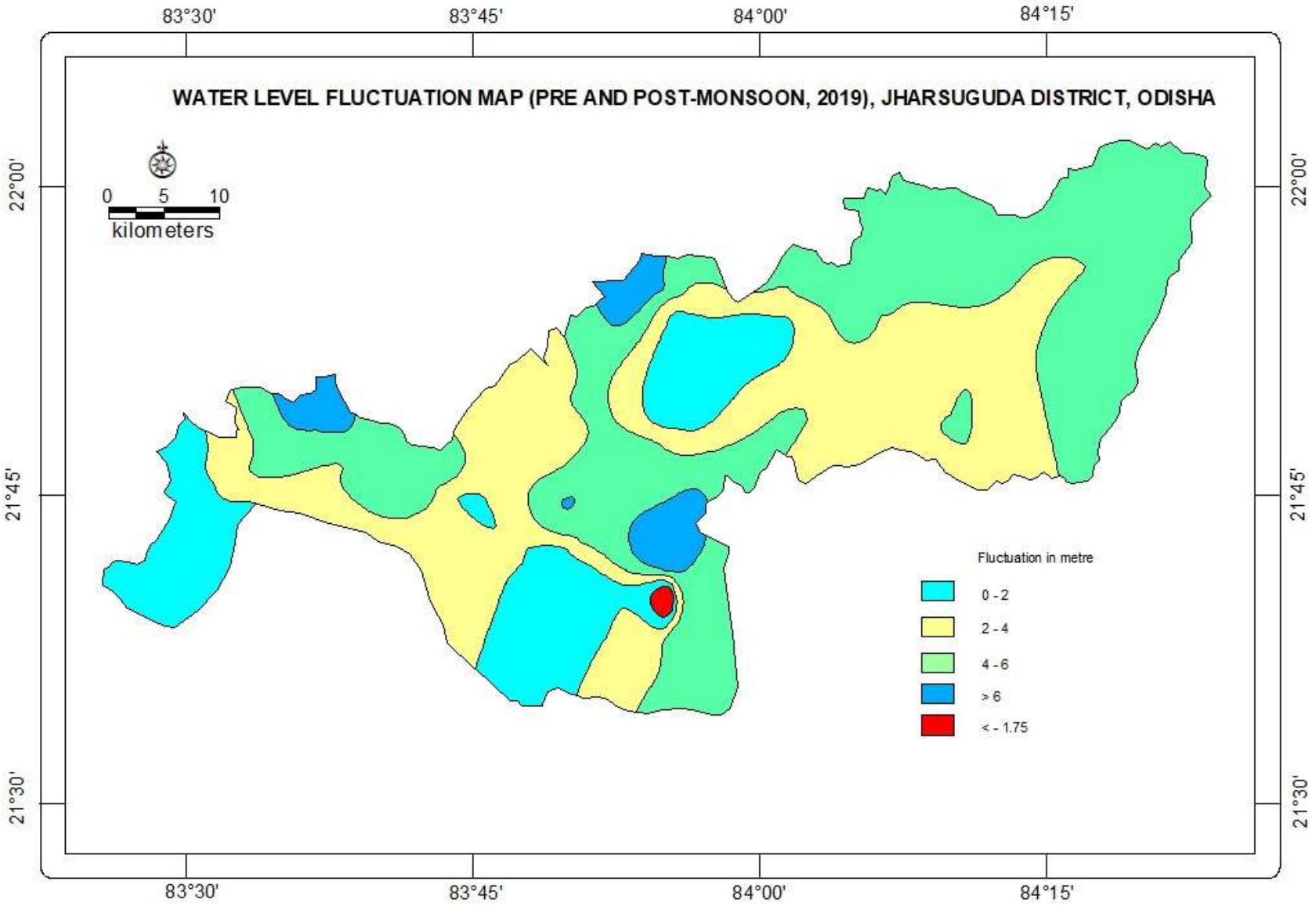


Fig.15d. Water Table Map (Pre monsoon, 2019), Jharsuguda District

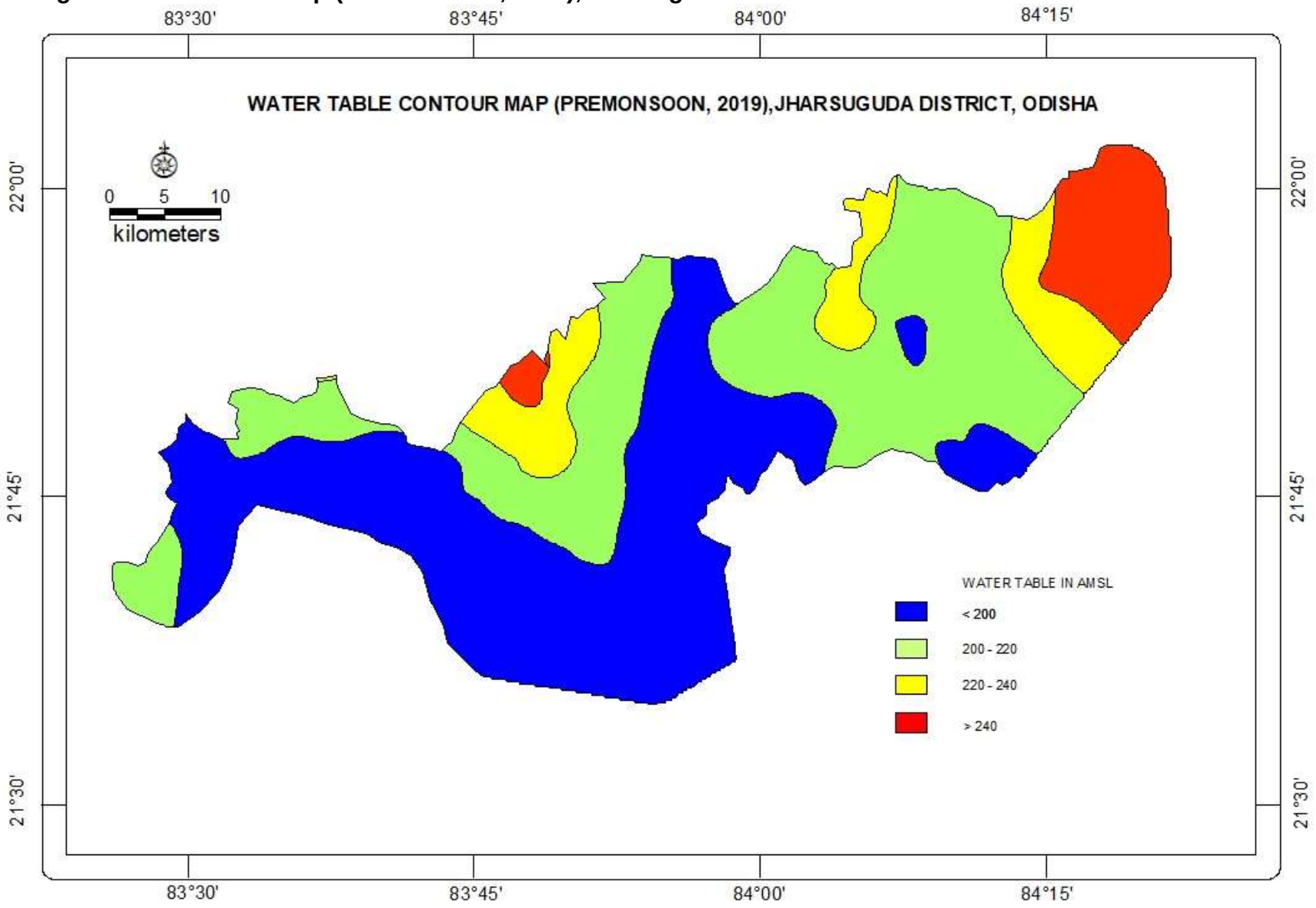


Fig.15e. Water Table (Post monsoon, 2019), Jharsuguda District

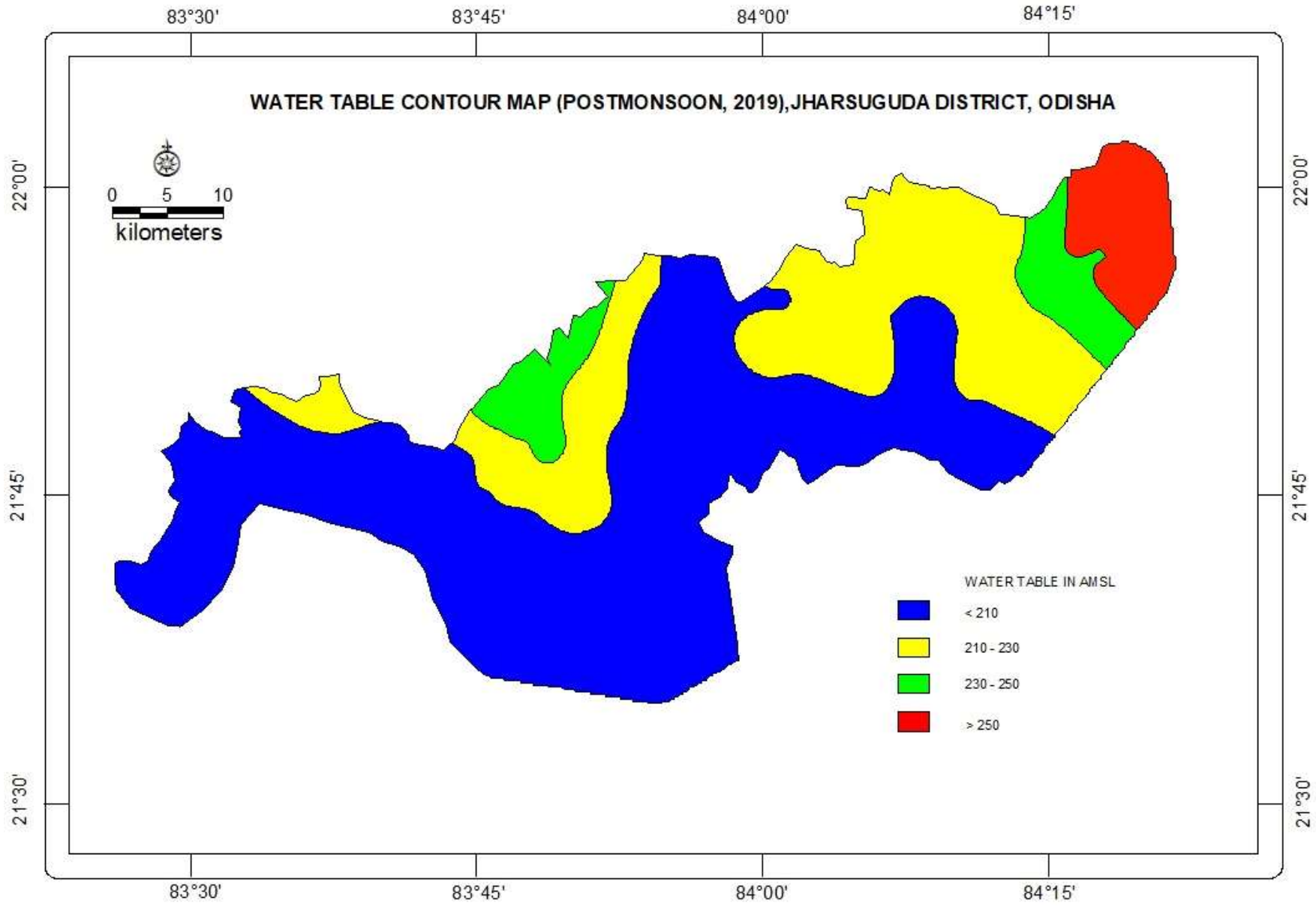


Fig.16a. Decadal Mean water level map, Jharsuguda District, Odisha

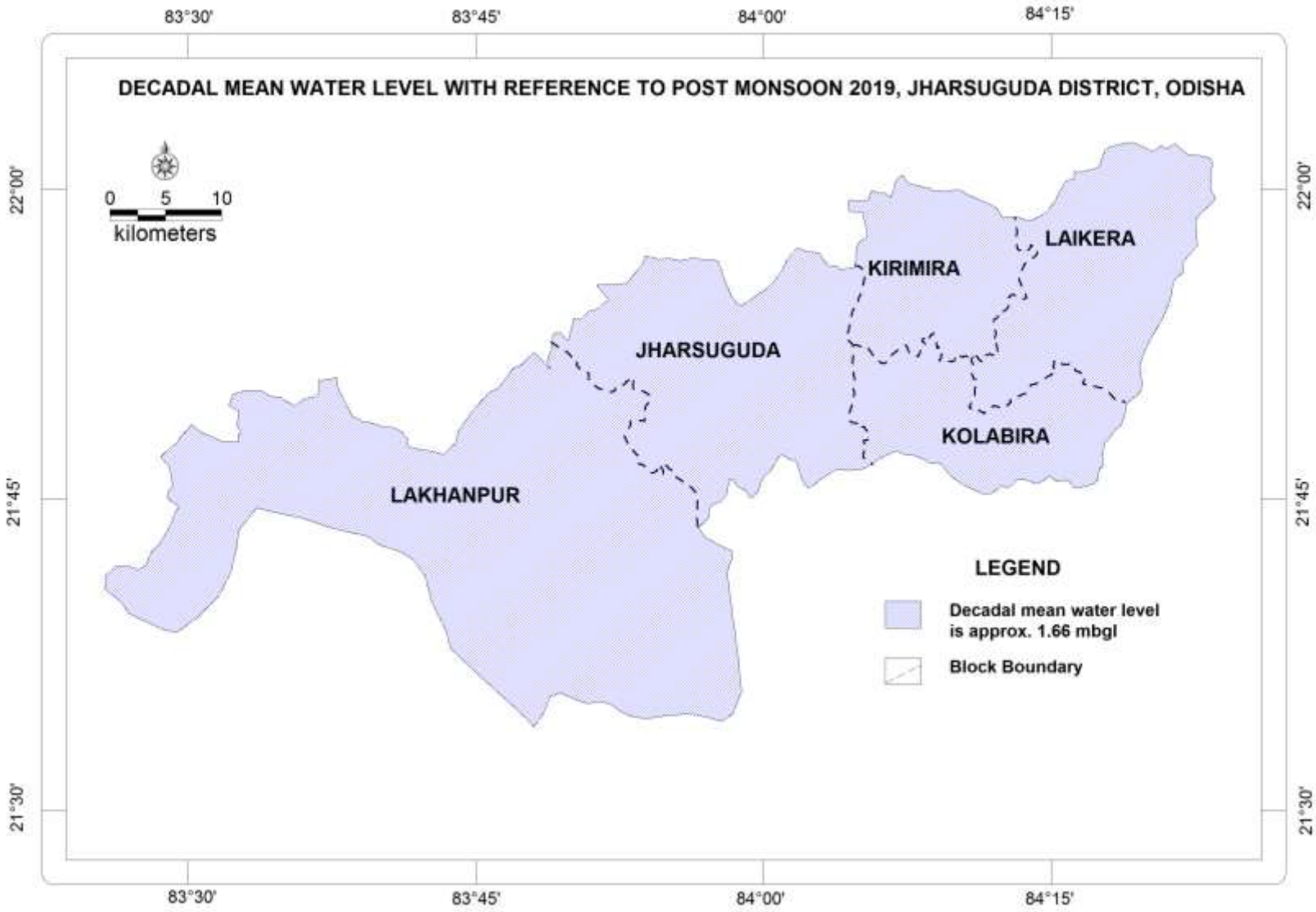


Fig.16b. **POSTMONSOON DECADAL MEAN WATER LEVEL (2019) WITH RESPECT TO DECADAL WATER LEVEL TREND MAP JHARSUGUDA DISTRICT, ODISHA**

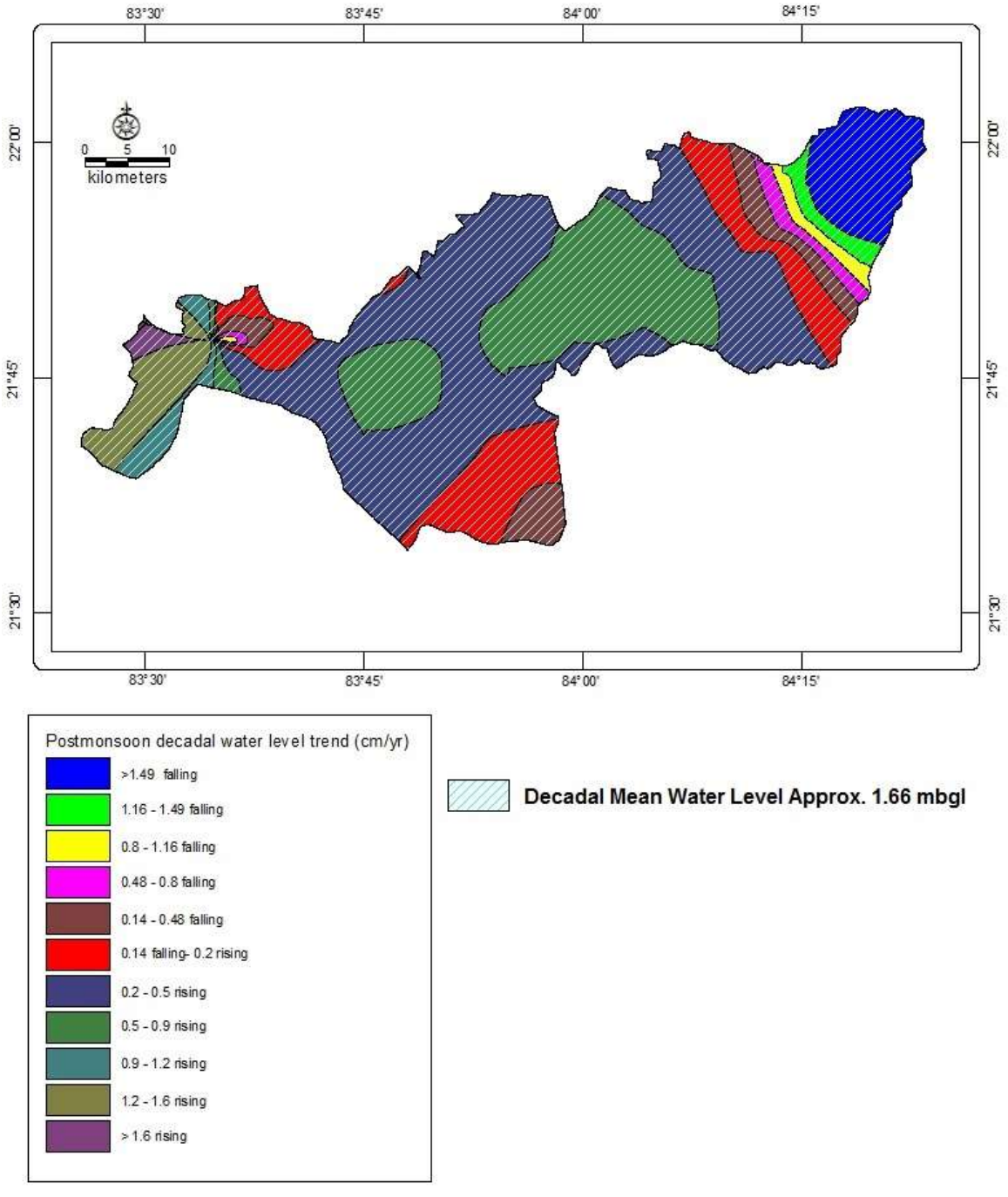
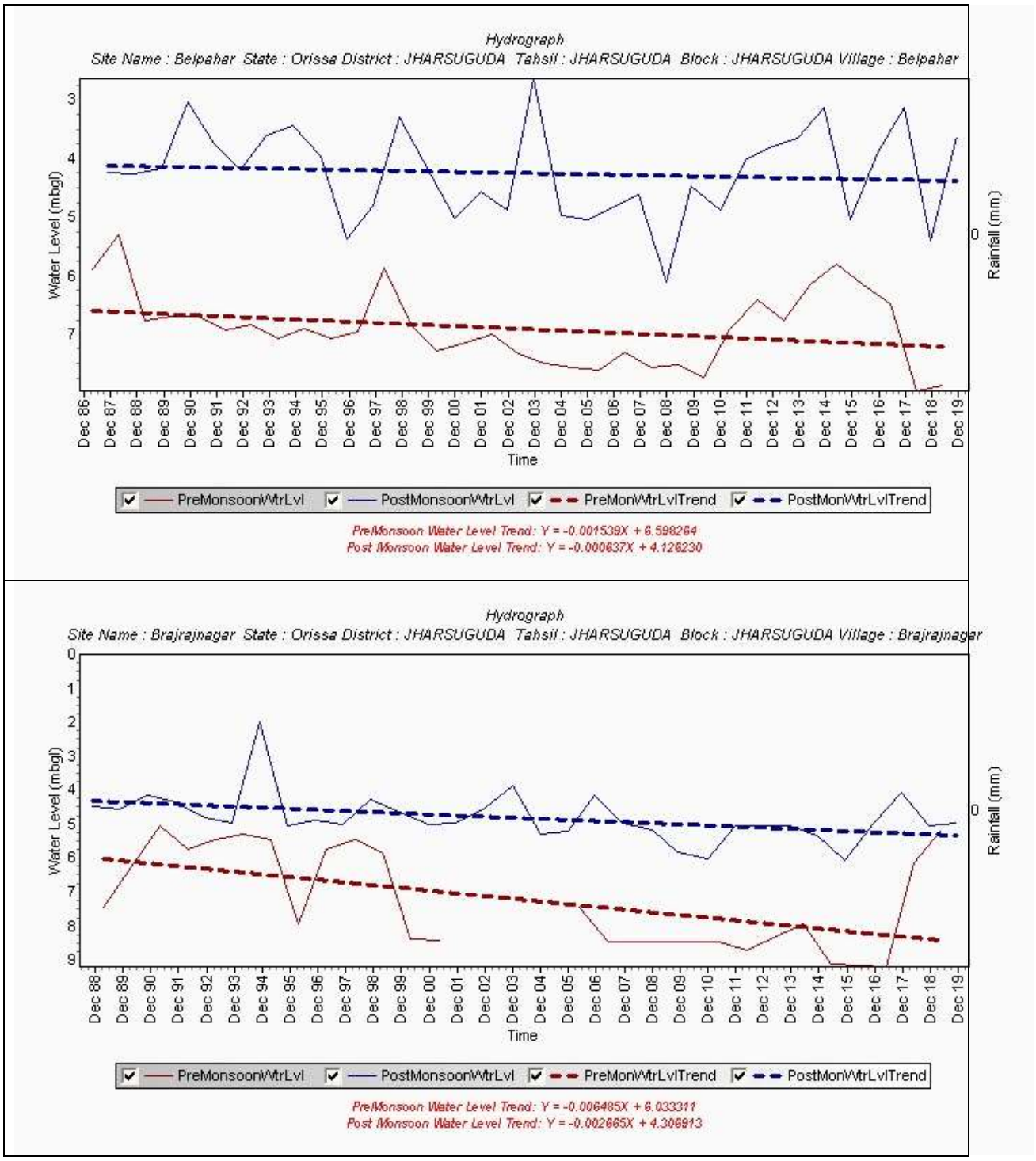
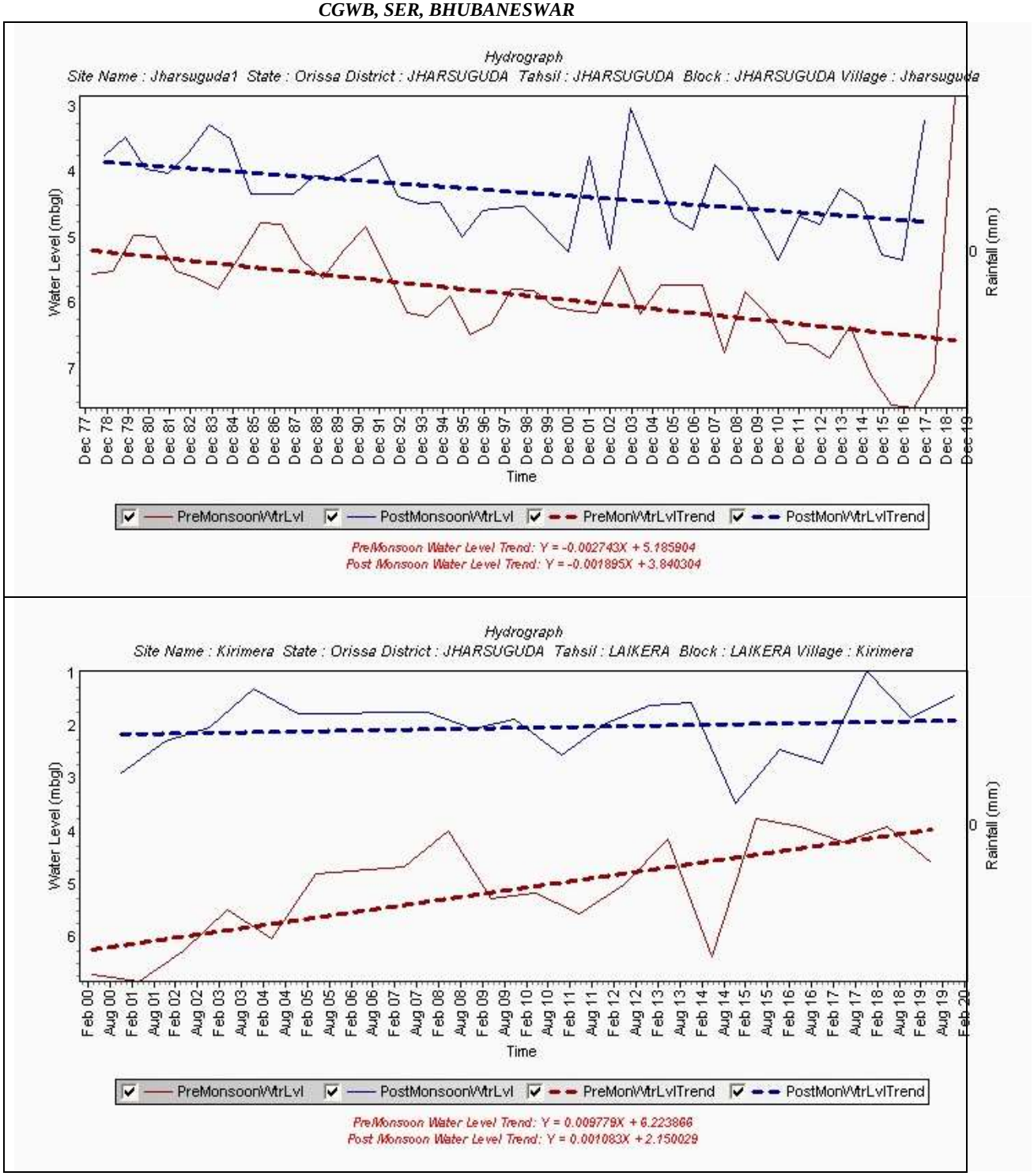
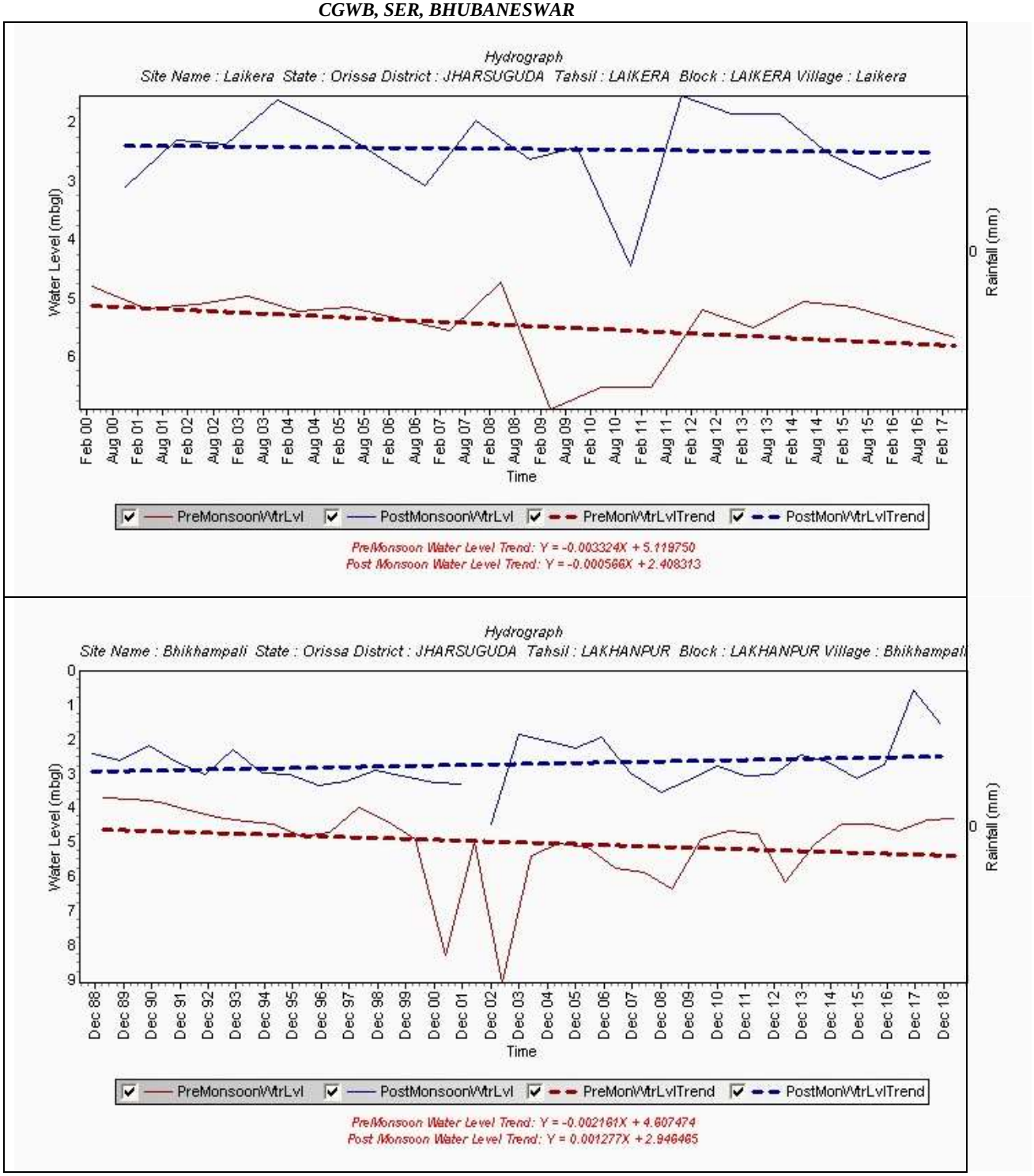
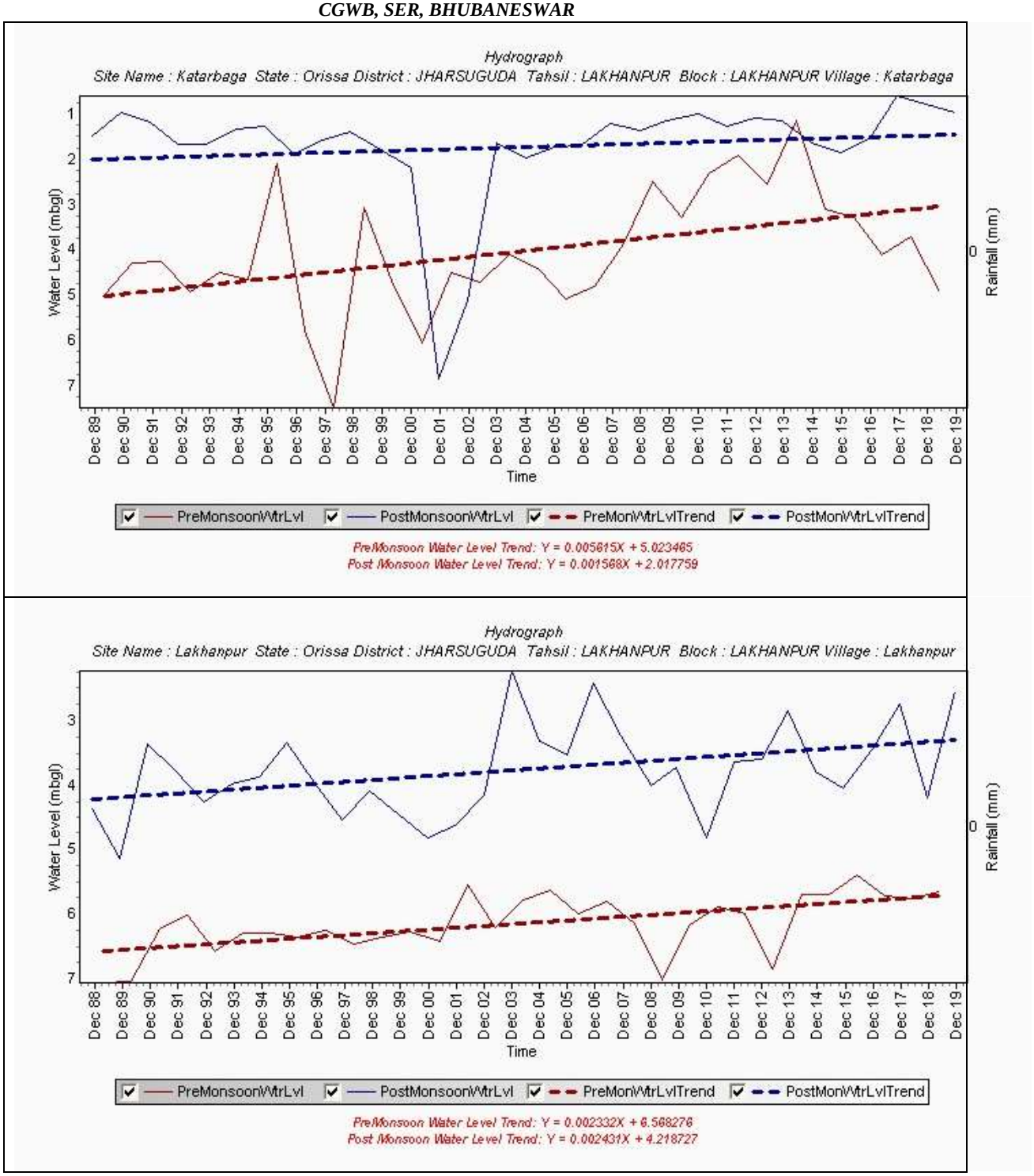


Fig.17. Hydrographs of selected NHS stations in Jharsuguda District, Odisha




Hydrograph
Site Name : Jharsuguda1 State : Orissa District : JHARSUGUDA Tahsil : JHARSUGUDA Block : JHARSUGUDA Village : Jharsuguda
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.002743X + 5.185904
Post Monsoon Water Level Trend: Y = -0.001895X + 3.840304
Hydrograph
Site Name : Kirimera State : Orissa District : JHARSUGUDA Tahsil : LAIKERA Block : LAIKERA Village : Kirimera
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.009779X + 6.223866
Post Monsoon Water Level Trend: Y = 0.001083X + 2.150029


Hydrograph
Site Name : Laikera State : Orissa District : JHARSUGUDA Tahsil : LAIKERA Block : LAIKERA Village : Laikera
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.003324X + 5.119750
Post Monsoon Water Level Trend: Y = -0.000566X + 2.408313
Hydrograph
Site Name : Bhikhampali State : Orissa District : JHARSUGUDA Tahsil : LAKHANPUR Block : LAKHANPUR Village : Bhikhampali
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.002161X + 4.607474
Post Monsoon Water Level Trend: Y = 0.001277X + 2.946465


Hydrograph
Site Name : Katarbaga State : Orissa District : JHARSUGUDA Tahsil : LAKHANPUR Block : LAKHANPUR Village : Katarbaga
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.005615X + 5.023465
Post Monsoon Water Level Trend: Y = 0.001568X + 2.017759
Hydrograph
Site Name : Lakhanpur State : Orissa District : JHARSUGUDA Tahsil : LAKHANPUR Block : LAKHANPUR Village : Lakhanpur
Water Level (mbgl)
Rainfall (mm)
Time
PreMonsoonWtrLvl
PostMonsoonWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.002332X + 6.568276
Post Monsoon Water Level Trend: Y = 0.002431X + 4.218727

F. HYDROCHEMISTRY OF SHALLOW AQUIFER (Aquifer-I): All groundwater samples collected from key wells during pre monsoon 2019 are analysed in Chemical Laboratory of CGWB, SER. The maximum and minimum value of analysed parameters are summarized in the Table 12. Distribution of EC is shown in Fig.18a. From the detailed analysis only iron and nitrate (fig.18b) concentration is seen above permissible at few locations. Presence of uranium is also noticed in 3 locations (Fig.18c).

Table-12. Range of parameters in shallow aquifer ground water samples.

Parameter	Unit	Min	Max
Ca	mg/l	16	123
Mg	mg/l	3	110
Na	mg/l	4	136
K	mg/l	2	115
Cl	mg/l	19	556
HCO^{3-}	mg/l	36	537
SO^{4-}	mg/l	0	129
F	mg/l	0.1	1.27
NO^{3-}	mg/l	1	52
TDS	mg/l	80	1093
Hardness	mg/l	69	703
Alkalinity	mg/l	30	440
pH		7.5	8.26

An attempt has been made to prepare a Piper diagram and Wilcox diagram to know the type of water, its utilization of irrigation etc. All these are presented in Fig.18d and 18e. Groundwater is bicarbonate type and is potable for drinking and irrigation.

F. HYDROCHEMISTRY OF DEEPER AQUIFER (Aquifer-I):

On the basis of chemical quality analysis of ground water samples from exploratory wells Piper Diagram (Fig. 18f) and Wilcox diagram (Fig. 18g) have been prepared. The analytical details are summarized in the Table- 13. Type of water is also bicarbonate type and is also suitable of irrigation.

Table-13. Range of parameters in Deeper aquifer ground water samples.

Parameter	Unit	Min	Max
Ca	mg/l	18	67
Mg	mg/l	5	55
Na	mg/l	5	70.1
K	mg/l	1	53
Cl	mg/l	15	156
HCO3	mg/l	94	386
SO4	mg/l	1	51.2
NO3	mg/l	Within permissible limit	
F	mg/l	0.125	0.496
pH		7.13	8.25

Fig.18a.

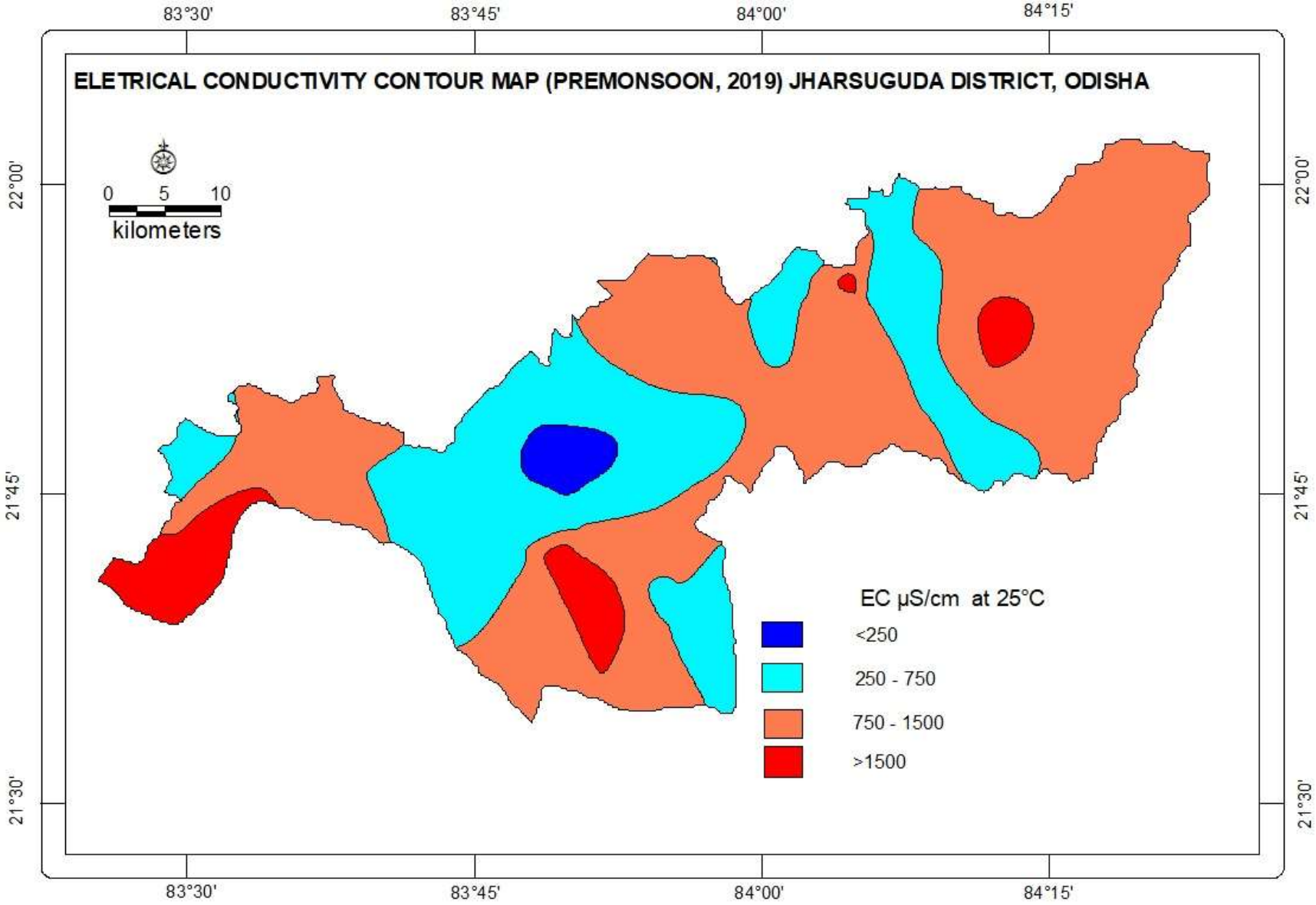

ELETRICAL CONDUCTIVITY CONTOUR MAP (PREMONSOON, 2019) JHARSUGUDA DISTRICT, ODISHA
83°30'
83°45'
84°00'
84°15'
22°00'
21°45'
21°30'
0 5 10
kilometers
EC µS/cm at 25°C
<250
250 - 750
750 - 1500
>1500

Fig.18b.

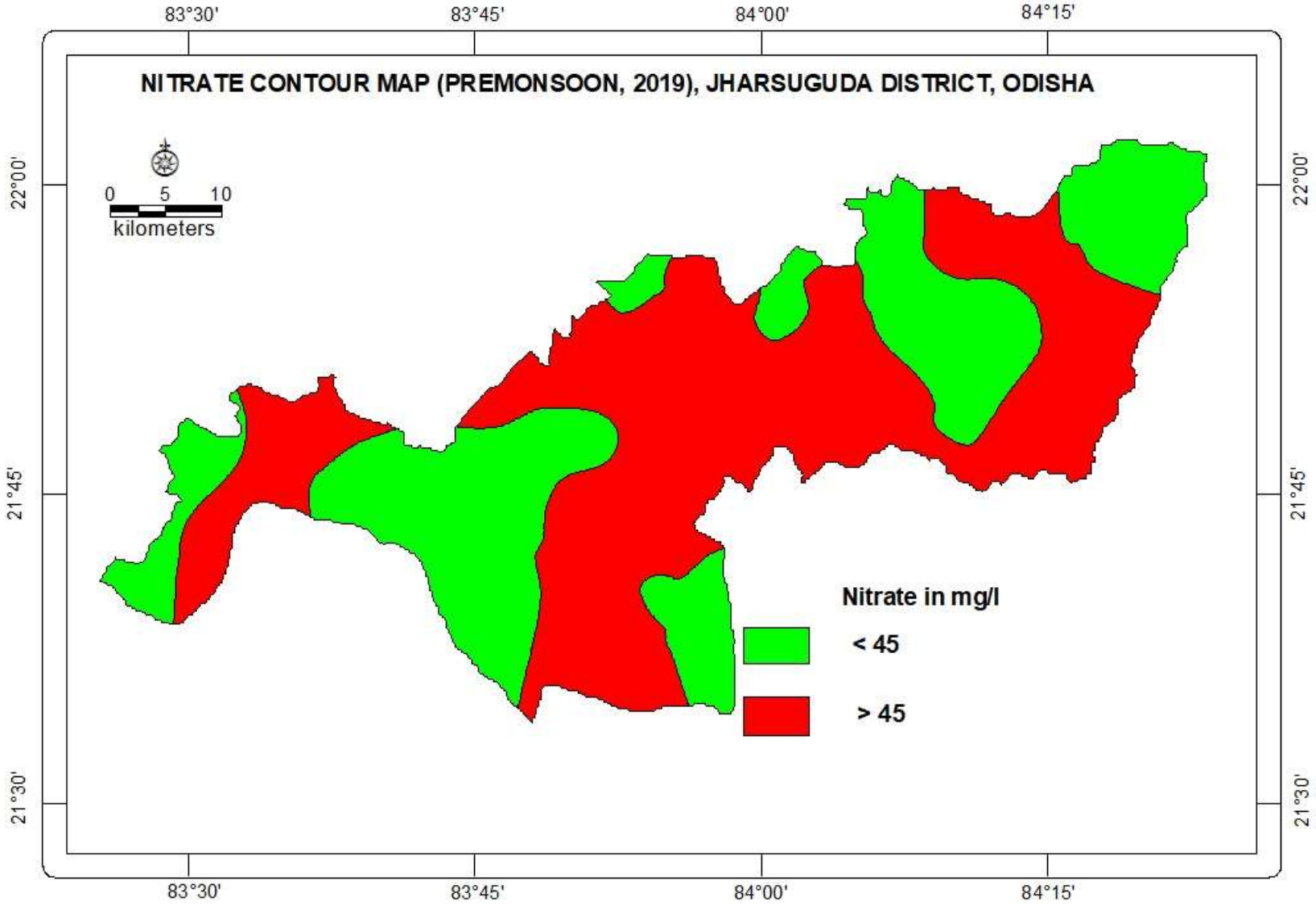

NITRATE CONTOUR MAP (PREMONSOON, 2019), JHARSUGUDA DISTRICT, ODISHA
83°30'
83°45'
84°00'
84°15'
22°00'
21°45'
21°30'
0 5 10
kilometers
Nitrate in mg/l
< 45
> 45

Fig.18c.

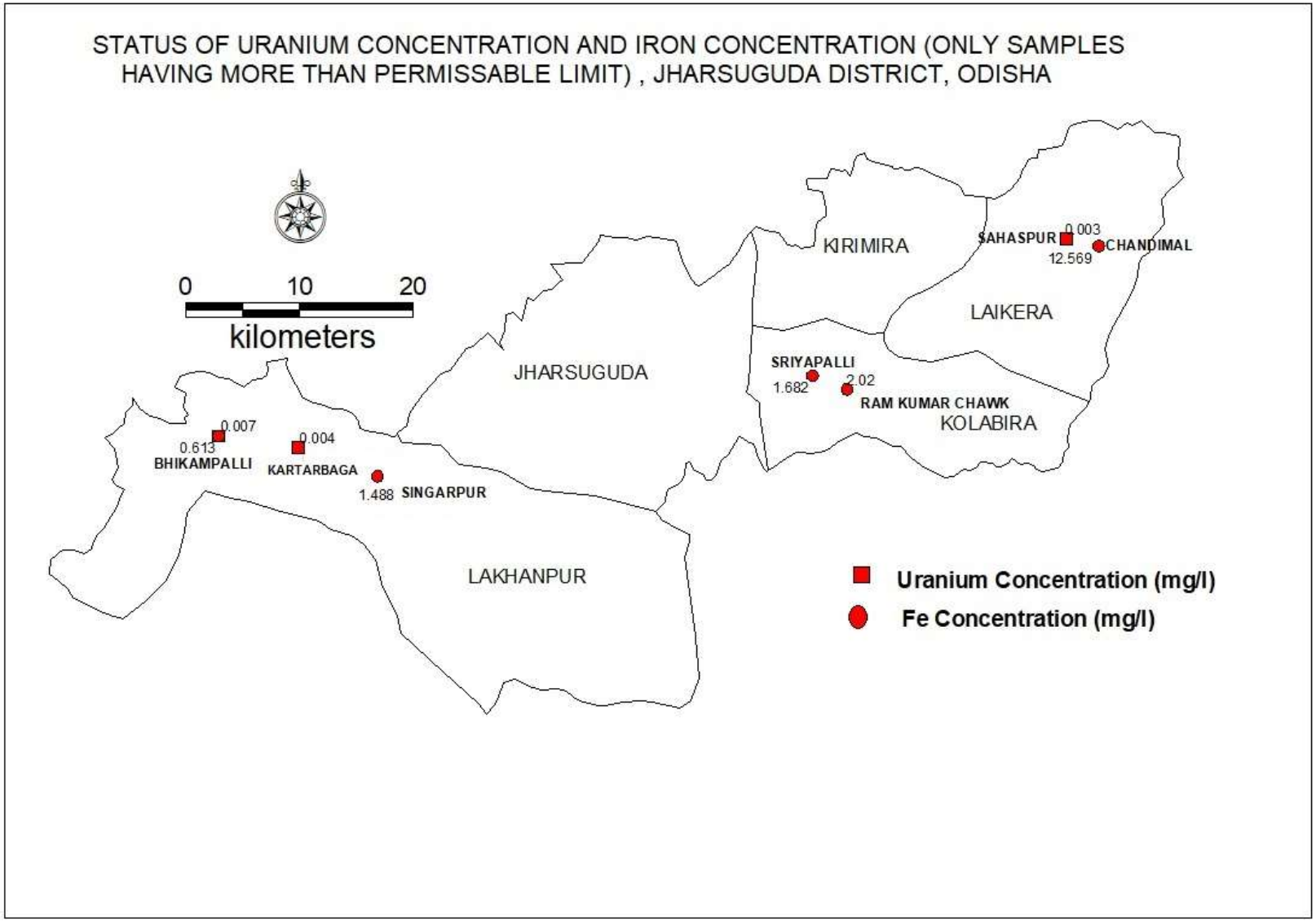

STATUS OF URANIUM CONCENTRATION AND IRON CONCENTRATION (ONLY SAMPLES HAVING MORE THAN PERMISSABLE LIMIT) , JHARSUGUDA DISTRICT, ODISHA
0
10
20
kilometers
KIRIMIRA
SAHASPUR
0.003
12.569
CHANDIMAL
LAIKERA
JHARSUGUDA
SRIYAPALLI
1.682
2.02
RAM KUMAR CHAWK
KOLABIRA
0.007
0.613
BHIKAMPALLI
0.004
KARTARBAGA
1.488
SINGARPUR
LAKHANPUR
Uranium Concentration (mg/l)
Fe Concentration (mg/l)

Fig.18d.Piper Diagram of ground water samples from shallow aquifers, Jharsuguda District,Odisha

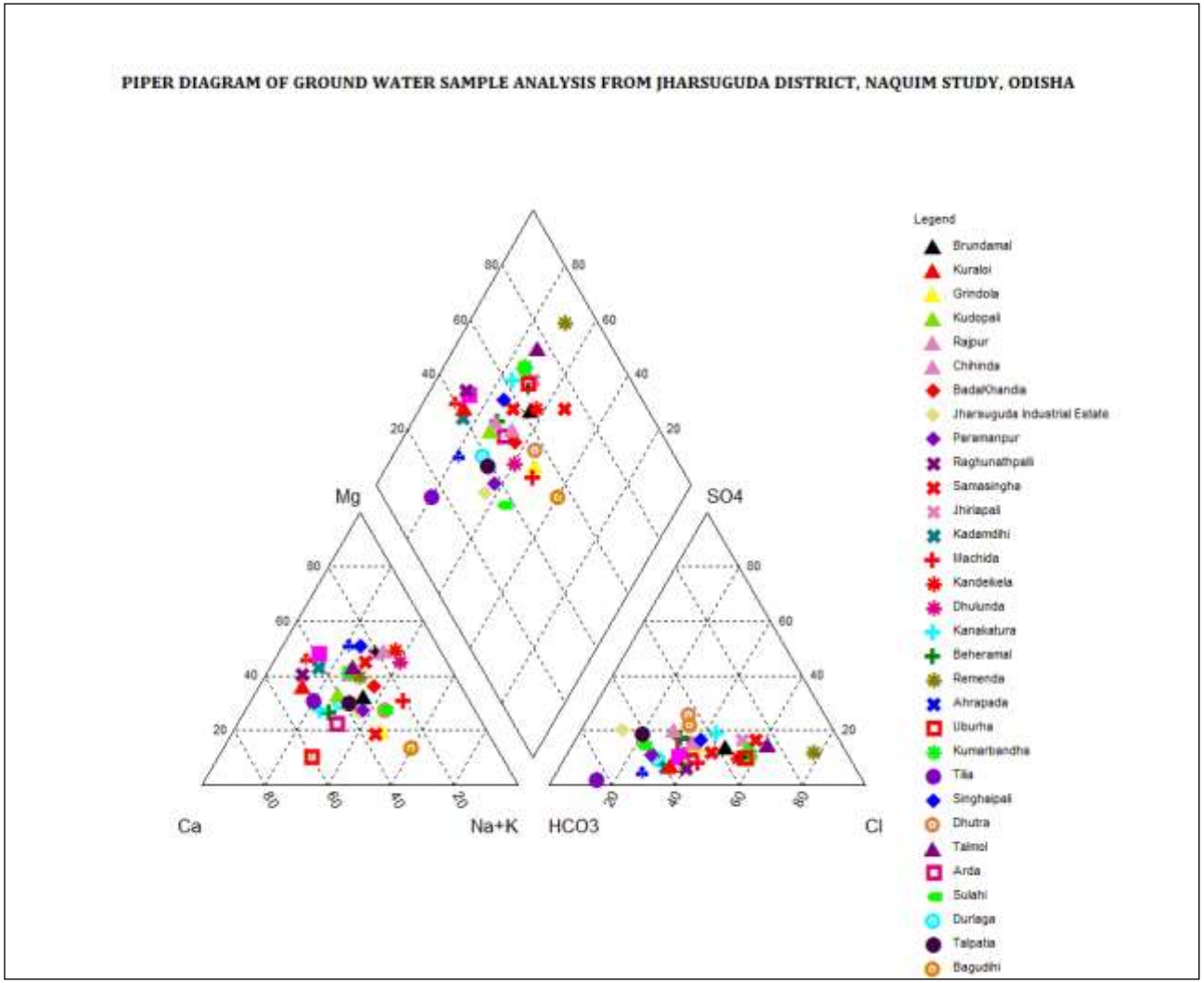


Fig.18e. Wilcox Diagram of ground water samples from shallow aquifers, Jharsuguda District,Odisha

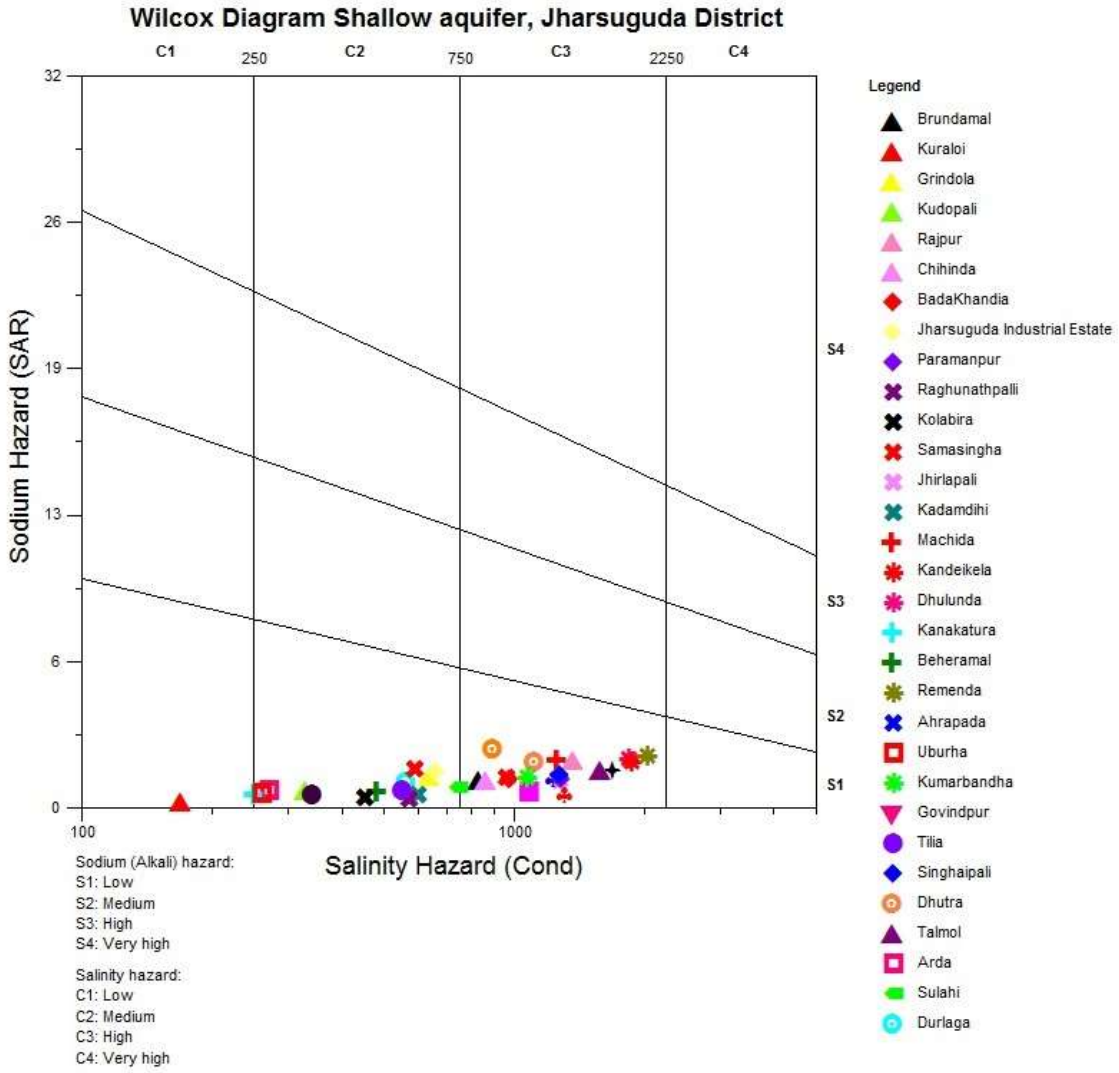


Fig.18f. Piper Diagram of ground water samples from exploratory tube wells, Jharsuguda District,Odisha

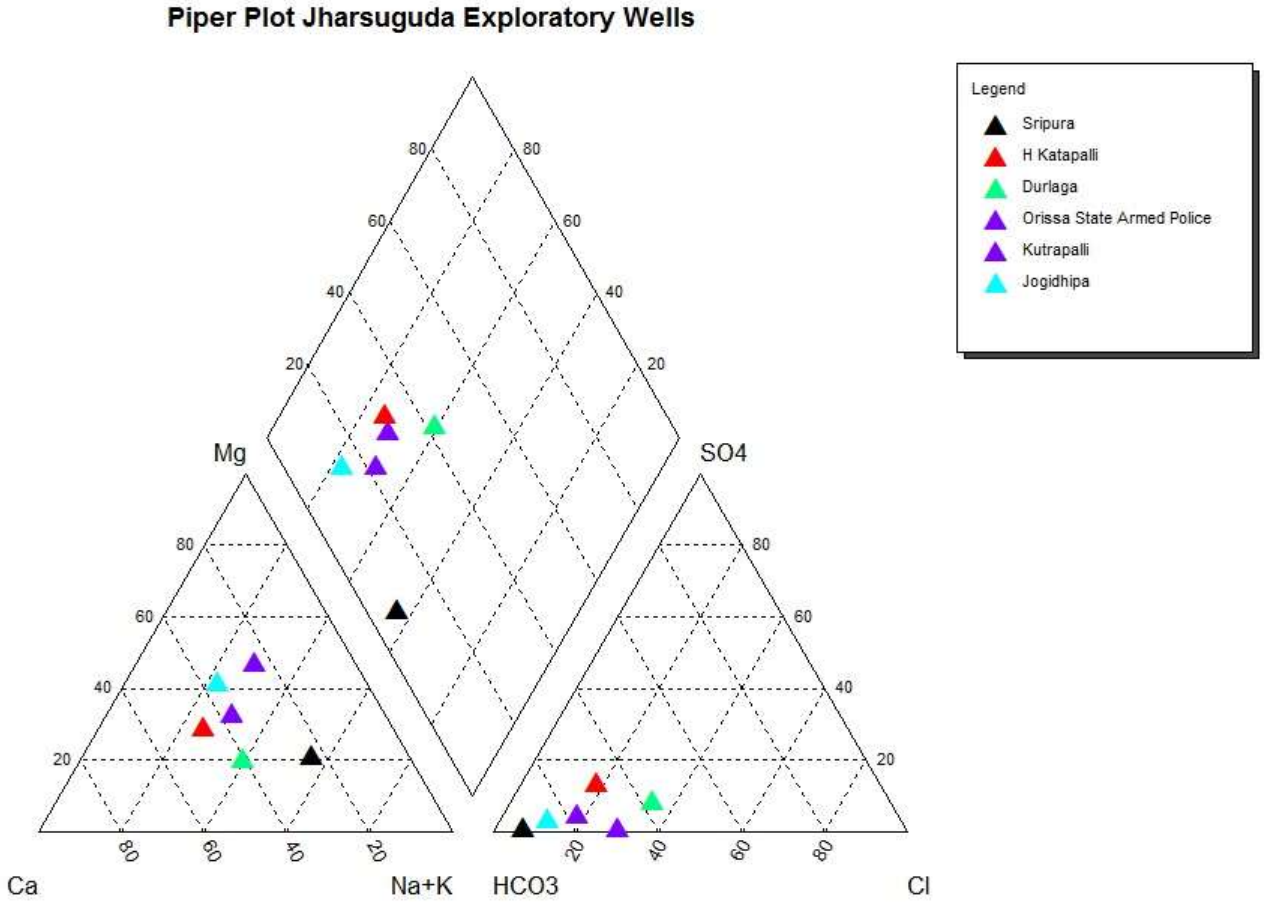
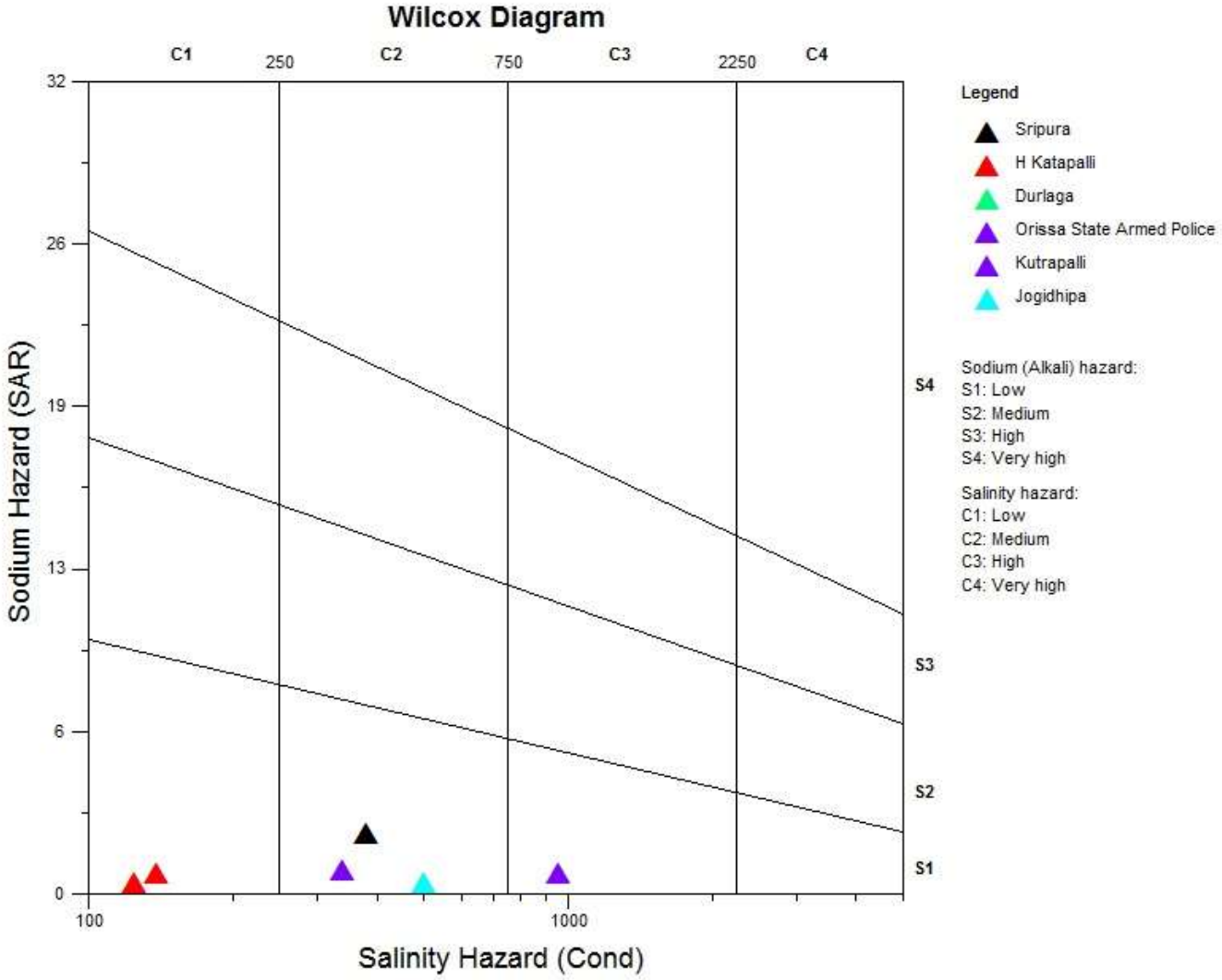


Fig.18g. Wilcox diagram for samples collected from Exploratory wells,Jharsuguda District,Odisha



4. **GROUND WATER RESOURCES:** Dynamic groundwater resources for Aquifer 1 estimated from year 2004 to year 2017 is summarized in the Table-14. Blockwise dynamic resources assesment (as on 31.03.2017) of Aquifer-I of Jharsuguda district have been summarized in Table-15. Blockwise static resouces assessment of Aquifer-1 is also formulated in Table-16. From the above table it is observed that yearwise stage of ground water development of Aquifer-I increases from 22.45% to 43.27% for the whole district.

Table-14. Yearwise dynamic groundwater resources calculations of Aquifer-I, Jharsuguda District

Year	Net Annual Ground Water Availability (ham)	Existing Gross Ground Water Draft for Irrigation (ham)	Existing Gross Ground Water Draft for domestic & Industrial Supply (ham)	Existing Gross Ground Water Draft for all uses (ham)	Provision for domestic & industrial requirement supply for next 25 years (ham)	Net Ground Water Availability for future irrigation development (ham)	Stage of Ground Water Development (%)
2004	17266	2733	1143	3876	5749	1921	22.45
2009	16791	3309	1507	4817	1485	11996	28.69
2011	16791	3590.2	1563	5153.2	1756.55	9881.25	30.69
2013	16791	3984.03	1458.93	5442.96	1829.50	10977.47	32.42
2017	20007.55	5616.27	3040	8656.34	2555.33	11012.9	43.27

Table-15 Dynamic Ground Water Resources of Aquifer-1, Jharsuguda District (As on 31.3.2017)

Sl No	Block	Utilizable Ground Water Resources	Gross Ground Water Draft for all uses	Balance Ground Water Resources	Allocation for Domestic and Industrial Requirement for next 25 years	Net Ground Water Availability for Future Irrigation Development	Stage of Ground Water Development	Category
		Ha. M	Ha. M	Ha. M	Ha. M	Ha. M	%	
1	Jharsuguda	4273.22	2562.5	1710.72	1295.98	1565.27	59.97	Safe
2	Kirimira	2392.86	893.29	1499.57	125.51	1489.34	37.33	Safe
3	Kolabira	2932.37	826.26	2106.11	162.88	2080.25	28.18	Safe
4	Laikera	2979.62	1672.27	1307.35	139.65	1299.68	56.12	Safe
5	Lakhanpur	7429.48	2702.02	4727.46	831.31	4578.36	36.37	Safe
District Total		20007.55	8656.34	11351.21	2555.33	11012.9	**43.27**	**Safe**

From Table -16, it can be understanding that stage of ground water development is minimum in Kolabira Block and maximum in Jharsuguda Block. A very significant amount of groundwater development is also observed in Lakhanpur Block.

Static groundwater resources (Table-16) have been calculated of Aquifer-I considering effective aquifer thickness of only 5%, as fracture zones are very thin and heterogeneously distributed throughout 100-meter depth (i.e., the bottom of aquifer-1).

Table-16. Static Ground Water Resources of Aquifer -1, Jharsuguda District (As on 31.3.2017)

Name of the Assessment Unit	Static Resources Area (ha)	Pre-monsoon water level (m)	Bottom of unconfined aquifer (m)	Difference (3-2) (m)	Effective Aquifer Thickness (m) {= (4) *5%}	Specific Yield (%)	Total Static Resources (ham) (7) = (1) *(5) *(6)
	1	2	3	4	5	6	7
Jharsuguda	41917	6.66	100	93.34	4.667	0.02	3912.53
Kirmira	19722	7.01	100	92.99	4.6495	0.02	1833.95
Kolabira	21193	7.71	100	92.29	4.6145	0.02	1955.9
Laikera	30224	5.53	100	94.47	4.7235	0.02	2855.26
Lakhanpur	98786	4.23	100	95.77	4.7885	0.03	14191.1

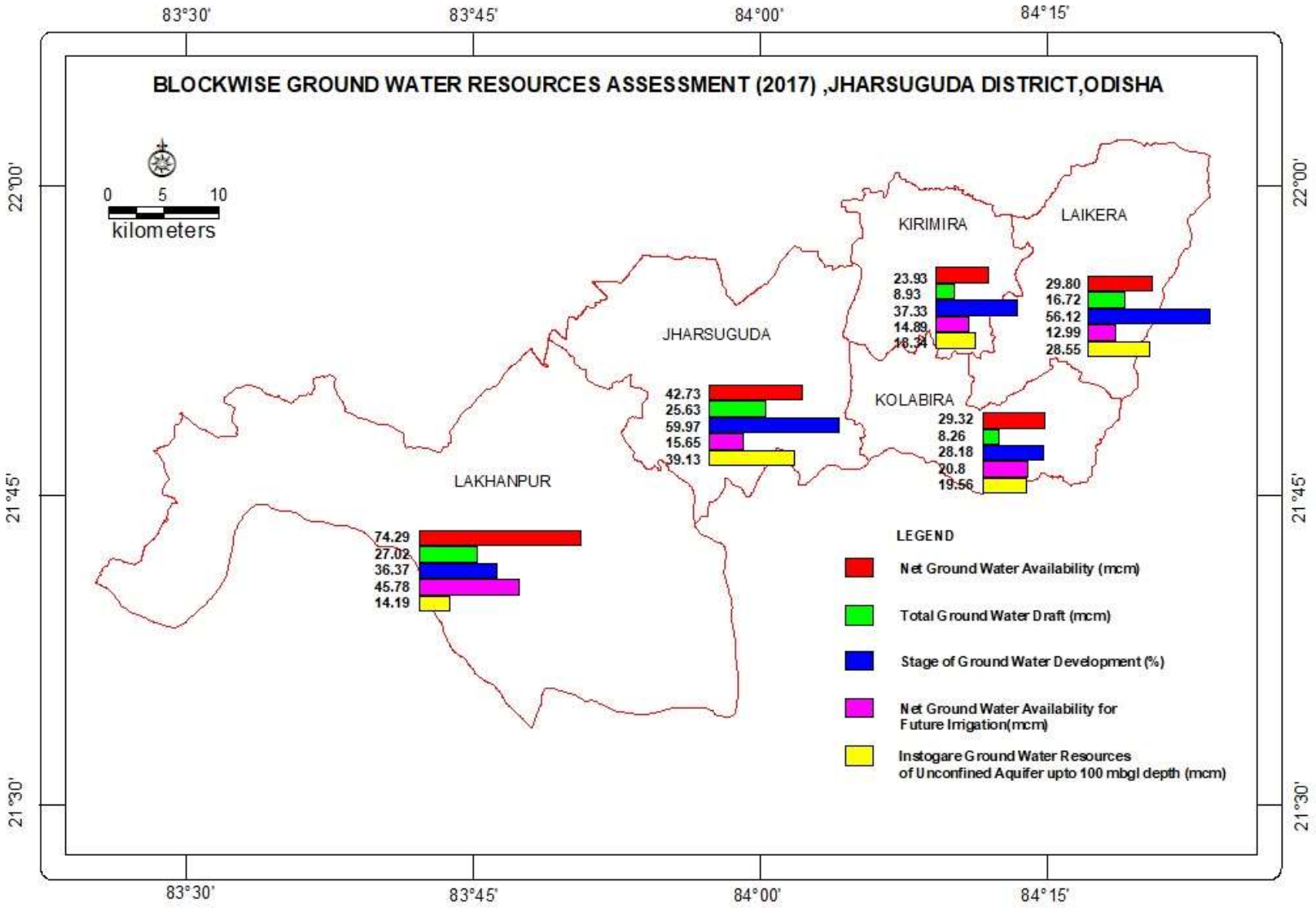
Block wise total groundwater resources of Aquifer-1have been summarized in table-17.

Table-17. Total Ground Water Resources (As on 31.3.2017), Jharsuguda District

Name of the Assessment Unit	Annual Extractable Ground Water Recharge of Aquifer -1	In storage Ground Water Resources of Aquifer-1	Total Ground Water Availability of Aquifer 1
	Aquifer-1		
1	2	3	4=2+3
Jharsuguda	4273.22	3912.53	8185.75
Kirmira	2392.86	1833.95	4226.81
Kulabira	2932.37	1955.9	4888.27
Laikera	2979.62	2855.26	5834.88
Lakhanpur	7429.48	14191.1	21620.58

Dynamic and static groundwater resources of Aquifer-2 could not be able to calculated due to nonavailability of sufficient tube well data beyond 100 meter depth. The details of Ground water resources estimation is shown in Fig. 19.

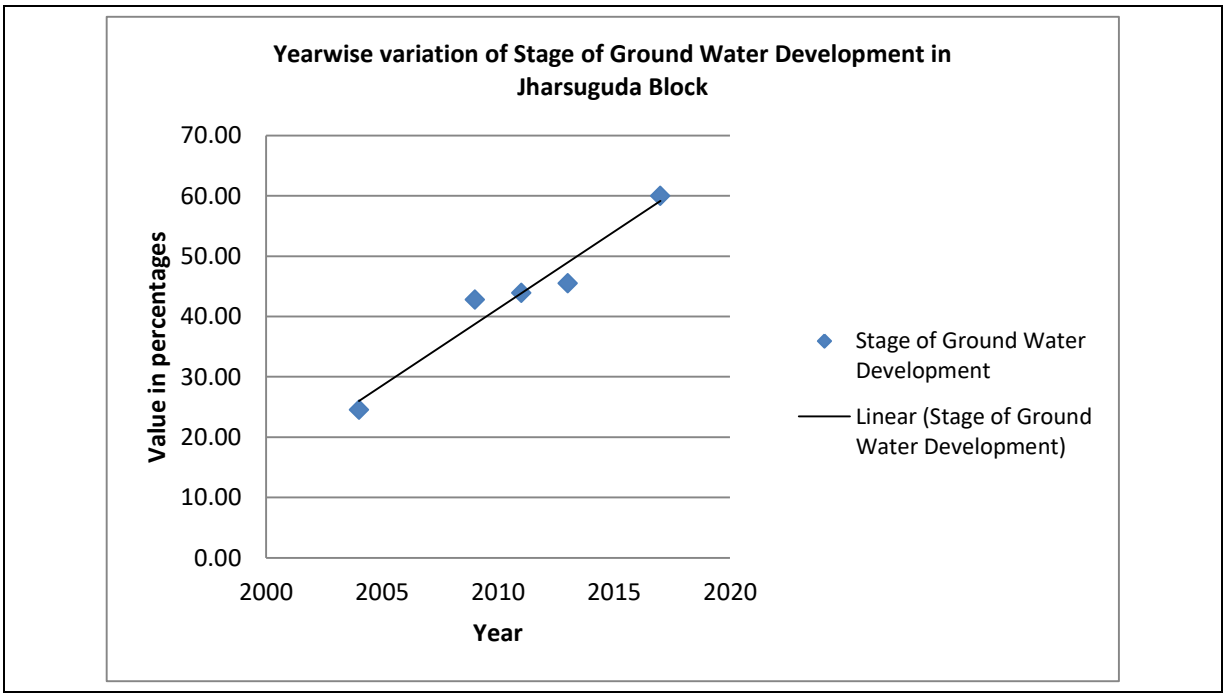
Fig.19. Groundwater Resources Assessment of Jharsuguda District, Odisha

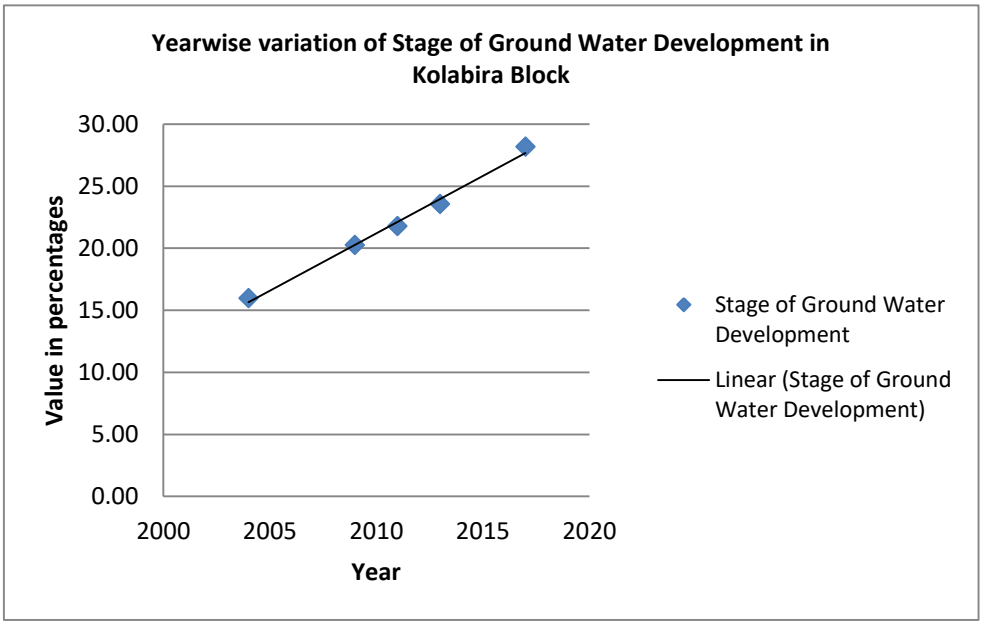


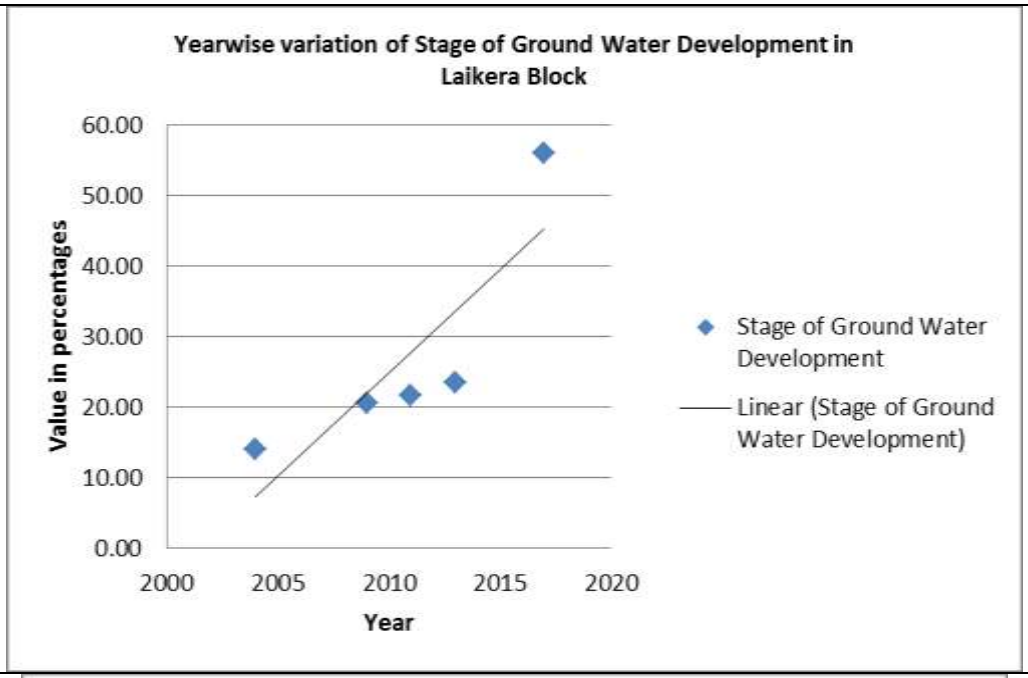
5. **GROUNDWATER RELATED ISSUES:** Groundwater related issues can be broadly divided into two categories, viz., area feasibility of ground water withdrawal from deeper aquifer and areas not feasible for groundwater withdrawal from deeper aquifer. From the three-dimensional aquifer model, it can emphasize only Sandstone, shale, coal of Lower Gondwana located in Lakhanpur Block will be feasible for ground water abstraction from deeper aquifer up to 200-meter depth. But deep tube wells are not feasible in other hydrogeological areas in Jharsuguda District.

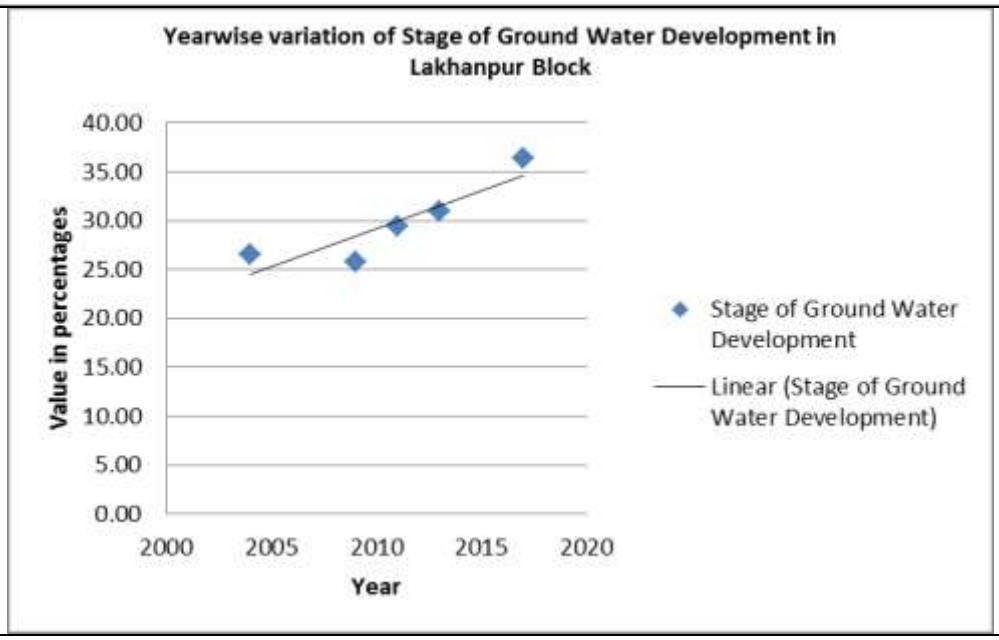
On the basis of ground water resource assessment, it can be said that quantity static ground water resources is much below the quantity of dynamic ground water resources in all the blocks except in Lakhanpur Block. Similarly, from dynamic ground water resources assessment over the years in all the blocks of Jharsuguda indicates a significant rise of SOD (stage of development) in four out of five Blocks (viz., 24.51% to 59.97% in Jharsuguda Block, 15.97% to 28.18% in Kolabira Block, 1397% to 56.12% in Laikera Block, 26.47 % to 36.37% in Lakhanpur Block). The details are shown in the Fig.20.

Fig.20.Yearwise Stage of Ground Water Development in 4 Blocks of Jharsuguda District.




Yearwise variation of Stage of Ground Water Development in Kolabira Block
Value in percentages
30.00
25.00
20.00
15.00
10.00
5.00
0.00
2000
2005
2010
2015
2020
Year
Stage of Ground Water Development
Linear (Stage of Ground Water Development)


Yearwise variation of Stage of Ground Water Development in Laikera Block
Value in percentages
60.00
50.00
40.00
30.00
20.00
10.00
0.00
2000
2005
2010
2015
2020
Year
Stage of Ground Water Development
Linear (Stage of Ground Water Development)


Yearwise variation of Stage of Ground Water Development in Lakhanpur Block
Value in percentages
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
2000
2005
2010
2015
2020
Year
Stage of Ground Water Development
Linear (Stage of Ground Water Development)

From Fig.16b.it is observed that about 502 sq.km area is under decadal falling ground water level trend and it is also correlated with few hydrographs (viz., Belpahar, Jharsuguda, Bhukampalli, Brjarajnar and Lykera).

Few large opencast coal mines are located in Jharsuguda District. As per data collection these mines have surplus unutilized ground water seepage conserved in old mines sump. The details of ground water dewatering/withdrawal are mentioned in the Table-18.

Table-18. Ground water withdrawal/ dewatering in MCL, Coal Mines, Jharsuguda District.

Name of Coal Mine	Daily Ground water withdrawal / dewatering in cubic meter/ day	Annual Ground water withdrawal /dewatering in cubic meter	Surplus water available for recharge in cubic meter /day	Surplus water available for recharge in cubic meter /annum	Ground Water dewatering/ Withdrawal
Belpahar OCP, Lakhanpur Area	1710	624150			Withdrawal
Lajkura OCP, IB Valley area	308	112420			Dewatering
Lakhanpur OCP, Lakhanpur Area	5233	1910045	4630	1689950	Dewatering
Samleswari OCP, IB valley area	2022	738030	271	98915	Dewatering
Total	9273	3384645	4901	1788865	**Total dewatering is 2.76 mcm**
		3.38 mcm	0.0049 mcm	1.78 mcm	

WATER DEMAND, AVAILABILITY AND GAP ANALYSIS:

For calculation of water demand and gap analysis domestic water demand, crop water demand, livestock water demand and industrial water demand data taken from PMKSY report, Irrigation department, Odisha and ground water availability data taken from CGWB, Ground water resources assessment (2017).

i.DOMESTIC WATER DEMAND: Gross domestic water demand of all the blocks in Jharsuguda district shall be 0.0090 BCM in 2020 for the projected population of 406742 persons, 0.0096 BCM in 2025 for a projected population of 433694 persons and 0.0108 BCM in 2035 for a projected population of 493075 persons. Projection

of population and domestic water demand for 2020, 2025 & 2035 in different Blocks have been elaborated below.

Table 19: Domestic water demand, Jharsuguda District

Sl. No	Name of the Block	Population in 2011	Projected population in 2020	Gross water demand (BCM)in 2020	Projected population in 2025	Gross water demand (BCM) in2025	Projected population in 2035	Gross water demand (BCM) in 2035
1	Jharsuguda	79440	89165	0.0020	95074	0.0021	108091	0.0024
2	Lakhanpur	142047	159437	0.0035	170001	0.0038	193278	0.0042
3	Kolabira	48003	53880	0.0012	57450	0.0013	65316	0.0014
4	Kirmira	42897	48149	0.0011	51339	0.0011	58368	0.0013
5	Laikera	49992	56112	0.0012	59830	0.0013	68022	0.0015
	Total:	362379	406742	0.0090	433694	0.0096	493075	0.0108

ii.CROP WATER DEMAND: Crop water demand for the district shall be 0.1470 BCM in 2020, 0.1524 BCM in 2025 and BCM in 2035. Jharsuguda district. Crop water demand in 2020 shall be 0.0330 BCM in Jharsuguda block, 0.0448 BCM in Lakhanpur block, 0.0264 BCM in Kolabira block, 0.0169 BCM in Kirmira block and 0.0260 BCM in Laikera block. In the year 2025, crop water demand shall be 0.0341 BCM in Jharsuguda block, 0.0463 BCM in Lakhanpur block, 0.0274 BCM in Kolabira block, 0.0177 BCM in Kirmira block and 0.0271 BCM in Laikera block. Crop water demand in 2035 shall be 0.0347 BCM in Jharsuguda block, 0.0472 BCM in Lakhanpur block, 0.0280 BCM in Kolabira block, 0.0182 BCM in Kirmira block and 0.0277 BCM in Laikera block. The detail enumeration is given below.

Table 20: Crop water demand, Jharsuguda District

Sl. No	Block	Crops	Area Sown (Ha)	Irrigated area (Ha)	Crop water demand in 2020 (BCM)	Crop water demand in 2025 (BCM)	Crop water demand in 2035 (BCM)	Existing water potential (BCM)	Water potential to be created (BCM)
1	Jharsuguda	Total Cereals, pulses, oilseeds, vegetables	18628	3098.3	0.0330	0.0341	0.0347	0.0288	0.0060
2	Lakhanpur	Total Cereals, pulses, oilseeds, vegetables	20858	9309.1	0.0448	0.0463	0.0472	0.0381	0.0091
3	Kolabira	Total Cereals, pulses, oilseeds, vegetables	12896	2068.8	0.0264	0.0274	0.0280	0.0246	0.0034
4	Kirmira	Total Cereals, pulses, oilseeds, vegetables	10219	2106.6	0.0169	0.0177	0.0182	0.0139	0.0043
5	Laikera	Total Cereals, pulses, oilseeds, vegetables	13169	7467.2	0.0260	0.0271	0.0277	0.0392	-0.0114
	Total:		75770	24050	0.1470	0.1524	0.1558	0.1445	0.0114

iii.LIVESTOCK WATER DEMAND: Total livestock water demand projection for the district shall be 0.00128 BCM. 0.00119 BCM in 2025 and 0.00102 BCM in 2035 considering the average growth trend of livestock population. Projection of livestock water demand for Jharsuguda block shall be 0.00032 BCM in 2020, 0.00029 BCM in 2025 & 0.00025 BCM in 2035. Livestock water demand for Lakhanpur block shall be 0.00041 BCM in 2020, 0.00038 BCM in 2025 & 0.00032 BCM in 2035. For Kolabira block, that will be 0.00018, 0.00017 & 0.00015 BCM in the year 2020, 2025 & 2035 respectively. Livestock water demand for Kirmira block shall be 0.00016 BCM in 2020, 0.00015 BCM in 2025 & 0.00013 BCM in 2035. In Laikera block the same will be 0.00021, 0.00020 & 0.00017 BCM in the year 2020, 2025 & 2035 respectively. The details has been mentioned below;

Table 21: Livestock water demand, Jharsuguda District

Sl. No	Name of the Block	Total number of live stock	Present water demand (BCM)	Water demand in 2020 (BCM)	Water demand in 2025 (BCM)	Water demand in 2035 (BCM)	Existing water potential (BCM)	Water potential to be created (BCM)
1	Jharsuguda	76959	0.00034	0.00032	0.00029	0.00025	0.02878	-0.02853
2	Lakhanpur	72732	0.00044	0.00041	0.00038	0.00032	0.03805	-0.03773
3	Kolabira	17957	0.00020	0.00018	0.00017	0.00015	0.02459	-0.02444
4	Kirmira	15682	0.00017	0.00016	0.00015	0.00013	0.01387	-0.01374
5	Laikera	51981	0.00023	0.00021	0.00020	0.00017	0.03917	-0.03900
	Total:	235311	0.00139	0.00128	0.00119	0.00102	0.02787	-0.02685

iv.INDUSTRIAL WATER DEMAND: The projection for total industrial water demand in 2020 for Jharsuguda district shall be 0.00062 BCM, 0.00185 BCM in 2025 & 0.00185 BCM in 2035. Industrial water demand projection for Jharsuguda block shall be 0.00027 BCM in 2020, 0.00081 BCM in 2025, 0.00370 BCM in 2035.

Projection for Lakhanpur block shall be 0.00019 BCM in 2020, 0.00057 BCM in 2025, 0.00113 BCM in 2035. Industrial water demand for Kolabira block shall be 0.00005 BCM in 2020, 0.00016 BCM in 2025, 0.00033 BCM in 2035 for Kirmira block shall be 0.00005 BCM in 2020, 0.00014 BCM in 2025, 0.00028 BCM in 2035. Industrial water demand projection for Laikera block shall be 0.00006 BCM in 2020, 0.00017 BCM in 2025, 0.00034 BCM in 2035 as mentioned here under;

Table 22: Industrial water demand, Jharsuguda District

Sl. No	Name of the Block	Present Water demand (BCM)	Water demand in 2020 (BCM)	Water demand in 2025 (BCM)	Water demand in 2035 (BCM)	Existing water potential (BCM)	Water potential to be created (BCM)
1	Jharsuguda	0.00009	0.00027	0.00081	0.00162	0.0288	-0.0272
2	Lakhanpur	0.00006	0.00019	0.00057	0.00113	0.0381	-0.0369
3	Kolabira	0.00002	0.00005	0.00016	0.00033	0.0246	-0.0243
4	Kirmira	0.00002	0.00005	0.00014	0.00028	0.0139	-0.0136
5	Laikera	0.00002	0.00006	0.00017	0.00034	0.0392	-0.0388
	Total:	0.00020	0.00062	0.00185	0.00370	0.14445	-0.1408

v.DEMAND, AVAILABILITY AND GAP: Total water availability in Jharsuguda district is 0.2493 BCM, out of which 0.0493 BCM is surface water & 0.2 BCM is ground water. Projected water demand for 2025, 2035 shall be 0.1650 BCM, 0.1713 BCM respectively. As per water availability of Jharsuguda there will be no gap exists during the year 2025 and 2035, but it is noticed that demand will be increasing over the years. Block wise water availability, demand have been elaborated hereunder.

Table 23: Water availability, water demand & gap, Jharsuguda District

Sl. No	Name of the block	Existing water availability (BCM)			Present water demand (BCM)	Projected Water demand (BCM)	
		Surface water	Ground Water	Total (BCM)	2020	2025	2035
1	Jharsuguda	0.0072	0.0427	0.0499	0.0356	0.0372	0.0390
2	Lakhanpur	0.0149	0.0743	0.0892	0.0489	0.0510	0.0529
3	Kolabira	0.0077	0.0293	0.037	0.0278	0.0290	0.0299
4	Kirmira	0.0071	0.0239	0.031	0.0182	0.0191	0.0198
5	Laikera	0.0123	0.0298	0.0421	0.0275	0.0288	0.0298
	Total:	0.0493	0.2	0.2493	0.158	0.1650	0.1713

6. **MANAGEMENT STRATEGIES:** As per water availability, water demand and gap analysis (Table-23) it is understand that a water demand will gradually increasing from 0.158 BCM during 2020 to 0.1713 BCM during the year 2035.This value came after considering existing dynamic groundwater resources (2017) of Aquifer-I and other surface water availability from the Irrigation Department, Govt. Of Odisha.

   From the three-dimensional aquifer model, it can be seen that ground water present mostly in the weathered zone (avg. thickness 20 meter) in most of the consolidated formation areas. Only in semi consolidated formation specially in Lakhanpur Block

presence of good quantity ground water resources (as per exploration) available up to the depth of 200 meter.

From decadal long term water trend map an area of 502 sq.km is showing a ground water level falling trend. This is also supported by step rise of ground water draft in most of the blocks. So, there is an urgent need to enhance the ground water resources.

i. **Ground Water Resources Enhancement:** On the basis of Census 2011 data, Block area, number of total households was taken. Then declining trend areas have been selected for construction of farm pond (one pond per hector) to arrest the rainwater for recharge. Similarly, 10% household will be considered in a particular village (with average rooftop area 150 sq. Meter per house) for calculation of recharge from roof top rainwater. Average five years rainfall to the tune of 1308 mm (year 2014– year 2018) is taken for calculation. Coefficient of rainfall taken 15% for farm recharge and 80% for roof top rainfall recharge. block wise details are summarized in Table 24 and 25.

Table-24. Enhancement of Groundwater Resources by adoption of Farm Recharge, Jharsuguda District

Sr.No.	Name of Block	Total area of the village (in hectares rounded up to one decimal place)	Actual area considered (ha)	10%of village area taken for farm recharge (sq m)	Total number of farm pond (1 farm pond / hector) for 10% area	Annual recharge (MCM)= (Area*Runoff 15%*Rainfall 1.308m/1000000)
1	Lakhanpur	59451	14820	14820000	1482	2.908
2	Jharsuguda	27521	27521	27521000	2752	5.400
3	Kirimira	19979	5669	5669000	567	1.112
4	Laikera	25598	25598	25598000	2560	5.022
5	Kolabira	24040	1466	1466000	147	0.288
Total Number of Farm Ponds to be adopted and quantity of rainwater to be conserve					7508	14.73

Table-25. Enhancement of Ground Water Resources by adoption of roof top rainwater harvesting structures, Jharsuguda District.

Sr.No	Name of CD block	Number of households (2011 census)	No of Houses taken for Artificial Recharge (10% of total households)	Total No of AR Structures (one structure for 10 households)	Annual Rainfall runoff Available for recharge (MCM) (No of households x avg rooftop area (150 sqm) x runoff coefficient (80%) x rainfall, 1.308m)
1	LAKHANPUR	30818	3082	3082	0.484
2	JHARSUGUDA	18139	1814	1814	0.285
3	KIRIMIRA	10482	1048	1048	0.165
4	LAIKERA	12752	1275	1275	0.200
5	KOLABIRA	12096	1210	1210	0.190
RWH Structure in RURAL Areas(Total Number and amount of water conservation)				**8429**	**1.324**
Sr.No	Name of Municipality	Number of households (2011 census)	No of Houses taken for Artificial Recharge (10% of total households)	Total No of AR Structures (one structure for 10 house holds)	Annual Rainfall runoff Available for recharge (MCM) (No of households x avg rooftop area(200 sqm) x runoff coefficient (80%) x rainfall, 1.308m)
1	Jharsuguda MC	21916	2192	2192	0.459
2	Brajarajnagar MC	17631	1763	1763	0.369
3	Belpahar MC	8821	882	882	0.185
RWH Structure in URBAN Areas(Total Number and amount of water conservation)				**4837**	**1.013**

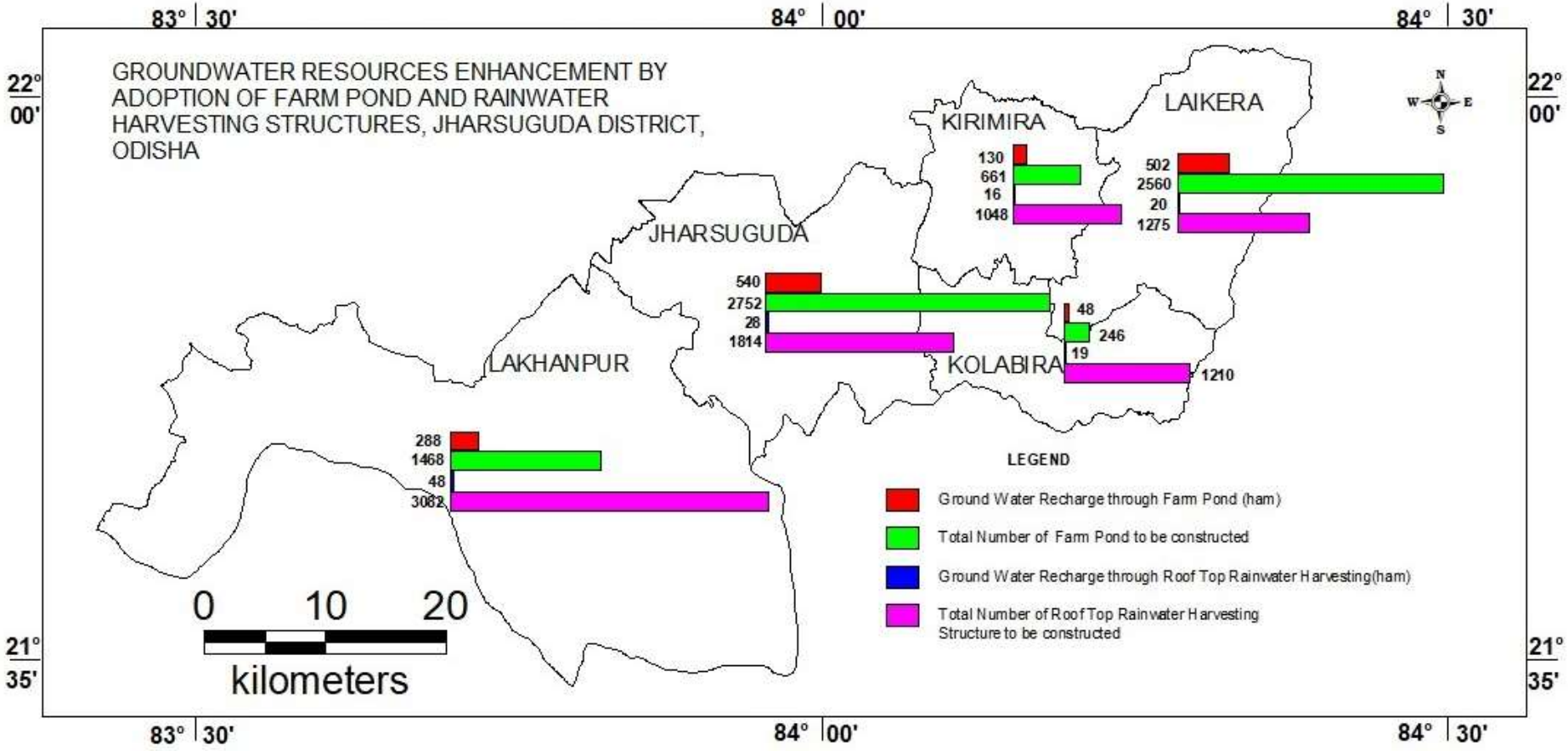
So, after combining the total amount of annual recharge a composite table have been prepared to know the exact improvement of groundwater resources. The details are given in Table-26 and Fig.21.

Table-26. Stage of Ground water Development Improvement, Jharsuguda District

Name of Block	Net GW Availability in mcm	GW Draft in mcm	Stage of Deveopment (%)	Quantity of Annual Farm Recharge/conservation in mcm	Quantity of Annual RWH Recharge/conservation in mcm	Total recharge/conservation quantity in mcm	Net GW availibility after recharge/ conservation	Stage of Deveopment (%) afterwards
Lakhanpur	74.29	27.02	36.37	2.908	0.484	3.392	77.687	34.78
Jharsuguda	42.73	25.63	59.97	5.400	0.285	5.685	48.417	52.94
Kirimira	23.93	8.93	37.33	1.112	0.165	1.277	25.207	35.43
Laikera	29.8	16.72	56.12	5.022	0.200	5.222	35.022	47.74
Kolabira	29.32	8.26	28.18	0.288	0.190	0.478	29.798	27.72
Total	**200.08**	**86.56**	**43.26**	**14.73**	**1.323**	**16.053**	**216.130**	**40.05**

So, considering **17.067 mcm** amount of rainwater may be conserved annually after adoption of farm pond and roof top rainwater harvesting structure which can fulfil the demand over the years as well as will increase the ground water storage.

Fig.21.Groundwater Resources Enhancement by adoption of farm pond and rainwater harvesting structures, Jharsuguda District, Odisha



ii. **Demand side Management:** For demand side ground water management, average crop water requirement for kharif and rabi season calculated on the basis of data obtained from Minor Irrigation census of Odisha (2014). As per ground water

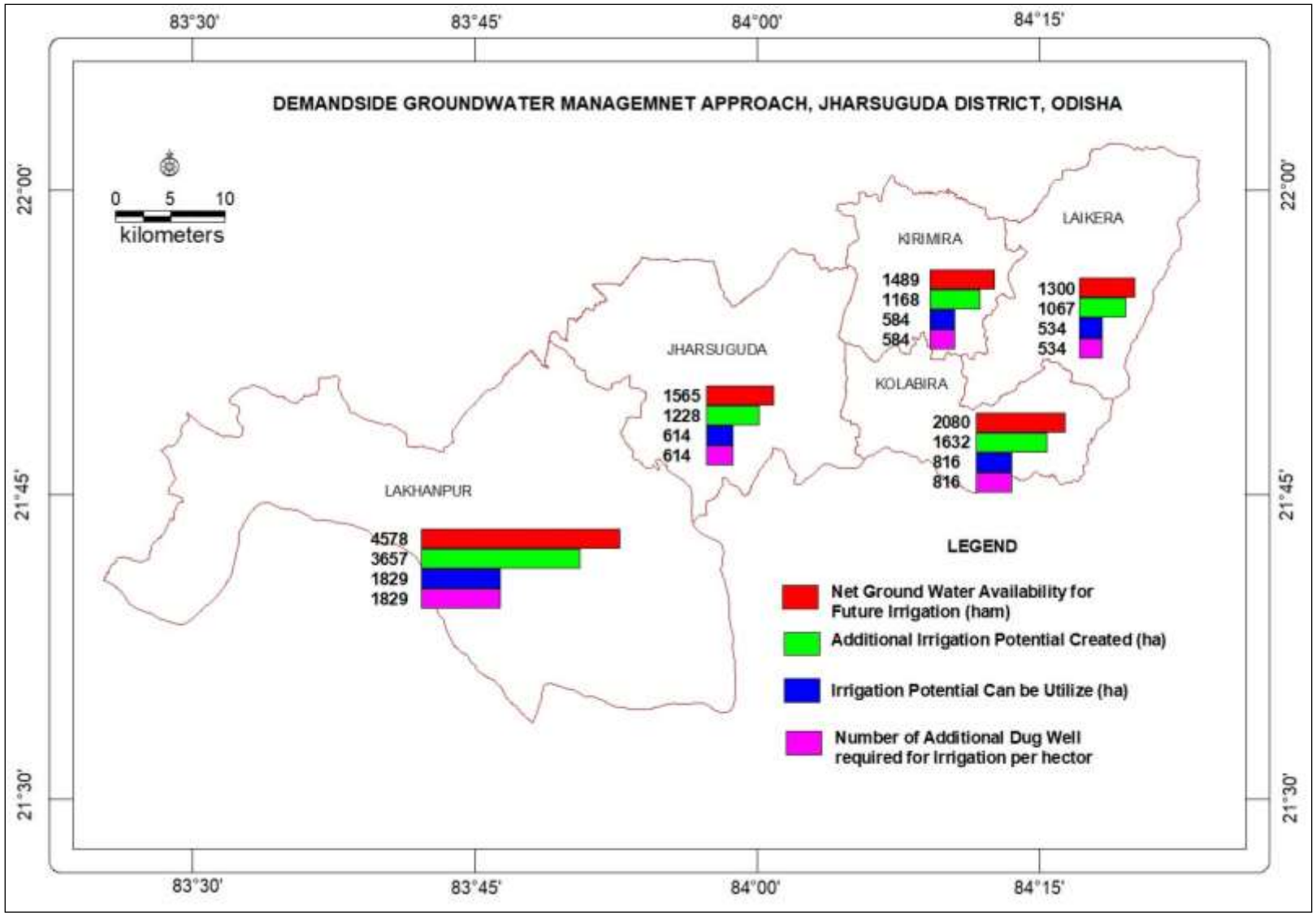
resources assessment 2017, total additional water availability for future irrigation have been considered. On that basis considering only 50% additional water for future irrigation 4376 ha additional irrigation potential area calculated and on that basis 4376 number of dug well may be suggested for construction for irrigation during summer season. The details are given in the table-27 and Fig.22.

Table 27. Additional Irrigation potential that can be created and feasible number of additional irrigations dug wells to be constructed, Jharsuguda District

Block	Kharif crop area (ha)*	Average Water requirement @ 1.275 m/ha *(ham)	Rabi crop area (ha)*	Average Water requirement @ 1.055 m/ha* (ham)	Total Water requirement (ham)	Average crop Water requirement in a year (m)	Net GW Resources available for future irrigation (ham)** As on 31.3.2017	Possible additional irrigation potential area that can be created with available resources(ha)	50% of the additional potential area taken for irrigation (ha)	100% Area to be irrigated by Dug well (ha) from additional potential areas(ha)	Command area of one Dug Well (ha)	Number of Additional Dug Well to be constructed
1	2	3	4	5	6(3+5)	7[6/(2+4)]	8	9(8/7)	10	11	12	13
Jharsuguda	325.00	414.375	0	0	414.375	1.275	1565.27	1227.662745	613.8314	613.8314	1	614
Kirmira	351.00	447.525	0	0	447.525	1.275	1489.34	1168.109804	584.0549	584.0549	1	584
Kulabira	57.00	72.675	0	0	72.675	1.275	2080.25	1631.568627	815.7843	815.7843	1	816
Laikera	2,688.00	3427.2	950.00	1002.25	4429.45	1.218	1299.68	1067.454388	533.7272	533.7272	1	534
Lakhanpur	1,652.00	2106.3	194.00	204.67	2310.97	1.252	4578.36	3657.188349	1828.594	1828.594	1	1829
Total	5073	6468.08	1144	1206.92	7675.00	6.30	11012.9	8751.98	4375.99	4375.99		4377

Source: *Minor Irrigation Census Odisha, 2014, **Ground water resources estimation of Orissa, 2017

Fig.22. Demand side Groundwater Management Approach, Jharsuguda District, Odisha



From the cropping pattern in Jharsuguda district, it has observed that during summer time crop production is very negligible. So, from the excess available water for future irrigation (Table-27) subsurface drip irrigation practices may be adopted which can reduce at least 60% water consumption. Crops suitable for drip irrigation are as follows:

i. Fruit crops: Grapes, banana, pomegranates, mango, orange, cashew nuts, papaya, litchi, watermelon.
ii. Vegetable plants: Onion, brinjal, bitter gourd, ridge gourd, cucumber, tomato, chilly, capsicum etc.
iii. Oil seeds: Sunflower, oil palm.
iv. Forest crop: Bamboo, teakwood

Therefore, after adopting this technique, 60% of future irrigation potential, i.e,60% of 5507 ham = 3304 ham ground water resources will be saved. So, a total amount of (5506.5+3303.9) =8810.4 ham ground water will be kept for future ground water irrigation as on year 2025 in Jharsuguda District.

To mitigate the wastage of water specially for commercial activity Department of Water Resources, Govt. of Odisha notifies a separate water pricing policy vide letter dated 24.4.2020. Concerned District Administration should strictly follow the water pricing policy for sustainable development of ground water (Annexure-1).

7.BLOCKWISE AQUIFER MAPS AND MANAGEMENT PLAN

i. Jharsuguda Block

1. Salient Information	
Name of the Block and Area (in Km^2)	Jharsuguda Area- 407.6 sq.km.
District/ State	Jharsuguda/ Odisha
Population	89165 (Projected population as on 2020 w.r.t 2011 census), growth rate is 12.24%
Rainfall	Normal Monsoon rainfall-1230 mm Non-monsoon Rainfall-160 mm
Agriculture and Irrigation	**Principal crops**-Cereal, Pulses, Oil Seeds, Vegetable Crops **Gross cropped area**-186.28 sq.km **Net sown area**- 194 sq. km. **Cropping intensity** – 96.02% **Irrigation practices** i.MIP-737.5 ha ii. LIP-2110 ha iii. Deep Bore Well-67.2 ha iv.Traditional Water harvesting structures- 1561ha v.Other sources Agriculture and OAIC- 20.8 ha **Total number irrigation dug well** during year **1999** was 1311, number of **irrigations bore well** was 2, but during **2017** number of dug well was 1212 and number of bore well was 217. Therefore, the growth rate of bore well is 10850%.
Ground water resource availability and extraction	**Aquifer – I** (Up to 100 mbgl depth) Dynamic Ground Water Resources- 4273 ha Total Ground Water Draft- 2563 ham In storage Ground Water Resources- 3913 ha
Existing and future water demands	a. Existing domestic water demand-2 mcm Domestic water demand during 2035- 2.4 mcm b. Existing irrigation water demand- 33 mcm Irrigation water demand during 2035- 34.7 mcm c. Existing industrial water demand- 0.27 mcm Industrial water demand during 2035- 1.62 mcm
Water level behaviour	2.75 to 9.15 mbgl during pre monsoon (Fg.25a) 1.7 to 4.05 mbgl during post monsoon (Fig.25b) 0.2 to 0.8 cm/year rising decadal water level trend (Fig-25d). But Jharsuguda city showing significant falling water level over the years.

2. Aquifer Disposition	
Number of aquifers	Single aquifer up to 100 mbgl depth (Fig.24 b, c, d)
3-D aquifer disposition and basic characteristics of each aquifer	Cross sections in various directions are presented in Fig.24.
	Geology- Precambrian granite gneiss, mica schists in most of the parts (Consolidated formation) and Lower Gondwana shale (semi-consolidated formation) in north western part (Fig.23). Depth of weathered zone varies from 5.6 mbgl to 25.5 mbgl. Discharge obtained in Gondwana Shale is 0.5 lps from 66-69 m fracture zone. Discharge obtained in mica schist is 0.5-08 lps from 46-60 m fracture zone. Discharge obtained in granite gneiss is 0.1-3.5 lps from 19-21,30-35,43,58-59,60-62,66-69 m fracture zone. Weathered zones are generally filled up with water beyond the pre and post monsoon water level. T value obtained in Sarbahal EW well was 14.37 m^2/day. Aquifer type is unconfined up to 50-60 mbgl depth and semiconfined beyond 50-60 mbgl depth.
3. Ground water resource, extraction, contamination and other issues	
Aquifer wise resource availability and extraction	As on 31.3.2017 Net Ground Water Avialabiliy-42.73 mcm Gross ground water draft-25.63 mcm Allocation for domestic and industrial requirement for 25 years- 12.96 mcm Net ground water availability for future irrigation-15.65 mcm Stage of Ground Water Extraction-59.97% Category- Safe
Chemical quality of ground water and contamination	Electrical Conductivity (µS/cm)-170 to1370 TDS (mg/l)-80 to 687 Ca^{++}(mg/l)-16 to 56 Mg^{++}(mg/l)-7 to 81 Na^{+}(mg/l)-4 to 99 K^{+}(mg/l)-2 to 55 HCO_3(mg/l)-54 to 368 $SO_4^{=*}$(mg/l)-5 to 94 Cl^{-}(mg/l)-19 to175 NO_3^{-*}-3 to 49 F-0.1 to 0.62 At Brundamal,Grindola, Rajpur, Badakhandia nitrate concentration seen more than permissible limit.Ec found >750 µS/cm at Brundamal, Rajpur, Badakhandia. Groundwater is potable for drinking and irrigation (Fig. 26).

Other issues	Present water availability is 49.9 mcm Water demand as on 2025 and 2035 will be 37.2 mcm, 39 mcm respectively. Possibility of shortage of aquifer storage.
4. Ground water resource enhancement	
Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone- 296 mcm (up to the maximum depth of 5.3 mbgl post monsoon water level) Rainfall recharge by adoption of 2752 number of farm pond (1 pond per hector) – 5.4 mcm Rainfall recharge by adoption of 1814 number of roof top rainwater harvesting structure (1 structure for 10 houses in village) – 0.29 mcm Average annual rainfall considered 1308 mm Total Volume of Water expected to be conserved- 5.685 mcm
5. Demand side interventions	
Advanced Irrigation Practices	614 ha area proposed to be covered for subsurface drip irrigation practices during summer and Volume of Water expected to be conserved will be 60% of 939 ham=469.5 ham
Change in cropping pattern	**Fruit crops**: Grapes, banana, pomegranates, mango, orange, cashew nuts, papaya, litchi, watermelon. **Vegetable plants**: Onion, brinjal, bitter gourd, ridge gourd, cucumber, tomato, chilly, capsicum etc. **Oil seeds**: Sunflower, oil palm. **Forest crop**: Bamboo, teakwood
Alternate water sources	i. Net GW Resources available for future irrigation (ham)** as per Ground water resources estimation (2017)- 1565.27 ham ii. Average crop Water requirement in a year (m)- 1.275 m iii. Possible additional irrigation potential area that can be created with available resources(ha)- 1227.66 ha iv. 50% of the additional potential area taken for irrigation (ha)-613.83 ha v. 100% Area to be irrigated by Dug well (ha) from additional potential areas(ha)- 613.83 ha vi. Total number of additional dug well to be constructed for drip irrigation during summer- 614
Regulation and Control	To mitigate the wastage of water specially for commercial activity Department of Water Resources, Govt. of Odisha notifies a separate water pricing policy vide letter dated 24.4.2020. Concerned District Administration should strictly follow the water pricing policy for sustainable development of ground water
Reflected results after adoption of Ground water enhancement and demand side interventions	An annual amount of approximately 10 mcm water will be saved.

Fig.23

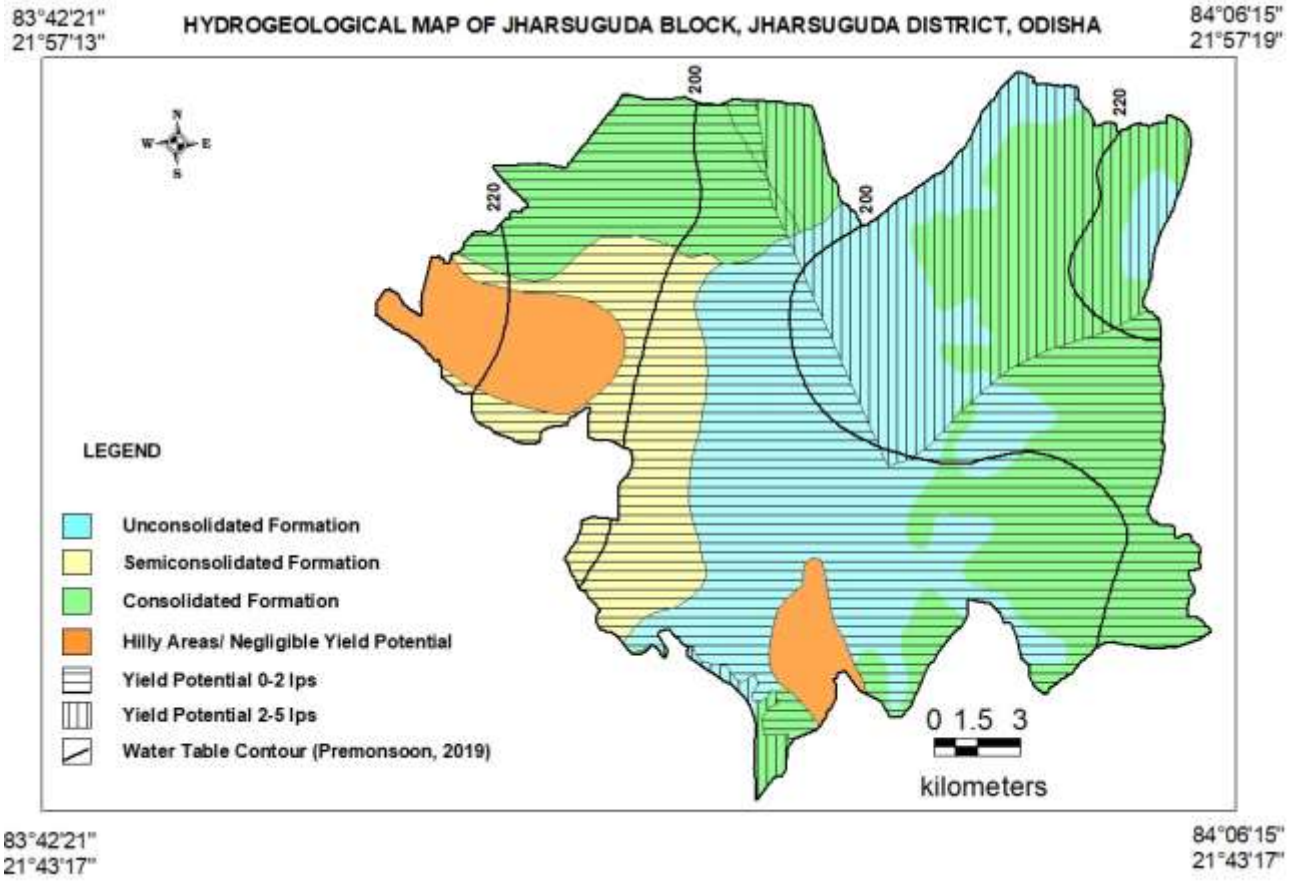


Fig.24a

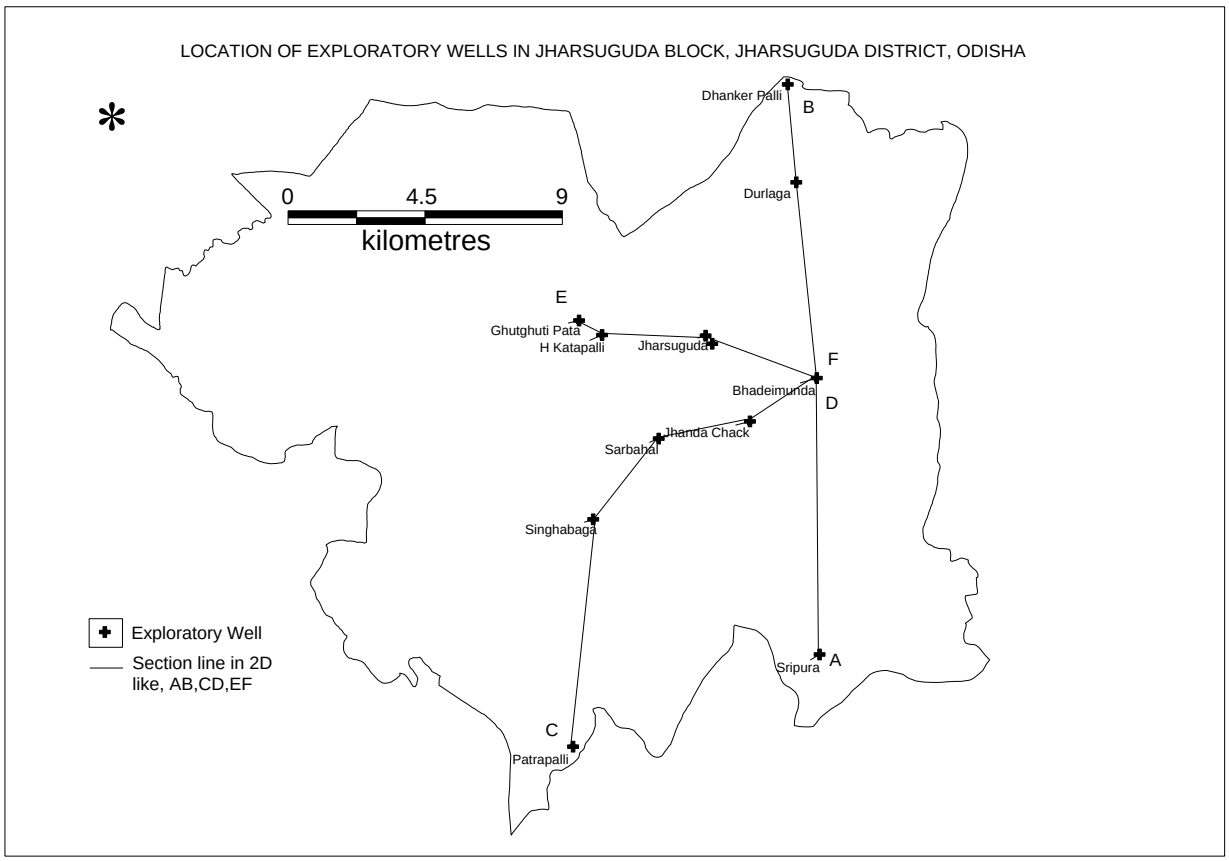


Fig.24b.

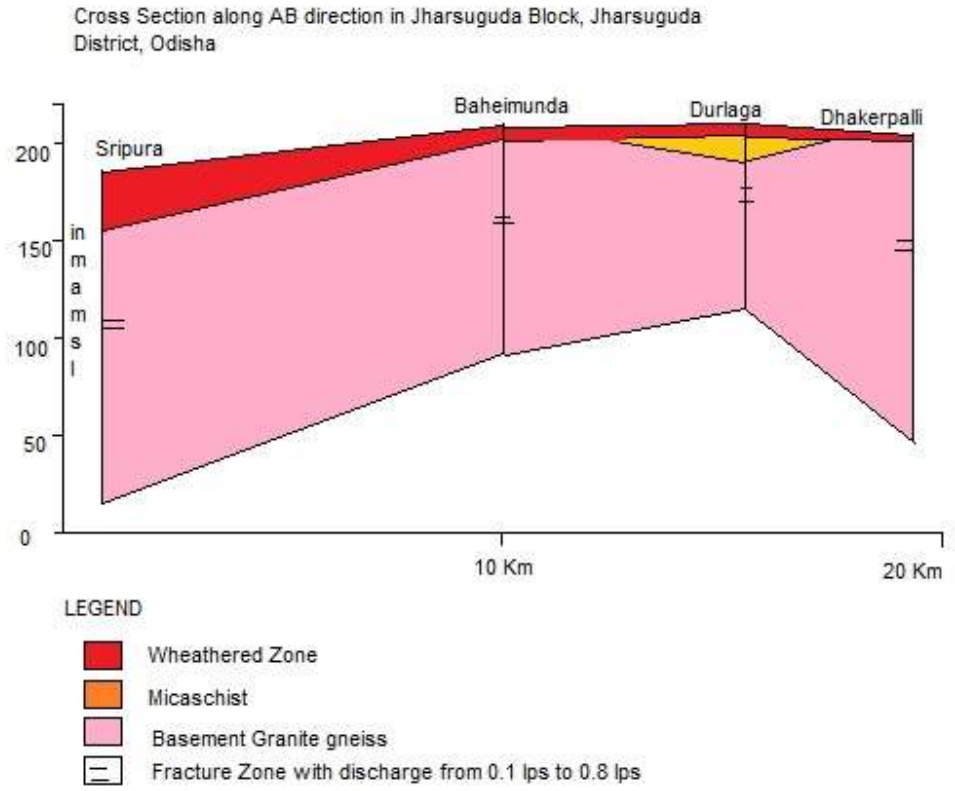


Fig.24c.

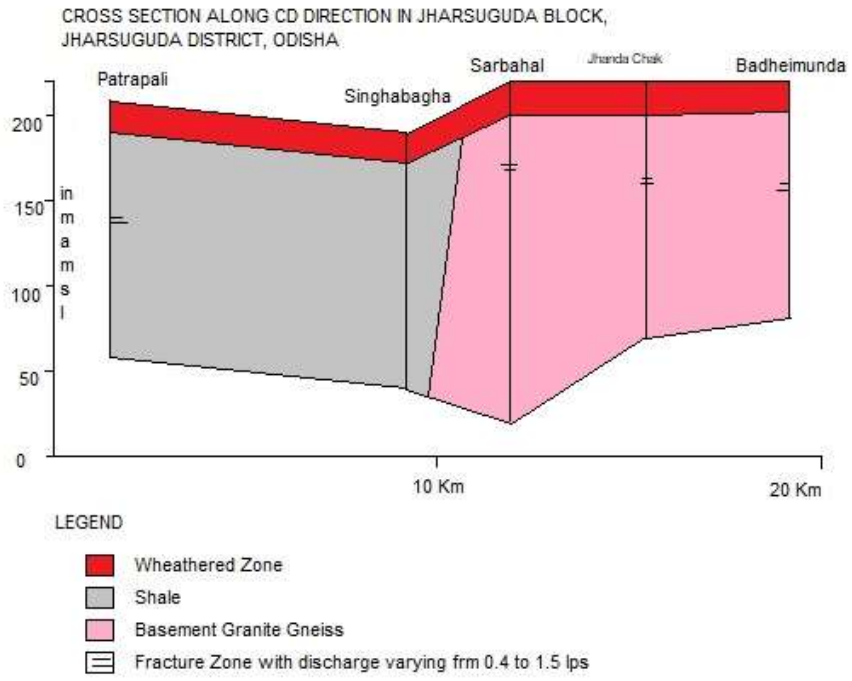


Fig.24d.

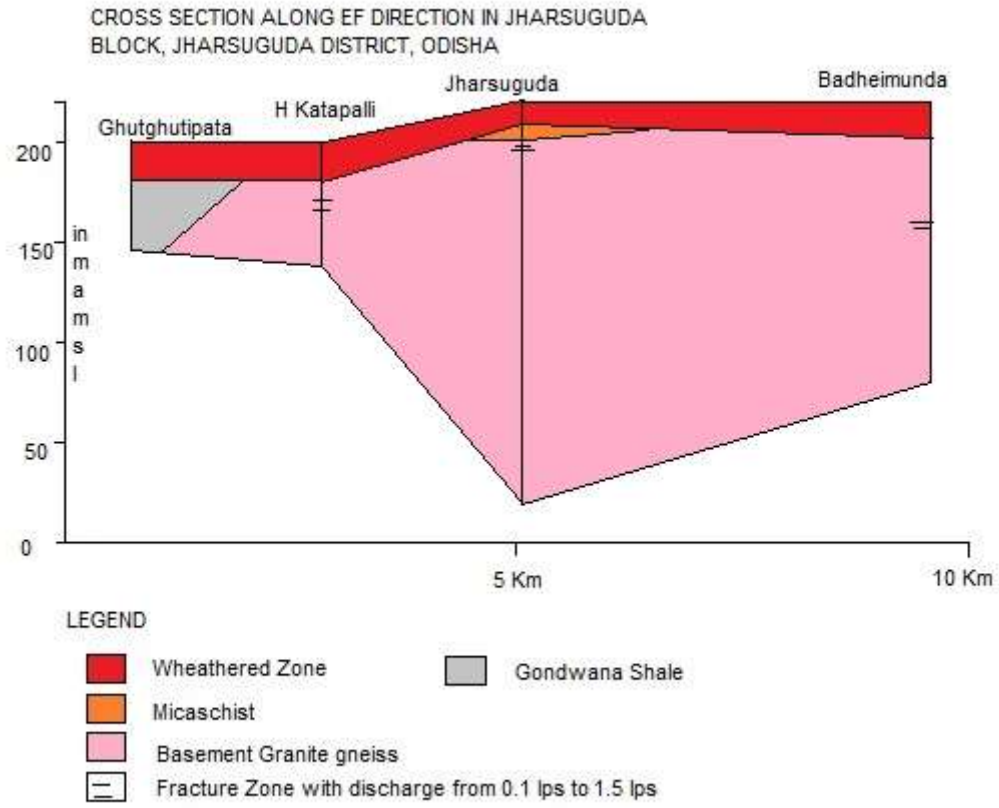


Fig.25a.

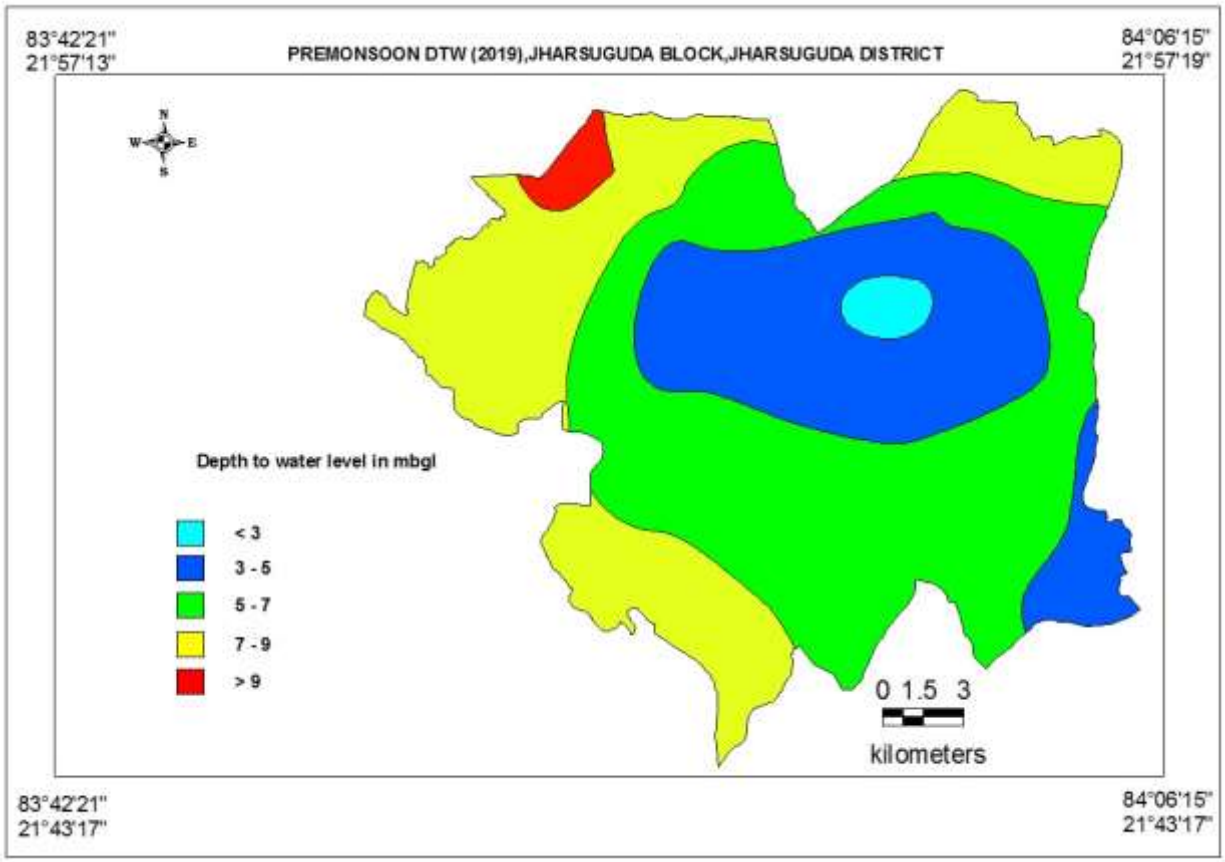


Fig.25b.

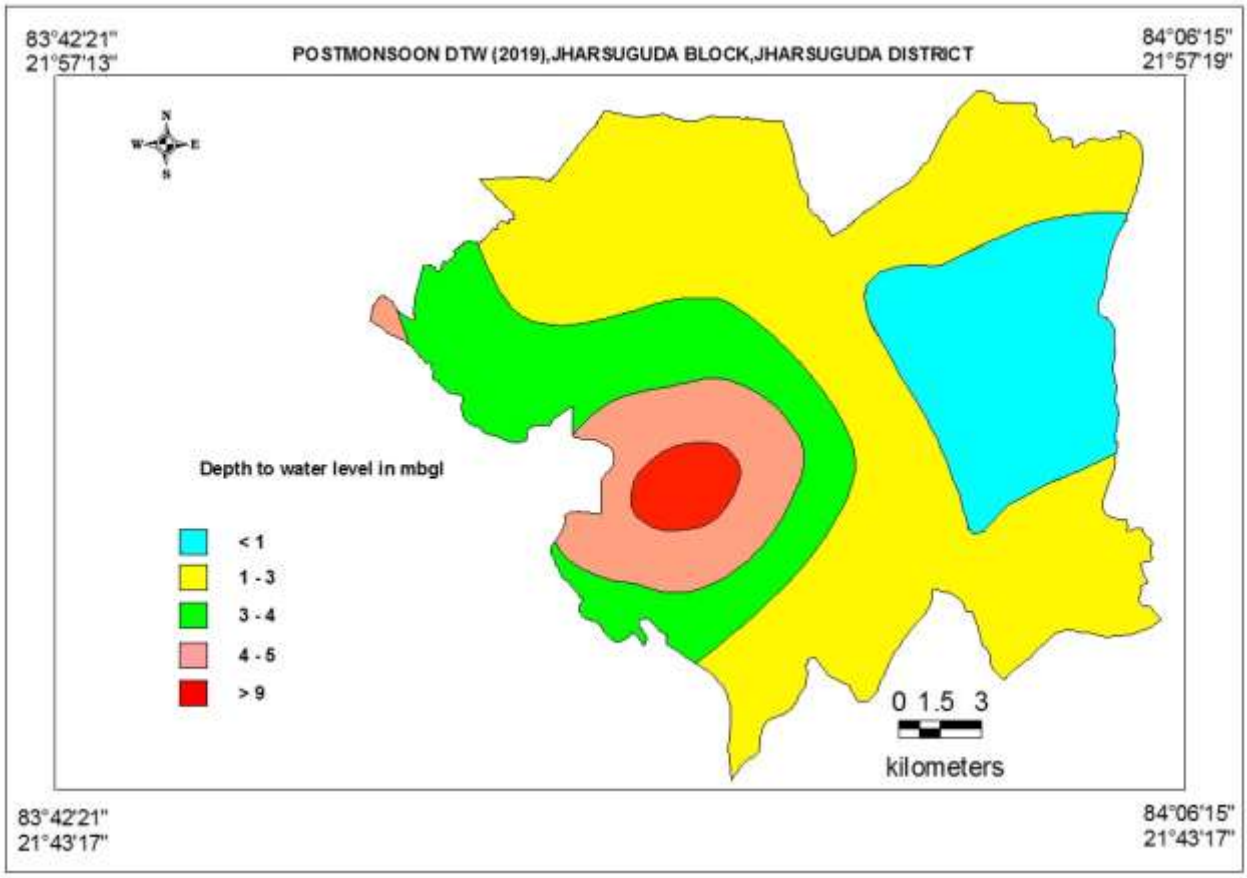


Fig.25c.

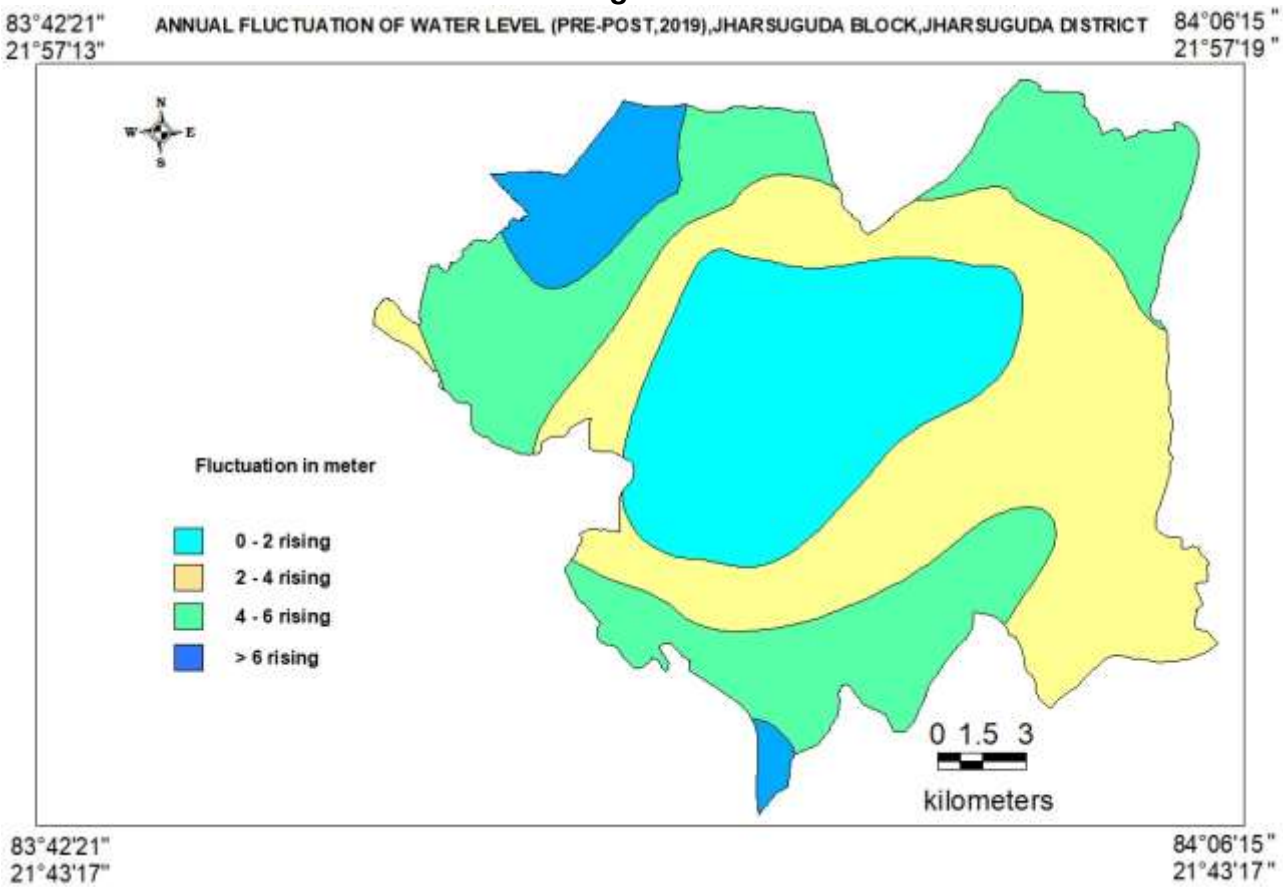


Fig.25d.

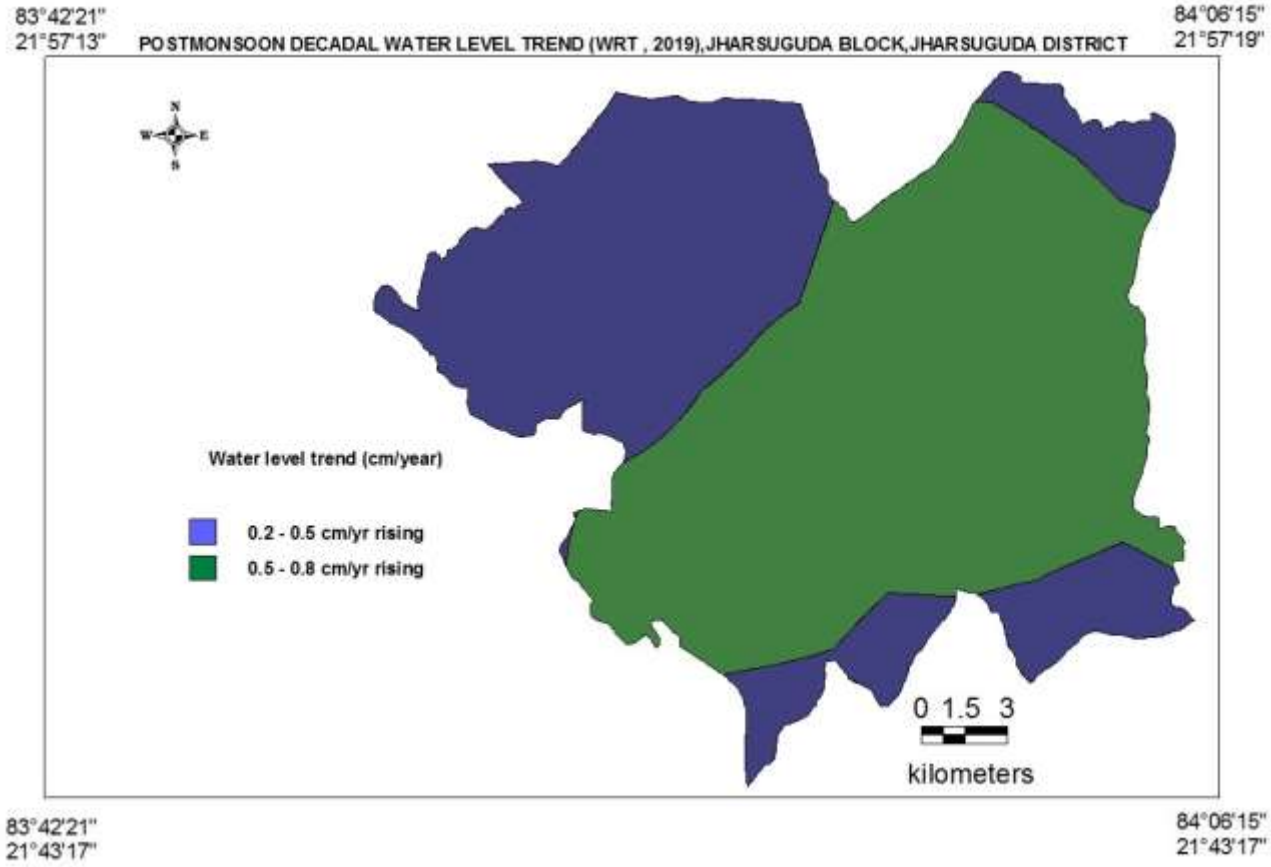
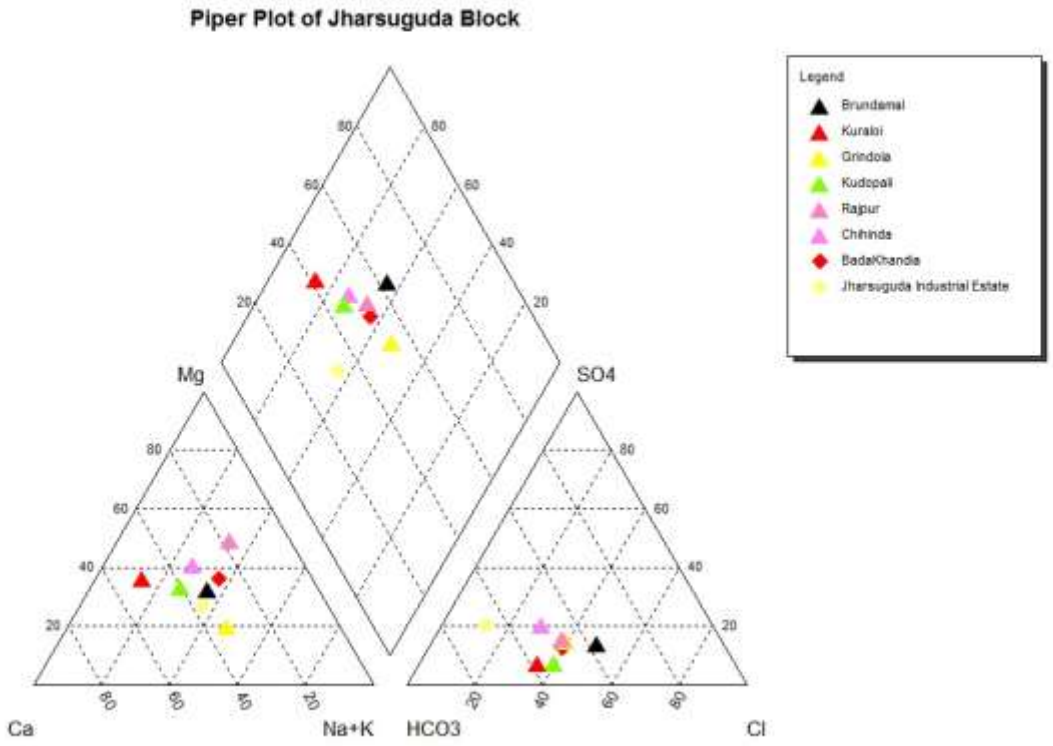


Fig.26. Piper Diagram of shallow aquifer samples, Jharsuguda Block



ii. Kirimira Block

1. Salient Information	
Name of the Block and Area (in Km^2)	Kirimira Area- 196.06 sq.km.
District/ State	Kirimira/ Odisha
Population	48149 (Projected population as on 2020 w.r.t 2011 census), growth rate is 12.24%
Rainfall	Normal Monsoon rainfall-1200 mm Non-monsoon Rainfall-140 mm
Agriculture and Irrigation	**Principal crops**-Cereal, Pulses, Oil Seeds, Vegetable Crops **Gross cropped area**-102.19 sq.km **Net sown area**- 105 sq. km. **Cropping intensity** – 97.32% **Irrigation practices** i.MIP-416.8 ha ii. LIP-536 ha iii.Deep Bore Well-103.2 ha iv.Traditional Water harvesting structures- 1785ha v.Other sources Agriculture and OAIC- 16.3 ha **Total number irrigation dug well** during year **1999** was 1350, number of **irrigations bore well** was 0, but during **2017** number of dug well was 1162 and number of bore well was 129.
Ground water resource availability and extraction	**Aquifer – I** (Up to 100 mbgl depth) Dynamic Ground Water Resources- 2392.86 ha Total Ground Water Draft- 893.29 ham In storage Ground Water Resources- 1833.95 ha
Existing and future water demands	a. Existing domestic water demand-1.1 mcm Domestic water demand during 2035 - 1.3 mcm b. Existing irrigation water demand- 16.9 mcm Irrigation water demand during 2035- 18.2 mcm c. Existing industrial water demand- 0.05 mcm Industrial water demand during 2035- 0.28 mcm
Water level behaviour	4.83 to 7.85 mbgl during pre monsoon (Fg.28a) 1.55 to 3.2 mbgl during post monsoon (Fig.28b) 0.2 to 0.9 cm/year rising and 0.14 – 1.16 cm/yr falling decadal water level trend (Fig-28d).
2. Aquifer Disposition	
Number of aquifers	Single aquifer up to 100 mbgl depth (Fig.14a)
3-D aquifer disposition and basic	Panel diagram presented in Fig.14a.

characteristics of each aquifer	Geology- Precambrian granite gneiss, mica schists in most of the parts (Consolidated formation) and unconsolidated formation in parts (Fig.27). 2 lps discharge obtained in one well as per Table 10e. Aquifer type is unconfined up to 50-60 mbgl depth and semiconfined beyond 50-60 mbgl depth.
3. Ground water resource, extraction, contamination and other issues	
Aquifer wise resource availability and extraction	As on 31.3.2017 Net Ground Water Avialabiliy-23.93 mcm Gross ground water draft-8.93 mcm Allocation for domestic and industrial requirement for 25 years- 1.26 mcm Net ground water availability for future irrigation-14.89 mcm Stage of Ground Water Extraction-37.33% Category- Safe
Chemical quality of ground water and contamination	Electrical Conductivity (µS/cm)-270 to1110 TDS (mg/l)-132 to 793 Ca^{++}(mg/l)-24 to 97 Mg^{++}(mg/l)-7 to 83 Na^{+}(mg/l)-13 to 89 K^{+}(mg/l)-2.5 to 80 HCO_3(mg/l)-72 to 278 $SO_4^{=}$ (mg/l)-16 to 129 Cl (mg/l)- 22 to 313 NO_3^{-}(mg/l) - 3 to 46 F (mg/l) -0.13 to 0.98 At Talmol nitrate concentration seen more than permissible limit. EC found >750 µS/cm at Bagudihi, Talmol, Dhutra. Groundwater is potable for drinking and irrigation (Fig. 29).
Other issues	Present water availability is 31 mcm Water demand as on 2025 and 2035 will be 19.1 mcm, 19.8 mcm respectively. Possibility of shortage of aquifer storage.
4. Ground water resource enhancement	
Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone- 17.82 mcm (up to the maximum depth of 4.1 mbgl post monsoon water level, considered 1.1 m beyond 3-meter depth) Rainfall recharge by adoption of 567 number of farm pond (1 pond per hector) – 1.1 mcm Rainfall recharge by adoption of 1048 number of roof top rainwater harvesting structure (1 structure for 10 houses in village) – 0.165 mcm Average annual rainfall considered 1308 mm Total Volume of Water expected to be conserved- 1.265 mcm
5. Demand side interventions	

Advanced Irrigation Practices	584 ha area proposed to be covered for subsurface drip irrigation practices during summer and Volume of Water expected to be conserved will be 60% of 745 ham=447 ham or 4.47 mcm.
Change in cropping pattern	**Fruit crops**: Grapes, banana, pomegranates, mango, orange, cashew nuts, papaya, litchi, watermelon. **Vegetable plants**: Onion, brinjal, bitter gourd, ridge gourd, cucumber, tomato, chilly, capsicum etc. **Oil seeds**: Sunflower, oil palm. **Forest crop**: Bamboo, teakwood
Alternate water sources	i. Net GW Resources available for future irrigation (ham)** as per Ground water resources estimation (2017)- 1489.34 ham ii. Average crop Water requirement in a year (m)- 1.275 m iii. Possible additional irrigation potential area that can be created with available resources(ha)- 1168.11 ha iv. 50% of the additional potential area taken for irrigation (ha)-584.05 ha v. 100% Area to be irrigated by Dug well (ha) from additional potential areas(ha)- 584 ha vi. Total number of additional dug well to be constructed for drip irrigation during summer- 584
Regulation and Control	To mitigate the wastage of water specially for commercial activity Department of Water Resources, Govt. of Odisha notifies a separate water pricing policy vide letter dated 24.4.2020. Concerned District Administration should strictly follow the water pricing policy for sustainable development of ground water
Reflected results after adoption of Ground water enhancement and demand side interventions	An annual amount of approximately 5.74 mcm water will be conserved.

Fig.27

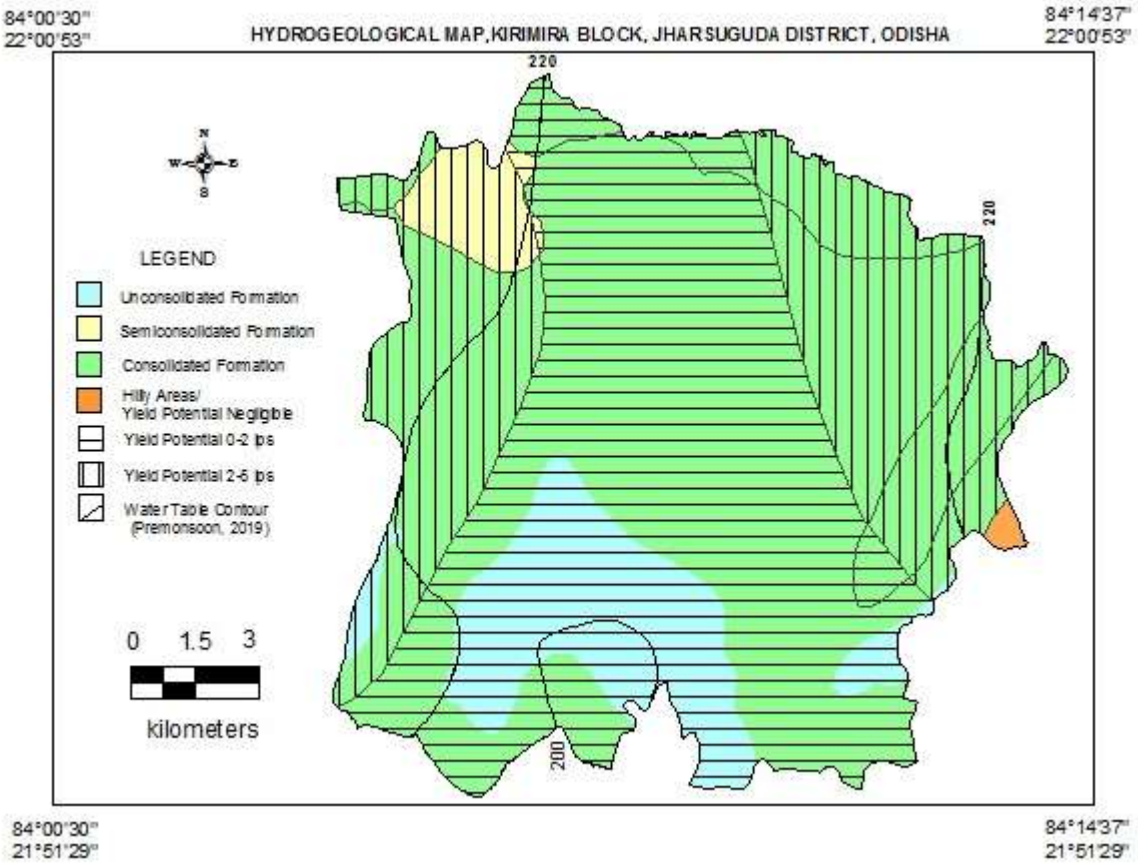


Fig.28a.

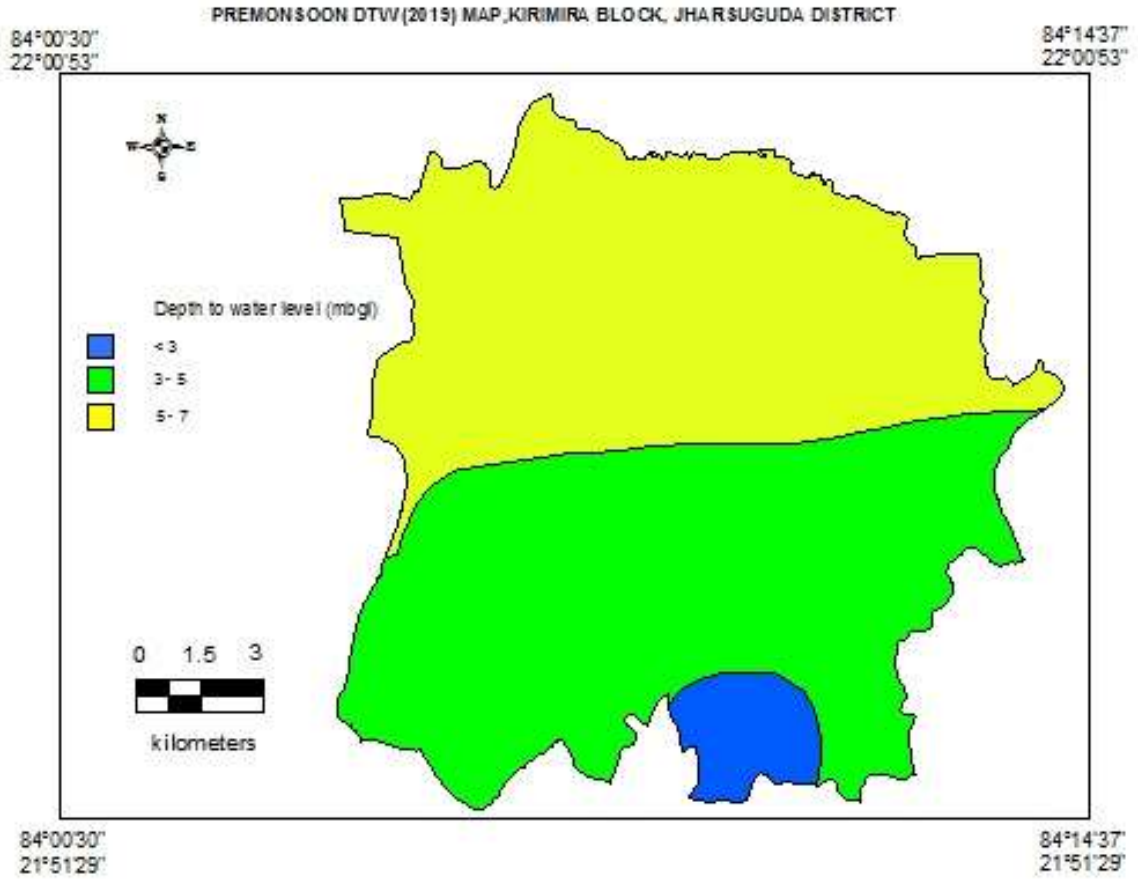


Fig.28b.

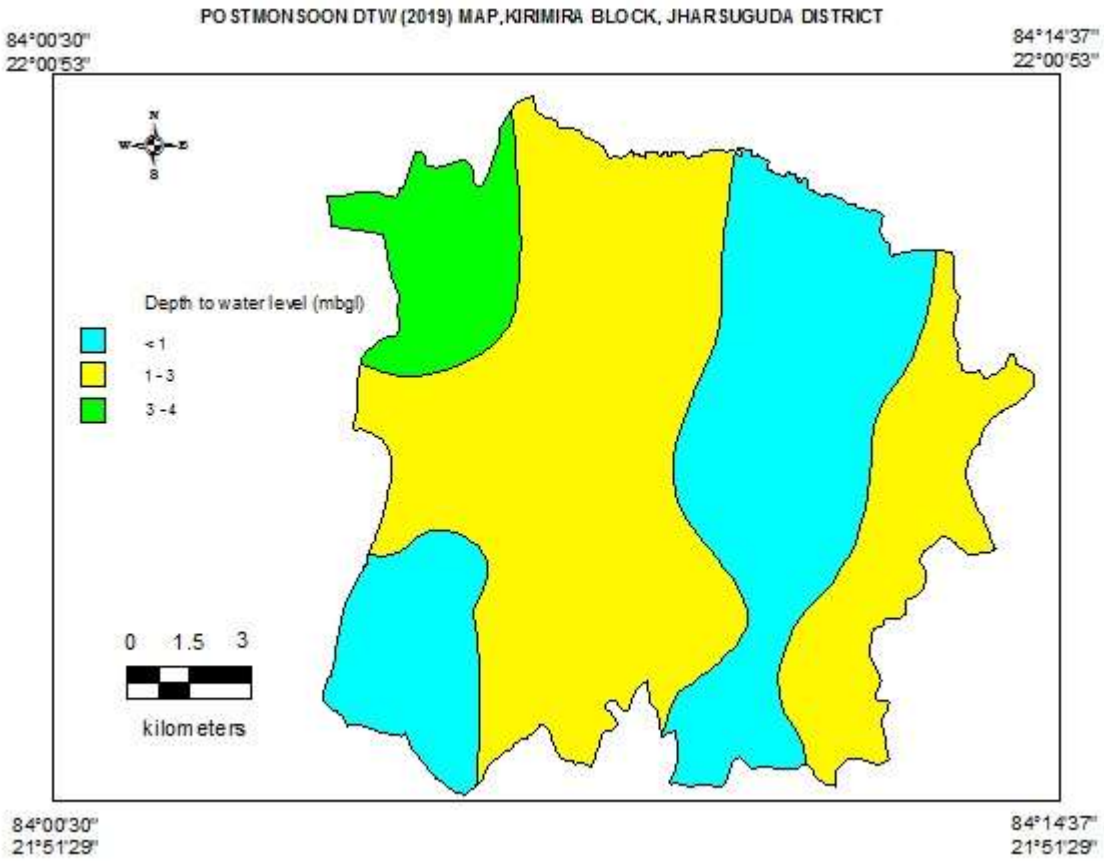


Fig.28c

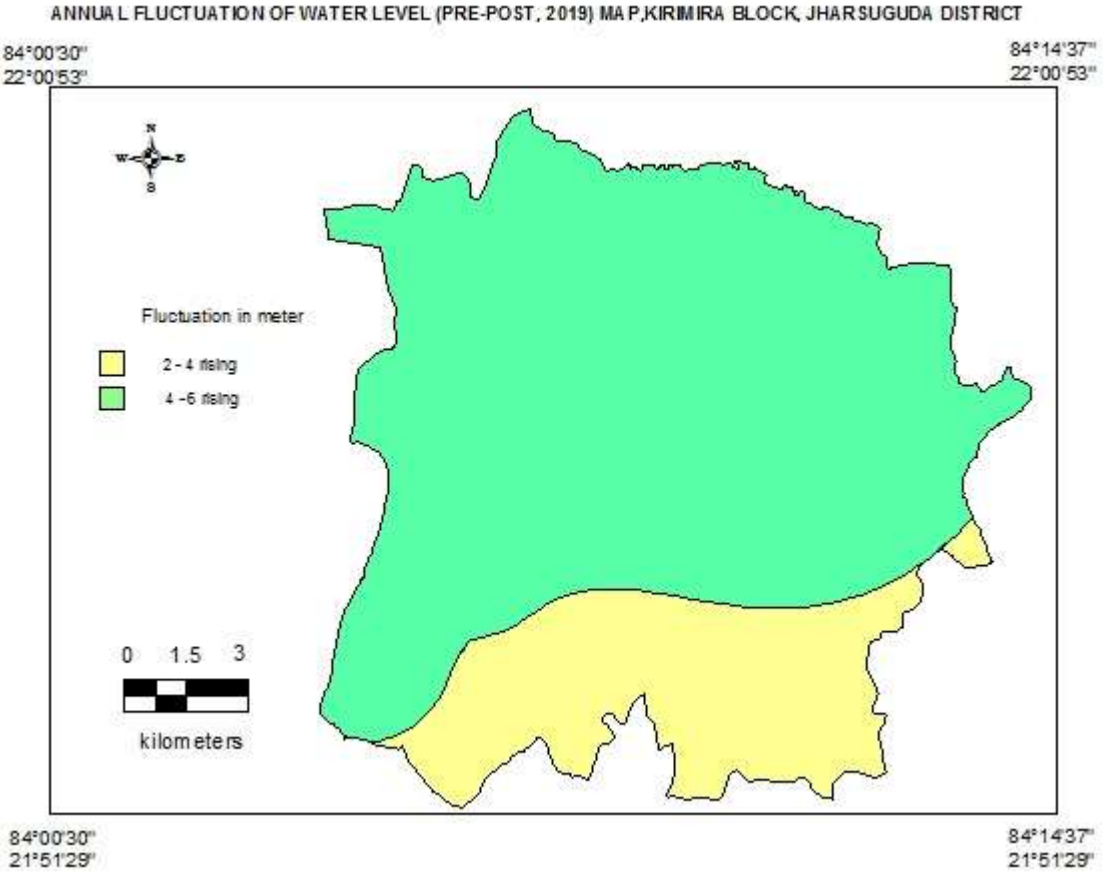


Fig.28d.

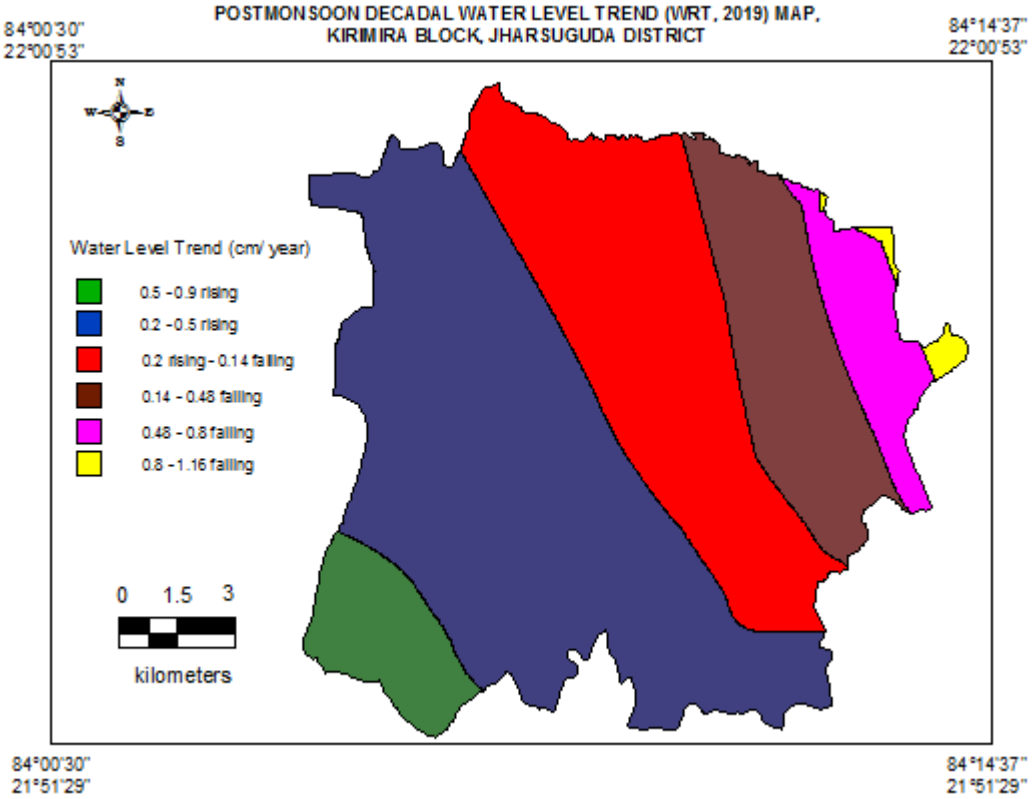
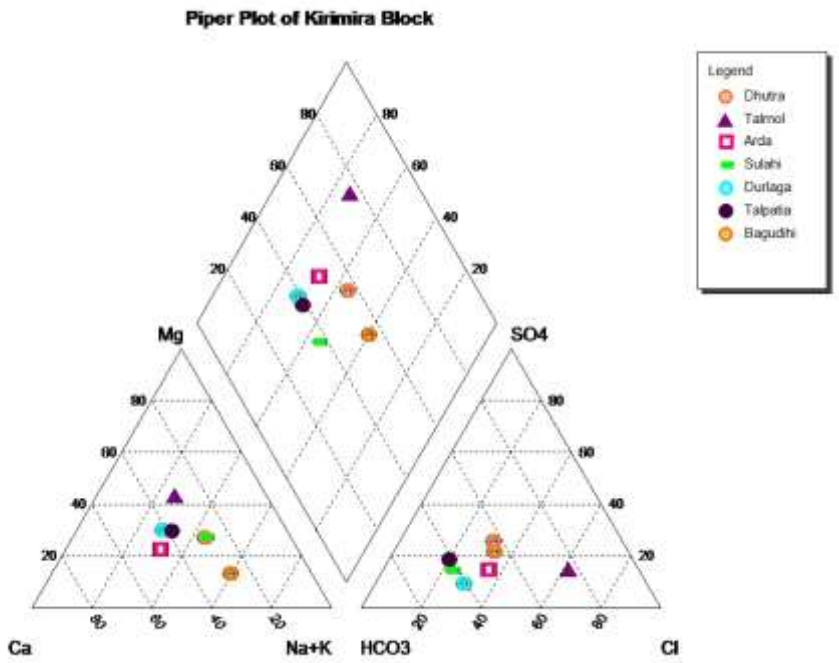


Fig.29. Piper Diagram of shallow aquifer samples, Kirimira Block



iii. Laikera Block:

1. Salient Information	
Name of the Block and Area (in Km^2)	Laikera Area- 256.01 sq.km.
District/ State	Laikera / Odisha
Population	56112 (Projected population as on 2020 w.r.t 2011 census), growth rate is 12.24%
Rainfall	Normal Monsoon rainfall-1120 mm Non-monsoon Rainfall-150 mm
Agriculture and Irrigation	**Principal crops**-Cereal, Pulses, Oil Seeds, Vegetable Crops **Gross cropped area**-131.69 sq.km **Net sown area**- 171 sq. km. **Cropping intensity** – 77.01% **Irrigation practices** i.MIP-3376.2 ha ii. LIP-658 ha iii.Deep Bore Well-1978.8 ha iv.Traditional Water harvesting structures- 3510ha v.Other sources Agriculture and OAIC- 30.8 ha **Total number irrigation dug well** during year **1999** was 1361, number of **irrigations bore well** was 0, but during **2017** number of dug well was 2115 and number of bore well was 399.
Ground water resource availability and extraction	**Aquifer – I** (Up to 100 mbgl depth) Dynamic Ground Water Resources- 2979.62 ha Total Ground Water Draft- 1672.27 ham In storage Ground Water Resources- 2855.26 ha
Existing and future water demands	a. Existing domestic water demand-1.2 mcm Domestic water demand during 2035 - 1.3 mcm b. Existing irrigation water demand- 26 mcm Irrigation water demand during 2035- 27.7 mcm c. Existing industrial water demand- 0.06 mcm Industrial water demand during 2035- 0.34 mcm
Water level behaviour	5.3 to 8.1 mbgl during pre monsoon (Fg.32a) 0.93 to 3.35 mbgl during post monsoon (Fig.32b) 0.2 to 0.5 cm/year rising and 0.14 – >1.49 cm/yr falling decadal water level trend (Fig-32d).
2. Aquifer Disposition	
Number of aquifers	Single aquifer up to 100 mbgl depth (Fig.14a)
3-D aquifer disposition and basic	Cross section presented in Fig.31b.

characteristics of each aquifer	Geology- Precambrian granite gneiss in most of the parts (Consolidated formation) and unconsolidated formation in parts (Fig.30). Discharge varies from negligible to 7 lps. Aquifer type is unconfined up to 50-60 mbgl depth and semi confined beyond 50-60 mbgl depth. Depth of weathered zone varies from 4.8 meter at Arda to 23.69 meter at Sahaspur. Depth of fracture zone encountered are at 20.5-23, 75-76, 49-50.5meter depth.
3. Ground water resource, extraction, contamination and other issues	
Aquifer wise resource availability and extraction	As on 31.3.2017 Net Ground Water Avialabiliy-29.79 mcm Gross ground water draft-16.72 mcm Allocation for domestic and industrial requirement for 25 years- 1.39 mcm Net ground water availability for future irrigation-12.99 mcm Stage of Ground Water Extraction-56.12% Category- Safe
Chemical quality of ground water and contamination	Electrical Conductivity (µS/cm)- 1090 to1690 TDS (mg/l)-521 to 886 Ca^{++}(mg/l)-69 to 115 Mg^{++}(mg/l)-63 to 99 Na^{+}(mg/l)-25 to 89 K^{+}(mg/l)-2.3 to 51 HCO_3(mg/l)-332 to 501 $SO_4^{=}$ (mg/l)-22 to 78 Cl (mg/l)- 117 to 330 NO_3^{-}(mg/l) – 2.6 to 47 F (mg/l) -0.28 to 0.59 At Dimirdihi nitrate concentration seen more than permissible limit. EC found >750 µS/cm at Laikera, Ramachipidi, Kukerma, Dimirdihi. Groundwater is potable for drinking and irrigation (Fig. 33). Uranium concentration found as 0.003 mg/l at Sahaspur and iron concentration found as 12.569 mg/l at Chandimal (Fig.18c).
Other issues	Present water availability is 42.1 mcm Water demand as on 2025 and 2035 will be 28.8 mcm, 29.8 mcm respectively. Possibility of shortage of aquifer storage.
4. Ground water resource enhancement	
Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone- 12.14 mcm (up to the maximum depth of 3.35 mbgl post monsoon water level, considered 0.35 m beyond 3meter depth) Rainfall recharge by adoption of 2560 number of farm pond (1 pond per hector) – 5.022 mcm Rainfall recharge by adoption of 1275 number of roof top

	rainwater harvesting structure (1 structure for 10 houses in village) – 0.2 mcm Average annual rainfall considered 1308 mm Total Volume of Water expected to be conserved- 5.22 mcm
5. Demand side interventions	
Advanced Irrigation Practices	534 ha area proposed to be covered for subsurface drip irrigation practices during summer and Volume of Water expected to be conserved will be 60% of 650 ham=390 ham or 3.9 mcm.
Change in cropping pattern	**Fruit crops**: Grapes, banana, banana, pomegranates, mango, orange, cashew nuts, papaya, litchi, watermelon. **Vegetable plants**: Onion, brinjal, bitter gourd, ridge gourd, cucumber, tomato, chilly, capsicum etc. **Oil seeds**: Sunflower, oil palm. **Forest crop**: Bamboo, teakwood
Alternate water sources	i. Net GW Resources available for future irrigation (ham)** as per Ground water resources estimation (2017)- 1299.68 ham ii. Average crop Water requirement in a year (m)- 1.218 m iii. Possible additional irrigation potential area that can be created with available resources(ha)- 1067.45 ha iv. 50% of the additional potential area taken for irrigation (ha)-533.72 ha v. 100% Area to be irrigated by Dug well (ha) from additional potential areas(ha)- 534 ha vi. Total number of additional dug well to be constructed for drip irrigation during summer- 534
Regulation and Control	To mitigate the wastage of water specially for commercial activity Department of Water Resources, Govt. of Odisha notifies a separate water pricing policy vide letter dated 24.4.2020. Concerned District Administration should strictly follow the water pricing policy for sustainable development of ground water
Reflected results after adoption of Ground water enhancement and demand side interventions	An annual amount of approximately 9.12 mcm water will be conserved.

Fig.30.

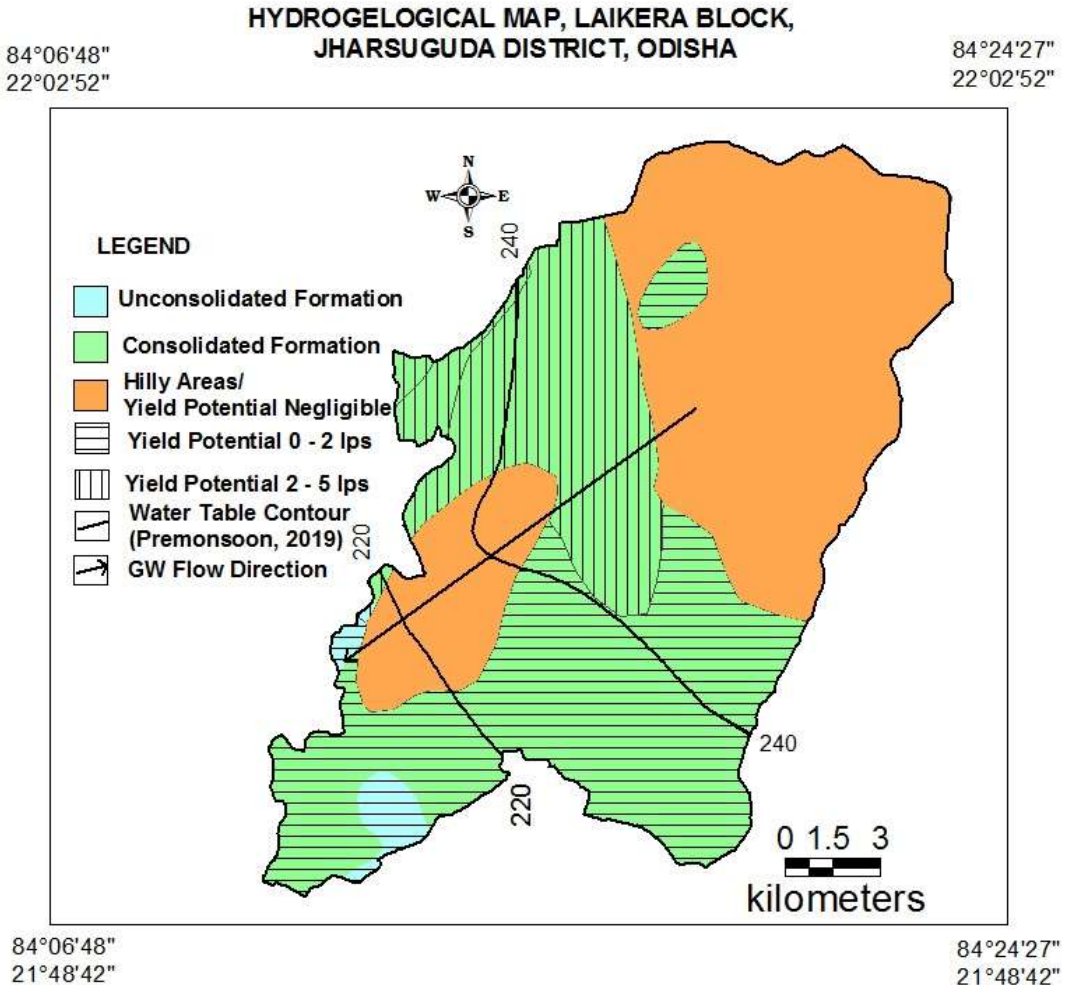


Fig.31a.

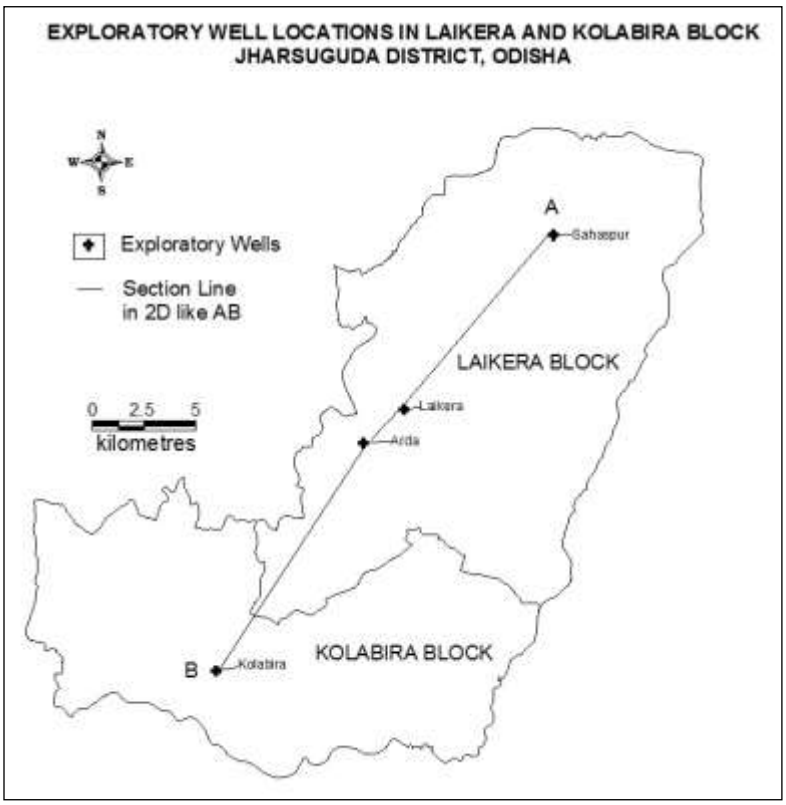


Fig.31b.

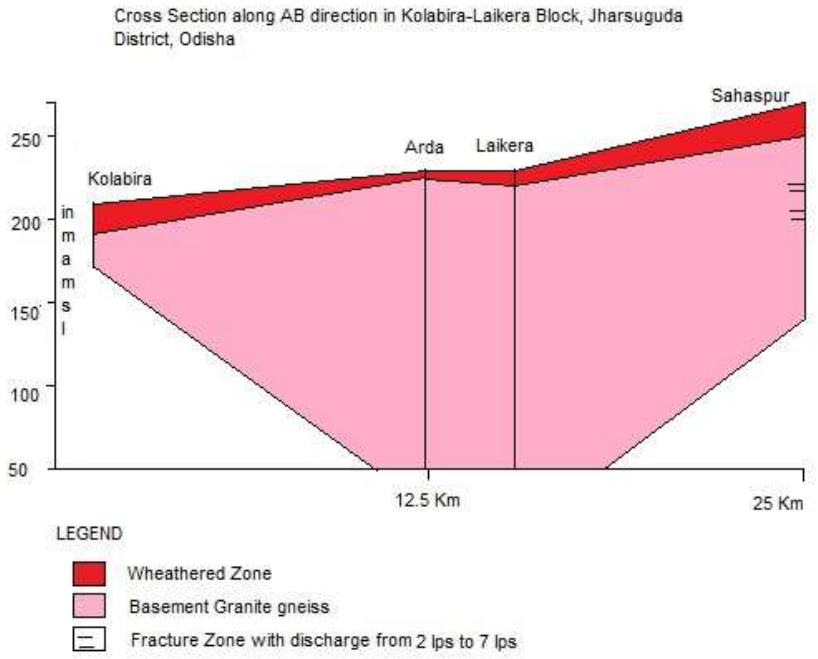


Fig.32a.

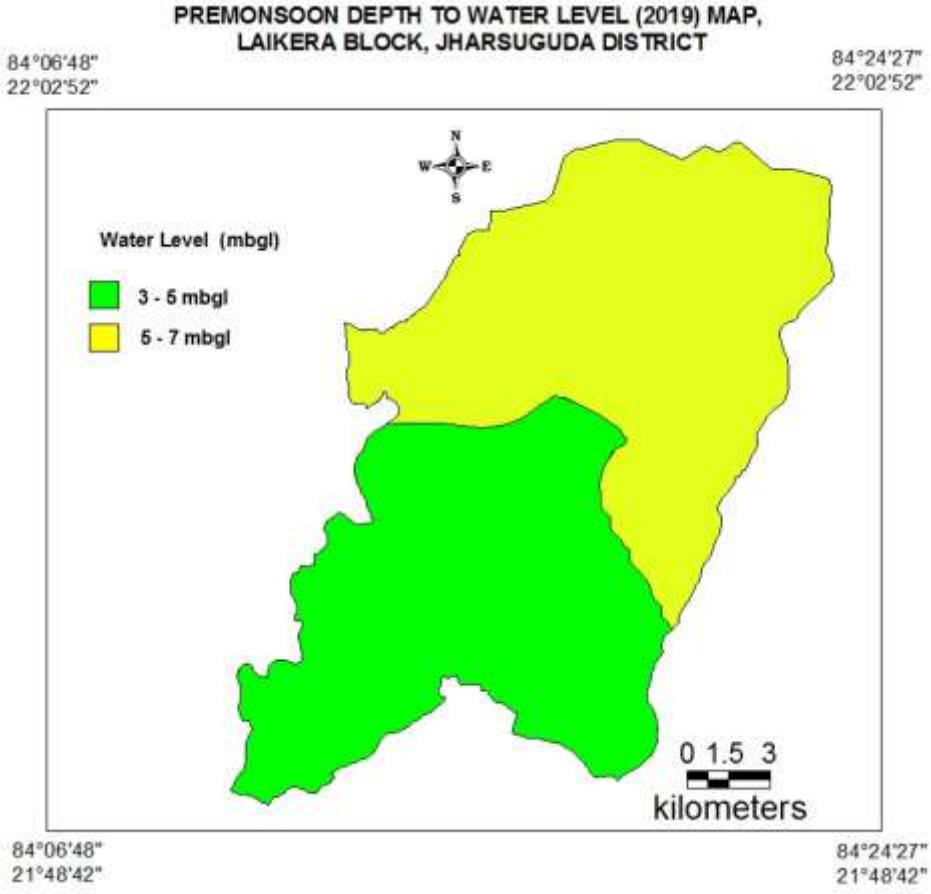


Fig.32b.

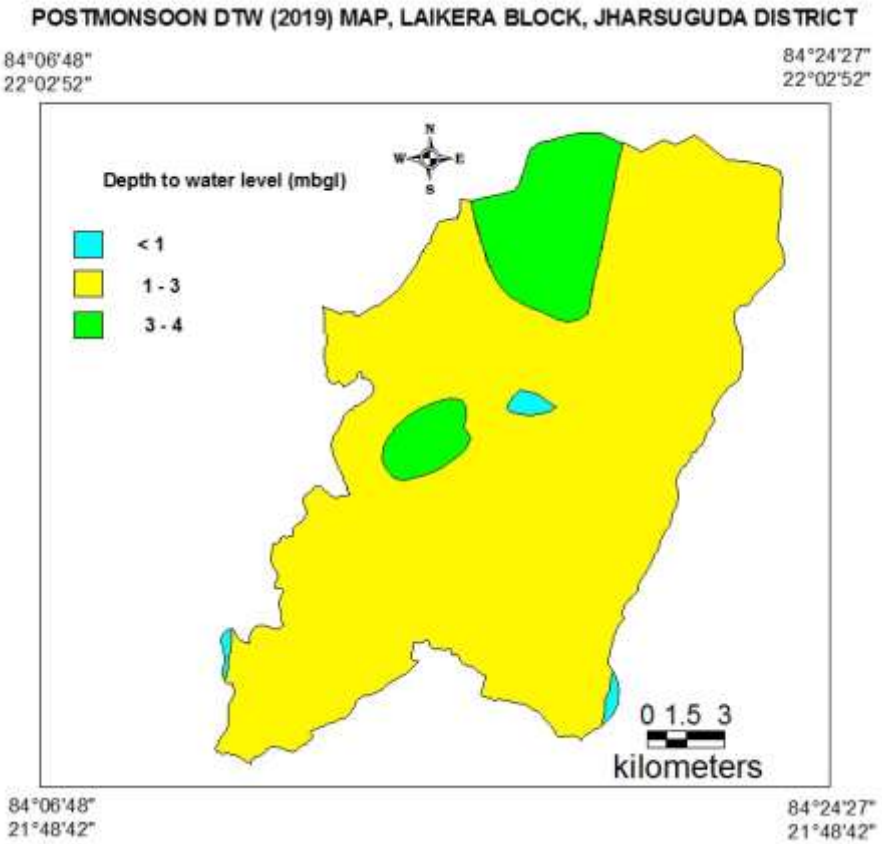


Fig.32c.

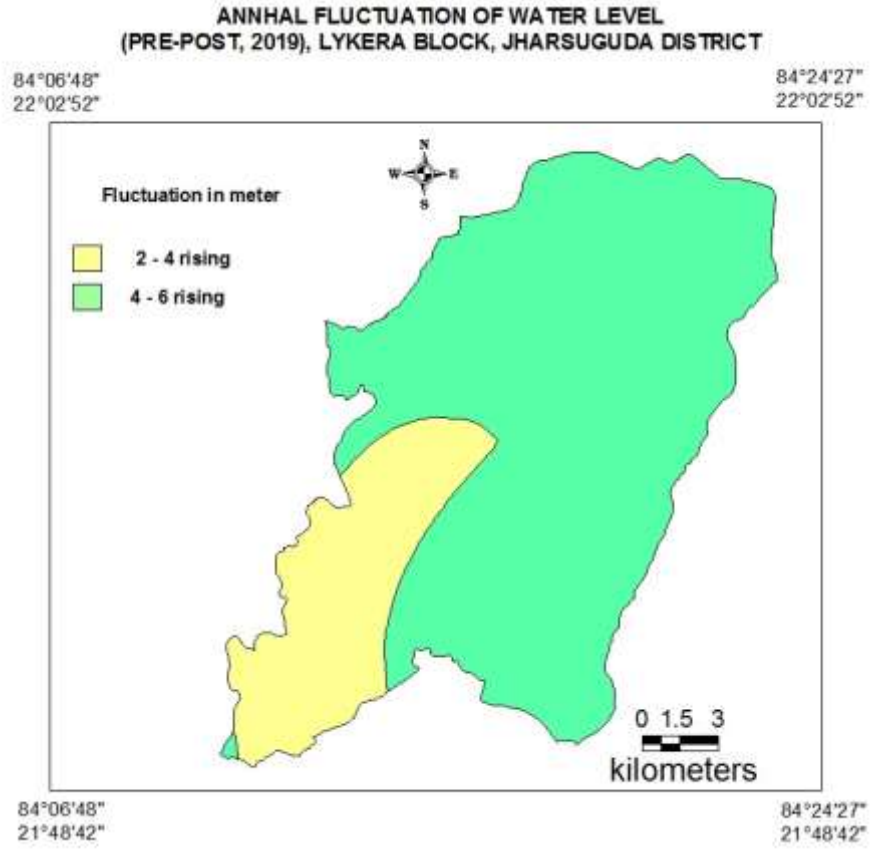


Fig.32d.

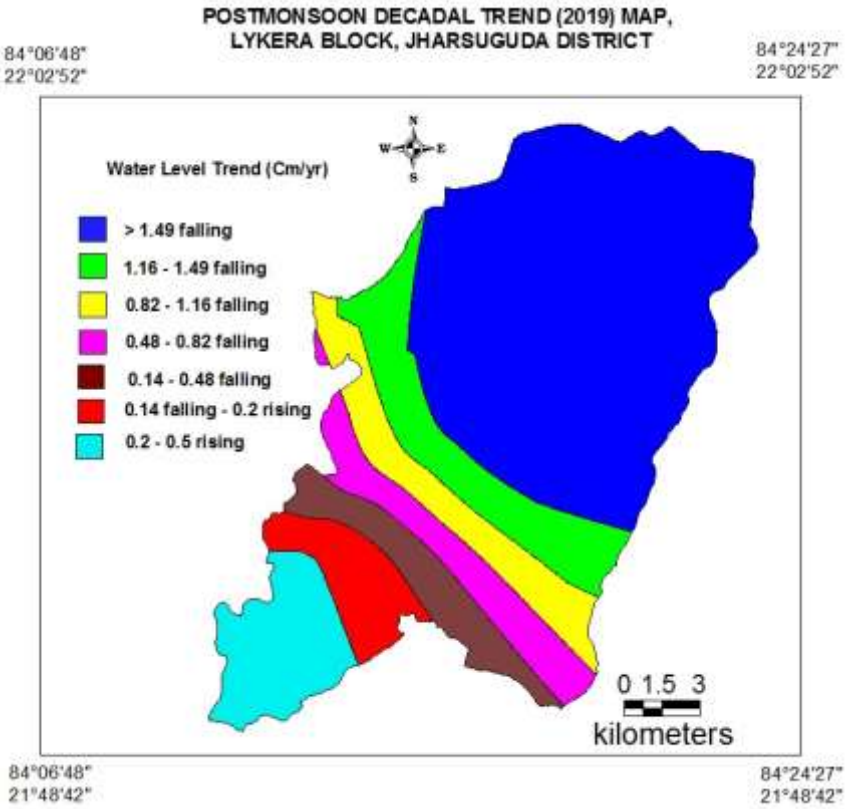
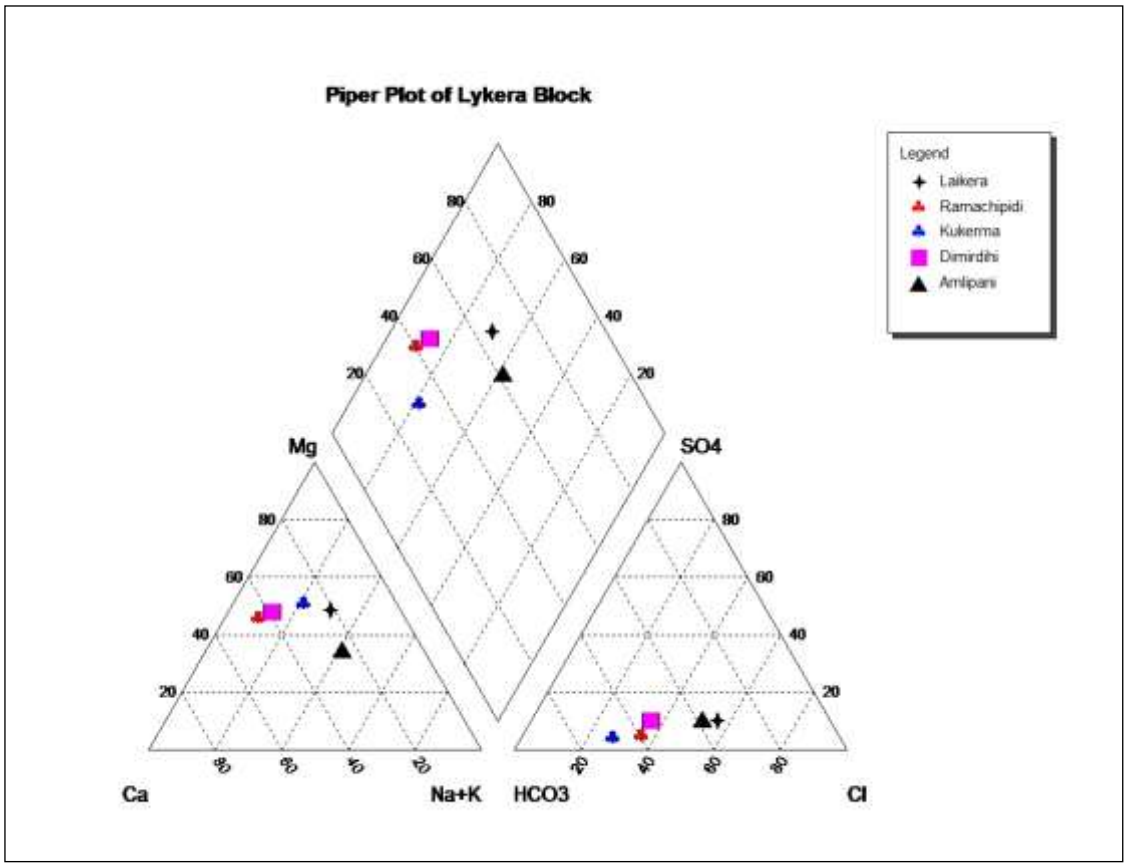


Fig.33. Piper Diagram of shallow aquifer samples, Laikera Block



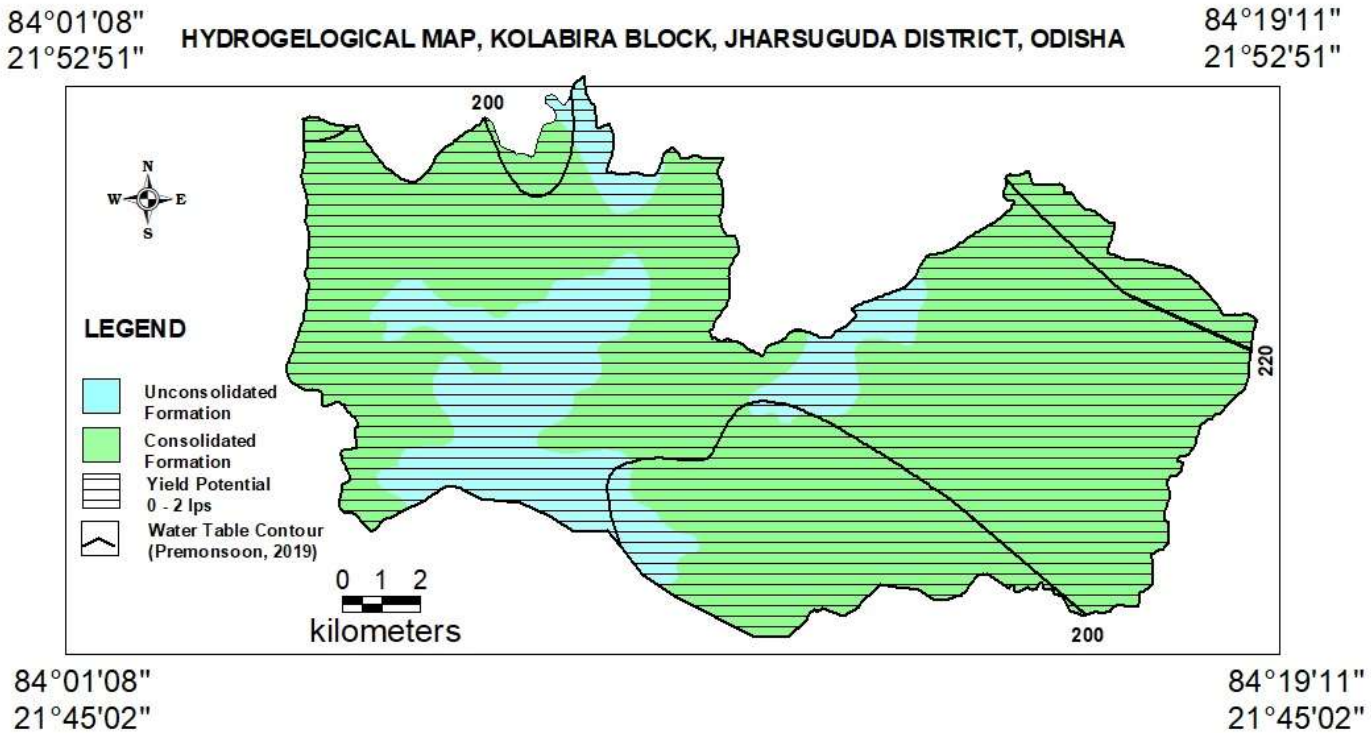
iv. Kolabira Block:

1. Salient Information	
Name of the Block and Area (in Km^2)	Kolabira Area- 240.46 sq.km.
District/ State	Kolabira / Odisha
Population	53880 (Projected population as on 2020 w.r.t 2011 census), growth rate is 12.24%
Rainfall	Normal Monsoon rainfall-1130 mm Non-monsoon Rainfall-140 mm
Agriculture and Irrigation	**Principal crops**-Cereal, Pulses, Oil Seeds, Vegetable Crops **Gross cropped area**-128.96 sq.km **Net sown area**- 150 sq. km. **Cropping intensity** – 85.97% **Irrigation practices** i.MIP-68.4 ha ii. LIP-990 ha iii.Deep Bore Well- 180 ha iv.Traditional Water harvesting structures- 1690ha v.Other sources Agriculture and OAIC- 9.2 ha **Total number irrigation dug well** during year **1999** was 860, number of **irrigations bore well** was 0, but during **2017** number of dug well was 1126 and number of bore well was 108.
Ground water resource availability and extraction	**Aquifer – I** (Up to 100 mbgl depth) Dynamic Ground Water Resources- 2932.37 ha Total Ground Water Draft- 826.26 ham In storage Ground Water Resources- 1955.9 ha
Existing and future water demands	a. Existing domestic water demand-1.2 mcm Domestic water demand during 2035 - 1.3 mcm b. Existing irrigation water demand- 26.4 mcm Irrigation water demand during 2035- 28 mcm c. Existing industrial water demand- 0.05 mcm Industrial water demand during 2035- 0.33 mcm
Water level behaviour	3.73 to 6.85 mbgl during pre monsoon (Fg.35a) 0.81 to 3.18 mbgl during post monsoon (Fig.35b) 0.2 to 0.8 cm/year rising and 0.14 – 0.47 cm/yr falling decadal water level trend (Fig-35d).
2. Aquifer Disposition	
Number of aquifers	Single aquifer up to 100 mbgl depth (Fig.14a)
3-D aquifer disposition and basic characteristics of each aquifer	Cross section presented in Fig.14b.
	Geology- Precambrian granite gneiss in most of the parts (Consolidated formation) and unconsolidated formation in parts (Fig.34). Discharge varies from 0.5 to 7 lps. Aquifer type is unconfined up to 50-60 mbgl depth and semi confined beyond 50-60 mbgl depth.

3. Ground water resource, extraction, contamination and other issues	
Aquifer wise resource availability and extraction	As on 31.3.2017 Net Ground Water Avialabiliy-29.32 mcm Gross ground water draft-8.26 mcm Allocation for domestic and industrial requirement for 25 years- 1.63 mcm Net ground water availability for future irrigation-20.8 mcm Stage of Ground Water Extraction-28.18% Category- Safe
Chemical quality of ground water and contamination	Electrical Conductivity (µS/cm)- 450 to 1280 TDS (mg/l)-221 to 675 Ca^{++}(mg/l)-42 to 91 Mg^{++}(mg/l)-9 to 57 Na^{+}(mg/l)-12 to 57 K^{+}(mg/l)-3 to 88 HCO_3(mg/l)-85 to 453 $SO_4^{=}$ (mg/l)-0 to 73 Cl (mg/l)- 29 to 177 NO_3^{-}(mg/l) – 8 to 52 F (mg/l) -0.1 to 0.28 At Paramanpur and Jhirlapali nitrate concentration seen more than permissible limit. Similarly, EC found >750 µS/cm at Paramanpur and Jhirlapali. Ground water is potable (Fig. 36). Although iron concentration found more than 1.5 mg/l at Sriyapalli and Ram Kumar Chak (Fig.18c).
Other issues	Present water availability is 37 mcm Water demand as on 2025 and 2035 will be 29 mcm, 29.9 mcm respectively. Possibility of shortage of aquifer storage.
4. Ground water resource enhancement	
Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone- 37.31 mcm (up to the maximum depth of 4.1 mbgl post monsoon water level, considered 1.1 m beyond 3-meter depth) Rainfall recharge by adoption of 147 number of farm pond (1 pond per hector) – 0.288 mcm Rainfall recharge by adoption of 1210 number of roof top rainwater harvesting structure (1 structure for 10 houses in village) – 0.19 mcm Average annual rainfall considered 1308 mm Total Volume of Water expected to be conserved- 0.48 mcm
5. Demand side interventions	
Advanced Irrigation Practices	816 ha area proposed to be covered for subsurface drip irrigation practices during summer and Volume of Water expected to be conserved will be 60% of 1040 ham=624 ham or 6.24 mcm.
Change in cropping pattern	**Fruit crops**: Grapes, banana, banana, pomegranates, mango, orange, cashew nuts, papaya, litchi, watermelon.

	Vegetable plants: Onion, brinjal, bitter gourd, ridge gourd, cucumber, tomato, chilly, capsicum etc. **Oil seeds**: Sunflower, oil palm. **Forest crop**: Bamboo, teakwood
Alternate water sources	i. Net GW Resources available for future irrigation (ham)** as per Ground water resources estimation (2017)- 2080.25 ham ii. Average crop Water requirement in a year (m)- 1.275 m iii. Possible additional irrigation potential area that can be created with available resources(ha)- 1631.56 ha iv. 50% of the additional potential area taken for irrigation (ha)-815.78 ha v. 100% Area to be irrigated by Dug well (ha) from additional potential areas(ha)- 816 ha vi. Total number of additional dug well to be constructed for drip irrigation during summer- 816
Regulation and Control	To mitigate the wastage of water specially for commercial activity Department of Water Resources, Govt. of Odisha notifies a separate water pricing policy vide letter dated 24.4.2020. Concerned District Administration should strictly follow the water pricing policy for sustainable development of ground water
Reflected results after adoption of Ground water enhancement and demand side interventions	An annual amount of approximately 6.78 mcm water will be conserved.

Fig.34.



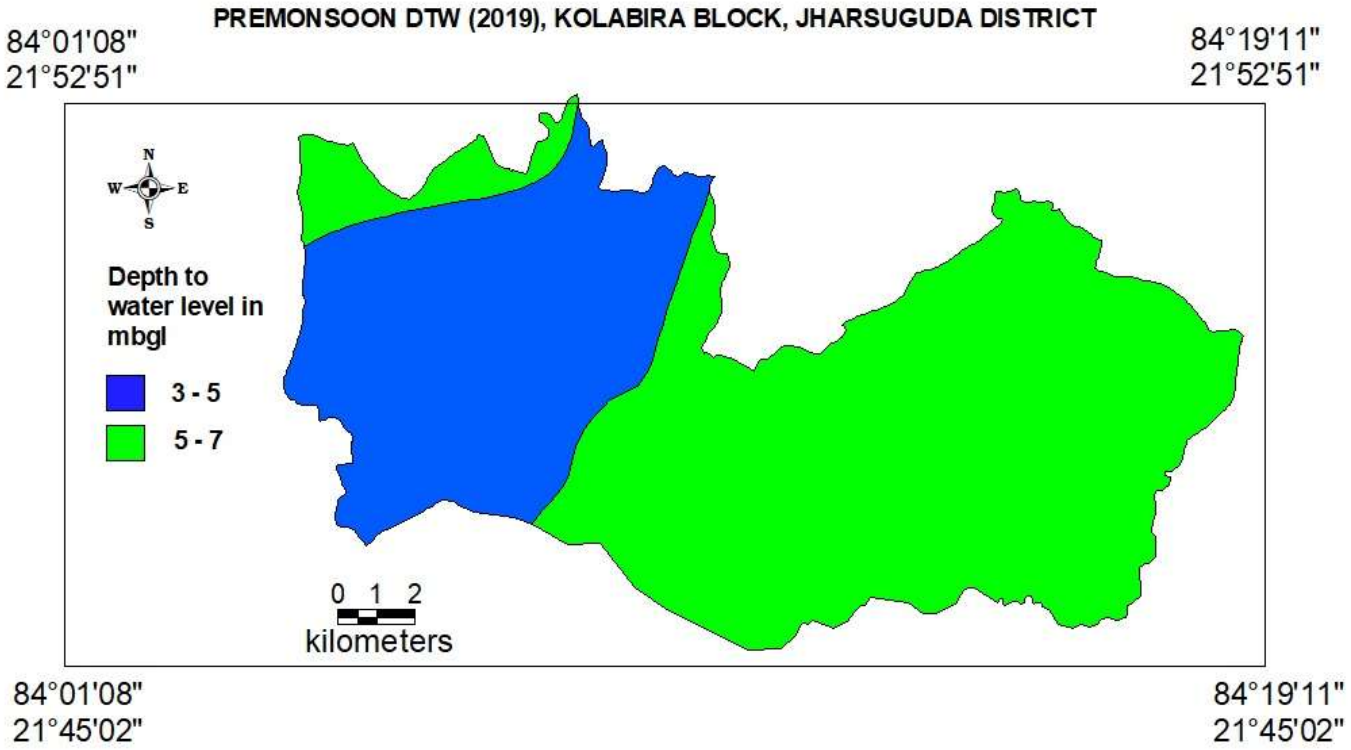


Fig.35a

Fig.35b

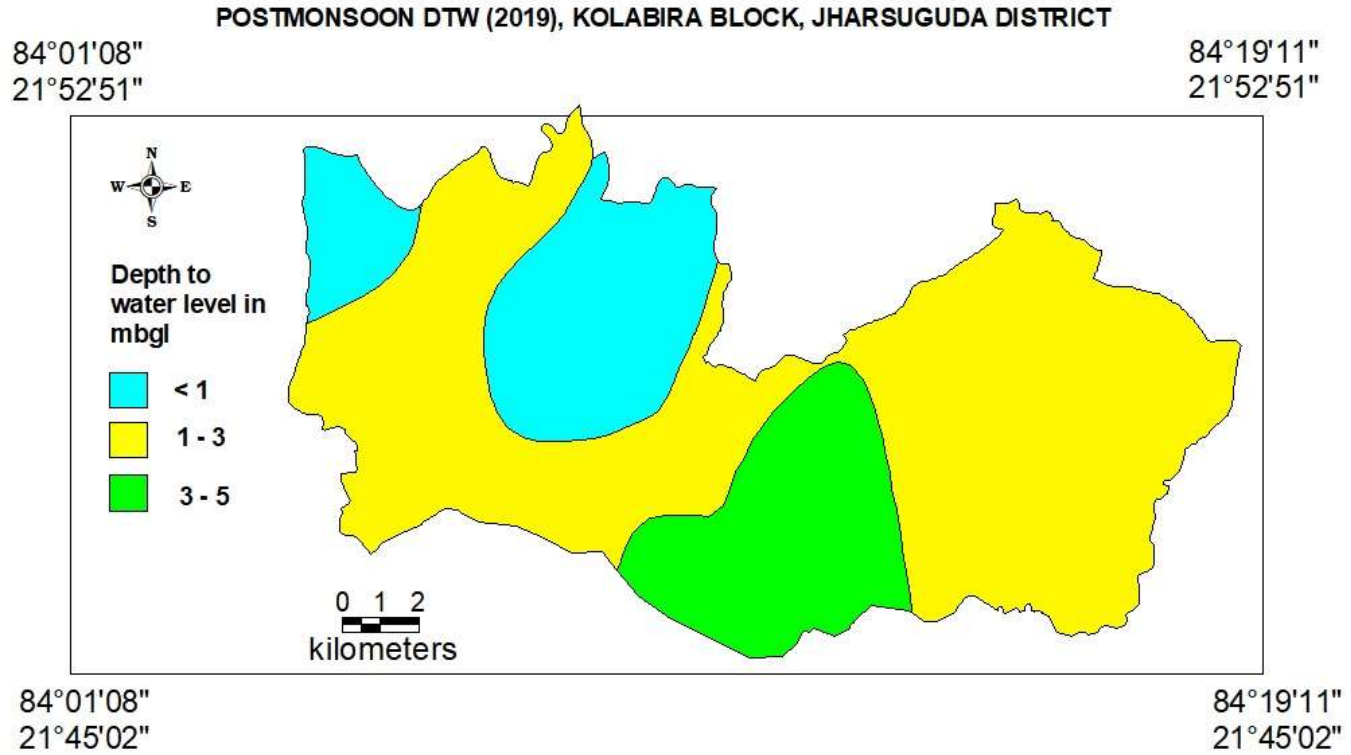


Fig.35c

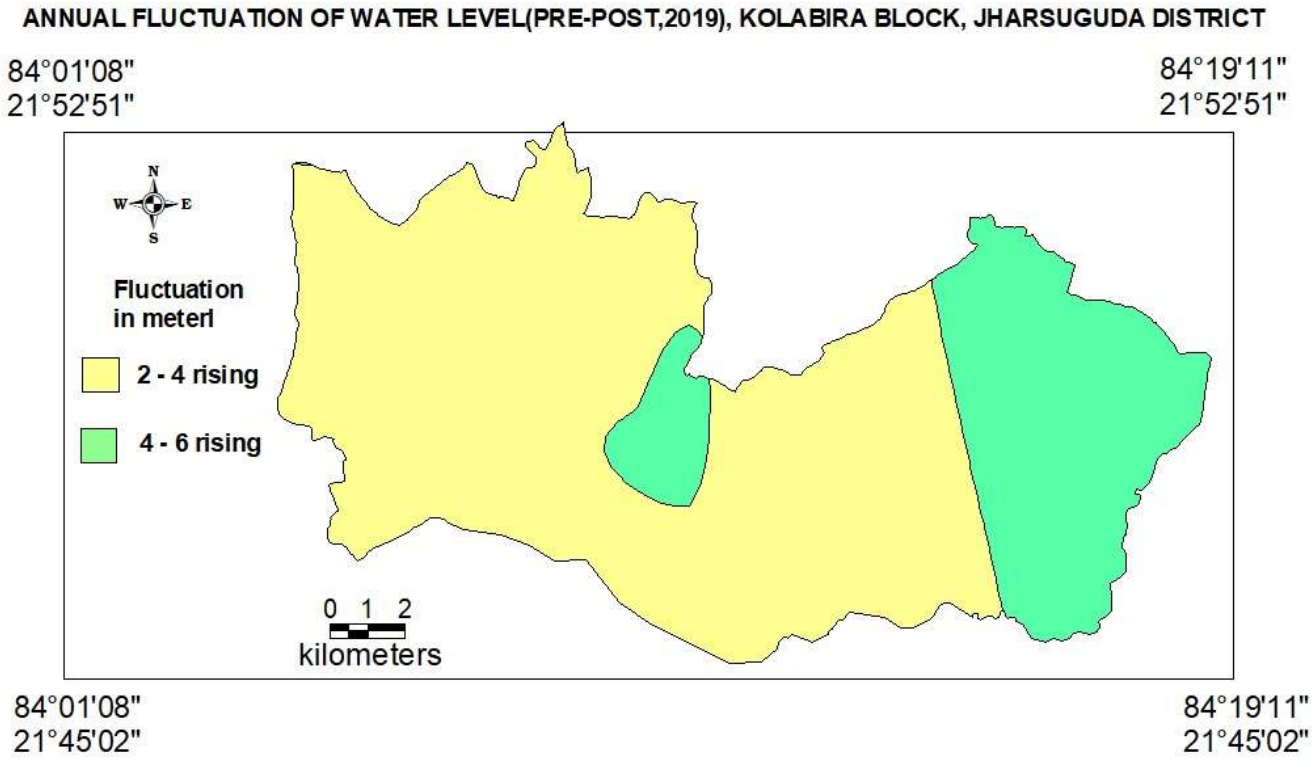


Fig.35d

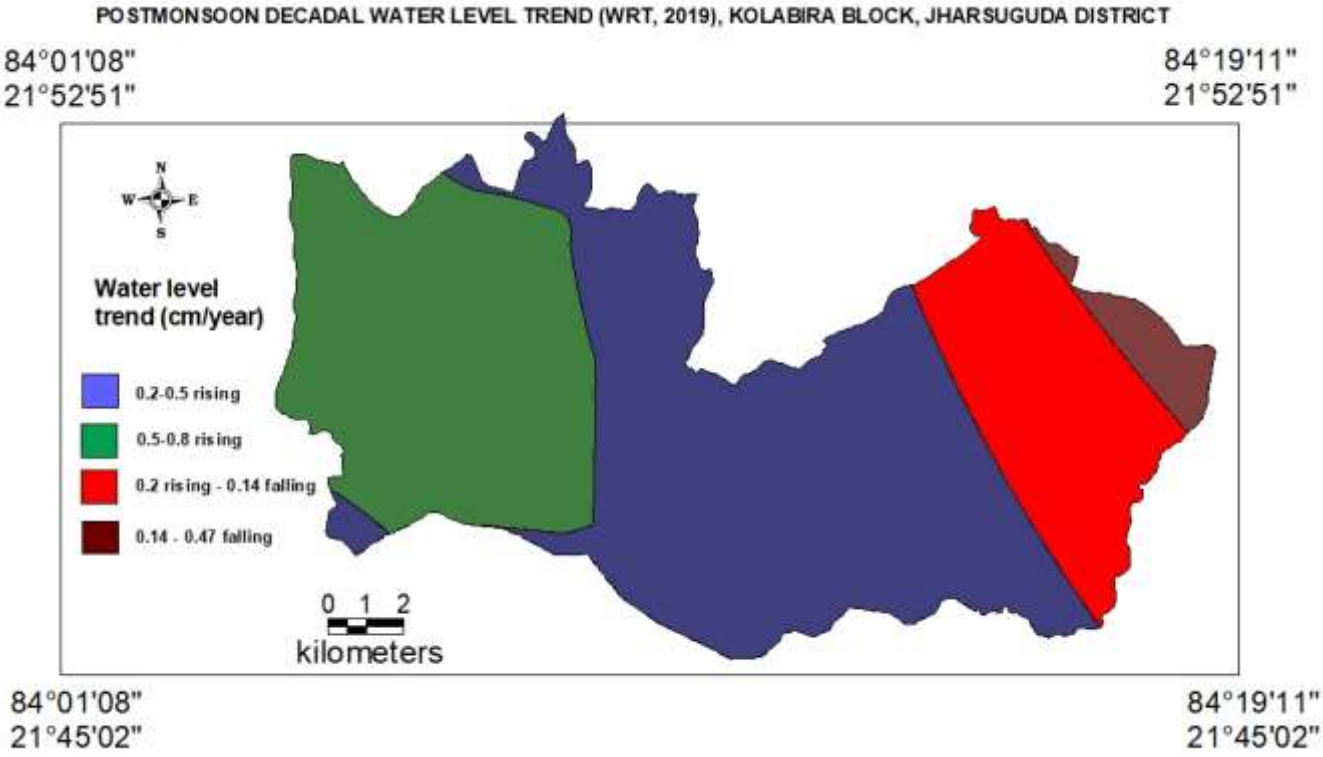
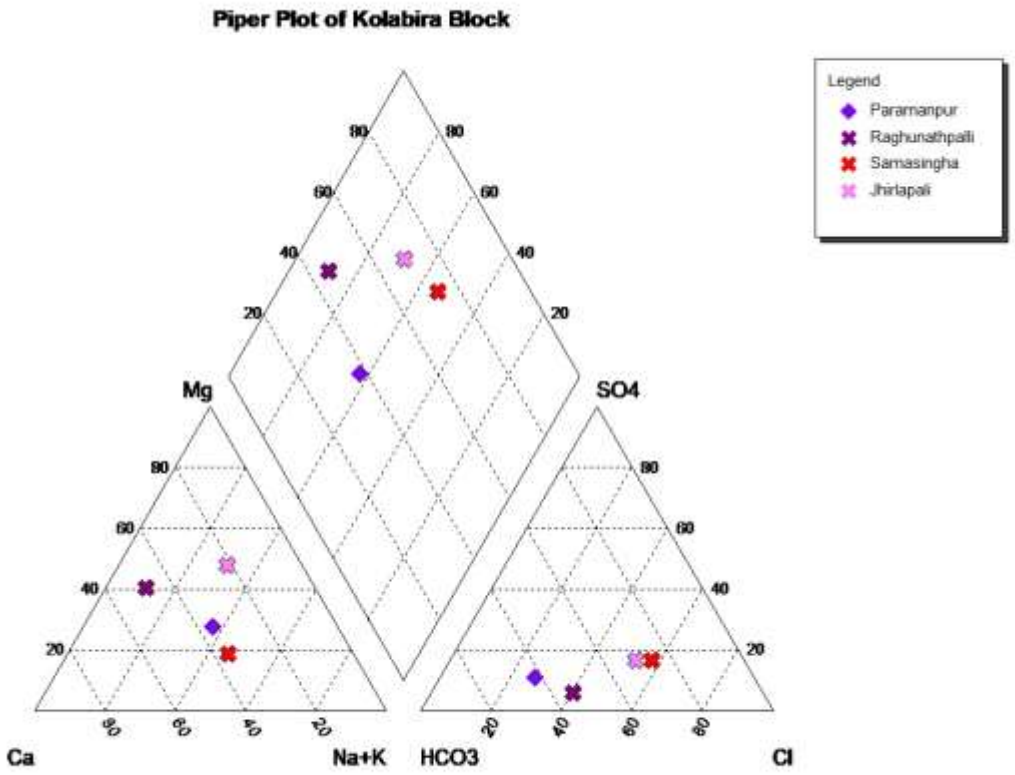


Fig.36. Piper Diagram of shallow aquifer samples, Kolabira Block



v. Lakhanpur Block:

1. Salient Information	
Name of the Block and Area (in Km^2)	Lakhanpur Area- 981.97 sq.km.
District/ State	Lakhanpur / Odisha
Population	159437 (Projected population as on 2020 w.r.t 2011 census), growth rate is 12.24%
Rainfall	Normal Monsoon rainfall-1170 mm Non-monsoon Rainfall-130 mm
Agriculture and Irrigation	**Principal crops**-Cereal, Pulses, Oil Seeds, Vegetable Crops **Gross cropped area**-208.58 sq.km **Net sown area**- 240 sq. km. **Cropping intensity** – 86.91% **Irrigation practices** i.MIP-2244.1 ha ii. LIP-2694 ha iii.Deep Bore Well- 1745.8 ha iv.Traditional Water harvesting structures- 5222 ha v.Other sources Agriculture and OAIC- 68.9 ha **Total number irrigation dug well** during year **1999** was 1376, number of **irrigations bore well** was 4, but during **2017** number of dug well was 1716 and number of bore well was 560.
Ground water resource availability and extraction	**Aquifer – I** (Up to 100 mbgl depth) Dynamic Ground Water Resources- 7429.48 ha Total Ground Water Draft- 2702.02 ham In storage Ground Water Resources- 14191.1 ha
Existing and future water demands	a. Existing domestic water demand- 3.5 mcm Domestic water demand during 2035 – 4.2 mcm b. Existing irrigation water demand- 44.8 mcm Irrigation water demand during 2035- 47.2 mcm c. Existing industrial water demand- 0.19 mcm Industrial water demand during 2035- 1.13 mcm
Water level behaviour	1.3 to 9.4 mbgl during pre monsoon (Fg.39a) 1.02 to 6.41 mbgl during post monsoon (Fig.39b) 0.2 to >1.16 cm/year rising and 0.14 – 1.16 cm/yr falling decadal water level trend (Fig-39d).
2. Aquifer Disposition	
Number of aquifers	Single aquifer up to 100 mbgl depth (Fig.14a, c)
3-D aquifer disposition and basic characteristics of each aquifer	Cross section presented in Fig.37b, c.
	Geology- Precambrian granite gneiss occupied in 540 aq.km area (Consolidated formation), Lower Gondwana group of sandstone, shale, coal and Vindhyan Sandstone are occupying 434 sq. Km area and unconsolidated formation (alluvium sands) in 2.7 sq. km

	parts (Fig.38). Discharge varies from 0.5 to 1.2 lps. in granite gneiss, 2 to 12 lps in Gondwana sandstone, shale, coal beds. Aquifer type is unconfined up to 50-60 mbgl depth and semi confined beyond 50-60 mbgl depth. Available Depth of Fracture in granite gneiss- 65-68 at Kumbhar bandh, 196-198 mbgl at Sukhadihi. Available Depth of Fracture in Gondwana Group- 31.7-50, 59.1-74.4, 89.6-101.8, 147.6-150.6, 162.1-172.1,181.2-184.3 mbgl (Fig.36a, b, c). T values obtained 13.76 – 18.98 m^2/day in Lower Gondwana group of rocks.
3. Ground water resource, extraction, contamination and other issues	
Aquifer wise resource availability and extraction	As on 31.3.2017 Net Ground Water Avialabiliy-74.29 mcm Gross ground water draft-27.02 mcm Allocation for domestic and industrial requirement upto 2025 – 8.31 mcm Net ground water availability for future irrigation-45.78 mcm Stage of Ground Water Extraction-36.37% Category- Safe
Chemical quality of ground water and contamination	Electrical Conductivity (µS/cm)- 250 to 2020 TDS (mg/l)-116 to 1093 Ca^{++}(mg/l)-24 to 123 Mg^{++}(mg/l)-3 to 110 Na^{+}(mg/l)-12 to 136 K^{+}(mg/l)-2 to 115 HCO_3(mg/l)-36 to 537 $SO_4^{=}$ (mg/l)-3.5 to 111 Cl (mg/l)- 27 to 556 NO_3^{-}(mg/l) – 1 to 46 F (mg/l) -0.1 to 1.27 At Arhapada, Kumarbandha, Singhaipali nitrate concentration seen more than permissible limit. Similarly, EC found >750 µS/cm at Arhapada, Kumarbandha, Machida, Singhaipali, Dhulunda, Kandeikela, Remenda. Ground water is potable (Fig. 40).
Other issues	Present water availability is 89.2 mcm Water demand as on 2025 and 2035 will be 51 mcm, 52.9 mcm respectively. Possibility of shortage of aquifer storage.
4. Ground water resource enhancement	
Aquifer wise space available for recharge and proposed interventions	Volume of unsaturated zone- 52.71 mcm (up to the maximum depth of 5.3 mbgl post monsoon water level, considered 0.3 m beyond 5meter depth) Rainfall recharge by adoption of 1482 number of farm pond (1 pond per hector) – 2.9 mcm Rainfall recharge by adoption of 3082 number of roof top rainwater harvesting structure (1 structure for 10 houses

	in village) – 0.48 mcm Average annual rainfall considered 1308 mm Total Volume of Water expected to be conserved- 3.39 mcm
5. Demand side interventions	
Advanced Irrigation Practices	1829 ha area proposed to be covered for subsurface drip irrigation practices during summer and Volume of Water expected to be conserved will be 60% of 2289 ham=1373 ham or 13.73 mcm.
Change in cropping pattern	**Fruit crops**: Grapes, banana, banana, pomegranates, mango, orange, cashew nuts, papaya, litchi, watermelon. **Vegetable plants**: Onion, brinjal, bitter gourd, ridge gourd, cucumber, tomato, chilly, capsicum etc. **Oil seeds**: Sunflower, oil palm. **Forest crop**: Bamboo, teakwood
Alternate water sources	i. Net GW Resources available for future irrigation (ham)** as per Ground water resources estimation (2017)- 4578.36 ham ii. Average crop Water requirement in a year (m)- 1.252 m iii. Possible additional irrigation potential area that can be created with available resources(ha)- 3657.18 ha iv. 50% of the additional potential area taken for irrigation (ha)-1828.59 ha v. 100% Area to be irrigated by Dug well (ha) from additional potential areas(ha)- 1829 ha vi. Total number of additional dug well to be constructed for drip irrigation during summer- 1829
Regulation and Control	To mitigate the wastage of water specially for commercial activity Department of Water Resources, Govt. of Odisha notifies a separate water pricing policy vide letter dated 24.4.2020. Concerned District Administration should strictly follow the water pricing policy for sustainable development of ground water
Reflected results after adoption of Ground water enhancement and demand side interventions	An annual amount of approximately 17.12 mcm water will be conserved.

Fig.37 a

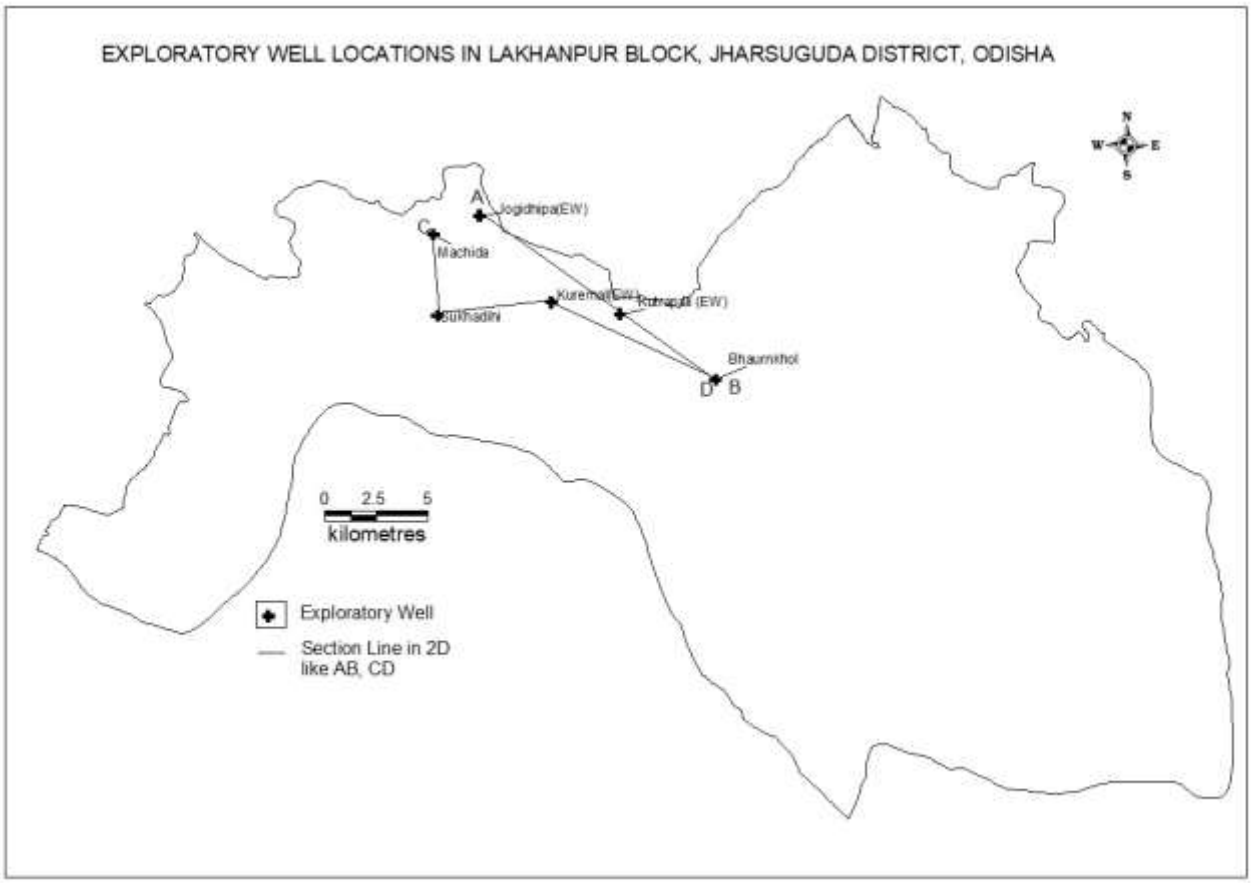


Fig.37b.

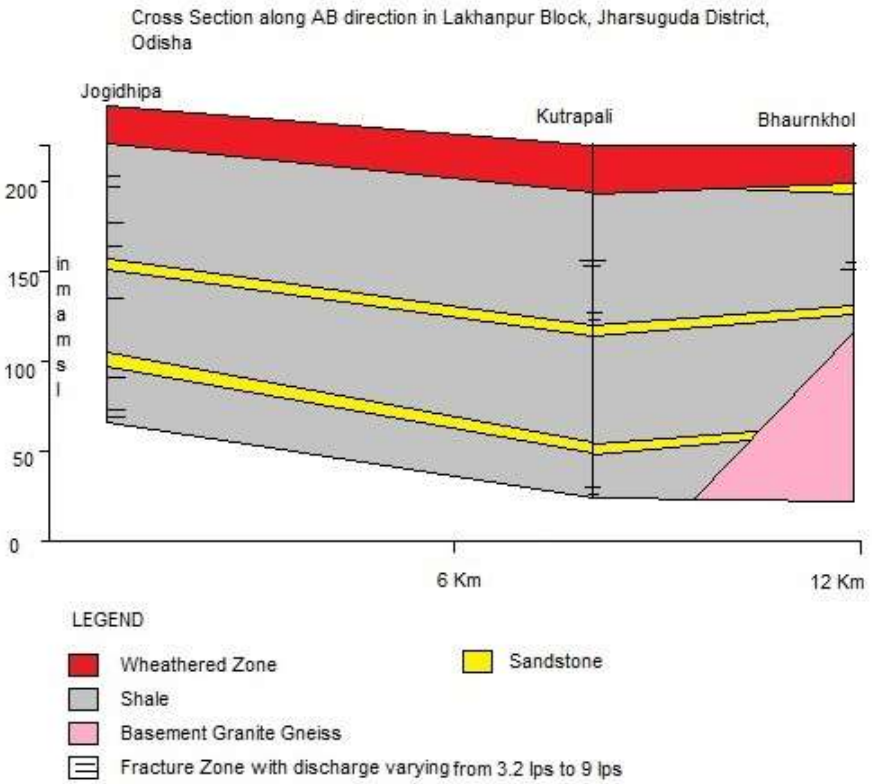


Fig.37c.

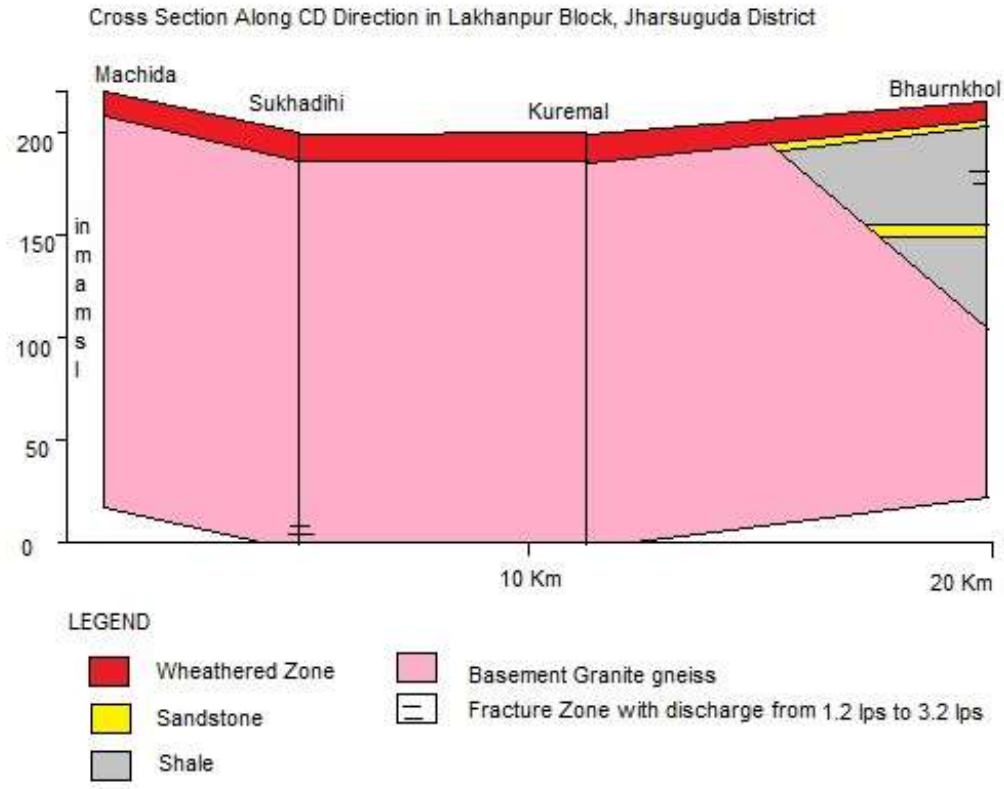
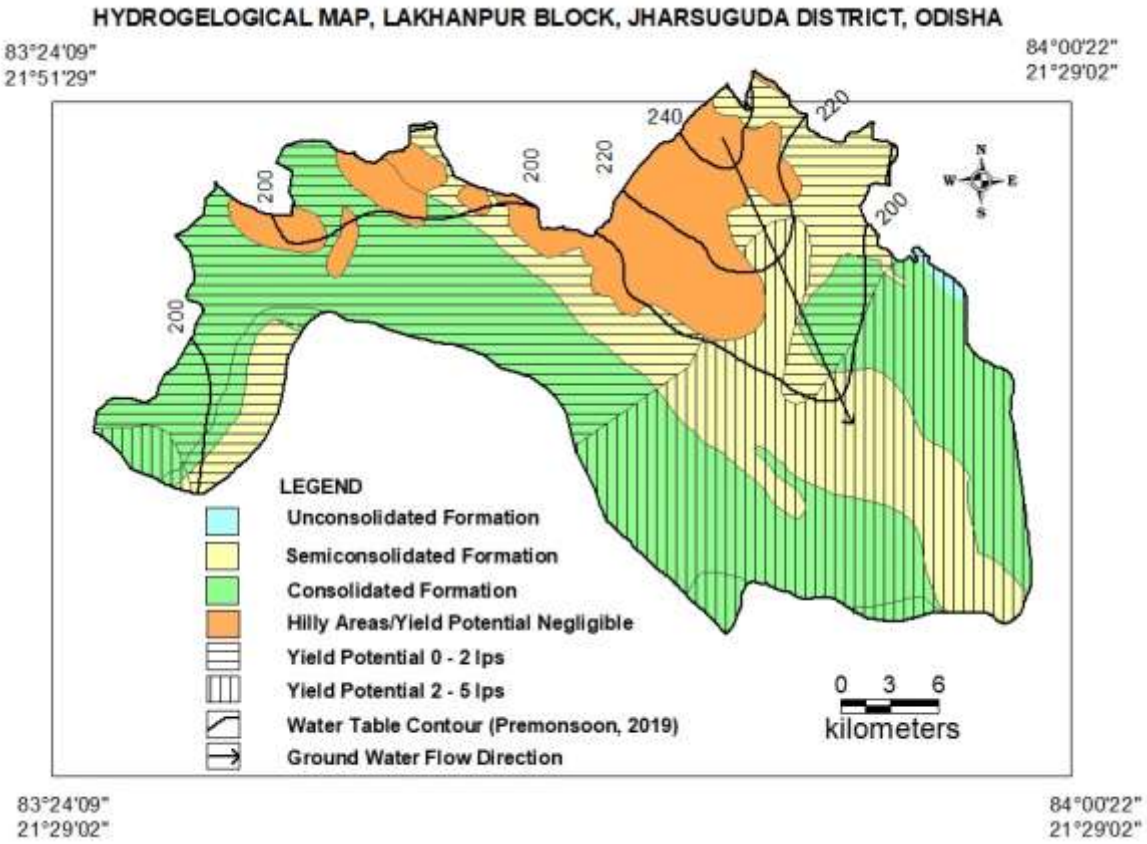


Fig.38



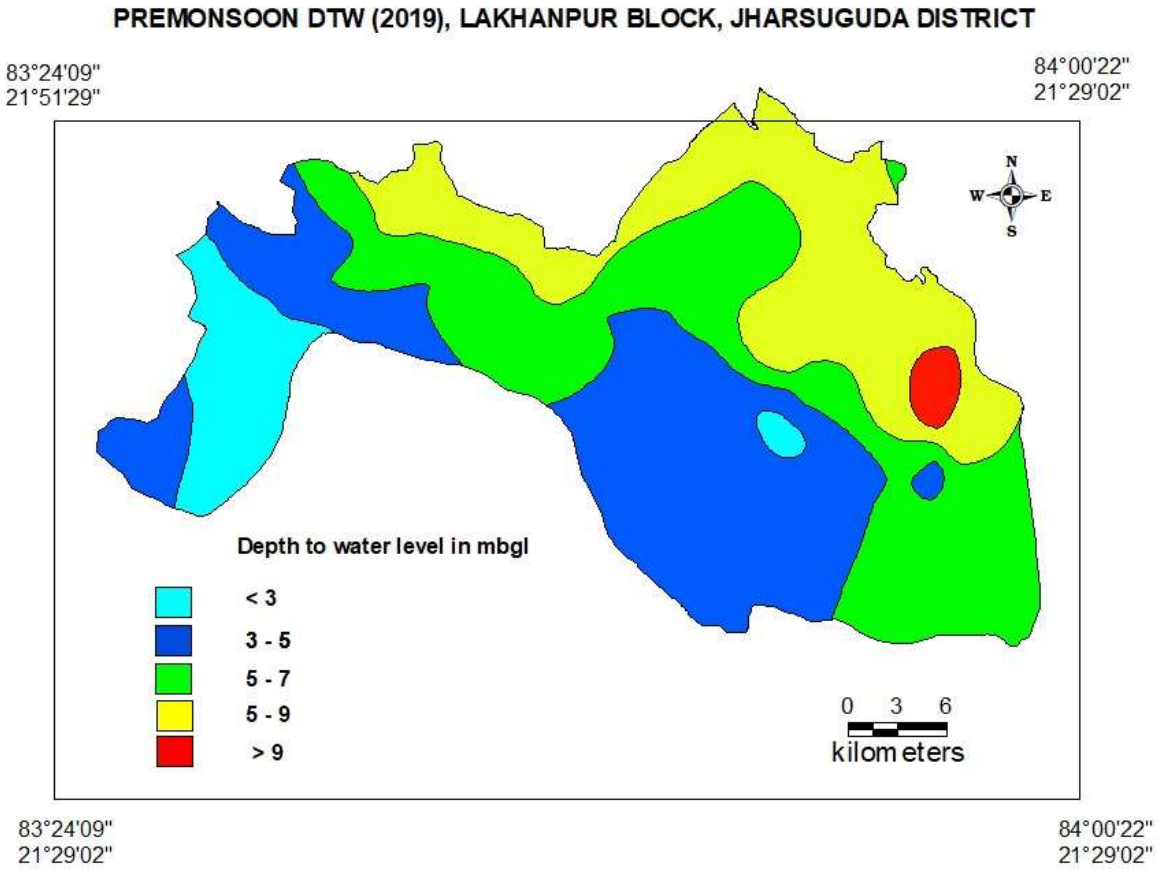
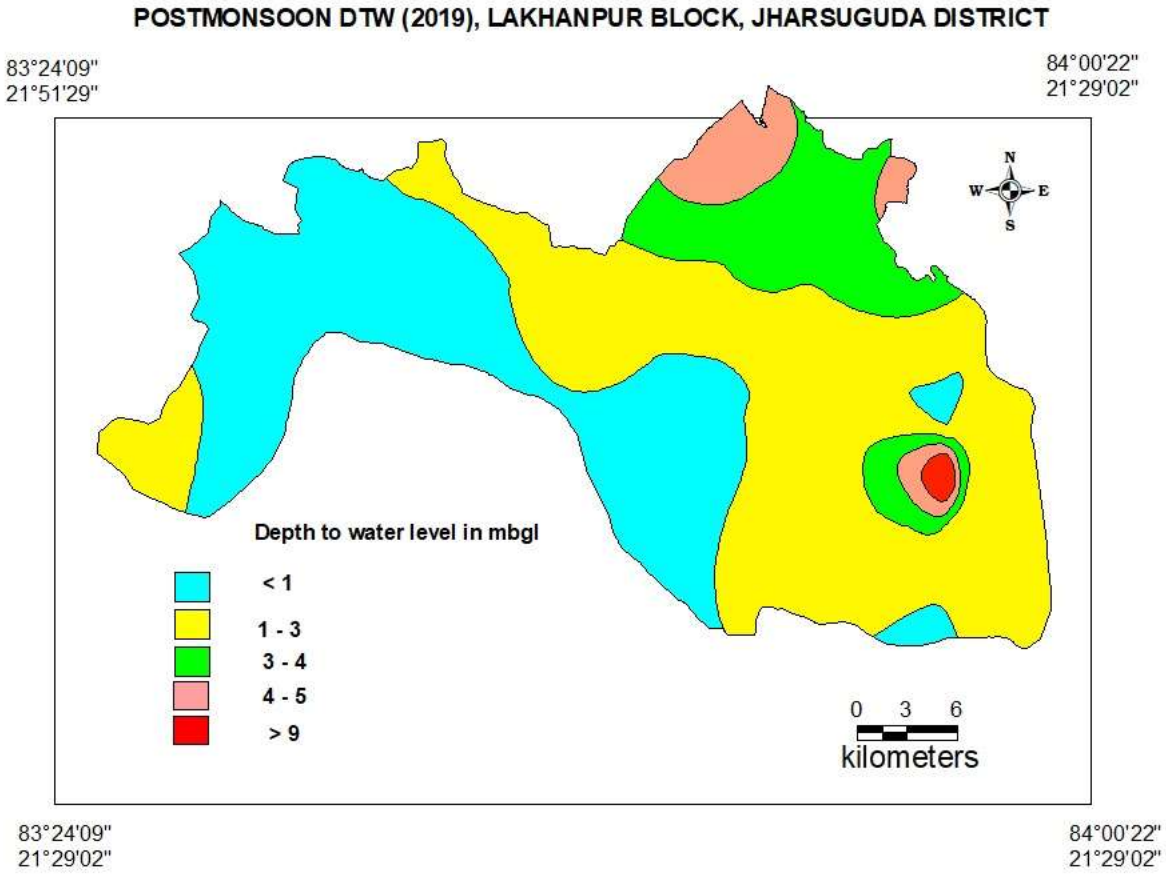


Fig.39a

Fig.39b.



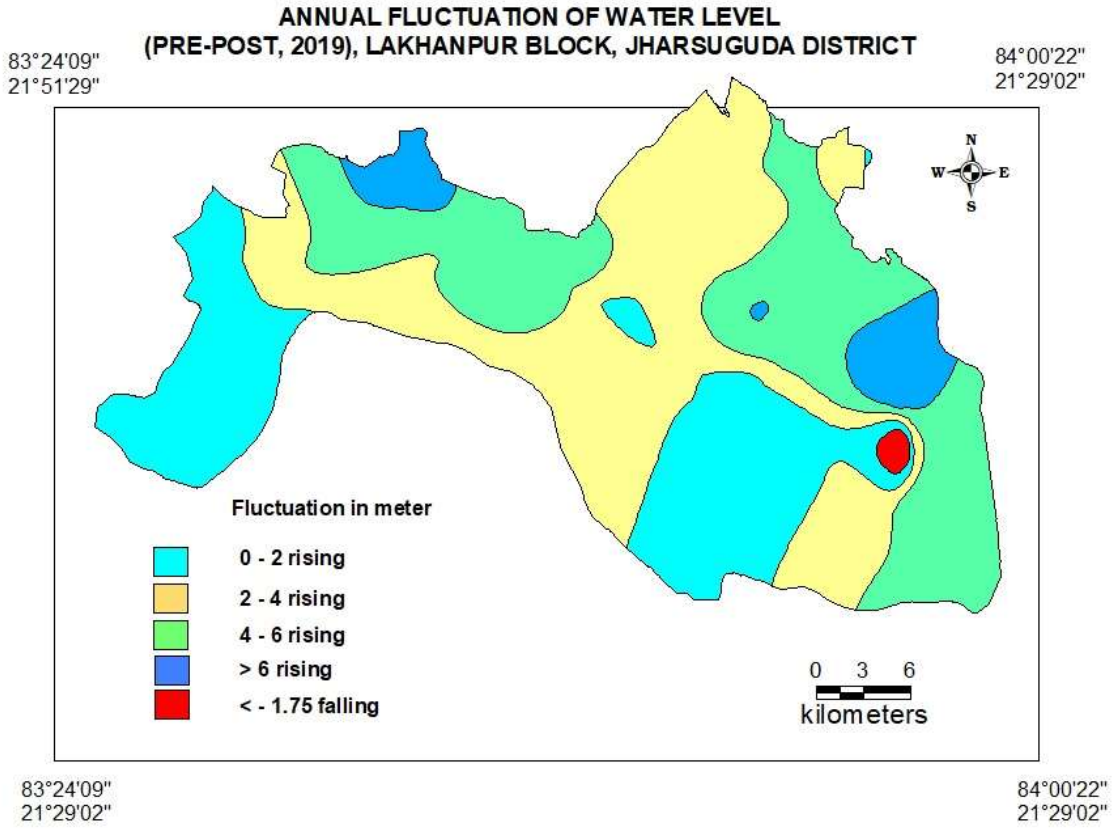

ANNUAL FLUCTUATION OF WATER LEVEL
(PRE-POST, 2019), LAKHANPUR BLOCK, JHARSUGUDA DISTRICT
83°24'09"
21°51'29"
84°00'22"
21°29'02"
N
W
E
S
Fluctuation in meter
0 - 2 rising
2 - 4 rising
4 - 6 rising
> 6 rising
< - 1.75 falling
0 3 6
kilometers
83°24'09"
21°29'02"
84°00'22"
21°29'02"

Fig.39c.

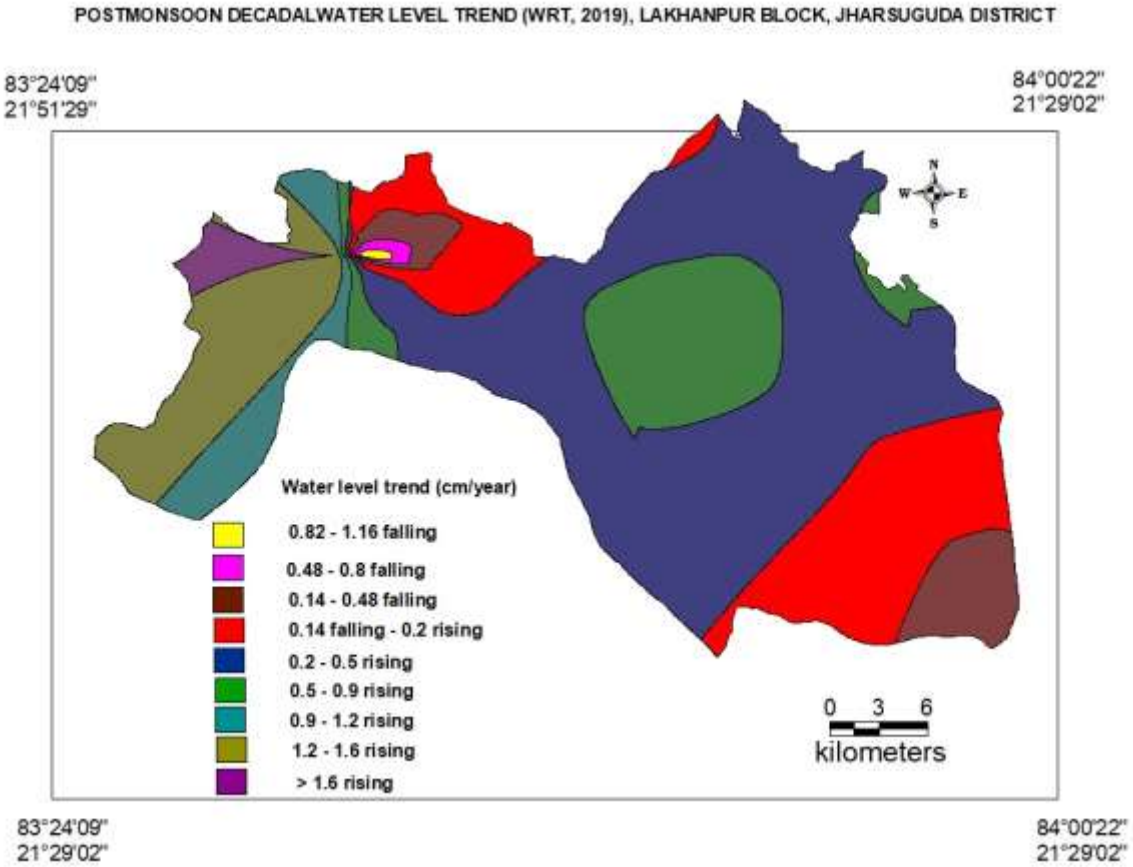
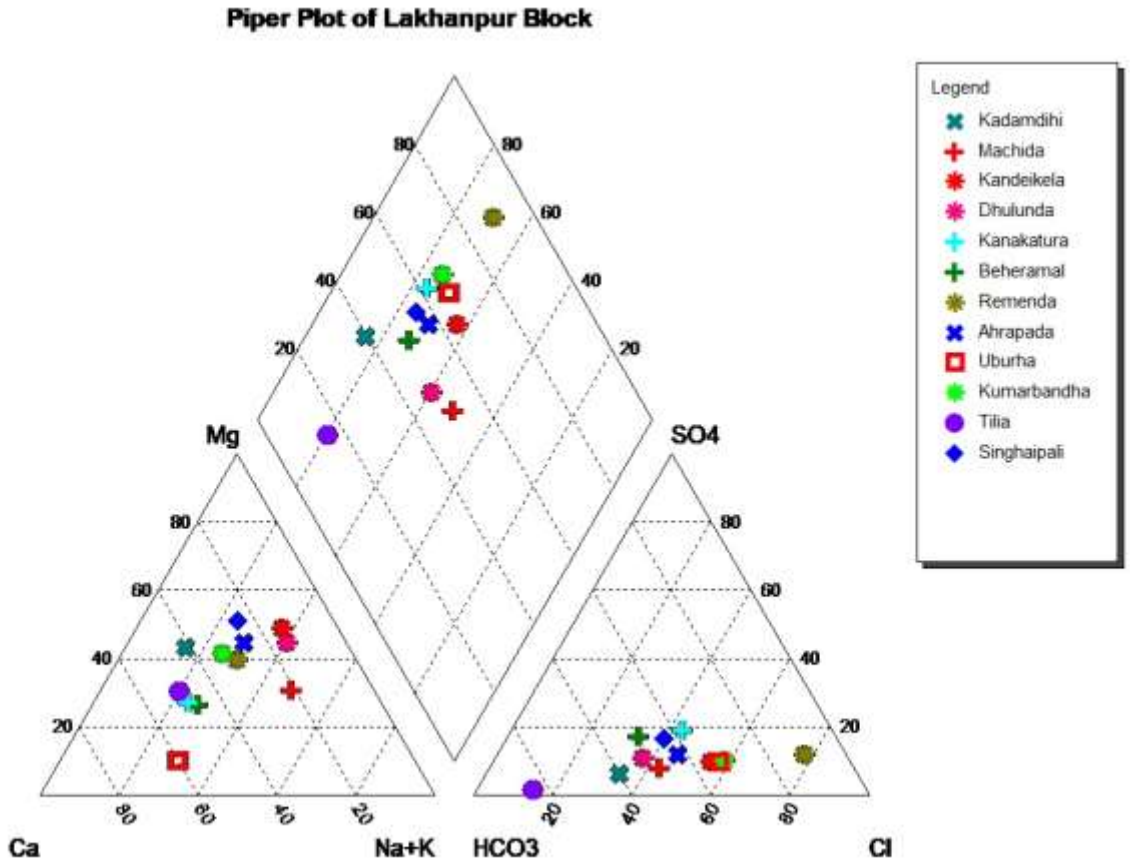

POSTMONSOON DECADALWATER LEVEL TREND (WRT, 2019), LAKHANPUR BLOCK, JHARSUGUDA DISTRICT
83°24'09"
21°51'29"
84°00'22"
21°29'02"
N
W
E
S
Water level trend (cm/year)
0.82 - 1.16 falling
0.48 - 0.8 falling
0.14 - 0.48 falling
0.14 falling - 0.2 rising
0.2 - 0.5 rising
0.5 - 0.9 rising
0.9 - 1.2 rising
1.2 - 1.6 rising
> 1.6 rising
0 3 6
kilometers
83°24'09"
21°29'02"
84°00'22"
21°29'02"

Fig.39d.

Fig.40. Piper Diagram of shallow aquifer samples, Lakhanpur Block



8. CONCLUSION:

i. Jharsuguda District comprises with three types of hydrogeological formations. Consolidated formations are occupying about 1360 sq. Km area, semi consolidated formations are occupying about 525 sq.km area and unconsolidated formations are occupying about 266 sq.km area of the district.

ii. Ground water potentiality is very less in consolidated formation beyond 100-meter depth compared to semi consolidated formations. Semi consolidated formation is occurring mainly western part of Jharsuguda and in major north east and north western part of Lakhanpur Block. Majority of coal mines are located in this Semi consolidated Lower Gondwana group of rocks.

iii. Long-term post monsoon trend of water level is falling in 25% area of Jharsuguda District. From CGWB hydrograph stations a remarkable decline of water level has been noticed at Jharsuguda, Belpahar, Brajarajnagar, Lykera stations.

iv. Total number of irrigations dug wells enhanced from 6258 during 1999 to 7331 during 2017 and number of irrigations bore wells also enhanced from 6 during 1999 to 1413 during 2017. Similarly, there is a multi-fold increase in domestic and industrial wells from year 1999 to year 2017.

v. Stage of ground water development for the whole district enhanced from 19.58% during 1999 to 43.27% during 2017.

vi. Quality of ground water for the whole district is potable except sporadic occurrences of nitrate and iron above permissible limit. At few hydrographs stations uranium concentration within permissible limit have also been noticed. Type of water is bicarbonate type in most of the cases and bicarbonate-chloride type in few cases.

vii. Deep tube well up to 200 mbgl depth is feasible in semi consolidated Lower Gondwana Group of rocks mostly in Lakhanpur Block. CGWB exploration shows discharge ranges from 3 lps to 12 lps in semi consolidated formation located just northern part of NW-SE trending major lineament in Lakhanpur Block.

viii. As per water demand-supply-gap analysis it is observed that a total amount of water demand will increases from 158 mcm during 2020 to 171.3 mcm during 2035 against a fixed present water availability of 249.3 mcm.So to combat the situation ground water enhancement and demand side intervention have been planned.

ix. In ground water enhancement category rainfall to be recharge by creating farm ponds in agricultural fields and roof top rainwater harvesting structure at village level households. By adoption of these techniques annually 17.067 mcm water will be recharge/ conserve and thus will improve the stage of ground water development from 43.27% to 40.05 % as per 2017 resources calculation.

x. In Demand side management after taking average crop water requirement and 50% of additional future irrigation potential, 4376 ha area may be converted to additional irrigation potential area for subsurface drip irrigation during summer season and thereby construction of additional 4377 dug wells may be planned. Considering 60% ground water consumption by drip irrigation 8810.4 ham water will also be kept for future irrigation.

9. **ACKNOWLEDGEMENTS**: The author is very much thankful to the present Chairman Dr. P Nandakumaran, Member East Shri Utpal Gogoi, Member Head Quarter Sh Anoop Nagar and Head of Office of CGWB, SER, Bhubaneswar Sh P K Mohapatra, Sh B K Sahoo, Scientist - D for their valuable suggestion for compilation of the report.

10. **REFERENCES:**

i. Ground water resources and development potentials of Jharsuguda District, Orissa; CGWB, SER, Bhubaneswar, 1997.

ii. Ground water resources assessment of Odisha State; CGWB, SER, Bhubaneswar, 2017.

iii. District irrigation plan of Jharsuguda, Odisha, PMKSY; District level implementation committee, Jharsuguda, 2016.

iv. Minor irrigation projects in Orissa as on 31.12.13; Department of Water Resources, Odisha, 2014.

v. Well completion report of exploratory well at Singhabaga, Jharsuguda District, CGWB, SER, Bhubaneswar, 2003.

vi. Well completion report of exploratory well at Bhademunda, Jharsuguda District, CGWB, SER, Bhubaneswar, 2003.

vii. Well completion report of exploratory well at Durlaga, Jharsuguda District, CGWB, SER, Bhubaneswar, 2003.

viii. Well completion report of exploratory well at Paprapalli, Jharsuguda District, CGWB, SER, Bhubaneswar, 2003.

ix. Well completion report of exploratory well at Jhanda Chack, Jharsuguda District, CGWB, SER, Bhubaneswar, 2003.

x. Well completion report of exploratory well at Ghutguri Pata, Jharsuguda District, CGWB, SER, Bhubaneswar, 2003.

xi. Well completion report of exploratory well at H. Katapali, Jharsuguda District, CGWB, SER, Bhubaneswar, 2003.

xii. Well completion report of exploratory well at Dhanker Palli, Jharsuguda District, CGWB, SER, Bhubaneswar, 2003.

xiii. Well completion report of exploratory well at Sripura, Jharsuguda District, CGWB, SER, Bhubaneswar, 2003.

xiv. Well completion report of exploratory well at Kutrapalli, Jharsuguda District, CGWB, SER, Bhubaneswar, 2020.

xv. Well completion report of exploratory well at Kuremal, Jharsuguda District, CGWB, SER, Bhubaneswar, 2020.

xvi. Well completion report of exploratory well at Jogidhipa, Jharsuguda District, CGWB, SER, Bhubaneswar, 2020.

xvii. Well completion report of exploratory well at Machida, Jharsuguda District, CGWB, SER, Bhubaneswar, 2020.

xviii. Well completion report of exploratory well at Sukhadihi, Jharsuguda District, CGWB, SER, Bhubaneswar, 2020.

xix. Well completion report of exploratory well at Bhaurnkhol, Jharsuguda District, CGWB, SER, Bhubaneswar, 2020.

xx. Well completion report of exploratory well at Bhaurnkhol, Jharsuguda District, CGWB, SER, Bhubaneswar, 2020.

ANNEXURE1

Government of Odisha
Department of Water Resources
*****

No. 8561 /WR.. Date: 21/4/2020
Irr.-II-WRC-92/20

From
Sri. R. N. Chinara
Under Secretary to Government.

To
The EIC, WR, Secha Sadan, Bhubaneswar.

Sub: Enhancement of licence fee & special water rate w.e.f 01.04.2020.

Sir,

In inviting reference to your Letter No. 8464 / WE dated 13.03.2020 on the subject noted above, I am directed to say that as per amendment made in Rule-23-A (2) (f) of Odisha Irrigation Rules, 1961vide Odisha Irrigation (Amendment) Rules, 2016, the licence fees / special water rate for drawal and use of water shall be enhanced @ 10% per annum w.e.f. 1st day of April.

Accordingly, the 4th annual enhancement @ 10% will be effective from 01.04.2020 to 31.03.2021. The enhanced rate chart of special water rate & licence fee are annexed vide Schedule-II & Schedule-III respectively.

It is, therefore, requested to circulate the above licence fees / special water rate among all Sub-Ordinate Officers under your administrative control for further follow up action.

Encl.:-As above.

Yours faithfully,

22/04/2020
Under Secretary to Government

Memo No. 8562 **/ Dt.** 21/4/2020

Copy forwarded to the CE, Water Services, O/o the EIC, WR for information and necessary action.

22/04/2020
Under Secretary to Government

1402

SPECIAL WATER RATES UNDER SCHEDULE-II FOR THE PERIOD FROM 01.4.2019 TO 31.3.2020 AFTER THE ENHANCEMENT @ 10% PER ANNUM AS PER RULE-23A(2)(f) AND RULE 26 OF THE ODISHA IRRIGATION RULES, 1961 FOR THE PURPOSES OTHER THAN IRRIGATION(INDUSTRIAL/ COMMERCIAL USES OF WATER) FROM THE IRRIGATION WORKS

Item No	Purpose for which supply is given	Special water rates as per Schedule II from 01.10.2010 to 31.3.2017 (in Rupees) (Base Rate)	Enhanced special water rate (for the period from 01.4.2019 to 31.03.2020) (in Rupees)	Enhanced special water rate (for the period from 01.4.2020 to 31.03.2021) (in Rupees)	Quantity	Remarks
1	2	3	4	5	6	7
1	Bricks or tile making	30.00	39.00	42.00	1000 Bricks or Tiles	
2	(i)For water actually drawn or allocated whichever is higher for industrial or commercial purpose					
	Slab-I-Consumption not exceeding 5 cusecs	4.20	5.46	5.88	1000 liter (1 m^3)	
	Slab-II-Consumption of 5 cusecs or more	5.60	7.28	7.84	1000 liter (1 m^3)	
	(ii) For water used for Hydro Power Generation	0.01	0.013	0.014	1 KWH	
3	(i) For bulk supply to Municipalities and Notified Area Councils and other local authorities for drinking, washing etc.	0.25	0.325	0.35	1000 liter (1 m^3)	
	(ii) For bulk supply to Municipalities and Notified Area Councils and other local authorities and cluster of villages by industrial, commercial or other establishments actually drawn or allocated whichever is higher for drinking, washing etc.	0.50	0.65	0.70	1000 liter (1 m^3)	
4	Construction of commercial buildings	7.10	9.23	9.94	1000 liter (1 m^3)	
5	For filling tanks	0.10	0.13	0.14	1000 liter (1 m^3)	
6	For filling tanks mainly for drinking purposes	0.05	0.065	0.07	1000 liter (1 m^3)	

N.B:- The enhancement of licence fees and special water rates @ 10 per centum per annum with effect from the first day of April is as per the Odisha Irrigation (Amendment) Rules, 2016.

27/04/2020

Under Secretary to Government,
Department of Water Resources.

RATE OF LICENCE FEE UNDER SCHEDULE-III FOR THE PERIOD FROM 01.4.2019 TO 31.3.2020 AFTER THE ENHANCEMENT @ 10% PER ANNUM AS PER RULE-23A(2)(f) OF THE ODISHA IRRIGATION RULES, 1961

FOR INDUSTRIAL/ COMMERCIAL USES OF WATER FROM THE GOVERNMENT WATER SOURCES

Item No	Purpose for which supply is given	Licence fees as per Schedule III from 01.10.2010 to 31.3.2017(in Rupees)(Base Rate)	Enhanced Licence Fee for the period from 01.4.2019 to 31.3.2020 (in Rupees)	Enhanced Licence Fee for the period from 01.4.2020 to 31.3.2021 (in Rupees)	Quantity	Remarks
1	2	3	4	5	6	7
1	Bricks or tile making	25.00	32.50	**35.00**	1000 Bricks or Tiles	
2	(i)For water actually drawn or allocated whichever is higher for industrial or commercial purpose					
	Slab-I-Consumption not exceeding 5 cusecs	3.40	4.42	**4.76**	1000 liter (1 m^3)	
	Slab-II-Consumption of 5 cusecs or more	4.50	5.85	**6.30**	1000 liter (1 m^3)	
	(ii) For water used for Hydro Power Generation	0.01	0.013	**0.014**	1 KWH	
3	(i) For bulk supply to Municipalities and Notified Area Councils and other local authorities for drinking, washing etc.	0.20	0.26	**0.28**	1000 liter (1 m^3)	
	(ii) For bulk supply to Municipalities and Notified Area Councils and other local authorities and cluster of villages by industrial, commercial or other establishments actually drawn or allocated whichever is higher for drinking, washing etc.	0.40	0.52	**0.56**	1000 liter (1 m^3)	
4	Construction of commercial buildings	5.30	6.89	**7.42**	1000 liter (1 m^3)	
5	For sub soil water actually used and consumed for industrial /commerical purpose					
	Slab I Consumption not exceeding 5 cusecs	6.80	8.84	**9.52**	1000 liter (1 m^3)	
	Slab II Consumption of 5 cusecs or more	9.00	11.70	**12.60**	1000 liter (1 m^3)	

N.B:- The enhancement of licence fees and special water rates @ 10 per centum per annum with effect from the first day of April is as per the Odisha Irrigation (Amendment) Rules, 2016.

22/04/2020

Under Secretary to Government,
Department of Water Resources.

ANNEXURE-2

Village Name	VES No	Weathered /Semi Weathered Zone (WZ/SWZ)		Compact Rock Formation (CR)				Fractured zone (FZ)	Bed Rock	GW Quality (GWQ)	Recommendations		
		Resistivity (ohm.m)	Depth(m) to bottom of WZ/SWZ aquifer & /probable depth to ("groundwater first strike")	Less Compact (Resistivity less than compact, could be due to variations in rock composition also)	Compact			Probable occurrence of thin fractured zone aquifer in compact rock in the depth range (m)	Depth (m) to Compact Rock (DCR)	Tentative in terms of salinity	Recommended for Dug Well(DW)/ Shallow Bore Well (SBW)/ Deep Bore Well (DBW)	Basis for Recommendation	Minimum Depth (m) of Dug well/ shallow well/ deep well construction, (probable depth of surface casing) and priority
				Resistivity (ohm.m)	Depth to top/bottom (m)	Resistivity (ohm.m)	Depth to top (m)						
Machida	374	25	13	126	83.7	VH	83.7	45-50, 65-70, 75-85, 130-150, 180-190	83.7	Potable	BW	Thin FZs may exist at depth ranges between 45-50, 65-70, 75-85, 130-150, 180-190m Based on the factor flat, current increase and curve break	BW: 200 m Casing: 14 m Low Priority
Dhulunda	375	109	18.6	435	175.6	VH	175.6	50-55, 110-140	175.6	Potable	BW	Thin FZs may exist at depth ranges between 50-55, 110-140 m Based on the factor flat, current increase and curve break	BW: 150m Casing: 19m Low Priority

Kanaktora	376	21	4	69	42.1	VH	42.1	10-12, 30-35, 70-75, 80-100, 120-180	42.1	Potable	BW	Thin FZs may exist at depth ranges between 10-12, 30-35, 70-75, 80-100, 120-180 m Based on the factor flat, current increase and curve break	BW: 200m Casing: 5 m Priority may be given
Kadamdini	377	12	8	---	---	VH	8	25-30, 35-40, 45-50, 65-70, 160-170, 180-190	8	Potable	BW	Thin FZs may exist at depth ranges between 25-30, 35-40, 45-50, 65-70, 160-170, 180-190 m Based on the factor flat, Current increase and curve break.	BW: 200 m Casing: 9 m Priority may be given
Grindola	378	85	9.7	28-92	195	VH	195	50-55, 65-70, 75-80, 85-90, 95-130, 140-180, 190-200	195	Potable	BW	Thin FZs may exist at depth ranges between 50-55, 65-70, 75-80, 85-90, 95-130, 140-180, 190-200 m Based on the factor flat, current increase and curve break	BW: 200 m Casing: 10 m Priority may be given
Tilia	379	---	---	35	148.5	VH	148.5	50-55, 65-70, 100-120, 180-190	148.5	Potable	BW	Thin FZs may exist at depth ranges between 50-55, 65-70, 100-120, 180-190 m Based on the factor flat, current increase and curve break	BW: 200 m Priority may be given

Kudopali	380	112	15.5	325	132.8	VH	132.8	45-50, 75-80, 90-95, 110-120, 140-170, 180-200	132.8	Potable	BW	Thin FZs may exist at depth ranges between 45-50, 75-80, 90-95, 110-120, 140-170, 180-200 m Based on the factor flat, current increase and curve break.	BW: 200 m Casing: 16 m Priority may be given
Chinchinda	381	21	11.5	---	---	VH	11.5	35-40, 50-55, 65-70, 90-95, 110-120, 130-150, 180-190	11.5	Potable	BW/DW	Thin FZs may exist at depth ranges between 35-40, 50-55, 65-70, 90-95, 110-120, 130-150, 180-190 m Based on the factor flat and curve break. No current increase.	BW: 200 m Low Priority DW: 12 m
Durlaga	382	13	5.2	18-292	36.6	VH	36.6	120-130, 140-170, 180-200	36.6	Potable	BW	Thin FZs may exist at depth ranges between 120-130, 140-170, 180-200 m. Based on the factor flat, current increase and curve break	BW: 200 m Casing: 6 m Priority may be given
Brundamal	383	42	10.9	27-272	41.4	VH	41.4	15-25, 30-35, 90-95, 110-150, 160-190	41.4	Potable	BW	Thin FZs may exist at depth ranges between 15-25, 30-35, 90-95, 110-150, 160-190 m Based on the factor flat, current increase and curve break	BW: 200 m Casing: 12 m Priority may be given

Sulahi	384	27	5	71	36.8	VH	36.8	8-10, 12-15, 35-40, 100-110, 120-170	36.8	Potable	BW	Thin FZs may exist at depth ranges between 8-10, 12-15, 35-40, 100-110, 120-170 m Based on the factor flat, and curve break. No current increase	BW: 180 m Casing: 6 m Priority may be given
Dhutra	385	21	15.1	---	---	VH	15.1	60-70, 75-80, 120-140, 160-180	15.1	Potable	BW	Thin FZs may exist at depth ranges between 60-70, 75-80, 120-140, 160-180 m Based on the factor flat and curve break (not prominent). No current increase	BW: 200 m Casing: 16 m Low Priority
Kukerama	386	34	16.8	---	---	912	16.8	12-15, 40-45, 55-65, 110-120, 140-150, 170-180	16.8	Potable	BW	Thin FZs may exist at depth ranges between 12-15, 40-45, 55-65, 110-120, 140-150, 170-180 m Based on the factor flat, current increase and curve break.	BW: 190 m Casing: 17 m Priority may be given
Dimirdihi	387	42	14.1	350	56.4	VH	56.4	35-40, 50-55, 75-80, 85-90, 110-120, 140-170	56.4	Potable	BW	Thin FZs may exist at depth ranges between 35-40, 50-55, 75-80, 85-90, 110-120, 140-170 m Based on the factor flat, current increase and curve break.	BW: 180 m Casing: 15 m Priority may be given

Samasingha	388	25	13	126	83.7	VH	83.7	45-50, 65-70, 75-85, 130-150, 180-190	83.7	Potable	BW	Thin FZs may exist at depth ranges between 45-50, 65-70, 75-85, 130-150, 180-190 m Based on the factor flat, current increase and curve break.	BW: 200 m Casing: 14 m Priority may be given
Jhirlapali	389	69	8.4	---	---	>887	8.4	12-15, 35-40, 100-120, 140-150	8.4	Potable	BW	Thin FZs may exist at depth ranges between 12-15, 35-40, 100-120, 140-150 m Based on the factor flat, current increase and curve break.	BW: 160 m Casing: 9 m Priority may be given
Raghunathpali	390	8	4.6	79	38.6	VH	38.6	12-15, 45-60, 70-80,100-110, 120-130, 140-150, 160-170, 180-200	38.6	Potable	BW	Thin FZs may exist at depth ranges between 12-15, 45-60, 70-80,100-110, 120-130, 140-150, 160-170, 180-200 m Based on the factor flat, current increase and curve break.	BW: 200 m Casing: 5 m Priority may be given

MICRO LEVEL AQUIFER MAPS

AND MANAGEMENT PLAN

FOR

KUMBARBANDH,

BAGDEHI AND

RAMACHIPIDI

VILLAGES

VILLAGE LEVEL AQUIFER MAPPING AND MANAGEMENT PLAN OF KUMBHARBAND VILLAGE, BLOCK-LAKHANPUR, DISTRICT JHARSUGUDA

1. Salient Information	
Name of the Village and Area (in Km^2)	Kumbharband Area- 925 ha
Block/District/ State	Lakhanpur /Jharsuguda/ Odisha
Population	2010 (Projected population as on 2020 w.r.t 2011 census), growth rate is 12.24%
Rainfall	Normal Monsoon rainfall-1120 mm (Considered Block avg.) Non-monsoon Rainfall-150 mm (Considered Block avg.)
Geomorphology	Pediment-718.3 ha Buried shallow pediment-192.6 ha Residual hill-6.3 ha (Fig.1)
Drainage and water body	25 number of first order stream, 5 second order stream 8 number of ponds (Fig.2)
Land use, Agriculture and Irrigation	**Forest-**79 ha **Area under non-agricultural use-**39.9 ha **Land under miscellaneous tree corps-**48.2 ha **Current fallow-**359 ha **Net shown area-**398.9 ha **Total irrigated area-** 398.9 ha **Principal crops**-Cereal, Pulses, Oil Seeds, Vegetable Crops (Considered Block avg.) **Irrigation practices** I. Canal irrigation- 398.9 ha (Fig.3)
Ground water resource availability and extraction	**Aquifer – I** (Up to 100 mbgl depth) Dynamic Ground Water Resources- 107.66 ham Total Ground Water Draft- 60.41 ham (On proportionate basis from block resources)
Existing and future water demands	d. Existing domestic water demand-2.93 ham Domestic water demand during 2035 – 43.45 ham e. Existing irrigation water demand- 94 ham Irrigation water demand during 2035- 1410 ham
Gap of demand during 2035	Considering 47 ham balance dynamic ground water resources during 2020, only 705 ham cumulative ground water resources will be available during 2035. Therefore, a gap of 748.45 ham dynamic groundwater resources will exist during 2035.
Water level behaviour	9.4 mbgl during pre monsoon (Fg.4a) 1.58 mbgl during post monsoon (Fig.4b) Annual Fluctuation – 7.82 metre rising (Fig.4c) 0.2 to 0.5 cm/year rising and 0.2 rising – 1.4 cm/yr. falling decadal water level trend (Fig-4d).

2. Aquifer Disposition	
Number of aquifers	Aquifer I- up to 30 mbgl in weathered zone Aquifer II- Fracture zone 65-68 mbgl depth ranges (Weathered zone-30 meter and rest is fractured granite gneiss, Fracture zone-65-68 mbgl, Discharge-2.5 lps).
	Geology- Precambrian granite gneiss in most of the parts (Consolidated formation) and unconsolidated formation along the drainage channels. Weathered zone up to 30 mbgl and as fracture zone 65-68 mbgl (as per exploratory tube well at Kumbha bandh). Aquifer is unconfined in weathered zone and semiconfined in fracture zone.
3. Ground water resource, extraction, contamination and other issues	
Aquifer wise resource availability and extraction	Dynamic ground water resources as on 31.3.2017 Dynamic Ground Water Resources- 107.66 ham Total Ground Water Draft- 60.41 ham Stage of Ground Water Extraction-56.12% Category- Safe
Chemical quality of ground water and contamination	Electrical Conductivity (µS/cm)- 1070 TDS(mg/l)-537 Ca^{++}(mg/l)-71 Mg^{++}(mg/l)-53 Na^{+}(mg/l)-58 K^{+}(mg/l)-7.5 HCO_3(mg/l)-187 $SO_4^{=}$ (mg/l)-59 Cl (mg/l)- 197 NO_3^{-}(mg/l) – 46 F (mg/l) -0.6 The concentration of cations for shallow aquifer is characterized by Ca>Na>Mg>K and concentration of anions is characterized by HCO_3>Cl> SO_4>NO_3>F. Here, alkaline earth elements are more than alkali elements and weak acid is more than strong acid. So, the type of water is Ca-Mg-HCO_3 type. High value of Na and TDS can be explained due to evapotranspiration and using higher quantity of fertilizer. All elements are found within permissible limit except nitrate. So, ground water will be suitable for drinking, irrigation and industrial use.
Other issues	Present water availability is 107.66 ham Water demand as on 2035- 1453.45 ham Gap will be 748.45 ham during 2035.
4. Ground water resource enhancement	
Artificial recharge techniques	Rainfall recharge by adoption of 75 number of farm pond (1 pond per hector only considering agricultural land area) – 14.7 ham Recharge by constructing 10 number of check dam at

	the confluence point of two streams- 2.5 ham (considering water holding capacity of one check dam is 2500 cubic metre) Rainfall recharge by adoption of 43 number of roof top rainwater harvesting structure (1 structure for 10 houses in village) – 0.7 ham Average annual rainfall considered 1308 mm Total Volume of Water expected to be conserved- 17.9 ham
5. Demand side interventions	
Advanced Irrigation Practices	750 ha agricultural area are proposed to be covered for subsurface drip irrigation practices during summer and Volume of Water expected to be conserved will be 60% of 57 ham (only irrigation draft) =34 ham. So, another 57 dug wells may be constructed for ground water development.
Change in cropping pattern	**Fruit crops**: Grapes, banana, banana, pomegranates, mango, orange, cashew nuts, papaya, litchi, watermelon. **Vegetable plants**: Onion, brinjal, bitter gourd, ridge gourd, cucumber, tomato, chilly, capsicum etc. **Oil seeds**: Sunflower, oil palm. **Forest crop**: Bamboo, teakwood
Reflected results after adoption of Ground water enhancement and demand side interventions	An annual amount of approximately 51.9 ham (considered recharge from farm pond, check dam, roof top and from drip irrigation) water will be conserved and after 15 years total conserved amount will be 778.5 ham which will exceed the gap of 748.45 ham during 2035.

Fig.1.

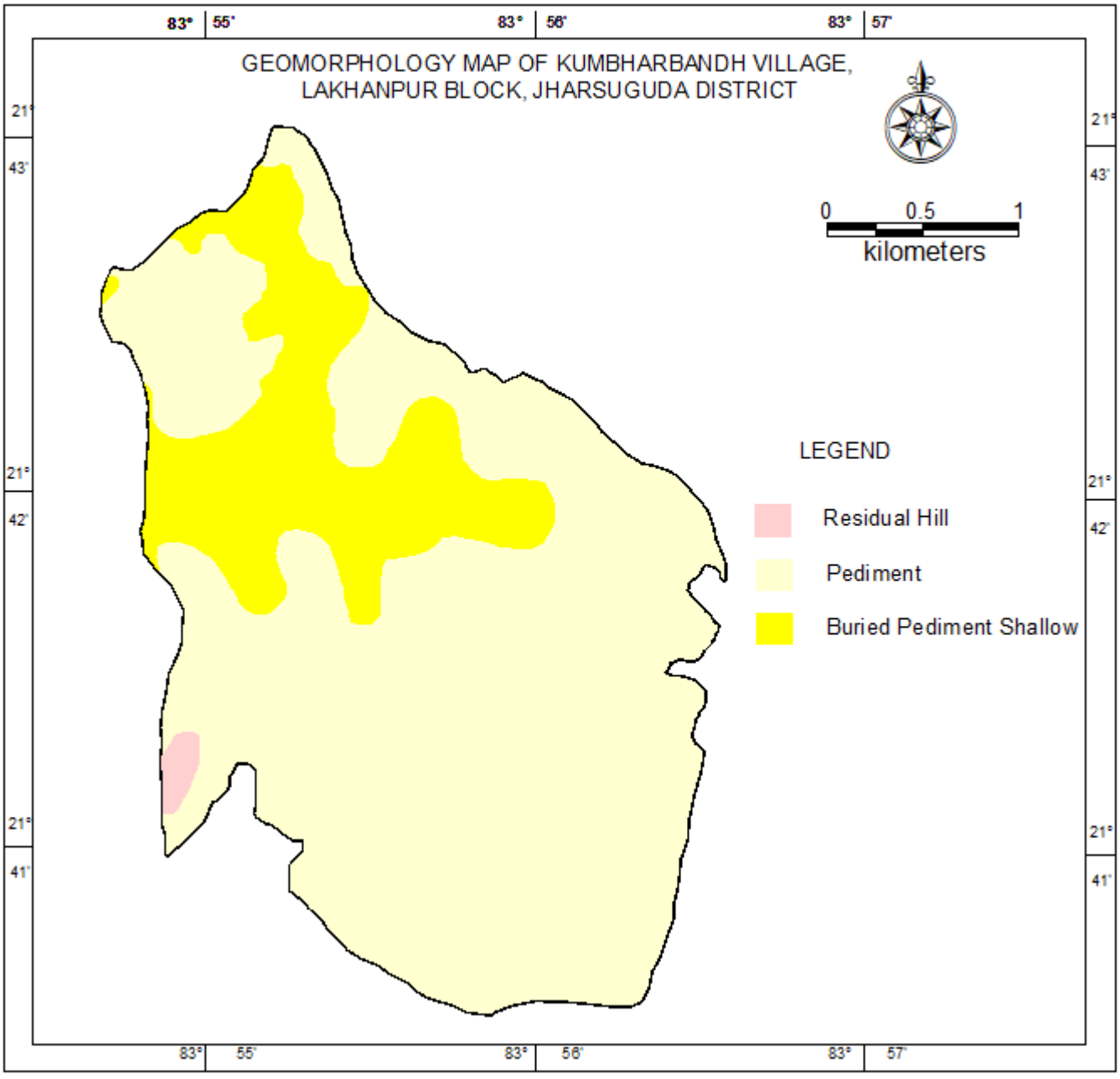

GEOMORPHOLOGY MAP OF KUMBHARBANDH VILLAGE,
LAKHANPUR BLOCK, JHARSUGUDA DISTRICT
83° 55'
83° 56'
83° 57'
21° 43'
21° 42'
21° 41'
0 0.5 1
kilometers
LEGEND
Residual Hill
Pediment
Buried Pediment Shallow

Fig.2.

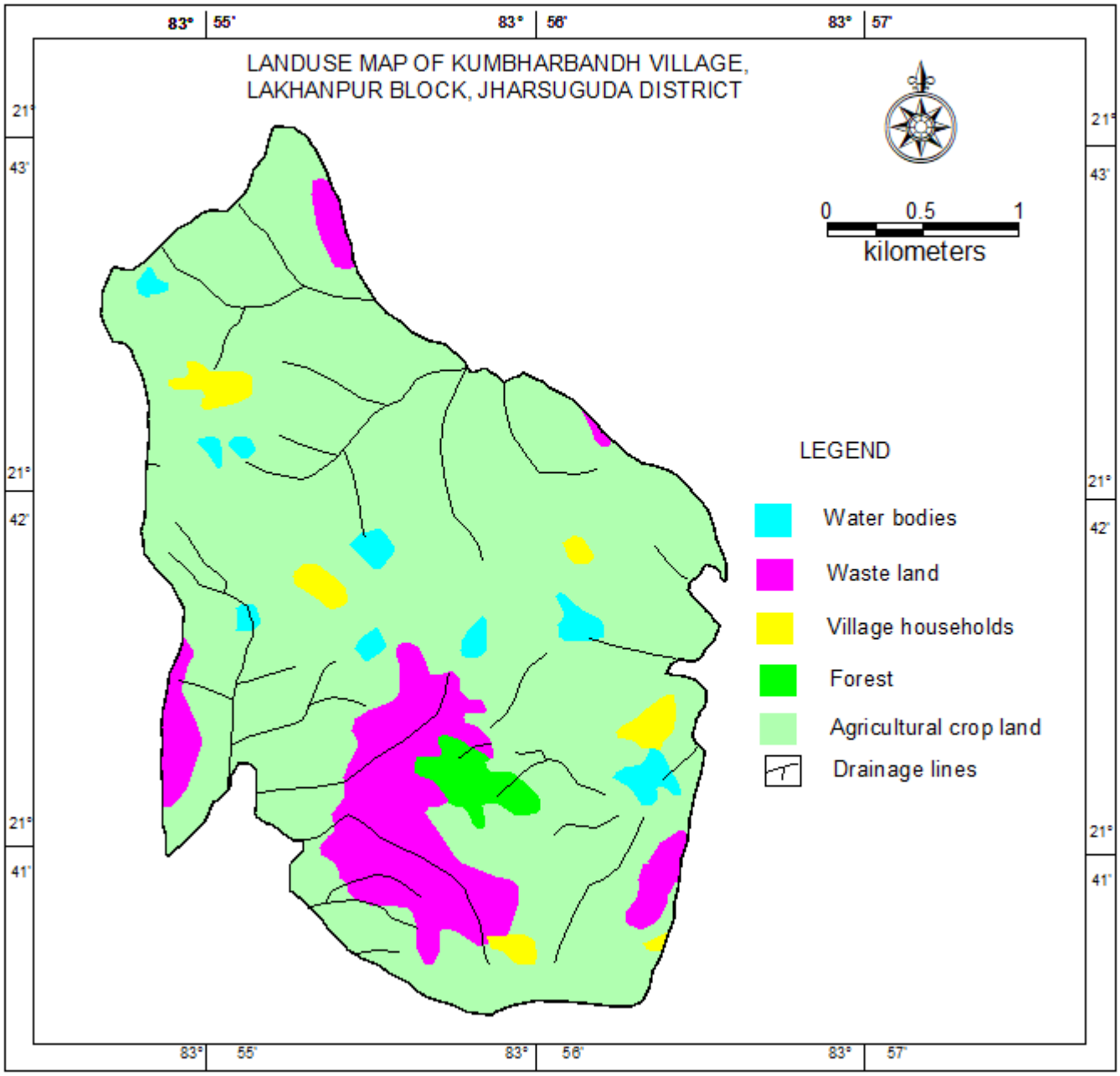

LANDUSE MAP OF KUMBHARBANDH VILLAGE,
LAKHANPUR BLOCK, JHARSUGUDA DISTRICT
83° 55'
83° 56'
83° 57'
21° 43'
21° 42'
21° 41'
0 0.5 1
kilometers
LEGEND
Water bodies
Waste land
Village households
Forest
Agricultural crop land
Drainage lines

Fig.3.

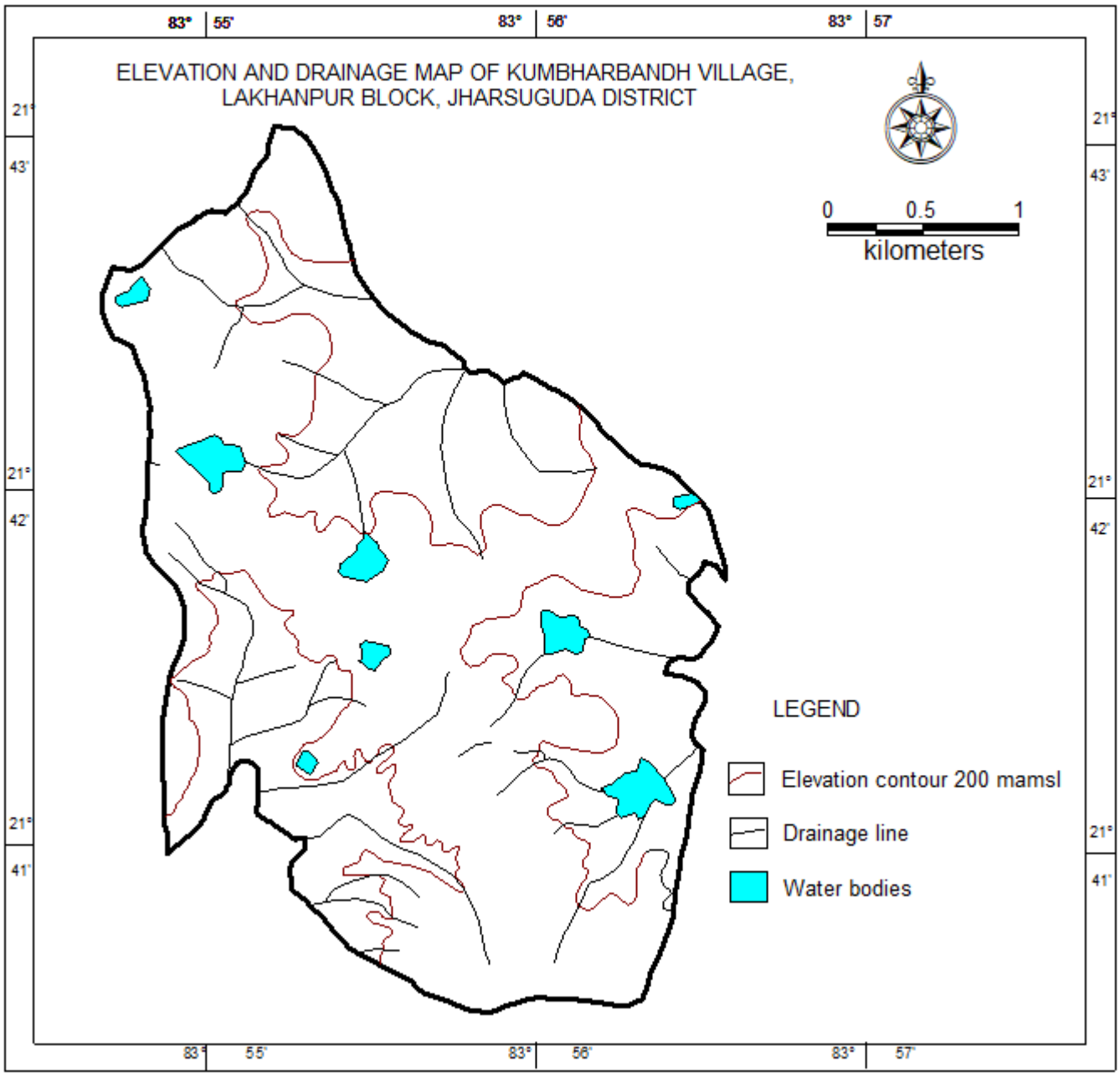

83° 55'
83° 56'
83° 57'
ELEVATION AND DRAINAGE MAP OF KUMBHARBANDH VILLAGE,
LAKHANPUR BLOCK, JHARSUGUDA DISTRICT
21° 43'
21° 42'
21° 41'
0 0.5 1
kilometers
LEGEND
Elevation contour 200 mamsl
Drainage line
Water bodies

Fig.4a.

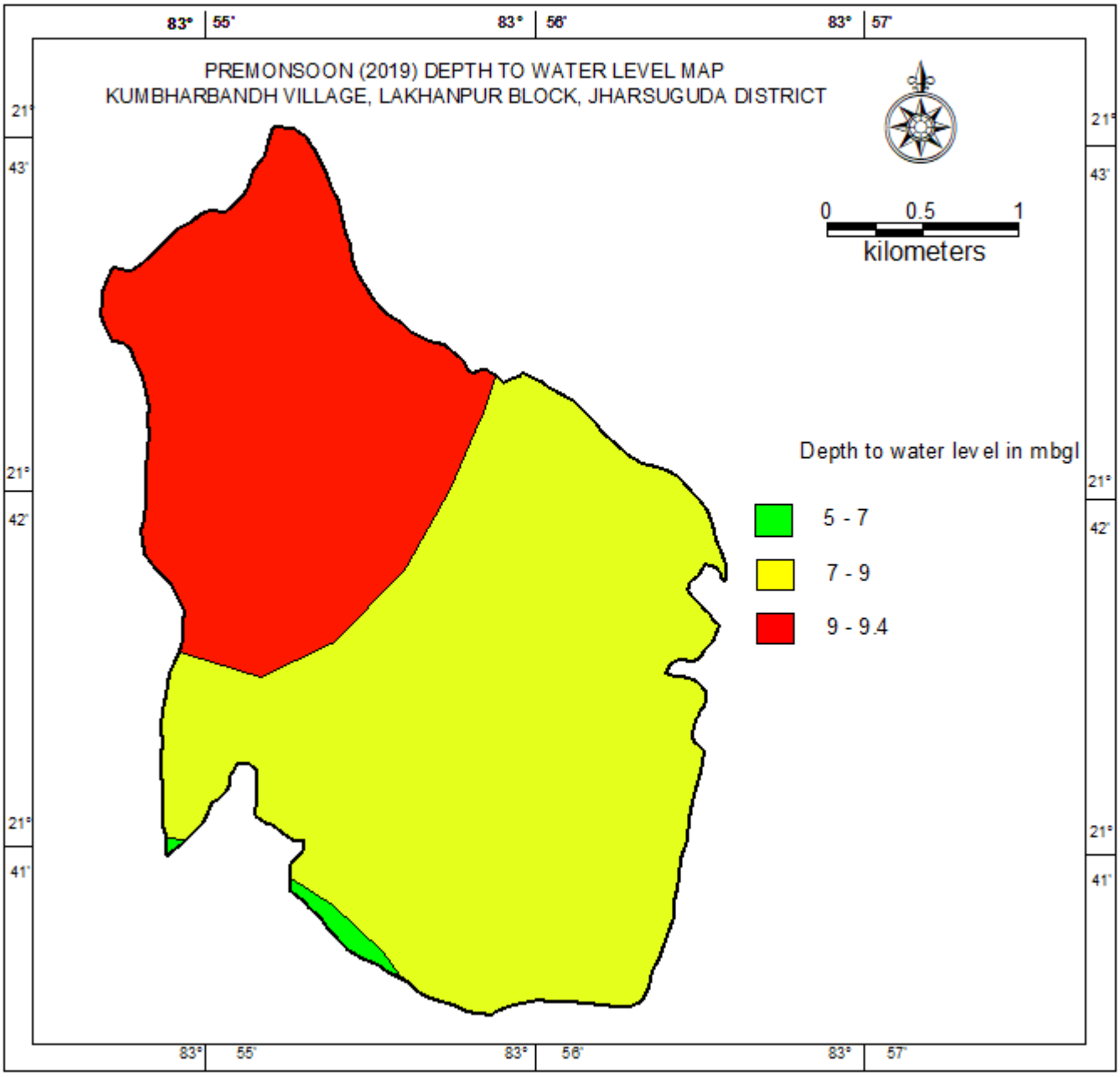

PREMONSOON (2019) DEPTH TO WATER LEVEL MAP
KUMBHARBANDH VILLAGE, LAKHANPUR BLOCK, JHARSUGUDA DISTRICT
83° 55'
83° 56'
83° 57'
21° 43'
21° 42'
21° 41'
0 0.5 1
kilometers
Depth to water level in mbgl
5 - 7
7 - 9
9 - 9.4

Fig.4b.

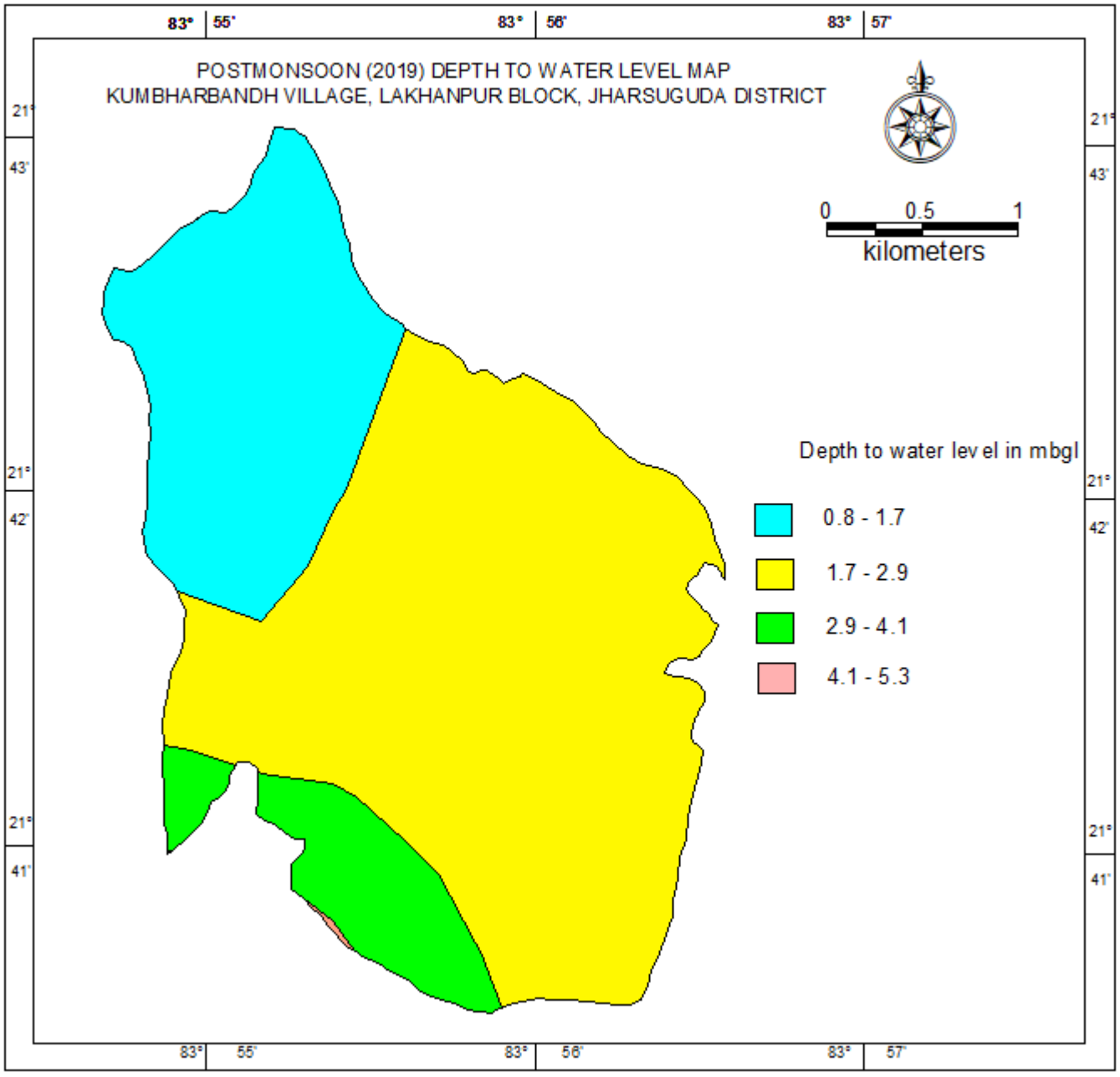

83° 55'
83° 56'
83° 57'
POSTMONSOON (2019) DEPTH TO WATER LEVEL MAP
KUMBHARBANDH VILLAGE, LAKHANPUR BLOCK, JHARSUGUDA DISTRICT
21° 43'
21° 42'
21° 41'
0 0.5 1
kilometers
Depth to water level in mbgl
0.8 - 1.7
1.7 - 2.9
2.9 - 4.1
4.1 - 5.3

Fig.4c.

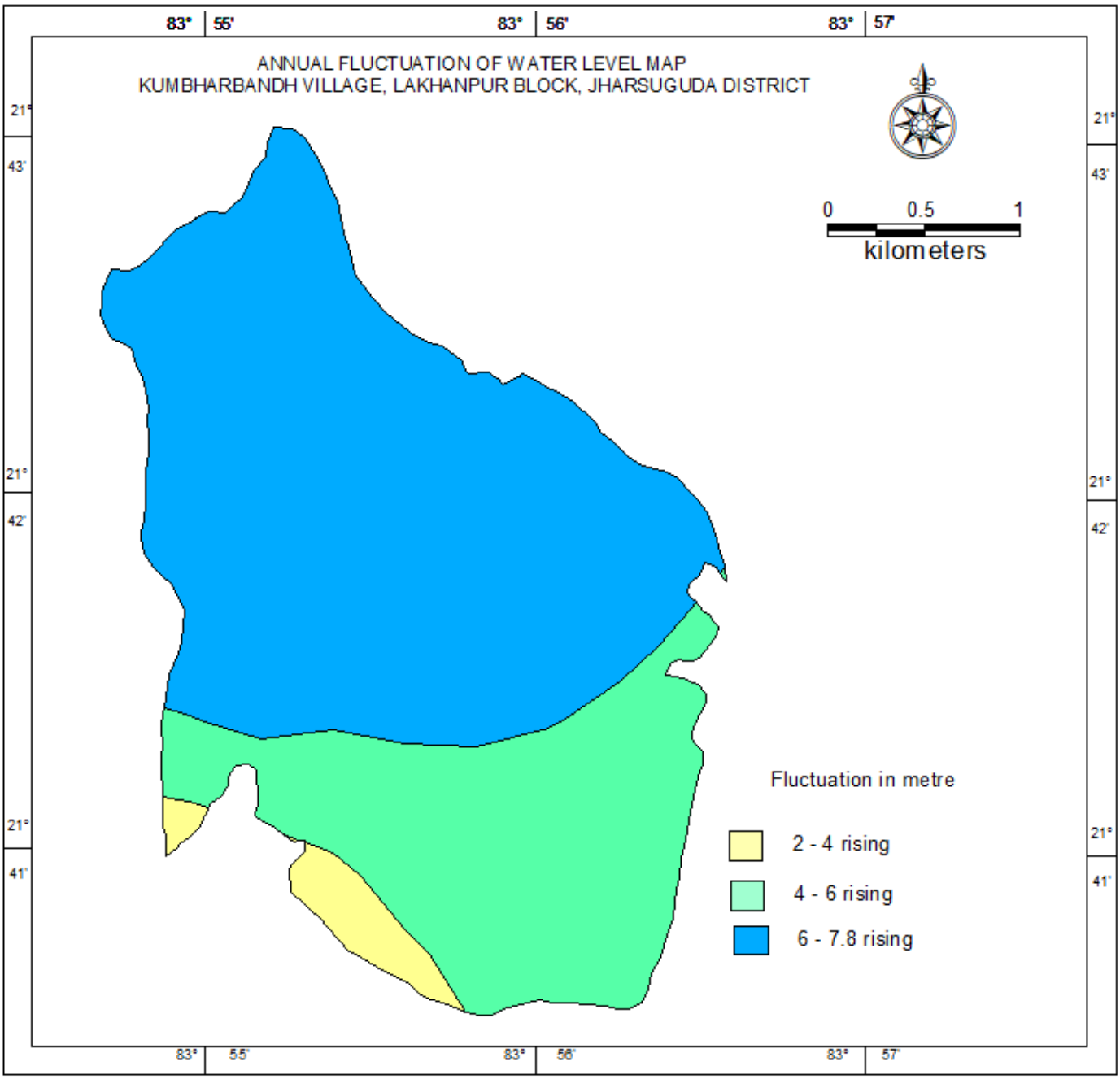
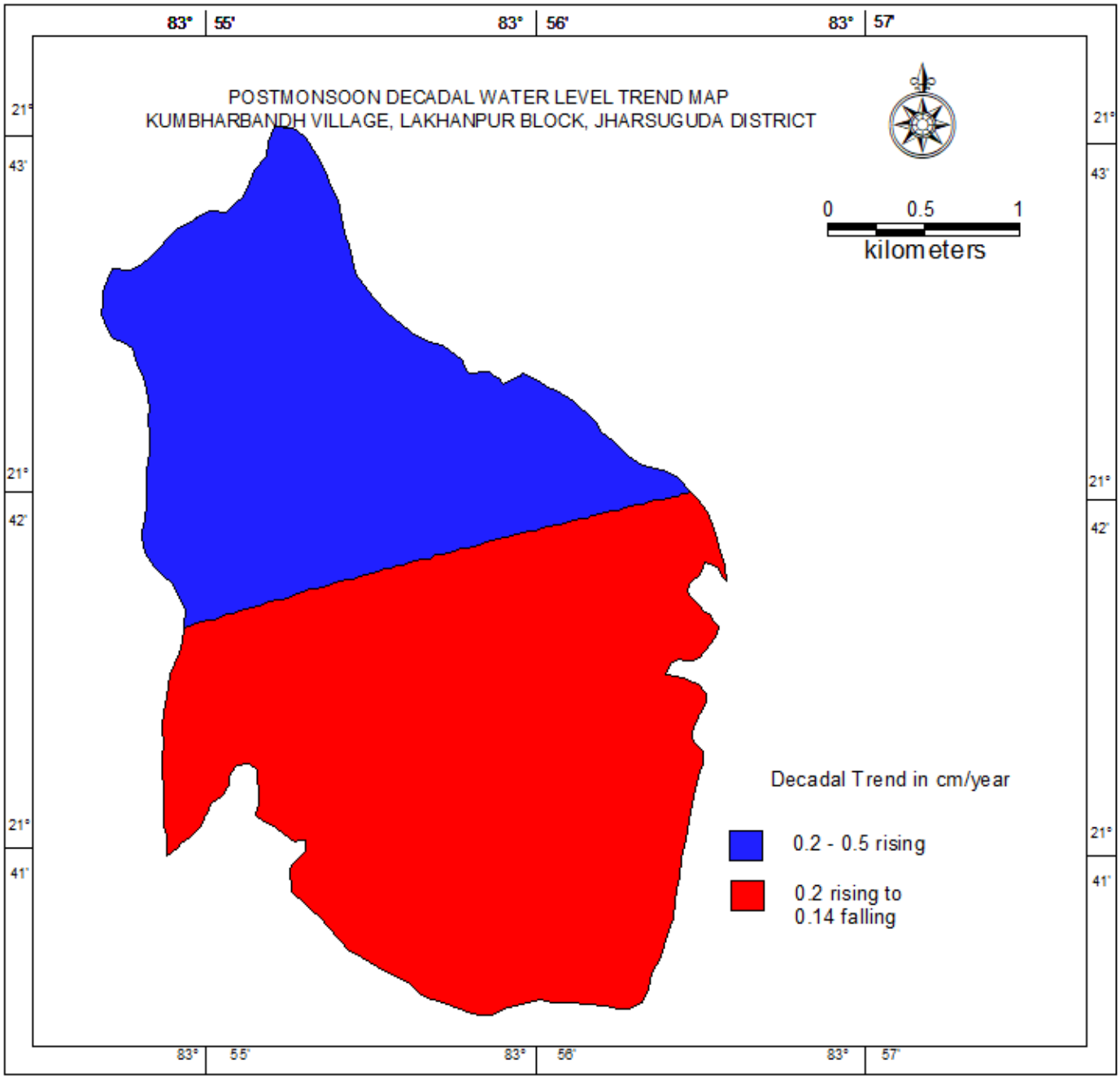

ANNUAL FLUCTUATION OF WATER LEVEL MAP
KUMBHARBANDH VILLAGE, LAKHANPUR BLOCK, JHARSUGUDA DISTRICT
83° 55'
83° 56'
83° 57'
21° 43'
21° 42'
21° 41'
0 0.5 1
kilometers
Fluctuation in metre
2 - 4 rising
4 - 6 rising
6 - 7.8 rising

Fig.4d.


83° 55'
83° 56'
83° 57'
POSTMONSOON DECADAL WATER LEVEL TREND MAP
KUMBHARBANDH VILLAGE, LAKHANPUR BLOCK, JHARSUGUDA DISTRICT
21° 43'
21° 42'
21° 41'
0 0.5 1
kilometers
Decadal Trend in cm/year
0.2 - 0.5 rising
0.2 rising to
0.14 falling

VILLAGE LEVEL AQUIFER MAPPING AND MANAGEMENT PLAN OF BAGDEHI VILLAGE, BLOCK-LAKHANPUR, DISTRICT JHARSUGUDA

1. Salient Information	
Name of the Village and Area (in ha)	Bagdehi Area- 161 ha
Block/District/ State	Kirimira /Jharsuguda/ Odisha
Population	415 (Projected population as on 2020 w.r.t 2011 census), growth rate is 12.24%
Rainfall	Normal Monsoon rainfall-1205 mm (Considered Block avg.) Non-monsoon Rainfall-130 mm (Considered Block avg.)
Geomorphology	Pediment Buried shallow pediment Valley fill Inselberg (Fig.5)
Drainage and water body	12 number of first order stream, 4 second order stream 9 number of ponds (Fig.6)
Landuse, Agriculture and Irrigation	**Forest-**7.8 ha **Area under non-agricultural use-**10.7 ha **Barren and uncultivable land-**5.9 ha **Permanent pastures and other grazing lands**-2.9 ha **Land Under Miscellaneous Tree Crops etc.-**2.1 ha **Culturable Waste Land**-4.7 ha **Fallow lands other than current fallows**- 0.5 ha **Current fallow-**42.6ha **Net shown area-**83.7 ha **Total irrigated area-** 83.7 ha **Principal crops**-Cereal, Pulses, Oil Seeds, Vegetable Crops (Considered Block avg.) **Irrigation practices** I. Canal irrigation- 83.7 ha (Fig.7)
Ground water resource availability and extraction	**Aquifer – I** (up to 100 mbgl depth) Dynamic Ground Water Resources- 19.52 ham Total Ground Water Draft- 7.29 ham (On proportionate basis from block resources)
Existing and future water demands	f. Existing domestic water demand-0.94 ham g. Cumulative Domestic water demand as on 2035 – 14.11 ham h. Existing irrigation water demand- 5.89 ham i. Cumulative irrigation water demand as on 2035- 88.35 ham (On proportionate basis from block resources)
Gap of demand during 2035, if any	Considering 12.23 ham balance dynamic ground water resources during 2020, only 183.45 ham cumulative ground water resources will be available during 2035. Therefore, a surplus ground water resources of 68.35 ham will exist during 2035.

Water level behaviour	7.2 mbgl during pre monsoon (Fg.8a) 1.55 mbgl during post monsoon (Fig.8b) Annual Fluctuation – 5.65 metre rising (Fig.8c) 0.19 cm/year rising and 0.14 – 1.16 cm/yr. falling decadal water level trend (Fig-4d).
2. Aquifer Disposition	
Number of aquifers	Single aquifer up to 100 mbgl depth (Weathered zone-10 meter and rest is fractured granite gneiss).
	Geology- Precambrian granite gneiss in 25% area (southern extreme parts) of the village (Consolidated formation), Precambrian schist, quartz schist in 75% area (north, central, east, west) and unconsolidated formation along the drainage channels. Weathered zone up to 10 mbgl and as fracture zone up to 30 meters (as per available information from hand pump of RWSS, Kirimira). Aquifer is unconfined.
3. Ground water resource, extraction, contamination and other issues	
Aquifer wise resource availability and extraction	Dynamic ground water resources as on 31.3.2017 Dynamic Ground Water Resources- 19.52 ham Total Ground Water Draft- 7.29 ham Stage of Ground Water Extraction-37.34% Category- Safe
Chemical quality of ground water and contamination	Electrical Conductivity (µS/cm)- 890 TDS (mg/l)-506 Ca^{++}(mg/l)-48 Mg^{++}(mg/l)-14 Na^{+}(mg/l)-77 K^{+}(mg/l)-76 HCO_3(mg/l)-223 $SO_4^{=}$ (mg/l)-85 Cl (mg/l)-97 NO_3^{-}(mg/l) – 42 F (mg/l) -0.13 The concentration of cations for shallow aquifer is characterized by Na>K>Ca>Mg and concentration of anions is characterized by HCO_3>Cl> SO_4>NO_3>F. Here, alkaline elements are more than alkali earth elements and weak acid is more than strong acid. So, the type of water is Na-K-Ca-Mg-HCO_3 type. High value of Na and TDS can be explained due to evapotranspiration and using higher quantity of fertilizer. All elements are found within permissible limit except nitrate. So, ground water will be suitable for drinking, irrigation and industrial use.
Other issues	Decadal water level trend in most of the areas are showing falling trend (0.14 cm/year to 1.16 cm/year falling). Annual ground water level fluctuation is more than 7 meter which may causes drying up of most of the

	dug wells and minimum discharge from shallow hand pump during summer time. So artificial recharge and water conservation needs to be adopted.
4. Ground water resource enhancement	
Artificial recharge techniques and Water conservation	Rainfall recharge by adoption of 16 number of farm pond (1 pond per hector only considering agricultural land area) – 3.2 ham Recharge by constructing 9 number of check dam/gully plug at the confluence point of two streams- 2.25 ham (considering water holding capacity of one check dam is 2500 cubic metre) Rainfall recharge by adoption of 11 number of roof top rainwater harvesting structure (1 structure for 10 houses in village) – 0.2 ham Average annual rainfall considered 1308 mm Total Volume of Water expected to be conserved- 5.65 ham All ponds need to be desilted before monsoon for water conservation.
5. Demand side interventions	
Advanced Irrigation Practices	Net ground water resources available for future irrigation-12.15 ham Possible additional irrigation potential area (only taking 50% surplus resources for future irrigation) can be created - 4.76 ha Agricultural area is proposed to be covered for subsurface drip irrigation practices during summer and Volume of Water expected to be conserved will be 60% of 6.07 ham (only irrigation draft) =3.64 ham. So, another 5 dug wells may be constructed for ground water development.
Change in cropping pattern	**Fruit crops**: Grapes, banana, banana, pomegranates, mango, orange, cashew nuts, papaya, litchi, watermelon. **Vegetable plants**: Onion, brinjal, bitter gourd, ridge gourd, cucumber, tomato, chilly, capsicum etc. **Oil seeds**: Sunflower, oil palm. **Forest crop**: Bamboo, teakwood
Reflected results after adoption of Ground water enhancement and demand side interventions	An annual amount of approximately 5.65 ham (Only considered farm recharge and household recharge) water will be conserved and after 15 years total conserved amount will be 20.65 ham which may improve the water level and quality in long run.

Fig.5.

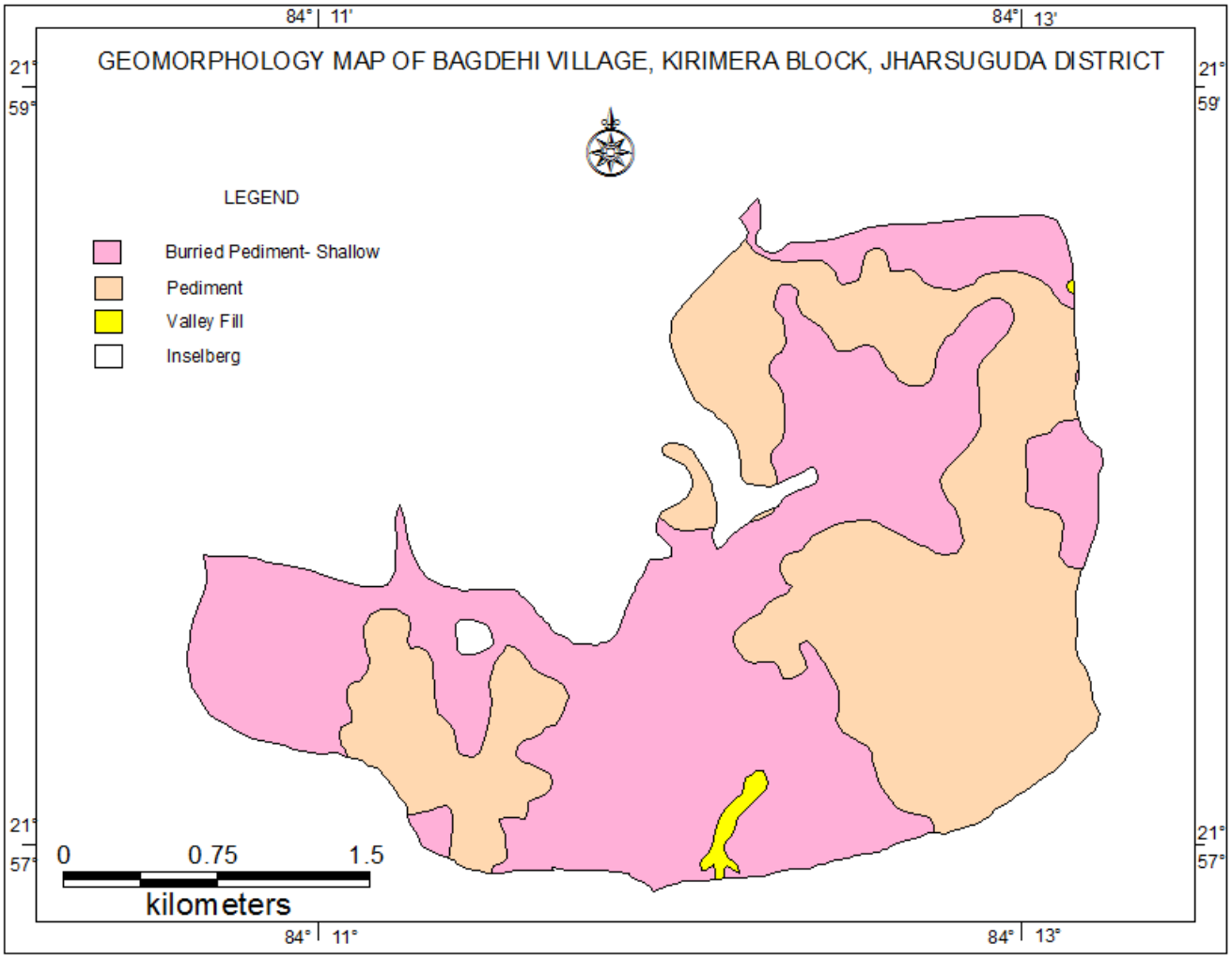

GEOMORPHOLOGY MAP OF BAGDEHI VILLAGE, KIRIMERA BLOCK, JHARSUGUDA DISTRICT
84° 11'
84° 13'
21° 59'
21° 57'
LEGEND
Burried Pediment- Shallow
Pediment
Valley Fill
Inselberg
0
0.75
1.5
kilometers

Fig.6.

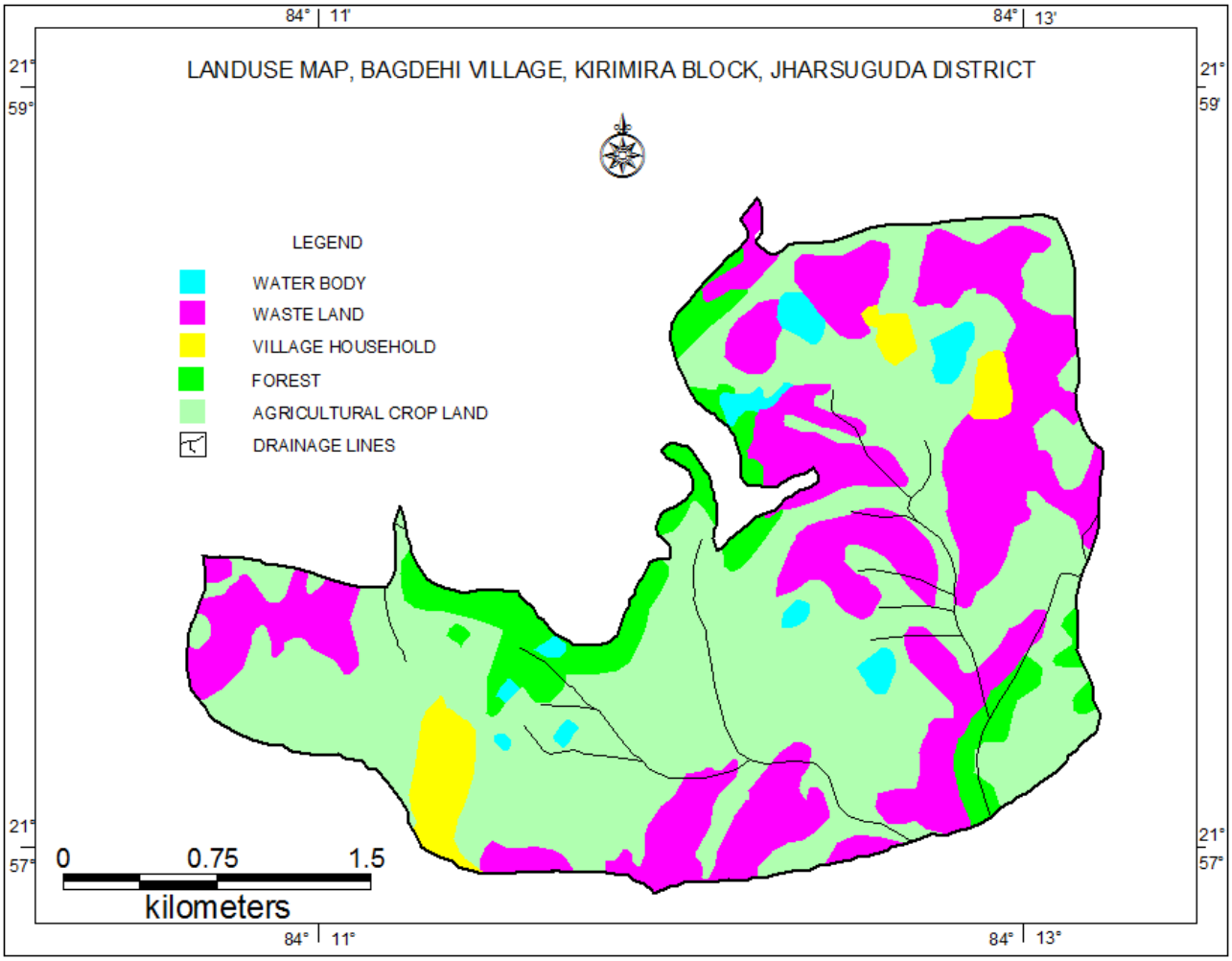

LANDUSE MAP, BAGDEHI VILLAGE, KIRIMIRA BLOCK, JHARSUGUDA DISTRICT
84° 11'
84° 13'
21° 59°
21° 57°
LEGEND
WATER BODY
WASTE LAND
VILLAGE HOUSEHOLD
FOREST
AGRICULTURAL CROP LAND
DRAINAGE LINES
0
0.75
1.5
kilometers

Fig.7.

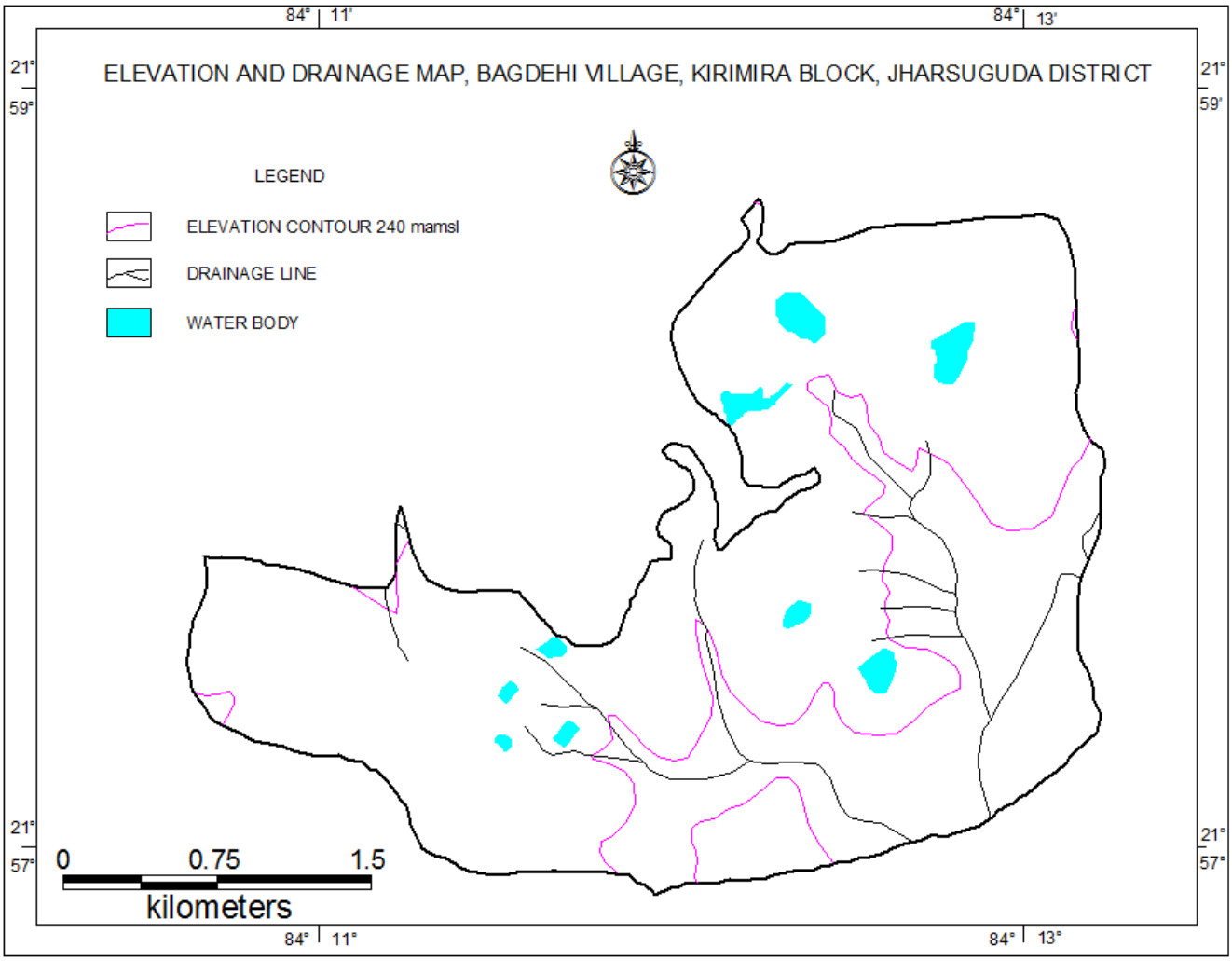

84° 11'
84° 13'
21° 59'
ELEVATION AND DRAINAGE MAP, BAGDEHI VILLAGE, KIRIMIRA BLOCK, JHARSUGUDA DISTRICT
LEGEND
ELEVATION CONTOUR 240 mamsl
DRAINAGE LINE
WATER BODY
21° 57'
0 0.75 1.5
kilometers
84° 11°
84° 13°

Fig.7a.

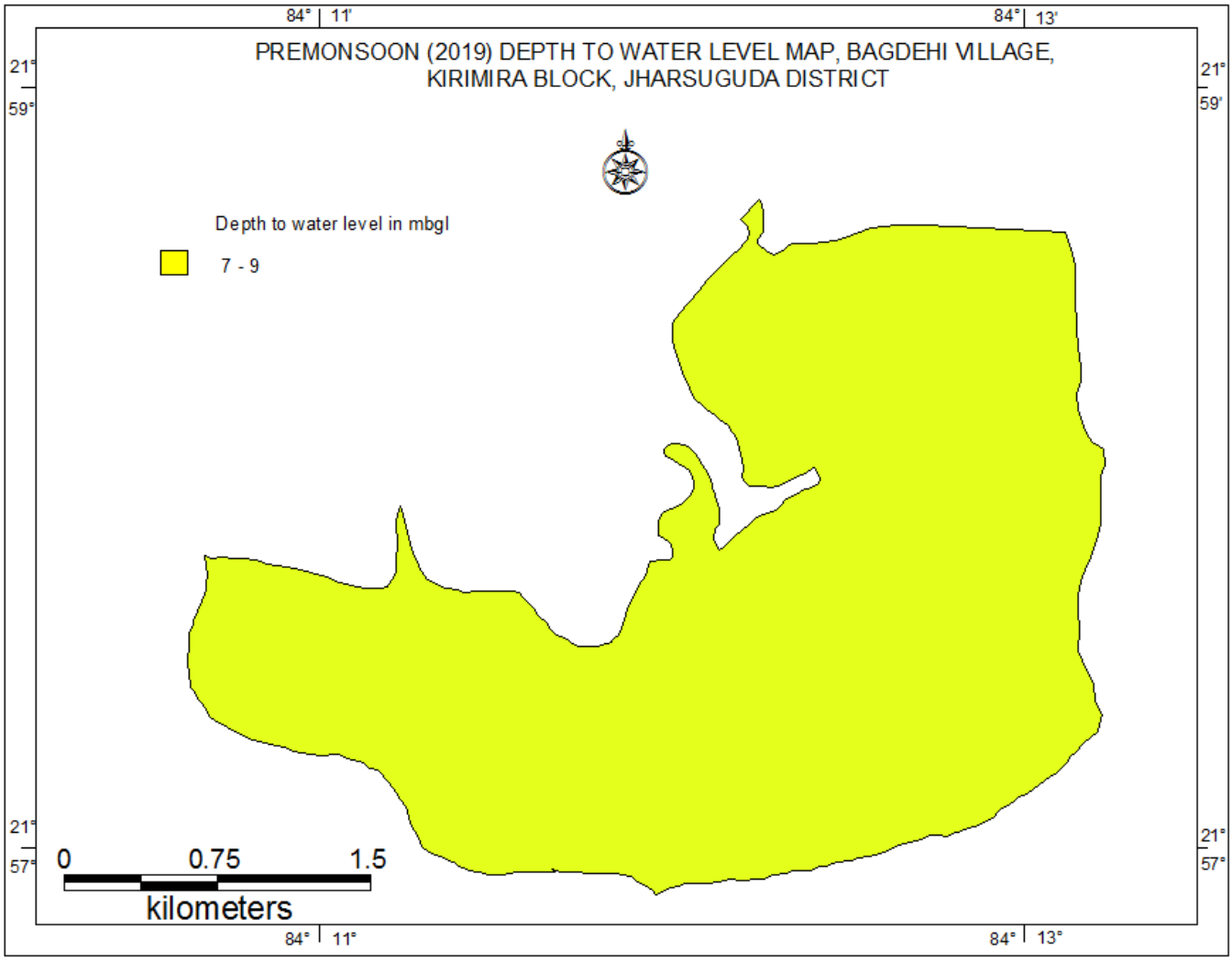

84° 11'
84° 13'
PREMONSOON (2019) DEPTH TO WATER LEVEL MAP, BAGDEHI VILLAGE,
KIRIMIRA BLOCK, JHARSUGUDA DISTRICT
21° 59'
Depth to water level in mbgl
7 - 9
21° 57'
0 0.75 1.5
kilometers
84° 11°
84° 13°

Fig.7b.

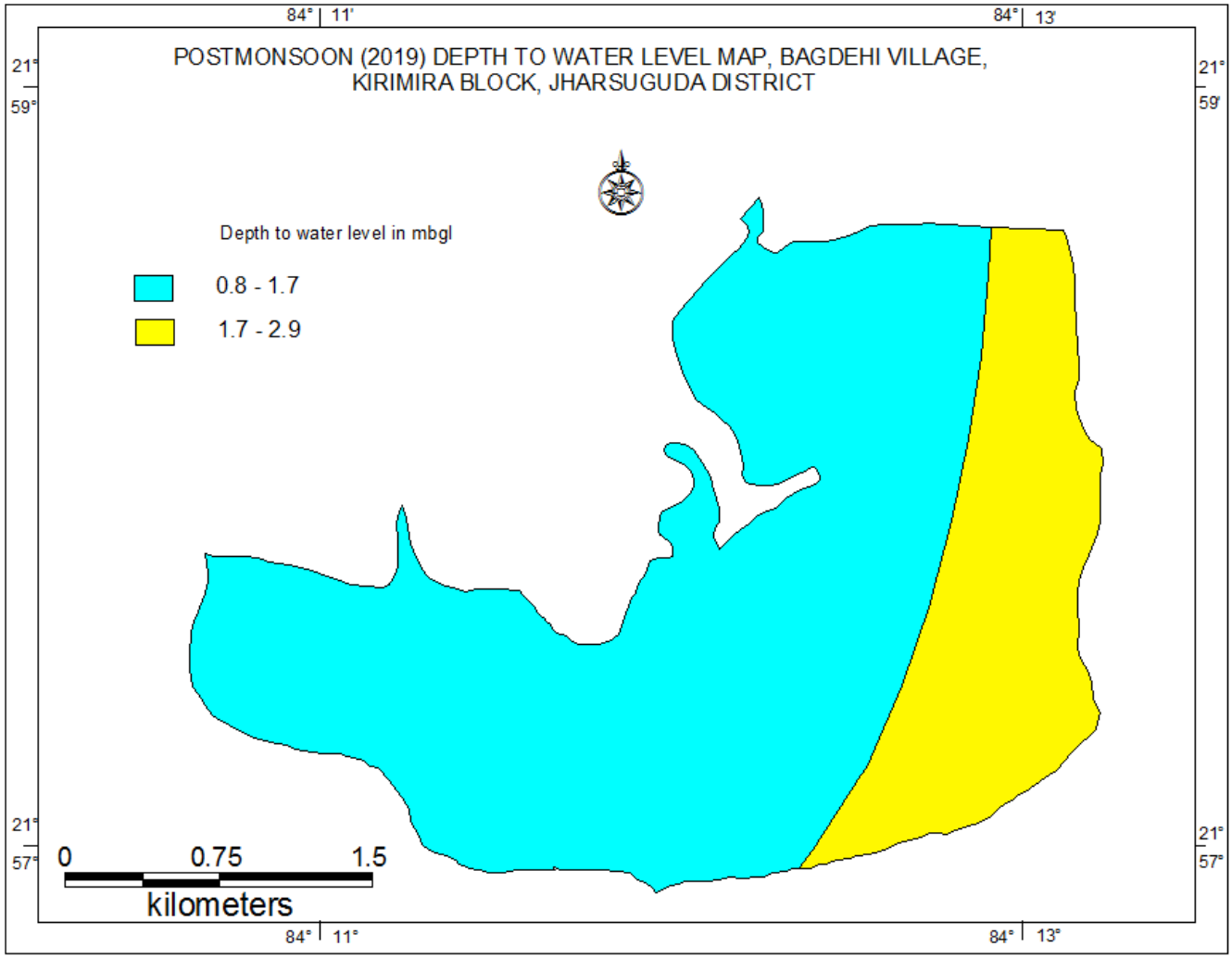

84° 11'
84° 13'
21° 59°
21° 59'
POSTMONSOON (2019) DEPTH TO WATER LEVEL MAP, BAGDEHI VILLAGE,
KIRIMIRA BLOCK, JHARSUGUDA DISTRICT
Depth to water level in mbgl
0.8 - 1.7
1.7 - 2.9
21° 57°
21° 57°
0
0.75
1.5
kilometers
84° 11°
84° 13°

Fig.7c.

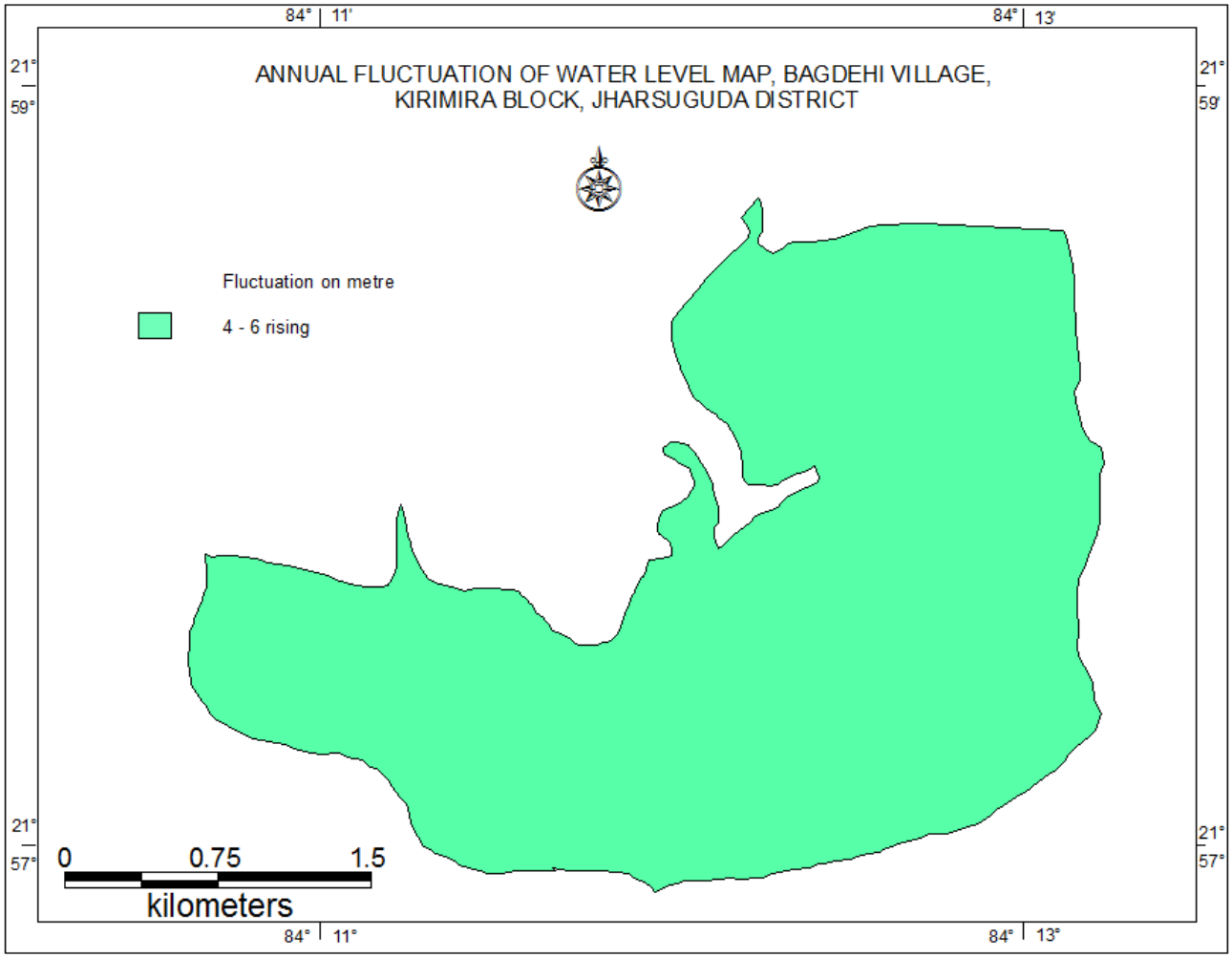
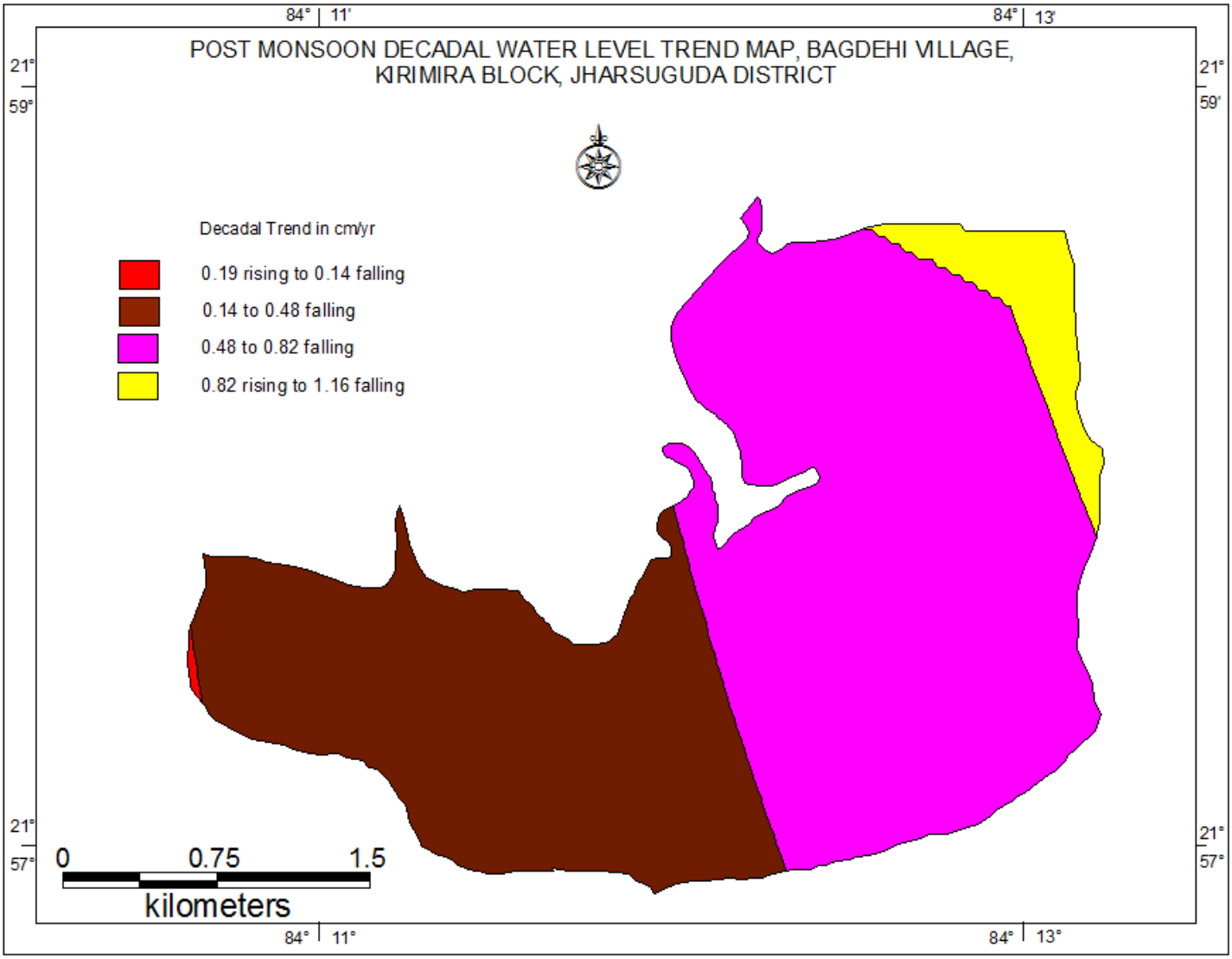

84° 11'
84° 13'
21° 59°
21° 59'
ANNUAL FLUCTUATION OF WATER LEVEL MAP, BAGDEHI VILLAGE,
KIRIMIRA BLOCK, JHARSUGUDA DISTRICT
Fluctuation on metre
4 - 6 rising
21° 57°
21° 57°
0 0.75 1.5
kilometers
84° 11°
84° 13°

Fig.7d.


84° 11'
84° 13'
POST MONSOON DECADAL WATER LEVEL TREND MAP, BAGDEHI VILLAGE,
KIRIMIRA BLOCK, JHARSUGUDA DISTRICT
21° 59'
21° 57'
Decadal Trend in cm/yr
0.19 rising to 0.14 falling
0.14 to 0.48 falling
0.48 to 0.82 falling
0.82 rising to 1.16 falling
0
0.75
1.5
kilometers
84° 11°
84° 13°

VILLAGE LEVEL AQUIFER MAPPING AND MANAGEMENT PLAN OF RAMACHIPIDI VILLAGE, BLOCK-LAIKERA, DISTRICT JHARSUGUDA

1. Salient Information	
Name of the Village and Area (in ha)	Ramachipidi Area- 448 ha
Block/District/ State	Laikera /Jharsuguda/ Odisha
Population	1011 (Projected population as on 2020 w.r.t 2011 census), growth rate is 12.24%
Rainfall	Normal Monsoon rainfall-1115 mm (Considered Block avg.) Non-monsoon Rainfall-150 mm (Considered Block avg.)
Geomorphology	Pediment Buried shallow pediment (Fig.8)
Drainage and water body	6 number of first order stream, 1 second order stream 8 number of ponds (Fig.9)
Land use, Agriculture and Irrigation	**Forest-**0.6 ha **Area under non-agricultural use-** 48.8 ha **Barren and uncultivable land-** 30.1 ha **Permanent pastures and other grazing lands**- 8.1 ha **Land Under Miscellaneous Tree Crops etc.-** 0.6 ha **Culturable Waste Land**- 3.2 ha **Fallow lands other than current fallows**- 3.7 ha **Current fallow-** 0 ha **Net shown area-** 352.8 ha **Total irrigated area-** 352.8 ha **Principal crops**-Cereal, Pulses, Oil Seeds, Vegetable Crops (Considered Block avg.) **Irrigation practices** i. Canal irrigation- 352.8 ha (Fig.10)
Ground water resource availability and extraction	**Aquifer – I** (up to 100 mbgl depth) Dynamic Ground Water Resources- 44.17 ham Total Ground Water Draft- 24.78 ham (On proportionate basis from block resources)
Existing and future water demands	j. Existing domestic water demand-1.96 ham k. Cumulative Domestic water demand as on 2035 – 29.34 ham l. Existing irrigation water demand- 22.15 ham m. Cumulative irrigation water demand as on 2035- 332 ham (On proportionate basis from block resources)
Gap of demand during 2035, if any	Considering 20.06 ham balance dynamic ground water resources during 2020, only 301 ham cumulative ground

	water resources will be available during 2035.So a gap of 60.44 ham will exist during 2035.
Water level behaviour	8.06 mbgl during pre monsoon (Fg.11a) 2.73 mbgl during post monsoon (Fig.11b) Annual Fluctuation – 5.33 metre rising (Fig.11c) cm/yr. falling decadal water level trend (Fig-11d).
2. Aquifer Disposition	
Number of aquifers	Single aquifer up to 100 mbgl depth (Weathered zone-10 meter and rest is fractured granite gneiss).
	Geology- Precambrian granite gneiss in 10% area (southern extreme parts) of the village (Consolidated formation), Precambrian volcanic, lava quartzites (Consolidated) in 90% area (north, central, east, west) and unconsolidated formation along the drainage channels. Weathered zone up to 10 mbgl and as fracture zone up to 30 meters (as per available information from hand pump of RWSS, Laikera). Aquifer is unconfined.
3. Ground water resource, extraction, contamination and other issues	
Aquifer wise resource availability and extraction	Dynamic ground water resources as on 31.3.2017 Dynamic Ground Water Resources- 44.17 ham Total Ground Water Draft- 24.78 ham Stage of Ground Water Extraction-56.1% Category- Safe
Chemical quality of ground water and contamination	Electrical Conductivity (µS/cm)- 1310 TDS (mg/l)-656 Ca^{++}(mg/l)-115 Mg^{++}(mg/l)-72 Na^{+}(mg/l)-25 K^{+}(mg/l)-10 HCO_3(mg/l)-483 $SO_4^{=}$ (mg/l)-29 Cl (mg/l)-168 NO_3^{-}(mg/l) – 17 F (mg/l) -0.4 The concentration of cations for shallow aquifer is characterized by Ca>Mg>Na>K and concentration of anions is characterized by HCO_3>Cl> SO_4>NO_3>F. Here, alkaline earth elements are more than alkali elements and weak acid is more than strong acid. So, the type of water is Ca-Mg-HCO_3 type. All elements are found within permissible limit except EC. This may be due to high evapotranspiration in shallow aquifer during summer time. So ground water will be suitable for drinking, irrigation and industrial use.
Other issues	Decadal water level trend in most of the areas are showing falling trend (>1.49 cm/year falling). Annual

	ground water level fluctuation is more than 5 meter which may causes drying up of most of the dug wells and minimum discharge from shallow hand pump during summer time. So artificial recharge and water conservation needs to be adopted.
4. Ground water resource enhancement	
Artificial recharge techniques and Water conservation	Rainfall recharge by adoption of 45 number of farm pond (1 pond per hector only considering agricultural land area) – 8.8 ham Rainfall recharge by adoption of 24 number of roof top rainwater harvesting structure (1 structure for 10 houses in village) – 0.4 ham Average annual rainfall considered 1308 mm Total Volume of Water expected to be conserved- 9.2 ham All ponds need to be desilted before monsoon for water conservation.
5. Demand side interventions	
Advanced Irrigation Practices	Net ground water resources available for future irrigation-19.27 ham (on proportionate basis from block resources) Possible additional irrigation potential (only considering 50% surplus resources) area can be created with surplus water- 7.91 ha Agricultural area is proposed to be covered for subsurface drip irrigation practices during summer and Volume of Water expected to be conserved will be 60% of 9.63 ham (only irrigation draft) =5.78 ham. So, another 8 dug wells may be constructed for ground water development.
Change in cropping pattern	**Fruit crops**: Grapes, banana, banana, pomegranates, mango, orange, cashew nuts, papaya, litchi, watermelon. **Vegetable plants**: Onion, brinjal, bitter gourd, ridge gourd, cucumber, tomato, chilly, capsicum etc. **Oil seeds**: Sunflower, oil palm. **Forest crop**: Bamboo, teakwood
Reflected results after adoption of Ground water enhancement and demand side interventions	An annual amount of approximately 9.2 ham (Only considered farm recharge and household recharge) water will be conserved and after 15 years total conserved amount will be 138 ham which may exceed the gap of 60.44 ham during 2035.

Fig.8.

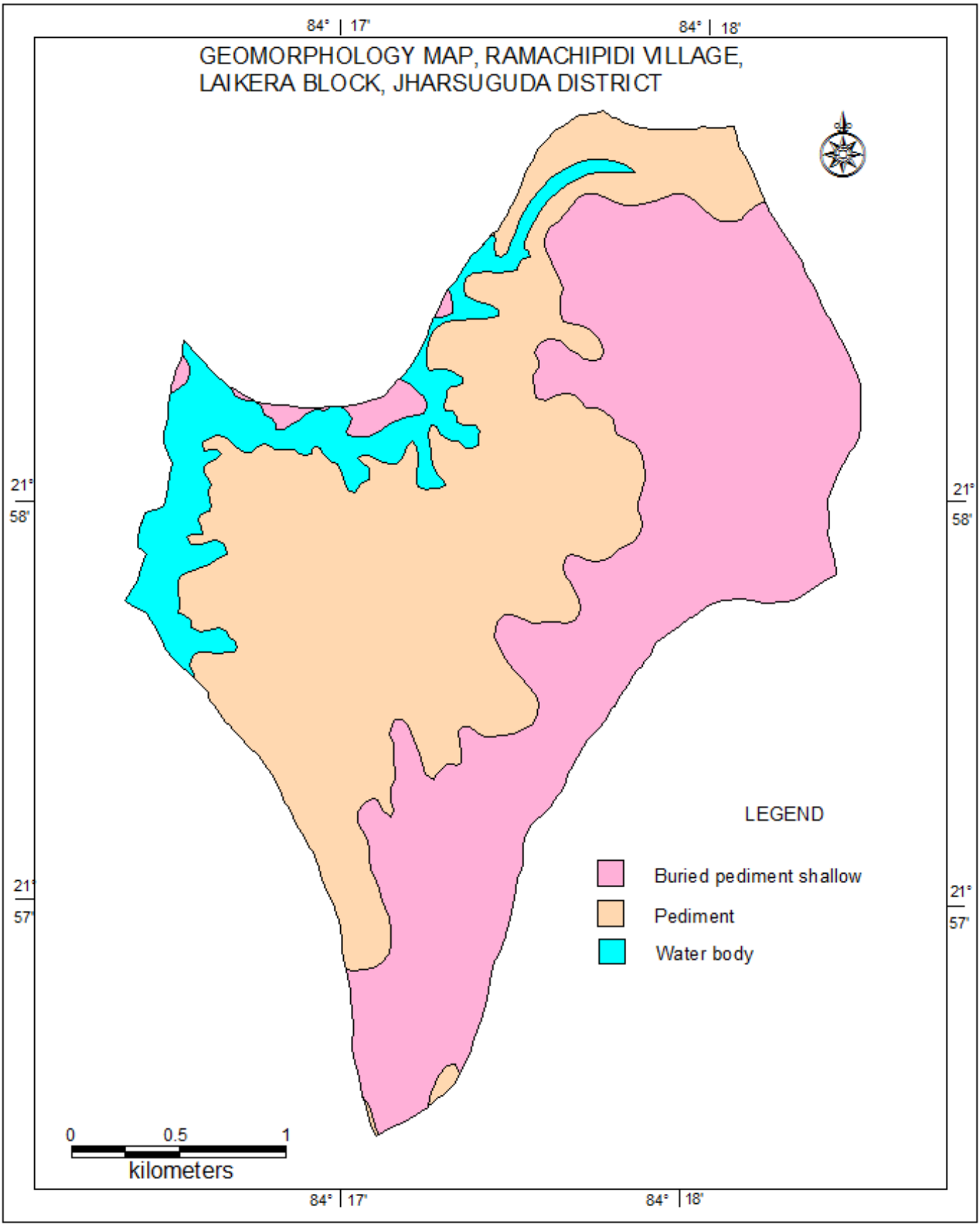

84° | 17'
84° | 18'
GEOMORPHOLOGY MAP, RAMACHIPIDI VILLAGE,
LAIKERA BLOCK, JHARSUGUDA DISTRICT
21° 58'
21° 57'
LEGEND
Buried pediment shallow
Pediment
Water body
0
0.5
1
kilometers

Fig.9.

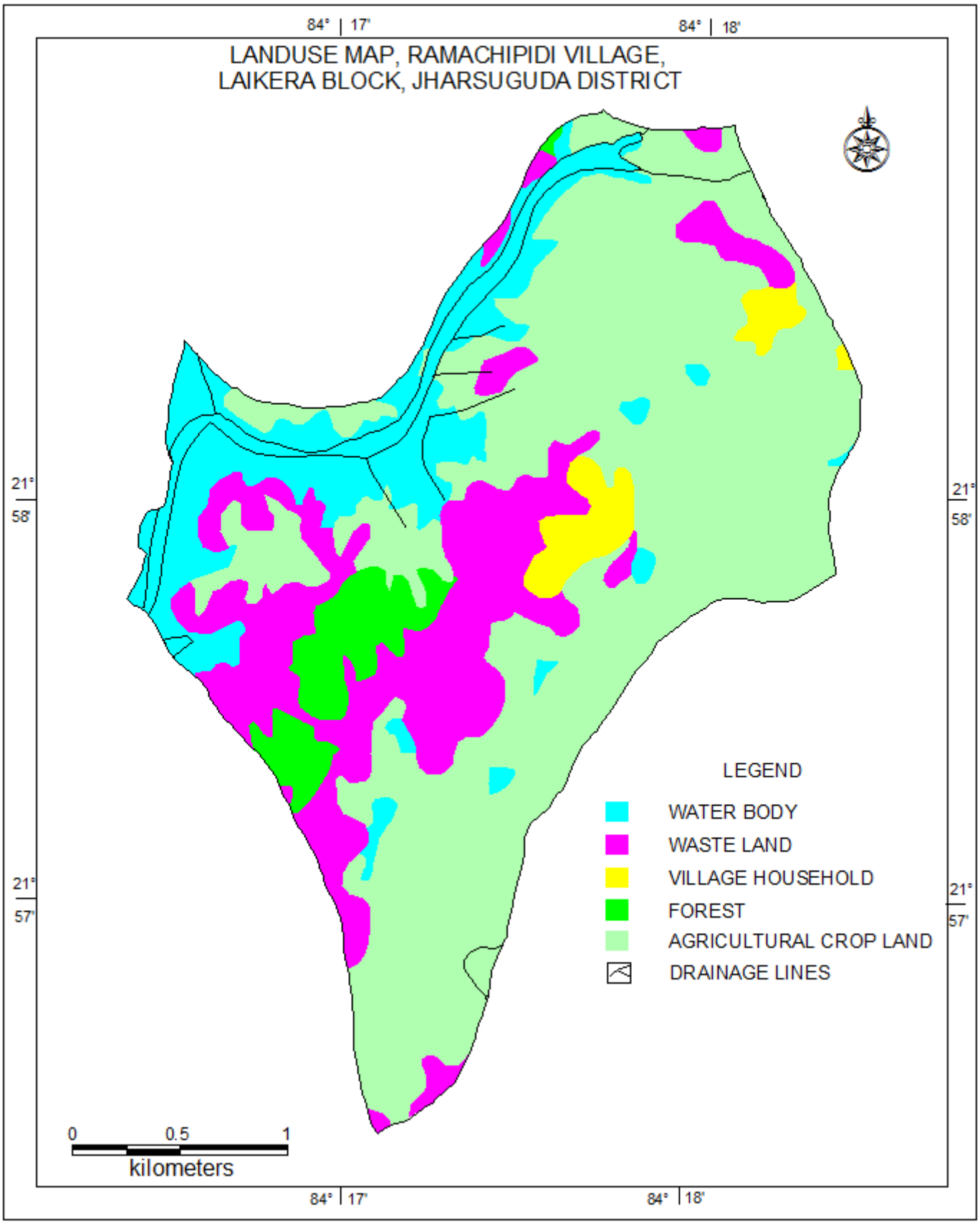

LANDUSE MAP, RAMACHIPIDI VILLAGE,
LAIKERA BLOCK, JHARSUGUDA DISTRICT
84° 17'
84° 18'
21° 58'
21° 57'
LEGEND
WATER BODY
WASTE LAND
VILLAGE HOUSEHOLD
FOREST
AGRICULTURAL CROP LAND
DRAINAGE LINES
0
0.5
1
kilometers

Fig.10.

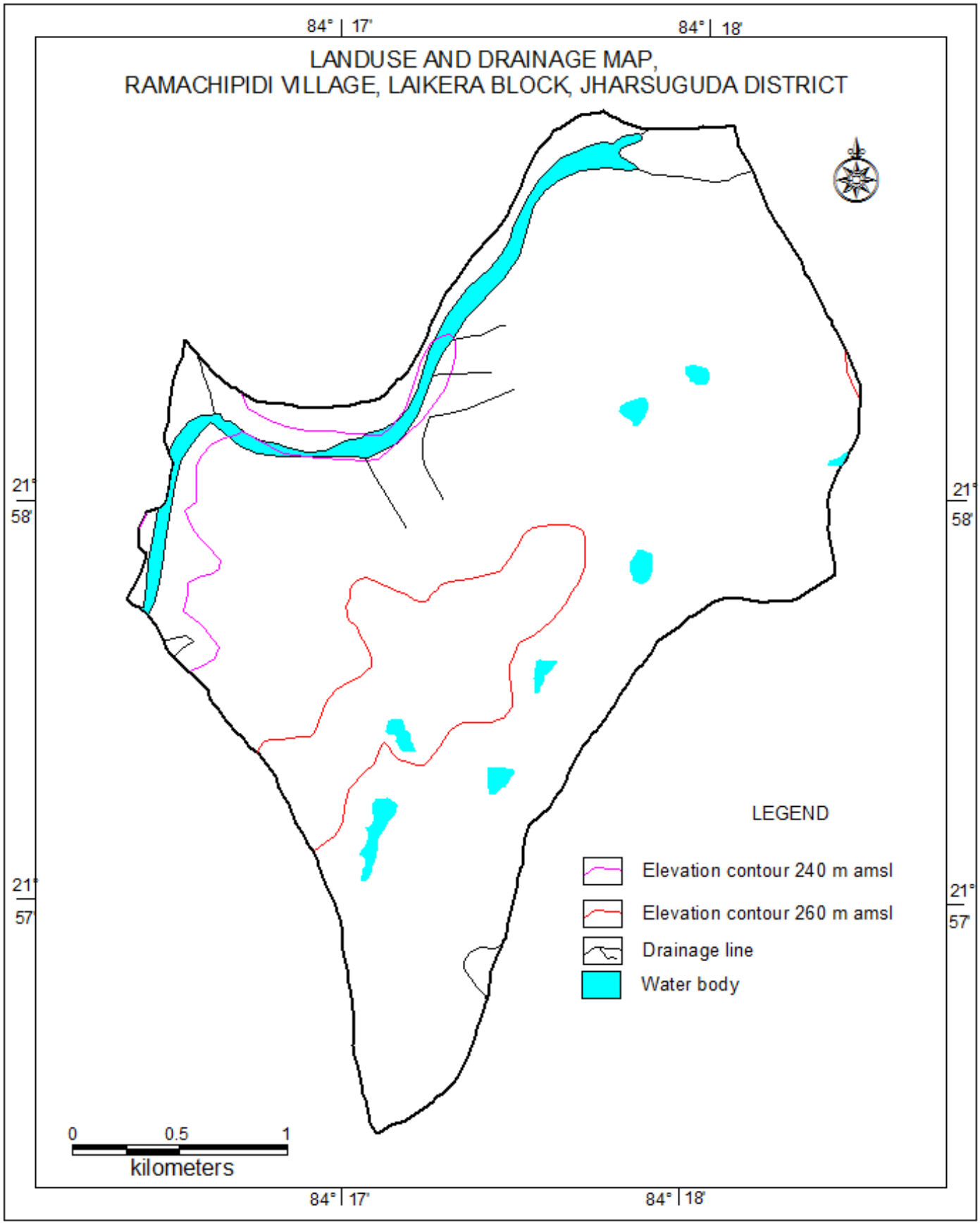

LANDUSE AND DRAINAGE MAP,
RAMACHIPIDI VILLAGE, LAIKERA BLOCK, JHARSUGUDA DISTRICT
84° 17'
84° 18'
21° 58'
21° 57'
LEGEND
Elevation contour 240 m amsl
Elevation contour 260 m amsl
Drainage line
Water body
0
0.5
1
kilometers

Fig.11a.

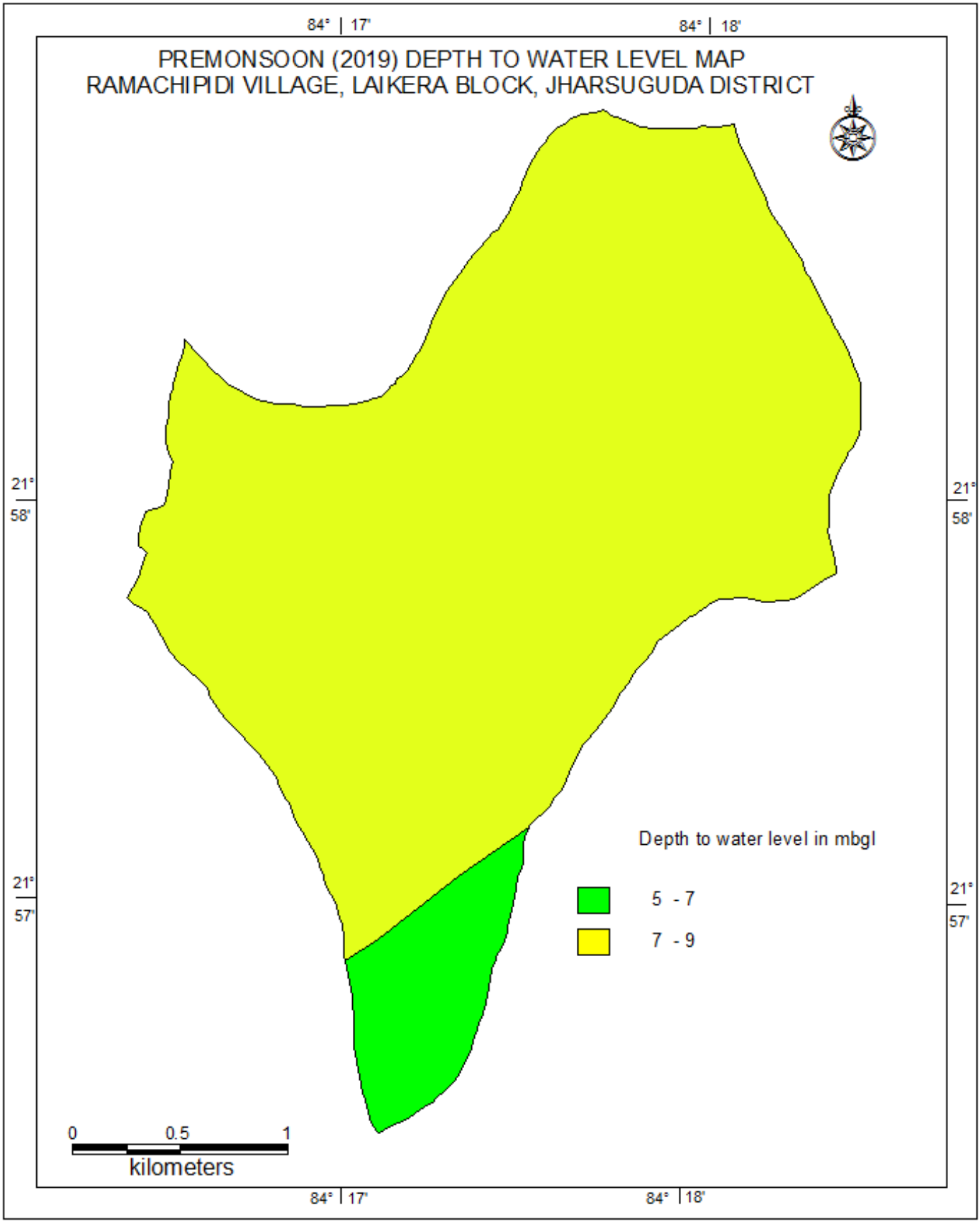

84° | 17'
84° | 18'
PREMONSOON (2019) DEPTH TO WATER LEVEL MAP
RAMACHIPIDI VILLAGE, LAIKERA BLOCK, JHARSUGUDA DISTRICT
21° 58'
21° 57'
Depth to water level in mbgl
5 - 7
7 - 9
0
0.5
1
kilometers

Fig.11b.

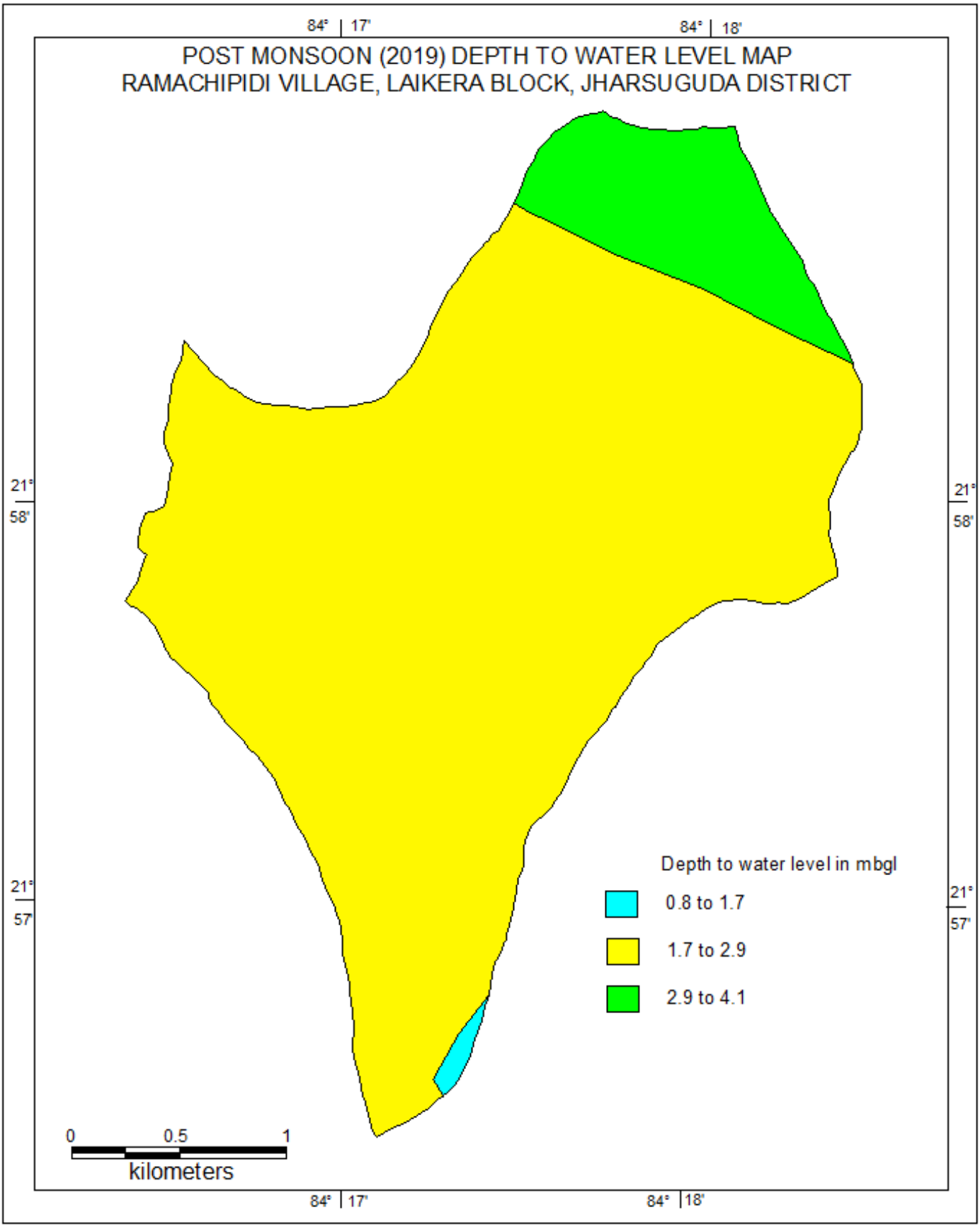

84° 17'
84° 18'
POST MONSOON (2019) DEPTH TO WATER LEVEL MAP
RAMACHIPIDI VILLAGE, LAIKERA BLOCK, JHARSUGUDA DISTRICT
21° 58'
21° 57'
Depth to water level in mbgl
0.8 to 1.7
1.7 to 2.9
2.9 to 4.1
0
0.5
1
kilometers

Fig.11c.

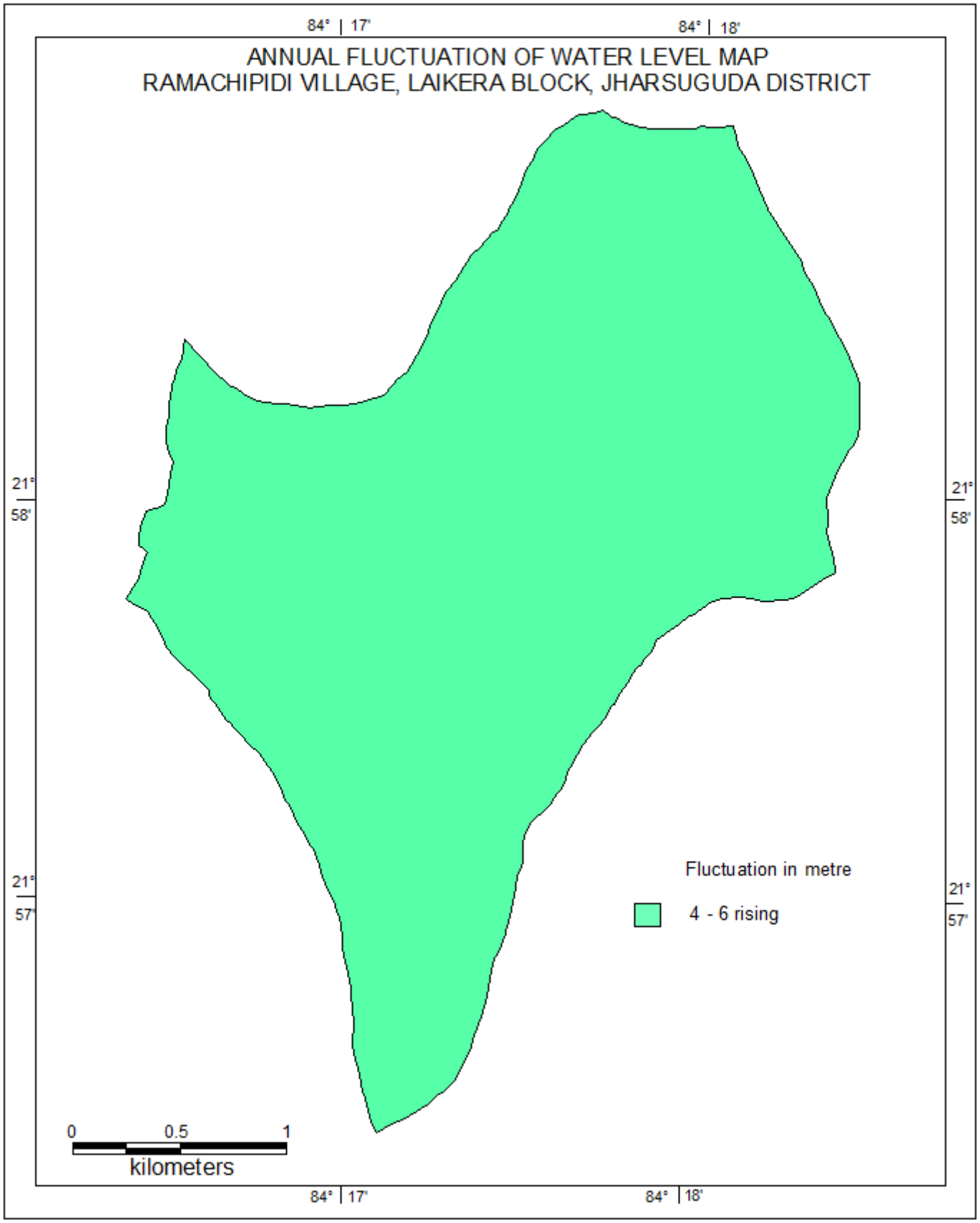
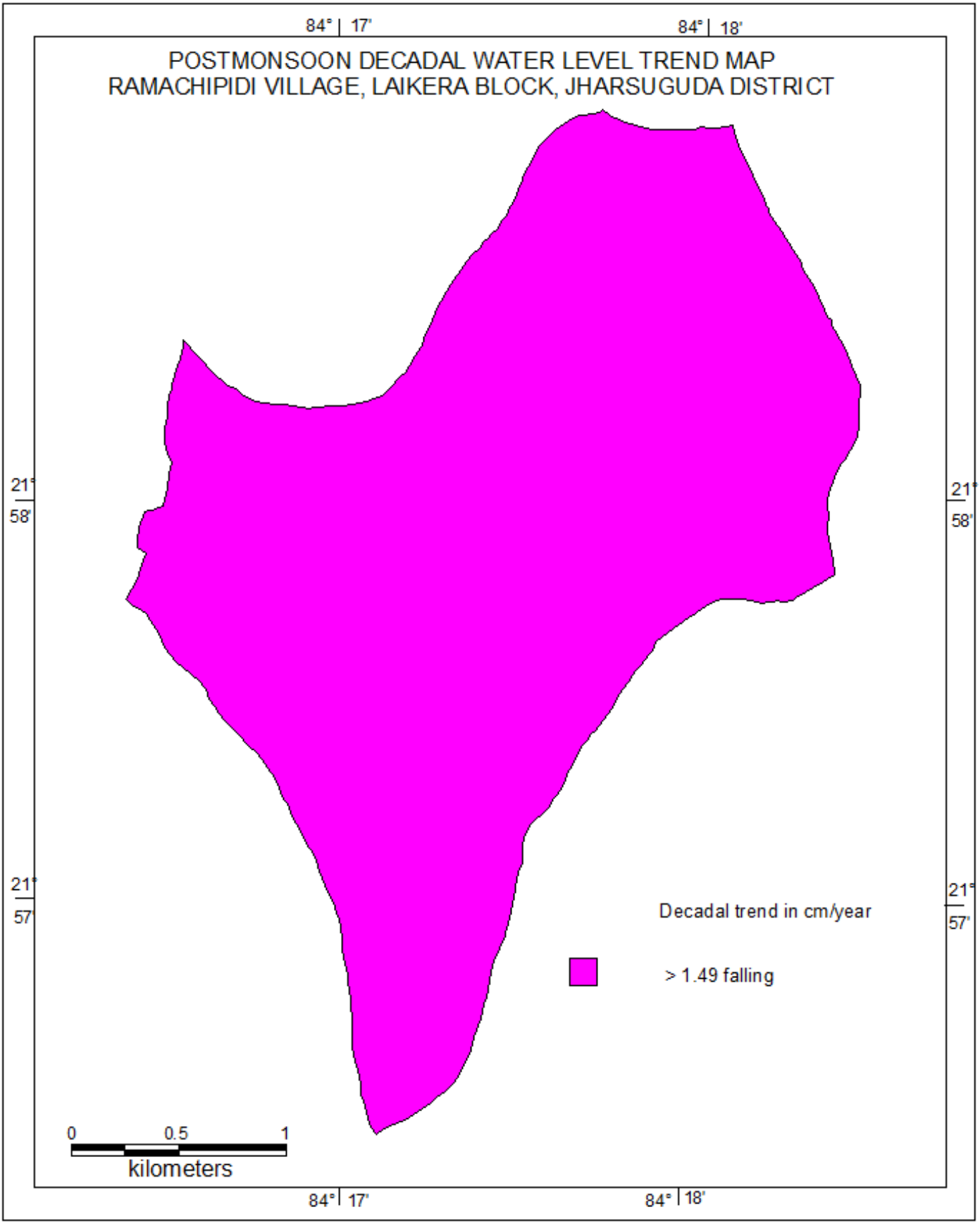

84° | 17'
84° | 18'
ANNUAL FLUCTUATION OF WATER LEVEL MAP
RAMACHIPIDI VILLAGE, LAIKERA BLOCK, JHARSUGUDA DISTRICT
21° 58'
21° 57'
Fluctuation in metre
4 - 6 rising
0 0.5 1
kilometers

Fig.11d.


84° 17'
84° 18'
POSTMONSOON DECADAL WATER LEVEL TREND MAP
RAMACHIPIDI VILLAGE, LAIKERA BLOCK, JHARSUGUDA DISTRICT
21° 58'
21° 57'
Decadal trend in cm/year
> 1.49 falling
0
0.5
1
kilometers

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