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

MAINPAT BLOCK, SURGUJA DISTRICT, CHHATTISGARH

उत्तर मध्य छत्तीसगढ़ क्षेत्र, रायपुर
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AQUIFER MAPPING AND MANAGEMENT PLAN FOR MAINPAT BLOCK (SURGUJA DISTRICT), CHHATTISGARH

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ABBREVIATIONS

DW	Dugwell	**m bgl**	meter below ground level
EC	Electrical Conductivity	**m2/day**	Square meter/ day
GS	Gabion structures	**m3/day**	cubic meter/day
GW/ gw	Ground Water	**MCM/mcm**	Million Cubic Meter
ha	Hectare	**mm**	Milimeter
Ham	Hectare meter	**OE**	Overexploited
HP	Handpump (Shallow)	**Sq Km**	Square Kilometer
lpm	litres per minute	**STP**	Sewage Treatment Plant
lps	liters per second	**T**	Transmissivity
m	meter	**TW**	Tubewell

AQUIFER MAP AND MANAGEMENT PLAN: MAINPAT BLOCK

1. Salient Information:

About the area: Mainpat Block is situated on the southern part of Surguja district of Chhattisgarh and is bounded in the west by Lakhanpur and Ambikapur Blocks, in the east by Sitapur Block, in the north by Batauli Block and in the south by Raigarh district. The block area lies between 22.64 and 22.96 N latitudes and 83.15 and 83.49 E longitudes. The geographical extension of the study area is 671.79 sq. km representing around 12.94 % of the district's geographical area. Administrative map of the block is shown in Fig. 1. Geomorphologically blocks comprises of region of plateau except south western part comprises of pediment. Geomorphology map is shown in Figure 2. The major drainage of the block includes Manchari and Gunghuta River, all of which are parts of Mahanadi basin. Drainage map shown in Fig. 3.

Population: The total population of Mainpat block as per 2011 Census is 76573. The population break up i.e. male- female and rural- urban is given below -

Table- 1: Population Break Up

Block	Total population	Male	Female	Rural population	Urban population
Mainpat	76573	38703	37870	76573	-

Source: CG Census, 2011

Growth rate: The decadal growth rate of the block is 16.48 as per 2011 census.

Rainfall: The study area receives rainfall mainly from south-west monsoon. About 87% of the annual rainfall is received during June to September and July and August are the months of maximum precipitation. The area gets some rainfall during winter season also. Average annual rainfall in the study area is (Average of the last five years i.e. 2013 to 2017) 998 mm with 70 to 80 rainy days.

Table-2: Rainfall data in Mainpat block in mm

Year	2013	2014	2015	2016	2017
Annual rainfall	1301.9	1041.0	914.3	913.2	819.8

Source: IMD

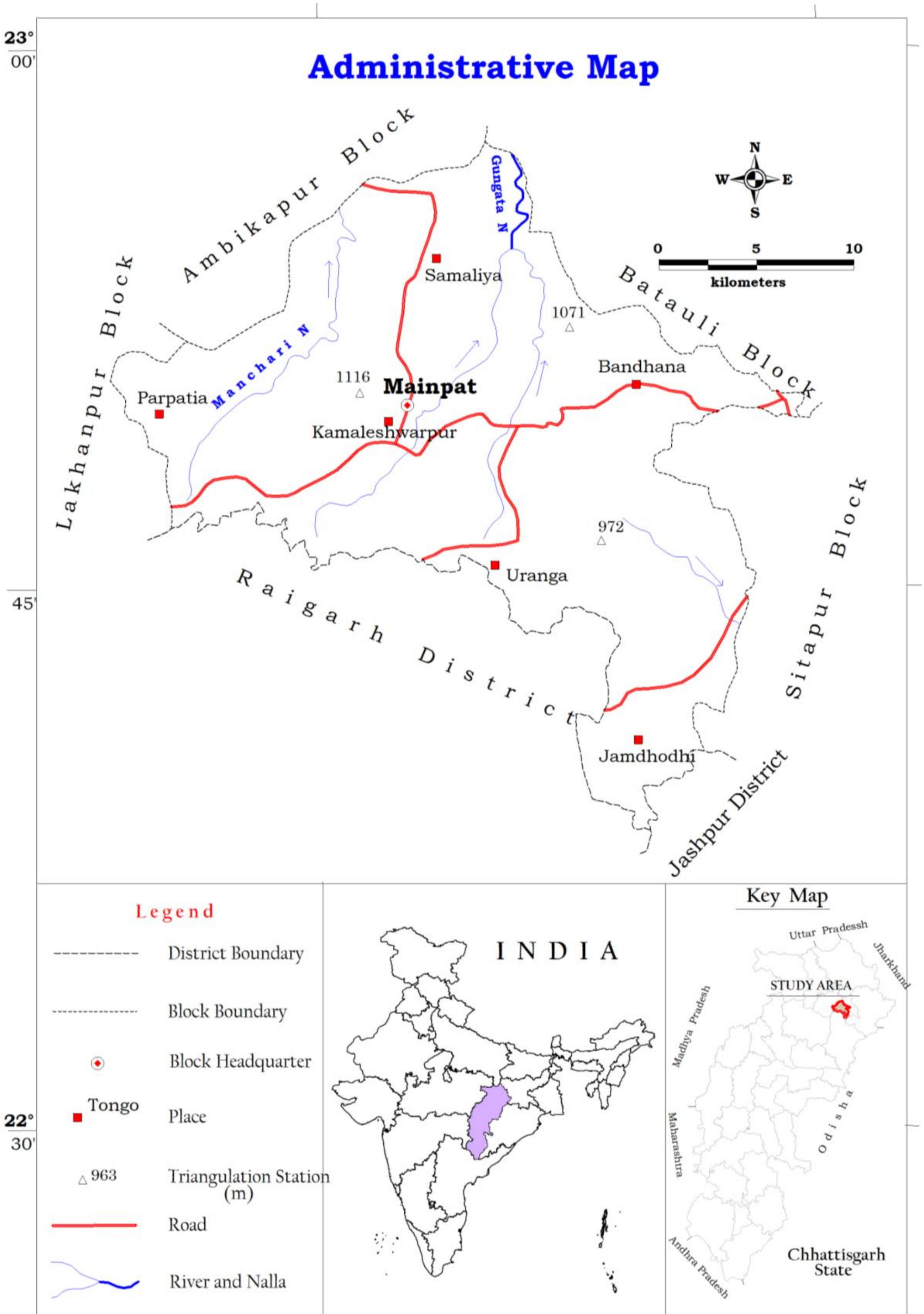

Figure 1 Administrative Map of Mainpat Block

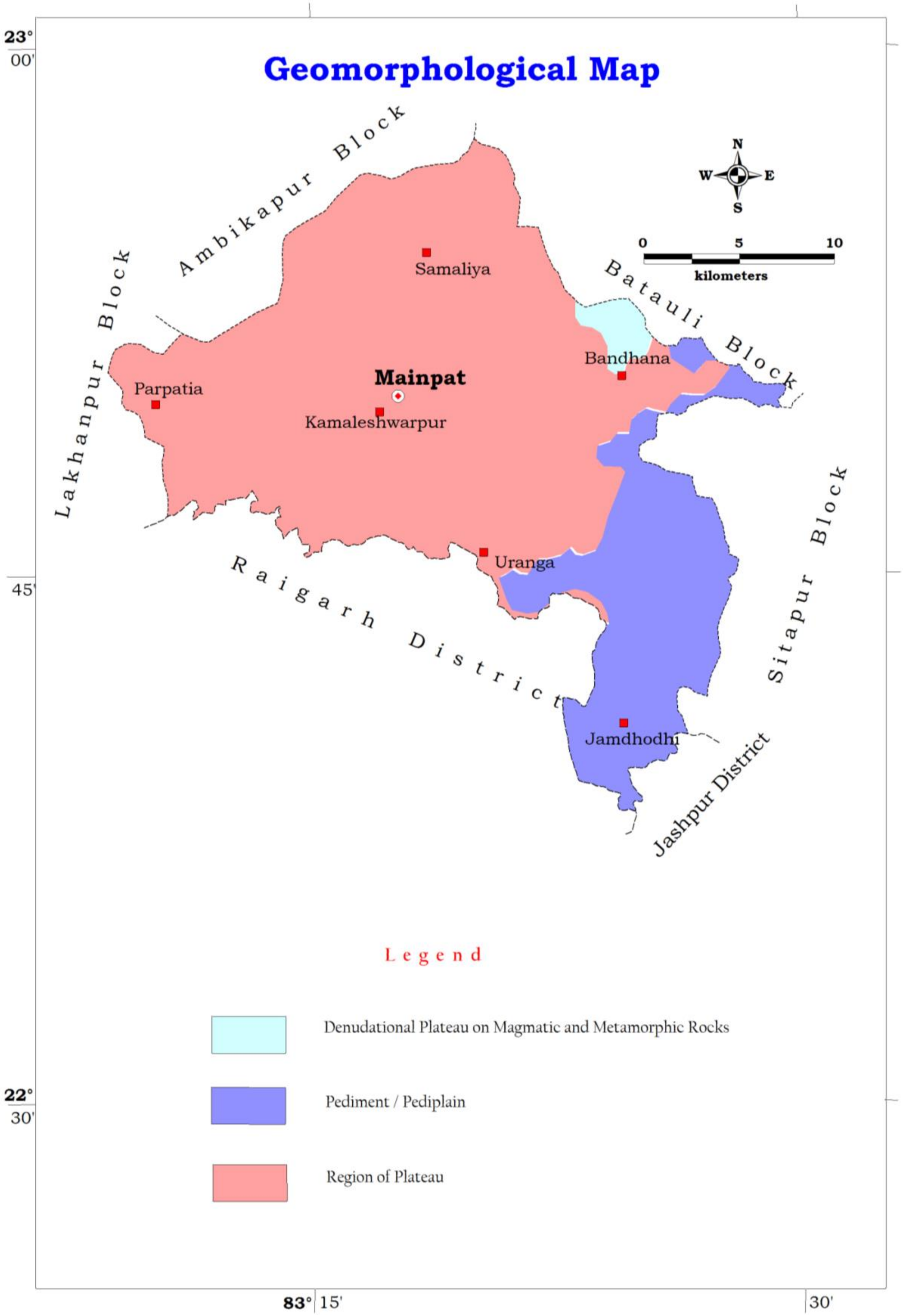

Figure 2 Geomorphology Map of Mainpat Block

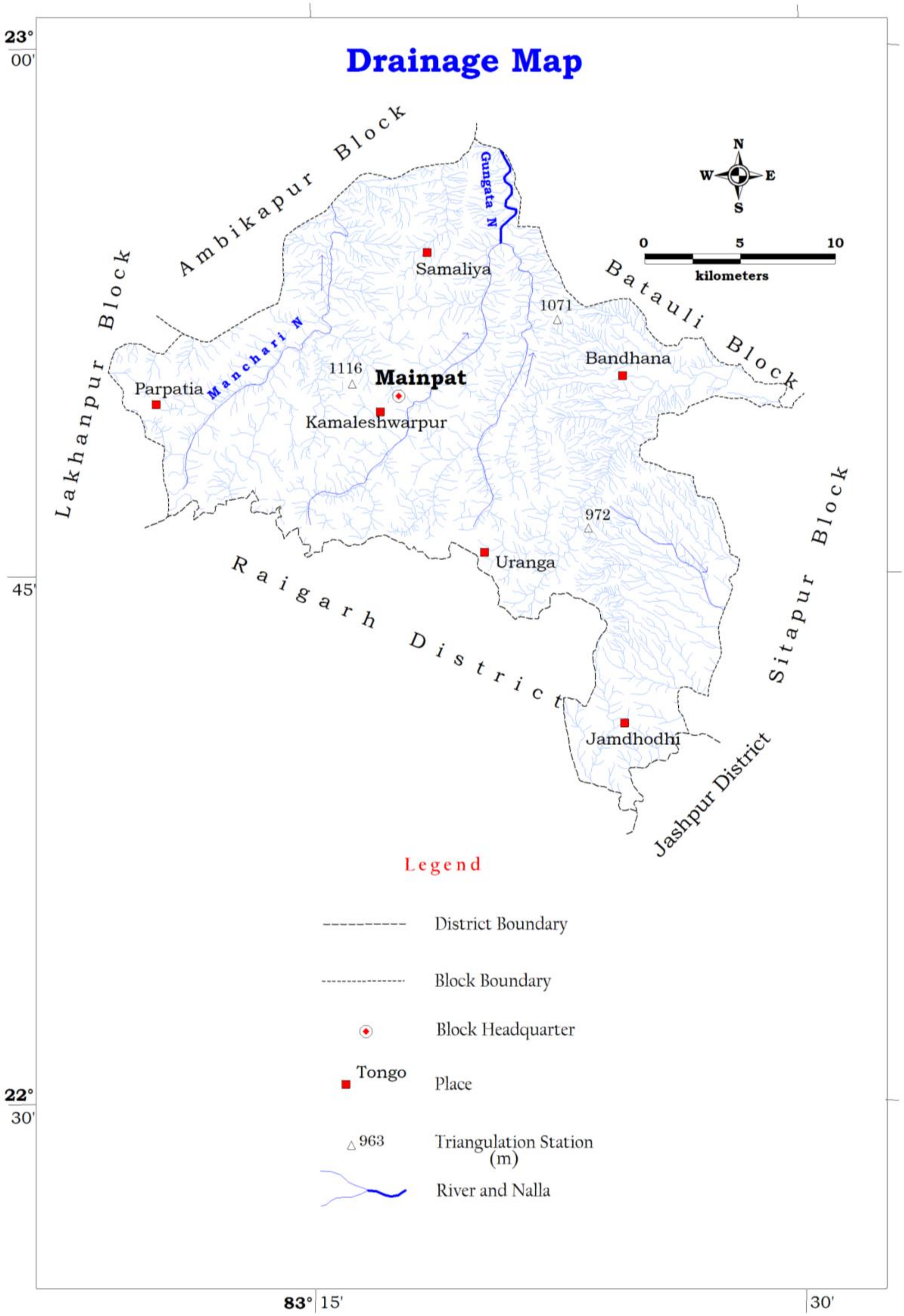

Figure 3 Drainage Map of Mainpat Block

Agriculture and Irrigation: Agriculture is practiced in the area during Kharif and Rabi season every year. During the Kharif, cultivation is done through rainfall while during the Rabi season; it is done through ground water as well as partly through surface water like canals and other sources. The groundwater abstraction structures are generally Dugwells, Borewells /tubewells. The principal crops in the block are Paddy, Wheat, Vegetables and pulses.

In some areas, double cropping is also practiced. The agricultural pattern, cropping pattern and area irrigated data of Mainpat block is given in Table 3 (A, B, C, D, and E).

Table 3 (A): Land use and Agricultural pattern (in ha)

Total geographical area	Forest area	Area not available for cultivation	Nonagricultural & Fallow land	Agricultural Fallow land	Net sown area	Double cropped area	Gross cropped area
67179	22521.4	2533	8300	2458	17629	1652	19281

Table 3 (C): Cropping pattern (in ha)

Kharif	Rabi	Cereal				Pulses	Tilhan	Fruits and Vegetables	Sugarcane	Mirch Masala
		Wheat	Rice	Jowar & Maize	Medo					
17643	1638	286	12084	989	1765	702	2515	763	106	51

Table 3 (D): Area irrigated by various sources (in ha)

No. of canals (private and Govt.)	Irrigated area	No. of bore wells/ Tube wells	Irrigated area	No. of dug wells	Irrigated area	No. of Talabs	Irrigated area	Irrigated area by other sources	Net Irrigated area	Gross irrigated area	% of irrigated area wrt. Net sown area
2	386	49	8	11	36	10	12	30	472	524	2.65

Table 3 (E): Statistics showing Irrigation by Ground water

Block	Net Irrigated Area	Net Irrigated Area by ground water	Percentage of Area Irrigated by ground water wrt. Net Irrigated Area
Mainpat	472	45	9.5

Groundwater Resource Availability and Extraction: Based on the resource assessment made, the resource availability in aquifer wise in Mainpat block is given in the table-4.

Table – 4 (A): Ground Water Budget of Mainpat block in Ham

Assessment Unit Name	Ground Water Recharge(Ham)				Total Annual Ground Water (Ham) Recharge	Total Natural Discharges (Ham)
	Monsoon Season		Non-monsoon season			
	Recharge from Rainfall	Recharge from Other Sources	Recharge from Rainfall	Recharge from Other Sources		
Mainpat	2525.08	51.72	290.43	127.75	2994.98	299.50

Table – 4 (B): Ground Water Dynamic Resource (Unconfined Aquifer) of Mainpat block in Ham

Annual Extractable Ground Water Recharge (Ham)	Current Annual Ground Water Extraction (Ham)				Annual GW Allocation for Domestic Use as on 2025	Net Ground Water Availability for future use	Stage of Ground Water Extraction (%)	Categorization (OE/Critical/ Semicritical/ Safe)
	Irrigation Use	Industrial Use	Domestic Use	Total Extraction				
2695.48	543.67	0.00	184.27	727.94	206.38	1945.43	27.01	Safe

Table – 4 (C): Ground Water Static Resource (Unconfined Aquifer) and Dynamic Resource (Confined Aquifer) of Mainpat block in Ham

Static Resources Area (Ha)	Difference Piezometric Head (Pre-post) m	Storativity (S)	Dynamic Ground Water Resource of Confined Aquifer (Ham)	Bottom level of the top confining layer (m)	In storage Ground Water Resource of Unconfined Aquifer (Ham)	Sum of Dynamic GW (Confined Aquifer) and In storage GW (Unconfined Aquifer) resource (Ham)
67632	6.4	0.000246	112.63	200	12326.67	12439.31

Existing and Future Water Demand (2025)*:* The existing draft for irrigation in the area is 543.67 Ham while the total extraction for all uses is 727.94 Ham. At present scenario to meet the future demand for water, a total quantity of 1945.43ham of ground water is available for future use.

Water Level Behavior: (i) Pre- monsoon water level: In the pre-monsoon period, it has been observed that in Mainpat block, water level in dugwells (phreatic aquifer) varies between 3.30 to 16.60 mbgl with average water level of 7.87 mbgl. In semiconfined aquifer, the maximum water level is 17.86 mbgl; the average water level is 14.46 mbgl.

Table 5A: Phreatic aquifer Depth to Water Level in mbgl (Pre-monsoon)

Block Name	Phreatic Aquifer		
	Min	Max	Avg
Mainpat	3.30	16.60	7.87

Table 5B: Semiconfined Aquifer Depth to Water Level in mbgl (Pre-monsoon)

Block Name	Semiconfined Aquifer		
	Min	Max	Avg
Mainpat	12.15	17.86	14.46

(ii) Post- monsoon water level**:** In the post-monsoon period, it has been observed that the water level varies from 1.40 to 10.40 mbgl with an average of 4.16 mbgl in phreatic aquifer. In semiconfined/fractured formation, the post monsoon water level variation range is 4.36 to 12.26 mbgl with average of 7.64 mbgl.

Table 5C: Phreatic Aquifer Depth to Water Level in mbgl (Post-monsoon)

Block Name	Phreatic Aquifer		
	Min	Max	Avg
Mainpat	1.40	10.40	4.16

Table 5D: Semiconfined Aquifer Depth to Water Level in mbgl (Post-monsoon)

Block Name	Semiconfined Aquifer		
	Min	Max	Avg
Mainpat	4.36	12.26	7.64

(iii) Seasonal water level fluctuation: The water level fluctuation data indicates that in Mainpat block, water level fluctuation in phreatic aquifer varies from 1.10 to 13.95 m with an average fluctuation of 3.71 m. Water level fluctuation in semiconfined Aquifer varies from 3.74 to 10.39 m with an average fluctuation of 6.82 m.

Table 5E: Phreatic Aquifer Depth to Water Level Fluctuation (meter)

Block Name	Phreatic Aquifer		
	Min	Max	Avg
Mainpat	1.10	13.95	3.71

Table 5F: Semiconfined Aquifer Depth to Water Level Fluctuation (meter)

Block Name	Semiconfined Aquifer		
	Min	Max	Avg
Mainpat	3.74	10.39	6.82

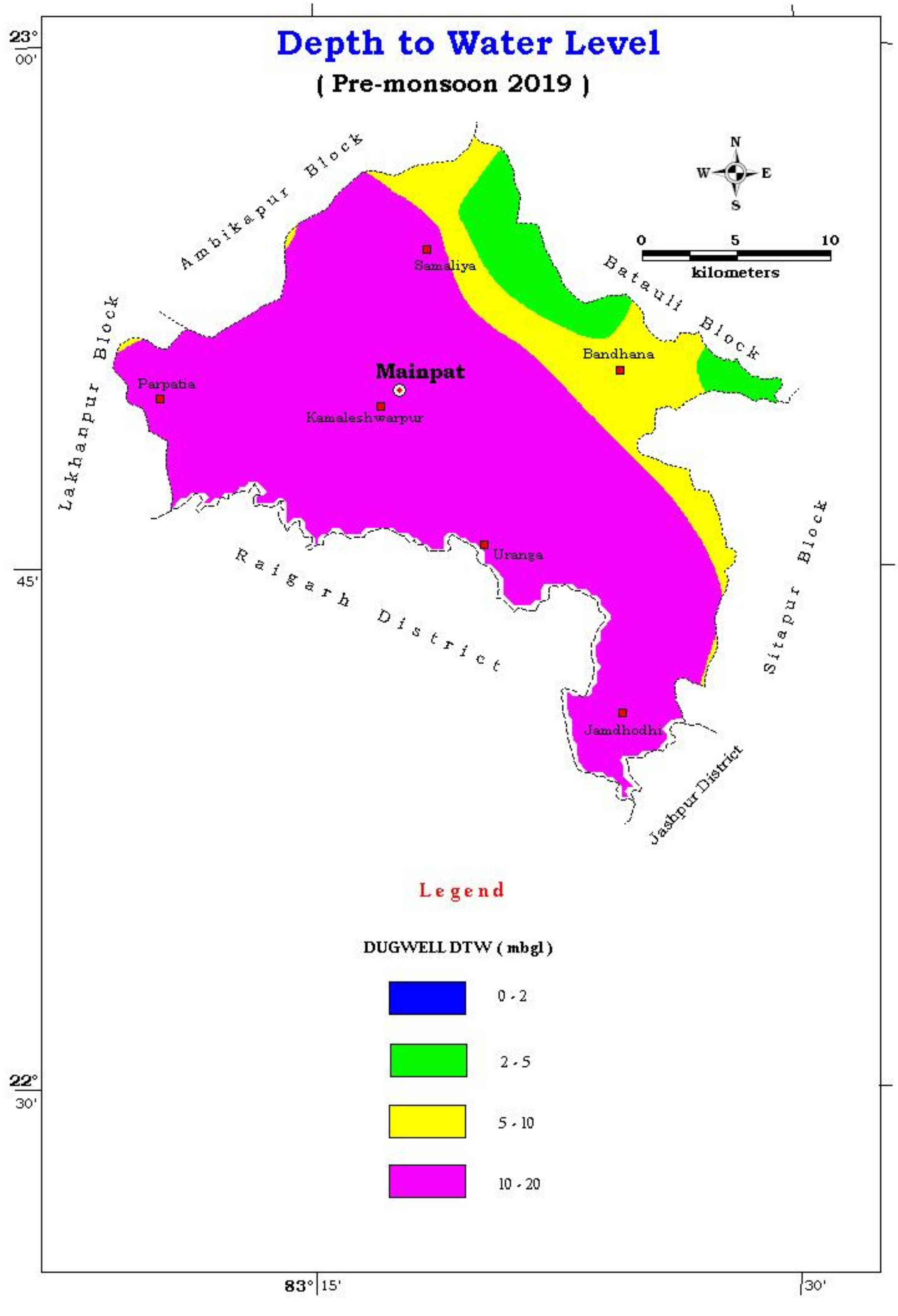

Figure 4 Depth to water level map Phreatic Aquifer (Pre-monsoon)

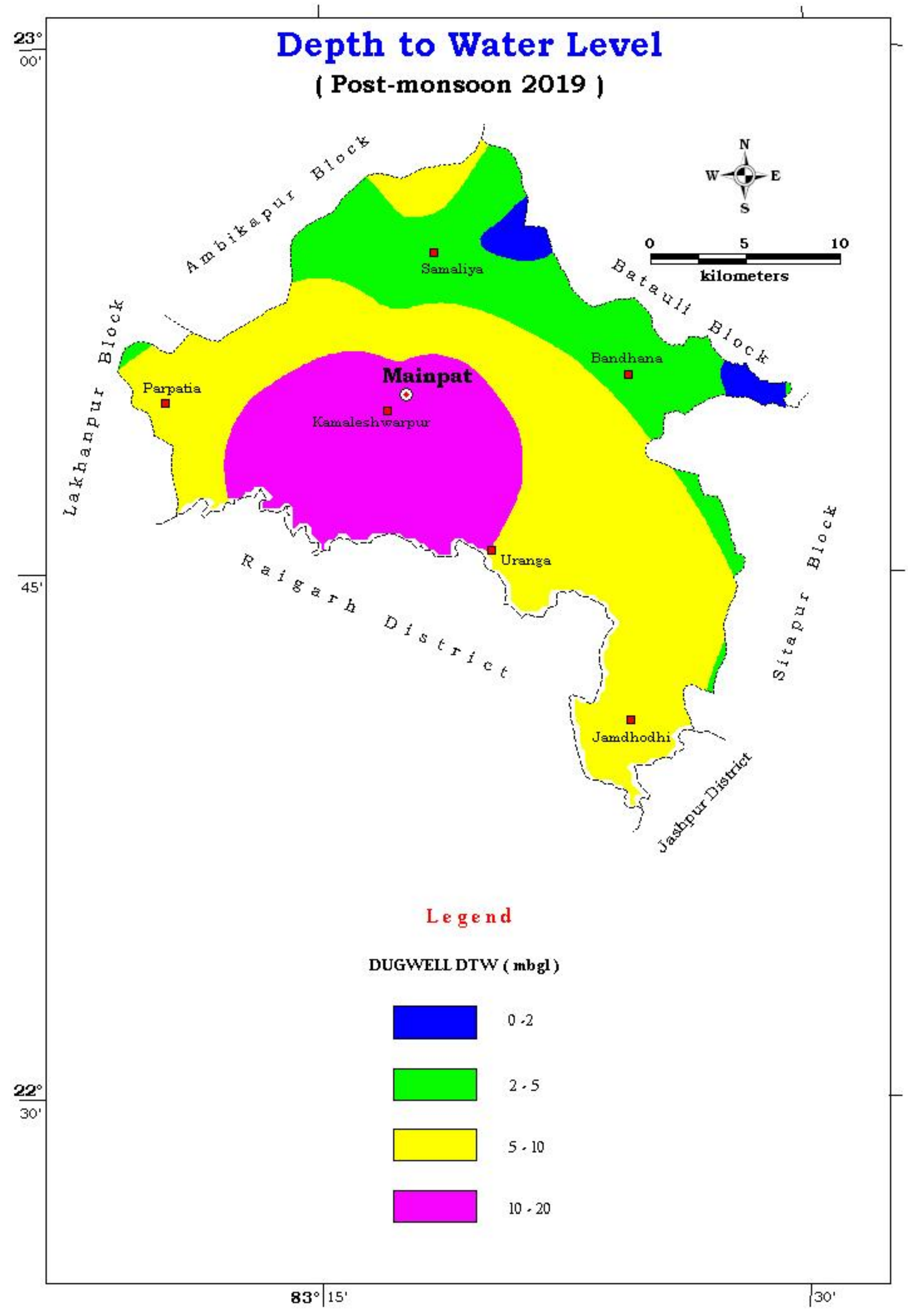

Figure 5 Depth to water level map Phreatic Aquifer (Post-monsoon)

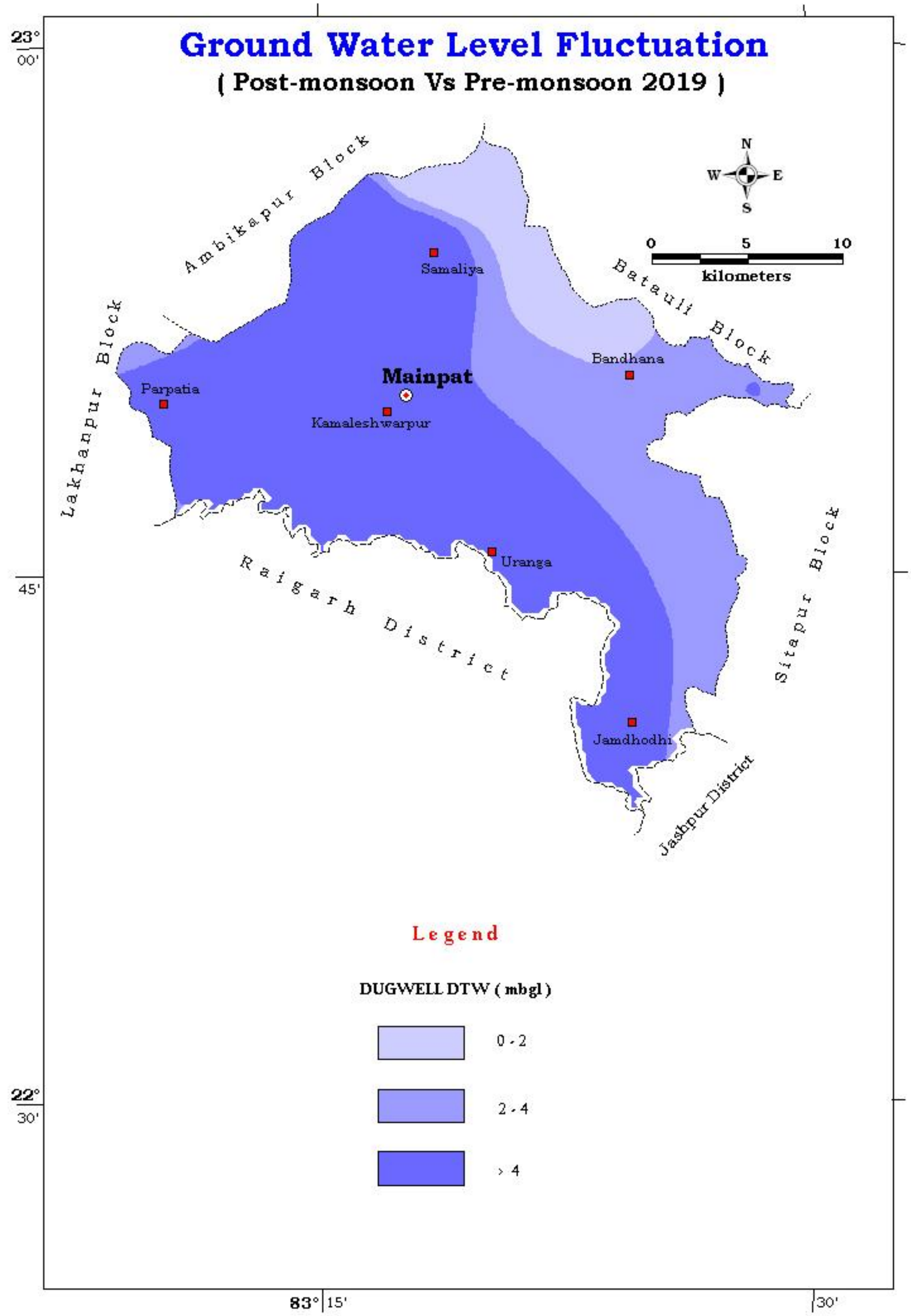

Figure 6 Depth to water level fluctuation map of Phreatic Aquifer

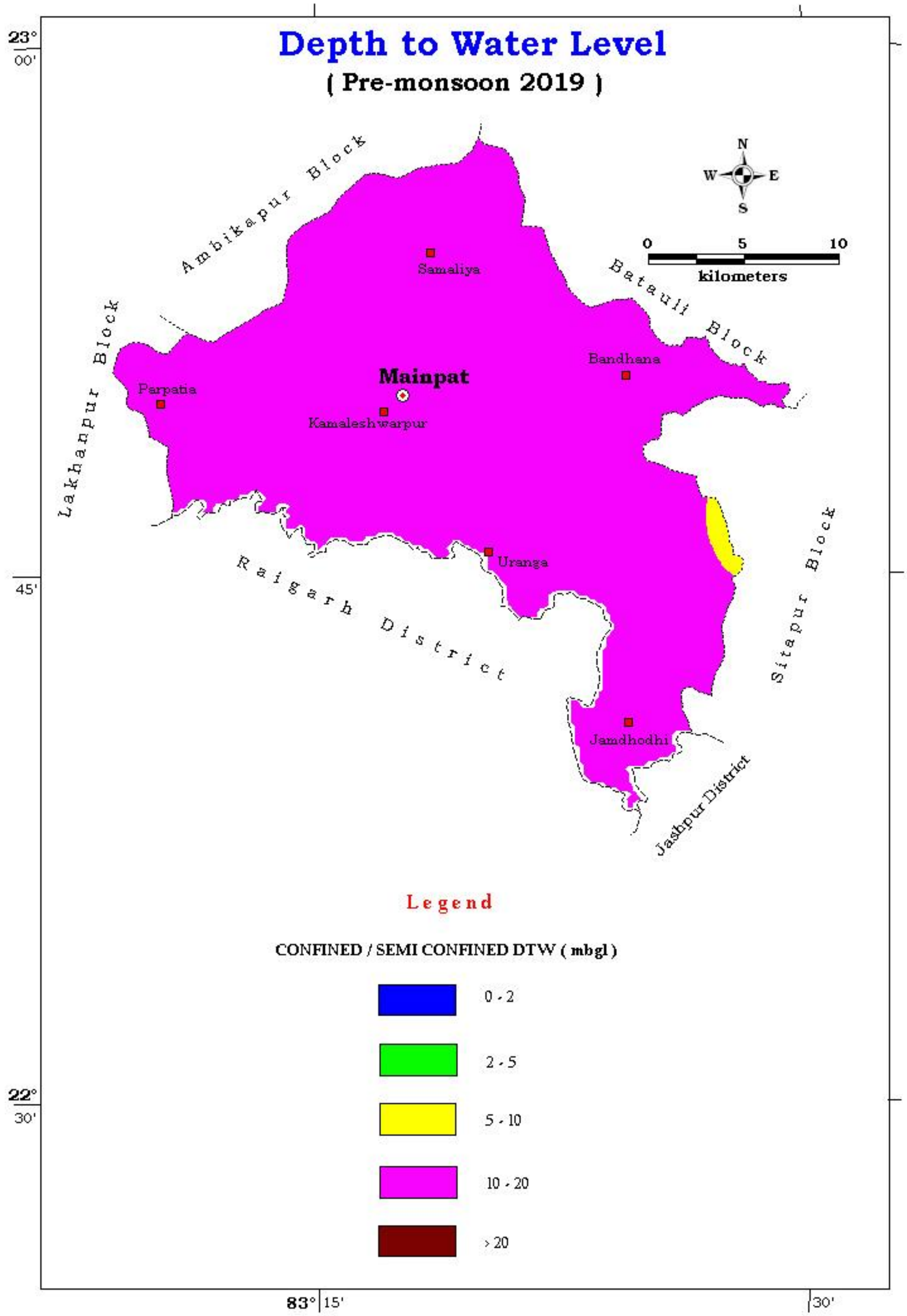

Figure 7 Depth to water level map Semiconfined Aquifer (Pre-monsoon)

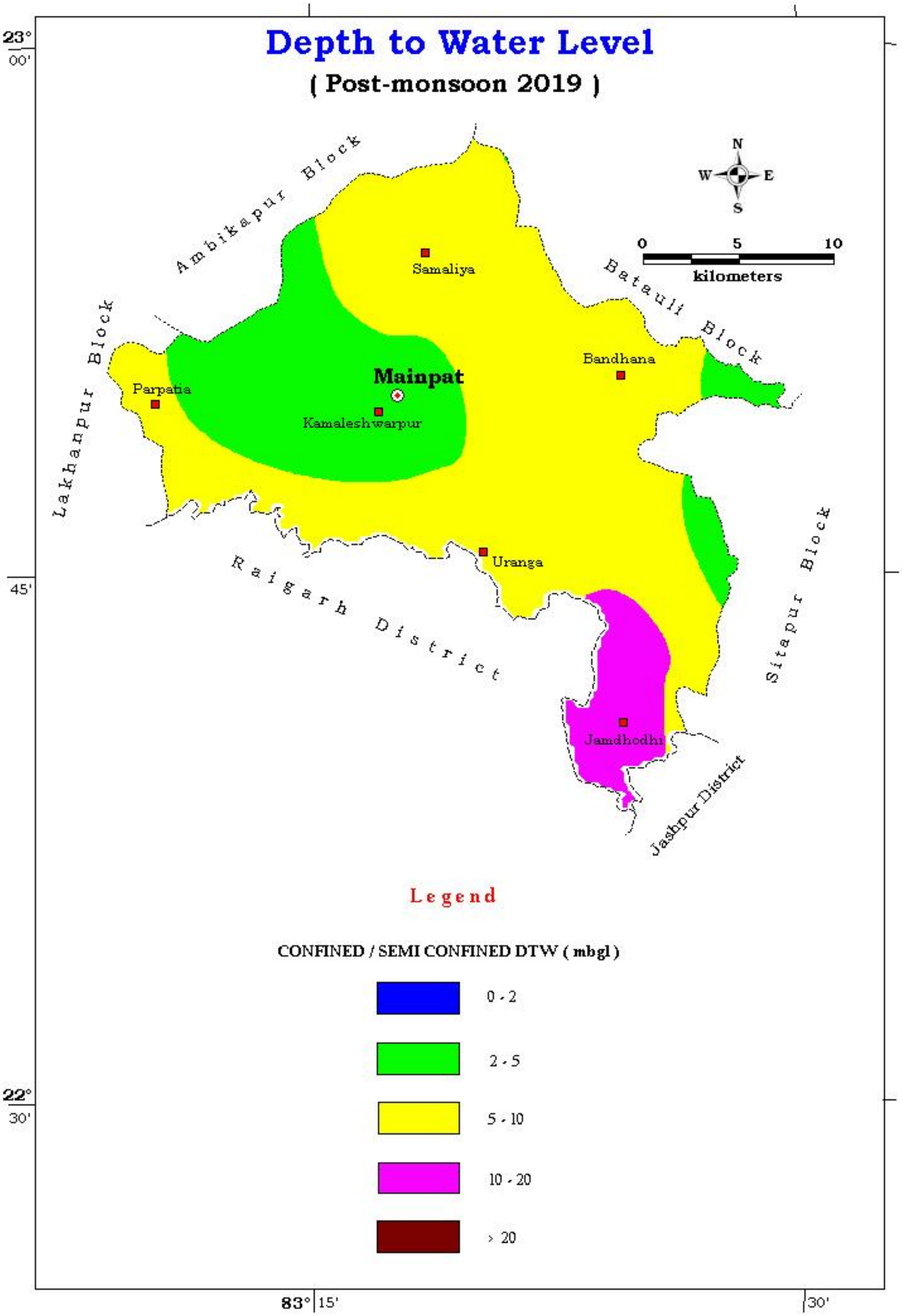

Figure 8 Depth to water level map Semiconfined Aquifer (Post-monsoon)

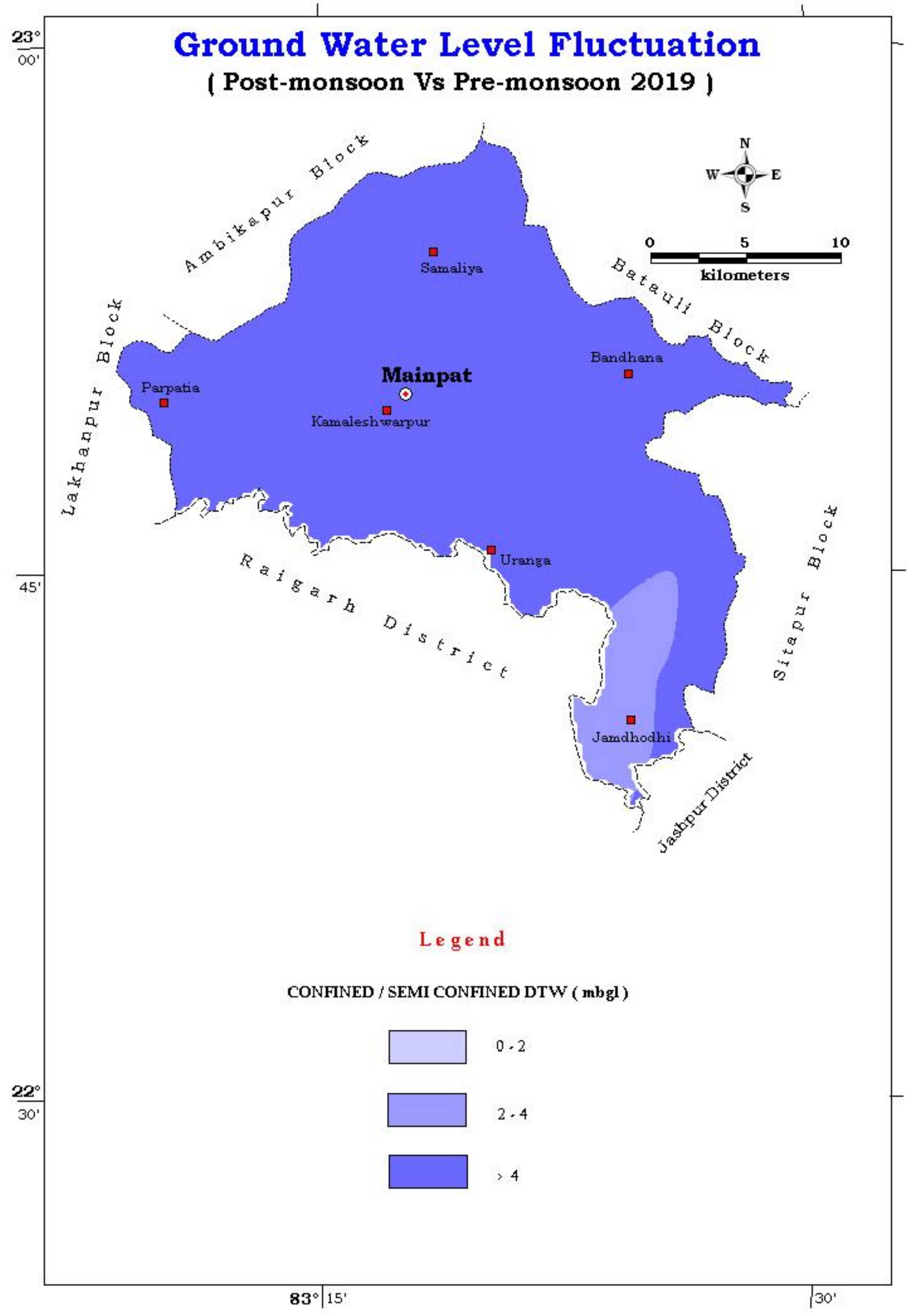

Figure 9 Depth to water level fluctuation map of Semiconfined Aquifer

(iv) The long term water level trend: There is no significant decline in water level in pre and post monsoon period in all observed NHS networks.

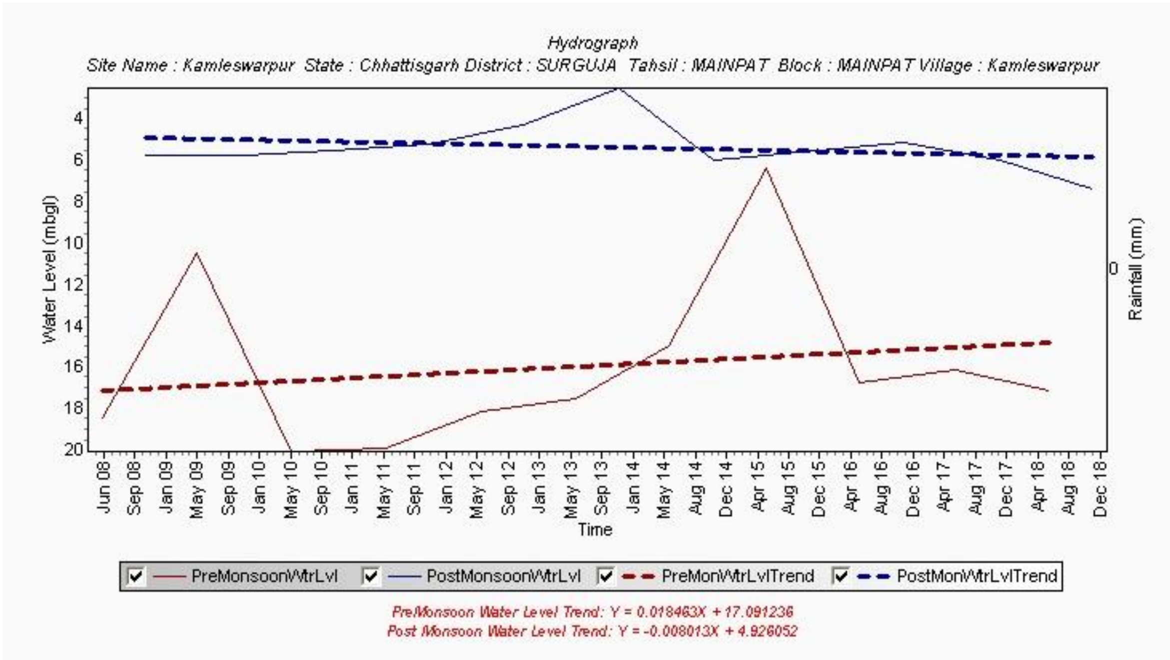

Figure 10 a: Hydrograph of Kamleshwarpur Village, Mainpat block

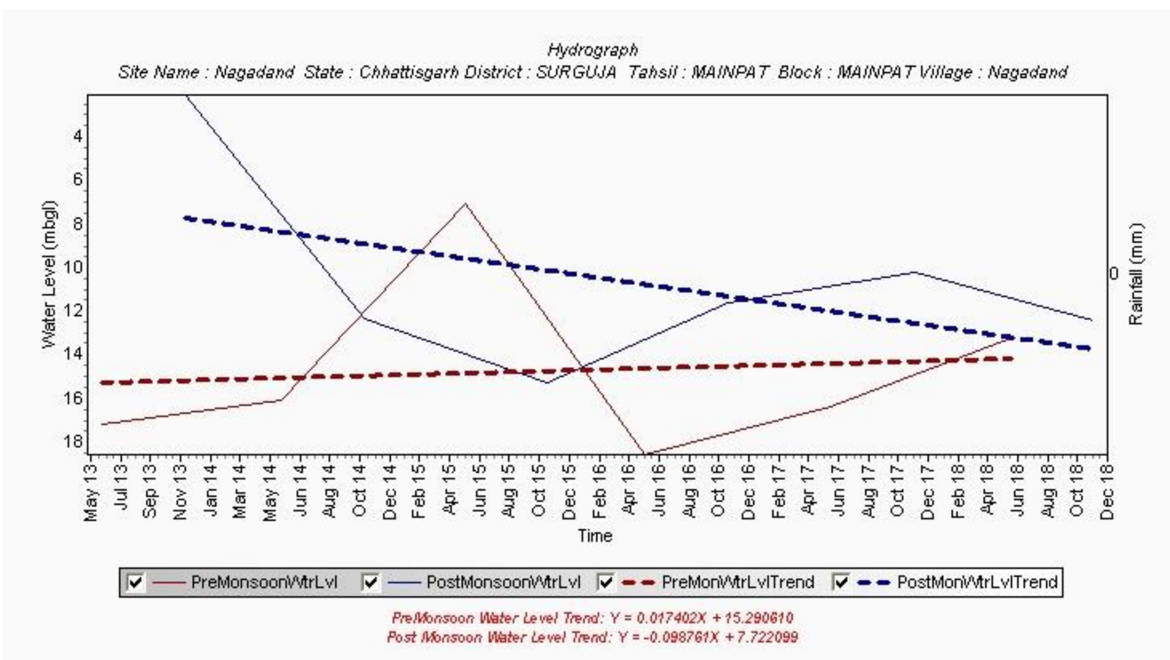

Figure 10 b: Hydrograph of Nagadand Village, Mainpat block

2. Aquifer Disposition:

Number of Aquifers: There are three major aquifer system viz. Granite Aquifer system, Sandstone Aquifer system and Basalt Aquifer system. All the aquifer system has the shallow aquifer and deeper aquifer which occurs in phreatic and semiconfined condition respectively.

3-d aquifer disposition and basic characteristics of each aquifer:

Granite Aquifer System:

Groundwater occurrence is largely limited to secondary permeability, such as weathered zones, joints, fractures or faults. The potential of weathered zones depends on the degree and depth of weathering and associated fracturing, and the saturated thickness. The aquifers are generally discontinuous, and often confined. Higher yields are obtained where thick weathered zones are associated with bedrock fracturing.

The average thickness of the weathered portion in the area is around 20 m. In general, the discharge varies from meagre to 5.5 lps. The average drawdown of the formation is around 29 m. DTH drilling technique is preferred in Granite aquifer where well construction is required depending upon the thickness of weathered zone. Water zone has been encountered up to 158 mbgl in the formation. Transmissivity range observed is upto 18.72 sq meter/day.

Sandstone Aquifer System:

After studying the exploratory well details in Sandstone aquifer system, it has been envisaged that Gondwanas rock comprise thick beds of sandstone, shale's, clays and coal seams. Sandstones having felsdpathic composition and medium to coarse grained, it is then porous and permeable and forms good aquifers. Sandstone having siliceous matrix behave like impervious hard rocks. Shales are fine grained, compact and though porous lack in permeability and so do not form good aquifers. Among Gondwana formation the Barakar and Suprabarakar sandstones are the most important water bearing formations. These sandstones are medium to coarse-grained felsdpathic and highly porous and permeable. The intergranular pore spaces, joints and fractures control ground water movement in them. Shale beds behave as confining layers and help to form different aquifer systems. The ground water occurs under phreatic, semi confined and confined conditions. Talchir sandstone which is very fine- grained and compact yield comparatively less ground water.

The average thickness of the weathered portion is around 21 m. In general, the discharge varies from meagre to 12.5 lps with an average yield of 4.33 lps. The average drawdown of the formation is around 26 m. Rotary drilling technique is preferred in sandstone aquifer where well construction is required depending upon the water zone and formation encountered. Water zone has been encountered up to 200 meters. Transmissivity range observed is 3.74 to 159.1 sq. meter/day.

Basalt Aquifer System:

Ground water occurs in weathered zone, joints and fracture and vesicular zones under both phreatic and semi-confined conditions. Semi confined conditions are observed in interflow zones at shallow depths, whereas confined conditions are observed in the interflow zones at deeper depth. It is observed that ground water in Deccan Traps occur in

(i). Weathered loose morrum like material in upper weathered zone.
(ii). Weathered ambygadaliodal basalts in each flow.
(iii). Exfoliated weathered zones covered by flows with columnar joints.
(iv) Fractured massive basalt, dykes etc.

The shallow aquifers are tapped by open wells of depth range of 8 to 25 mbgl. in which depth to water level range from1.5 to 21.0 mbgl The yield of shallow dug wells ranges from 20 to 100 m3/day, while those wells located in topographic lows near the confluences of streams or at intersection of fractures often yields from 50 to 150 m3/day.

The borewells tapping interflow zones between 60 to 100 mbgl have piezometric head ranges from 15 to 25 mbgl. The yield of shallow/ deep boreholes depends on the thickness of vesicular and jointed horizons and it's inter connection with the overlying recharge zone and ranges from 5-to 35 m3/per hour.

Laterites capping on the top of Deccan trap and basement crystalline are seen in plateau areas. The capping are porous, permeable and thickness ranges from 1-5 meters. Laterite forms good and high yielding aquifers in low-lying areas. The depth of dug wells range from 5 to 21 mbgl. The yield of shallow dugwells in laterite varies from 40 to 60-m3/ day. The depth of tube wells ranges from 60 to 100 m and their yield varies from 30 to 70 m3/day.

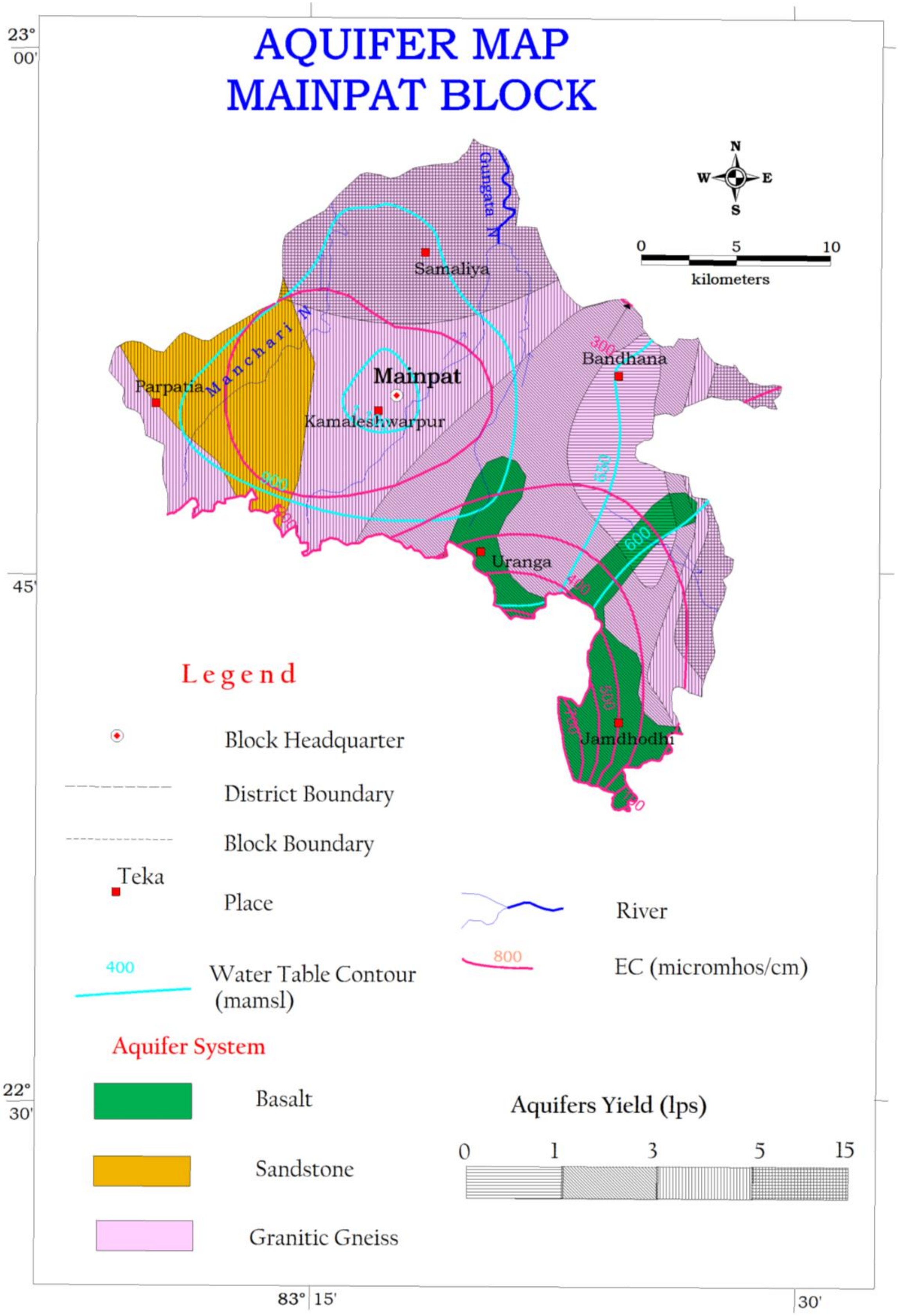

Figure 11: Aquifer map of Mainpat block

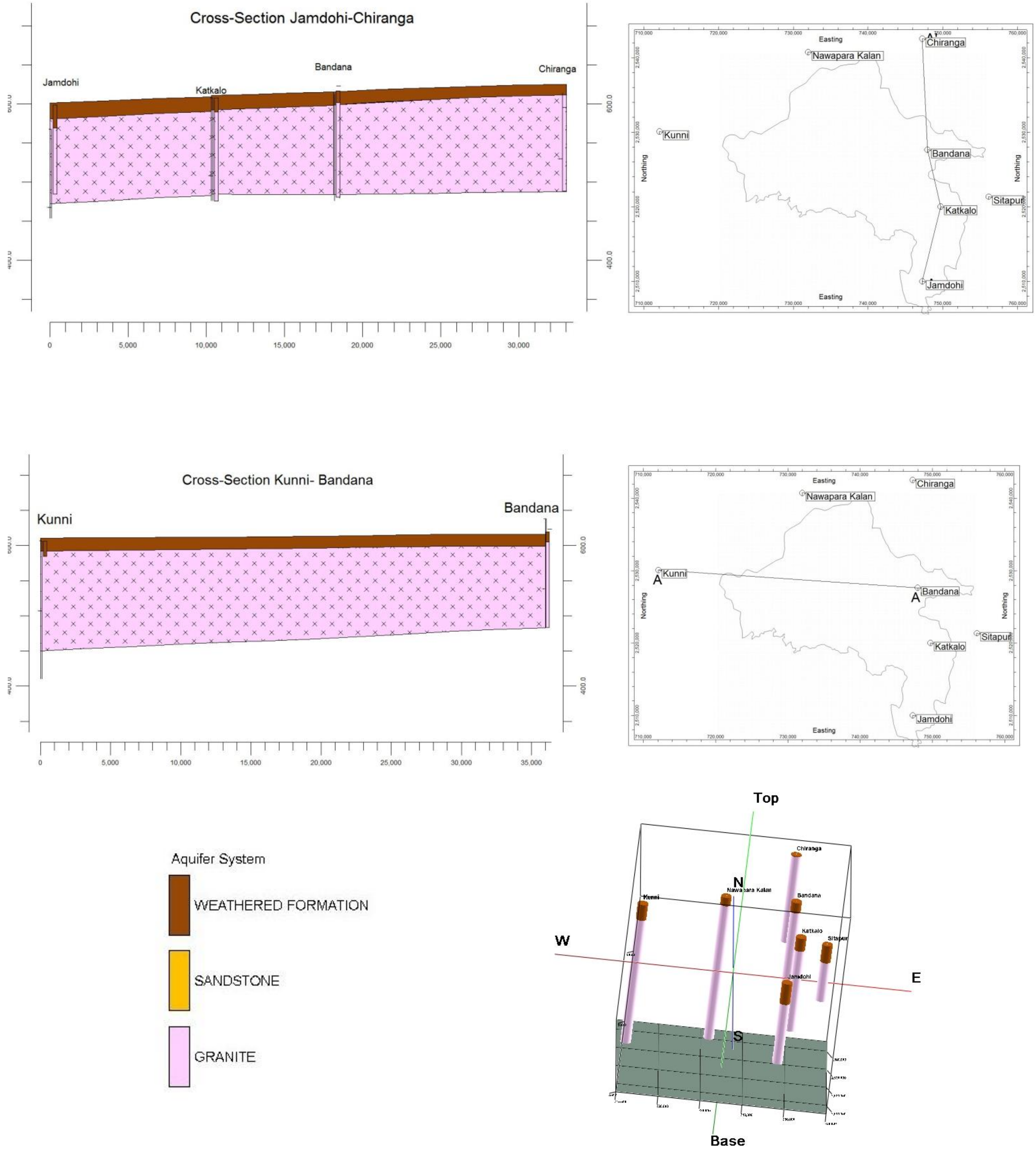

Figure-12, Disposition of Aquifer, Mainpat Block

3. **Ground water Resource, extraction, contamination and other issues:**

Resource availability of Mainpat block is given in the table -4 where net ground water availability for future use is 1945.43 ham. The extraction details and the future scenario (2025) along with the categorisation are also depicted in the table-4.

Table 7 Categorization of Assessment Unit

District	Block	Stage of Ground water development (%)	Categorisation
Mainpat	Mainpat	27.01	Safe

Categorisation: Mainpat block falls in safe category. The stage of Ground water development is 27.01 %. The Annual Extractable Ground Water Recharge is 2695.48 ham. The Ground water draft for all uses is 727.94 Ham.

Chemical Quality of Ground water and Contamination**:** Throughout the study area, the water samples from both dugwell and handpumps were collected and chemical analysis has been completed (Annexure I). Several villages have Iron and Flouride concentration more than permissible limit. Overall ground water of the study area is suitable for the drinking, agriculture and industrial purpose. In Mainpat at 18 villages Fluoride contamination and at 30 villages Iron contamination reported. (Source: https://ejalshakti.gov.in/IMISReports/MIS.html)

4. **Ground Water Resource enhancement:**

Aquifer wise space available for recharge and proposed interventions:

Table -8: Summarised detail of Volume of porous space available for recharge (Aquifer wise)

Major Aquifer	Area Identified for Artificial Recharge (Sq. Km)	Sp. Yield for the formation	Volume of vadose zone available for recharge(mcm)	Sub surface storage potential (mcm)
Basalt and Granite gneiss	113.32	0.013	405	5.260

5. Issues:

(i) During summer, dugwells in villages becomes dry at many locations. Several handpumps also stop yielding water. The aquifer itself is a low yielding one.

(ii) In Granite aquifer system potential zone for ground water is related with occurrence of fracture, so drilling a high yield well is always a challenge. Proper scientific study coupled with geophysical investigation may minimize the failure of well.

(iii) Problems in Tube well / Bore well construction in Sandstone Aquifer System: In case of filter point wells drilled with hand bores, the depth of penetration is variable and whenever the Shale or any other compact layers are encountered, further drilling becomes difficult. When portable rotary rigs are deployed for drilling, the drilling operations become very slow and the pore spaces in fine grained layers are invaded by drilling fluid as a result the discharges tend to be poor. Proper well development is seldom carried out by private drillers and as a result fine sands get deposited in the bore. Sometimes caving of wells are commonly reported particularly when the top loss sand is cased and the bottom shales are drilled with down the hole hammer rig.

(iv) Problems in ring well construction Sandstone Aquifer System: The common problem is sand filling inside the rings during and after the lowering of rings, thereby practically eliminating the change of deepening of wells to tap more saturated column in summer months. The weep holes provided in the rings allow water with fine sands and gets filled up as and when sand removal is in progress thereby making it difficult for lowering of rings is highly saturated sands.

(v) High value of Fluoride and Iron has been reported from several locations.

6. Management Plan:

(i) It has been observed during fieldwork, there is colossal wastage of groundwater through private well and public water supply system. So, Information, Education and Communication (IEC) activities need to be organized to sensitize people on the issues of depleting groundwater resource. Massive awareness campaigns are essential to aware people about the importance of community participation in saving water.

(ii) Desiltation of existing Tanks and Talabs to be carried out for efficient storage of rainwater. Also Rain water harvesting structures may be constructed in villages to reduce stress on groundwater.

(iii) It has been observed that the demand of ground water is increasing for irrigation, industrial and domestic uses. At locations where water level is declining, we have to go for artificial recharge on a long-term sustainability basis. Artificial Recharge structures may be constructed at suitable locations especially in the areas where the water level remains more than 3m in the post-monsoon period in this block to arrest the huge non-committed run-off and augment the ground water storage in the area. The different types of artificial structures feasible in the block are described in table-9.

Table-9: Types of Artificial Recharge structures feasible

Name of Block	**Area Feasible for recharge (sq.km)**	**Volume of Sub Surface Potential for Artificial recharge (MCM)**	**Types of Structures Feasible and their Numbers**			
			Percolation tank	**Nalas bunding cement plug/ check dam**	**Gravity head /Dug well/ tube well/Recharge shaft**	**Gully plugs Gabion structures**
Mainpat	113.32	5.897	16	26	130	66
	Recharge Capacity (MCM)/structure		0.2192	0.0326	0.00816	0.0073

(iv) Fluoride and Iron filter plant may be installed in the villages having higher value of contaminants.

(v) Treatment of sewage water in village through soak pit for the individual houses and Seechewal model or similar model for community level may be adopted to avoid contamination of ground water. Treated water may also be reused for irrigation and other industrial purposes.

(vi) Since the stage of development in the block is 27.01 %. There is scope of utilizing more ground water for future irrigation purpose. Additional number of Ground water abstraction structure may be developed for the effective utilization of ground water resources in the block. The ground water is presently developed through dug wells and tube wells. Yield potential for the block has been shown in Aquifer map (fig 11). Sites for wells need to be selected only after proper scientific investigation. The ground water quality also needs to be ascertained and the wells used for water supply should be first checked for Iron, Fluoride and other pollutants.

Table 10: Potential of Additional GW abstraction structure creation

Net Groundwater availability (ham)	Stage of ground water Developm ent (%)	Present ground water draft (Ham)	Ground water draft at 70% stage of developmen t (ham)	Surplus ground water at present Stage of Development (ham)	Number of TW Recommended in each block (Assuming unit draft as 1.6 ham/structure/year)	Number of DW Recommended in each block (Assuming unit draft as 0.72 ham/structure/year)
2695.48	27.01	727.94	1886.84	1158.90	435	644

7. Conclusion:

For effective utilization of Ground water existing draft for irrigation may be coupled with micro irrigation system. Change in irrigation pattern, optimum use of available resource, use of ground water potential created after artificial recharge can lead to groundwater savings and increase in gross cropped area of the block (Table: 11).

Table 11: Detail of groundwater saved through change in cropping pattern and other interventions

Block	Existing Gross Ground Water Draft for Irrigation in Ham	Additional Saving of GW after using Micro Irrigation methods in Ham(Assuming 30 % saving)	GW Potential created after Artificial recharge structure in Ham	Development by new GW abstraction structure	Additional GW irrigation Potential created in Ham	Additional Irrigation potential creation for Maize/ wheat in winter season in Ha (Assuming 500 mm water requirement)	Percent increase in Crop area compare to Gross cropped area
Mainpat	543.67	163.10	589.74	1158.90	1847.95	3695.89	19.17%