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

DURG DISTRICT, CHHATTISGARH

उत्तर मध्य छत्तीसगढ़ क्षेत्र, रायपुर

North Central Chhattisgarh Region, Raipur

स्वच्छ जल : स्वच्छ भारत

केन्द्रीयभूमिजलबोर्ड

उत्तर मध्य छत्तीसगढ़ क्षेत्र

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REPORT ON AQUIFER MAPPING IN DURG DISTRICT, CHHATTISGARH

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Executive summary

Aquifer mapping is a multidisciplinary scientific process wherein a combination of geological, hydrogeological, geophysical, hydrological and quality data is integrated to characterize the quantity, quality and movement of ground water in aquifers. However, due to paradigm shift in focus from development to management of ground water in last one decade, the need for more reliable and comprehensive aquifer maps on larger scale has been felt for equitable and sustainable management of the ground water resources at local scale. Volumetric assessment of ground water and strategies for future development and management are the primary objectives of aquifer mapping.

Under the aquifer mapping programme, an area of 2506 sq. km comprising of three(3) development blocks namely Dhamdha, Durg and Patan of Durg district was taken up for study. Durg district is situated in the Western part of the Chhattisgarh state. It falls in the Survey of India's Degree Sheet No. 64C, G and H between the Latitude 20.90ºN : 21.50ºN and Longitude 81.16 º E : 81.6º E.

As per Census 2011 (provisional), the population of the district is 17, 21,726. In which 6, 17,184 is rural population and 11, 04,542 is urban population.

The study area experiences sub-tropical climate. Average annual rainfall in the study area is 1217.33 mm taking rainfall from 2011-2015 into consideration 50 to 60 rainy days out of which the monsoon rainfall contributes about 92 %.

Geomorphologically the study area displays Structural Plains, flood plains and pediment/pediplain with an elevation ranging from 241 to 470 masl.

The net sown area is 147146hectare, while double-cropped area is 43291hectare. Gross cropped area accounts 190437hectare. . Rice is sown in nearly 95% of the net sown area.

The net irrigated area in the study area is 93215 hectares. The percentage of the irrigated area to net sown area is 61%. Irrigation by surface water covers almost 62.12 % of the net irrigated area while 30.41 % of the net irrigated area is irrigated by ground water.

This district has high quality rich deposits of limestone. The quarrying of limestone is ongoing at Nandini, Semariya, Khundani, Pithaura, Sahgaon, Deurjhaal, Ahiwara, Achcholi, Matragota, Ghotwani and Medesara. Limestone is utilized mainly by ACC for cement production and BSP for steel production.

The major aquifers present in the study area are (1) Tarenga formation calcareous shale (2) Chandi formation argillaceous limestone (3) Chandi formation sandstone (4) Gunderdehi formation calcareous shale; both in phreatic and fractured condition.

UNCONFINED AQUIFER: In the pre-monsoon period, it has been observed that in Tarenga formation calcareous shale, the minimum water level is 3.9m bgl, maximum water level is 10.8 mbgl and average water level is 7.35 mbgl. It has been observed that in Chandi formation argillaceous limestone, the minimum water level is 1.48 mbgl maximum water level is 17.07 mbgl, the average water level is 6.03 mbgl. It has been observed that in Chandi formation sandstone, the minimum water level is 3.7 mbgl maximum water level is 7.5 mbgl, the average water level is 5.6 mbgl. It has been observed that in Gunderdehi formation calcareous shale, the minimum water level is 2.34 mbgl maximum water level is 9.72 mbgl, the average water level is 5.51 mbgl.

In the post-monsoon period, it has been observed that in Tarenga formation calcareous shale, the minimum water level is 2.38m bgl, maximum water level is 7.26 mbgl and average water level is 4.82 mbgl. It has been observed that in Chandi formation argillaceous limestone, the minimum water level is 0.84 mbgl maximum water level is 3.57 mbgl, the average water level is 2.14 mbgl. It has been observed that in Chandi formation sandstone, the minimum water level is 1.2 mbgl maximum water level is 4.17 mbgl, the average water level is 2.69 mbgl. It has been observed that in Gunderdehi formation calcareous shale, the minimum water level is 1.13 mbgl maximum water level is 2.05 mbgl, the average water level is 1.53 mbgl.

However due to unplanned exploitation of ground water in the backdrop of more population and inadequate recharge, some of the areas shows water level deeper that is > 5mbgl. So these places are to be given special attention with regular monitoring and artificial recharge.

It has been observed that in Tarenga formation calcareous shale, the minimum water level fluctuation is 1.52m, maximum water level fluctuation is 3.54 m and average water level fluctuation is 2.53 m. It has been observed that in Chandi formation argillaceous limestone, the minimum water level fluctuation is 0.25 m, maximum water level fluctuation is 13.97 m, and the average water level fluctuation is 3.89 m. It has been observed that in Chandi formation sandstone, the minimum water level is fluctuation 2.5 m, maximum water level fluctuation is 3.33 m, and the average water level fluctuation is 2.92 m. It has been observed that in Gunderdehi formation calcareous shale, the minimum water level fluctuation is 1.21 m, maximum water level fluctuation is 7.67 m, and the average water level fluctuation is 3.98 m.

The long term water level trend indicates that there is decline in pre-monsoon water level in Dhamdha block, decline in both pre-monsoon and post-monsoon water level in Durg block and no appreciable change in water level both in pre-monsoon and post-monsoon period in Patan block.

SHALLOW CONFINED AQUIFER: In the pre-monsoon period, it has been observed that in Tarenga formation calcareous shale, the minimum water level is 27.54m bgl, maximum water level is 30.88 mbgl and average water level is 29.21 mbgl. It has been observed that in Chandi formation argillaceous limestone, the minimum water level is 5.6 mbgl maximum water level is 23.1 mbgl, the average water level is 14.39 mbgl. It has been observed that in Chandi formation sandstone, the minimum water level is 12.35 mbgl maximum water level is 25.2 mbgl, the average water level is 18.76 mbgl. It has been observed that in Gunderdehi formation calcareous shale, the minimum water level is 3.5 mbgl maximum water level is 12.42 mbgl, the average water level is 7.96 mbgl.

In the post-monsoon period, it has been observed that in Tarenga formation calcareous shale, the minimum water level is 4.31m bgl, maximum water level is 7.86 mbgl

and average water level is 6.09 mbgl. It has been observed that in Chandi formation argillaceous limestone, the minimum water level is 3.62 mbgl maximum water level is 12.22 mbgl, the average water level is 8.14 mbgl. It has been observed that in Chandi formation sandstone, the minimum water level is 8.21 mbgl maximum water level is 13.57 mbgl, the average water level is 10.89 mbgl. It has been observed that in Gunderdehi formation calcareous shale, the minimum water level is 1.73 mbgl maximum water level is 7.62 mbgl, the average water level is 4.68 mbgl.

It has been observed that in Tarenga formation calcareous shale, the minimum water level fluctuation is 23.02m, maximum water level fluctuation is 23.23 m and average water level fluctuation is 23.13 m. It has been observed that in Chandi formation argillaceous limestone, the minimum water level fluctuation is 0.05 m, maximum water level fluctuation is 13.0 m, and the average water level fluctuation is 6.25 m. It has been observed that in Chandi formation sandstone, the minimum water level is fluctuation 4.14 m, maximum water level fluctuation is 11.63 m, and the average water level fluctuation is 7.89 m. It has been observed that in Gunderdehi formation calcareous shale, the minimum water level fluctuation is 1.77 m, maximum water level fluctuation is 4.8 m, and the average water level fluctuation is 3.2 m.

Argillaceous limestone (Raipur group): The average thickness of the weathered portion in the area is around 18.5 m. The occurrences of fractures at depth in the area are not common and whenever occur are less potential in ground water point of view. Fractures are mostly confined to 100m depth. In general, the discharge varies from negligible to 3 lps with an average yield of 1.5 lps. The development in these formations is mostly by way of dug wells. The average drawdown of the formation is around 20.1 m. The thickness of fractured aquifer is around 0.2 m.

Tarenga shale: The average thickness of the weathered portion in the area is around 10.36 m. The occurrences of fractures at depth in the area are not common and whenever occur are less potential in ground water point of view. Generally 1 to 2 sets of fractures are encountered within 50 m depth and 1to 2 sets of fractures are encountered within 50 to 200 m depth. The potential zones are present wthin 50 m depth below ground level.In general the discharge varies from negligible to 2 lps with an average yield of 1.5 lps. The The development in these formations is mostly by way of bore wells. The average drawdown of 35.2 m.

Chandi limestone is controlled by the solution cavities, joints and fractures. Generally 1 to 2 sets of fractures are encountered within 50 m depth, 1 to 3 sets of fractures within 50 to 200 m depth. The discharge varies from 0.1 to 2.0lps. At Shivkokri, Dhamdha exceptional discharge of 18lps was obtained. The drawdown varies widely from 2m to 29.7m.These formations are mostly developed by the way of dug wells, bore wells and tube wells.

The ground water in Gunderdehi shale occurs under phreatic/water table conditions in the weathered portion while semi-confined to confined conditions in deeper part consisting of fractures.The average thickness of the weathered portion in the area is around 12.7 m. Generally 1 to 2 sets of fractures are encountered within 50 m depth and 1to 2 sets of fractures are encountered within 50 to 200 m depth. The potential zones are present wthin50 m depth below ground level. In general the discharge varies from negligible to 0.5 lps. The development in these formations is mostly by way of bore wells. The average drawdown of 35.08 m.

So far as chemical quality is concerned, high iron content (>0.3 mg/l) is also found in ground water in Durg district. Other heavy metals like lead and chromium contamination in groundwater has been reported by CGWB during study around Durg industrial cluster(Industrial cluster report, Durg,2011-12)in locations around Bhilai Industrial Cluster.

The Total Annual Replenishable Groundwater Resources and Net Available Groundwater Resources for the study area 28246.08 and 26364.13 Ham respectively. Out of this 17234.14 Ham is being used for irrigation, 4190.77 Ham for industrial and domestic sector taking the gross annual ground water draft for all uses to 21424.91 Ham. This translates to an overall stage of ground water development in the study area at 81.24 %. A ground water resource of 4825.31 Ham & 4304.68 Ham has been kept reserved for future domestic and industrial requirement and irrigation development respectively for next 25 years. So All the blocks fall in semi-critical category.

Sub Surface Potential to be recharged through other methods in the study area has been calculated to be 7.81 MCM.

(i) The major ground water issues identified during the survey in the study area are as follows: (i) The aquifers are low yielding ones in terms of groundwater. (ii) During summer, dugwells in most villages go dry except. Several handpumps also stop yielding water. Hence there is scarcity of water. (iii) It has been observed during fieldwork in pre-monsoon period, there is colossal wastage of groundwater through public water supply system. (iv) Contamination of groundwater by anthropogenic sources like industrial effluent sources as well as geogenic sources (vi)In some areas the water level remains below 5m during the post-monsoon period in the study area which needs to be attended for intervention.

So far as Management strategies are concerned, Artificial Recharge structures may be constructed in suitable locations especially in the areas where the water level remains deeper than 5m in the post-monsoon period, 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. Massive awareness campaigns are essential to teach people about the importance community participation in saving water. Farmers may be encouraged to take up maize/ millets cultivation for Rabi period and practice of microirrigation. The problem of iron contamination in drinking water may be tackled by setting up of small filtration units in affected villages.

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Scientist-'B'

A Report on Aquifer Mapping
In Durg district, Chhattisgarh

CONTENTS

AQUIFER MAPS AND MANAGEMENT PLANS OF DURG DISTRICT, CHHATTISGARH

1. Introduction

1.1 Objective

Groundwater is one of the most valuable resource for a country. However, due to rapid and uneven development, this resource has come under stress in several parts of the country. Central Ground Water Board (CGWB) is, therefore, involved in hydrogeological investigations for Re-appraisal of ground water regime. CGWB has also carried out ground water exploration in different phases with prime objective of demarcating and identifying the potential aquifers in different terrains for evaluating the aquifer parameters and also for developing them in future. The reports and maps generated from the studies are mostly based on administrative units such as districts and blocks and depict the subsurface disposition of aquifer on regional scale. However, due to paradigm shift in focus from development to management of ground water in last one decade, the need for more reliable and comprehensive aquifer maps on larger scale has been felt for equitable and sustainable management of the ground water resources at local scale.

1.2 Scope of study

The demand for ground water for various types of use is increasing day by day; consequently indiscriminate development of ground water has taken place and the ground water resource has come under stress in several parts of the country. On the other hand, there are also areas where adequate development of ground water resources has not taken place. These facts underscore the need for micro- level study of the aquifer systems of the country. The water resource managers and planners to develop and implement effective long term as well as short term aquifer management strategies, a host of of scientific questions must be answered. These questions can be best answered through a comprehensive process that integrates the available scientific data. Aquifer mapping study thus is a multidisciplinary scientific process wherein a combination of geological, hydrogeological, geophysical, hydrological and quality data is integrated to characterize the quantity, quality and movement of ground water in aquifers. It primarily depends on the existing data that are assembled, analysed and interpreted from available sources. The data gap analysis carried out helped to generate data from data newly collected through activities such as exploratory drilling, groundwater level monitoring on a regular basis for a considerable period and groundwater quality analysis. These existing as well as generated data were analysed in ordered to prepare regional hydrogeological, thematic, water quality maps, cross-sections, 2 –D and 3-D aquifer disposition maps. The aquifer maps are the maps depicting aquifer disposition, giving lateral and vertical extension. The maps will also provide information on the quantity and quality. It explains the components of the Aquifer Classification System, outlines the assumptions underlying the map information presented and summarizes the content of an aquifer classification map. The goal is to help the map users understand the strengths and limitations of the information contained on the aquifer classification maps so that they can apply that information appropriately to their particular water and land management needs. The system and maps are designed to be used together and in conjunction with other available information as a screening tool for setting groundwater management priorities. These provide a way of comparing aquifers within a consistent hydrogeological context and prioritizing future actions at

various planning levels. The maps may provide some background information for site-specific projects. However, the maps are not to be used for making site-specific decisions. The classification of an aquifer reflects the aquifer as a whole and at a specific time. Groundwater conditions, such as the degree of vulnerability and water quality, may vary locally and over time respectively. This variability in the data sometimes requires subjective decision-making and generalizing of information for an entire aquifer.

1.3 Approach and Methodology

The activities under the aquifer project can be summarized as follows:
i) **Data Compilation & Data Gap Analysis:** One of the important aspect of the aquifer mapping programme was the synthesis of the large volume of data already collected during specific studies carried out by the Central Ground Water Board and various other government organizations with a new set of data generated that broadly describe an aquifer system. The data were compiled, analyzed, synthesized and interpreted from available sources. These sources were predominantly non-computerized data that were converted into computer based GIS data sets. On the basis of these available data, Data Gaps were identified.
ii) **Data Generation:** It was evident from the data gap that additional data should be generated to fill the data gaps in order to achieve the objective of the aquifer mapping programme. This was done by multiple activities like exploratory drilling, hydrochemical analysis, use of geophysical techniques as well as detail hydrogeological surveys.
iii) **Aquifer map Preparation:** On the basis of integration of data generated through various hydrogeological and geophysical studies, aquifers have been delineated and characterized in terms of quality and potential. Various maps have been prepared bringing out the Characterization of Aquifers. These maps may be termed as Aquifer Maps depicting spatial (lateral and vertical) variation of the aquifers existing within the study area, quality, water level and vulnerability (quality and quantity).
iv) **Aquifer Management Plan:** Based on the integration of these generated, compiled, analysed and interpreted data, the management plan has been prepared for sustainable development of the aquifer existing in the area.

1.4 Area Details

Under the aquifer mapping programme, an area of 2506 sq. km comprising of three(3) development blocks namely Dhamdha, Durg and Patan of Durg district was taken up for study. Durg district is situated in the Western part of the Chhattisgarh state. It falls in the Survey of India's Degree Sheet No. 64C, G and H between the Latitude 20.90ºN : 21.50ºN and Longitude 81.16 º E : 81.6º E. The district is bounded by Raipur and Dhamtari district in the East, Bemetara district in the north, Rajnandgaon district in the West, and Balod district in the South.
Located on the Howrah-Mumbai main line of South-Eatern Railway Zone, this district has National Highway i.e. NH 6 (Mumbai-Kolkata highway) passing through. Most of the destinations are well connected with tar roads in the district. The district has a well developed road network.

1.4.1 Administrative Division : District includes 03 blocks and 388 villages. The block headquarters are located at Dhamdha, Durg, and Patan towns. The administrative map for the study area is given in **Fig 1.**

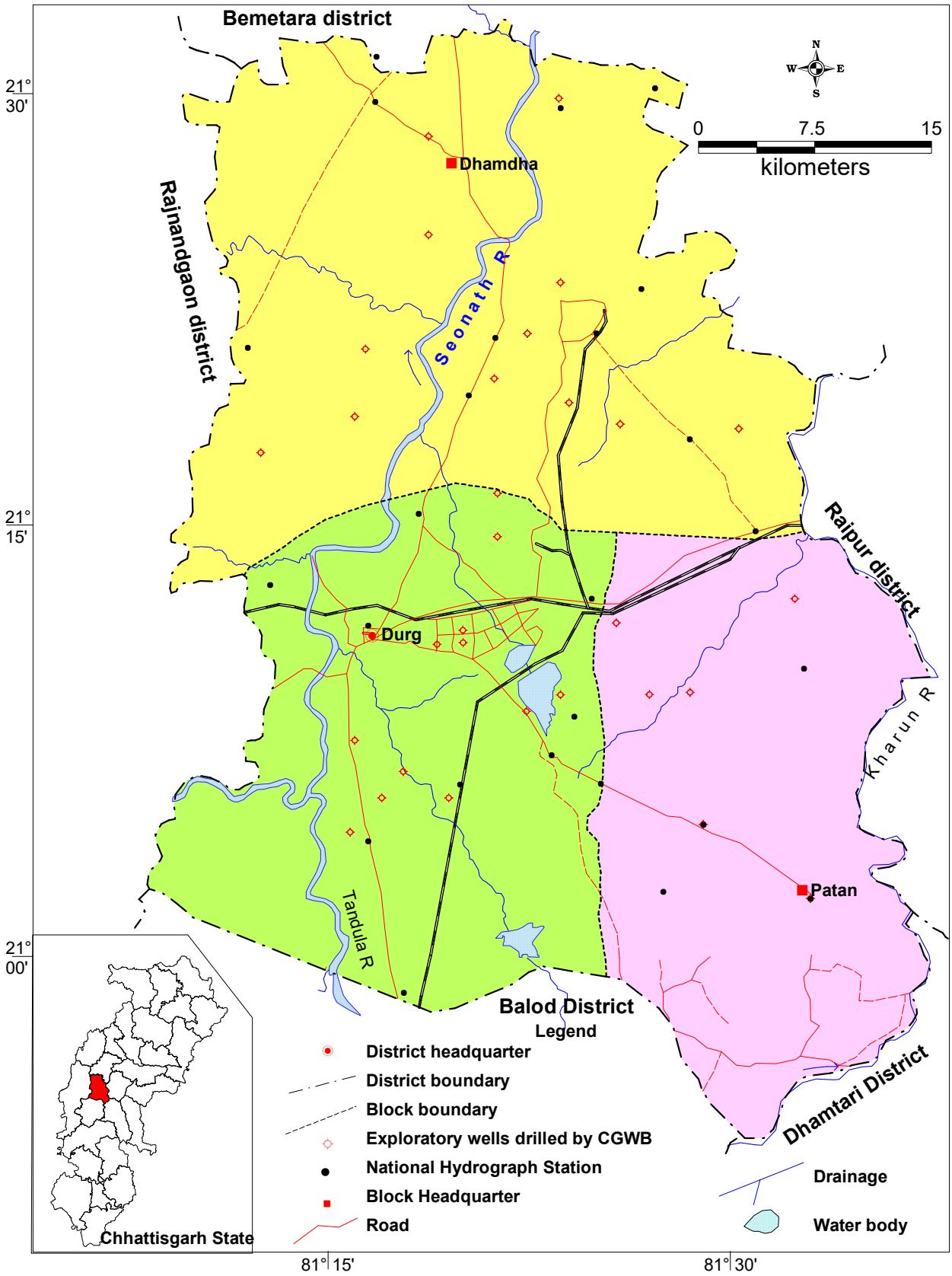


Fig.1 Administrative Map of Durg District

1.5 Data Availability, Data Adequacy and Data gap Analysis

The hydrogeological data already available including number of key wells, VES, exploratory wells, chemical parameters have been collected and analysed which shows that in the study area the required number of ground water monitoring stations is 80 against which only 30 stations are available leading to the data gap of 50. Similarly, the required number of ground water exploratory wells is 75 against which 64 stations are available leading to the data gap of 11. Likewise, the required number of ground water quality monitoring stations is 90 against which only 30 stations are available leading to the data gap of 60. Lastly, the required number of VES is 40 against which 34are available leading to the data gap of 06.

1.5.1 Data Gap Analysis

On the basis of the NHS data, VES data and chemical data available in the study area, the data gap analysis has been prepared to ascertain the data gap in the study area which is presented in summary in Table 2(A).

Activity	Required	Available	Gap
Exploration EW/OW	75	64	11
GW Monitoring	80	30	50
Quality monitoring	90	30	60
VES	40	34	6

1.6 Rainfall

The study area receives rainfall mainly from south-west monsoon. It sets in third/fourth week of June and continues till mid-August/September with heaviest showers in the months of July and August and nearly 95% of the annual rainfall is received during this period. The average annual rainfall for the study area is around 1217.33 mm (Average of the last three years i.e. 2010 to 2015) which is presented below in **Table 3**.

Table 3 Annual Rainfall (mm) in Durg district for the years (2010 to 2015)

Year	2010-11	2011-12	2012-13	2013-14	2014-15
Durg	1205.33	1182.7	1154.37	1376.97	1168.17

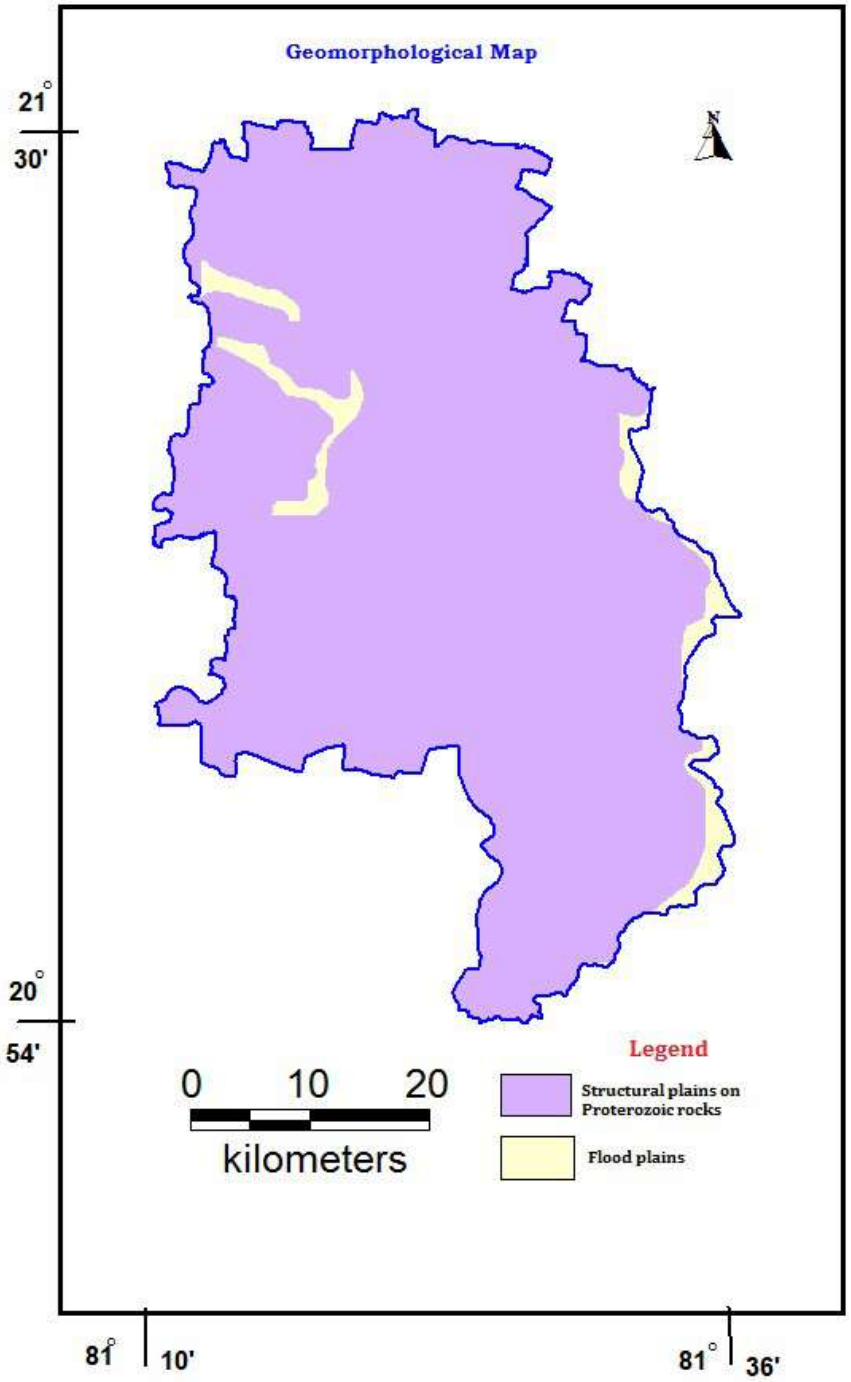
Source: IMD. Raipur

1.7 Physiography/Geomorphology

Geomorphologically the study area displays structural plains, flood plain and pediment/pediplain which comes under the physiographic unit belonging to Chhattisgarh basin area. The Central Chhattisgarh Plain is represented by Structural Plain on Proterozoic rocks which cover major area of the study area. This unit is developed over rocks of Purana sedimentary basin of Chhattisgarh. Overall the topography in the district varies between 241 m to 470 m amsl. The

area has general slope towards north & north-east direction with average elevation of 300 m amsl. **Fig 2** shows the Geomorphology in the study area.

Fig 2 Geomorphology Of the study area.



1.8 Land use

There is no revenue forest and protected forest, other forest in the district. Area not available for cultivation is 40294 ha. Details are presented in Table 4.

Table 4: District Land Use Pattern (Ha)

Block	Total geographical area	Revenue + Protected forest area	Area not available for cultivation	Non agricultural& Fallow land	Agricultural Fallow land	Net sown area	Double cropped area	Gross cropped area
Dhamdha	102100	nil	9974	9320	5326	59649	16889	76538
Durg	57800	nil	22021	5403	4342	33548	10946	44494
Patan	90700	nil	8299	2839	8380	53949	15456	69405
District total	**250600**	**nil**	**40294**	**17562**	**18048**	**147146**	**43291**	**190437**

1.9 Soil

The soils in the district are having wide variations. They are Vertisols (Kanhar-clyey), Inceptisol (Matasi-sandy loam), Alfisol(Dorsa-clayloam), Bharri and Entisol(Bhata-gravely).
Lateritic soil is exposed in northern, extreme eastern, central and south- eastern part in the Durg district.

Vertisols:

Vertisol is a soil in which the content of clay size particles is 30% or more by mass in all horizons of the upper half-metre of the soil profile. They are are characterized by a high content of expanding and shrinking clay known as montmorillonite. They may also be characterized by salinity and well defined layers of calcium carbonate or gypsum.
Vertisols contain high level of plant nutrients, but, owing to their high clay content, they are not well suited to cultivation without painstacking management. Vertisols are especially suitable for rice because they are almost impermeable when saturated. Rainfaid farming is very difficult because vetisols can be worked only under a very narrow range of moisture conditions as they become very hard when dry and become very sticky when wet.

Alfisols

They are considered as very fertile soils and are frequently used for agriculture. This soil exhibit well developed contrasting soil horizons depleted in calcium carbonate but enriched in aluminum and iron bearing minerals. In this soil, below surface horizon accumulation of migrated layer

silicate clay is present which is called as argillic horizon and is characterized by a relatively high content of available calcium, magnesium, potassium and sodium ions.

1.10 Hydrology and Drainage

The general slope of the district is towards the north and north east and locally in some places towards east. Sheonath and Kharun rivers contribute the most in the drainage system of the district. All the small rivulets and rivers are the tributaries either of Sheonath river or Kharun river. Sheonath river flows nearer to the western border of the district whereas river Kharun forms the eastern border of the district which ultimately joins Sheonath river. The river Sheonath itself forms the part of big Mahanadi basin.

Drainage pattern of the area is dendritic to sub-dendritic in nature. Drainage density is more or less same in most of the part of the study area.. The drainage density is found comparatively low in the area which is attributed to plain area indicating somewhat low runoff and higher infiltration (**Fig.3**).

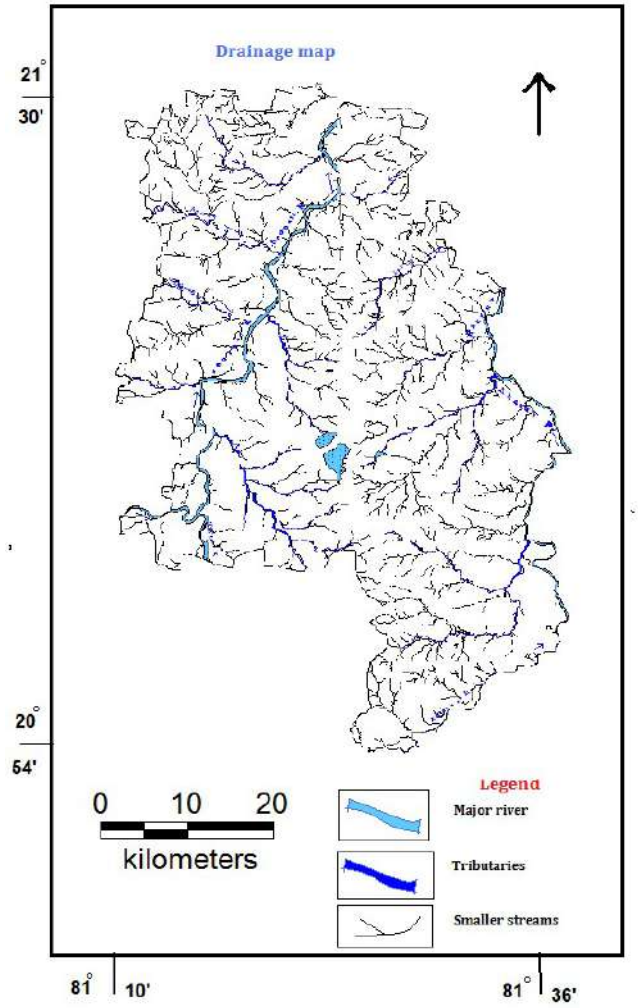


Fig.3 Drainage map of Durg

1.11 Geology and Hydrogeology

Geologically, the district comprises of rocks of Raipur Group of Chhattisgarh Supergroup of Proterozoic age. The rocks of Raipur Group mainly represented by Gunderdehi formation, Chandi formation and Tarenga formation.

Table 1 Generalized geological successions in Durg district

Lithology	Stratigraphic status			Age	Nature and Characteristics
Pebble bed	Khamaria Pebble bed			Quaternary	Epiclastic, extra formatic, polymictic gravel of fluviatile origin
Laterite				Cainozoic	Red, dark brown, pisolitic, massive, cavernous, hard, compact, ferrugenous
	Maniyari Formation	**Raipur Group**	**Chhattisgarh Supergroup**	Neo to Meso Proterozoic	
	Hirri Formation				
Shale with chert & green clay bands	**Tarenga Formation**				Shale is green, grey and purple in colour and compact. Chert is greenish grey hard, compact with porcellinite. Clay is greenish, compact and massive
Ferruginous sandstone	**Chandi Formation**				Reddish brown, fine to coarse grained, hard, compactrock. Occures as intercalations in Chandi Formation(Deodongar Member)
Stromatolitic limestone					Purple to grey, fine grained, hard and compact, calcareous rock showing stromatolitic structure
Purple caicareous shale	**Gunderdehi formation**				Purple to white, fine grained,friable,calcareous with intercalations of stromatolitic limestone
	Charmuriya Formation				
		Chandrapur Group			
Nandgaon Group(= Kotri Group)				Palaeo Proterozoic	

Bailadila Group	Paleao Proterozoic to Archaean	
Basement Gneissic Complex(Bengpal Group)	Archean	

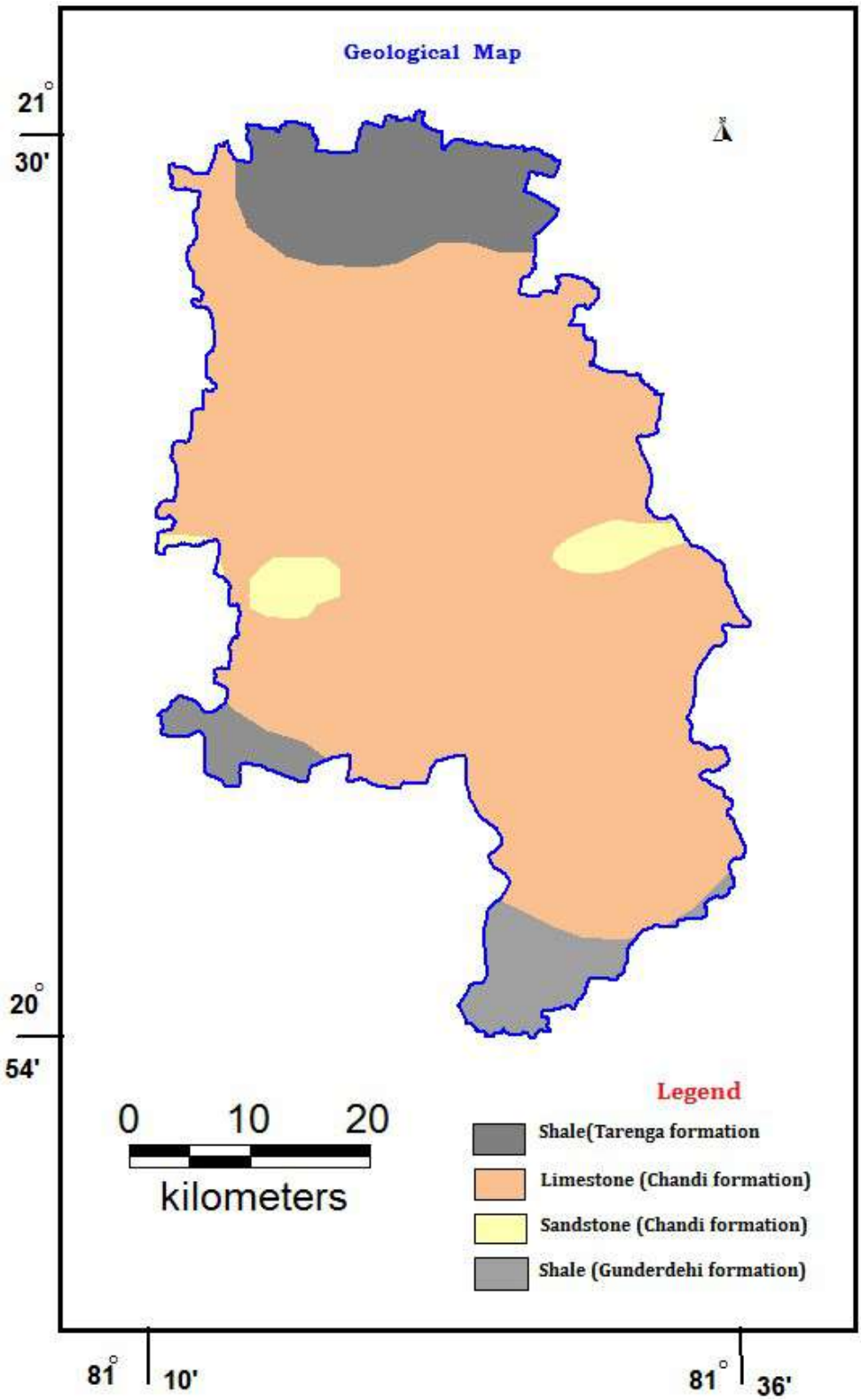
i) Gunderdehi Formation: Charmuria Formation is conformably overlain by Gunderdehi Formation, which is dominantly a calcareous argillite developed as a distinct facies in the sub-basin. Although the purple-coloured shale with intercalated limestone is the dominate member, a buff-coloured shale and a ferruginous arenite are also two prominent members occurring at the middle of the formation. The purple shale is generally calcareous, highly friable in character and is associated with impersistent limestone bands. Locally intra-formational conglomerate lenses are present in the upper part. Besides this, lenses and pockets of stromatolitic limestone appearing towards top indicate a gradational contact with the overlying formation. It is reported that at subsurface Gunderdehi purple shale grades to black shale.

ii) Chandi Formation: This comprises a major stromatolitic limestone sequence developed in southern & western periphery of the district. Chandi Formation had been classified into three major carbonate members based on dominant carbonate facies. The Deodongar arenite include lensoidal pockets of siliciclastic rocks within Chandi Formation. They, however occupy a definite stratigraphic level within the formation. The revised sequence stands as Newari, Pendri, Deodongar and Nipania Member in ascending order.

iii) Tarenga Formation: The Chandi Formation is conformably overlain by Tarenga Formation which is classified into Kusmi argillite, Dagauri green clay-chert and Bilha dolomitic argillite from bottom to top. It is also developed in southern & western part of the district.

The rocks of the Chhattisgarh Super group show sub-horizontal dips. The overlying formations are nearly flat dipping. The district is also traversed by minor lineaments. The NE-SW trending lineaments are predominant. The most of the drainages are controlled by lineaments indicating drainage is probably due to structural disturbances (Fig.4).

Fig.4-Geology map of Durg district



Hydrogeologically Durg district can be categorized into Precambrian sedimentary province. The Precambrian sedimentary province of the district includes Chhattisgarh Super Group of rocks of Upper Proterozoic age of marine origin. This province occupies whole district area. It mainly consists of arenaceous-argillaceous-calcareous rocks and is dominated by limestone/ dolomite and calcareous shale. The ground water in these formations occurs under semi-confined and confined conditions. The weathered, cavernous and fractured part of the formation constitutes the aquifers in the area.

(i) Tarenga shale: The average thickness of the weathered portion in the area is around 10.36 m. The occurrences of fractures at depth in the area are not common and whenever occur are less potential in ground water point of view. Generally 1 to 2 sets of fractures are encountered within 50 m depth and 1to 2 sets of fractures are encountered within 50 to 200 m depth. The potential zones are present wthin 50 m depth below ground level.In general the discharge varies from negligible to 2 lps with an average yield of 1.5 lps. The The development in these formations is mostly by way of bore wells. The average drawdown of 35.2 m.

(ii) Chandi limestone is controlled by the solution cavities, joints and fractures. Generally 1 to 2 sets of fractures are encountered within 50 m depth, 1 to 3 sets of fractures within 50 to 200 m depth. The discharge varies from 0.1 to 2.0lps. At Shivkokri, Dhamdha exceptional discharge of 18lps was obtained. The drawdown varies widely from 2m to 29.7m.These formations are mostly developed by the way of dug wells, bore wells and tube wells.

(iii) The ground water in Gunderdehi shale occurs under phreatic/water table conditions in the weathered portion while semi-confined to confined conditions in deeper part consisting of fractures.The average thickness of the weathered portion in the area is around 12.7 m. Generally 1 to 2 sets of fractures are encountered within 50 m depth and 1to 2 sets of fractures are encountered within 50 to 200 m depth. The potential zones are present wthin50 m depth below ground level. In general the discharge varies from negligible to 0.5 lps. The development in these formations is mostly by way of bore wells. The average drawdown of 35.08 m.

In the district a total of 74 nos of wells were drilled under Aquifer mapping and exploration programme using DTH rigs as on March 2017. Out of this 53 number are EW, 5 is OW and 15 are Piezometers to delineate the aquifer geometry and to estimate different aquifer parameters in the district.

1.12 Agriculture, Irrigation, Cropping Pattern

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 Dug wells, Bore wells /tube wells. The principal crops in the block are Paddy, Wheat and Gram.

In some areas, double cropping is also practiced. The agricultural pattern, cropping pattern and area irrigated data of Durg district is given in Table 5 (A, B, C).

Table 5 (A): Cropping pattern (in ha)

Block& District	Kharif	Rabi	Cereal				Pulses	Tilhan	Fruits Vegetables	Reshe	Mirch Masala	Sugar-cane
			Wheat	Rice	Jowar & Maize	Kodo kutki						
Dhamdha	55342	21173	3385	42901	77	30	14656	7568	7391	30	22	379
Durg	33099	11395	1537	32673	77	6	7026	2773	2530	nil	1	41
Patan	53624	15654	1442	54893	331	0	9900	678	2060	nil	62	39
Total	**142065**	**48222**	**6364**	**130467**	**485**	**36**	**31582**	**11019**	**11981**	**30**	**85**	**459**

Table 5 (B): Area irrigated by various sources (in ha)

Block& District	No. of canal s (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	Gross irrigated area	Net Irri-gated area	% of irrigated area wrt. Net sown area
Dhamdha	10075	10078	26978	16083	112	96	206	nil	799	28087	27914	50 %
Durg	14637	14637	11005	851	425	425	857	nil	1482	23773	23033	64 %
Patan	33194	33194	12763	10548	123	123	424	nil	1015	41526	41525	69 %
Total	57906	57909	50746	27482	660	644	1487	nil	3296	93386	92476	61%

Table 5 (C): Statistics showing Agricultural land Irrigated (in ha)

Block &District	Net Irrigated Area	Net Irrigated Area by ground water	Percentage of Area Irrigated by ground water
Dhamdha	27914	16179	57.95
Durg	23033	1276	34.75 %
Patan	41525	10671	25.7 %
Total	**92476**	**28126**	**30.41%**

2.0 Data Collection and Generation

2.1 Hydrogeological Data The major aquifers present in the study area are (1) Tarenga limestone and shale (2) Chandi limestone/shale (3) Gunderdehi shale; both in phreatic and fractured condition In general two aquifers exist in the area although both are hydraulically connected. The first shallow unconfined/ phreatic aquifer between 0-20 mbgl and the second semi confined to confined aquifer below 20 mbgl. It has been found that within the second aquifer, there are 2-3 set of aquifers which are not well connected. The different sets of aquifers are of different thickness as well as of varying horizontal extent. In the study area, key wells were established during the pre-monsoon period and have been subsequently monitored in the post-monsoon period. The key wells are distributed throughout the study area (Fig.5) covering all the geological formations, the details of which are presented in the Table No 6.

Fig.5: Map showing location of keywell

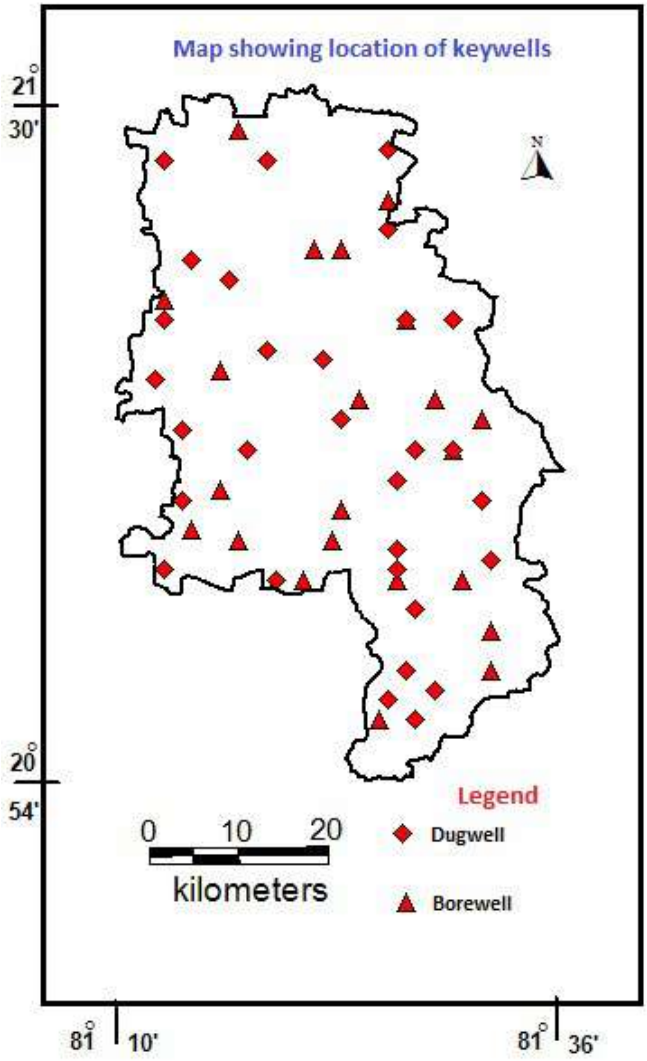


Table 6: Detail of Key (observation) Wells established in the study area							
SL.NO.	**LOCATION**	**BLOCK**	**LONGITUDE**	**LATITUDE**	**TYPE**	**Geology**	**DETAILS**
1	Kapasda	Dhamdha	81.51	21.31	DW	Chandi limestone/shale	Govt.well infront of Ugal Kumari Sharma's house, near tank,about 5km from Kumhari
2	Murmunda	Dhamdha	81.46	21.31	DW	Chandi limestone/shale	In the house of Mayaram, RHS of main road from Kumhari towards Ahiwara
3	Girhola	Dhamdha	81.44	21.40	DW	Chandi limestone/shale	Private well of Sh.Premraj, RHS of road from Ahiwara towards Berla, in the Gouthan
4	Mohrenga	Dhamdha	81.44	21.48	DW	Tarenga limestone/shale	Govt. well Infront of Lekhram's house, LHS of road from Mohrenga towards Gota, near Yatri pratikshalay
5	Birjhapur	Dhamdha	81.31	21.47	DW	Tarenga limestone/shale	Govt.well,3km from Dhamdha, just beside main road, adjacent to Andhra bank atm, LHS of road from Dhamdha towards Gandai
6	Raunda	Dhamdha	81.20	21.47	DW	Chandi limestone/shale	Private well in the house of Thanwar, end of village from bazar chowk, 15 km from Dhamdha,Pendri ---->Jalbandha ---->Thelka Chowk ----->(turn right) ,after Paraskol turn left near a four road cross-section point(where a woman fruitseller has set up shop)
7	Arsi	Dhamdha	81.23	21.37	DW	Chandi limestone/shale	Govt.well, 3km from Dodki on Dhamdha to Jalbandha road,near Yadav Samaj Samudayik Bhawan
8	(Badi)Birejhar Kalan	Dhamdha	81.20	21.31	DW	Chandi limestone/shale	Govt.well infront of house of Mohan lal, opposite to temple, near Sinha niwas and general store

9	Bori buzurg	Dhamdha	81.27	21.35	DW	Chandi limestone/shale	Govt.well beside anganwadi kendra, infront of Jaitkhamb
10	Meresara	Dhamdha	81.36	21.38	HP	Chandi limestone/shale	In the bazar chowk, close to water tank 100m from main road
11	Urla	Patan	81.49	21.23	HP	Gunderdehi shale/limestone	Govt.well in Gandhi Chowk, infront of Adivasi Samaj memorial
12	Dhaur	Durg	81.37	21.27	DW	Chandi limestone/shale	Private well in Roopdas's house, about 3km from Jamul, LHS of main road from Jamul towards Kachandur
13	Samoda	Durg	81.31	21.28	DW	Chandi limestone/shale	Girdhar Deshmukh's well behind Samoda Panchayat Bhawan
14	Borai	Durg	81.19	21.25	DW	Chandi limestone/shale	Govt.well infront of Dhanesh Yadav's house and Durga manch, Kuanchowk
15	Rasmara	Durg	81.22	21.20	DW	Chandi limestone/shale	Govt.well near Rasmara Railway Station (behind railway station)
16	Thanaud	Durg	81.22	21.13	DW	Chandi limestone/shale	Govt.well infront of Deshmukh traders, near new ration shop, Thanaud
17	Nikum	Durg	81.20	21.06	DW	Gunderdehi limestone/shale	Govt.well beside Samudayik Swasth Kendra, infront of Sai Baba Mandir
18	Kuthrel	Durg	81.28	21.09	HP	Chandi limestone/shale	Govt. well infront of Babla Chandrakar's house and Gayatri mandir manch, Bastipara, near talab(pond)

19	Bhilai	Durg	81.39	21.21	DW	Chandi limestone/shale	Ektanagar, before Khursipar Chowk, infront of Bishwanath Shiv Mandir, opposite side of road to Guru Ghasidas Satnam Dham(Shivaji nagar)
20	Durg	Durg	81.29	21.18	DW	Chandi sandstone	govt.well near the entrance gate to satnami para, Santoshi chowk, ward no.44, near Satrupa Shitala mandir,Menonite church--->Ravi Shankar stadium---->Utai road,Civil lines
21	Khopli	Durg	81.38	21.09	HP	Chandi limestone/shale	infront of khopli govt.primary school, near pond and samudayik bhawan
22	Machandur	Durg	81.35	21.05	HP	Chandi limestone/shale	govt.well infront of kala manch, close to bazar chowk
23	Risama	Durg	81.32	21.05	DW	Chandi limestone/shale	Atal chowk, bhatapara, near railway crossing
24	Gondpendri	Patan	81.45	21.08	DW	Chandi limestone/shale	private well in the garden of Manohar Sahu, opposite to IDBI Bank and atm
25	Manikchauri	Patan	81.45	21.06	DW	Chandi limestone/shale	at the end of village, beside Pardeshi Ram Sahu's house
26	Pahanda	Patan	81.54	21.21	HP	Chandi limestone/shale	infront of up-swastha kendra, Pahanda, about 50m-60m from Anganwadi.infront of transformer, LHS of road
27	Batang	Patan	81.51	21.18	DW	Chandi limestone/shale	govt.well infront of Govt.Ayurvedic Aushadhalay
28	Ruhi	Patan	81.54	21.13	DW	Chandi limestone/shale	infront of shiv mandir and anganwadi kendra no.1

29	Bathena	Patan	81.55	21.07	DW	Chandi limestone/shale	govt.well near bazar chowk,bathena
30	Teligundra	Patan	81.55	21.00	HP	Chandi limestone/shale	govt. well beside Samudayik bhawan (Kosaria Marar Patel Samaj), Infront of Anganwadi Kendra no.5,opposite to Samudayik Bhawan (Adivasi Samaj), K
31	Karela	Patan	81.49	20.94	DW	Chandi limestone/shale	near post office, infront of Baldau's house
32	Surpa	Patan	81.47	20.91	DW	Gunderdehi limestone/shale	infront of Loma's house, just after crossing canal, near bazar chowk
33	Aunri	Patan	81.44	20.93	DW	Gunderdehi limestone/shale	govt.well in Bajrang chowk, infront of Maanbodh's house
34	Bharar	Patan	81.46	20.96	DW	Chandi limestone/shale	infront of Anganwadi kendra no.5 and big banyan tree and village stage
35	Dhuma	Patan	81.47	21.02	DW	Chandi limestone/shale	govt.well infront of Kala manch and Dr.G.R.Adil dawakhana
36	Pahandor	Patan	81.45	21.15	DW	Chandi limestone/shale	govt.well inside the premises of Govt.ayurved aushadhalay
37	Aundhi	Patan	81.47	21.18	DW	Chandi limestone/shale	govt.well infront of sarpaanch Rajesh Chandrakar's house
38	Murmunda	Dhamdha	81.46	21.31	HP	Chandi limestone/shale	HP located in the premises of Shashakiya Purv Madhyamik Shala, beside gram panchayat karyalay

39	Pandritarai	Dhamdha	81.44	21.43	HP	Chandi limestone/shale	HP located near Jaitkhamb, infront of Ram Khilawan's house
40	Pendri	Dhamdha	81.28	21.50	HP	Tarenga limestone/shale	HP is located on LHS of main road from Dhamdha towards Gandai infront of Ujala Bhawan
41	Hasda	Dhamdha	81.20	21.33	HP	Chandi limestone/shale	HP is licated infront of Gouthan, beside karyalay gram panchayat, Hasda, behind Anganwadi Kendra
42	Nandini Khundini	Dhamdha	81.39	21.38	HP	Chandi limestone/shale	HP is located on RHS of road from nandini towards Ahiwara, beside pintu kirana stores
43	Hathkhoj	Durg	81.41	21.23	HP	Chandi limestone/shale	HP in Shitalapara, infront of Mandirwala house and tea stall
44	Bhendsar	Durg	81.26	21.26	HP	Chandi limestone/shale	HP is located opposite to Kamalesh Deshmukh's house. Handpump No.523154/26
45	Changori	Durg	81.23	21.10	HP	Chandi limestone/shale	HP is located infront of Ganesh Chowri, under blackberry tree
46	Kolihapuri	Durg	81.26	21.14	HP	Chandi limestone/shale	HP is on LHS of main road from Chandkhuri towards Durg, infront of Itwari Sahoo's house, near Rudra Dental clinic(Dr.Prashant Verma),near banyan tree
47	Dumardih	Durg	81.39	21.12	HP	Chandi limestone/shale	HP is infroont of Jaitkhamb, 500m from village entrance, beside community water supply 500litre tank
48	Matang	Patan	81.45	21.05	HP	Chandi limestone/shale	HP is located at the entrance to village, infront of house of Kaushal

49	Batang	Patan	81.51	21.18	HP	Chandi limestone/shale	HP is located infront of Govt.Ayurved Aushadhalay
50	Pandar	Patan	81.52	21.05	HP	Chandi limestone/shale	HP is located infront of Jwala Prasad's house, behind Satnam Bhawan near village entrance
51	Ashoga	Patan	81.55	20.96	HP	Chandi limestone/shale	HP is located infront of Tilak Satnami's house
52	Dhamna	Patan	81.43	20.91	HP	Gunderdehi limestone/shale	HP is located infront of Jagat's house and Gulshan Tandon's house.

2.2 Hydrochemical Data

To know the hydro chemical behaviour of the ground water in the study area, 72 nos. of ground water samples were collected from the key wells and 30 nos.NHNS during pre-monsoon period of measurement (June, 2016) and analysed in the chemical laboratory of Central Ground Water Board, NCCR, Raipur for determination of various chemical parameters. The results and findings are presented in Table no. 7(A), 7(B). Groundwater has high concentration of iron(>0.3 mg/l, BIS 2012) in the entire study area.

Table 7 (A): Result of chemical analysis of ground water (NHNS samples), year 2016-17 (concentration in mg/l, EC in µS)

S. No.	Block	Location	pH	EC	TH	Ca	Mg	Na	K	TA	CO3	HCO3	Cl	SO4	F	SiO2	PO4	Fe
1	Dhamdha	Ahiwara	7.9	561	190	64	7.2	29.2	2	105	0	128	85.2	15.4	0.1	16.1	0.2	0.000
2	Durg	Anda	7.9	853	285	76	22.8	47.6	4.1	110	0	134	145.6	55.3	0.3	25.3	0.2	2.126
3	Durg	Bhilai	8.2	564	175	50	12	43.3	3.2	85	0	104	74.6	30.9	0.1	22.0	0.1	0.000
4	Durg	Binayakpur	8.3	496	105	22	12	70	1.2	205	3	244	21.3	15.7	1.6	34.0	0.2	0.000
5	Dhamdha	Dargaon	8	849	330	72	36	47.2	2.1	150	0	183	28.4	257.0	0.2	12.7	0.2	0.000
6	Patan	Dewada	8.33	346	155	50	7.2	8.6	2.1	140	0	171	28.4	11.3	0.2	25.9	0.2	0.461
7	Dhamda	Dhaba	8.2	536	185	62	7.2	31.5	3.1	155	0	189	56.8	29.4	0.3	34.7	0.1	0.000
8	Patan	Funda	8.17	408	165	58	4.8	17.1	0.2	110	0	134	49.7	20.1	0.1	22.8	0.2	0.942
9	Durg	Ganiyari	7.92	1121	405	120	25.2	42.8	7.3	95	0	116	170.4	68.8	0.1	25.9	0.2	2.496
10	Dhamdha	Girola	7.98	961	395	142	9.6	10.7	1.3	115	0	140	149.1	9.6	0.1	34.7	0.1	0.702
11	Durg	Janjgiri	7.85	1710	585	164	42	84.8	16	90	0	110	330.2	108.6	0.0	24.8	0.3	0.831
12	Durg	Jeora-sirsa	8.09	514	205	66	9.6	14.1	0.3	115	0	140	71.0	25.3	0.1	28.6	0.2	0.276
13	Durg	Kachandur	8.16	639	160	48	9.6	62.3	11	205	0	250	63.9	31.0	0.3	25.3	0.2	0.000
14	Patan	Kashi	8.31	529	175	56	8.4	26.8	23	180	3	214	53.3	32.1	0.2	35.1	0.2	0.000
15	Dhamdha	Kodiya	8.18	252	125	40	6	5.1	0.3	140	0	171	3.6	3.9	0.1	35.2	0.2	1.331
16	Patan	Marra	8.09	526	215	52	20.4	28	0.5	145	0	177	74.6	16.9	0.5	24.0	0.2	0.000
17	Patan	Motipur	8.06	798	200	62	10.8	35.2	53	165	0	201	92.3	63.8	0.1	37.9	0.2	0.110
18	Durg	Nagpura	7.84	1230	430	114	34.8	41.8	17	130	0	159	227.2	71.2	0.8	19.9	0.2	2.848
19	Durg	Powara	7.83	1044	375	122	16.8	50.5	12	115	0	140	181.1	66.2	0.1	19.2	0.3	0.091

20	Dhamdha	Ravelidih	8.06	523	215	70	9.6	17.8	1.3	70	0	85	78.1	7.3	0.0	13.1	0.2	0.276
21	Durg	Selud	8.18	309	150	48	7.2	10.6	0.3	145	0	177	21.3	9.9	0.2	14.6	0.2	0.165
22	Patan	Tarra	8.13	457	195	56	13.2	19	1.6	135	0	165	46.2	17.6	0.1	16.3	0.2	2.163
23	Durg	Utai(Adarshnagar)	8.05	447	200	64	9.6	13.1	0.3	140	0	171	53.3	19.8	0.3	18.2	0.2	0.000
24	Patan	Zhit	8.09	454	175	46	14.4	25.9	9.6	165	0	201	42.6	13.0	0.1	22.2	0.3	0.000
25	Dhamda	Murmunda	8.08	582	130	36	9.6	46.4	48	85	0	104	103.0	8.9	0.1	12.2	0.2	1.022
26	Patan	Kharra	7.97	1397	470	150	22.8	35	0.5	105	0	128	308.9	63.0	0.3	14.5	0.3	1.459
27	Patan	Bohardih	8.11	755	280	68	26.4	46.9	1.9	125	0	153	134.9	24.2	0.4	4.2	0.3	0.744
28	Dhamdha	Dhamda-D	8.32	320	145	36	13.2	29.6	0.5	165	3	195	17.8	5.9	0.1	0.1	0.3	0.373
29	Patan	Kumhari	8.84	911	370	78	42	36.1	1.2	225	12	250	81.7	114.1	0.9	10.1	0.1	0.797
30	Patan	Patan	8.23	526	145	50	4.8	55.3	1.3	110	0	134	60.4	22.5	0.2	5.3	0.1	1.009

Table 7 (B): Result of chemical analysis of ground water (key wells), year 2016 (concentration in mg/l, EC in µS)

S. No	Block	Location	Longitude	Latitude	pH	EC	CO3	HCO3	Cl	SO4	F	TH	Ca	Mg	Na	K	Si	PO4	Fe
1	Dhamdha	Kapasda	81.509	21.307	7.500	492	0	122	50	55	0.71	230	52	24	31	42	15	0	0.003
2	Dhamdha	Murmunda	81.464	21.308	7.380	201	0	73	35	0	0.74	60	12	7.2	22	0.39	5	0	0.104
3	Dhamdha	Girhola	81.436	21.397	7.300	610	0	85	124	5	0.68	255	78	14	10	3.1	12	0	0.891
4	Dhamdha	Mohrenga	81.445	21.479	7.370	226	0	110	14	7.2	0.56	100	20	12	7.2	0.8	11	0	0.028
5	Dhamdha	Birjhapur	81.311	21.475	7.340	500	0	122	89	44	0.66	165	32	20	48	2.7	14	0	0.104
6	Dhamdha	Raunda	81.202	21.468	7.340	276	0	134	25	5	0.7	115	30	9.6	14	3.12	4	0	0.028
7	Dhamdha	Arsi	81.226	21.374	7.420	277	0	134	21	5	0.67	110	20	14	16	5.4	10	0	0.003
8	Dhamdha	Birejhar Kalan	81.195	21.307	7.320	300	0	92	50	0	0.67	120	32	9.6	8.4	9	13	0	0.003
9	Dhamdha	Bori Buzurg	81.274	21.355	7.310	677	0	244	96	11	0.5	290	88	17	30	11	14	0	0.053
10	Dhamdha	Meresara	81.358	21.377	7.510	208	0	79	21	10	0.7	80	20	7.2	13	1.6	7	0	0.231
11	Patan	Urla	81.491	21.225	7.420	364	0	110	53	20	0.66	145	32	16	16	1.9	14	0	0.307
12	Durg	Dhaur	81.368	21.273	7.420	295	0	122	32	22	0.61	110	20	14	21	1.1	11	0	0.028
13	Durg	Samonda	81.307	21.283	7.360	657	0	201	106	25	0.59	160	34	18	88	4.7	12	0	0.003

14	Durg	Borai	81.190	21.251	7.510	326	0	128	39	22	0.57	130	32	12	22	2	10	0	0.053
15	Durg	Rasmara	81.217	21.204	7.400	650	0	146	121	7	0.6	200	44	22	66	5.4	30	0	1.449
16	Durg	Thanaud	81.215	21.133	7.530	503	0	159	64	42	0.62	115	28	11	61	20	15	0	0.815
17	Durg	Nikum	81.202	21.057	7.520	604	0	183	85	22	0.58	160	40	12	75	7.8	16	0	0.282
18	Durg	Kuthrel	81.278	21.094	7.480	520	0	122	57	57	0.62	175	40	18	45	10	13	0	0.079
19	Durg	Bhilai	81.394	21.208	7.510	485	0	183	35	54	0.67	110	20	14	69	3.9	9	0	0.003
20	Durg	Durg	81.289	21.182	7.520	371	0	110	35	40	0.62	90	24	9.6	42	3.5	5	0	0.713
21	Durg	Khopli	81.380	21.091	7.560	248	0	85	14	24	0.62	80	16	9.6	17	0.39	8	0	0.256
22	Durg	Machandur	81.354	21.050	7.570	658	0	207	64	55	0.57	110	8	22	89	19	9	0	0.079
23	Durg	Risama	81.323	21.055	7.600	649	0	195	82	5	0.6	160	40	14	84	19	8	0	0.206
24	Patan	Gondpendri	81.454	21.085	7.640	362	0	85	35	66	0.64	150	40	12	32	13	7	0	0.459
25	Patan	Manikchauri	81.447	21.064	7.560	244	0	116	7	20	0.6	90	16	12	16	5.4	3	0	0.739
26	Patan	Pahanda	81.541	21.210	7.330	397	0	110	73	22	0.67	150	36	14	17	10	10	0	6.5
27	Patan	Batang	81.511	21.180	7.520	247	0	122	7	19	0.64	65	14	7.2	29	5.4	7	0	0.028
28	Patan	Ruhi	81.539	21.129	7.430	400	0	134	39	44	0.63	140	28	17	30	12	12	0	0.891
29	Patan	Bathena	81.547	21.070	7.380	565	0	159	71	27	0.55	230	60	19	31	1.9	10	0	0.459
30	Patan	Teligundra	81.552	20.999	7.480	399	0	183	21	23	0.54	130	24	17	32	6.2	11	0	0.536
31	Patan	Karela	81.494	20.944	7.360	559	0	122	106	43	0.58	200	56	14	46	4.3	16	0	0.459
32	Patan	Surpa	81.471	20.909	7.650	563	0	146	99	35	0.64	155	44	23	70	1.7	12	0	1.754
33	Patan	Aunri	81.440	20.933	7.510	892	0	110	177	67	0.61	390	120	34	45	1.1	10	0	1.779
34	Patan	Bharar	81.459	20.958	7.610	663	0	244	92	18	0.3	210	64	12	47	1.1	11	0	0.307
35	Patan	Dhuma	81.469	21.015	7.600	337	0	159	28	12	0.46	120	24	14	30	1.2	11	0	0.52
36	Patan	Pahandor	81.447	21.147	7.420	467	0	122	71	45	0.57	175	52	11	30	0.9	13	0	1.627
37	Patan	Aundhi	81.469	21.181	7.370	486	0	146	35	85	0.68	210	62	13	26	2.3	9	0	4.673
38	Dhamdha	Murmunda	81.464	21.308	7.510	185	0	98	7	6	0.65	70	18	6	10	3.7	8	0	2.008
39	Dhamdha	Pandritarai	81.440	21.431	7.320	510	0	171	60	23	0.72	220	64	14	19	0.7	9	0	4.926
40	Dhamdha	Pendri	81.277	21.496	7.420	440	0	146	64	18	0.63	215	60	16	11	1.4	8	0	0.764
41	Dhamdha	Hasda	81.203	21.326	7.420	768	0	183	156	0	0.68	130	36	9.6	117	3.4	8	0	0.434
42	Dhamdha	Nandini Khundini	81.392	21.384	7.600	152	0	85	7	0	0.62	55	16	3.6	12	0.7	0	0	1.348
43	Durg	Hathkhoj	81.407	21.228	7.470	218	0	91	28	0	0.67	100	24	9.6	7.8	0.3	5	0	11.86

44	Durg	Bhendsar	81.265	21.256	7.570	535	0	244	57	0	0.44	130	28	14	74	1.8	6	0	0.612
45	Durg	Changori	81.229	21.097	7.630	257	0	110	35	0	0.63	70	16	7.2	31	1.6	8	0	0.586
46	Durg	Kolihapuri	81.263	21.139	7.700	839	0	122	213	0	0.57	390	76	48	92	1.2	13	0	2.058
47	Durg	Dumardih	81.389	21.124	7.650	221	0	110	21	0	0.63	90	20	9.6	15	0.6	6	0	2.033
48	Patan	Matang	81.449	21.047	7.380	618	0	110	149	5	0.64	230	76	9.6	41	12.4	12	0	1.779
49	Patan	Batang	81.510	21.180	7.770	290	0	146	14	0	0.62	150	32	17	38	0.7	12	0	1.982
50	Patan	Pandar	81.521	21.046	7.540	432	0	134	71	0	0.62	190	34	25	22	0.9	15	0	2.312
51	Patan	Ashoga	81.550	20.959	7.360	1521	0	122	354	140	0.56	355	102	24	105	169	15	0	0.079
52	Patan	Dhamna	81.432	20.910	7.650	283	0	122	21	18	0.64	80	16	9.6	33	1	12	0	0.053
53	Dhamdha	Dumar	81.475	21.363	7.670	258	0	140	7	14	0.62	80	14	11	29	0.9	11	0	0.434
54	Dhamdha	Sonesarar	81.359	21.442	7.570	221	0	98	14	16	0.64	65	16	6	24	1.9	14	0	0.536
55	Dhamdha	Kutha	81.290	21.488	7.470	336	0	73	67	11	0.7	150	36	14	10	0.4	11	0	0.079
56	Dhamdha	Purda Kalan	81.239	21.337	7.530	203	0	91	21	5	0.69	95	16	13	13	0.5	13	0	7.871
57	Patan	Dev Baloda	81.476	21.220	7.560	227	0	134	35	13	0.67	75	18	7.2	17	0.7	6	0	0.815
58	Patan	Charoda	81.452	21.220	7.460	386	0	152	32	24	0.7	150	40	12	23	2.6	35	0	0.51
59	Durg	Jamul	81.388	21.256	7.440	399	0	122	46	10	0.69	150	40	12	16	1.2	5	0	0.206
60	Durg	Rawelidi/ Boregaon	81.337	21.326	7.510	279	0	134	28	13	0.73	85	20	8.4	29	1.1	7	0	0.688
61	Durg	Kapri(Kutelabhata)	81.309	21.239	7.510	280	0	98	35	16	0.74	90	8	17	17	1.9	16	0	1.322
62	Durg	Beloudi	81.271	21.238	7.820	403	0	189	21	24	0.46	70	8	12	12	1.1	11	0	5.231
63	Durg	Birejhar	81.205	21.116	7.720	222	0	79	28	14	0.62	65	16	6	6	2.3	18	0	0.764
64	Durg	Chingri	81.271	21.075	7.570	293	0	110	28	20	0.64	120	20	12	12	0.6	11	0	0.409
65	Durg	Konari	81.265	21.111	7.880	546	0	305	34	24	0.43	50	4	9.6	9.6	1.5	6	0	0.891
66	Durg	Ghugsidih	81.367	21.070	7.730	175	0	61	18	15	0.65	75	32	8.4	8.4	2.2	5	0	0.739
67	Patan	Chunkatta	81.420	21.109	7.520	294	0	85	28	18	0.55	110	24	12	12	0.5	13	0	0.612
68	Patan	Santra	81.466	21.050	7.500	203	0	73	21	12	0.65	90	28	4.8	4.8	0.6	14	0	0.18
69	Patan	Kurudih	81.518	21.204	7.370	372	0	134	43	27	0.55	150	32	17	17	1.9	14	0	3.53
70	Patan	Sawni	81.536	21.112	7.500	364	0	159	32	20	0.5	120	24	14	14	1.1	13	0	1.246
71	Patan	Matiya	81.525	21.008	7.610	298	0	134	28	8	0.6	70	16	7.2	7.2	0.6	14	0	0.358
72	Patan	Kharra	81.544	20.987	7.260	284	0	116	28	15	0.6	55	12	6	6	2.7	11	0	0.354

2.3 Geophysical Data

Geophysical surveys (Vertical Electrical Sounding or VES) have been conducted in the study area during AAP 2009-10 to delineate the disposition of the existing aquifer system and 34 nos. of soundings were carried out.

Interpreted layer parameters of VES observed in Durg district

VES No.	Location	Longitude	Latitude	Respective layer resistivity (ohm-m)				Respective layer depth (m)		
				ρ_1	ρ_2	ρ_3	ρ_4	D_1	D_2	D_3
VES1	Rakhi	81.3394	21.5806	62	22	400	-	7	26	-
VES2	Saja	81.3161	21.6563	20	80	20	100	0.5	1.5	18
VES3	Parpori	81.2094	21.5859	400	62	2000	-	1.4	33	-
VES4	Binjapur	81.3069	21.4784	150	28	650	-	0.8	5	-
VES5	Medesara	81.3624	21.3737	150	48	1000	-	1.3	6.5	-
VES6	Chorbhati	81.571	21.6789	65	12	1100	-	2	8	-
VES7	Kachandur	81.3019	20.9736	300	120	16	250	0.7	1.5	10
VES8	Bori	81.2734	21.3527	14	98	21	2000	0.8	6.5	30
VES9	Charoda	81.4728	21.2267	385	108	21	180	1.8	5.4	37
VES10	Utai	81.3827	21.1162	7.5	25	62	-	2.8	8.5	-
VES11	Latabod	81.2641	20.785	5	33	700	-	6	36	-
VES12	Karhibhadar	81.3167	20.696	400	58	2000	-	4.8	33	-
VES13	Sankara	81.2044	20.8016	45	95	25	2000	1	7	20
VES14	Ghughuwa	81.5033	21.108	240	18	470	-	1	13	-
VES15	Gabhara	81.5142	21.1024	280	27	2000	-	2	20	-
VES16	Pahandor	81.5103	21.1202	4	16	650	-	2.5	14	-
VES17	Funda	81.526	21.0535	45	20	500	25	2.2	5	24
VES18	Dhour	81.3635	21.2706	7	21	350	-	3.2	29	-
VES19	Okhara	81.3709	21.2995	270	40	2000	-	4.3	30	-
VES20	Vinayakpur	81.2538	21.0669	45	210	40	-	9.5	54	-
VES21	Chandrakhuri	81.2569	21.1225	6	21	850	-	1.5	18	-
VES22	Paura	81.3134	21.0985	45	278	2000	-	4.5	37	-
VES23	Kaudia	81.3517	21.092	7.5	1400	-	-	4	-	-
VES24	Hirri	81.1995	21.3478	300	10	2000	-	1.8	10	-

VES25	Nawagaon	81.2596	21.3204	135	20	500	45	2.8	14	45
VES26	Gajra Watershed	81.587	21.918	135	20	250	-	2.8	14	-
VES27	Murkuta	81.6567	21.9564	6.3	38	800	-	4.3	33	-
VES28	Baba Mohtara	81.6916	21.7658	18	75	-	-	23	-	-
VES29	Tuma	81.7708	21.9173	9.5	18	1500	-	7	19	-
VES30	Junwanikhurd	81.6948	21.7116	10	60	1500	-	10	90	-
VES31	Mohrenga	81.3601	20.9095	95	28	700	-	1	12	-
VES32	Tandula Commond	81.416	20.8264	6.4	30	2000	-	6.3	27.3	-
VES33	Armarikala	81.4285	20.7769	15	40	2000	-	2.3	18	-
VES34	Basin	81.481	20.7466	4.5	14	1000	-	5	19	-

2.4 Exploratory Data

2.4.1 Status of Groundwater Exploration

A total of 64 bore wells exist in the study area as on 31-03-2017 out of which 54 nos. are exploratory bore wells and 10 nos are observation bore wells in the study area. Table 9 summarizes the status of exploratory wells in the study area.

Table 9 Detail of Exploration in the study area

NO.	location	LAT	LONG	Depth (m)	Casing (m)	Formation	Zone_encountered (mbgl)	SWL (mbgl)	Discharge (lps)	Drawdown (m)
1	Banbad	21.3347	81.3533	60.06		chandi Lst	15.22-18.22	3.73	2.5	2.4
2	Birjhapur	21.475	81.3125	300.57	5.3	Tarenga shale and Chandi Lst	8-11.0	0.82	1.9	35.42
3	Bolhari	20.875	81.45	84.35		Charmuria Lst	4.67-5.0,74.00-84.35	8.7	2.3	20.7
4	Bori (Dhamdha)	21.3517	81.2733	304.57	25	Chandi Lst	19-25	4.66	1.9	21.65
5	Daragaon	21.4972	81.3936			Charmuria Lst				
6	Dundera-I	21.1514	81.3944	69.09	14.1	Chandi Lst	14.5-15.00	4.35	0.27	29.7
7	Gorhi	21.3208	81.4	69.85		Chandi Lst		1.9	0.5	35
8	Kapasada	21.3056	81.5056	58.86	25	Chandi Lst	19.00-25.00,25.00-58.86	5.01	3.15	19.04
9	Kareli	21.4181	81.3125	114.5	24.5	Chandi Lst	23.35-34.35,46.15-49.15,53.75-68.95,109.55-114.55	4.96	9.1	0.47
10	Kuthrel	21.0917	81.2833	196.7	6.5	Gunderdehi Sh	13.00-49.5	3.65	1	
11	Maresara	21.3608	81.3739			Chandi Lst				

12	Nandini	21.3903	81.3944	71.02		Chandi Lst	3.26, 21.7	7.5	Negligible	
13	Pahanda	21.2069	81.5403	33.29		Chandi Lst	10.00-33.29	15.1	0.5	0.8
14	Patan	21.0333	81.55	194	11	Gunderdehi Sh	18-19,134	8.9	3.5	6.4
15	Purana	21.1931	81.4292	63.57	18.64	Chandi Lst	26.09-38.77	4.71	3	7.4
16	Purana OW	21.1931	81.4292	36.05	16	Chandi Lst		4.01		
17	Ghughwa	21.1417	81.3733	123	9	Chandi limestone	54-60	10.7	12	
18	Gabhara	21.1528	81.475	122	12.5	Chandi limestone	12--14	2.2	0.5	
19	Pahndore	21.1517	81.45	98	11.78	Chandi limestone	10.5-15	0.8	4	
20	Funda	21.0764	81.4833	104	8.5	Chandi limestone	8-9.5	7	0.5	
21	Vinakpur	21.0717	81.2639	128	5.5	Chandi limestone	6--6.5	4.05	0.5	
22	Chandkhuri	21.125	81.2667	122	13.5	Chandi limestone	25,35	2.4	2.5	
23	Pauwara	21.0917	81.325	122	6	Chandi limestone	6--8	1.3	0.5	
24	Kodia	21.1069	81.2967	116	7.75	Chandi limestone	12--14	3.06	0.5	
25	Navagaon	21.3125	81.2667	98	12	Chandi limestone	14--18	2.8	6	
26	Hirri	21.2917	81.2083	150	14.5	Chandi limestone	24--30	4.4	0.5	
27	Okhra	21.3083	81.4317	150	20	Chandi limestone	24--25	7	0.8	
28	Dhour	21.2683	81.3556	65	23.8	Chandi limestone	25--32	8	1.8	
29	Bhilai (Sector VII)	21.1806	81.3178	19.5	12	Chandi limestone	17-17.5	3	5.5	
30	Bhilai (Sector VII)	21.1806	81.3178	70	30.5	Chandi limestone	35-35.5	6.5	0.5	

31	Bhilai (Sector I)	21.1817	81.3342	70	19.5	Chandi limestone	20-25	4.2	1.5	
32	Bhilai (Sector I)	21.1817	81.3342	28.3	18.3	Chandi limestone	20.1-23.7	4.67	0.5	
33	Bhilai (Sector IV)	21.1889	81.3339	70	16.6	Chandi limestone	23.7-24.7	2.32	0.5	
34	Bhilai (Sector IV)	21.1889	81.3339	20	14	Chandi limestone	18.7-19	1.97	0.5	
35	Deori	21.5253	81.3344	204.1	18.5	Shale both of Argillaceous & Ferruginous	72.90-76.00, 94.30-76.00	9.52	-Dry-	-
36	Litia	21.3528	81.2167	204.1	30	Shale both of Argillaceous & Ferruginous	72.90-76.00, 91.20-94.30	16.81	2.13	21.49
37	Litia	21.3528	81.2167		30	Shale both of Argillaceous & Ferruginous	36.30-39.40, 60.70-63.80	17.36	1.79	19.14
38	Ghota	21.4236	81.2278	131	25.5	Shale	28-31,122.5-125.5	13.19		6.99
39	Ghota	21.4236	81.2278	202	27.5	Shale	nil			
40	Potia	21.2506	81.2083	202	31.7	Shale	131-134	12.95		27.32
41	Potia	21.2506	81.2083	202	22.5	Shale	31-34,67-70,	14.24		13.41
42	Temri	21.2833	81.1667	202	30	Shale	nil	17.5		
43	Biroda	21.4736	81.3714	202	6	Shale/sst	15.9-19	11.65	0.5	40
44	Raunda	21.4681	81.2056	204.1	14.5	Shale	30-33	20.55	1.12	28.75
45	Girhola	21.3894	81.4297	202	31.7	Shale	34-37,49-52	22.25	1.12	11.21
46	Balodi	21.2444	81.2833	202	11.5	Shale/Sst	46-49,195-198	7.55	0.1	
47	Kachandur	21.2494	81.3333	165.4	12	Shale	162-165.4	27.69	12	2
48	Kachandur	21.2494	81.3333	165.4	12.75	Shale	162-165.4	12.1	12.75	2
49	Gandadih	21.0347	81.425	202	12	Shale	Dry		dry	

50	Pahanda	21.2056	81.5361	202	14	Shale	28-34	7.1	3	24.3
51	Pahanda	21.2056	81.5361	202	18.5	Shale	31-34,	7.74	dry	
52	Nikum	21.0556	81.2228	204.1	18.5	Shale/Lis	24-27,33-36	7.62	0.51	35.08
53	Ganiyari	21.2167	81.2333	204.1	18.5	Shale	191-194	72.73	0.2	
54	Shiv kokri	21.3333	81.2494	130.9	19.6	Shale/Clayey	45.5-48.5,76-79,	15	5	
55	Dhaurabhata	21.0642	81.3894	204.1	5.99	Slale	42682	2.01	0.1	
56	Bharar	20.9542	81.4506	200	12.5	Shale	57-60,137-140	20.8	0.78	20.6
57	Pachpedi	21.1569	81.45	201.1	18	Shale	36-39,66-69,76-79,194-198	14.03	3.3	32.29
58	Pachpedi	21.1569	81.45	201.1	18	Shale	36-39,66-69,76-79,194-198	14	3	
59	Girhola	21.3894	81.4297	307.1	26.5	Clay/Shale	34.5-37.6	12.3	0.6	
60	Shiv Kokri	21.3333	81.2494	147.4	62.09	Clay/Shale	22-25,31-34,			
61	Phagunda	20.8819	81.4714	202	21	Charmuria Formationa and Granite	85	26.73	1	7.74
62	Dundera	21.1487	81.398	201.1	15.1	Sandstone Shale				
63	Shivkokri	21.3333	81.2494	202.3	27.6 (with slotted 14.00)		24-27		16	
64	Ranitarai	20.9468	81.542	202	12	Shale Gunderdehi	nil	19.5	0.01	

3. Data Interpretation, Integration and Aquifer Mapping

Based on the depth to water level periodical monitoring data of the key wells established in the study area, pre-monsoon and post-monsoon depth to water level maps as well as seasonal fluctuation maps have been prepared.

Water Level Behavior: (i) Phreatic aquifer: In the pre-monsoon period, it has been observed that in Tarenga formation calcareous shale, the minimum water level is 3.9m bgl, maximum water level is 10.8 mbgl and average water level is 7.35 mbgl. It has been observed that in Chandi formation argillaceous limestone, the minimum water level is 1.48 mbgl maximum water level is 17.07 mbgl, the average water level is 6.03 mbgl. It has been observed that in Chandi formation sandstone, the minimum water level is 3.7 mbgl maximum water level is 7.5 mbgl, the average water level is 5.6 mbgl. It has been observed that in Gunderdehi formation calcareous shale, the minimum water level is 2.34 mbgl maximum water level is 9.72 mbgl, the average water level is 5.51 mbgl.

Fractured aquifer: In the pre-monsoon period, it has been observed that in Tarenga formation calcareous shale, the minimum water level is 27.54m bgl, maximum water level is 30.88 mbgl and average water level is 29.21 mbgl. It has been observed that in Chandi formation argillaceous limestone, the minimum water level is 5.6 mbgl maximum water level is 23.1 mbgl, the average water level is 14.39 mbgl. It has been observed that in Chandi formation sandstone, the minimum water level is 12.35 mbgl maximum water level is 25.2 mbgl, the average water level is 18.76 mbgl. It has been observed that in Gunderdehi formation calcareous shale, the minimum water level is 3.5 mbgl maximum water level is 12.42 mbgl, the average water level is 7.96 mbgl.

Table 10A: Aquifer wise Depth to Water Level (Pre-monsoon)

District Name	Formation	Phreatic Aquifer		
		Min	Max	Avg
Durg	Tarenga shale	3.9	10.8	7.35
	Chandi limestone	1.48	17.07	6.03
	Chandi sandstone	3.7	7.5	5.6
	Gunderdehi shale	2.34	9.72	5.51

Water Level (in mbgl)

Table10B: Aquifer wise Depth to Water Level (Pre-monsoon)

District Name	Formation	Fractured Aquifer		
		Min	Max	Avg
Durg	Tarenga shale	27.54	30.88	29.21
	Chandi limestone	5.6	23.1	14.39
	Chandi sandstone	12.35	25.2	18.76
	Gunderdehi shale	3.5	12.42	7.96

(ii) Phreatic aquifer: In the post-monsoon period, it has been observed that in Tarenga formation calcareous shale, the minimum water level is 2.38m bgl, maximum water level is 7.26 mbgl and average water level is 4.82 mbgl. It has been observed that in Chandi formation argillaceous limestone, the minimum water level is 0.84 mbgl maximum water level is 3.57 mbgl, the average water level is 2.14 mbgl. It has been observed that in Chandi formation sandstone, the minimum water level is 1.2 mbgl maximum water level is 4.17 mbgl, the average water level is 2.69 mbgl. It has been observed that in Gunderdehi formation calcareous shale, the minimum water level is 1.13 mbgl maximum water level is 2.05 mbgl, the average water level is 1.53 mbgl.

Fractured aquifer: In the post-monsoon period, it has been observed that in Tarenga formation calcareous shale, the minimum water level is 4.31m bgl, maximum water level is 7.86 mbgl and average water level is 6.09 mbgl. It has been observed that in Chandi formation argillaceous limestone, the minimum water level is 3.62 mbgl maximum water level is 12.22 mbgl, the average water level is 8.14 mbgl. It has been observed that in Chandi formation sandstone, the minimum water level is 8.21 mbgl maximum water level is 13.57 mbgl, the average water level is 10.89 mbgl. It has been observed that in Gunderdehi formation calcareous shale, the minimum water level is 1.73 mbgl maximum water level is 7.62 mbgl, the average water level is 4.68 mbgl.

Table 5C: Aquifer wise Depth to Water Level (Post-monsoon)

District Name	Formation	Phreatic Aquifer		
		Min	Max	Avg
Durg	Tarenga shale	2.38	7.26	4.82
	Chandi limestone	0.84	3.57	2.14
	Chandi sandstone	1.2	4.17	2.69
	Gunderdehi shale	1.13	2.05	1.53

Water Level (in mbgl)

Table 5D: Aquifer wise Depth to Water Level (Post-monsoon)

District Name	Formation	Fractured Aquifer		
		Min	Max	Avg
Durg	Tarenga shale	4.31	7.86	6.09
	Chandi limestone	3.62	12.22	8.14
	Chandi sandstone	8.21	13.57	10.89
	Gunderdehi shale	1.73	7.62	4.68

(iii) Seasonal water level fluctuation: Phreatic aquifer: It has been observed that in Tarenga formation calcareous shale, the minimum water level fluctuation is 1.52m, maximum water level fluctuation is 3.54 m and average water level fluctuation is 2.53 m. It has been observed that in Chandi formation argillaceous limestone, the minimum water level fluctuation is 0.25 m, maximum water level fluctuation is 13.97 m, and the average water level fluctuation is 3.89 m. It has been observed that in Chandi formation sandstone, the minimum water level is fluctuation 2.5 m, maximum water level fluctuation is 3.33 m, and the average water level fluctuation is 2.92 m. It has been observed that in Gunderdehi formation calcareous shale, the minimum water level fluctuation is 1.21 m, maximum water level fluctuation is 7.67 m, and the average water level fluctuation is 3.98 m.

Fractured aquifer: It has been observed that in Tarenga formation calcareous shale, the minimum water level fluctuation is 23.02m, maximum water level fluctuation is 23.23 m and average water level fluctuation is 23.13 m. It has been observed that in Chandi formation argillaceous limestone, the minimum water level fluctuation is 0.05 m, maximum water level fluctuation is 13.0 m, and the average water level fluctuation is 6.25 m. It has been observed that in Chandi formation sandstone, the minimum water level is fluctuation 4.14 m, maximum water level fluctuation is 11.63 m, and the average water level fluctuation is 7.89 m. It has been observed that in Gunderdehi formation calcareous shale, the minimum water level fluctuation is 1.77 m, maximum water level fluctuation is 4.8 m, and the average water level fluctuation is 3.2 m.

Table 5E: Aquifer wise Depth to Water Level Fluctuation

District Name	Formation	Fractured Aquifer		
		Min	Max	Avg
Durg	Tarenga shale	1.52	3.54	2.53
	Chandi limestone	0.25	13.97	3.89
	Chandi sandstone	2.5	3.33	2.92
	Gunderdehi shale	1.21	7.67	3.98

Water Level (in m)

Table 5F: Aquifer wise Depth to Water Level Fluctuation

District Name	Formation	Fractured Aquifer		
		Min	Max	Avg
Durg	Tarenga shale	23.02	23.23	23.13
	Chandi limestone	0.05	13.0	6.25
	Chandi sandstone	4.14	11.63	7.89
	Gunderdehi shale	1.77	4.8	3.2

The long term water level trend indicates that there is decline in pre-monsoon water level in Dhamdha block, decline in both pre-monsoon and post-monsoon water level in Durg block and no appreciable change in water level both in pre-monsoon and post-monsoon period in Patan block.

Groundwater Resource Availability and Extraction: Based on the resource assessment made, the resource availability in aquifer wise in Durg district upto 200 m depth is given in the table-6.

Table – 6: Aquiferwise Ground Water Resources of Durg district in Ham

	Tarenga Shale			
	Phreatic		Fractured	
	Dynamic	Static (below pre monsoon water level up to weathered Zone)	In-storage (below Weathered Zone to 200 meter)	Total resource
Durg	3131.37	863.72	60.55	**4055.64**
	Chandi limestone			
	20938.91	23091.11	369.09	**44399.11**
	Chandi Sandstone			
	320.36	181.08	6.56	**508.00**
	Gunderdehi shale			
	1435.62	508.0	26.2	**1969.82**

Existing and Future Water Demand (2025)*:* The existing demand for irrigation in the area is 17234.14 Ham while the same for domestic and industrial field is 4190.77 Ham. To meet the future demand for ground water, a total quantity of 9129.99 ham of ground water is available for future use.

Table – 7: Ground Water Resources of Durg district in Ham

Sl.No	District Assessment Unit / Block	Total Annual Recharge in Ham	Net Ground Water Availability in Ham	Existing Gross Ground Water Draft for Irrigation in Ham	Existing Gross Ground Water Draft for Domestic & Industrial Water Supply in Ham	Existing Gross Ground Water Draft for All Uses in Ham	Allocation For Domestic & Industrial Water Supply in Ham	Net Ground Water Availability for Future Irrigation Development in Ham	Stage of Ground Water Development in %
1.	**Dhamdha**	11851.09	11183.45	8041.63	660.24	8701.87	761.02	2380.80	77.81
2.	**Durg**	7677.39	7171.60	3918.23	2579.25	6497.48	3058.07	195.30	90.60
3.	**Patan**	8717.60	8009.08	5274.28	951.28	6225.56	1006.22	1728.58	77.73
	DISTRICT TOTAL	**28246.08**	**26364.13**	**17234.14**	**4190.77**	**21424.91**	**4825.31**	**4304.68**	**81.27**

4. AQUIFER GEOMETRY AND CHARACTERIZATION

Based on the exploratory drilling data generated for the blocks, the existing aquifer systems in the area may be divided into two namely phreatic and deeper fractured aquifer. The major aquifers present in the study area are (1) Tarenga formation calcareous shale (2) Chandi formation argillaceous limestone (3) Chandi formation sandstone (4) Gunderdehi formation calcareous shale .These are presented in Fig no 15(A,B,C) and 16(A,B,C).

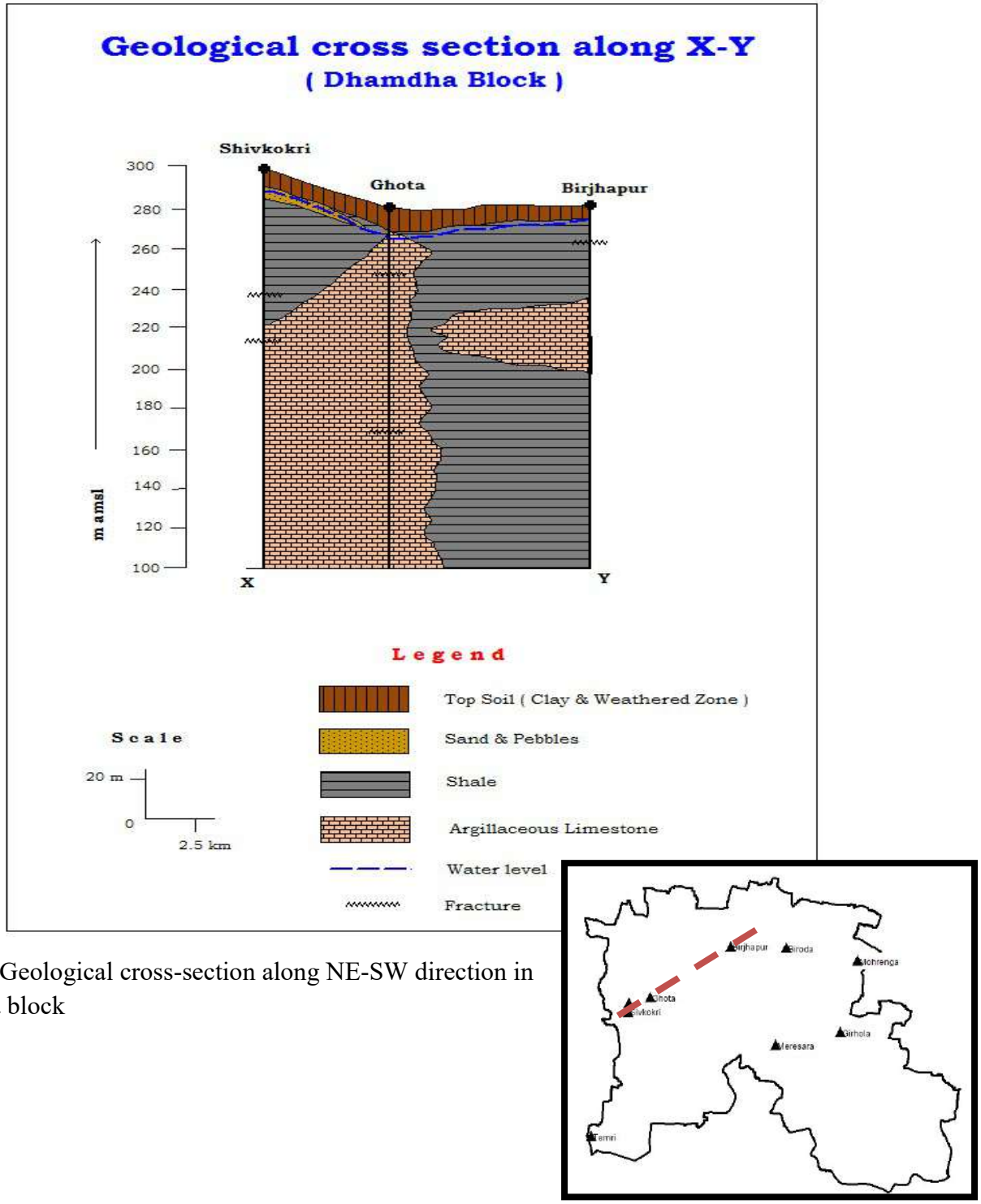


Fig 15A: Geological cross-section along NE-SW direction in Dhamdha block

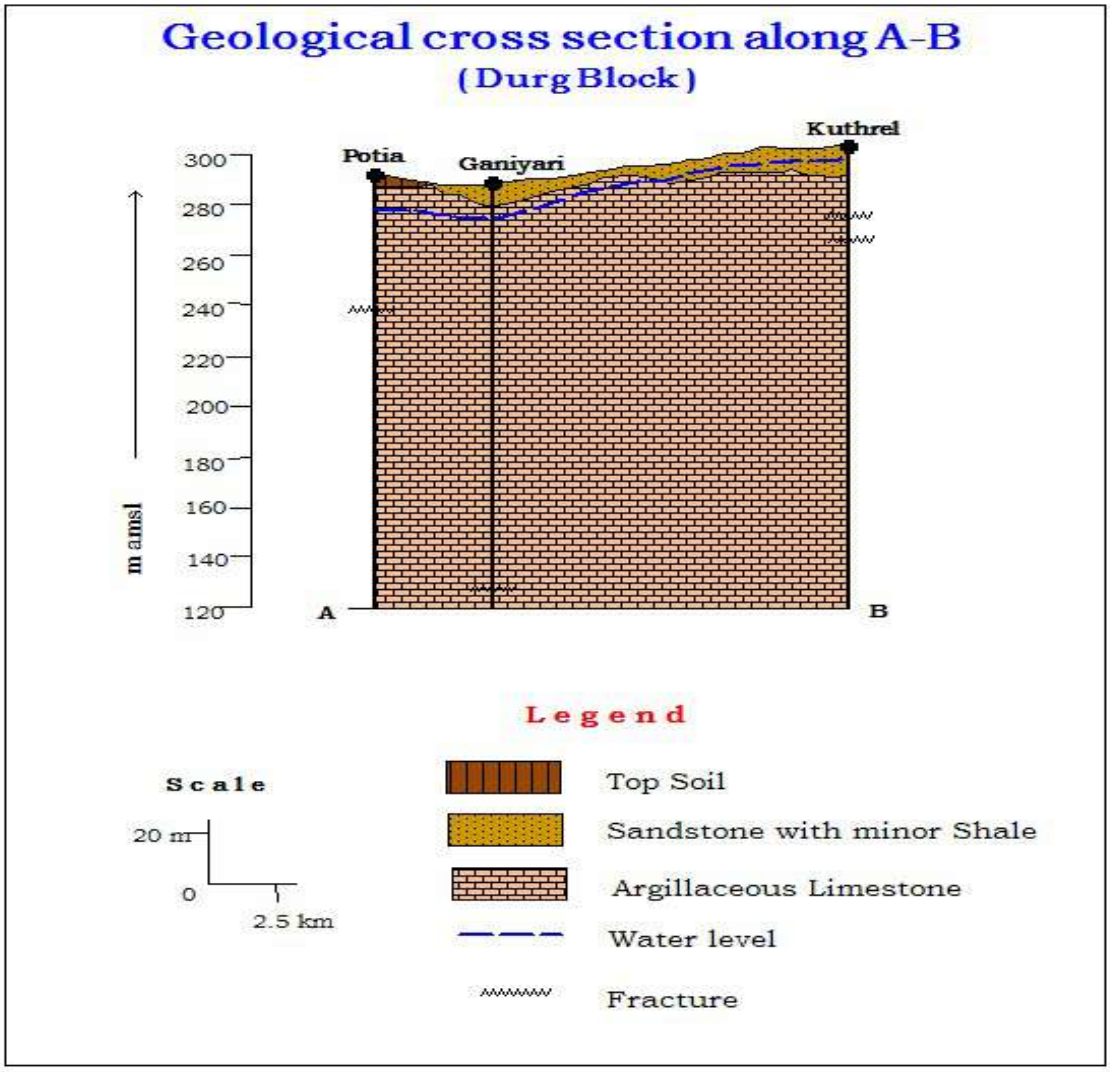
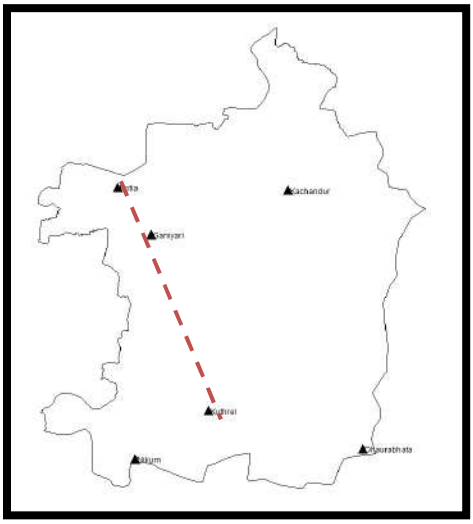


Fig 15B: Geological cross-section along NW-SE direction in Durg block



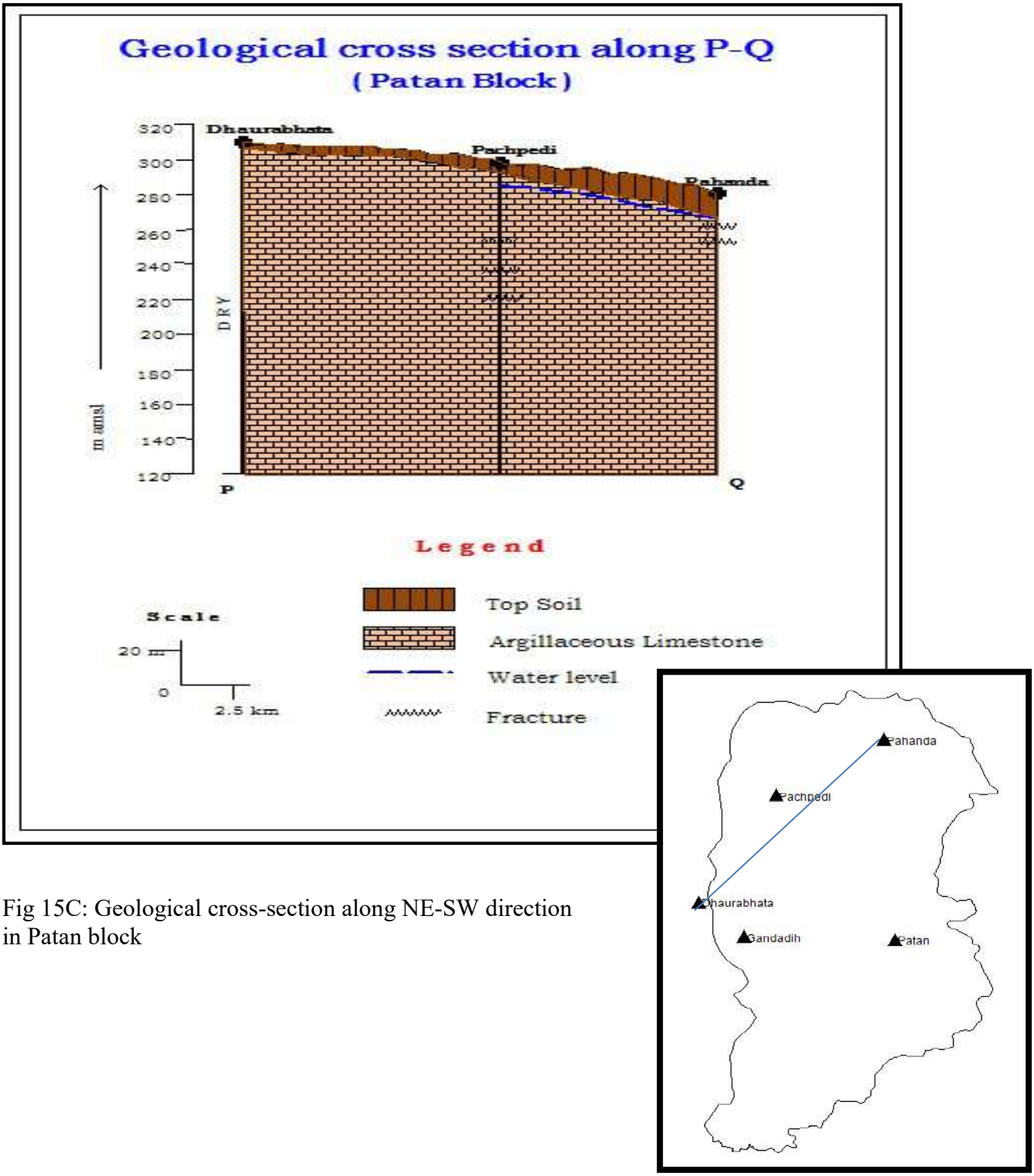


Fig 15C: Geological cross-section along NE-SW direction in Patan block

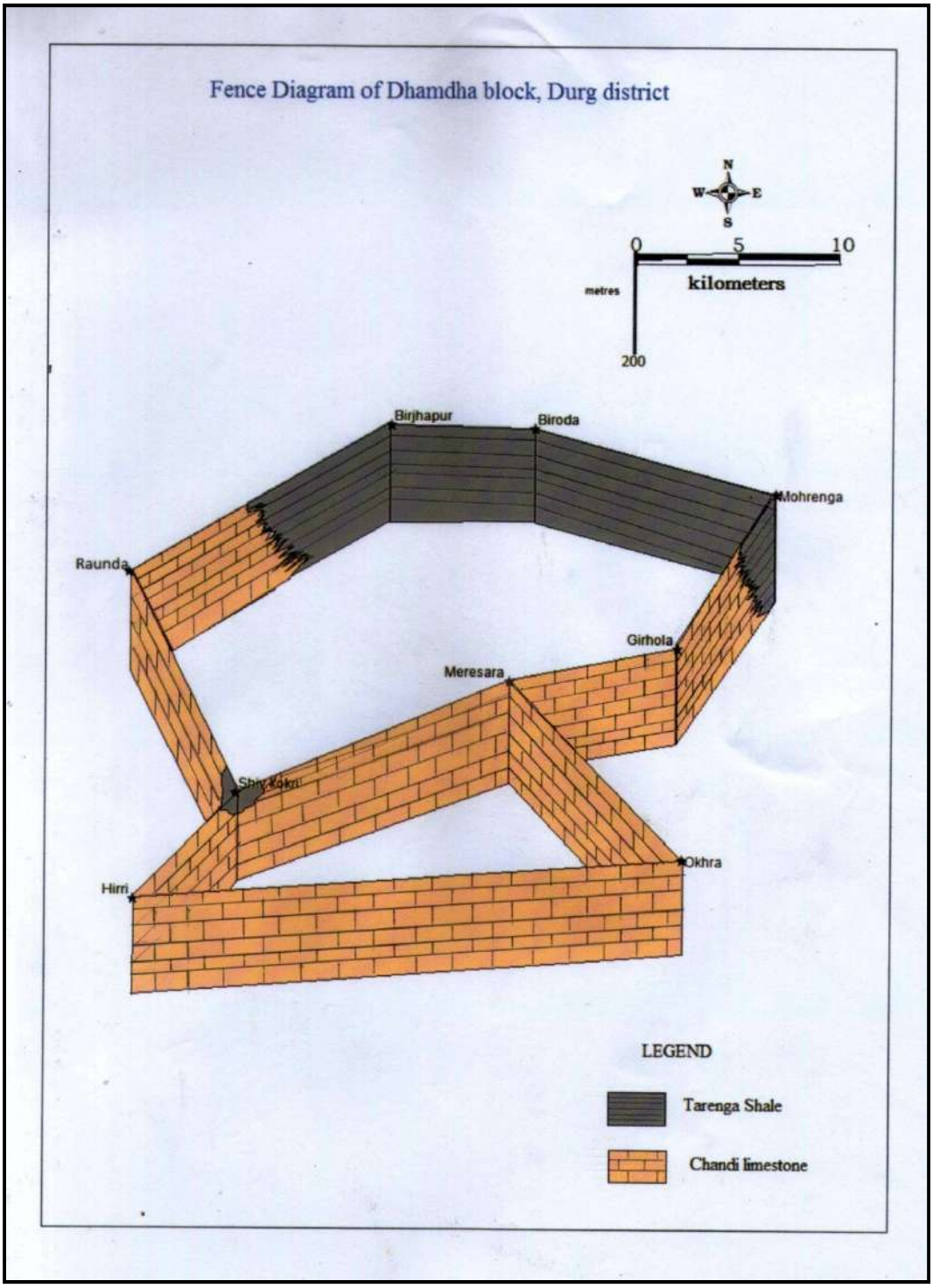


Fig 16A: Fence diagram of Dhamdha block

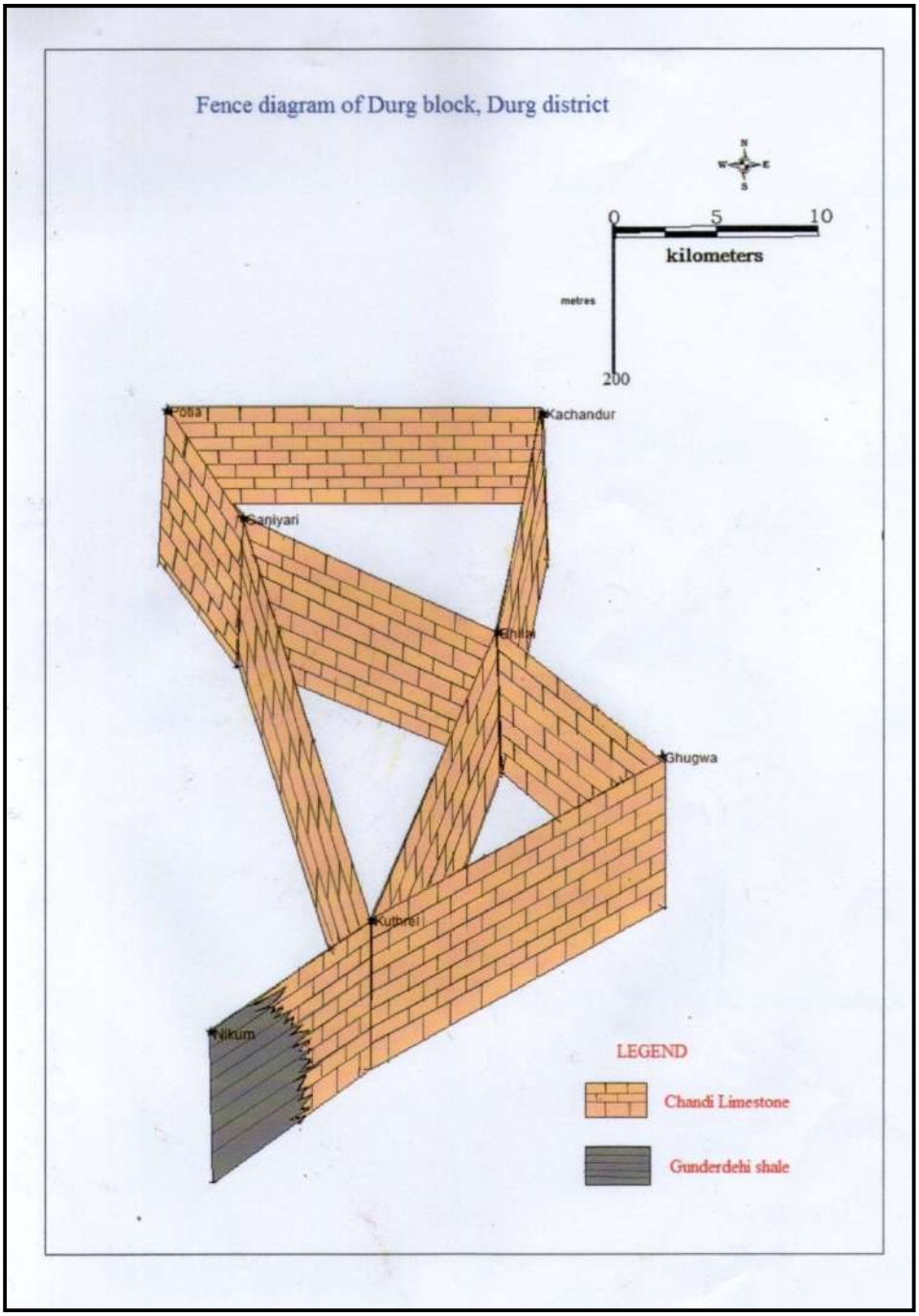


Fig 16B: Fence diagram of Durg block

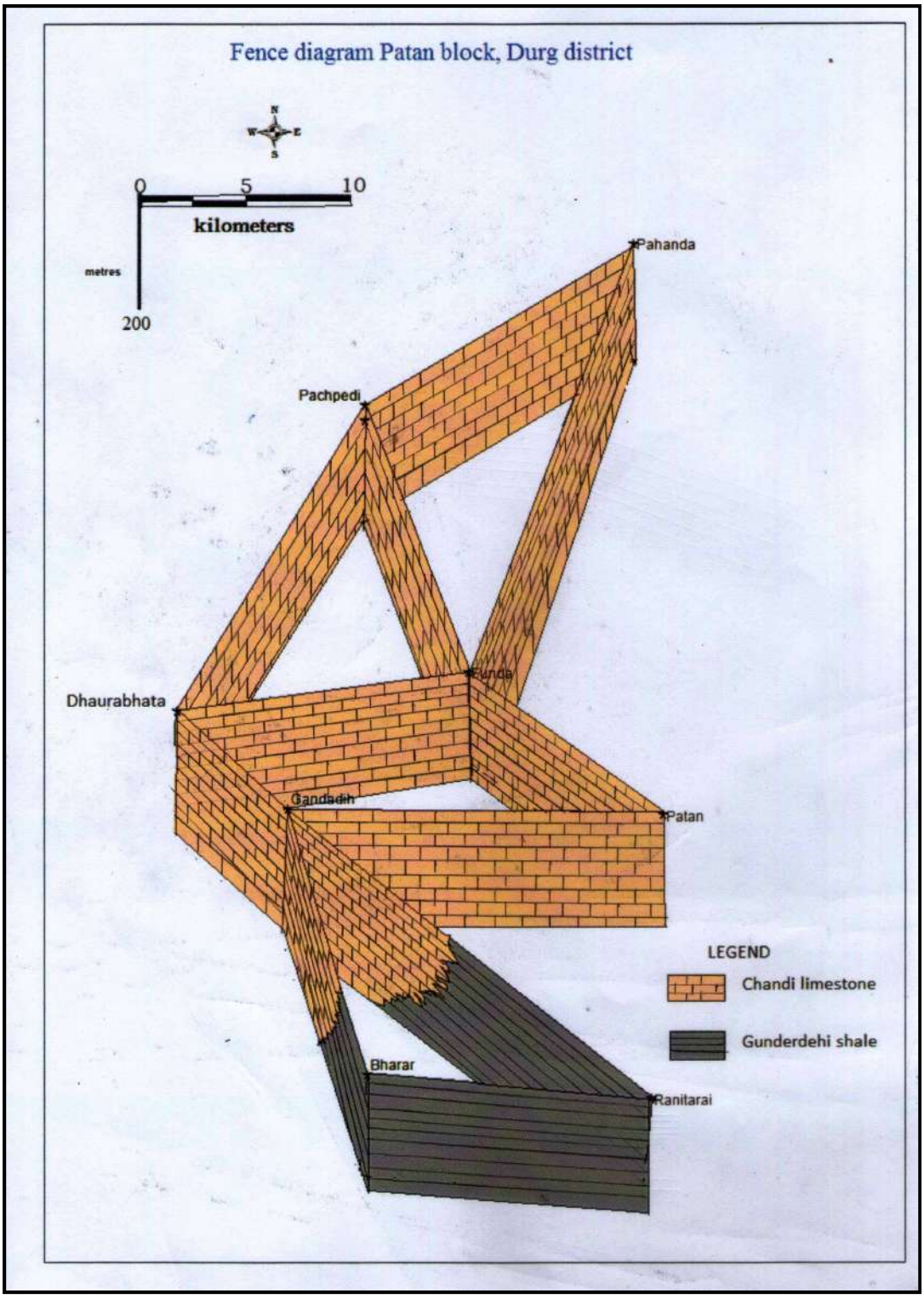


Fig 16C: Fence diagram of Patan block

5. Ground water related Issues

(i) Low water yielding aquifer and scarcity during summer months.

(ii) As per Industrial cluster report, Durg,2011-12,nitrate contamination has been found at the following locations:- Ahiwara, Ravelidih, Anda, Jeora-Sirsa and Pauwara.

(iii) As per Industrial cluster report, Durg,2011-12,Locations around Bhilai Industrial Cluster have problem of following contaminants:

Table – 8: Locations showing high value of fluoride

Element	Location	Conc.(mg/l),
Fluoride	Sirsabhata	1.8
	Parewadih	1.6
Iron	Bhilai sector 1	0.83
	Bhilai E block	0.47
	Utai	0.5
	Somni	0.64
Chromium	Somni	0.106
	Utai	0.53
	Maroda	0.53
Lead	Somni	0.046
	Dundera	0.027
	Maroda	0.01
	Bhilai	0.01

(iv) Concentration of iron in groundwater is more than the acceptable limit of 0.3mg/l as prescribed by BIS 2012.

(v) It has been observed during fieldwork in pre-monsoon period, there is colossal wastage of groundwater through public water supply system.

Reasons for groundwater issues:

(i) Durg district experienced drought situation because of poor monsoon in the year 2016.

(ii) Drying up of wells and depletion of groundwater level during pre-monsoon is due to excessive groundwater withdrawal for irrigation of paddy in Rabi season and wastage during domestic uses.

(iii) Uneven distribution of yield potential and fractures in rocks.

(iv) In Chhattisgarh, power available at subsidized cost has been continuously leading to long duration and uncontrolled pumping of ground water withdrawal.
(v) Contamination of groundwater by anthropogenic sources like industrial effluent sources as well as geogenic sources.

6. MANAGEMENT STRATEGY

a) Supply side interventions:

(i) Durg district experiences drought like situation because of poor monsoon. Sanctuary wells may be constructed for drinking needs as a step towards crisis management.

(ii) It has been observed during fieldwork in pre-monsoon period, there is colossal wastage of groundwater through public water supply system. The government has dug borewells of about 150-200feet depth, lowered a pump in the well to draw out water and constructed a small tank to hold water. Unfortunately, people do not switch off the pump once the tank is full. Also the pipes are not fitted with taps to control the flow of water.
So Information, education and Communication (IEC) activities to be organized to sensitize people on the issues of depleting groundwater resource. Massive awareness campaigns are essential to teach people about the importance community participation in saving water.

(iii) De-siltation 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.

(iv) In command or non-command area wherever ground water has been used for field irrigation of pulses and vegetables should be replaced with micro irrigation methods such as sprinklers, drip irrigation etc which can save upto 30% to 40% groundwater.

(v) It has been observed that though the long term trend lines are declining during pre-monsoon period, so 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.

(vi) The practice of providing free electricity to operate irrigation borewells should be strictly monitored and put to an end in case of overconsumption. After a simple calculation it has been found that Rs 16000/ hectare is the expenses of electricity (@Rs. 2.5/unit) for paddy field. So monitoring mechanism for electricity consumption should be strengthened for farmers taking summer rice.

Even if farmers use solar pump or other method of ground water irrigation for summer paddy, it should not be flooding method. Proper pipes are to be used to transfer water from one plot to another.

Govt. may set up network of grids to purchase electricity generated from solar panels. This will encourage the farmers not to waste electricity by extracting groundwater unnecessarily and also provide alternative income.

(vii)The water user association body should be strengthened so that there will be a balance between cropping time and availability of surface water through canal.Hence Pradhan Mantri

Krishi Sinchayee Yojana (PMKSY) must be given priority in implementation to extend the coverage of irrigation ‘Har Khet ko pani’ and improving water use efficiency ‘More crop per drop' in a focused manner with end to end solution on source creation, distribution, management, field application and extension activities.

(viii) Iron removing filters or plants may be set up at appropriate locations.

(ix) The industrial effluent has been discharged in Somni nala and all the heavy metals are present in water samples of Somni nala. Therefore monitoring measures are essential for keeping a close watch on Somni nala water quality.

(ix) Furthermore, in order to strike a balance between the ground water draft and the available resource, suitable artificial structures at appropriate locations be constructed through successive phases after tentatively every 20 no.s of groundwater abstraction structures become operative.