केन्द्रीय भूमि जल बोर्ड

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विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

Surendranagar District
Gujarat

पश्चिम मध्य क्षेत्र, अहमदाबाद

West Central Region, Ahmedabad

AQUIFER MAP AND MANAGEMENT PLAN
SURENDRANAGAR DISTRICT
GUJARAT STATE

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ACKNOWLEDGEMENT

I would like to take an opportunity to thank Shri G Krishnamurthy, Regional Director, Central Ground Water Board, West Central Region, Ahmedabad, Gujarat for offering such opportunity of detailed study of the district. I am very much delighted to express my deep sense of gratitude and regards to my respected colleagues/ seniors Shri Sanjeev Mehrotra Scientist-D (Ex. HOO), Dr. A K Jain Scientist -D (Retired), Shri Satyendra Kumar, Scientist-B, MER Patna, Shri Ramesh Jena, Scientist-B, Shri Ankit Vishwakarma, Scientist-B, Shri. Kamar Ujjam Khan, Scientist -B, Dr. Gajanan Ramteke, Scientist-B, Shri Saddam Husain, Assistant Hydrogeologist, Shri Abdurrahman, Assistant Hydrogeologist, Shri, Shah Izhar Ahmed, Assistant Hydrogeologist and Shri Avinash Chandra, STA (HG), WCR, Ahmedabad for their valuable and meticulous guidance and support during the study.

I am deeply thankful to Smt. Puja Mehrotra, Scientist-D, OIC Chemical Lab, Dr. H.B Meena Asst Chemist and Smt. Adiba Khan STA (Chem) and all other scientists of chemical team for timely analysis of the water samples of the district.

I would like to extend my gratitude to Shri Neelesh Dhokia, Draftsman, for suggested map preparation. The help and co-operation of all Scientists, staffs, MTS of CGWB, WCR, Ahmedabad is greatly recognizable.

Last but not least, I would like to acknowledge my family members for their unselfish sacrifices, constant blessing and moral support at every stage in my life.

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AQUIFER MAP AND GROUNDWATER MANAGEMENT PLAN, SURENDRANAGAR DISTRICT, GUJARAT STATE

Chapter 1: INTRODUCTION

Surendranagar district is located in the north eastern part of Saurashtra Peninsula of Gujarat State. The Rann of Kachchh towards north, the vast low-lying alluvial tract plains of North Gujarat towards east and uplands of the central Saurashtra towards and south and west encircle the district. The district covers an area of around 9225 Sq. Km. A major portion of the district is drought prone. This report deals with the salient features of hydrogeological conditions and ground water potential of Surendranagar district. This district is essentially an underdeveloped district, having diverse terrain conditions and varied but limited endowments of nature (Figure 1 &2).

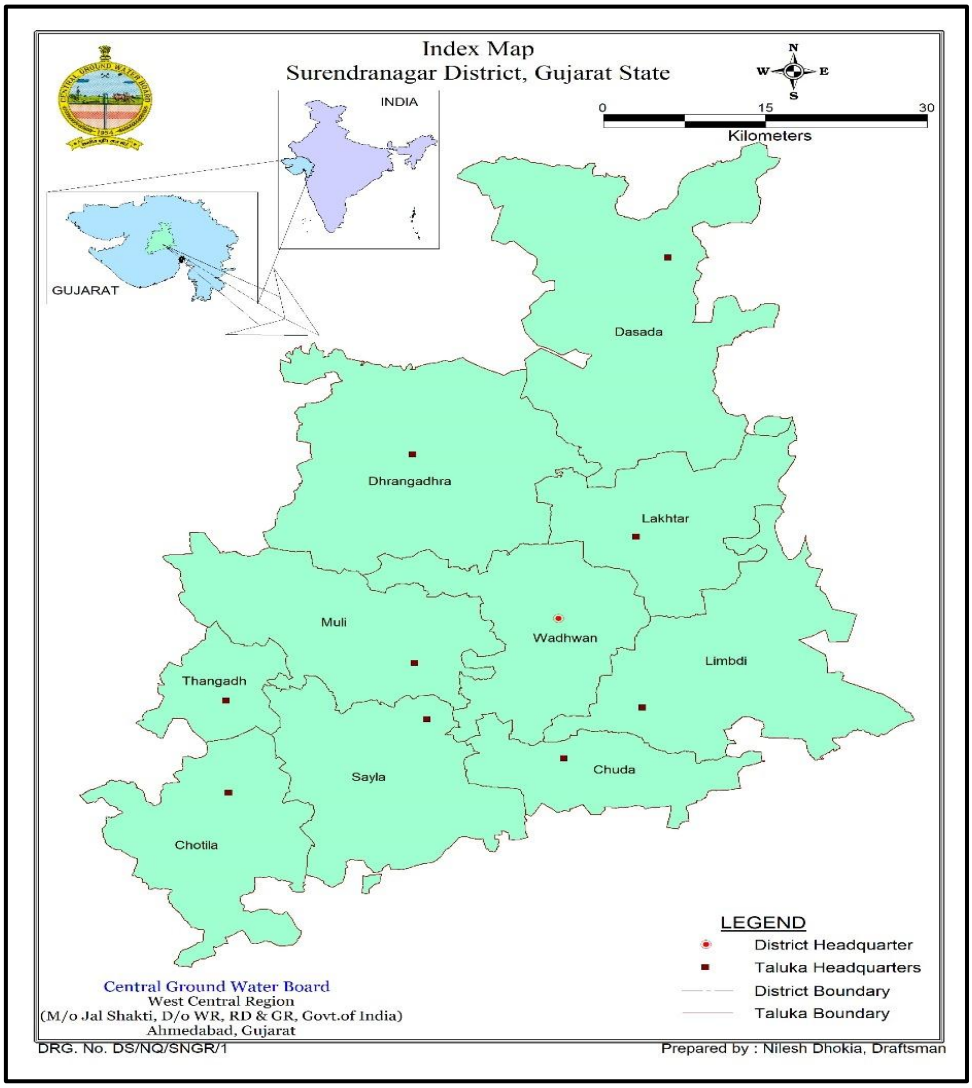

Figure 1: Index map showing the Surendranagar district, Gujarat, India

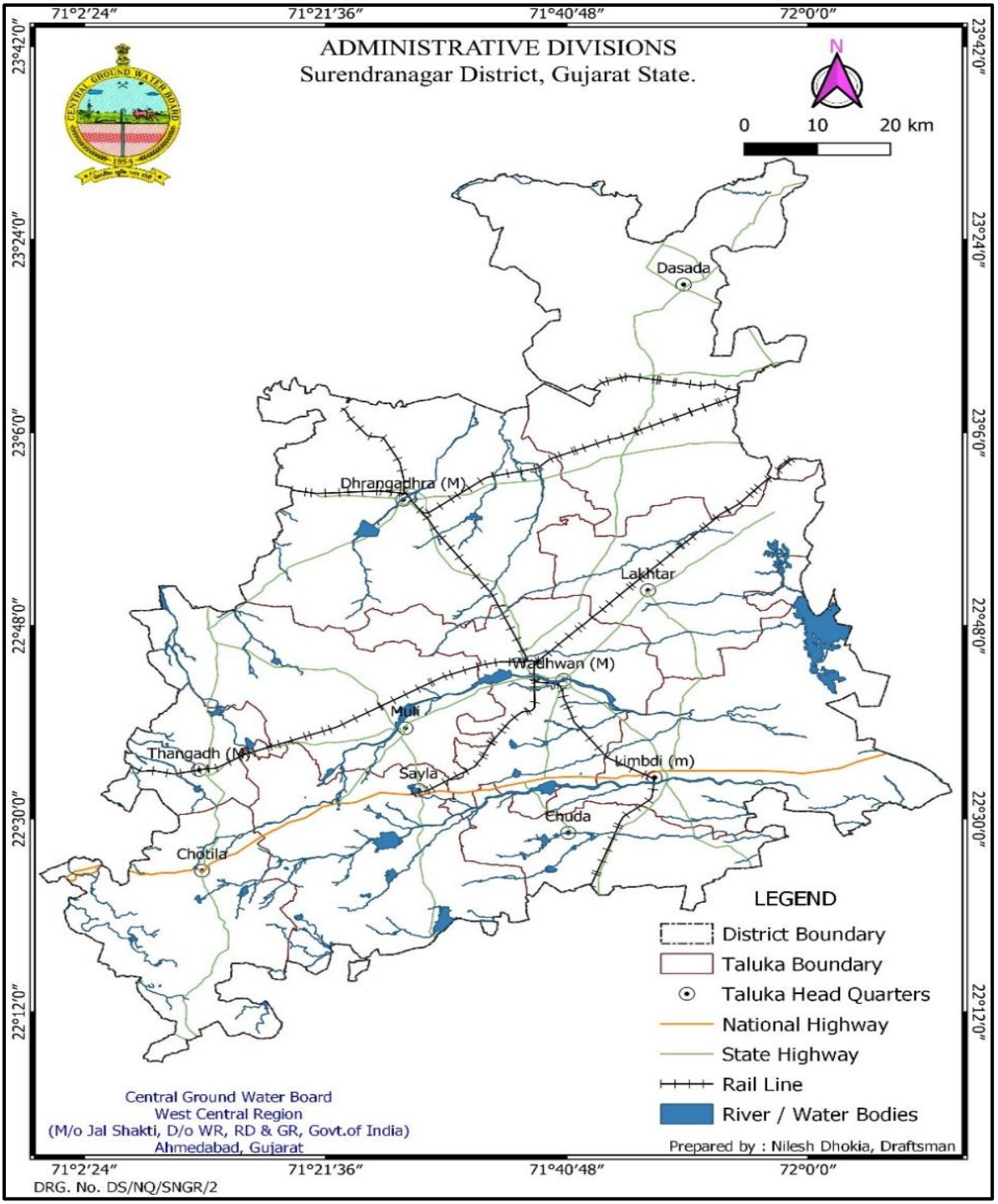

Figure 2: Administrative map of Surendranagar district.

1.1 Objective

The primary objective of the Aquifer Mapping Exercise can be summed up as "Know your Aquifer, Manage your Aquifer". Demystification of Science and thereby involvement of stake holders is the essence of the entire project. The involvement and participation of the community will infuse a sense of ownership amongst the stakeholders. This is an activity where the Government and the Community work in

tandem. Greater the harmony between the two, greater will be the chances of successful implementation and achievement of the goals of the Project. As per the Report of the Working Group on Sustainable Ground Water Management, "It is imperative to design an aquifer mapping programme with a clear-cut groundwater management purpose. This will ensure that aquifer mapping does not remain an academic exercise and that it will seamlessly flow into a participatory groundwater management programme. The aquifer mapping approach can help integrate ground water availability with ground water accessibility and quality aspects.

1.2 Methodology

Methodology involves creation of database for each of the principal aquifer. Delineation of aquifer extent (vertical and lateral). Standard output for effective presentation of scientific integration of Hydrogeological, geophysical, geological, hydro chemical data facts and on GIS platform, identification of issues, manifestation of issues and formulation of strategies to address the issues by possible interventions at local and regional level. The activities of the Aquifer Mapping can be grouped as follows.

1.2.1 Data Compilation & Data Gap Analysis:

One of the important aspects of the aquifer mapping programme was the synthesis of the large volume of data already collected during specific studies carried out by Central Ground Water Board and various Government organizations with a new data set generated that broadly describe an aquifer system. The data were assembled from the available sources, analysed, examined, synthesized and interpreted. These sources were predominantly non-computerized data, which was converted into computer-based GIS data sets and on the basis of available data, data gaps were identified.

1.2.2 Data Generation

There a strong need for generating additional data to fill the data gaps to achieve the task of aquifer mapping. This was achieved by multiple activities such as data gap analysis, site selection, exploratory drilling, PYT, pumping test, geophysical techniques, hydro-geochemical analysis, remote sensing, and hydrogeological surveys to delineate multi aquifer system to bring out the efficacy of various geophysical techniques and a protocol

for use of geophysical techniques for aquifer mapping in different hydrogeological environs.

1.2.3 Aquifer Map Preparation

On the basis of integration of data generated from various studies of hydrogeology & geophysics, aquifers have been delineated and characterized in terms of quality and potential. Various maps have been prepared bringing out details of Aquifers, these are termed as Aquifer maps providing spatial variation (lateral & vertical) in reference to aquifer extremities (i.e., quality & quantity).

1.2.4 Aquifer Management Plan Formulation

Aquifer response Model has been utilized to identify a suitable strategy for sustainable development of the aquifer in the area.
All the above activities under the ground National Aquifer Mapping programme are presented in (Figure 3)

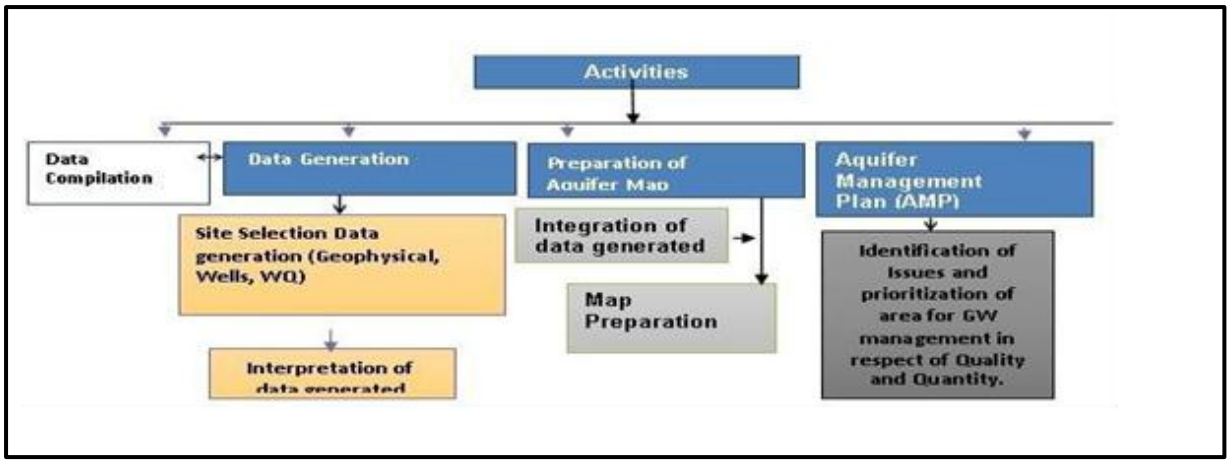

Figure 3 :Activities under National Aquifer Mapping Programme

1.3 Demography

The total population of the district is 1585298 of which male population constitutes about 821825(51.84%) and female population is 763443(48.16%). Wadhwan taluka comprises maximum population 359325 of the district whereas Thangadh taluka has minimum

population 42351 in the district. The district consists of 571 villages and 10 talukas (table 1 and Figure 4).

Table 1 Demographic details of the Surendranagar district. (Source- census 2011)

Sr.No.	Taluka	Male	Female	Total	Male (%)	Female (%)
1	Dhrangadhra	113961	104080	218041	52.27	47.73
2	Dasada	93468	87173	180641	51.74	48.26
3	Lakhtar	38932	36674	75606	51.49	48.51
4	Wadhwan	186434	172891	359325	51.88	48.12
5	Muli	61556	57346	118902	51.77	48.23
6	Chotila	92602	85902	178534	51.87	48.12
7	Sayla	71327	67316	138643	51.45	48.55
8	Chuda	50609	47307	97916	51.69	48.31
9	Limbdi	90809	84530	175339	51.79	48.21
10	Thangadh	22,127	20,224	42351	52.25	47.75
11	Surendranagar	821825	763443	1585298	51.84	48.16

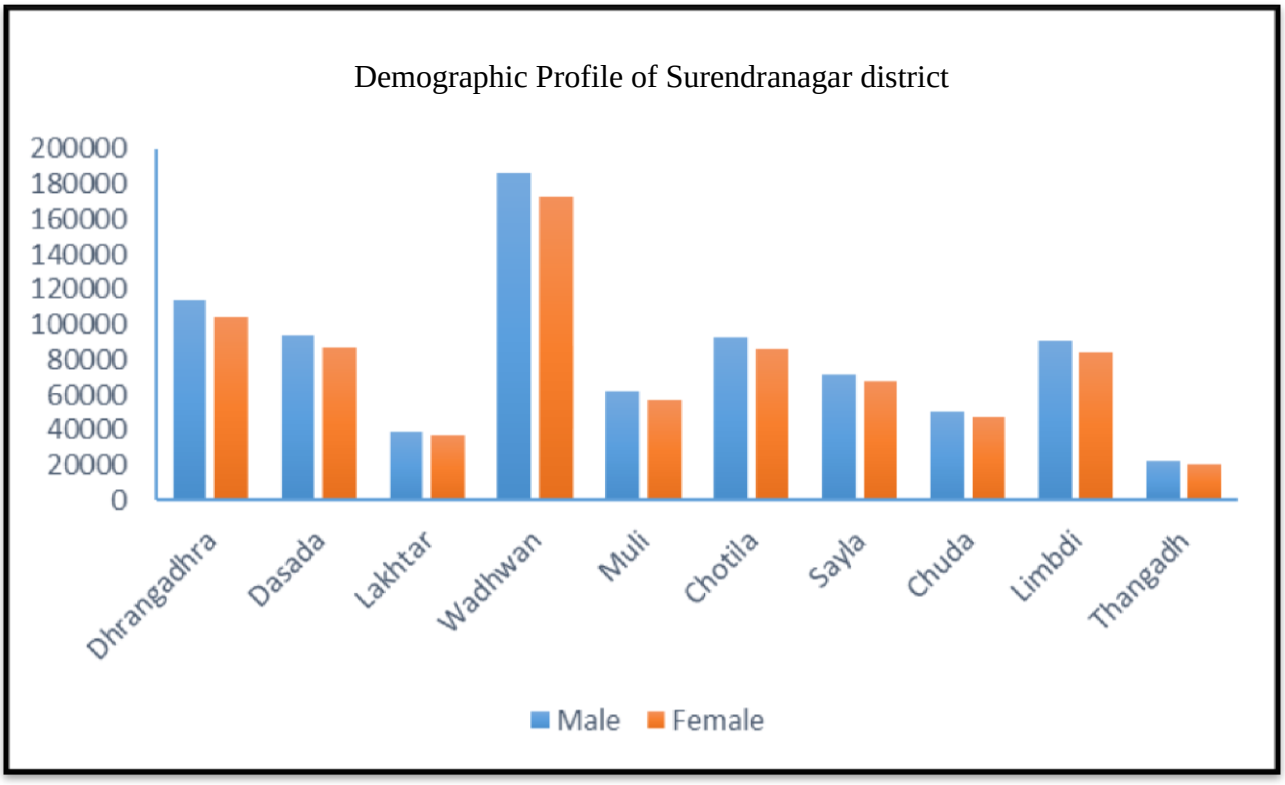

Figure 4: Histographic representation of demography of Surendranagar district

1.4 Studies/Activities by CGWB

Hydrogeological investigation to Exploratory drilling, at least one bore well in almost every taluka has been done. Short term investigation for water supply in Dhrangadhra, 1971, Systematic survey in Kharaghoda area (1974), Dhragdhra(1963), Surendranagar town(1961), Again dhrangdhra(1975), Limdi (1982), Sayla (1982) for Ground water Quality, Discharge and availability in different aquifer has been done.

1.5 Hydrometeorology

Surendranagar district is located in the north western part of Saurashtra Peninsula of Gujarat State. The Rann of Kachchh towards north, the vast low-lying alluvial tract plains of North Gujarat towards east and uplands of the central Saurashtra towards south and west encircle the district.

1.5.1 Temperature

The period from March to May records gradual increase in temperature and May being the hottest month. The maximum temperature in summer reaches 46° Celsius with an average of 41.9° Celsius. With the onset of the south west monsoon, by about June, there is an appreciable drop in the day temperatures. From the beginning of November month onwards, both day and night temperatures drop rapidly (even up to 5°C) till January which is being the coldest month. The mean daily maximum and minimum temperatures works out to be 28.3° C and 12.9° C respectively for period of observation.

1.5.2 Humidity

The relative humidity is generally over 60% in the south west monsoon. In the rest of the year the air is comparatively dry, especially in the afternoons. During the period of November to May the relative humidity varies between 20% and 30%.

1.5.3 Wind

In the south west monsoon season, the wind direction is westeraly to south westeraly. In the post monsoon/cold season, wind blow from the north-north east direction. In summer seasons the direction of the wind is mainly between north west and south west. The wind speed gradually increases from February and reaches the peak of 20.3 km/hr in July when the south west monsoon is most active. It again decreases from August and becomes as low as 6.7 km/hr.

1.5.4 Rainfall

The rainfall data of Surendranagar, Chotila, Dasada, Dhrangadhra, Sayla, Lakhtar, Limbdi, Thangadh and Muli Rain gauge stations published by the Water Resources Investigation Circle, Department of Irrigation, Gujarat have been utilized for this writ up. More than 90% of the rainfall occurs during the monsoon. Rainfall during the winter and summer months is negligible. The average rainfall (1987 to 2021) of the district is 578.1 mm and in the 2021 it is 497 mm only which is 16 % lesser than of the average rainfall (table.2).

Table 2 rain fall data, surendranagar district, Gujrat

Rain fall data, Surendranagar district, Gujrat										
Taluka / Year	Chotila	Chuda	Dasada	Dhrangadhra	Lakhtar	Limbdi	Muli	Sayla	Thangadh	Wadhwan
1987	136	210	113	170	27	210	203	190	136	79
1988	731	664	672	705	449	664	770	690	731	443
1989	830	658	259	547	357	658	1037	717	830	449
1990	591	743	790	538	1035	743	886	381	591	603
1991	215	222	322	158	166	222	351	177	215	202
1992	584	778	360	423	463	778	857	564	584	488
1993	466	368	568	580	484	368	607	685	466	338
1994	928	654	683	568	831	654	1039	778	928	619
1995	355	439	419	405	182	439	304	359	355	334
1996	422	614	311	411	400	614	330	346	422	369
1997	1053	1041	773	870	1164	1041	809	869	1053	708
1998	529	626	381	452	507	753	372	439	529	453
1999	295	532	402	253	333	579	238	253	295	195
2000	311	393	356	303	352	340	334	322	311	326
2001	740	632	597	605	692	609	355	570	740	671
2002	282	233	353	274	316	255	303	260	282	636
2003	761	421	433	488	561	750	483	657	761	525
2004	723	608	499	524	650	595	736	550	723	590
2005	1113	1230	996	839	757	1245	932	1100	1113	919
2006	643	516	721	763	501	777	598	621	643	733
2007	986	777	798	744	836	1087	875	877	986	974

Rain fall data, Surendranagar district, Gujrat										
2008	745	730	622	757	1127	1018	708	517	745	844
2009	440	188	303	312	237	286	320	372	440	243
2010	885	578	1059	909	638	1264	590	626	885	916
2011	816	456	671	632	650	884	681	519	816	848
2012	435	211	424	226	503	501	263	270	435	349
2013	758	500	832	575	860	536	645	606	758	802
2014	593	620	587	597	876	327	598	390	765	695
2015	625	313	619	414	364	216	351	308	473	314
2016	323	404	495	220	432	207	356	335	339	439
2017	1525	597	943	924	805	470	818	674	731	1068
2018	377	313	212	199	161	250	210	213	205	326
2019	997	1240	703	1259	914	730	852	974	1034	1040
2020	824	790	692	649	1116	851	700	720	718	1100
2021	683	528	391	401	390	448	569	552	508	500
Minimum	**136**	**188**	**113**	**158**	**27**	**207**	**203**	**190**	**136**	**79**
Maximum	**1525**	**1240**	**1059**	**1259**	**1164**	**1264**	**1039**	**1100**	**1113**	**1100**
Average	**649**	**566**	**553**	**534**	**575**	**611**	**574**	**528**	**616**	**575**
Dist. Average	**578.1**									

1.6 Geomorphology

The physiography aspect of the district varies in different talukas. The Wadhvan, Limbdi, Sayla, Lakhtar, Dasada talukas are mostly plain country, Dharangadhra is gently undulating, while Chotila, thangadh and Muli are hilly. The district can be divided into following three main geomorphic units shown in figure no.5. (i) Almost the entire eastern half is a plain alluvial area with elevations varying from 5 m above mean sea level (amsl)

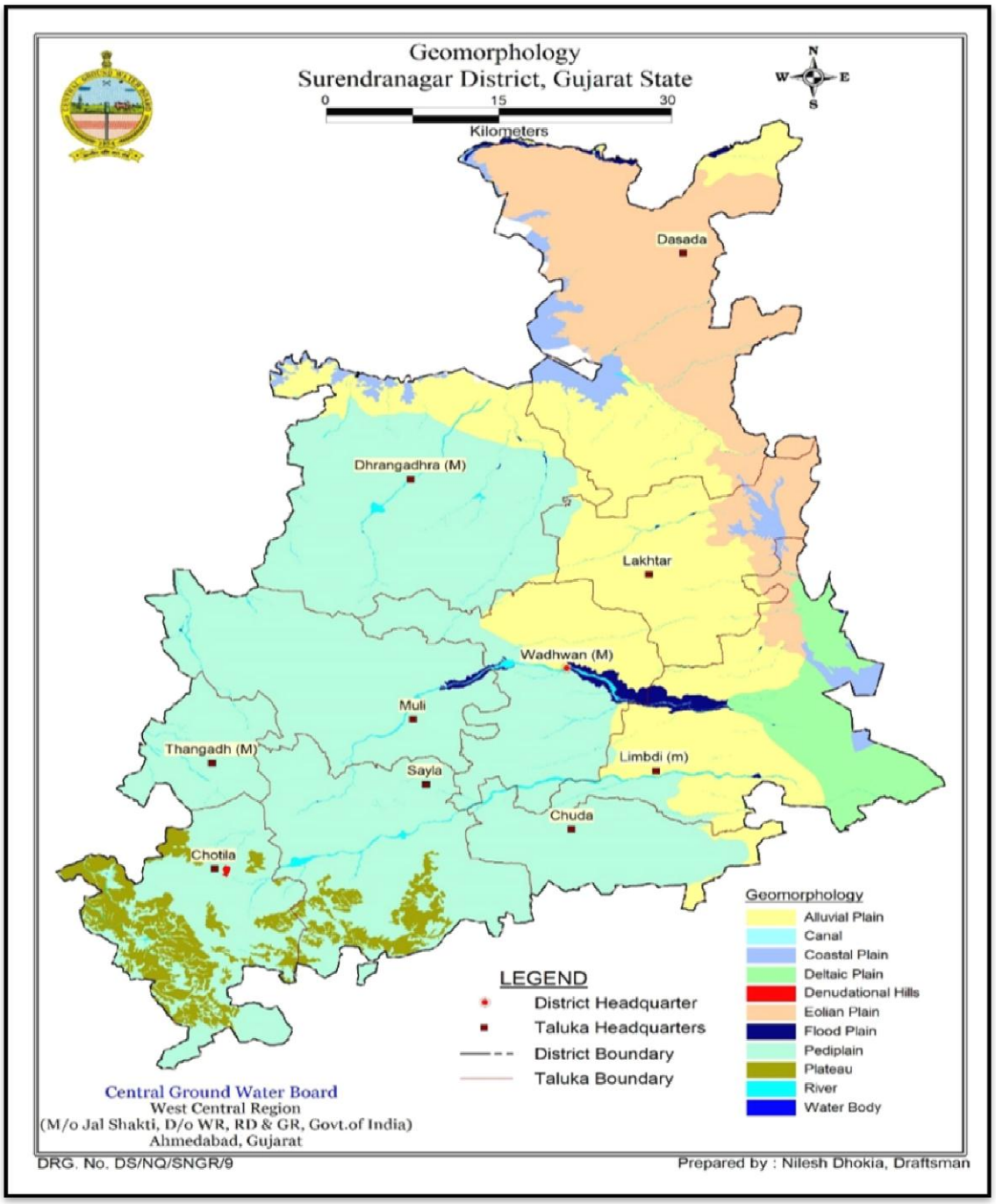

Figure 5: Geomorphological map of Surendranagar district, Gujarat state

to 40 m amsl. (ii) The north western part forms the gently undulating terrain comprising mainly the semi consolidated sedimentary rocks with elevations varying from 30 m to 144m amsl, except in the extreme north where there is sudden fall in elevation to 8 m amsl near Little Rann of Kachchh. (ii) The south western pat forms rugged topography with many isolated hill ranges and hillocks of Deccan traps rising to heights ranging from 100 m to 3m amsl (Chotila hill) (Figure 5).

1.6.1 Drainage

The drainage in the northern most and eastern parts comprises mostly short streams which disappear into the Little Rann of Kachchh towards north in the low-lying saline/partly marshy land and towards east in the sandy tracts (figure no.6).

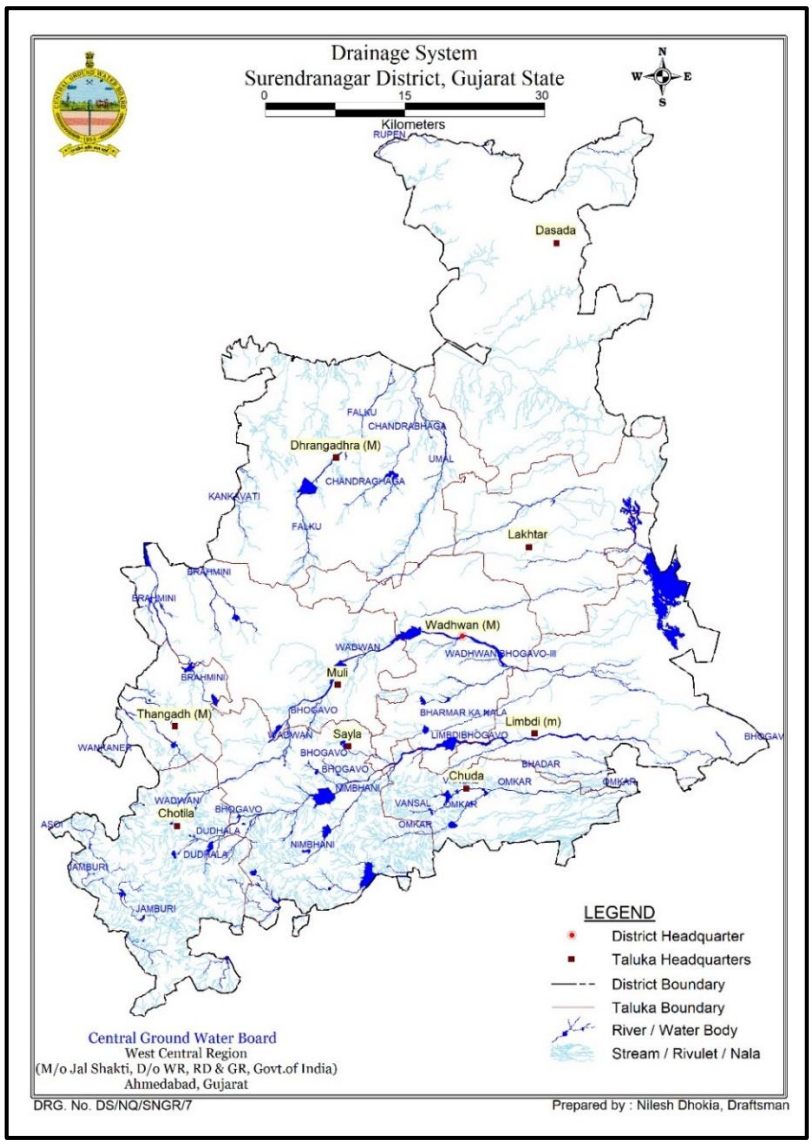

Figure 6: Drainage system of Surendranagar district , Gujarat

Limbdi- Bhogava I and Wadhvan- Bhogava II i.e., Bhogava II which originate from the hilly range of Chotilla about 64 km. west of Surendernagar are two east flowing rivers. These rivers have almost no tributaries in the alluvial tracts. Instead, here are several small / insignificant interdunal drains and also many west-east flowing streams which are running parallel to the Bhogava II. There are many small northerly flowing streams out of which the Brahmanani or Bhambani and Kankavati are the only major streams and are ephemeral.

1.8 Soil Types

The soils of Surendranagar district may be classified into three main categories:

a. Medium black soils

b. Red Sandy soils

c. Silty soils

Medium black soils generally occur at shallow depths (less than 5m) where basalts/shale forms the main rock unit and is exposed on the surface in the south, southwest and central part of the area. These soils are good in fertility but not suitable for heavy irrigation. The red sandy soils occur in north east, east and south east part of the area. The silty soils are found along a narrow strip close to the little Ran of Kachchh in the north east and along shallow alluvial tracts and hard rock areas in central uplands has appreciable content of sand (Figure 7).

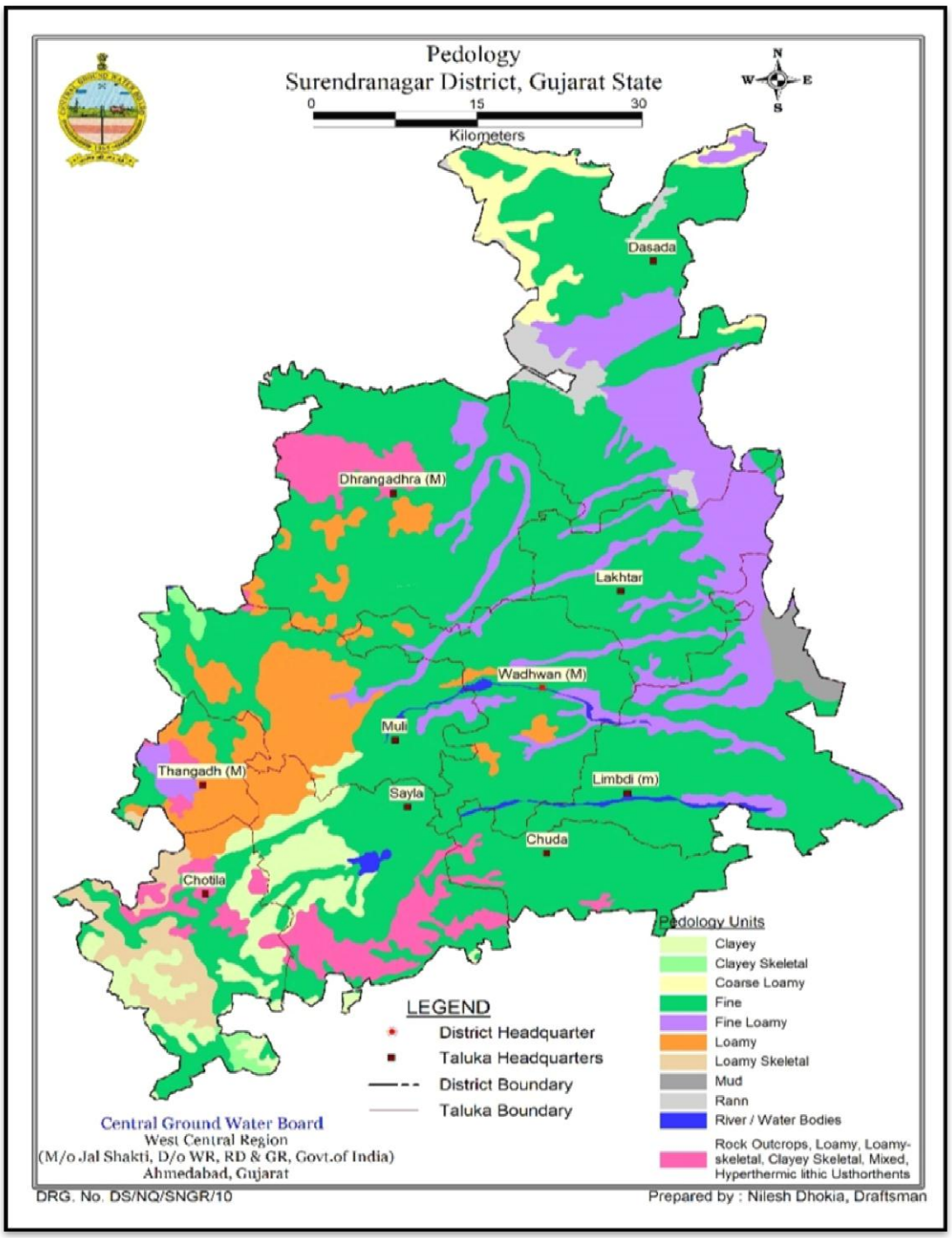

Figure 7: Map showing the soil texture in Surendranagar district of Gujarat district

1.9 Land Use Pattern

The total geographical area of the district is 922500 Ha out of which nearly 623934 Ha (67.63%) is under agriculture. The land under non agriculture use is 50855 Ha which is 5.52% of the total geographical area of the district. Out of the land under nonagricultural use Dasada block has the highest (8821 Ha) followed by Chotila (7718 Ha) and

Dhrangadhra (6975 Ha). The forest area covers 4.86 % of the total geographical area which is 44821 Ha Source (DIP (2016-2020), Surendranagar). The land use pattern in Surendranagar district is shown in the map below, Figure 8.

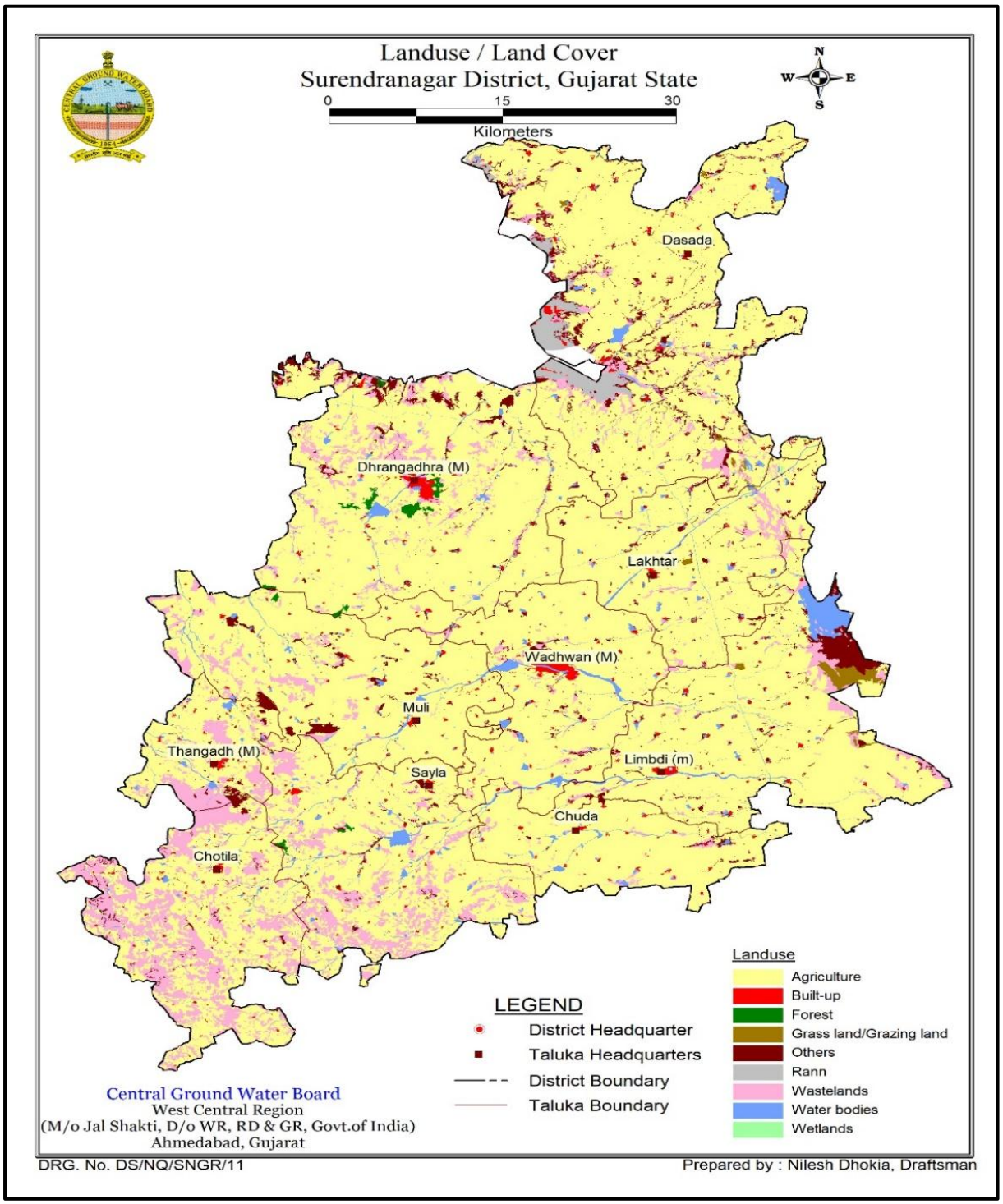

Figure 8: Map showing the land use/ land cover in Surendranagar district of Gujarat district

1.7 Geology

The general geological succession of the rock formations occurring in the Surendranagar district is as given below (Table 3). The geology of the district is depicted in Figure 9.

Table 3 Geological succession of Surendranagar district

Age	Formation	Lithology
Pleistocene to Recent	Soil/ Alluvium	Black cotton soil and. Clay, sandy soil, clay, silt, brown sand and gravel.
--Unconformity--		
Upper Cretaceous to Lower Miocene	Deccan Traps and related intrusive	Basalts, volcanic tuff, porcellanitic, Dolerite dykes, & related volcanic rocks
Middle Cretaceous	Wadhwan Formations	Reddish brown to brick red colored sandstone, fossiliferous cherty limestone and pebbly grit.
Upper Jurassic to Cretaceous	Dhrangadhra Formations	Medium to coarse grained sandstone, ferruginous, current bedded, intercalated with red, grey and black shales and carbonaceous matter.

1.7.1 Description of the rock units:

Dhrangadhra Formations: Dhrangadhra formations constitute the oldest exposed rocks in Saurashtra region, covering an area of about 3000 Sq. Km and 400 m in thickness.

Wadhwan Formations: The Wadhwan sandstone are exposed around Wadhwan Surendernagar, near Doliya and along the Wadhwan Bhogava River covering an area about 300 Sq. Km. It is considered to be younger in age than Dhargandhra formation though apparently no clear demarcation of the boundary exists.

Deccan Traps: The basaltic lava flows unconformably overlying the Wadhwan and the Dhrangadhra formations are exposed in South eastern part of the district covering an area of about 2100 sq. km. The basalts are compact, fin grained too porphyritic and sparsely joint**.** The major fracture pattern in the Deccan traps is in NE—SW and NW-SE directions with high angle dips. Columnar jointing is also seen in the massive basalts. The joints are mainly cooling joints and seldom interrupt more than flow. However, a few major shear zones intersecting several flows are also encountered.

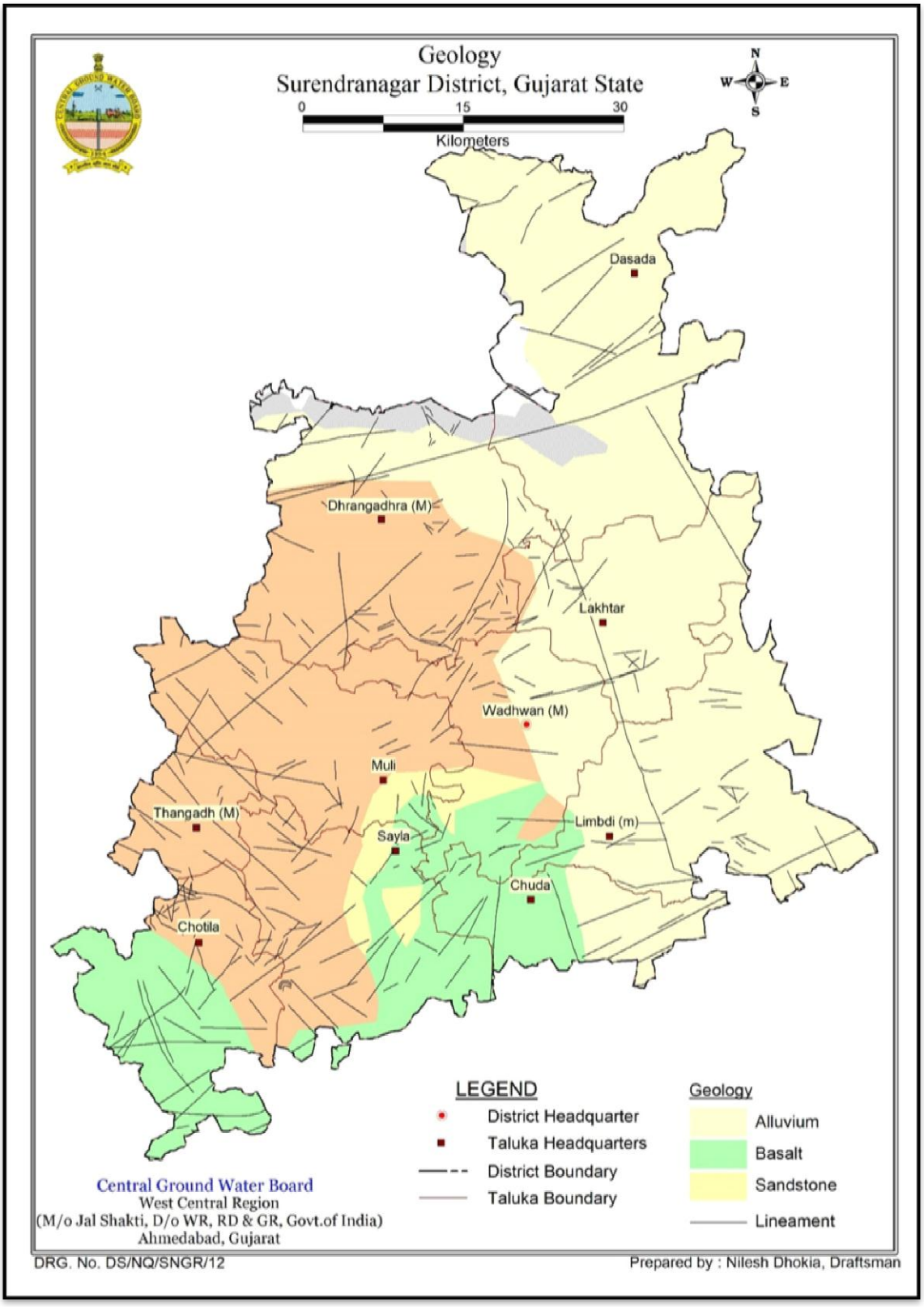

Figure 9: Map showing the geological units in Surendranagar district of Gujarat district

Basic Intrusive: The basic intrusive are mainly Dolerite dykes. These dykes are mostly manifested in the Dhrangadhra formation at many places. The dykes are generally compact but highly jointed/fractured dykes are also observed.

Alluvium: The eastern part of the district comprises unconsolidated to semi consolidated sediments of Recent to Pleistocene age covering an area about 5500 Sq. Km. The top few meters of the area invariably comprise blown sand deposits.

Chapter 2: HYDROGEOLOGY

The groundwater in the area occurs phreatic, semi-confined and confined conditions. The ground water occurrence is controlled by topography, drainage, lithology and disposition of fractures and joints. The medium to coarse grained sandstone act as good repository of ground water. The main water bearing formations identified with in the area as follows (Figure 10).

2.1 Ground Water in alluvium

Most of the northern and eastern parts of the district, covering an area of about 5375 Sq. Km, comprise semi and unconsolidated formations. The ground water occurs under unconfined to confined conditions. The depth of the wells in this formation ranges between 2.00 and 30.00 m bgl. The depth of water levels ranges from 0.20 to 20.0 m bgl. The yield of shallow dug wells varies from 40 to 60 m3/day. The depth of the tube wells ranges from 60 to 300 m. The free flow discharge of these well ranges from 5 to 60 m3/day.

2.2 Ground Water in Dhrangadhra Sandstone

The Dhrangadhra sandstone are the most important water bearing formations in the district. it occupies about 2700 Sq.Km. area and situated in the central and north-western parts of the district. The shallow dug wells in the depth range between 5 and 28m, tapping Upper Dhrangadhra sandstone have water yielding capacity of 20 to 60 m3/day. The general range of water level in this aquifer is around 4 to 22 m. A number of tube wells sited, in Middle Dhrangadhra formations, down to depths ranging between 90 and 157 m are in operation. The yield of tube wells varies from 25 to 80 m3/day. The piezometric head in this aquifer vary from 10 to 30 mbgl.

2.3 Ground Water in Deccan Traps

The Deccan basalts, unconformably overlying the Dhrangadhra formation form aquifers in southern part of the district, covering an area of 2100 Sq.Km. The movement of ground water is controlled by weathered zone, joints and fissures. The groundwater occurs under both water table and semi-confined conditions. The depth of the dug wells in the traps range from 6.0 to 28.0 m and depth to water level rests between 1.0 and 20 m bgl. The yield of shallow dug wells ranges from 20.0 to 50.0 m3/day. The depth of the boreholes tapping interflow zones range from 80 to 110 m, where in the piezometric head

rests between 18 and 25 m bgl. As such the yield of the shallow/deep boreholes in the traps are ranging from 35 to 70 m3/day.

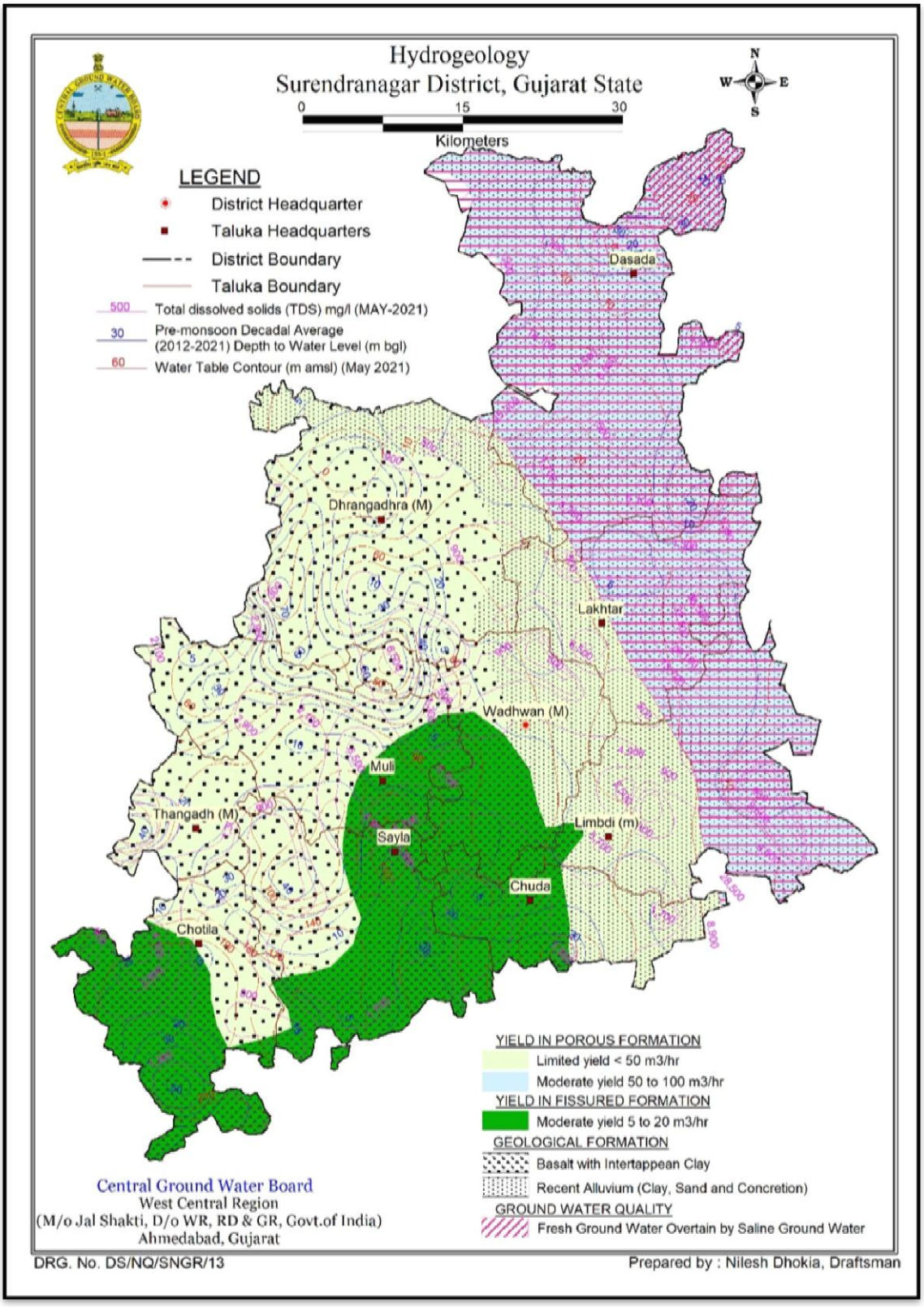

Figure 10: Hydrogeological map of Surendranagar district.

Chapter 3: DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

Collection and compilation of data for aquifer mapping studies is carried out in conformity with Expenditure Finance Committee (EFC) document of XII plan of CGWB encompassing various data generation activities (Table-4).

Table 4: Brief activities showing data compilation and generations

S.No.	Activity	Sub-activity	Task
1	Compilation of existing data/ Identification	Compilation of Existing data on groundwater	Preparation of base map and various thematic layers, compilation of information on Hydrology, Geology, Geophysics, Hydrogeology, Geochemical etc. Creation of data base of Exploration Wells, delineation of Principal aquifers (vertical and lateral) and compilation of Aquifer wise water level and draft data etc.
		Identification of Data Gap	Data gap in thematic layers, sub-surface information and aquifer parameters, information on hydrology, geology, geophysics, hydrogeology, geochemical, in aquifer delineation (vertical and lateral) and gap in aquifer wise water level and draft data etc.
2	Generation of Data	Generation of geological layers (1:50,000)	Preparation of sub-surface geology, geomorphologic analysis, analysis of land use pattern.
		Surface and sub-surface geo-electrical and gravity data generation	Vertical Electrical Sounding (VES), bore-hole logging, 2-D imaging etc.
		Hydrological Parameters On groundwater recharge	Soil infiltration studies, rainfall data analysis, canal flow and recharge structures.

S.No.	Activity	Sub-activity	Task
		Preparation of Hydrogeological map (1:50, 000 scale)	Water level monitoring, exploratory drilling, pumping tests, preparation of sub-surface hydrogeological sections.
		Generation of additional Water quality parameters	Analysis of groundwater for general parameters Including fluoride.
3	Aquifer Map Preparation (1:50,000 scale)	Analysis of data and preparation of GIS layers and preparation of aquifer maps	Integration of Hydrogeological, Geophysical, Geological and Hydro-chemical data.
4	Aquifer Management Plan	Preparation of aquifer management plan	Information on aquifer through training to Administrators, NGO's, progressive farmers and stakeholders etc. and putting in public domain.

3.1 Data Generation

In order to establish the three-dimensional disposition of aquifer system in the area, the existing data of lithological logs and Electrical logs of Exploratory wells studies carried out and used in prepare a hydro geological cross section, Fence diagram and 3D Model. The data has been analyzed using Rockworks 16 software and is presented below in the Hydrogeological cross sections A-A' to C-C' and Solid Model of the district showing the depiction of Aquifer Groups and Aquitard up to 200 m. The stratigraphic sections depicting unconfined aquifer, Confined Aquifer for alluvium and weathered aquifer & fractured aquifer for Basaltic rock are placed at Figs (12 to 14). Fence Diagram and 3D Solid Model of district is depicted in Fig. 15 and 16, respectively.

Table 5: Data integration in respect to Surendranagar district

Type of Data & source	No of Wells
Aquifer Disposition	
CGWB	**15**
Long term Fluctuation	
CGWB+GWRDC	**26+96**
Decadal Analysis water Level	
CGWB+GWRDC	**48+109**
Analysis of water Quality	
CGWB	**90**

3.2 Conceptualization of Aquifer system in 2D

A total of 15 exploratory wells and piezometers lithologs are utilized to decipher the subsurface geometry of the aquifer by using Rockworks 16 software prepared hydro geological cross sections, Fence diagram and 3D Model up to the depth of 200 mbgl. And three hydrogeological cross sections (2D) are drawn in different direction to cover entire area as per the availability of data point in the district and represented in figure 12 (A-A') to figure 14 (C-C').

1. Section A-A' (Fig. 12)- Section is drawn roughly NW-SE direction and in between Dharangadhra and Limdi, passing through Alindra, Surendranagar and Khajeli. Stratigraphicaly from Section, it is deciphered that sandstone, intercalation of Shale and sandstone and alluvium forms the major aquifer system in the district with very thin layer of basalt sandwiched between sandstone and alluvium.

2. Section B-B' (Fig. 13)- Section is drawn roughly NE-Sw direction and in between Parali and Depaliya passing through Limdi, Chuda, Vantavarch, Karadi and Devpara Navagam. Section is represented Stratigraphicaly, from section it is deciphered that that Hard rock formation (weathered & fractured), sandstone and Alluvium forms the major aquifer system in the district along drawn section line
3. Section C-C' (Fig. 14)- Section is drawn roughly SW-NE direction and in between Moti Moladi and Parali, passing through Doliya, Surendranagar and Khajeli. Section is represented Stratigraphicaly, from section it is deciphered that that Hard rock formation (weathered & fractured) and sandstone forms the major aquifer system in the district and rested on intercalation of shale and sandstone along drawn section line

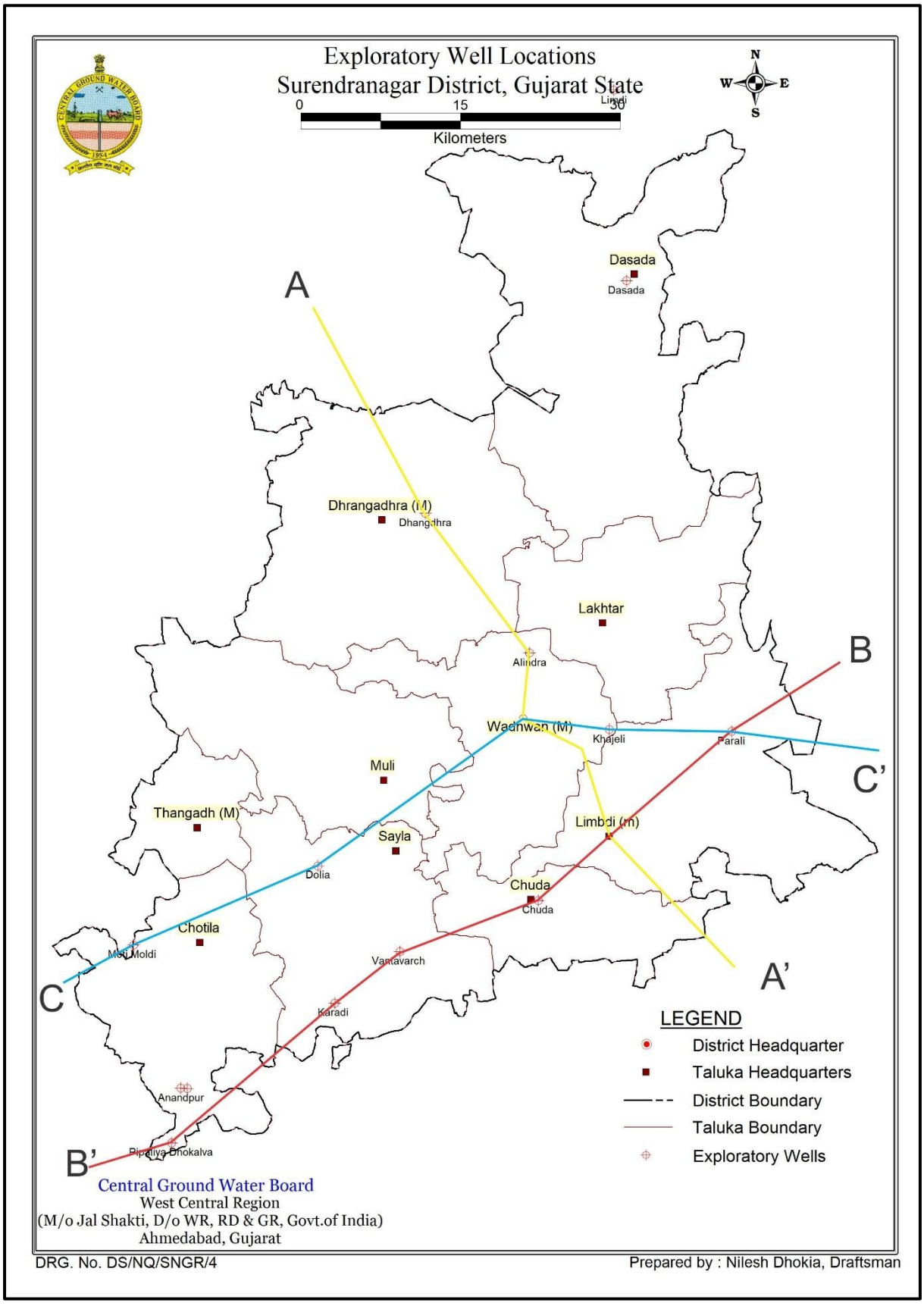

Figure 11: Map showing drawn section lines

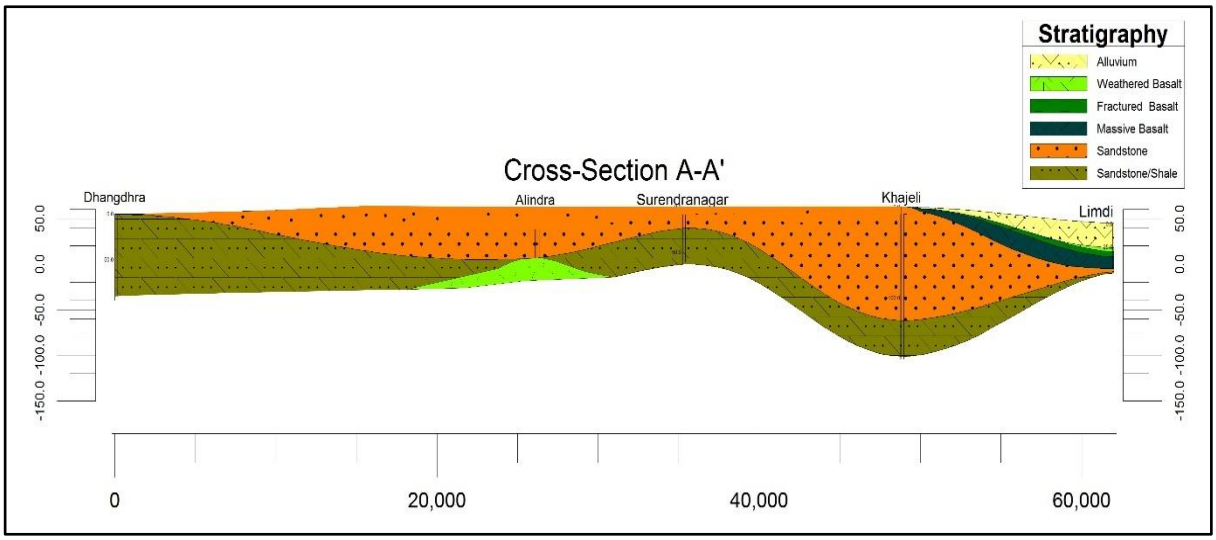

Figure 12: Hydrogeological cross section between Dhrangadhra and Limdi(A-A')

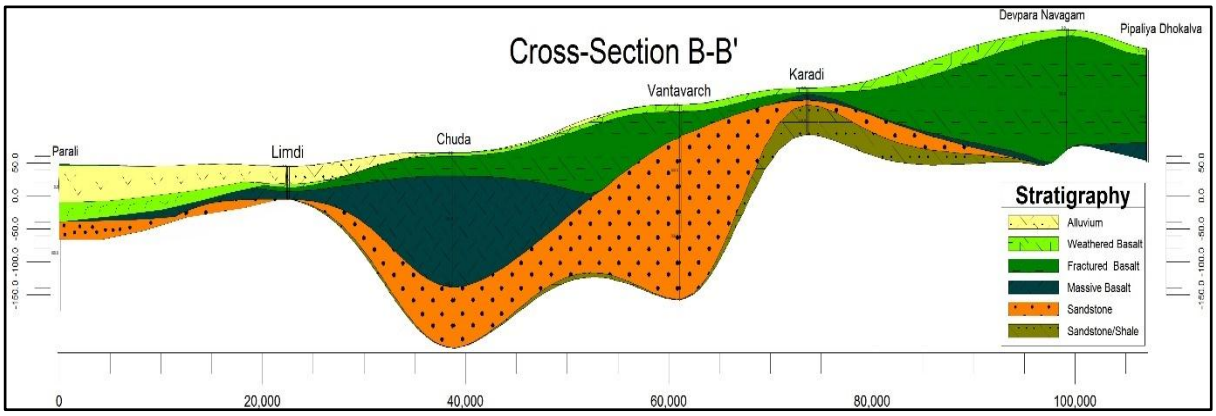

Figure 13: Hydogeological cross section between Parali and pipaliya Dhokalva(B-B')

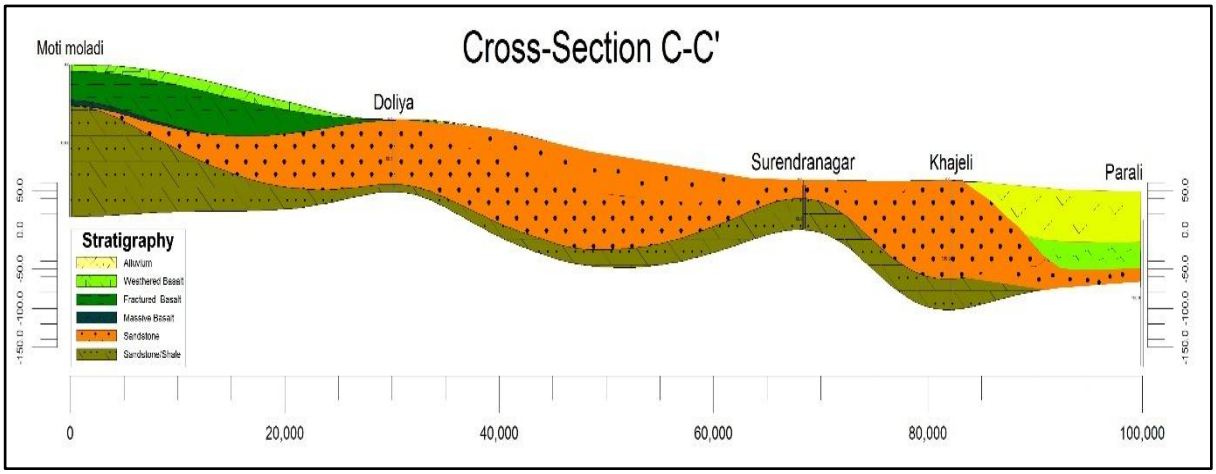

Figure 14: Hydogeological cross section between Moti Moladi and Parali(C-C')

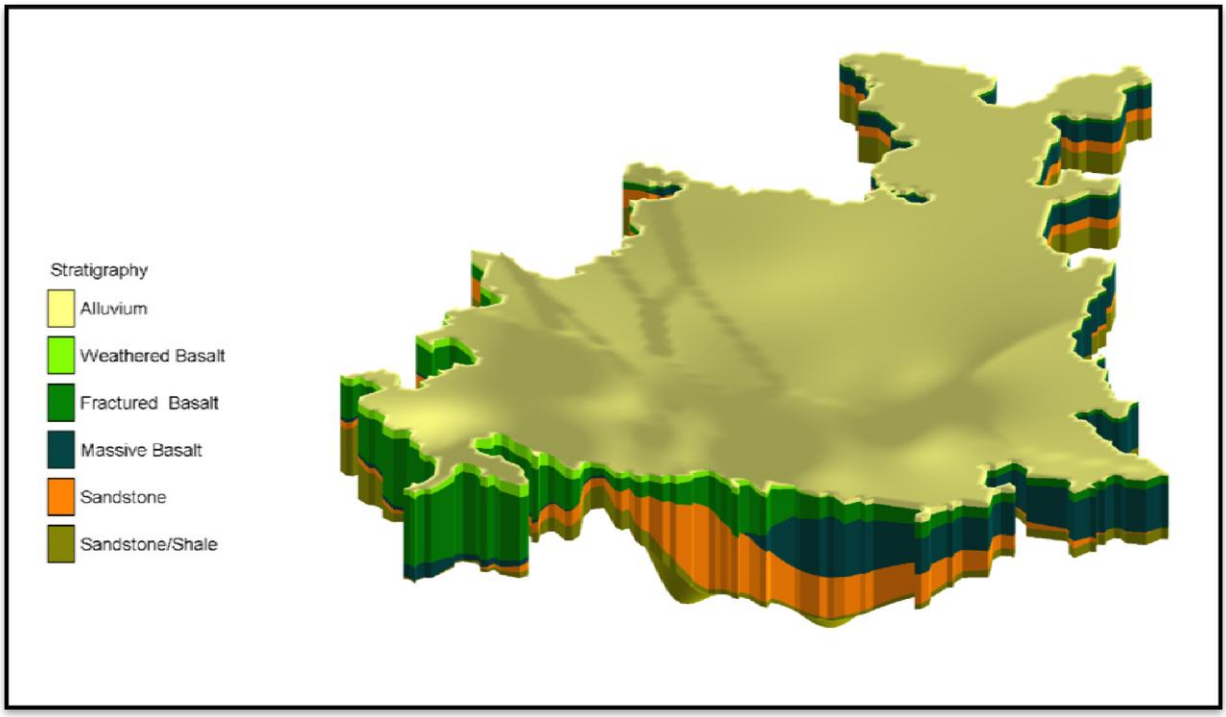

Figure 15: 3D- Aquifer disposition/ model of Surendranagar district

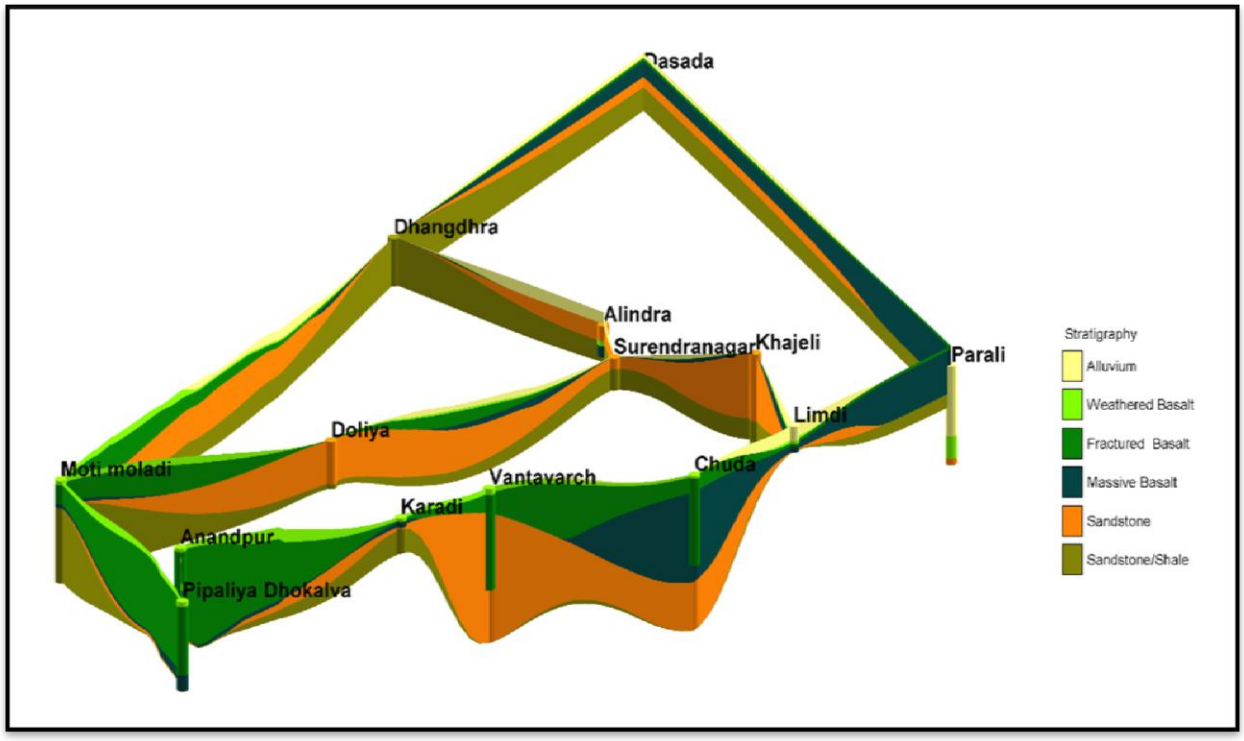

Figure 16: Fence diagram of Surendranagar district

Table 6Aquifer characterization and disposition of Surendranagar district.

Aquifer Characterization and Disposition (Surendranagar)										
Stratigraphy	**Aquifer Nomenclature**	**Lithological Characteristics**	**Depth of occurrence Aquifer (mbgl)**	**Thickness Range (m)**	**Water Level (mbgl) Range (mbgl)**	**Quality (TDS) Range Mg/l**	**Discharge Range lps**	**Transmissivity Range m2/day**	**Nature of Aquifer**	**Remarks**
Pleistocene to Recent	**Alluvium**	Clay, silt, brown sand and gravel.	0 to 132	0 to 132	2 to 5	358-8007	0.2 to 2		Phreatic	Fresh to saline
Cretaceous Upper Proterozoic	**Weathered Basalt**	Basalts, volcanic tuff, pocellanites, Doleritedykes, & related volcanic rocks	0 to 197	0-43	5 to 10	213-2905			Phreatic	Fresh to moderately saline
	Fractured Basalt		6 to 280	0-269	10 to 130	437-2447	0.05 to 8	0.14 to 19.32	Semi confined	Fresh to moderately saline
	Massive Basalt		38 to 280	0 to 37						
Upper Jurassic to Cretaceous	**Sandstone**	Raddish brown to brick red coloured sandstone, fossiliferous cherty limestone and pebbly grit.	0 to 300	0-127	2 to 45	667 to 4545	0.8 to 7		Phreatic, semiconfined, confined	Fresh to saline
	Sandstone/shale	Medium to coarse grained sandstone, ferruginous, current bedded, intercalated with red, grey and black shales and thin strigers of coal and carbonaceous matter.	0-194	0-143	10-70	667 to 4545	3 to 8		semiconfined, confined	Fresh to saline

Chapter 4: GROUND WATER SCENARIO

4.1 Behaviour of Water levels

The behaviour of water levels was studied based on the water level data collected from the National Network of Hydrograph Stations (NNHS). The water level data of May 2021 and November 2021 was used for preparing the depth to water level maps. The seasonal fluctuation in water levels was calculated between May and November 2021. Total 192 nos. of monitoring stations including 109 nos. monitoring station of Gujarat Water Resources Development Corporation (GWRDC) were taken during preparation of maps (figure 17).

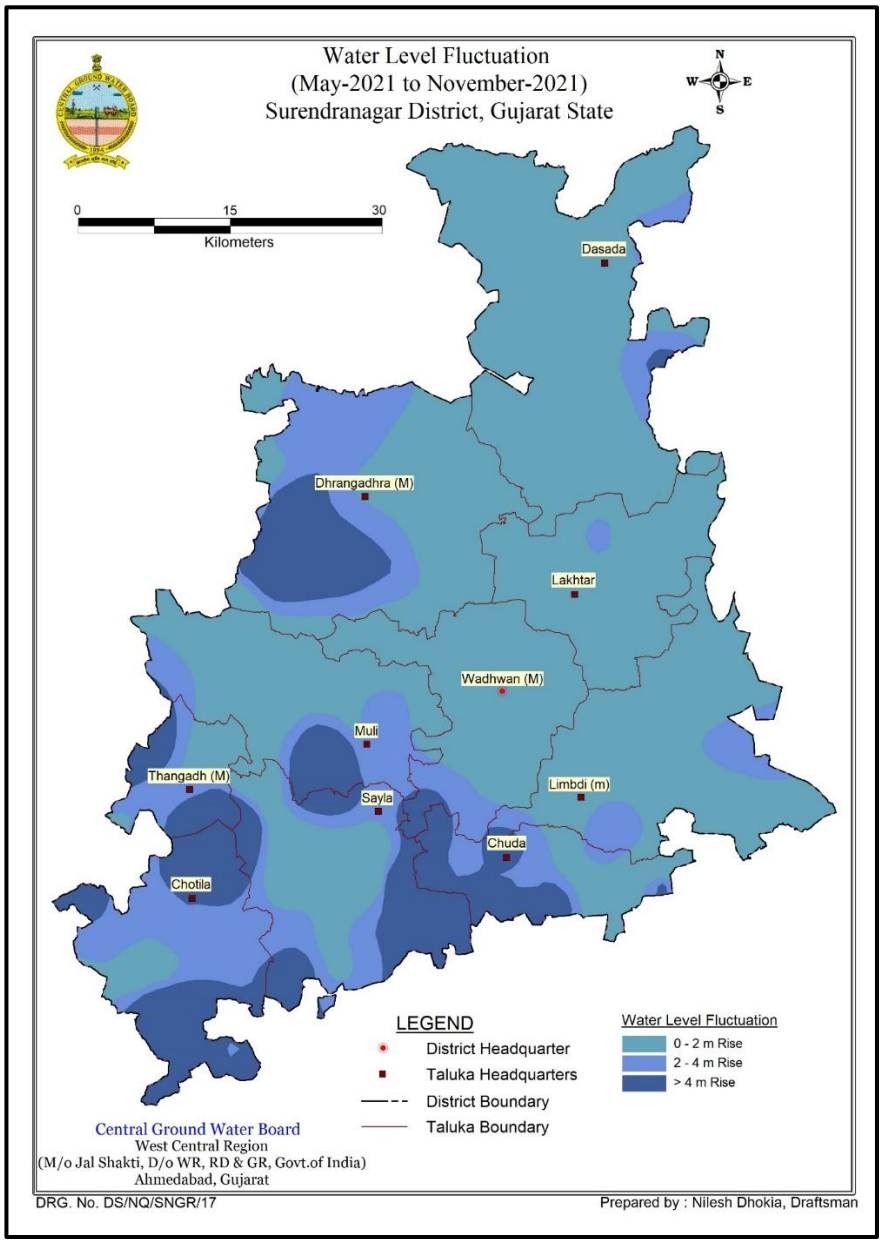

Figure 17: Map showing groundwater fluctuation of pre to post monsoon season 2021

4.2 Depth to water level (Pre monsoon)

Pre monsoon depth to water levels of Surendranagar district is shown in the (Fig. 18), which depict that water levels in most part of the Eastern talukas (Dasada, Lakhtar, and Limdi) ranges in between 2 m bgl to 5 m bgl, with few patches having less than 2 m bgl and few are having more than 5 m bgl. Western talukas (Dhrangadhra, Wadhwan, Muli, Thangadh, Chotila, Sayla and Chuda) showing the ranges of WL between 5 m bgl to 40m bgl with some patches having WL less than 5m bgl and few having more than 40 m bgl.

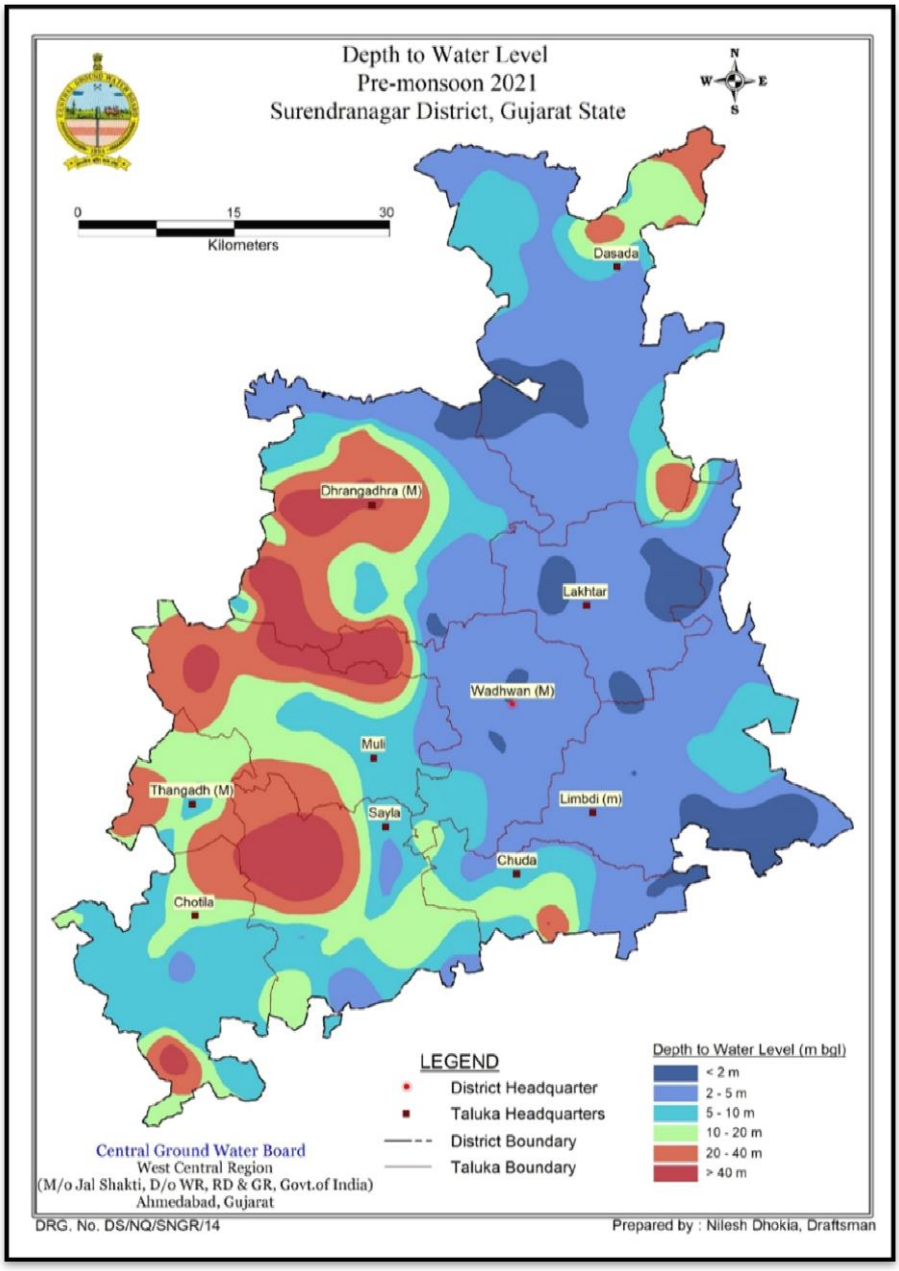

Figure 18: Map showing Pre-monsoon (May 2021) depth to water level of Surendranagar District

4.3 Dept of Water level (Post monsoon)

Post monsoon depth to water levels of Surendranagar district is shown in the (Figure 19) which depict that water levels in most part of district varies between 2m bgl to 20 m bgl, with few patches in Eastern part of the district have WL less than 2m bgl and few in the western margin have the WL more than 20m Bgl. Very few locations in western margin of the district showing the WL more than 40m bgl.

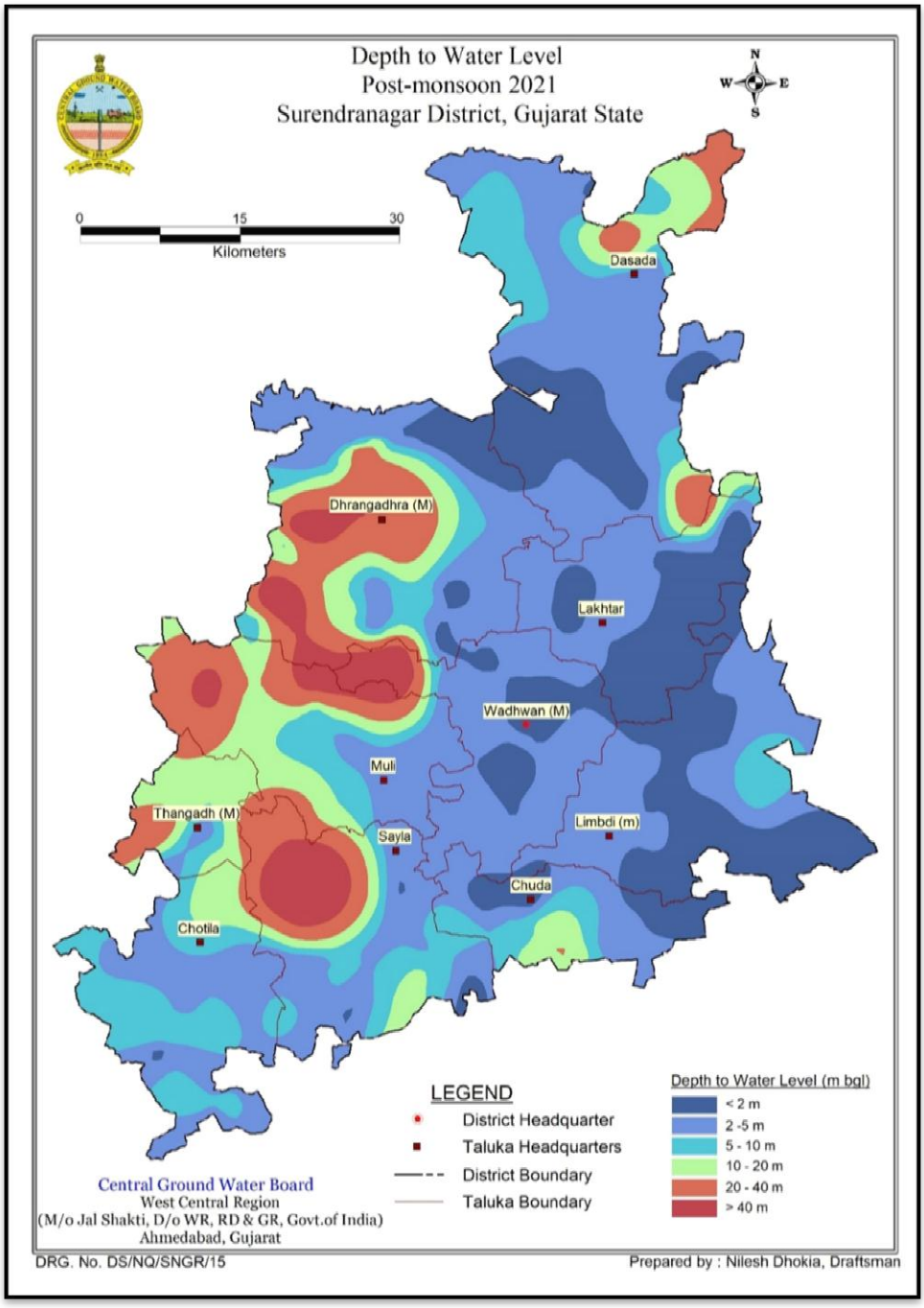

Figure 19: Post-monsoon (Nov. 2021) depth to water level of Surendranagar District

4.5 Water table and Groundwater movement

The elevation of water table in Pre monsoon 2021 is observed higher along SW (Chotila taluka) adjoining district boundary with Rajkot district where water table contour ranges in between 135 m amsl to 235m amsl which flowing towards NE direction, with many local domes shaped contour showing radial flow (Figure 20).

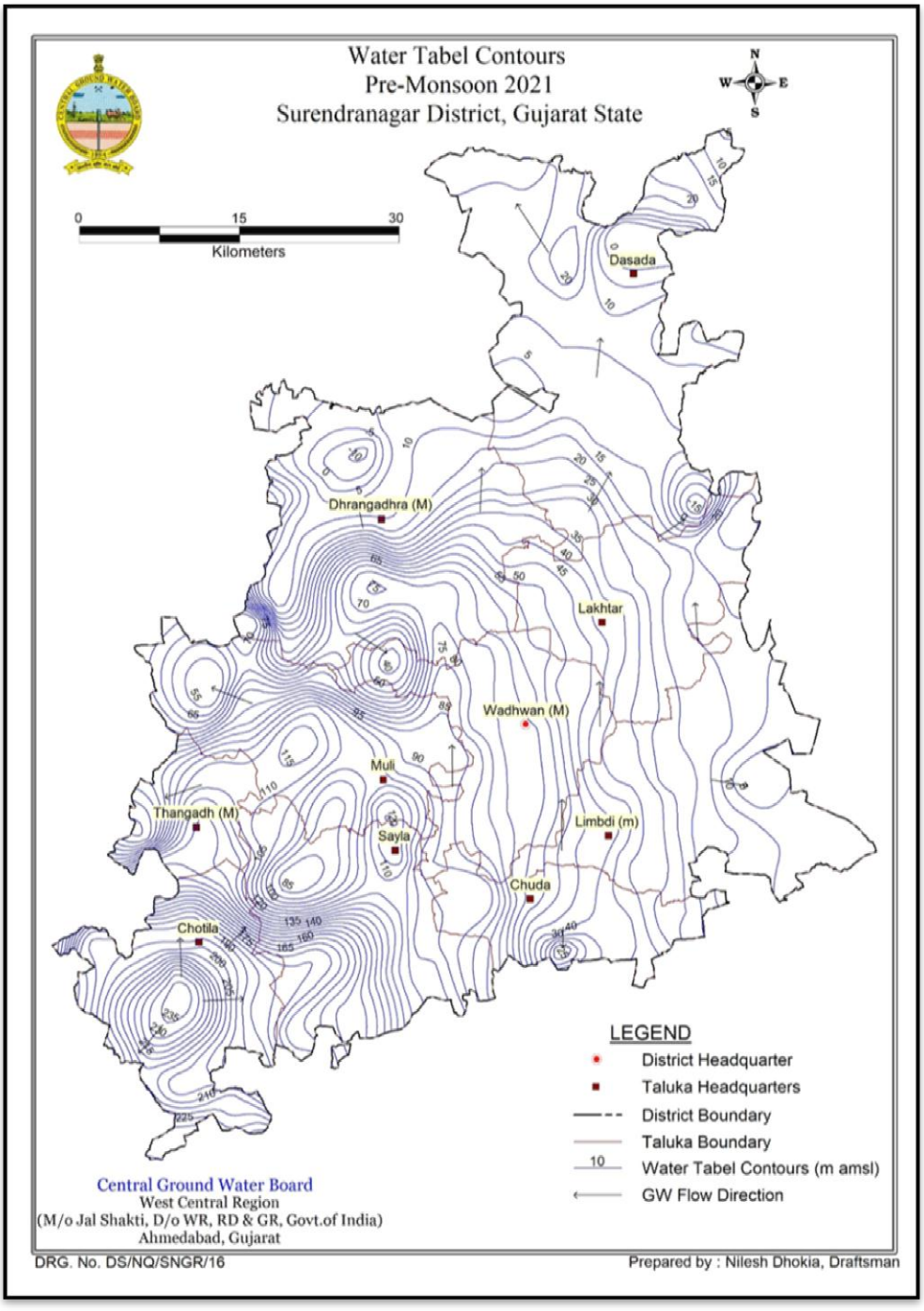

Figure 20: Water level contour map (Pre-Monsoon_2021) of Surendranagar district

4.6 Ground water decadal average depth to water level (2012-2021) Map

Decadal trend of ground water level for the period of 2012 to 2021 has been prepared and presented in figure 21 and 22.

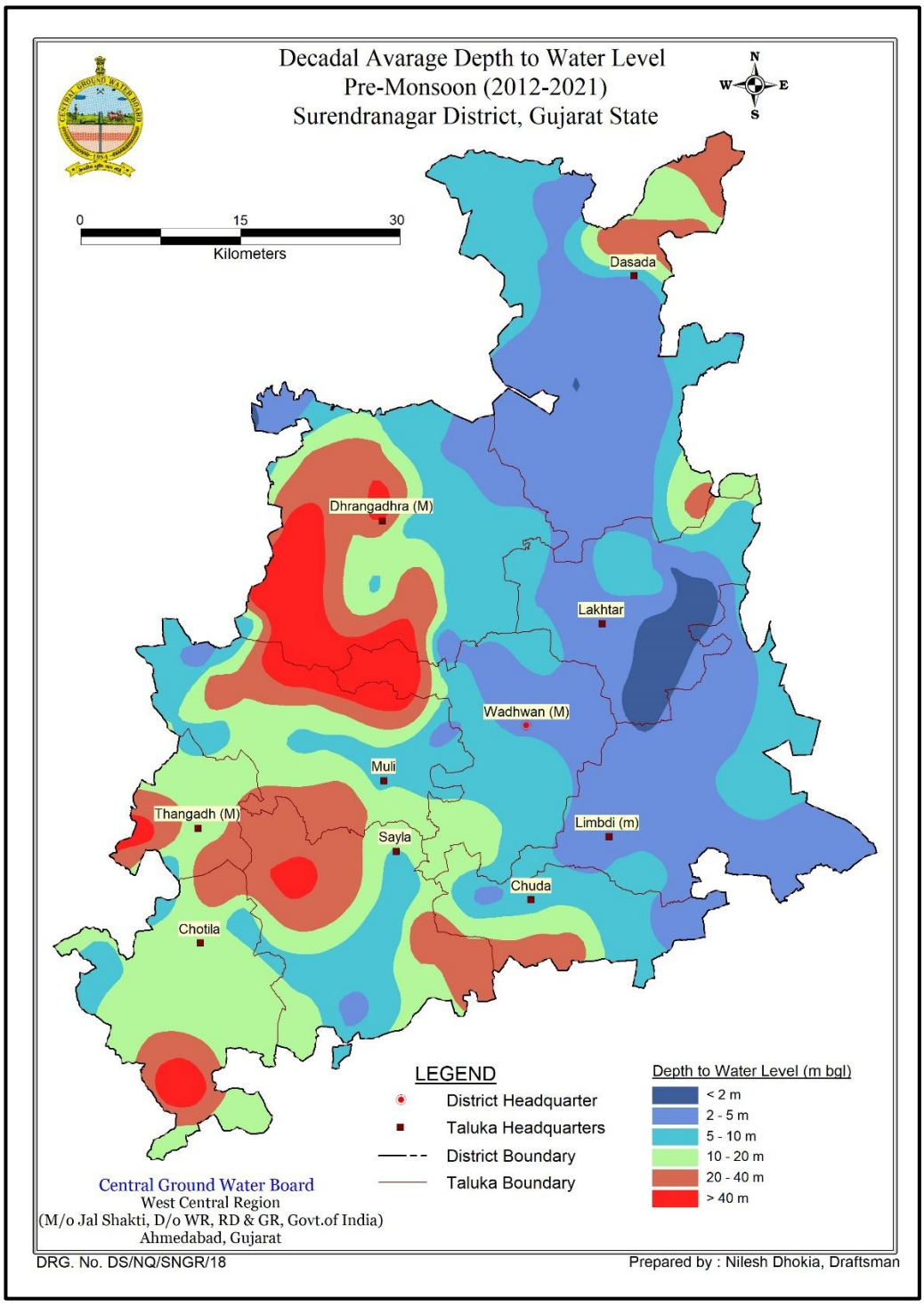

Figure 21: Ground water decadal trend Pre-Monsoon (2012-2021)

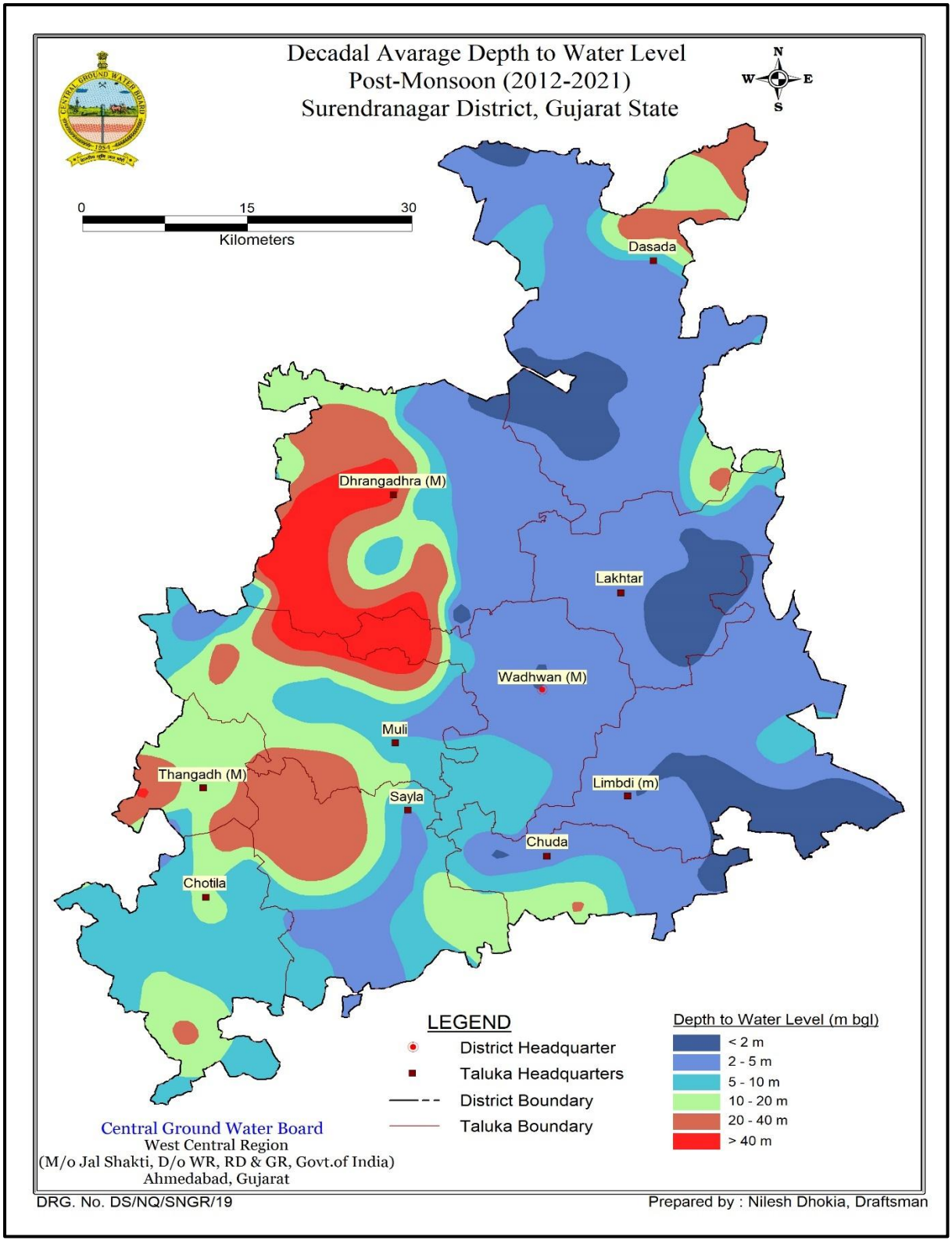

Figure 22: Ground water decadal trend post-Monsoon (2012-2021)

4.7 Hydrograph and water level trend (2012-2021)

From the analysis of water level trend of the Surendranagar district from 2012 to 2021, it is observed that during pre-monsoon season, the water level has a rise of 0.003892 m/year (Bajana, Dasada) to 0.087824m/year (Sarla, Muli) and also has fall of 0.000224 m/year (Limdi) to 0.0344 m/year (Lakhtar) Similarly from the analysis of the post monsoon data of 2012 to 2021 the rise shown by the water level of 0.007275 m/year (Limdi) to 0.069161 m/year (Sarla) and also has fall of 0.004575 m/year(Ratanpur) to 0.087034m/year (Navaraisangpura). Pre monsoon and Post monsoon long-term rising and decline trend of water level of various hydrograph stations established by CGWB are also studied in graphic form. The hydrographs are showing falling and rising trend in the pre monsoon season.

Table 7Long Term Trend of Water Level from 2012 to 2021of Surendranagar District

Sr.No.	Location	Taluka	District	Pre-Monsoon			Post Monsoon		
				Data Point	Rise	Fall	Data Point	Rise	Fall
1	Bamanbor	Chotila	Surendranagar	6	0.006135		9	0.012	
2	Chotila	Chotila	Surendranagar	10		0.025	8	0.0129	
3	Vanala	Chuda	Surendranagar	6		0.012635	9	0.017855	
4	Bajana	Dasada	Surendranagar	7	0.003892		10	0.014789	
5	Ratanpur	Dhrangadhra	Surendranagar	7		0.011642	6		0.004575
6	Lakhtar	Lakhtar	Surendranagar	10		0.0344	10		0.022841
7	Limdi	Limbdi	Surendranagar	9		0.000224	9	0.007275	
8	Sarla	Muli	Surendranagar	8	0.087824		10	0.069161	
9	Nava Raysigpur	Muli	Surendranagar	4		0.007033	9		0.087034
10	Sayla	Sayla	Surendranagar	9		0.024809	9	0.023813	
11	Tarnetar	Thangadh	Surendranagar	7	0.016275		10	0.008679	
12	Surendranagar	Wadhwan	Surendranagar	8	0.017605		10	0.00877	

Historical data of water level were used for preparing the hydrographs as well as for computing long term trend. Few of the hydrographs representing the falling trends of water level of Surendranagar district are presented below.

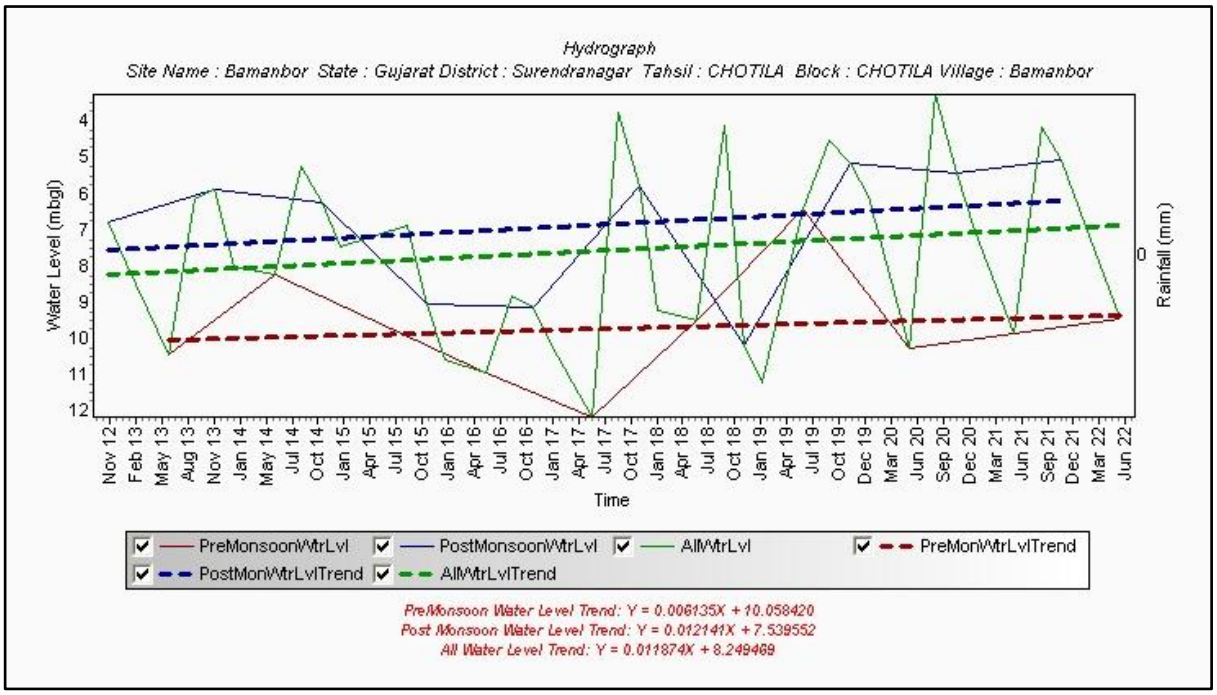

Figure 23: Hygrograph and WL trend at Bamanbor, Chotila, Surendranagar

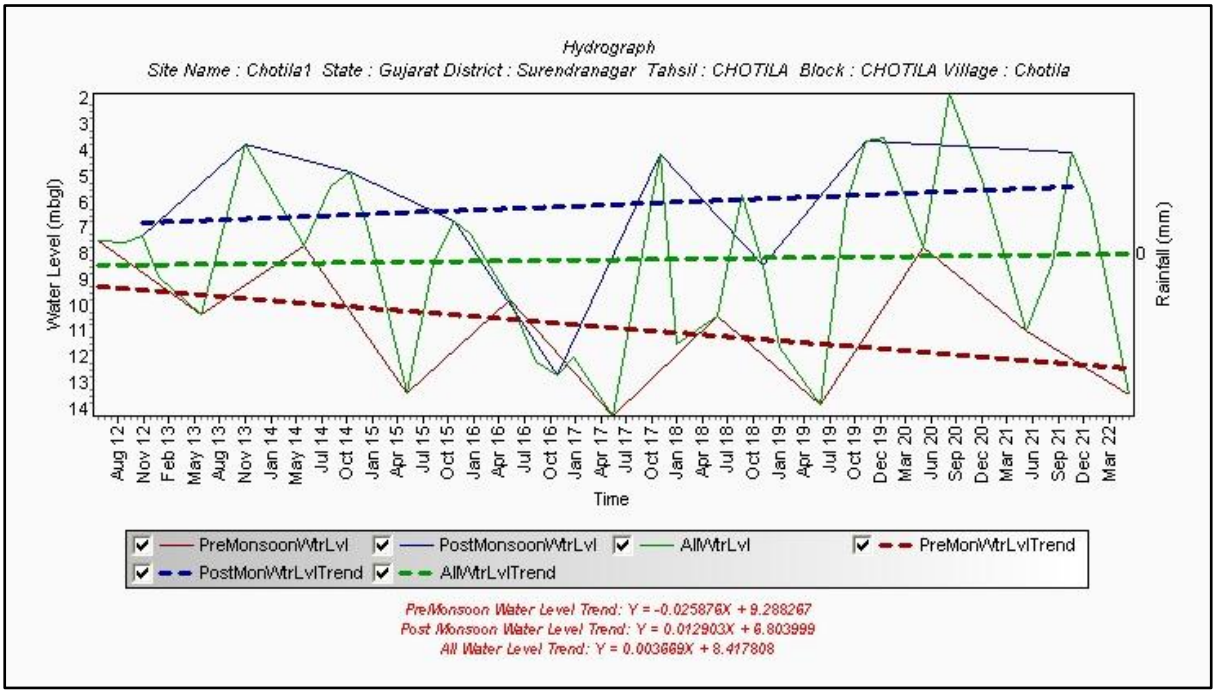

Figure 24: Hygrograph and WL trend at Chotila, Chotila, Surendranagar

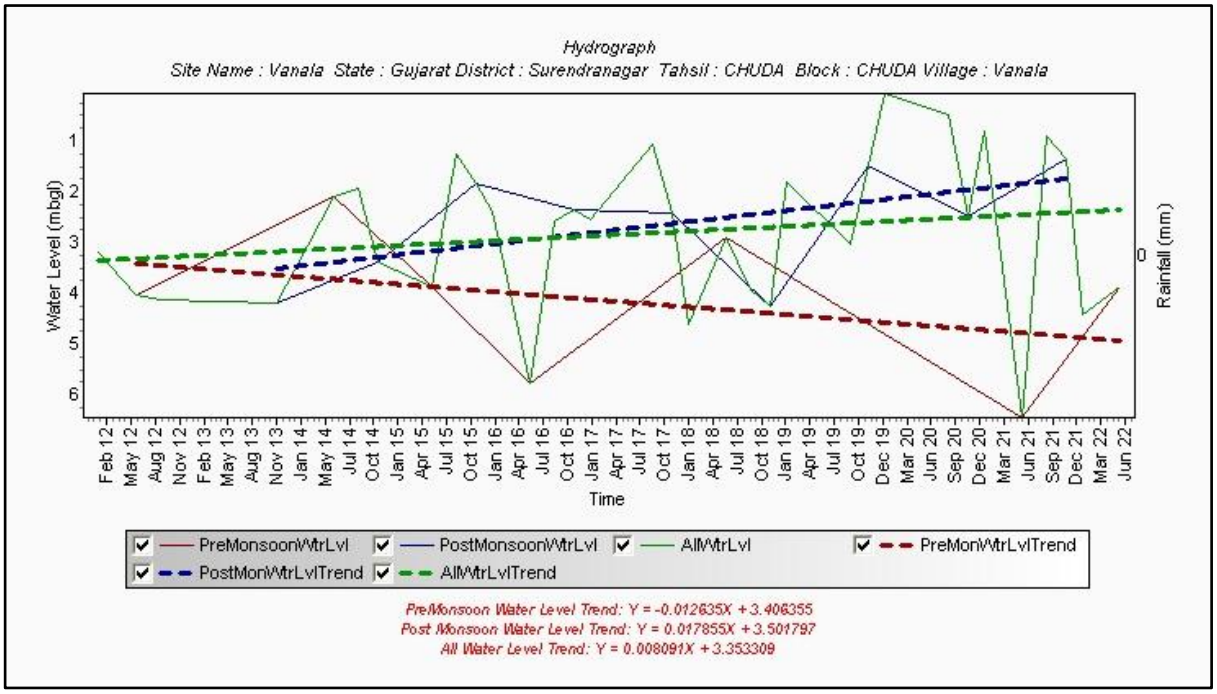

Figure 25: Hygrograph and WL trend at Vanala, Chuda, Surendranagar.

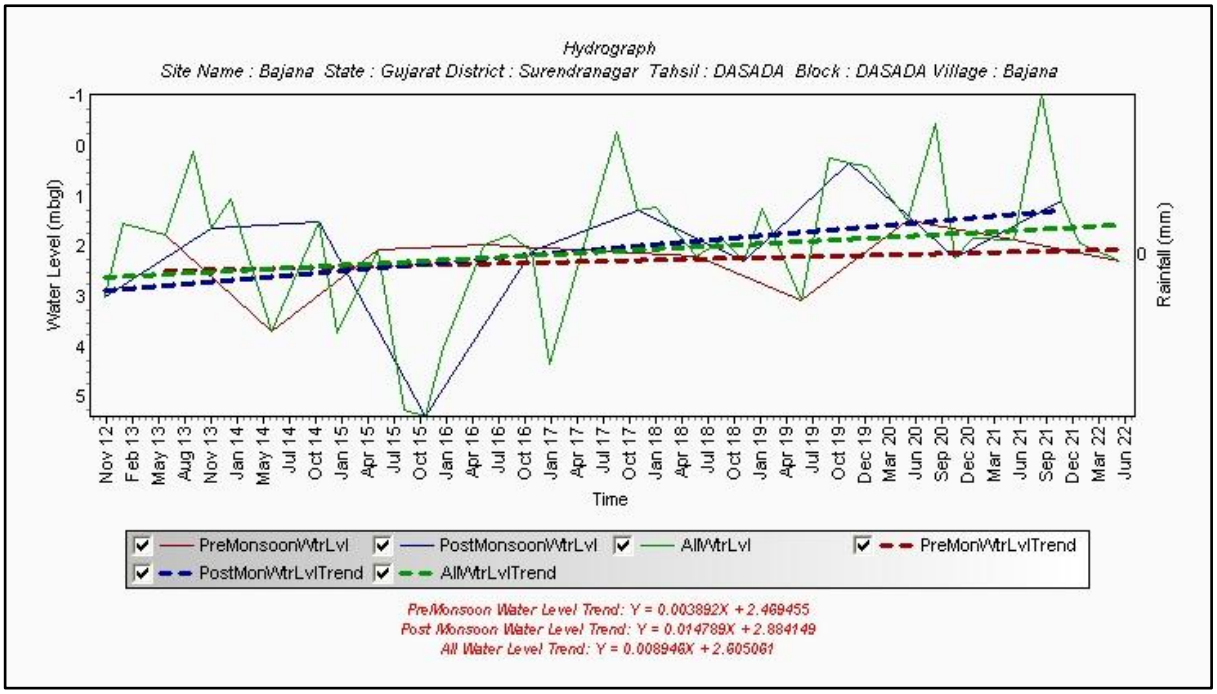

Figure 26: Hygrograph and WL trend at Bajana, Dasada, Surendranagar.

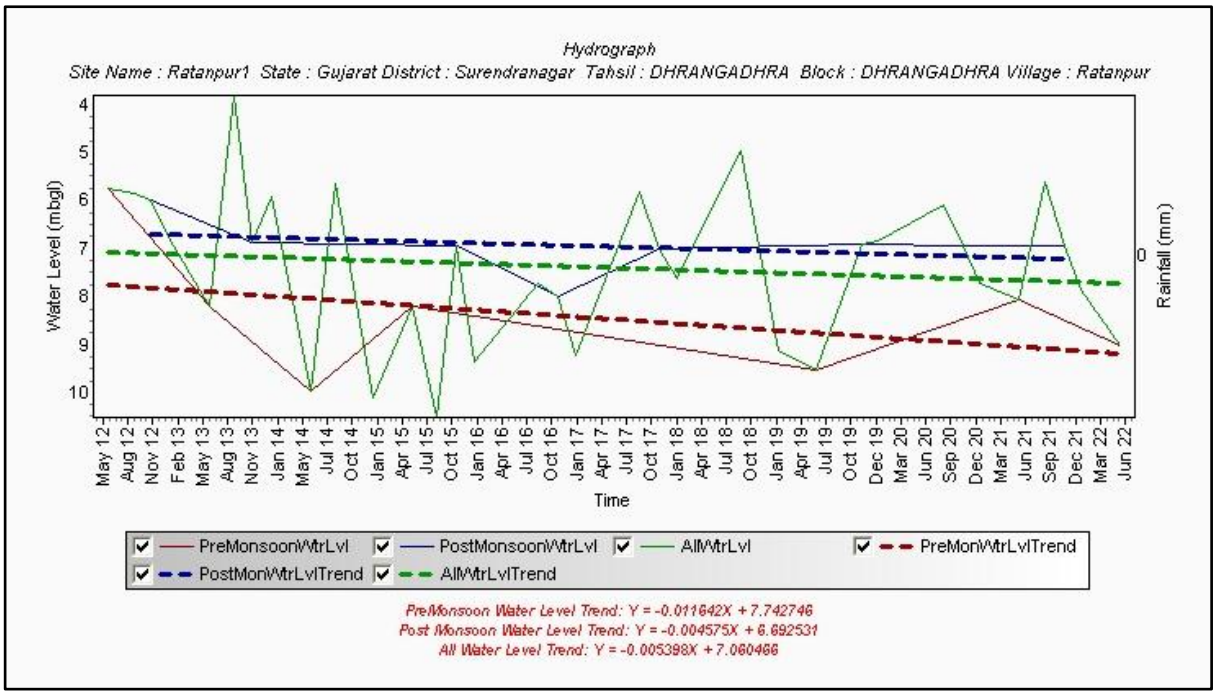

Figure 27: Hygrograph and WL trend at Ratanpur, Drangadhra, Surendranagar.

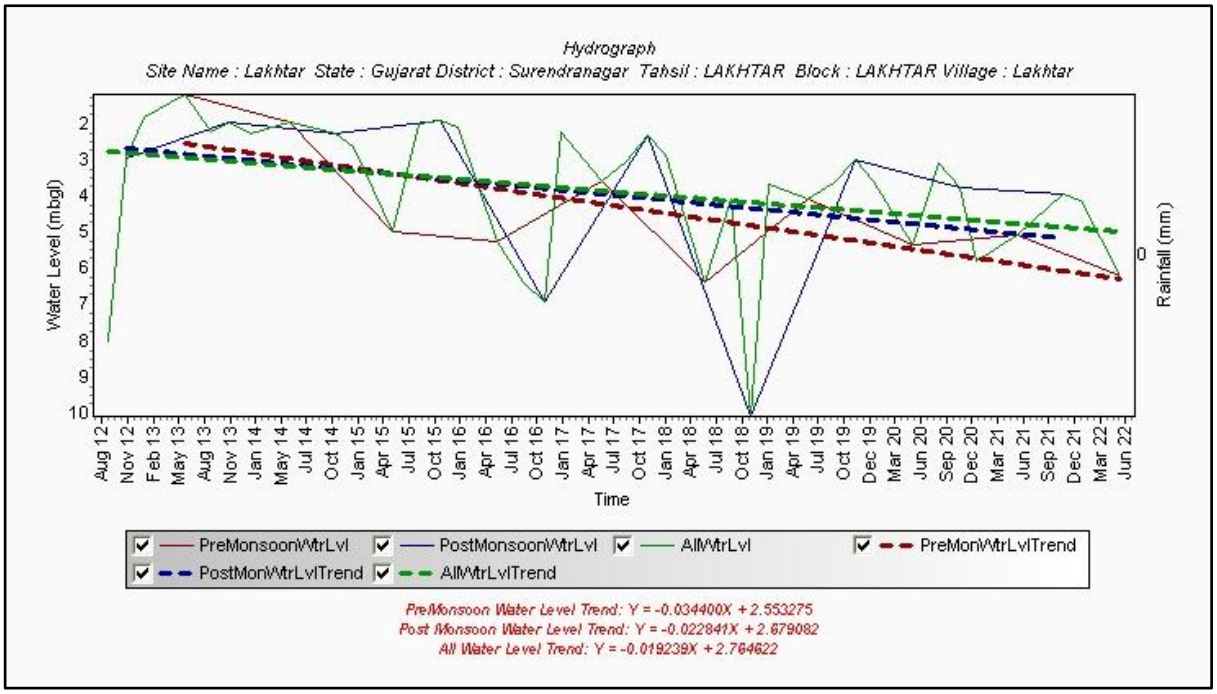

Figure 28: Hygrograph and WL trend at Lakhtar, Lakhtar, Surendranagar

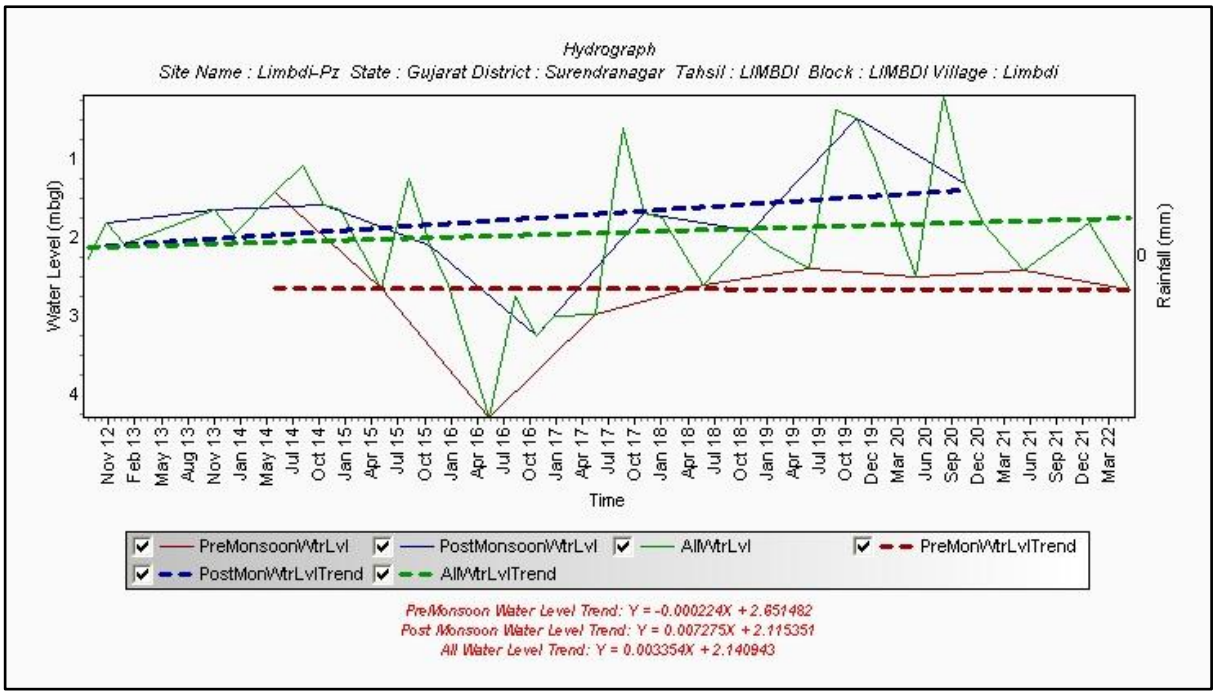

Figure 29: Hygrograph and WL trend at Limdi, Limdi, Surendranagar

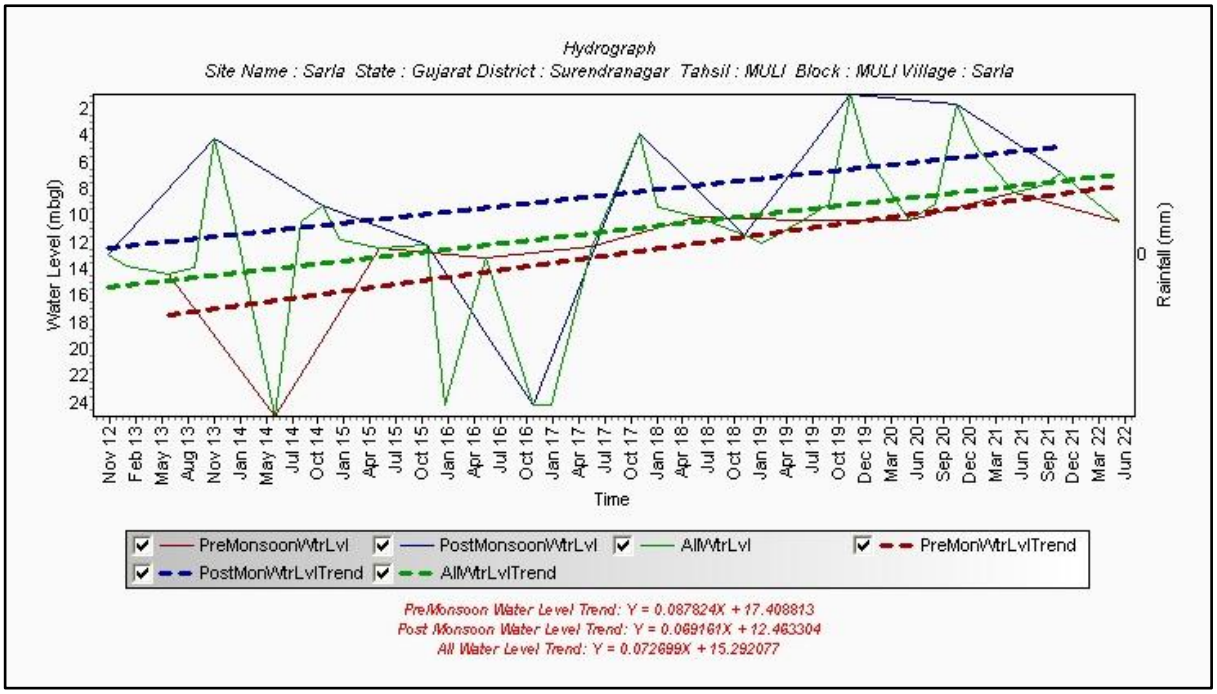

Figure 30: Hygrograph and WL trend at Sarla, Muli, Surendranagar

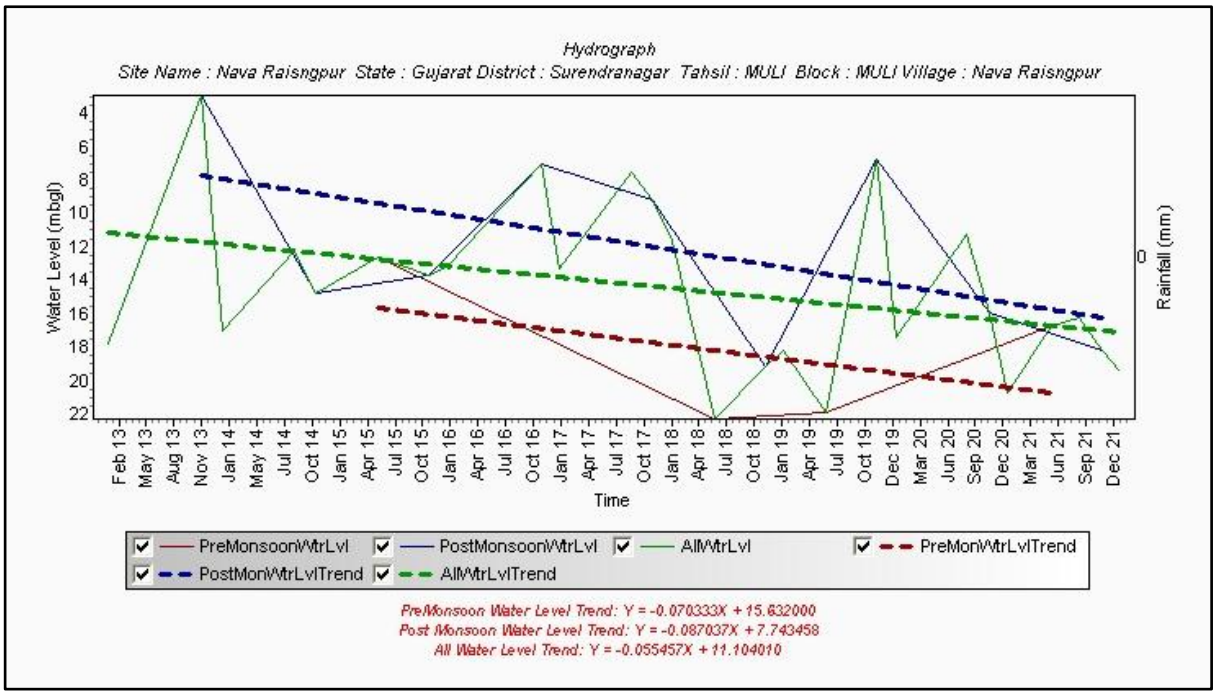

Figure 31: Hygrograph and WL trend at Navaraisingpur, Muli, Surendranagar

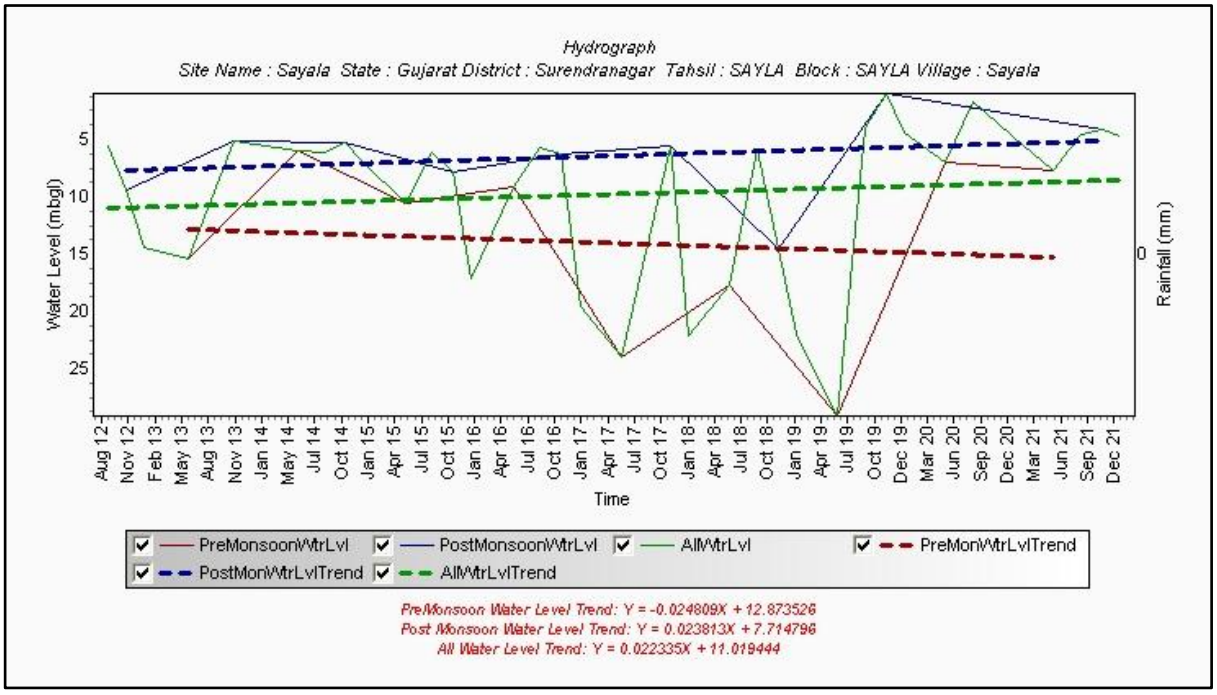

Figure 32: nHygrograph and WL trend at Sayla, Sayla, Surendranagar

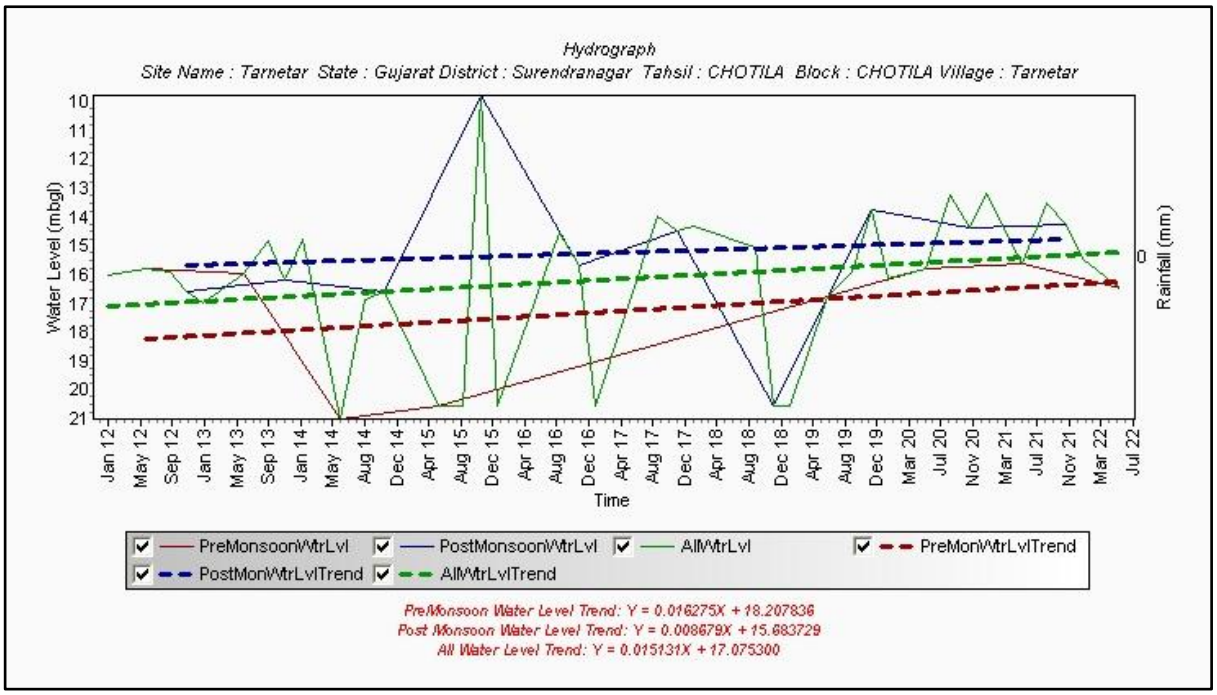

Figure 33: Hygrograph and WL trend at Tarnetar, Thangadh, Surendranagar

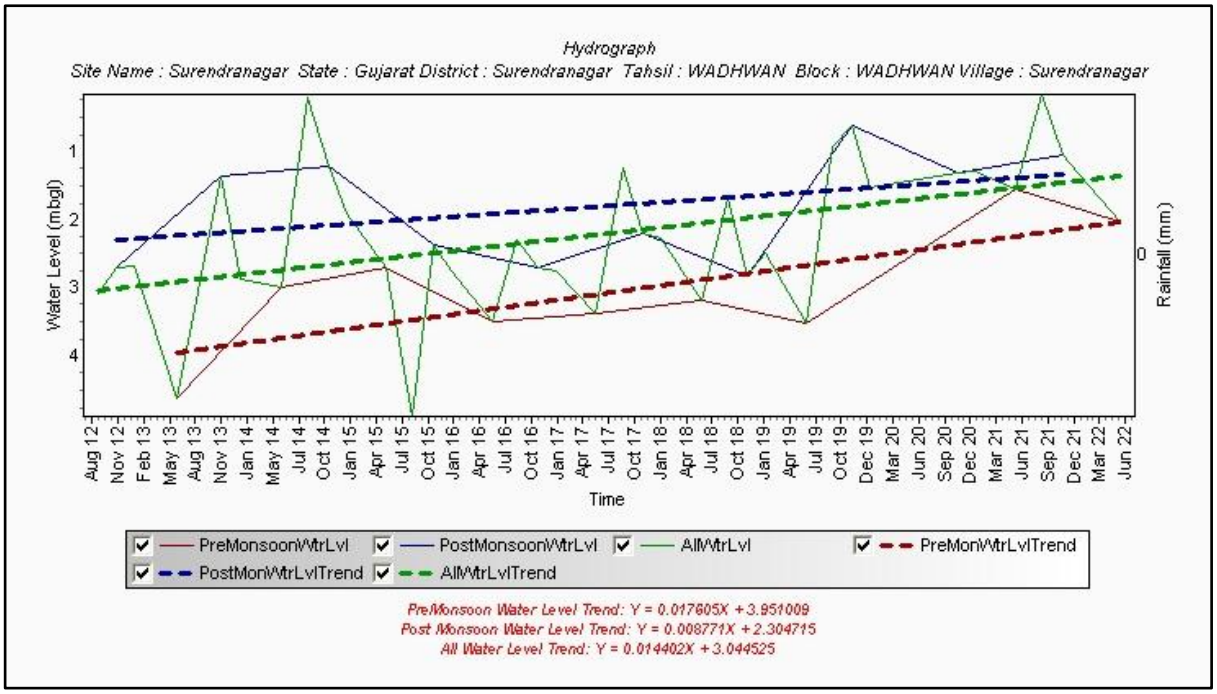

Figure 34: Hygrograph and WL trend at Surendranagar, Wadhawan, Surendranagar

Chapter 5: GROUND WATER RESOURCE POTENTIAL

The ground water resources of the district were calculated as on March 2020 in collaboration with the Government of Gujarat using the GEC-2015 methodology suggested by Ground Water Resource Estimation Committee (GWRE-2020). These resources were computed after reorganization of the districts, talukas of the district are considered as Assessment Unit (AU) and total area of 9218.12 sq. km are taken as area of assessment of the district including 10 talukas. Computed resource is presented in tabulated (table-8) and graphically represented as below (figure 35).

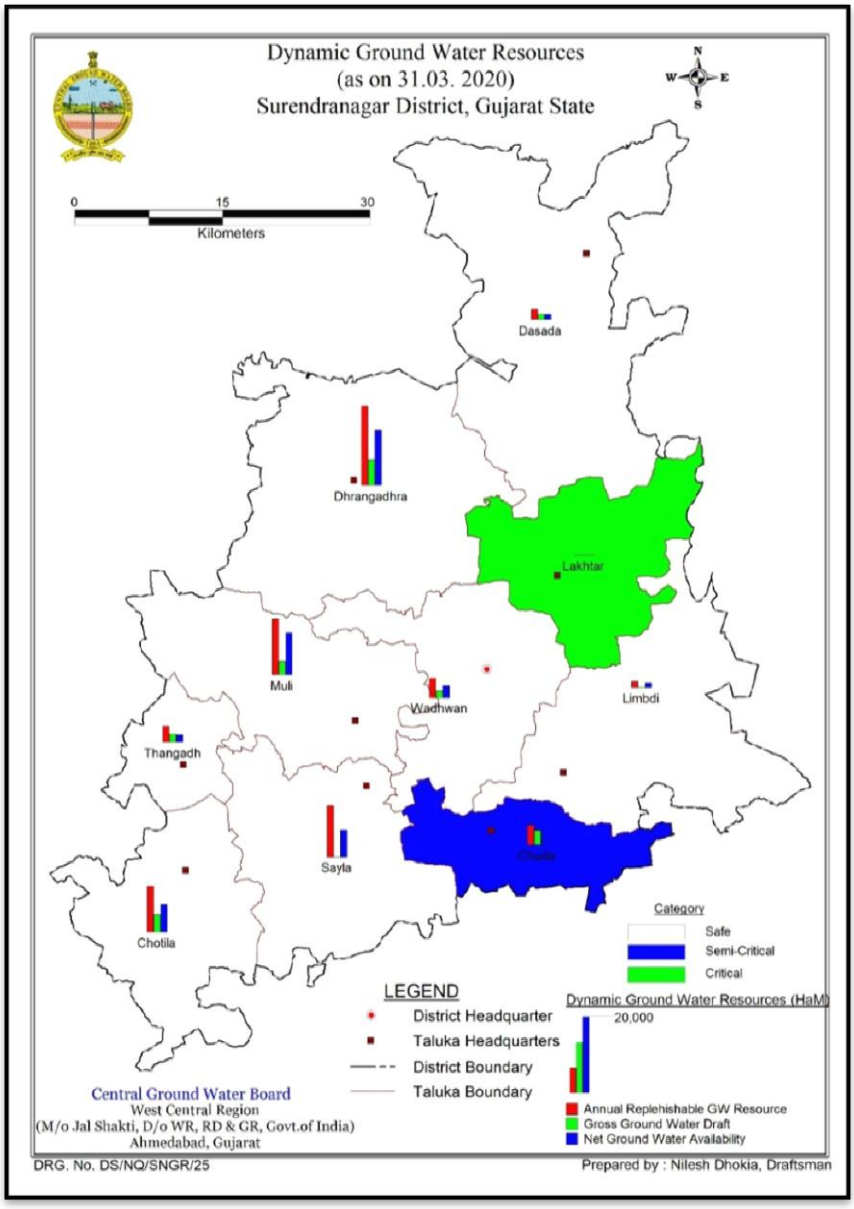

Figure 35: Map showing Dynamic GW resources of Surendranagar Distric

Table 8 Taluka wise Ground Water resources, Availability, Utilization and Stage of Ground Water Development.

Taluka Wise Ground Water Resources, Availability, Utilization and Stage of Ground Water Development (2020)														
Taluka	ANNUAL REPLENISHABLE GROUND WATER RESOURCE (mcm)					Natural Discharge during non-monsoon season (mcm)	Net Annual Ground Water Availability (mcm)	ANNUAL GROUND WATER DRAFT (mcm)			Projected Demand for Domestic and Industrial uses upto 2025 (mcm)	Ground Water Availability for future irrigation (mcm)	Stage of Ground Water Development (%) (12/9) * 100	Category
	Monsoon		Non-Monsoon		Total Annual Ground Water Recharge			Irrigation	Domestic And Industrial uses	Total				
	Recharge from rainfall	Recharge from other sources	Recharge from rainfall	Recharge from other sources										
CHOTILA	106.70	6.80	0.00	8.66	122.16	6.11	116.05	45.08	0.00	45.08	0	70.97	38.85	safe
CHUDA	40.93	3.83	0.00	8.24	53	2.65	50.35	38.05	0.00	38.05	0	12.30	75.58	semi critical
DASADA	21.77	2.04	0.00	3.39	27.2	1.36	25.84	12.61	0.00	12.61	0	13.23	48.81	safe
DHRANGADHRA	190.72	9.10	0.00	9.31	209.13	10.46	198.68	61.84	0.00	61.84	0	136.83	31.13	safe
LAKHTAR	0	0	0.00	0.006	0.006	0.0006	0.0054	0	0.00	0	0	0.0054	0.00	salinity
LIMBDI	8.59	3.69	0.00	3.53	15.81	0.79	15.00	1.77	0.00	1.77	0	13.23	11.80	safe
MULI	134.34	4.38	0.00	7.40	146.12	7.31	138.82	34.57	0.00	34.57	0	104.25	24.90	safe
SAYLA	115.27	8.70	0.00	12.71	136.68	6.83	129.85	61.44	0.00	61.44	0	68.41	47.31	safe
THANGADH	30.75	4.88	0.00	5.70	41.33	2.07	39.27	20.88	0.00	20.88	0	18.38	53.18	safe
WADHWAN	45.96	2.80	0.00	4.80	53.56	2.68	50.88	12.77	6.30	19.07	11.50	31.21	37.48	safe
Total	695.03	46.22	0	63.746	805.00	40.26	764.75	289.01	6.3	295.31	11.5	468.82	38.62	

5.1 Ground Water Recharge

Total Annual Ground Water Recharge Form Rainfall and other sources for both monsoon and non-monsoon season for the district is 805.00 mcm. And ground water recharge in talukas varies from 0.006 mcm (Lakhtar taluka) to 209.13 mcm (Dhrangadhra Taluka).

5.2 Net Ground Water Availability

Annual Extractable Ground Water Resource/ Net Ground Water Availability of the district is 764.72 mcm which computed after deducting total natural discharge of 40.26 mcm from total annual ground water recharge.

5.3 Annual Ground Water Draft

The gross ground water draft for all uses (i.e., Irrigation, Domestic and Industrial uses) in the district is 295.31 mcm. The existing gross ground water extraction for all uses varies from 0.00 mcm (Lakhtar taluka) to 61.84 mcm (Dhrangadhra Taluka). Approximately 98 % of ground water extraction are used for Irrigational purposes, remaining 2% are being extracted mainly for Domestic and Industrial purposes (very less).

5.4 Projected demand for Domestic and Industrial use up to 2025

The total Projected demand of ground water for Domestic and Industrial uses in the district is 11.5 mcm. Projected demand for domestic uses varies from 0.00 mcm (Lakhtar taluka) to 11.5 mcm (Wadhwan taluka).

5.5 Ground water Availability for future Irrigation

Net ground water availability for future use in the district is 468.82 mcm. Taluka wise it varies from 0.0054 mcm (Lakhtar taluka) to 136.83 mcm (Dhrangadhra taluka).

5.6 Stage of Ground Water Extraction

As per the Ground Water Resource Estimation (GWRE-2020), the stage of Ground Water extraction of the district is 38.62 % which categorized as Safe. Whereas in taluka it varies varies from 0% (Saline, Lakhtar Taluka) to 75.58 % (Chuda Taluka) and all the 06 talukas of the district are categorized as Safe.

Chapter 6: HYDROCHEMISTRY

The chemical quality of groundwater in shallow aquifer of the district has been analyzed based on the water samples collected during National Hydrographs Monitoring Stations (NHS) and NAQUIM(Pre-monsoon) in May 2021 from CGWB, and presented in Table-9. The ground water is in general alkaline in nature.

Table 9 Statistical Analysis of Chemical Constituents of Ground Water in Surendranagar District, May 2021.

Constituents	Minimum	Maximum	Average
pH	7.12	8.80	7.93
EC (uS/cm)	214	19220	2636.21
Alkalinity (mg/l)	70	540	255.60
TDS (mg/l)	143	12877	1766.28
HCO_3 (mg/l)	85	659	303.8
Cl (mg/l)	14	6665	604.46
SO_4 (mg/l)	1	1282	207.88
NO_3 (mg/l)	0.24	685	48.51
Ca (mg/l)	8	749	103.30
Mg (mg/l)	2	1136	66.65
Na (mg/l)	24	2390	282.63
K (mg/l)	0.19	245	15.06
F (mg/l)	0.08	7	1.28
Fe(mg/l)	0	0.346	0.083

6.1 Hydrogen Ion Concentration (pH)

The pH is an indicator of acidity of the water. The ground water in the district is generally alkaline with pH more than 7. The value of pH ranges between 7.12 (Moti Moladi) & 8.80 (Gavana) in the district.

6.2 Electrical conductivity

As per the BIS standards [IS 10500: 2012] for drinking water, acceptable limit and permissible limit of Total Dissolve Solid (TDS) are 500 mg/l and 2000 mg/l respectively. The value of EC for the district lies between 214 uS/cm (Tavi) and 19220 uS/cm (Kharaghoda). Average EC value of the district is greater than the permissible limit. Out of the 90 Locations 35 locations have greater value of EC than 2500 uS/cm.

6.3 Total Dissolved Solid (TDS)

As per the BIS standards [IS 10500: 2012] for drinking water, acceptable limit and permissible limit of Total Dissolve Solid (TDS) are 500 mg/l and 2000 mg/l respectively.

Total Dissolved Solid (TDS) is an overall parameter indicating salinity of ground water. The Total Dissolved Solid of ground water in the district varies from 143 mg/l (Tavi) to about 12877 mg/l (Kharaghoda) (Figure 36).

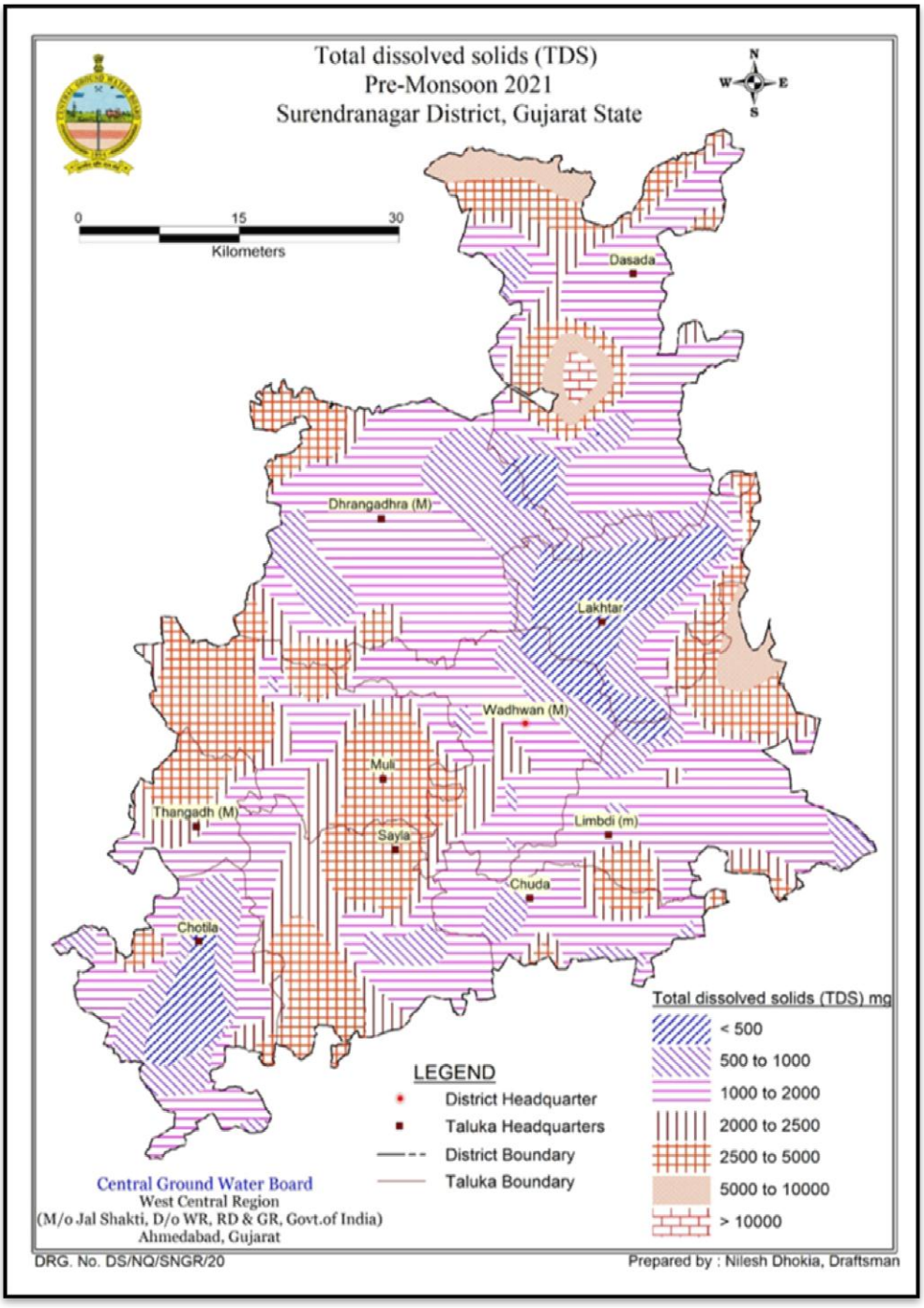

Figure 36: Map showing Taluka wise Total Dissolved Solid (TDS) values of Surendranagar District

6.4 Chloride (Cl)

As per the BIS standards [IS 10500: 2012] for drinking water, Acceptable limit and Permissible limit of Chloride are 250 mg/l and 1000 mg/l respectively. It is depicted from the map shown in figure-37, that except few patches Cl concentration is within permissible

limit. The values of Cl concentrations are varying from 14 mg/l(Lakhanka) to 6665 mg/l (gharaghoda) in the district. Thirteen locations out of 90 locations have the Cl concentration greater than permissible limit.

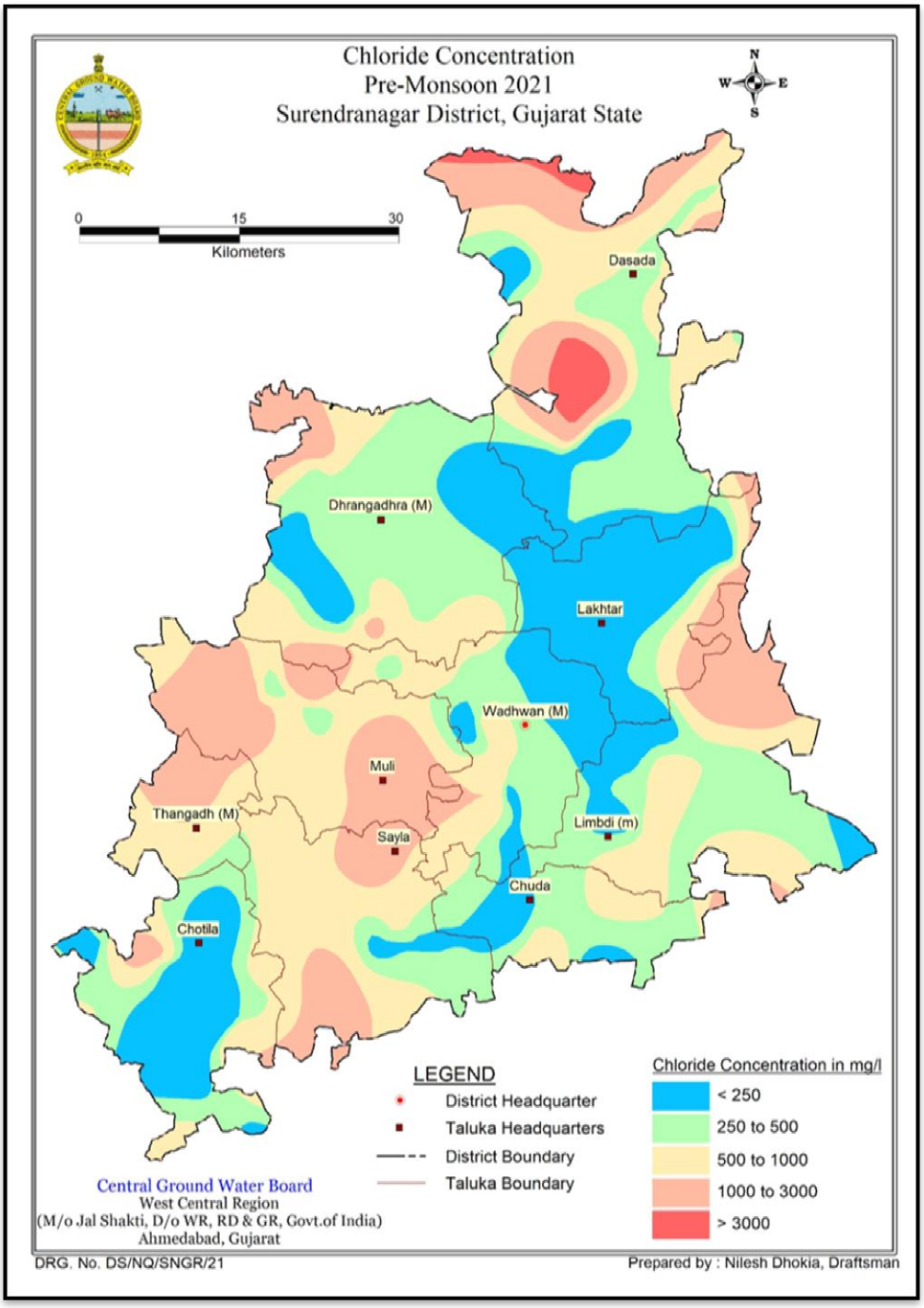

Figure 37 : Map showing Taluka wise Chloride (Cl) concentration in Surendranagar District.

6.5 Nitrate (NO_3)

As per the BIS standards [IS 10500: 2012] for drinking water, acceptable limit is 45 mg/l (maximum) and there is no relaxation in permissible limit. Nitrate concentration in the ground water in district varies between 0.24 mg/l (Mithaghoda) and 685 mg/l (Baldana).

There are 31 isolated locations out of 90 locations, where these values are more than the permissible limit as per BIS drinking water standards (45 mg/l) as shown in figure 38.

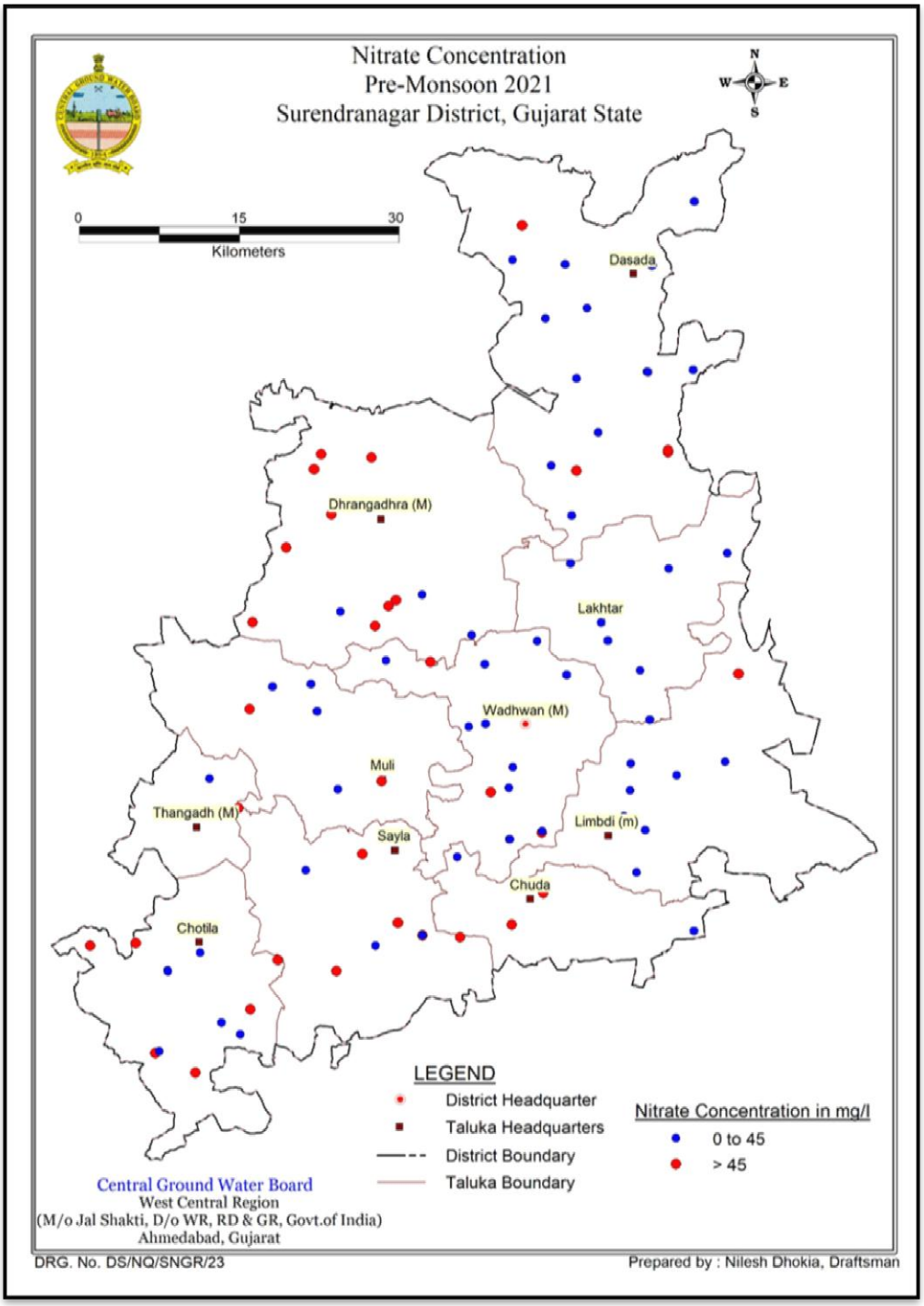

Figure 38: Map showing Taluka wise Nitrate (NO3) concentration in Surendranagar District

6.6 Carbonate (CO3) and Bicarbonate (HCO3)

The ground water in Surendranagar district contain Carbonate only in Dasada taluka and few places in Wadhwan and Muli Talukas, its values vary from 12mg/l (zainabad) to

60mg/l (Sadla). The Bicarbonate concentration in district are varies in between 85 mg/l (Tavi) to 659 mg/l (Mota Ankewaliya and Surendranagar).

6.7 Sulphate (SO4)

As per the BIS standards [IS 10500: 2012] for drinking water, Permissible limit of Chloride is 400 mg/l. In the district, Sulphate concentration varies from 1 mg/l (Jhinjhuwada) to 1282 mg/l (Borana) with the average concentration of 207.88 mg/l in 90 locations. There are 12 isolated locations out of 90 locations, where these values are more than the permissible limit as per BIS drinking water standards (400mg/l).

6.8 Calcium (Ca)

Calcium concentration in district varies between 8 mg/l (Kherali) and 749 mg/l (Moti Kathechi). There are 10 isolated locations where calcium concentration is more than permissible limit (permissible limit as per BIS norms is 200 mg/l).

6.9 Magnesium (Mg)

The Concentration of Magnesium in the district ranges from 2 mg/l (Olak) to 1136 mg/l(Kharaghoda).). There are 13 isolated locations where Magnesium concentration is more than permissible limit (Permissible limit as per BIS norms is 100 mg/l).

6.10 Sodium (Na)

Sodium concentration in the district varies between 24 mg/l (Lakhanka) and 2390 mg/l (Kharaghoda).

6.11 Potassium (K)

The concentration of Potassium in shallow ground water ranges from 0.19 mg/l (Kherali) to

45 mg/l (Dhama).

6.12 Fluoride (F)

As per the BIS standards [IS 10500: 2012] for drinking water, Acceptable limit and Permissible limit of Fluoride (mg/l) are 1 mg/l and 1.5 mg/l respectively. Fluoride concentration in the district varies in between 0.08 mg/l (Jarwala) and 7.00 mg/l (Mota Ankewaliya). There are 19 isolated locations where Fluoride concentration is more than permissible limit as presented in figure 39.

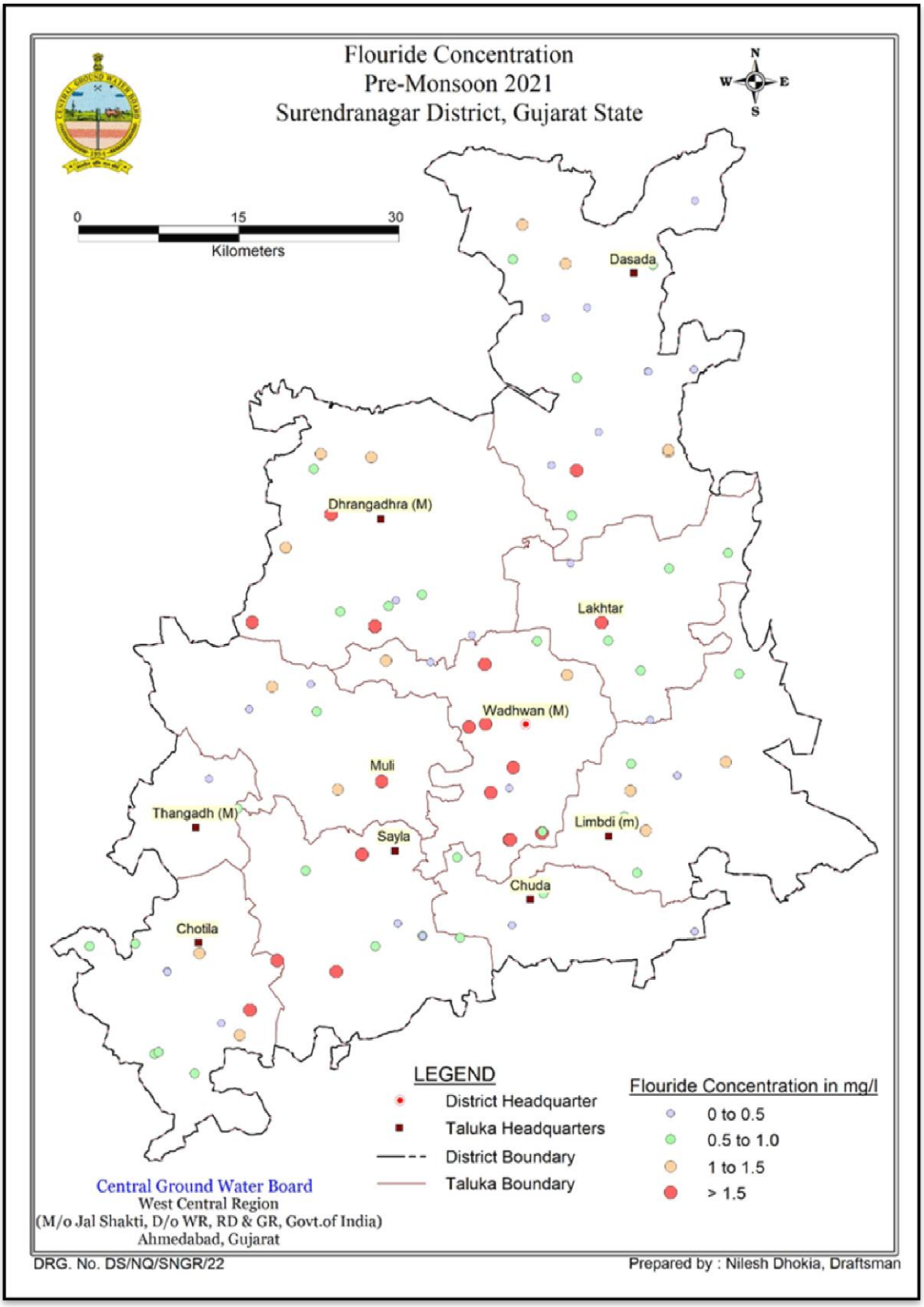

Figure 39: Map showing Taluka wise Fluoride (F) concentration in Surendranagar District.

6.13 Iron (Fe)

As per the BIS standards [IS 10500: 2012] for drinking water, Permissible limit of Fe (mg/l) is 0.3 mg/l. Iron concentration in the district varies between 0.00 mg/l (Dedarda,

Ghaghretiya, Kalasar, Piprali, Narichana, Moti majethi, Gavana) and 0.346 mg/l (Dhajala). Fe concentration in surendranagar district is within the permissible limit except two locations (Vanala (0.336) &Dhajala (0.346)) (Figure 40).

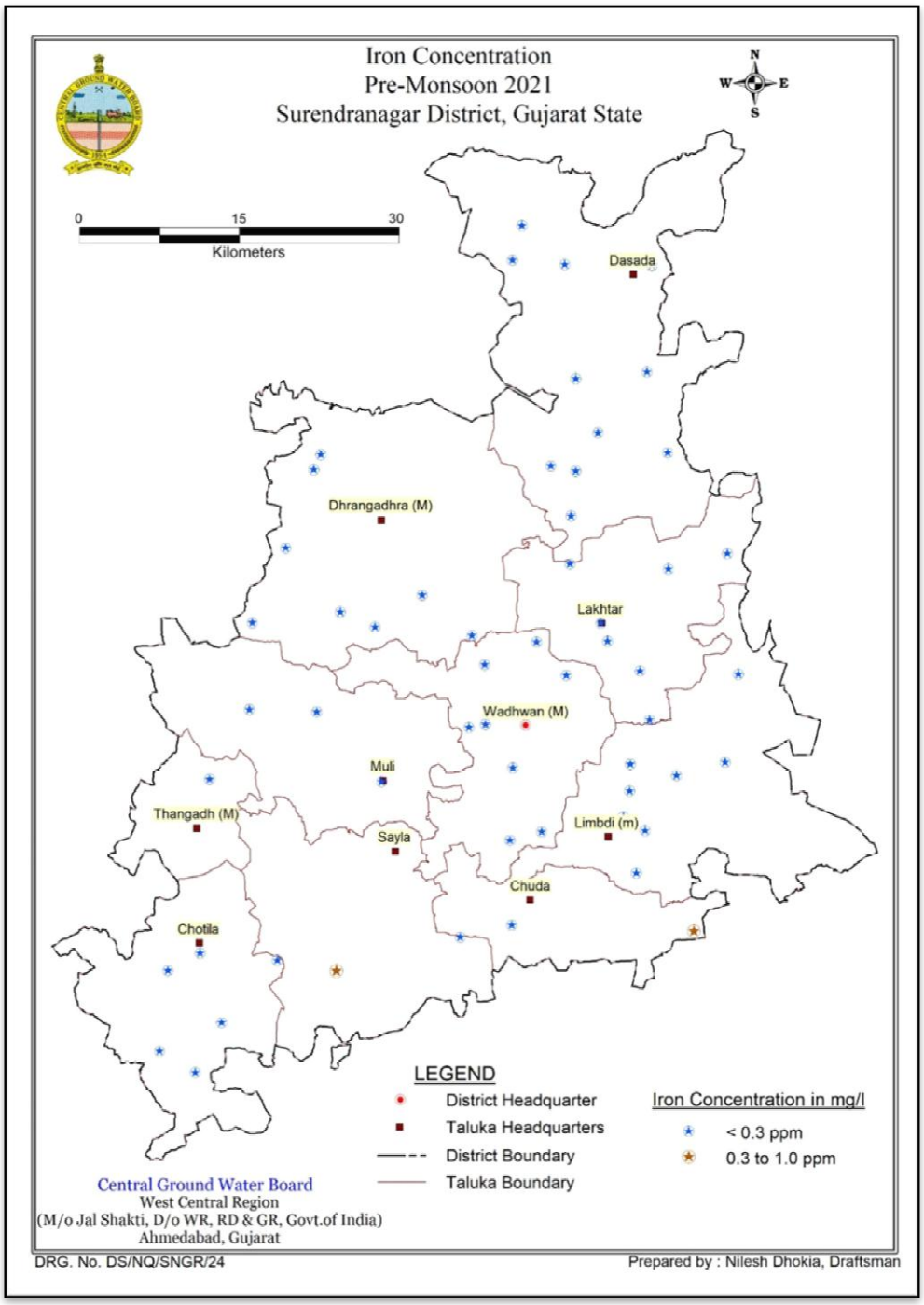

Figure 40: Map showing Taluka wise iron (Fe) concentration in Surendranagar District.

Chapter 7: SUSTAINABLE GROUNDWATER DEVELOPMENT AND MANAGEMENT

7.1 Groundwater related issue:

7.1.1 Low Ground water development

As per GWRE 2020 the total ground water resources of the district are in order of 805.00 mcm/year and utilizable resources are 764.75 mcm/year. The net annual drafts of 295.31 mcm/year leaves a balance of 469.44 mcm/year of ground water available for future development. Low Ground water Development: Stage of Ground water development of the district is 38.62 %, however talukas wise it ranges from 11.80% (Limdi taluka) to 75.8% (Chuda taluka).

7.1.2 Pollution (Geogenic and Anthropogenic)

We have collected 68 pre-monsoon ground water samples from shallow aquifer for this study. Chemical analysis of these samples is showing that 47 samples are potable and fit for domestic, drinking, irrigation and other industrial purposes and remaining 21 sample are not fit for drinking purpose but may be used for irrigation and other industrial purposes. We also collected 22 samples from deeper aquifer, 15 samples are potable and fit for domestic, drinking, irrigation and other industrial purposes and remaining 7 sample are not fit for drinking purpose but may be used for irrigation and other industrial purposes. Occurrence of Fluoride (31 Locations) and Nitrate (18 Locations) beyond acceptable limit (As per the BIS standards [IS 10500: 2012] for drinking water) in Shallow and deep aquifers identified in localized isolated villages.

7.2 Management Strategies

As per the estimate of ground water resources and irrigation potential, there exists a scope for further development of ground water resources in major parts of the district. As per GWRE 2020 Eight (08) talukas out Ten (10) talukas of the district are under safe category with one saline (Lakhtar) and another is semi critical (Chuda). Stage of Ground water development of the district is 38.62 %, however talukas wise it ranges from 11.80% (Limdi taluka) to 75.8% (Chuda taluka). Thus, further ground water development could be augmented in a judicious way.

7.3 Management plan

The uneven distribution of groundwater availability and its utilization indicates that a single management strategy cannot be adopted and requires integrated hydrogeological aspects along with socio-economic conditions to develop appropriate management strategy (table 12). The study suggests notable measures for sustainable groundwater management, which involves a combination of various measures given below.

- Ground water development Plan
- Supply side measures
- Demand side measures
- Regulatory measures
- Institutional measures

7.3.1 Ground water Development Plan

To elevate the stage of ground water development in all blocks, 2143 nos. of Dug wells (30 m depth) and 1303 nos. of Tube well (100m depth) are proposed as feasible extraction structures (table 10). The extraction structures will result as expected annual ground water draft of 3026.00 ham which will create 6724.44 Ha additional irrigation potential in the district.

Table 10 Feasible Extraction structures to elevate the Stage of GW development

Extraction / Talukas	Feasible Extraction structures to elevate the Stage of GW development			G.W Draft from Extraction structures (ham)	Additional Irrigation Potential Created (Ha)
	TW	DW	Total		
Chotila	318	698	1016	826.00	1835.56
Chuda	0	0	0	0.00	0.00
Dasada	250	580	830	665.00	1477.78
Dhrangadhra	293	40	333	459.50	1021.11
Lakhtar	0	0	0	0.00	0.00
Limbdi	0	0	0	0.00	0.00
Muli	90	100	190	185.00	411.11
Sayla	300	640	940	770.00	1711.11
Thangadh	0	0	0	0.00	0.00
Wadhwan	52	85	137	120.50	267.78
District	1303	2143	3446	3026.00	6724.44

7.3.2 Supply side interventions

As per Master Plan 2019, surplus surface water of 17.85 mcm non committed is allocated to suggest artificial recharge in district of Surendranagar. To harvest the surface water the different artificial recharge structures are proposed as check dam, Percolation tank and use existing defunct tube well to recharge the aquifer which is presented in table 13. Expected annual Groundwater recharge is 601.73 ham (6 mcm) through check dams of total 202 nos. of 17000 m^3capacity, 36 nos. of percolation tank of 90000m^3 capacity and 90 nos. of defunct tube wells, are recommended for harvesting the part of available runoff and to recharge the Groundwater as in table 11.

Table 11- Proposed Artificial Recharge and WUE Interventions in Surendranagar District

Recharge / Talukas	Check Dam (17000 m3 Capacity) Nos.	Percolation Tank (~ 90000 m3 capacity) Nos.	Recharge through defunct tube wells @3Ham Nos.	On-farm Activities (in ha)	Numbers of Farm Pond of capacity 0.3645ham	Additional Recharge from Recharge interventions (ham)
Chotila	4	1	2	2004	100	214.5193
Chuda	6	1	3	2537	110	272.179
Dasada	24	4	11	561	90	127.0159
Dhrangadhra	45	8	20	2749	100	408.6924
Lakhtar	0	0	0	0	105	1.35966
Limbdi	0	0	0	79	110	7.9
Muli	63	11	28	1536	110	339.8293
Sayla	37	7	16	2730	115	383.9537
Thangadh	20	4	9	928	105	154.9966
Wadhwan	3	0	1	568	90	61.83949
District	202	36	90	13692	1035	1970.926

7.3.4 Demand side intervention

Feasible extraction structures are proposed to elevate the stage of ground water development to 42.14%, to avoid further exploitation demand side management is also recommended to restrict the stage of ground water development to 40.93 %. An area of 13692 Ha is proposed for on farm activities (Laser leveling/Bench terracing/Contour banding), 1035 no of farm ponds are recommended to recharge the ground water. And expected conservation of ground water through efficiency enhancement measures is 1369.20 ham is expected for the district.

- **Farm pond**

A farm pond is a large hole dug out in the earth, usually square or rectangular in shape (Fig. 41), which harvests rainwater and stores it for future use. It has an inlet to regulate inflow and an outlet to discharge excess water. The pond is surrounded by a small bund, which prevents erosion on the banks of the pond. The size and depth depend on the amount of land available, the type of soil, the farmer's water requirements, the cost of excavation, and the possible uses of the excavated earth. Water from the farm pond is conveyed to the fields manually, by pumping, or by both methods.

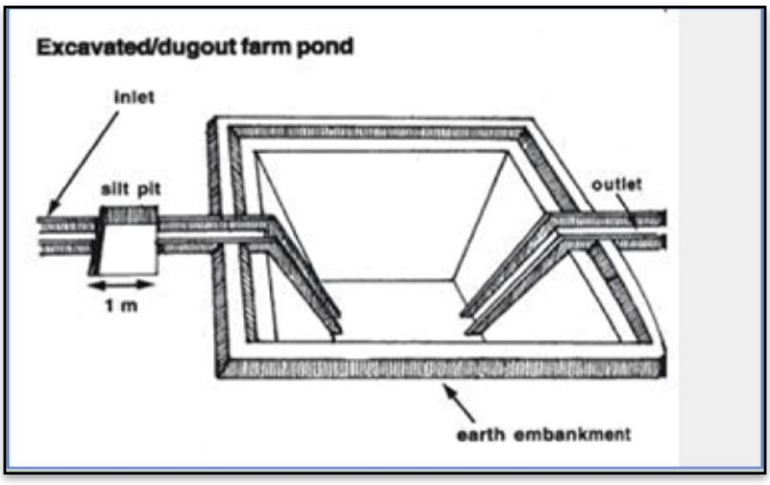

Figure 41: Schematic diagram of Farm Pond.

Advantages of Farm Ponds

- They provide water to start growing crops, without waiting for rain to fall.
- They provide irrigation water during dry spells between rainfalls. This increases the yield, the number of crops in one year, and the diversity of crops that can be grown.
- Bunds can be used to raise vegetables and fruit trees, thus supplying the farm household with an additional source of income and of nutritious food.
- Farmers are able to apply adequate farm inputs and perform farming operations at the appropriate time, thus increasing their productivity and their confidence in farming.
- They check soil erosion and minimize siltation of waterways and reservoirs.
- They supply water for domestic purposes and livestock
- They promote fish rearing.
- They recharge the ground water.
- The excavated earth has a very high value and can be used to enrich soil in the fields, leveling land, and constructing farm ponds.

Table 12 Projected Status of Groundwater Resource after implementation of GW Management Plan, Surendranagar District (Gujarat)

Projected Status of Groundwater Resource after implementation of GW Management Plan, Surendranagar District (Gujrat)												
	Net G.W. Availability (Ham)	Additional Recharge from Recharge interventions (ham)	Additional Recharge from Return flow of GW Irrigation	Total Net G.W. Availability after intervention (Ham)	Existing G.W Draft for all purpose (ham)	Conservation of Ground water through WUE, on farm activity & farm ponds (ham)	G.W Draft from Extraction structures (ham)	Net GW draft after interventions (ham)	Present stage of G.W. Development (%)	Projected stage of G.W. Development after construction of extraction structures (%)	Projected stage of GW development after construction of extraction structures & implementation of conservation & Rechare measures (in %)	Additional Irrigation Potential Created (Ha)
Chotila	11604.57	214.5193	214.76	12033.85	4508	121.1625	826	5212.838	38.84676	45.12946	43.31812	1835.556
Chuda	5035.02	272.179	0	5307.199	3805.5	148.2458	0	3657.254	75.58063	75.58063	68.9112	0
Dasada	2584.25	127.0159	172.9	2884.166	1261.3	53.12925	665	1873.171	48.8072	69.86562	64.94671	1477.778
Dhrangadhra	19867.76	408.6924	119.47	20395.92	6184.3	154.6875	459.5	6489.113	31.12731	33.24022	31.81573	1021.111
Lakhtar	Saline											0
Limbdi	1500.22	7.9	0	1508.12	177	37.63575	0	139.3643	11.79827	11.79827	9.240926	0
Muli	13881.9	339.8293	48.1	14269.92	3457.1	103.2008	185	3538.899	24.90349	26.14556	24.79971	411.1111
Sayla	12984.57	383.9537	200.2	13568.72	6143.5	158.4799	770	6755.02	47.31385	52.4355	49.78375	1711.111
Thangadh	3926.6	154.9966	0	4081.597	2088.2	74.29163	0	2013.908	53.18087	53.18087	49.34119	0
Wadhwan	5088.18	61.83949	31.33	5181.349	1906.97	53.44425	120.5	1974.026	37.47843	39.60281	38.09868	267.7778
District	76473.16	1970.926	786.76	79230.85	29531.87	904.2773	3026	31653.59	38.62	42.14	39.91	6724.45

Chapter 8: CONCLUSION AND RECOMMENDATIONS

- Artificial recharge structures like recharge shaft and through defunct tube well are proposed in the district to encounter needed surface runoff.
- To elevate the stage of ground water development 42.14 to in district, 4143 no of Dug wells (20 m depth) in Hard rock and 1303 no. of Tube wells (100m depth) are proposed as feasible extraction structures.
- The extraction structures will result as expected annual ground water draft of 3026.00 ham which will create 6724.44 Ha additional irrigation potential in the district.
- To prevent Over Exploitation, water conservation activities like on farm activities, farm ponds and check dams are recommended.
- 13692 Ha area is proposed for on farm activities (Laser leveling/Bench terracing/Contour banding) and 1040 nos. of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.
- Ground water return flow of 786.76 ham is expected from irrigation of fields in the district.
- 936.81 ham conservation of ground water through WUE measures, on activities & farm ponds is expected for the district.
- As a conservation measure, farmers should be encouraged and educated to adopt modern irrigation techniques like drip, sprinkler irrigation etc. to effect minimum withdrawal and maximum utilization of groundwater.
- The water quality of the district is very inconsistent, with 62 locations having potable water and 28 locations having non potable water out of 90 locations. Almost every taluka in the district has the patches of both potable and non-potable water. In GWRE-2020, Lakhtar taluka of the district is saline but in the Water quality map it is fresh, this is because of samples are collected from very shallow aquifer. In addition to this higher Nitrate, fluoride and Fe concentration is observed in isolated pockets. Ground water in such areas may be used after blending with surface water. In areas where ground water has higher concentration of Nitrate is observed, necessary sanitation measures should be adopted.
- Taking into consideration drought prone area, the ‘Mass Awareness Programme’ and 'Water Management Training Programme‟ should be organized in regular basis in the district for awareness on the depletion of groundwater resources and quality problems.
- Present supply side interventions are suggested based on availability17.85 MCM non committed source of water is referred by State Government (Reference Master Plan of Artificial recharge 2020). Proposed enhancements of present Groundwater development stage are subjected to implementation of recharge interventions, availability of cultivable land and yield of Groundwater structures.
- These interventions also need to be supported by regulation, so that the ground water resources are protected for future generation and also serve as ground water sanctuary in times of distress/drought. IEC activities and capacity building activities needs to be aggressively propagated to establish the institutional framework for participatory ground water management.

References

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