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GOVERNMENT OF INDIA
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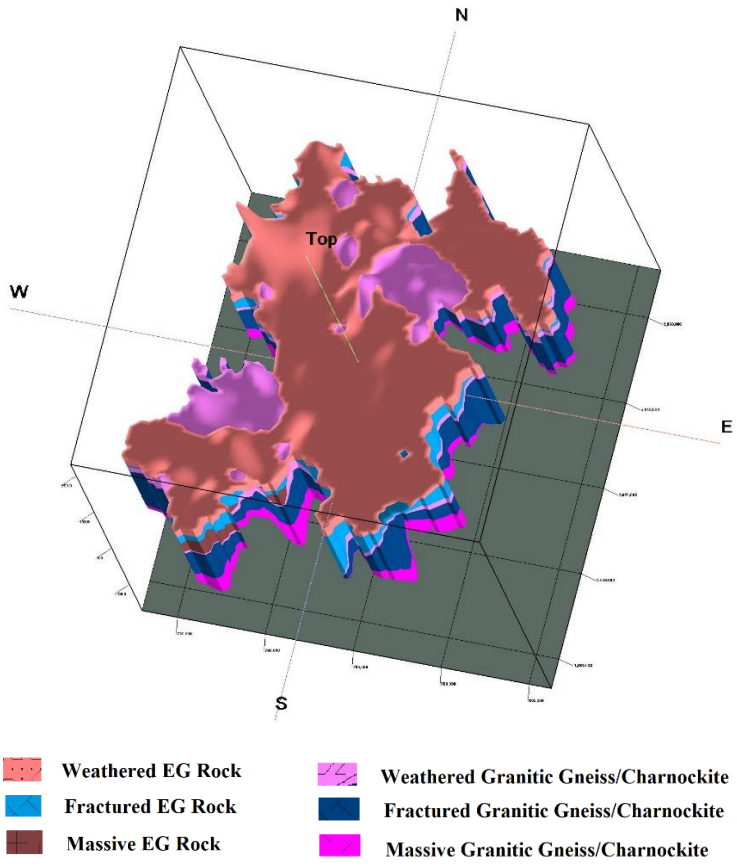
DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT AND
GANGA REJUVENATION

REPORT ON
AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN VIZIANAGARAM DISTRICT, ANDHRA PRADESH STATE



CENTRAL GROUND WATER BOARD
AP STATE UNIT OFFICE
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REPORT ON
AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN HARD ROCK AREAS OF VIZIANAGARAM DISTRICT, ANDHRA PRADESH STATE

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REPORT ON
AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN VIZIANAGARAM DISTRICT, ANDHRA PRADESH STATE

Executive summary

Co n t e n t s

Figures

Table

REPORT ON
AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN VIZIANAGARAM DISTRICT, ANDHRA PRADESH STATE

AT A GLANCE

S. No.	Item		Particulars
1	Districts	:	Vizianagaram
2	Revenue Mandals	:	27
3	Villages	:	955 Nos
4	Geographical area	:	4123 km^2
5	Mappable area	:	3836 km^2
5	Population (2011 Census)	:	19.30 lakh
6	Density of population (2011 Census)	:	468 persons/km^2.
7	Location	:	North latitude 17°83´ to 18°70´ East longitude 83°00´ to 83°85´
8	Rainfall (Normal)	:	1116 mm (SW: 71 % & NE: 11 %)
9	Geomorphology	:	Structural hills, Pediplain and Alluvium.
10	Major Rivers	:	Nagavali, Gosthani and Chempavathi
11	Watersheds	:	8 basin
12	Land Utilization (Ha) (2019)	:	Total cropped area (~48%), Forest (~7%), Barren and uncultivable land (9%), land put to non-agricultural uses (16%) and Cultivable waste (1%)
13	Soils	:	Deep, well drained, clayey soils (44%), Very deep, moderate to well drained, clayey soils (28%), Moderately deep, moderately well drained, cracking clay, calcareous soils (9%), Very deep, moderately well drained, cracking clay soils (4%), Shallow, somewhat excessively drained, gravelly clay soils (4%), Deep, moderately well drained, loamy soils (4%), Moderately shallow, somewhat excessively drained, gravelly clay soils (3%)
14	Cropping Pattern (2019)	:	**Kharif season:**Rice, Sugarcane, Dry fruits, Oil seeds and Vegetable. **Rabi season:** Maize, Sugarcane, Dry fruits, Oil seeds, Seasmum, Rice, Vegetable.
15	Irrigation	:	Ongoing major irrigation projects: Thotapalli Barrage Project: 47300 hectares (part ayacut) Uttarandhra Sujala Sravanthi Project: 196126 ha ayacut Gajapathinaharam Branch Canal: 6070 hectares ayacut Ongoing medium irrigation projects: Tarakarama Thirtha Sagaram Reservoir Project: 8755 hectares ayacut Andra HLC: 1659 hectares ayacut

			Completed medium irrigation projects: Vengala Raya Sagaram Project: 5235 ha Part ayacut Peddankalam Anicut: 12517 ha ayacut Thatipudi Reservoir: 13057 ha ayacut Andra Reservoir Project: 8733 ha ayacut Denkada Anicut: 3749 ha ayacut Pedda Gedda Reservoir Project: 2493 ha ayacut
16	Prevailing Water Conservation/Recharge Practices	:	232 percolation tanks and 3962 Check dams
17	Geology	:	Khondalite (60%), Charnockite (23%), Granite gneiss (13%), Quartzite, Laterite and other (4%)
18	Hydrogeological data points	:	Hydrological Data: 254 Water Level: 54 (CGWB-22 & SGWD-32) Water Quality:98 (CGWB-25 & SGWD-73) Aquifer Geometry: 44 (CGWB: EW & OW), 38 (CGWB: VES), 20 (SGWD: VES) Geophysical: 58 (CGWB-38 & SGWD-20)
19	Number of ground water structures	:	As on 31/03/2021, CGWB drilled 44 bore wells
20	Ground water yield (lps)	:	Granitic gneisses/Charnockite: < 0.1 to 5.2 lps (avg. < 1 lps) Khondalite: < 0.1 to 3.3 lps (avg. 1.5 lps). Yield <1 lps: ~33 % of area, 1 to 2 lps: 51 % and 2 to 3 lps: ~14 % of area Deepest Fracture: 199 m at Bobbili.
21	Water Levels (2020) Depth to water levels (m bgl)	: :	54 wells (CGWB:22, SGWD:32) DTWL: Avg. DTWL varies from 1.48 to 14.27 (m bgl) (avg. 5.51 m bgl) and 0.37 to 12.26 m bgl (avg. 2.87 m bgl) during pre-monsoon and post-monsoon seasons respectively. WTE: Pre and post-monsoon season (May and November,2020), the water-table elevation ranges from 2.71 to 145.70 and 7.09 to 148.5 meter above mean sea level (m amsl) respectively Pre-monsoon season: 5.0 to 10 m bgl in 56%, 2.0 to 5.0 m bgl in 43%, <2.0 to 5.0 m bgl in 1% and >10 m bgl in 1% of area. Post-monsoon: 2.0 to 5.0 m bgl in 77%, 5.0 to 10 m bgl in 17%, < 2.0 m bgl in 6 % of area.
22	Water Level Fluctuations (May vs. November 2020)	:	Fluctuation ranges: 0.15 to 6.90 m. bgl. Fluctuation ranges: Rise-2 to 3 m bgl in 52 %, 3 to 4 m bgl in 26%,3 <2.0 m bgl in 19 % and >4.0 m bgl in 2% of area.
23	Long term water level trends (2011-20)	:	**Pre-monsoon:** Falling trends- 11 wells (0.002 to 0.22 m/yrs.) Rising trends- 38 wells shows 0.01 to 0.78 m/yrs. **Post-monsoon:** Falling trends- 9 wells (0.007 to 0.88 m/yr) Rising trends- 40 wells shows 0.001 to 0.66 m/yr.
24	Geophysical data (down to 200 m)	:	58 VES (CGWB-38 & SGWD-20)

			Weathered khondalite (5.0 to 125 Ω m), Fractured khondalite (18 to 93 Ω m) Massive khondalite (53 to 940 Ω m) ,Weathered charnockite (< 40 Ω m), Fracture charnockite (38 to 225 Ω m), Massive charnockite (> 3275 Ω m).	
25	Hydrochemistry (2020)	:	Total 194 data Pre-monsoon-98 (CGWB-25 & SGWD-73) and Post-monsoon-96 (CGWB-27 & SGWD-69)	
25.1	Electrical Conductivity (µ Siemens/cm)	:	Pre-monsoon: 241 to 3950 µ Siemens/cm (avg. 1347), EC >3000 µ Siemens/cm covering < 1% area. Post-monsoon: 180 to 4362 µ Siemens/cm (avg. 1391), EC >3000 µ Siemens/cm covering < 1% area.	
25.2	Fluoride (mg/l)	:	Pre-monsoon: Fluoride concentration varies from 0.08 to 2.31 mg/L and all samples falling within permissible limits of 1.5 mg/L, except in Kothavalasa (1.72 mg/L), S. Kota (1.52 mg/L) and Darmapuri (2.31 mg/L) Post-monsoon: Fluoride concentration varies from 0.034 to 2.49 mg/L and all samples is below BIS permissible limits of 1.5 mg/L except in Kothavalasa (2.34 mg/L) and Palligantredu (2.49 mg/L)	
25.3	Nitrate (mg/l)	:	Pre-monsoon: Nitrate concentration in all samples is below BIS permissible limits of 45 mg/L, except 7 samples, and varies between 0.26 to 94.55 mg/L (avg. 18.17 mg/L). The Nitrate concentration >45 mg/L found in ground water at Tarapuram (68.22 mg/L), Almanda (73.72 mg/L), Bondapalli (68.23 mg/L), Agraharam (49.9 mg/L), Garbham (46.44 mg/L), Bobbili (99.55 mg/L) and Jannivalasa (51.54 mg/L) Post-monsoon: Nitrate concentration in all samples is below permissible limits of 45 mg/L, varies between 0.07 to 437.2 mg/L (avg.30.04 mg/L). Out of 96 samples, 14 sample nitrate concentration is >45 mg/L ranges from 69.61 to 588.14 mg/L.	
26	Conceptualization		Weathered zone (Aquifer-I): 6 to 57 m bgl	Fractured zone (Aquifer-II): 10 to 199 m bgl
27	Aquifer Characterization	:	Thickness of weathered zone: 20 to 30 m covering in ~65 % of area, < 20 m occurs in ~29 % of the area Khondalite: 6 to 48 m bgl Granitic gneiss and Charnockite: meagre to 57 m bgl	The fracture zone is more predominant in 100 to 150 m depth (44 % of the area), 60 to 100 m fractures occur in 41 % area; 30 to 60 m fractures occur in 9 % of area. The deep fractures > 150 m occur in 8 % of area. Deepest fracture at 199 m at Bobbili..
27.1	Aquifer wise Ground water yield	:	Yield of the wells in weathered portion vary from 0.03 to 3.0 lps	Yield in granitic gneisses aquifers varies < 0.1 to 5.2 lps (avg. < 1 lps) and khondalite aquifers varies from < 0.1 to 3.3 lps (avg. 1.5 lps).

27.2	Transmissivity (m^2/day)	:	-	0.144 to115 m^2/day
27.3	Specific Yield	:	-	-
27.4	Storativity	:	-	4.8×10^{-5} to 1.2×10^{-3}
28	Ground water Resources (Year)	:	**2020**	**2022**
28.1	Net Dynamic groundwater availability (MCM)	:	1554	1400
28.2	Gross GW Draft(MCM)	:	335	328
28.3	Provision for Domestic utilization (2025) (MCM)	:	50	32
28.4	Average Stage of Ground water development (%)		23	26
28.5	Net GW Availability for future use (MCM)	:	1208	1086
28.6	In storage GW Resources	:	-	
28.7	Categorization of mandals		Mandal wise it varies from 4.0 % (Rajam) to 51 % (Gurla) Safe:27 mandals	
29	Major Ground Water Issues Identified	:	**Groundwater Yield** • The low yield (<1 lps) occurs in ~33 % of area and 1 to 2 lps yield occurs in ~51 % of area covering district. **Deep water levels** • Deep water levels (> 10 m bgl) are observed during pre as well as post-monsoon season in 32 sq.km and 6 sq.km of the area respectively. • Out of 49 wells analysed, 11 wells during pre-monsoon and 9 wells during post-monsoon shown falling trend in the last 10 years (0.002 to 0.22 m/yrs and 0.007 to 0.88 m/yrs) respectively. **Water Logging** ➢ In Vizianagaram district, at present there is no water logging. However, during post monsoon period in places around S.Kota, Jami, Gantyada, Vizianagaram, Nellimerla, Pusapatirega, Bobbili, Badangi, Vangara, Santhakaviti and Regidiamavalavasa mandals, the water levels are < 2.0 m bgl (6 % of area) indicating that these areas are prone to water logging. **Pollution (Geogenic and Anthropogenic)** ➢ Nitrate concentration in the entire district is within the permissible limit except in Tarapuram (68.22 mg/L), Almanda (73.72 mg/L), Bondapalli (68.23 mg/L), Agraharam (49.9 mg/L), Garbham (46.44 mg/L), Bobbili (99.55 mg/L) and Jannivalasa (51.54 mg/L) during pre-monsoon season. During post-monsoon, out of 96 samples, 14 sample nitrate concentration is >45 mg/L ranges from 69.61 to	

			588.14 mg/L. ➢ Fluoride concentration throughout the district is within permissible limit except in in Kothavalasa (1.72 mg/L), Darmapuri (2.31 mg/L) and S. Kota (1.52 mg/L) during pre-monsoon and in Kothavalasa (2.34 mg/L) and Palligantredu (2.49 mg/L) during post-monsoon period. ➢ The high concentration of EC (>2000 µ Siemens/cm) in occurring 143 sq.km and 404 sq.km area is observed during pre and post-monsoon period respectively. (along the coast line where fresh water is limited).
30	Ground Water Development and Management Strategies	:	• The total utilization of ground water is 328 MCM against the total ground water potential of 1086 MCM available for future use. • Ground water development is only 26%. • Vast scope for further ground water development by construction of additional wells for irrigation. • In Vizianagaram district, 14135 hectares area can be irrigated by construction of 13368 ground water extraction structures with estimated cost 62941 lakhs and 732 villages will be benefited under PMKSY-HKKP (GW) / YSR Jalakala. • While taking up the developmental schemes in the district, priority may be given to those mandals where level of groundwater development is less than 20 percent. Next priority may be given to those mandals where level of ground water development is 20 to 35 percent. • The developmental activities of the district may be reviewed critically, once the level of groundwater development crosses 50 % in any mandal. • During aquifer mapping, a total 698 sq. kms is identified for artificial recharge and unsaturated volume of aquifer is 27 MCM. • The CDs and PTs are calculated by taking 5 fillings for Check dams and 2 fillings for Percolation Tanks and a total 1100 number of AR structures (569 number of PTs, 531 number of CDs) are feasible in the district. After considering the existing AR Structures and data gap, a total 354 number of AR structures (343 number of PTs, 11 number of CDs) are recommended in the district. • A total 4194 recharge structure already created (3538 check dams, 424 check walls, 146 PT's and 86 mini PT's) through MGNREGS and IWMP scheme (source: Department of Rural Development and Panchayat Raj). At present, @1 artificial recharge structure existed per square km area in the district. The considering the SOP, it is also suggested that instead of planning for new artificial recharge structure, the

			existing CD's and PT's shall be desilted and maintained. • The yield of bore wells is <1.0 lps identified in 33 % of area, and 1.0 to 2.0 lps in 51% of the area. This may be due to poor interconnection among fractures or fracture becomes closed by clay due to chemical dissolution action of weathered portion in khondalite formation. As sustainability of bore well is low, the sprinkler and drip irrigation system with suitable cropping pattern wherever feasible may be practiced as a measure for groundwater conservation, protection and management. • The depth to ground water levels in the contemplated Uttarandhra Sujala Sravanthi project is <3 m in 1182 sq. kms and 3 to 5 m in 665 sq. kms. Upon completion of the project, there is likelihood of ~255 MCM of return irrigation which may result in water logging conditions. It is recommended for Conjunctive use of surface and ground water in the contemplated Uttandhra Sujala Sravanthi project areas (159446 ha) • Roof top rain water harvesting in 2 Municipalities (Bobbili and Vizianagaram) as per the existing post monsoon depth to water levels, provisions of AP WALTA and proper waste water management are other recommended measures in the district. • In urban and rural area, the sewerage line should be constructed to arrest leaching of nitrate.

ABBREVATIONS

2D	:	2 Dimensional
3D	:	3 Dimensional
ARS	:	Artificial Recharge Structures
Avg	:	Average
BDL	:	Below Detection Level
BW	:	Bore Well
CD	:	Check dam
CGWB	:	Central Ground Water Board
Cr	:	Crore
DTW	:	Depth to water
DW	:	Dug well
EC	:	Electrical conductivity
EL	:	East Longitude
F	:	Fluoride
FP	:	Farm Pond
GEC	:	Ground Water Estimation committee
GW	:	Ground Water
Ha	:	Hectare
Ha.m	:	Hectare meter
ID	:	Irrigated dry
IMD	:	India Meteorological Department
Km^2	:	square kilometre
LPS	:	Litres per second
M	:	meter
M^3	:	Cubic meter
m bgl	:	Metres below ground level
MCM	:	Million cubic meter
Mg/l	:	Milligram per litre
MI	:	Micro irrigation
Min	:	Minimum
max	:	Maximum
MPT	:	Mini percolation tank
MSP	:	Minimum Support price
NL	:	North Latitude
NO_3	:	Nitrate
OE	:	Over Exploited
PGWM	:	Participatory ground water management
PT	:	Percolation tank
SGWD	:	State Ground Water Department
S	:	Storativity
Sy	:	Specific Yield
T	:	Transmissivity
WCM	:	Water conservation measures

EXECUTIVE SUMMARY

Vizianagaram district is one of the nine coastal districts of Andhra Pradesh. The district lies between north latitude of 17° 83´ and 18° 70´ and east longitudes of 83° 00' and 83° 85' with an aerial extent of 4,123 km^2. The district headquarters is located at Vizianagaram town. The district governed by 27 revenue mandals and 955 villages. As per the 2011 census the population of the district is ~ 19.30 lakhs. The decennial growth rate from 2001 to 2011 is 4.22 percent. The density of population of the district is 468 persons per sq. km.

The district is physiographically comprises Eastern Ghats hilly region in the west and north. Plains with scattered hills in the central, southern and eastern parts. The topographic elevation of the hilly area varies from 300 to 950 m amsl, whereas the elevation of plains varies from 10 to 150 m amsl. The major rivers that drains the district are Nagavali, Gosthani and Champavathi and their tributaries viz. Suvarnamukhi and Vegavathi. They originate in the Eastern Ghats and after flowing through the district, joins Bay of Bengal. The drainage exhibits sub-dendritic to dendritic pattern, medium to coarse texture and drainage density is worked out to be 0.6 to 1 km/sq.km.

The normal annual rainfall of the district is 1116 mm of which SW monsoon 71 % and north-east monsoon contributes 11 %. During the year 2016, 2017, 2018, 2019 and 2020 the district received rainfall of 1059 mm (-6% less), 994 mm (-12 less), 1071 mm (-5 less) 841 mm (-26 % less) and 1188 mm (6% more), rainfall respectively.

The area is underlain mainly by khondalites, granite gneiss, charnockites, quartzites and laterites. Geomorphologically, the district can be broadly divided into 4 distinct units viz.; structural hills, pediplains, alluvial plains and coastal plains. Total cropped area is ~48%, forest occupies ~7%, barren and uncultivable land is 9%, land put to non-agricultural uses is 16% and cultivable waste 1% etc. of the total geographical area. During Kharif season, main crops grown are rice, sugarcane, dry fruits, oil seeds and vegetable etc. During Rabi season, main crops grown are maize, sugarcane, dry fruits, oil seeds, seasmum, rice, vegetable etc. The soils are Deep, well drained, clayey soils (44%), Very deep, moderate to well drained, clayey soils (28%), Moderately deep, moderately well drained, cracking clay, calcareous soils (9%), Very deep, moderately well drained, cracking clay soils (4%), Shallow, somewhat excessively drained, gravelly clay soils (4%), Deep, moderately well drained, loamy soils (4%), Moderately shallow, somewhat excessively drained, gravelly clay soils (3%).

The ongoing major irrigation projects are Thotapalli Barrage Project and with total 47300 ha part ayacut and Uttarandhra Sujala Sravanthi Project with 196126 ha ayacut. The Gajapathinaharam Branch Canal with 6070 ha ayacut. The ongoing medium irrigation projects are Tarakarama Thirtha Sagaram Reservoir Project with 8755 ha and Andra HLC with 1659 ha ayacut. Besides these, completed medium irrigation projects are Vengala Raya Sagaram Project (5235 ha), Peddankalam Anicut (12517 ha), Thatipudi Reservoir (13057 ha), Andra Reservoir Project (8733 ha), Denkada Anicut (3749 ha) and Pedda Gedda Reservoir Project (2493 ha). There are 232 percolation tanks and 3962 Check dams, artificial recharge structures (ARS) in the district.

CGWB drilled 44 no's bore wells (38 no's exploratory and 6 no's observation), 34 wells were drilled in granite gneiss area and 10 wells were drilled in khondalitic area. Data analysed from CGWB wells indicates, 5 no's well of depth ranges 24-100 m, 9 no's (100-150 m), 30 no's (150-200 m) depth. Ground water yield of granitic gneisses aquifers varies vary from <0.1 to 5.2 lps (avg. < 1 lps) and khondalite aquifers varies from <0.1 to 3.3 lps (avg. 1.5 lps). Majority of fractures occur within 100 to 150 m depth and deepest fracture is encountered at 199 m bgl at Bobbili.

Geophysical data from 58 VES data (CGWB & SGWD) reveals resistivity 5.0-125 Ω m for the weathered khondalite (5-46 m), 18-93 Ω m for underlying fractured khondalite with depth ranges between 24-95 m and 53-940 Ω m for massive khondalite. The resistivity < 40 ohm (Ω) m for the weathered charnockite (7-25 m), 38-225 Ω m for underlying fractured charnockite (30-107 m) and > 3275 Ω m for massive charnockite rocks.

Water levels are monitored through 54 Piezometer (CGWB: 22 & SGWD: 32) during pre and post-monsoon season of 2021. The DTW varies from 1.48 to 14.27 m bgl (avg. 5.51 m bgl) and 0.37 to 12.26 m bgl (avg. 2.87) during pre and post-monsoon season respectively. During pre-monsoon season, 5.0 to 10 m water level covering 56% of the area, followed by 2.0 to 5.0 m bgl (43%) and >10 m bgl (1%). During post-monsoon season, 2.0 to 5.0 m water level covering 77% of the area, followed by 5.0 to 10 m bgl (17%), < 2.0 m bgl (6%). Water level fluctuation (Nov'2021 Vs. May'2021) data indicates that water levels rise is observed throughout the district. Water level fluctuations vary from 0.15 to 6.90 m with average rise of 2.74 m. Long-term water level trends during pre-monsoon, 11 wells show falling trends ranging 0.002 to 0.22 m/yrs and 38 wells shows a rising trend in the range of 0.01 to 0.78

m/yrs. During post-monsoon season, 9 wells show falling trends in the range of ranging 0.007 to 0.88 m/yrs and 40 wells show rising trends in the range of 0.001 to 0.66 m/yrs.

During Pre and post-monsoon season, EC is in the range of 1000 to 2000 µ Siemens/cm covering 81% and 73 % of area respectively. During pre-monsoon season, Nitrate concentration in all samples is below BIS permissible limits of 45 mg/L, varies between 0.26 to 94.55 mg/L (avg. 18.17 mg/L), except in Tarapuram (68.22 mg/L), Almanda (73.72 mg/L), Bondapalli (68.23 mg/L), Agraharam (49.9 mg/L), Garbham (46.44 mg/L), Bobbili (99.55 mg/L) and Jannivalasa (51.54 mg/L). Fluoride concentration varies from 0.08 to 2.31 mg/L (avg. 0.61 mg/L) and all samples falling under permissible limits of 1.5 mg/L, except in Kothavalasa (1.72 mg/L), Darmapuri (2.31 mg/L) and S. Kota (1.52 mg/L). In post-monsoon, Nitrate concentration in all samples is below permissible limits of 45 mg/L, varies between 0.07 to 437.2 mg/L (avg.30.04 mg/L). Out of 96 samples, 14 sample nitrate concentration is >45 mg/L ranges from 69.61 to 588.14 mg/L. Fluoride concentration all samples is below BIS permissible limits of 1.5 mg/L and varies from 0.034 to 2.49 mg/L, except in Kothavalasa (2.34 mg/L) and Palligantredu (2.49 mg/L).

Based on 254 hydrogeological data points, aquifers from the area can be conceptualized in to 2 no's namely, 1) weathered zone (6 to 57 m) and 2) fractured zone (10 to 199 m). Weathered zone in the range of 20 to 30 m in most part of area covering ~65 % of area, <20 m weathering thickness occurs in ~29 % of the area, 30 to 40 m in 5% of the area and deeper (>40 m) weathering occurs in rest of the area. Ground water yield of this zone varies from 0.03 to 3.0 lps. The fractures in the range of 100 to 150 m depth are more predominant (44 % of the area), 60 to 100 m fractures occur in 41 % area; 30 to 60 m and The deep fractures >150 m fractures occur in 9 % and 5 % of area respectively. The discharge in the exploratory wells vary from meagre to as high as 5.2 lps with general range of 0.1 to 2.0 lps. The specific capacity of the bore wells varies from 1.05 to 72.7 lpm /m.d whereas the Transmissivity ranges from 0.144 to115 m^2/day. The storage co-efficient of bore wells vary from 4.8 x 10^{-5} to 1.2 x 10^{-3}.

Net dynamic replenish able ground water availability as on 2022 is 1400 MCM, gross ground water draft is 328 MCM, provision for drinking and industrial use for the year 2025 is 32 MCM and net available balance for future use is 1086 MCM. The stage of ground water development varies from 4 % to 51% (avg. 26 %).

The low yield (<1 lps) occurs in ~33 % of area and 1 to 2 lps yield occurs in ~51 % of area covering district. The deep water levels (>10 m bgl) are observed during pre as well as post-monsoon season in 32 sq.km and 6 sq.km of the area respectively. During pre-monsoon, 11 wells showing falling trend in the range of 0.002 to 0.22 m/yrs and 9 wells during post-monsoon shown falling trend in the range of 0.007 to 0.88 m/yrs in the last 10 years.

In Vizianagaram district, a vast scope for further ground water development by construction of additional wells for irrigation. At present the ground water abstraction in the district is quiet low as the overall level of ground water development is 26 % only. The total utilization of ground water is 328 MCM against the total ground water potential of 1400 MCM available for future use.

Under Pradhan Mantri Krishi Sinchayee Yojana- Her Khet Ko Pani (GW)/YSR Jalakala, 14,135 ha area can be irrigated by construction of 13,368 ground water extraction structures with estimated cost 62,941 lakhs and 732 villages will be benefited. By extracting more ground water through bore-wells / Tube wells. This will be generating more ayacut in irrigation sector and more subsurface ground water recharge potential for artificial recharge structure in future.

While taking up the developmental schemes in the district, priority may be given to those mandals where level of groundwater development is less than 20 % and there are 11 such mandals. Next priority may be given to those mandals where level of ground water development is 20-35 % and there are 8 such mandals in the district. There is one mandal Gurla where the groundwater development is 51 %.

The coastal parts of the district, in Bhogapuram and Pusapatirega electrical conductivity of groundwater is higher than other parts of the district. So, ground water development in these two mandals has to be taken up very judiciously to avoid any possibility of sea water ingress/intrusion.

The area suitable for artificial recharge has been demarcated based on the analysis of average post-monsoon depth to water level data of the observation wells for the period 2013-2022. A total 698 sq. kms is identified which is spread over in 216 villages in 7 mandals of the district. The availability of unsaturated sub surface volume of aquifers is computed as the product of area, thickness of aquifer zone between 5 m bgl and the average post-monsoon water level and specific yield of the aquifers. The unsaturated volume of the aquifers is

calculated as 27 MCM. Out of the total run off available, only 20% is considered for recommendation of artificial recharge structures.

The Check dams and Percolation Tanks are calculated by taking 5 fillings for Check dams and 2 fillings for Percolation Tanks and a total 1100 number of AR structures (569 number of PTs, 531 number of CDs) are feasible in the district. After considering the existing AR Structures and data gap, a total 354 number of AR structures (343 number of PTs, 11 number of CDs) are recommended for 698 sq. kms of the district.

A total 4194 recharge structure (3538 check dams, 424 check walls, 146 PT's and 86 mini PT's) through MGNREGS and IWMP scheme. At present, @1 artificial recharge structure existed @per square km area in the district. The considering the SOP, it is also recommended that instead of planning for new artificial recharge structure, the existing CD's and PT's shall be desilted and maintained. In future, artificial recharge structure shall be recommended in specific areas, where vulnerabilities for groundwater resources increase.

The yield of bore well is <1.0 lps occur in 33 % of area and 1.0 to 2.0 lps in 51% of the area. This may be due to low interconnection among fractures or fracture becomes closed by clay due to chemical dissolution action of weathered portion in khondalite formation. As yield of bore wells is low, the sprinkler and drip irrigation system with suitable cropping pattern wherever feasible may be practiced as a measure for groundwater conservation, protection and management.

The depth to ground water levels in the contemplated Uttarandhra Sujala Sravanthi project is <3 m in 1182 sq. kms and 3 to 5 m in 665 sq. kms. Upon completion of the project, there is likelihood of ~255 MCM of return irrigation which may result in water logging conditions. It is recommended for Conjunctive use of surface and ground water in the contemplated Uttandhra Sujala Sravanthi project areas (159446 ha).

It is recommended to follow the anti-water logging measures like conjunctive use of surface and ground water in the feasible areas as the number of surface water irrigation projects are coming up in the district. Roof top rain water harvesting in 2 Municipalities (Bobbili and Vizianagaram) as per the existing post monsoon depth to water levels, provisions of AP WALTA and proper waste water management are other recommended measures in the district. In urban and rural area, the sewerage line should be constructed to arrest leaching of nitrate.

NUMBER OF DATA POINTS USED FOR PREPARATION OF VARIOUS MAPS/FIGS- VIZIANAGARAM DISTRICT, ANDHRA PRADESH STATE

S. No.	Data	Aquifer	Total Data Points	Source	
				CGWB	SGWD
1	Panel Diagram (3-D)	Combine	102	Expl:44 VES:38	20
2	Hydrogeological Sections	3 no	102	Expl:44 VES:38	20
3	Fence/panel Diagrams	1 no	102	Expl:44 VES:38	20
4	Depth of weathering	1 no	102	Expl:44 VES:38	20
5	Depth of fracturing	1 no	102	Expl:44 VES:38	20
6	Groundwater Yield	Combine	44	44	-
7	Transmissivity (m^2/day)	Combine	44	44	-
8	Depth to Water Level Maps	Combine	54	22	32
9	Water Level Fluctuation	Combine	54	22	32
10	Long term water level trends	Combine	54	22	32
11	Water quality	Combine	194 Pre:98 Post:96	 25 27	 73 69

1. INTRODUCTION

Aquifer mapping is a process wherein a combination of geological, geophysical, hydrological and chemical analyses is applied to characterized the quantity, quality and sustainability of ground water in aquifers. In recent past, there has been a paradigm shift from "**groundwater development**" to "**groundwater management**". As large parts of India particularly hard rock have become water stressed due to rapid growth in demand for water due to population growth, irrigation, urbanization and changing life style. Therefore, in order to have an accurate and comprehensive micro-level picture of groundwater in India, aquifer mapping in different hydrogeological settings at the appropriate scale is devised and implemented, to enable robust groundwater management plans. This will help in achieving drinking water security, improved irrigation facility and sustainability in water resources development in large parts of rural and many parts of urban India. The aquifer mapping program is important for planning suitable adaptation strategies for sustainable development and management of ground water resources of the country. As a part of NAQUIM in Andhra Pradesh, the Vizianagaram district has been selected and completed during AAP 2021-2022.

Hard rock (Granites/Gneisses) lack primary porosity, and groundwater occurrence is limited to secondary porosity developed by weathering and fracturing. Weathered zone is the potential recharge zone for deeper fractures and excessive withdrawal from this zone leads to drying up in places and reducing the sustainability of structures. Besides these quantitative aspects, groundwater quality also represents a major challenge which is threatened by both geogenic and anthropogenic pollution. In some places, the aquifers have high level of geogenic contaminants, such as fluoride, rendering them unsuitable for drinking purpose. High utilization of fertilizers for agricultural productions and improper development of sewage system in rural/urban areas lead to point source pollution viz., nitrate and chloride.

1.1 Objectives: In view of the above challenges, an integrated hydrogeological study was taken up to develop a reliable and comprehensive aquifer map and to suggest suitable groundwater management plan on 1: 50,000 scale.

1.2 Scope of study: The main scope of study is summarised below.

1. Compilation of existing data (exploration, geophysical, groundwater level and groundwater quality with geo-referencing information and identification of principal aquifer units.

2. Periodic long term monitoring of ground water regime (for water levels and water quality) for creation of time series data base and ground water resource estimation.
3. Quantification of groundwater availability and assessing its quality.
4. To delineate aquifer in 3-D along with their characterization on 1:50,000 scale.
5. Capacity building in all aspects of ground water development and management through information, education and communication (IEC) activities, information dissemination, education, awareness and training.
6. Enhancement of coordination with concerned central/state govt. organizations and academic/research institutions for sustainable ground water management.

1.3 Area details: The Vizianagaram district, Andhra Pradesh having geographical area of 4,123 km^2, lies between north latitude 17°83´ to 18°70´ and east longitude 83°00´ to 83°85´(**Fig.1.1**). Administratively the district is governed by 27 revenue mandals and 955 villages with a population of ~19.30 lakhs (2011 census) (urban: 22 %, rural: 78 %). The density of population is 468 persons/ km^2 and there is an increase in 4.22 % growth rate over last 10 years. (2011 census)

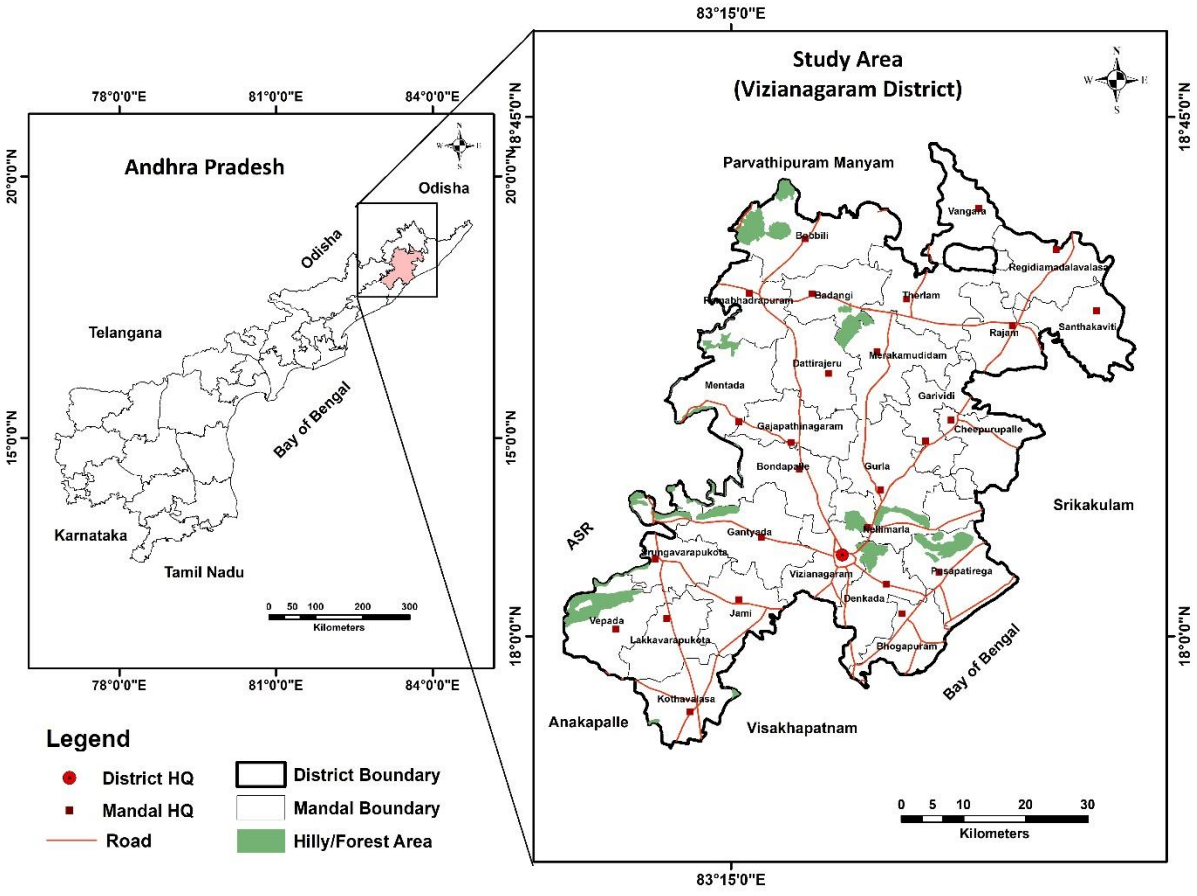


Fig.1.1: Location map of Vizianagaram district.

1.4 Climate and Rainfall: The climate of the district is moderate and characterized by high humidity all through the year and good seasonal rainfall. The mean daily maximum temperature in the district is about 35°C and the mean daily minimum temperature is about 27°C. The mean monthly relative humidity is 79%. The relative humidity increases after the onset of monsoon.

The normal annual rainfall of the district is 1116 mm (Indian Meteorological Department). This varies between 1002 mm (Gajapathinagaram) to 1317 mm (Vepada) (**Fig.1.2**). The South west monsoon (June to September) contributes ~71 %, North east monsoon (October to December) contributes ~11%, and remaining by winter and summer season. During the year 2016, 2017, 2018, 2019 and 2020 the district received rainfall of 1059 mm (-6% less), 994 mm (-12 less), 1071 mm (-5 less) 841 mm (-26 % less) and 1188 mm (6% more), rainfall respectively. The annual rainfall and trend of annual rainfall are depicted in **Fig.1.3**

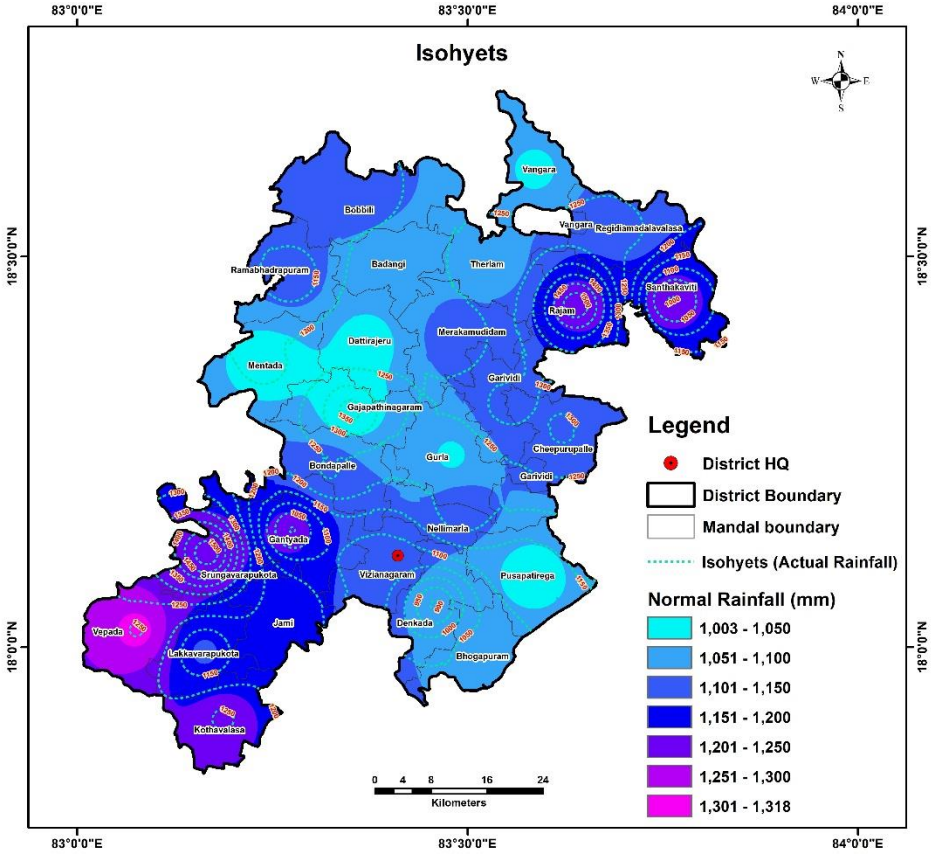


Fig.1.2: Isohyetal map of Vizianagaram district.

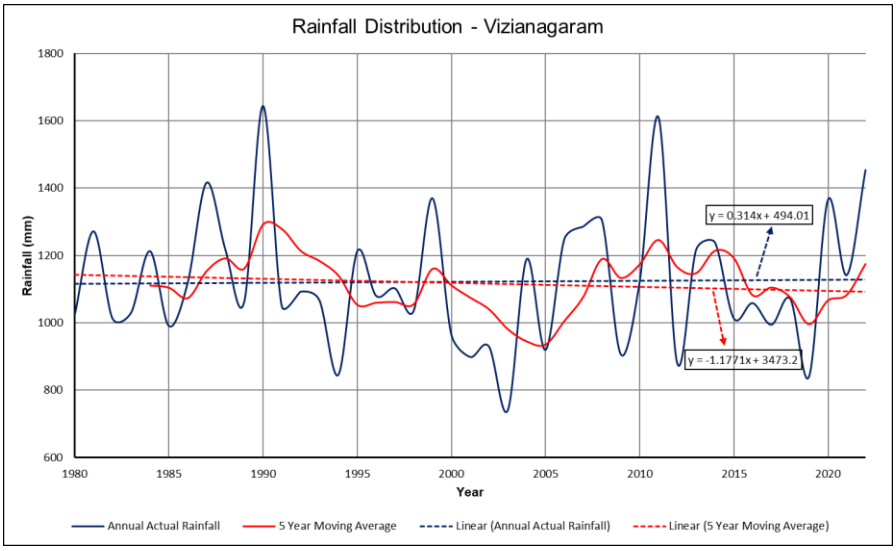


Fig.1.3: Annual rainfall and trend of annual rainfall of Vizianagaram district.

1.5 Geomorphological Set up: Geomorphologically, the district can be broadly divided into 4 distinct units viz.; structural hills, pediplains, alluvial plains and coastal plains. The western parts of Vizianagaram district are occupied by structural hills and also they occur in isolated patches. They occur as linear to arcuate hills showing definite trend lines and all are composed of charnockites and Khondalites. The pediplains occupy larger parts of the district, comprising shallow buried pediplain, deeply buried pediplain, pediment, residual hills and inselbergs of granites and gneisses. Generally, they form poor aquifers except along the major fractures. The pediment is a broad and generally sloping rocky surface with low relief and thin veneer of detritus.

The alluvial plains are developed along major river courses, valleys and at the feet of structural hills in the district. The alluvial plains along major river courses are known as flood plains and consist of unconsolidated gravels, sands, silts and clays. The alluvial plains along valley fills consists of gravels, sands, silts and clays and the thickness of valley fills is considerable extending up to 35 meters, they are generally capable of giving very high yields. The occurrence of alluvial plains in the district is seen partly in the northwest, northeast and in the central mid plains and also in the southeast and south western parts. The coastal plain occurs parallel and nearer to the sea and is of marine origin consisting of generally saline aquifers except on beach ridges where moderate to fresh water aquifers occur. The beach ridges are suitable for construction of very shallow dug wells of 2 to 3 m in depth and infiltration galleries. **(Fig.1.4.)** The distribution of different geomorphic unit is shown in given below table.

Sl.No.	Geomorphology	Area (Sq.km)	% Area
1	Pediplain	3319	85.63
2	Structural hill	239	6.17
3	Flood/Coastal plain	153	3.95
4	Channel fill	83	2.14
5	Linear ridges	39	1.00
6	Structural valley	37	0.95
7	Paleo channel	6	0.15

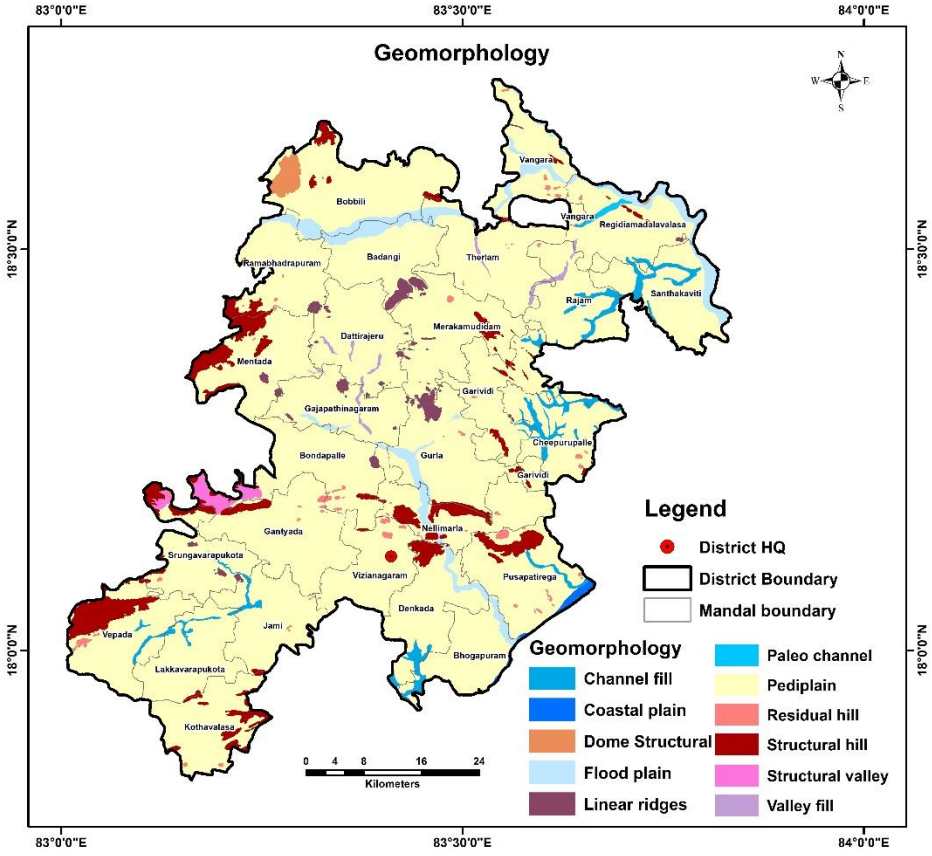


Fig.1.4: Geomorphological map of Vizianagaram district.

1.6 Drainage and Structures: There are six rivers draining the district, viz. Nagavali, Gosthani, Suvarnamukhi, Champavathi, Vegavathi, and Gomukhi. They originate in the Eastern Ghats and after flowing through the district, finally join Bay of Bengal.

The Nagavali, Champavathi and Gosthani basin covering major portion of the district; Peddagedda and Kandivalasagedda basin occur in SE part and Sarada basin in SW part of the

district. The drainage exhibits sub-dendritic to dendritic pattern, medium to coarse texture and drainage density is worked out to be 0.6 to 1 km/sq.km.

The district has consolidated formations which include crystalline (khondalites, charnockites and granitic gneisses) and meta sediments (dolomites, shales, phyllites and quartzites) of Archaean and Pre-cambrian ages respectively. The khondalite group of rocks are seen as prominent hill ranges (strike ridges). The rocks of khondalite, charnockite groups and the layered complex show foliation trending dominantly N-S with local swerves to NE-SW and NW-SE (Map depicting drainage, river and basin is presented in **Fig.1.5**.)

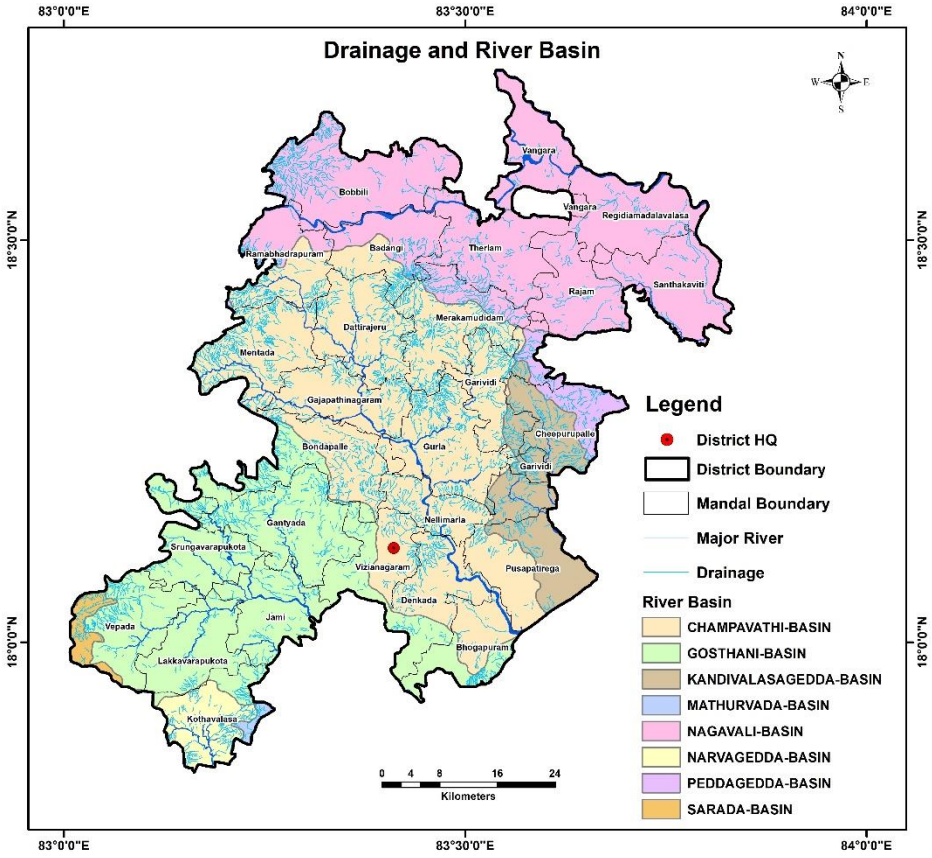


Fig.1.5: Drainage and Basin map of Vizianagaram.

1.7 Land use and cropping pattern: Total cropped area is 279697 ha, area sown more than once is 80087 ha, forest occupies 28795 ha, barren and uncultivable land is 35959 ha, land put to non-agricultural uses is 65925 ha, cultivable waste is 3012 ha etc. of the total geographical area 412399 ha.

During Kharif season (203078 ha), main crops grown are rice, sugarcane, dry fruits, oil seeds and vegetables etc. During Rabi season (76619 ha), main crops grown are Maize,

Sugarcane, dry fruits, oil seeds, seasmum, rice, vegetable and cotton etc. The other crops are onion, sunflower, chillies etc. Land use and land cover map of the district is depicted in **Fig. 1.6.** The season wise irrigated area **(Fig.1.6a).** In the district there are 356254 marginal farmers (< 1 ha of land), 43685 small farmers (1.0 to 2.0 ha), 16043 semi-medium (2.0 to 4.0 ha), 5830 medium (4.0 to 10 ha) and 530 large farmers (> 10 ha)

S.No.	LULC	Ha	% Area
1	Total geographical area	412399	100
2	Forest	28795	7
3	Barren & uncultivable land	35959	9
4	Land put to non-agricultureal uses	65925	16
5	Cultivable waste	3012	1
6	Permanent pastures and other grazing lands	4008	1
7	Land under miscellaneous tree crops & groves	10414	3
8	Current fallows	47872	12
9	Other fallow lands	16794	4
10	Fish & Prawn Culture	10	0
11	Net Area Sown	199610	48

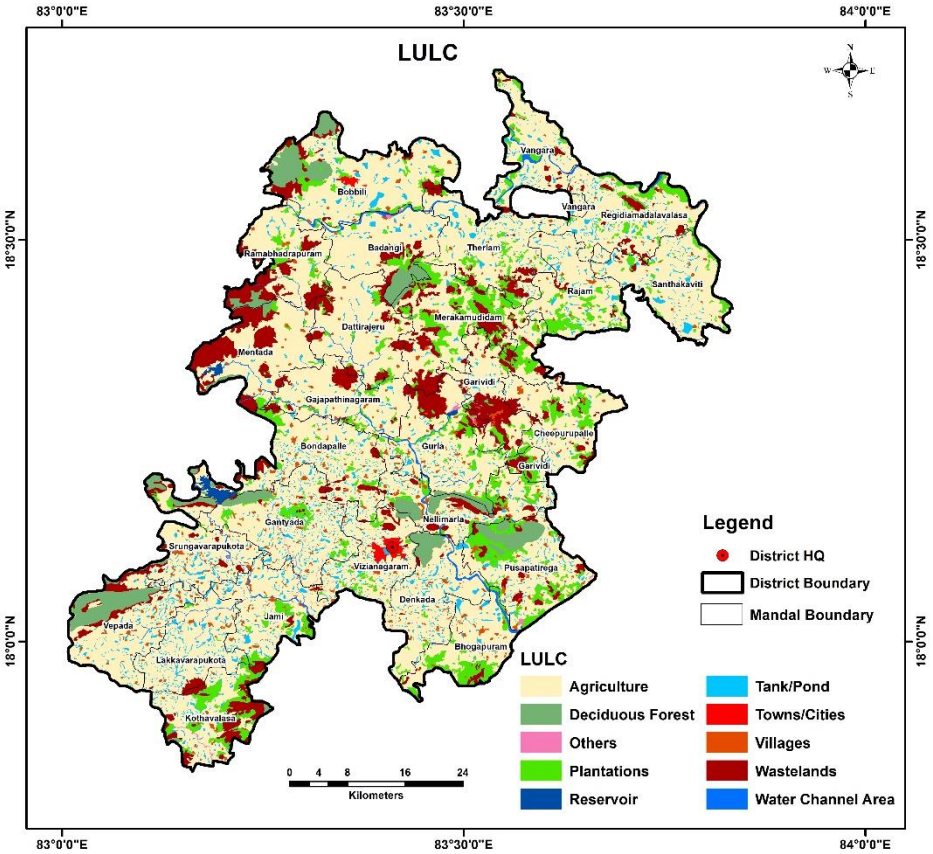


Fig.1.6: Land use and land cover map of Vizianagaram district.

S.No.	Irrigation	Area (Ha)
1	Total Cropped Area	279697
2	Area Sown More than Once	80087
3	Kharif	203078
4	Rabi	76619

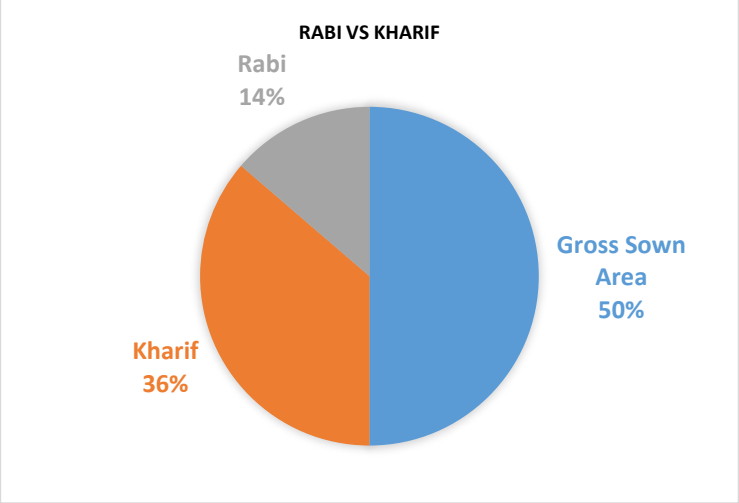


Fig.1.6a: Irrigated area season wise.

1.8 Soils: The area is mainly occupied by Deep, well drained, clayey soils (44%), Very deep, moderate to well drained, clayey soils (28%), Moderately deep, moderately well drained, cracking clay, calcareous soils (9%), Very deep, moderately well drained, cracking clay soils (4%), Shallow, somewhat excessively drained, gravelly clay soils (4%), Deep, moderately well drained, loamy soils (4%), Moderately shallow, somewhat excessively drained, gravelly clay soils (3%) and Moderately deep, somewhat excessively drained, loamy soils; Deep, well drained, loamy soils and Very deep, somewhat excessively drained, sandy soils covering the remaining parts of the district.(**Fig.1.7**)

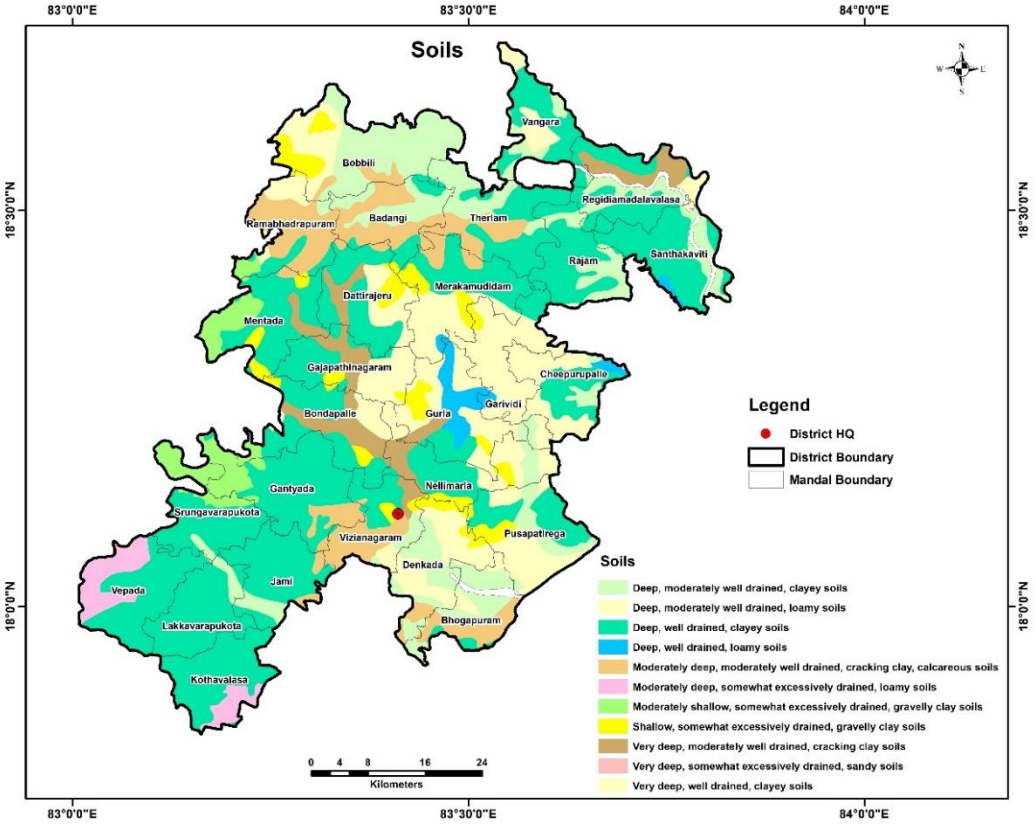


Fig.1.7: Soil map of Vizianagaram district

1.9 Irrigation:

The major river basin of the district is Nagavali, Champavathi, Gosthani and their tributaries. The major contemplated irrigation project in Vizianagaram district is Uttarandhra Sujala Sravanthi Project with 196126 ha ayacut. The ongoing major irrigation projects are Thotapalli Barrage Project (Nagavali River) with 47300 ha (part ayacut).

The medium irrigation projects completed in the district are Vengala Raya Sagaram Project with 5235 ha Part ayacut, Peddankalam Anicut with 12517 ha ayacut, Thatipudi Reservoir with 13057 ha ayacut, Andra Reservoir Project with 8733 ha ayacut, Denkada Anicut with 3749 ha ayacut, Pedda Gedda Reservoir Project with 2493 ha ayacut.

The ongoing medium irrigation project is Tarakarama Thirtha Sagaram Reservoir Project Champavathi River) with 8755 ha ayacut, and Andra HLC (Champavathi River) with 1659 ha ayacut. Around 17221 ha area irrigated under medium/others irrigation project. **(Fig.1.8)** The area irrigated under different sources is depicted in **Fig.1.8a**.

S.No.	Sources	Gross Irrigation (Ha)	Net Irrigation (Ha)
1	Canal	47096	38185
2	Tanks	59753	54177
3	Tube Wells	23776	9685
4	Dug Wells	7913	3932
5	Others	580	577
Total		**139118**	**106556**

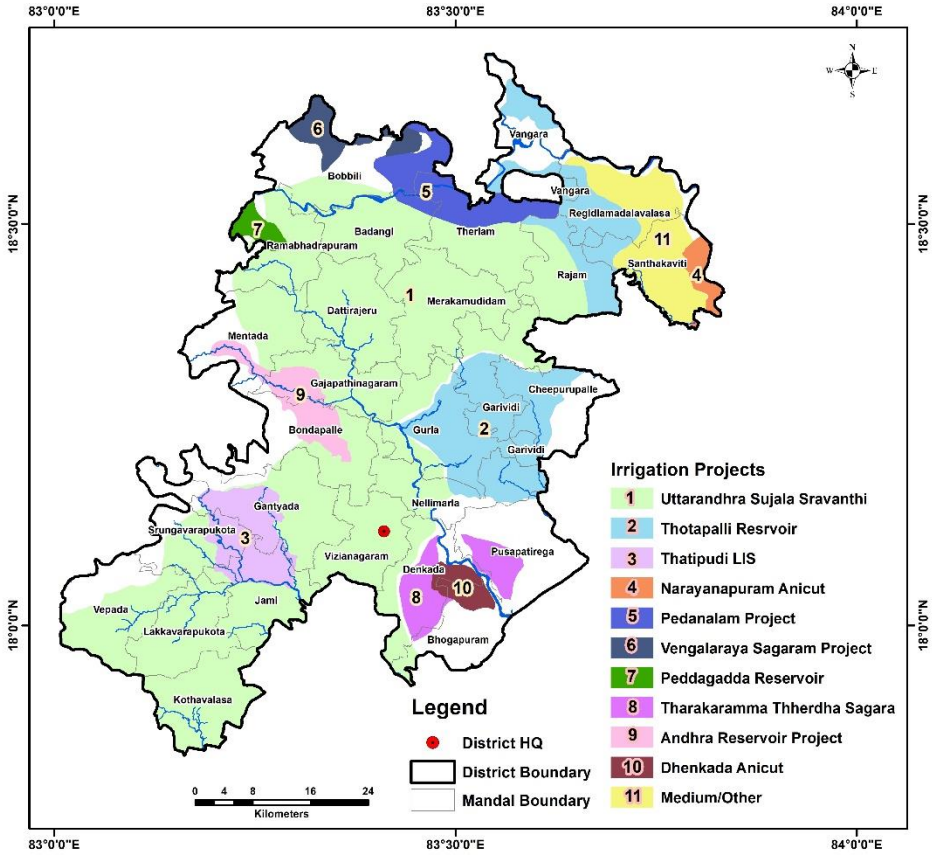
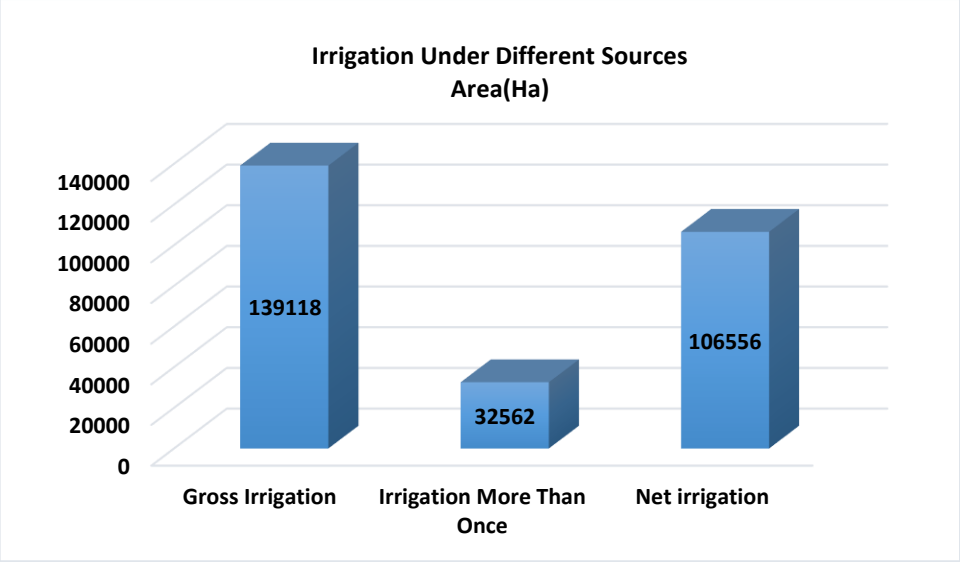


Fig. 1.8: Major and Medium Irrigation Projects of Vizianagaram District
(Source: Water Resource Department)



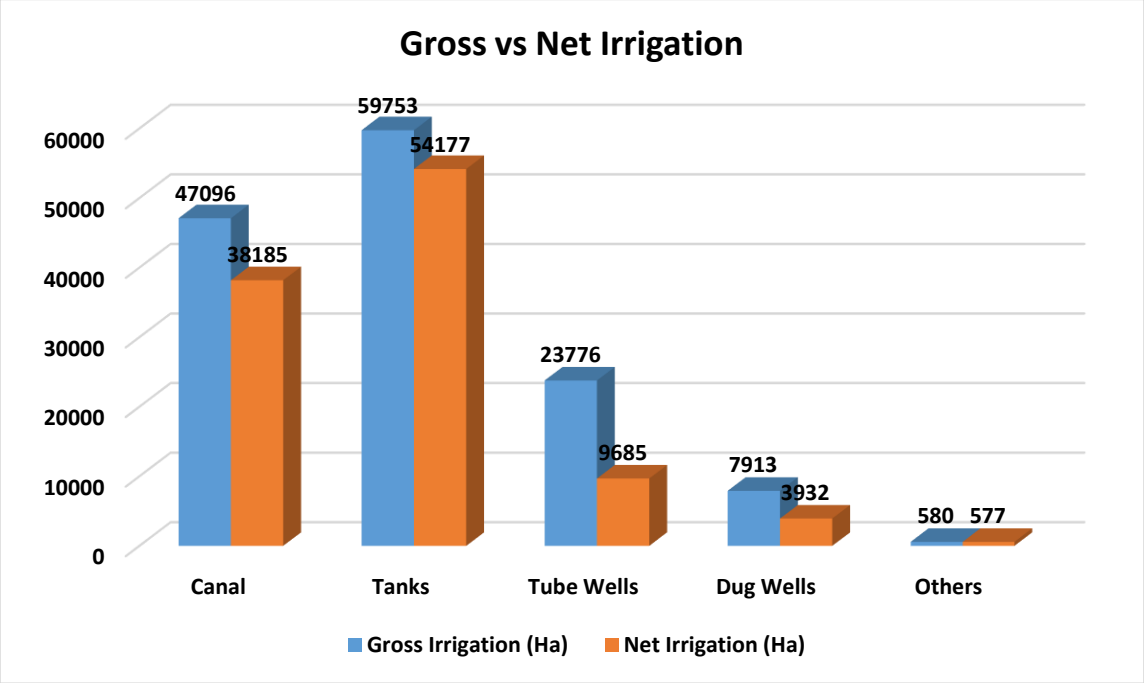


Fig. 1.8a: Area irrigated under different sources.

1.10 Prevailing water conservation/Recharge practices: In the district there are 4194 nos. artificial recharge structures (ARS) and water conservation structures (WCS) are exist among them 232 nos. are percolation tanks and 3962 nos. Check dams (Source: APWRIMS)

1.11 Geology: The Vizianagaram district is underlain by various geological formations, namely Khondalite (60%), Granite gneiss (13%), Charnockites (24%), Alluvium (2%), Quartzite (1%) and Laterite (1%). The Khondalite group include quartzite, talc-granulite, talc-silicate, garnetiferrous quartzo-feldspathic gneisses with sillimanite and graphite. The Charnockite group include pyroxene granulite (basic charnockite) and charnockite (acid/intermediate). The Migmatite group include porphyroblastic hypersthene-biotite gneiss, hypersthene-quartz-feldspar augen gneiss, cordierite-hypesthene gneisses with biotite and granitoid gneiss. The Upper Gondwanas and Tertiaries are represented by sandstones and shales, but these formations are not exposed in the study area as laterite occur as capping on the Khondalite. The alluvium occurs along the river courses consisting of sandy clay, sands and gravel. The general geological succession of the area is given in **Table 1.1** & **Fig.1.9.**

Sl.No.	Geology	Area (sq.km)
1	Khondalite	2357
2	Charnockite	929
3	Granite Gneiss	500
4	Alluvium	71
5	Quartzite	52
6	Laterite	36

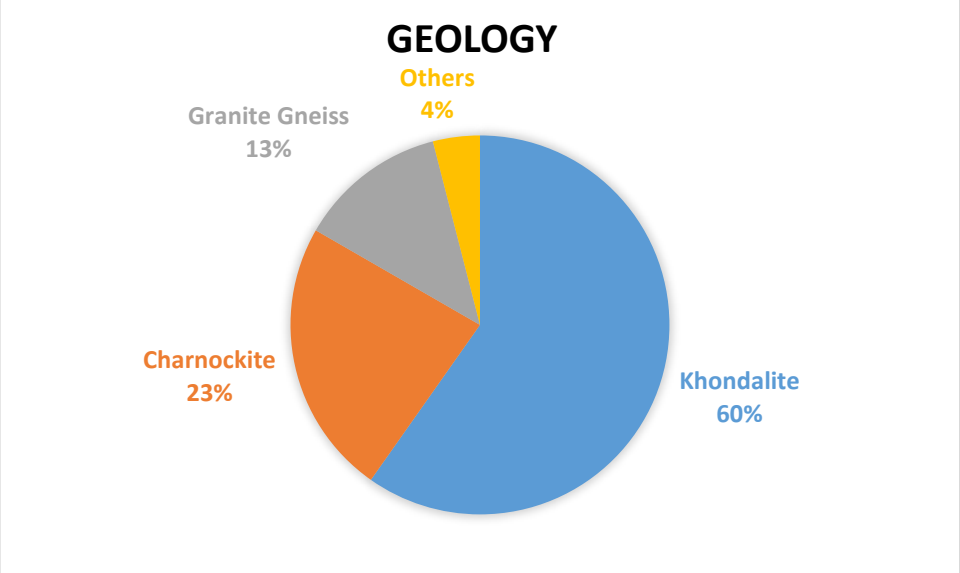


Table 1.1: Geological Succession of the Study Area

Age	Super Group	Group	Formation	Lithology
Quaternary			Soils/Alluvium	Soil, sand, silt and clay.
Cenozoic			Laterite	Laterite
Cretaceous to Jurassic		Upper Gondwana	-	Sandstones and clays
Archaean	Eastern Ghat Super Group	Migmatite Group	Younger Intrusive	Pegmatites and quartz veins Porphyroblastic charnockites Porphyroblastic gneissic granites
			Migmatites	Biotite gneisses Charnockites Migmatised quartzite Cordiorite bearing gneisses Migmatised sillimanite gneisses
			Old Intrusive	Quartzo feldspathic gneisses
		Charnockite Group	Basic Charnockite	Pyroxene granulites
		Khondalite Group	Khondalite Suite (Meta sediments)	Calc-sillicate rocks Quartzites Granites sillimanite gneisses

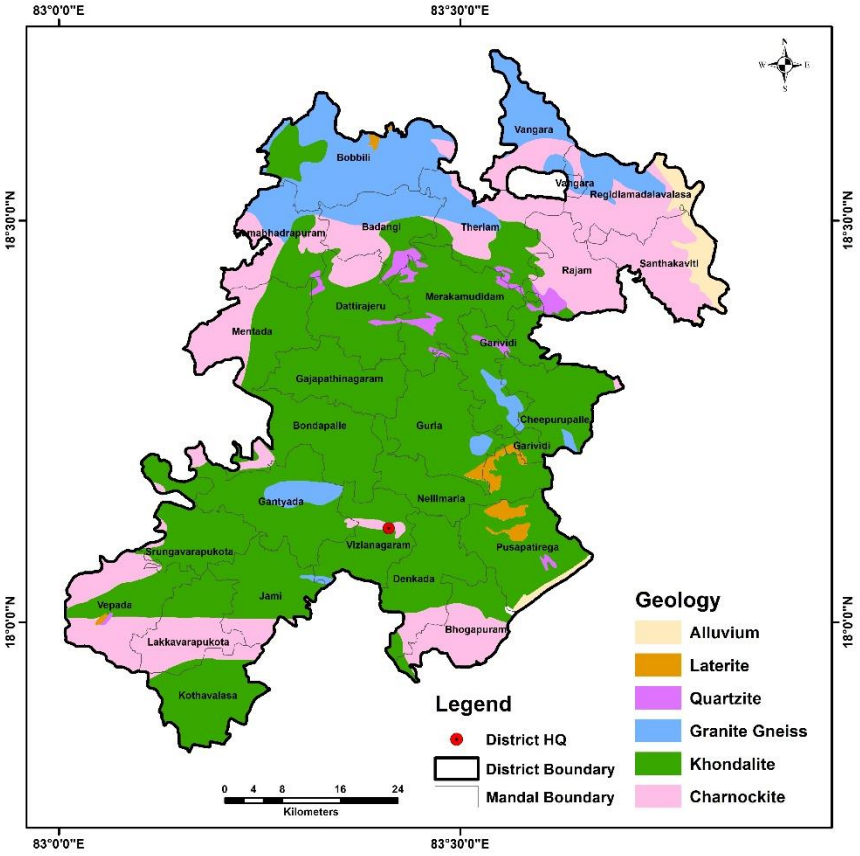


Fig.1.9: Geological map of Vizianagaram district.

2. DATA COLLECTION AND GENERATION

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-2.1)**.

Table-2.1: Brief activities showing data compilation and generations.

S. No.	Activity	Sub-activity	Task
1	Compilation of existing data/ Identification of Principal Aquifer Units and Data Gap	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.
		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.

2.1 Hydrogeological Studies

Hydrogeology is concerned primarily with mode of occurrence, distribution, movement and chemistry of ground water occurring in the subsurface in relation to the geological environment. The occurrence and movement of water in the subsurface is broadly governed by geological frameworks i.e., nature of rock formations including their porosity (primary and secondary) and permeability. The principal aquifer in the area is granites gneisses, Charnockites, khondalites, migmatites, quartzites and intrusives. The occurrence and movement of ground water in these rocks is controlled by the degree of interconnection of secondary pores/voids developed by fracturing and weathering. Based on 254 hydrogeological data points, hydrogeological map is prepared. (**Fig.2.1)** The details of data availability is given bellow-

Organisation	Water Level	Water Quality	Aquifer Geometry		Geophysical
			EW/OW	VES	VES
CGWB	22	25	44	38	38
State GW Dept.	32	73	-	20	20
Total	54	98	44	58	58

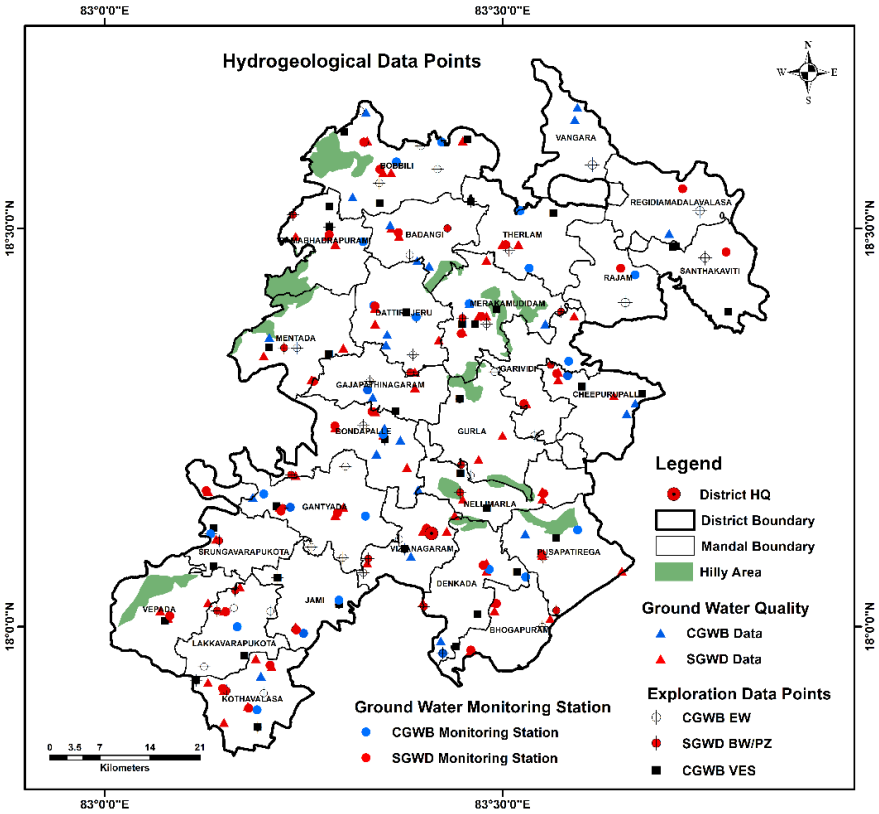


Fig. 2.1: Hydrogeological data availability.

2.1.1 Ground water occurrences and movement: Ground water occurs under unconfined and semi-confined/confined conditions and flows downward from the weathered zone into the fracture zone. The main aquifers constitute the weathered zone at the top, followed by a discrete anisotropic fractured/fissured zone at the bottom, generally extending down to 200 m depth. The potential fracture zones were encountered within the depth range of 30 to 100 m only. The discharge in the exploratory wells vary from meagre to as high as 5.2 lps with general range of 0.1 to 2.0 lps. The specific capacity of the bore wells varies from 1.05 to 72.7 lpm /m.d whereas the Transmissivity ranges from 0.144 to115 m^2/day. The storage co-efficient of bore wells vary from 4.8 x 10^{-5} to 1.2 x 10^{-3}. The hydrogeological map of the area is presented in **Fig. 2.2.**

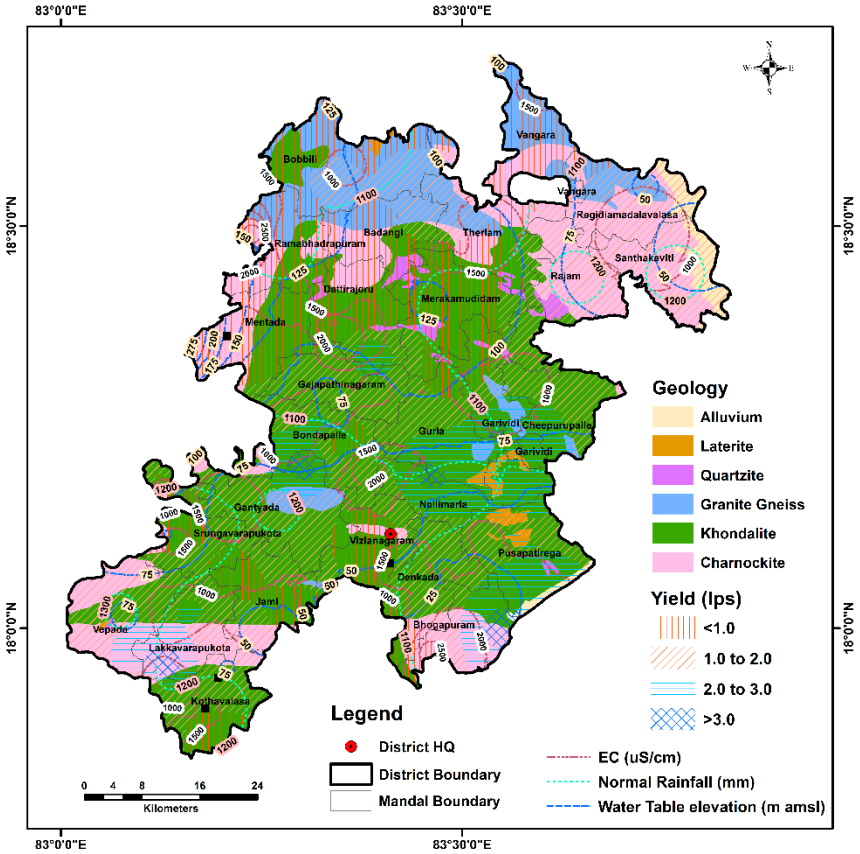


Fig.2.2: Hydrogeological map of Vizianagaram district.

2.1.2 Exploratory Drilling: As on 31/03/2022, CGWB drilled 44 no's bore wells (38 no's exploratory and 6 no's observation), 34 wells were drilled in granite gneiss area and 10 wells were drilled in khondalitic area. Data analysed from CGWB wells indicates, 5 no's well of depth ranges 24-100 m, 9 no's (100-150 m), 30 no's (150-200 m) depth. The deepest fracture was encountered at 197 m. bgl at Bobbili, Bobbili mandal.

2.1.3 Ground water Yield: Ground water yield of granitic gneisses aquifers varies from <0.1 to 5.2 lps (avg: < 1 lps) and khondalite aquifers varies from <0.1 to 3.3 lps (avg. 1.5 lps). The low yield (<1 lps) occurs in ~33 % of area; 1 to 2 lps yield occurs in ~51 % of area; 2 to 3 lps yield occurs in ~14 % of area and >3.0 lps yield covering reaming part (2%) of the district. (**Fig.2.3)**

S.No.	Yield	Area (Sq. Km)	% Area
1	<1.0	1318	33
2	1.0 to 2.0	2014	51
3	2.0 to 3.0	552	14
4	>3.0	63	2

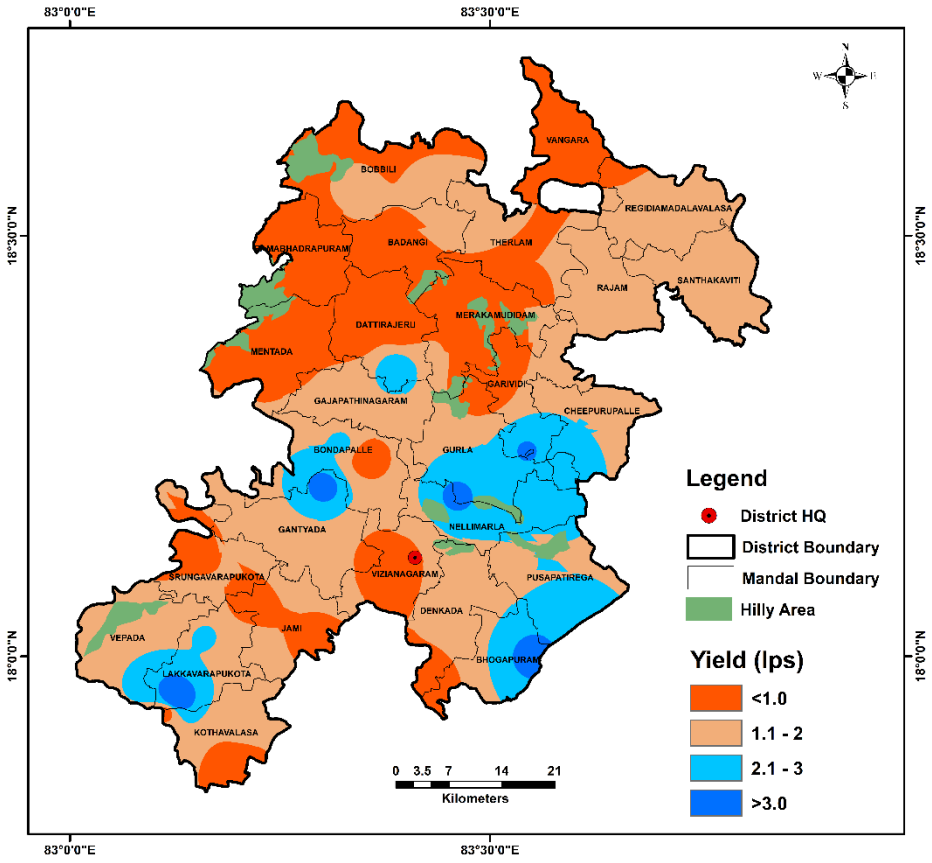


Fig.2.3: Ground water yield potential map of Vizianagaram district.

2.2 Water Levels: Ground water levels from 54 piezometers (CGWB: 22 and SGWD: 32 were monitored for pre-monsoon and post-monsoon season.

2.2.1 Water Table Elevations: During pre and post-monsoon season (May and November), the water-table elevation ranges from 2.71 to 145.7 and 7.09 to 148.5 meter above mean sea

level (m amsl) respectively and general ground flow is towards Nagavali river in north and central parts and towards Champavati and Gosthani river in southern parts i.e., towards SW in the northern parts, East and NE in the central parts of the district and SE direction in the southern parts of the district. (**Fig.2.4**)

2.2.2 Depth to Water Levels (DTWL): The average DTWL of 10 years (2011 to 2021) for pre-monsoon and post-monsoon were analysed, the avg. DTWL varies from 1.48 to 14.27 meter below ground level (m bgl) (average: 5.51 m bgl) and 0.37 to 12.26 m bgl (average: 2.87 m bgl) during pre-monsoon and post-monsoon seasons respectively.

Pre-monsoon season: Majority of the water levels during this season are in the range of 5.0 to 10 m covering 56 % of the area, followed by 2.0 to 5.0 m bgl (43 %) <2 m bgl (1%) and >10 m bgl (1%). The water levels > 10 m bgl occupy in parts of Ramabhadrapuram, Bhogapuram and Kothavalasa mandals. (**Fig.2.5**)

Sl.No.	Pre-monsoon WL	Area (Sq.km)	% Area
1	5-10m	2201	56
2	2-5m	1688	43
3	<2m	26	1
4	>10m	32	1

Post-monsoon season: Majority of the water levels during this season are in the range of 2.0 to 5.0 m covering 77 % of the area, followed by 5.0 to 10 m bgl (17 %), < 2.0 m bgl (6 %). The water levels > 10 m bgl occupy only 6 sq.km of the area falling in parts of Kothavalasa mandal only. The shallow water level < 2.0 m bgl occupy in parts of S. Kota, Jami, Gantyada, Vizianagaram, Nellimerla, Pusapatirega, Bobbili, Badangi, Vangara, Santhakaviti and Regidiamavalavasa mandals. (**Fig.2.6**)

Sl.No.	Post-monsoon WL	Area (Sq.km)	% Area
1	5-10m	674	17
2	2-5m	3025	77
3	<2m	240	6
4	>10m	6	0

2.2.3 Water Level Fluctuations (May vs. November): The water level fluctuations vary from 0.15 to 6.90 m with average rise of 2.74 m (**Fig.2.7**). The water levels rise is observed throughout the district and no fall in water level is recorded. Rise in water level range of 2 to 3 m covers majority of the area with 52 % followed by 3 to 4 m rise in 26 % and <2 m rise in 19% of the area. The rise of water levels > 4 m is observed only in 2 % of area in parts of Bhogapuram, Therlam, Garividi and Gurla mandal.

Sl.No.	WL Fluctuation	Area (Sq.km)	% Area
1	2-3 m	2067	52
2	3-4m	1018	26
3	<2m	766	19
4	>4m	96	2

2.2.4 Long term water level trends: Trend analysis for the last 10 years (2011-2021) is studied from 49 hydrograph stations of CGWB and SGWD. It is observed that during pre-monsoon season 38 wells shows rising trend ranging 0.01 to 0.78 m/yrs and 11 wells shows falling trends ranging 0.002 to 0.22 m/yrs. During post-monsoon season 40 wells shows raising trend ranging 0.001 to 0.66 m/yrs and 9 wells shows falling trends ranging 0.007 to 0.88 m/yrs. The magnitude of trend values indicates that significant change is not occurred in the ground water scenario except at few places. The Long-term water level trends of Pre-monsoon and Post-monsoon map is shown in **Fig.2.8 & Fig.2.9** respectively and representative hydrograph are shown in **Fig.2.10.**

S.No.	Pre-monsoon WL Trend	Area (Sq.km)	% Area
1	0.00-0.22	273	7
2	-0.5 to -0.25	805	20
3	0 to -0.25	2826	72
4	<-0.50	43	1

S.No.	Post-monsoon WL Trend	Area (Sq.km)	% Area
1	.001 to 0.88	338	9
2	-0.5 to -0.25	172	4
3	-0.25 to 0	3397	86
4	<-0.50	40	1

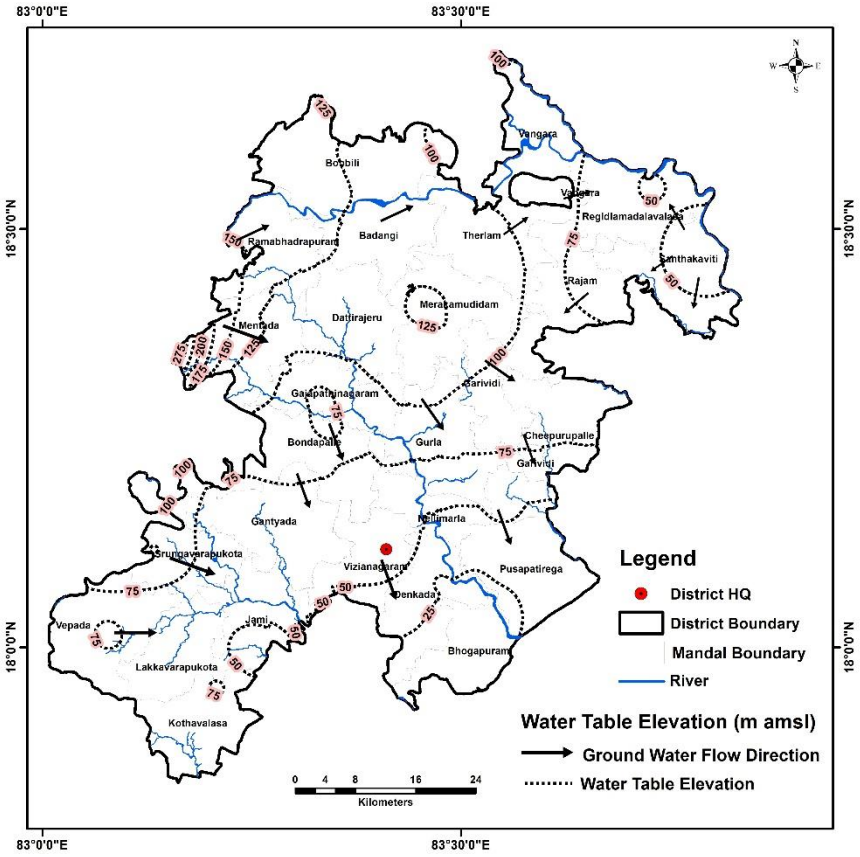


Fig.2.4: Water table elevation map (m amsl)

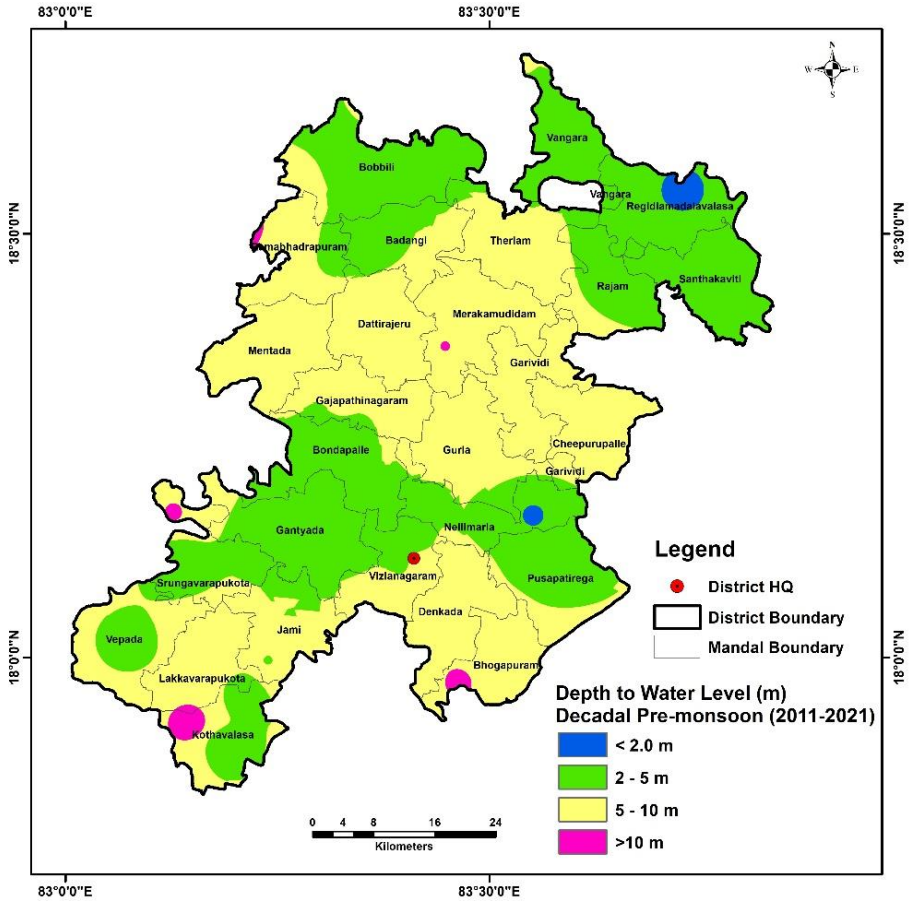


Fig.2.5: Depth to water levels Pre-monsoon (Average).

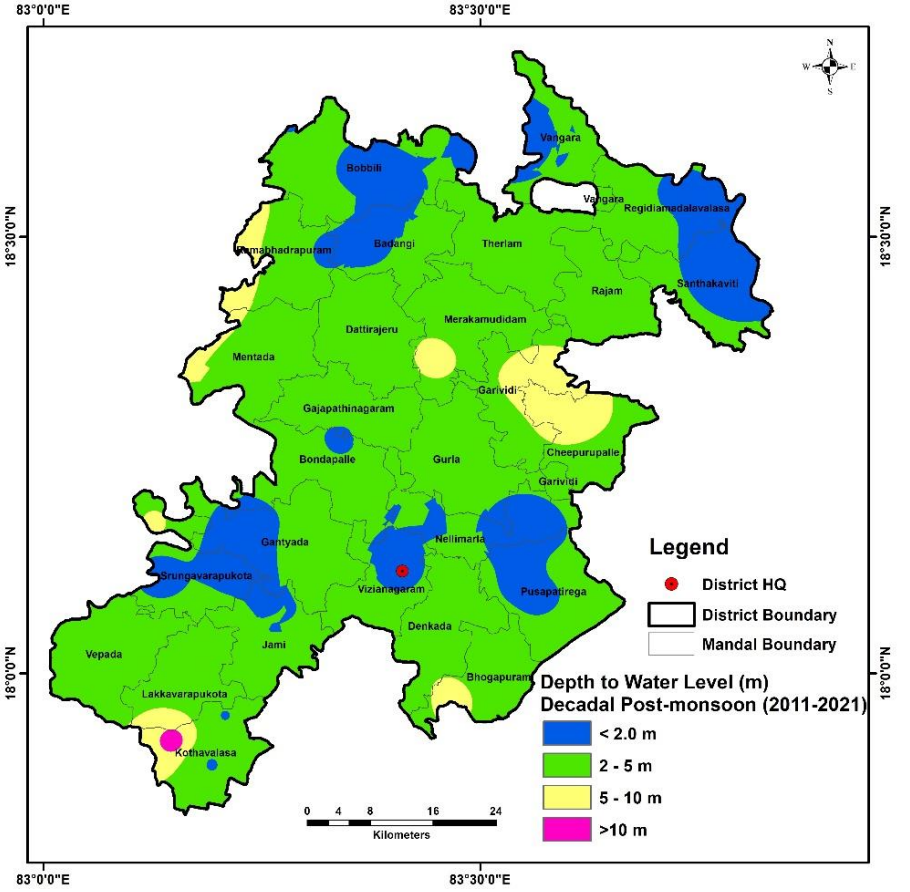


Fig.2.6: Depth to water levels Post-monsoon (Average).

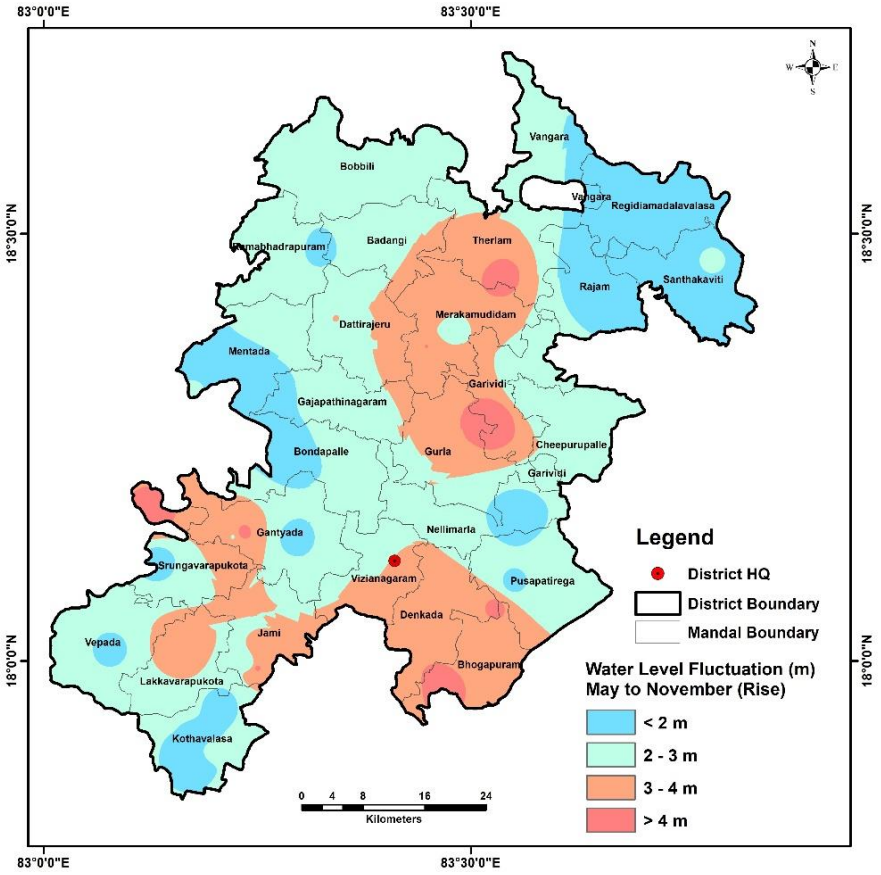


Fig.2.7: Water Level Fluctuations (m) (Nov with respect to May).

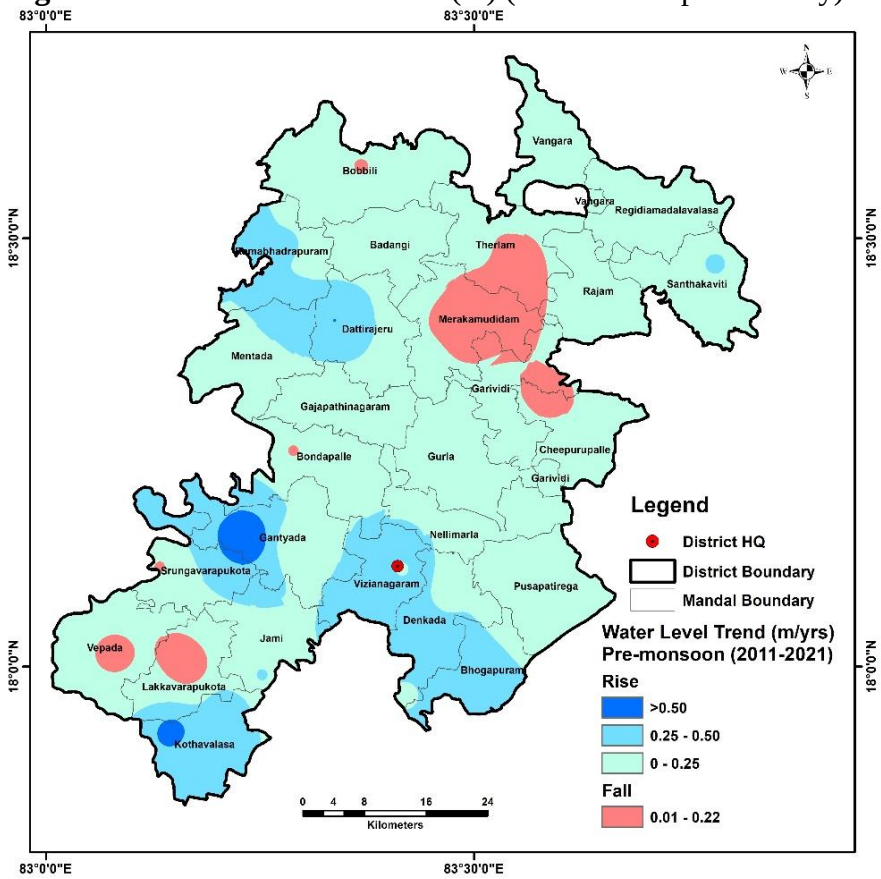


Fig. 2.8: Long-term water level trends of Pre-monsoon (2011-2021).

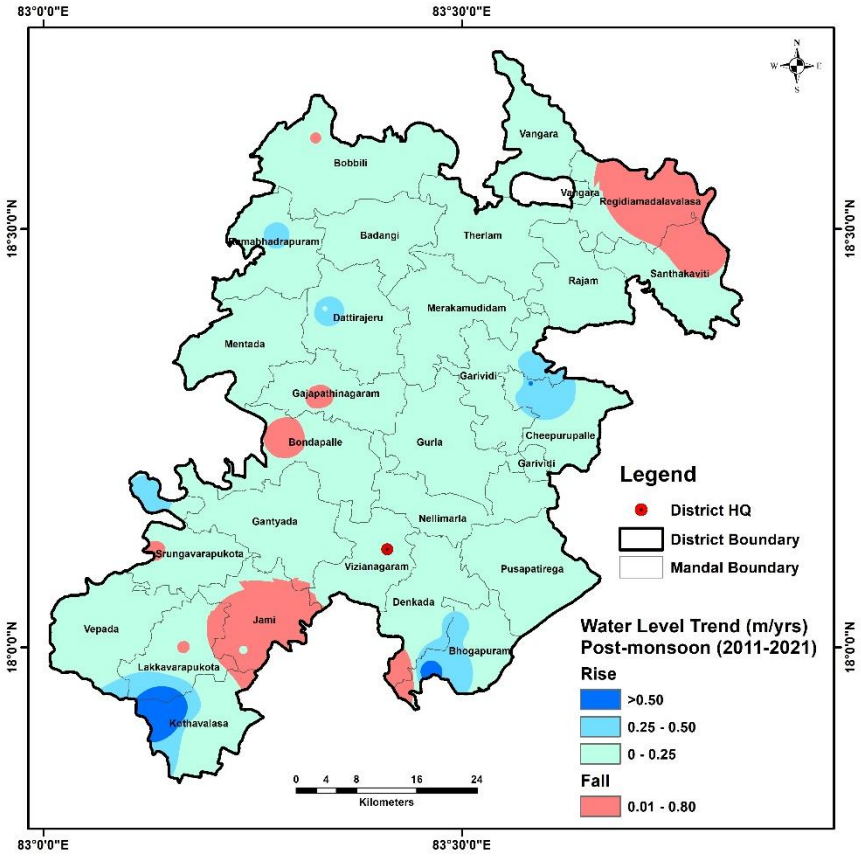
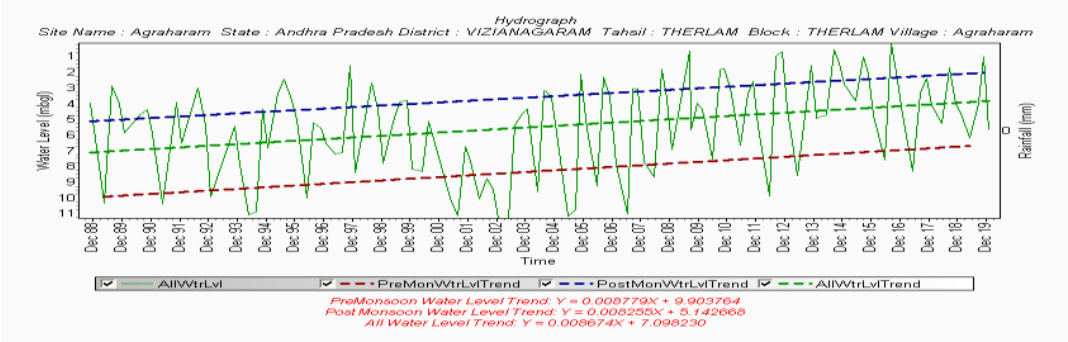


Fig. 2.9: Long-term water level trends of Post-monsoon (2011-2021).



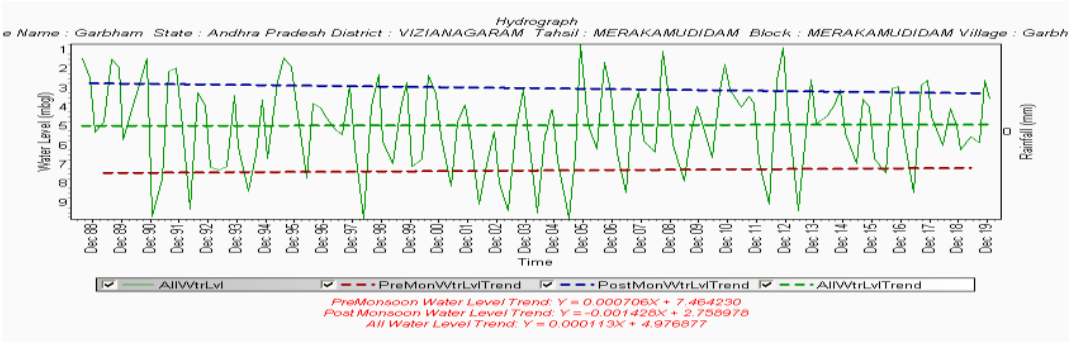


Fig.2.10: Representative Hydrographs of Vizianagaram district.

2.3 Geophysical Studies:

Vertical Electrical Sounding (VES) were carried out in 38 locations across the of Vizianagaram district and able to demarcate semi-weathered, weathered, fracture zone and basement of khondalites and charnockites. Attempt on factor analysis of VES data at each location marked probable occurrence of fractured aquifer in compact rocks. An analysis of VES curve matches more or less with the occurrence of aquifers and lithology of exploratory drilling.

A total of 38 VES data is interpreted, which reveals resistivity 5.0-125 ohm (Ω) m for weathered khondalite (5-46 m), 18-93 Ω m for underlying fractured khondalite with depth ranges between 24-95 m and 53-940 Ω m for massive khondalite. Resistivity < 40 ohm (Ω) m for weathered charnockite (7-25 m), 38-225 Ω m for underlying fractured charnockite (30-107 m) and > 3275 Ω m for massive charnockite rocks.

2.4 Hydro chemical Studies:

To understand chemical nature of groundwater, 194 data are being used for spatial and temporal variation of ground water quality. (Pre-monsoon:98 and post-monsoon: 96). The parameters namely pH, EC (in µS/cm at 25° C), TH, Ca, Mg, Na, K, CO_3, HCO_3, Cl, SO_4, NO_3 and F were analysed.

Data Source	Pre-monsoon	Post-monsoon
CGWB	25	27
CGWD	73	69
Total	**98**	**96**

2.4.1 Pre-monsoon:

Groundwater from the area is mildly alkaline to alkaline in nature with pH in the range of 6.56 to 8.78 (Avg: 7.89). Electrical conductivity varies from 241 to 3950 (avg: 1347) µ Siemens/cm**.** In 81 % of area EC is within 1000 to 2000 µ Siemens/cm; in 15 % area, it is 500 to 1000 µ Siemens/cm; in 1 % area it is < 500 µ Siemens/cm; in 3 % area, EC is within 2000 to 3000 µ Siemens/cm, occur in coastal and portion of central western part of the district and EC above >3000 µ Siemens/cm covering < 1% area. (**Fig.2.11).** Nitrate concentration in all samples is below BIS permissible limits of 45 mg/L except 7 samples, and varies between 0.26 to 94.55 mg/L (avg. 18.17 mg/L). The Nitrate concentration >45 mg/L found in ground water at Tarapuram (68.22 mg/L), Almanda (73.72 mg/L),

Bondapalli (68.23 mg/L), Agraharam (49.9 mg/L), Garbham (46.44 mg/L), Bobbili (99.55 mg/L) and Jannivalasa (51.54 mg/L) (**Fig.2.12**). Fluoride concentration varies from 0.08 to 2.31 mg/L (avg. 0.61 mg/L) and all samples falling under permissible limits of 1.5 mg/L, except in Kothavalasa (1.72 mg/L), Darmapuri (2.31 mg/L) and S. Kota (1.52 mg/L) (**Fig 2.13**)

S.No.	Pre-monsoon		
	EC (uS/cm)	Area (Sq.km)	% Area
1	<500	22	1
2	500 to 1000	588	15
3	1000 to 2000	3195	81
4	2000 to 3000	132	3
5	>3000	11	0

2.4.2 Post-monsoon:

The groundwater is mildly alkaline to alkaline in nature with pH in the range of 6.26 to 8.77 (avg. 7.65). Electrical conductivity varies from 180 to 4362 µ Siemens/cm (avg. 1391 µ Siemens/cm). In 73 % of area, EC is within 1000 to 2000 µ Siemens/cm; in 16 % area, it is 500 to 1000 µ Siemens/cm; in 1 % area it is < 500 µ Siemens/cm; in 9 % area, EC is within 2000 to 3000 µ Siemens/cm, occur in coastal and portion of central western part of the district and EC above 3000 µ Siemens/cm covering < 1% area. (**Fig.2.14)** Nitrate concentration in all samples is below permissible limits of 45 mg/L and varies between 0.07 to 437.2 mg/L (avg.30.04 mg/L). Out of 96 samples, 14 sample nitrate concentration is >45 mg/L ranges from 69.61 to 588.14 mg/L (**Fig.2.15)** Fluoride concentration all samples is below BIS permissible limits of 1.5 mg/L and varies from 0.034 to 2.49 mg/L, except in Kothavalasa (2.34 mg/L) and Palligantredu (2.49 mg/L) (**Fig 2.16**)

S.No.	Post-monsoon		
	EC (uS/cm)	Area (Sq.km)	% Area
1	<500	24	1
2	500 to 1000	625	16
3	1000 to 2000	2893	73
4	2000 to 3000	369	9
5	>3000	35	1

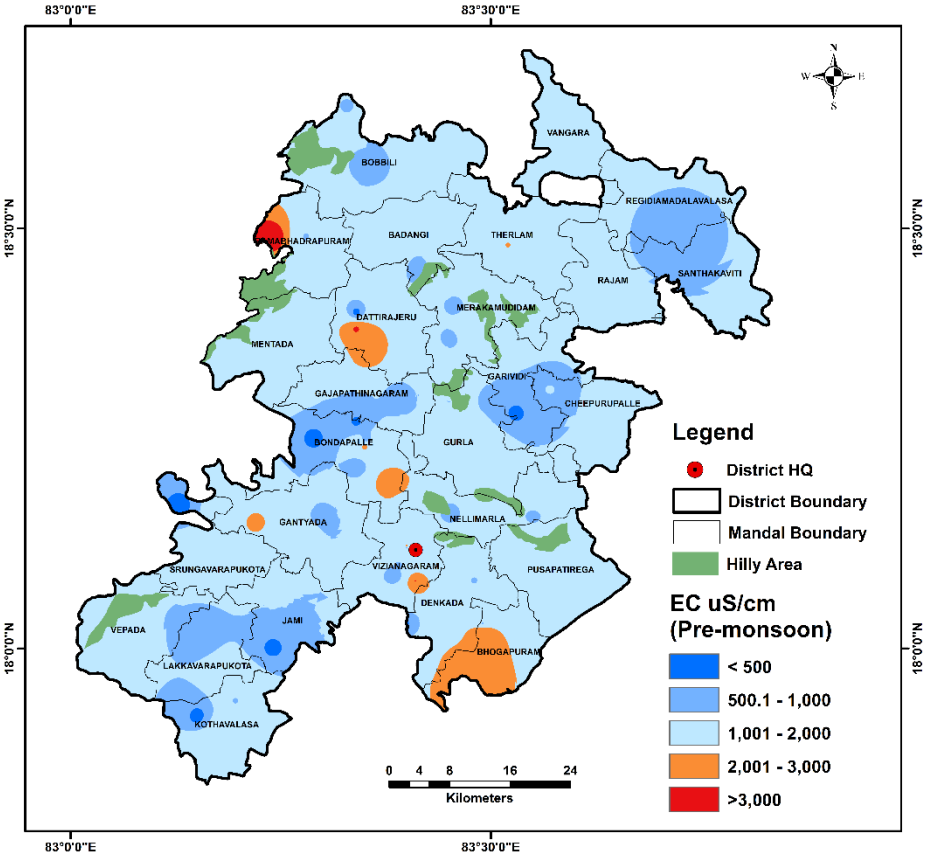


Fig.2.11: Distribution of Electrical conductivity (Pre-monsoon).

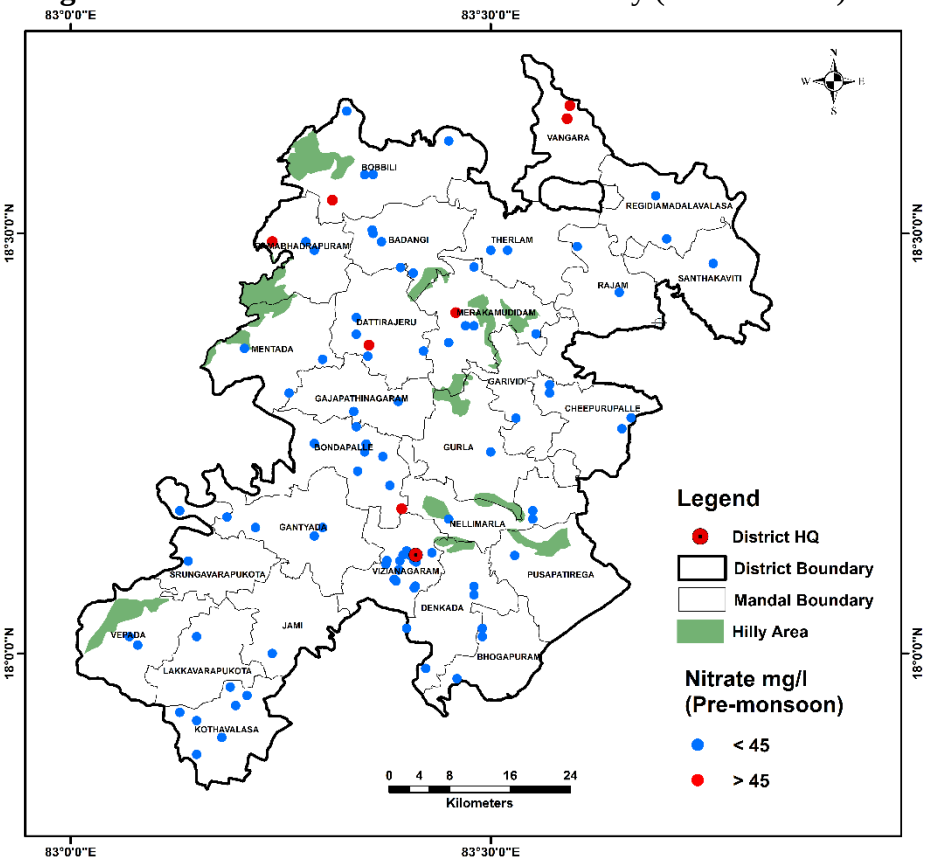


Fig.2.12: Distribution of Nitrate (Pre-monsoon).

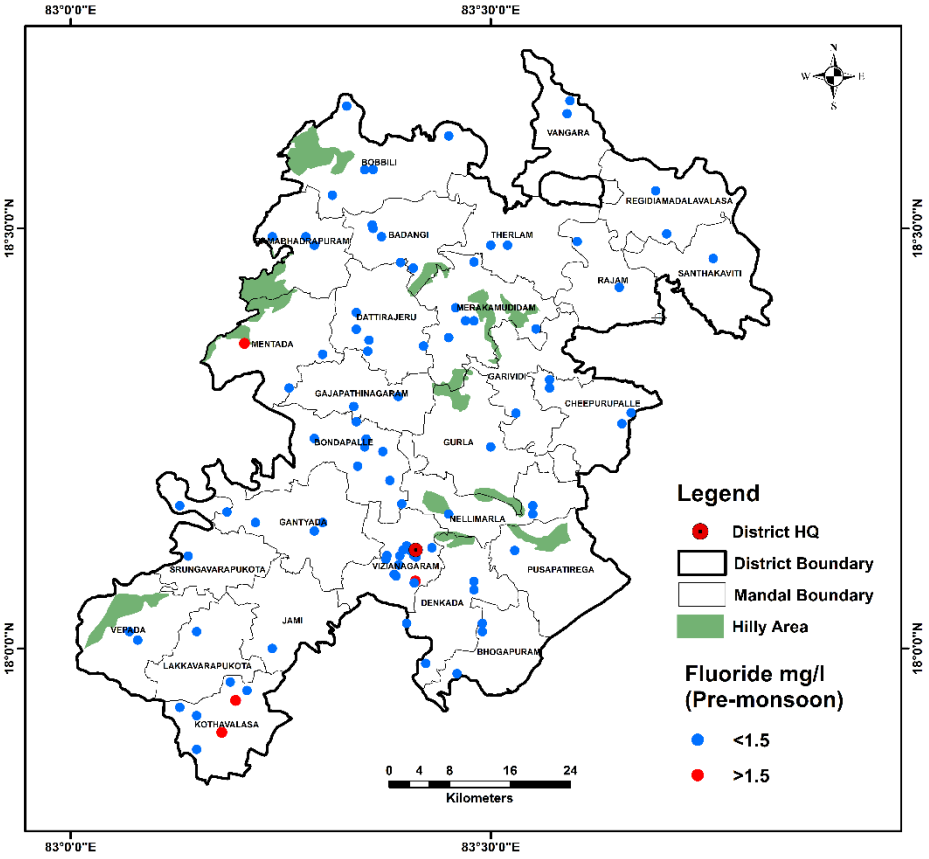


Fig.2.13: Distribution of Fluoride (Pre-monsoon).

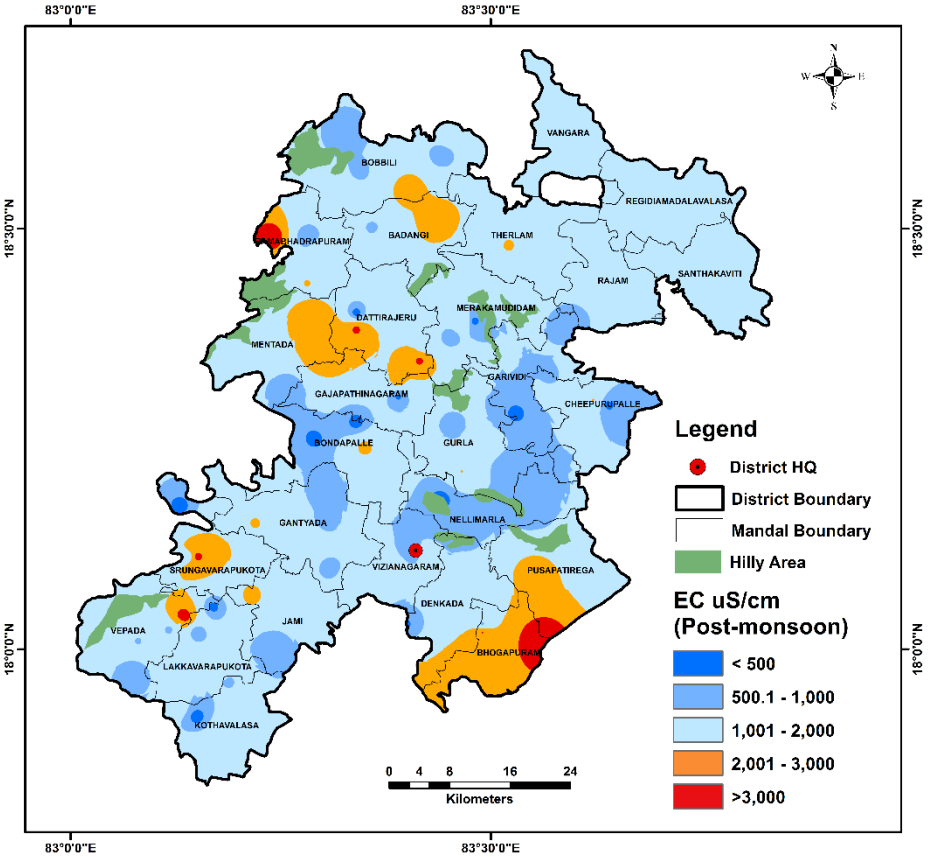


Fig.2.14: Distribution of Electrical conductivity (Post-monsoon).

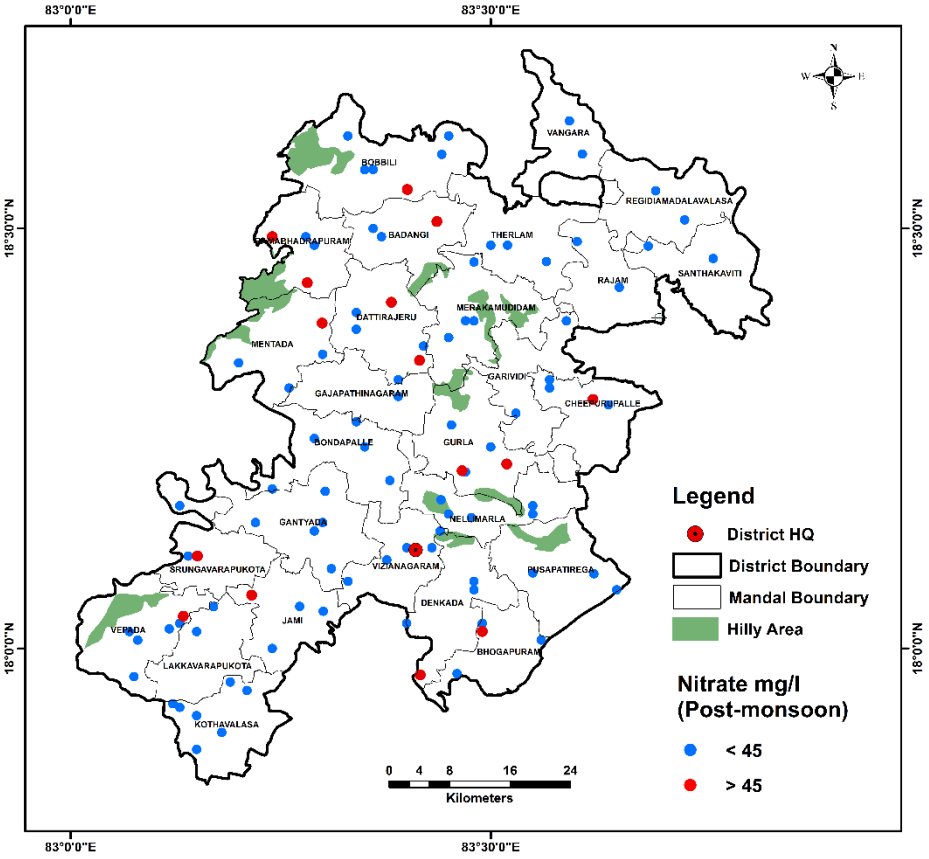


Fig.2.15: Distribution of Nitrate (Post-monsoon).

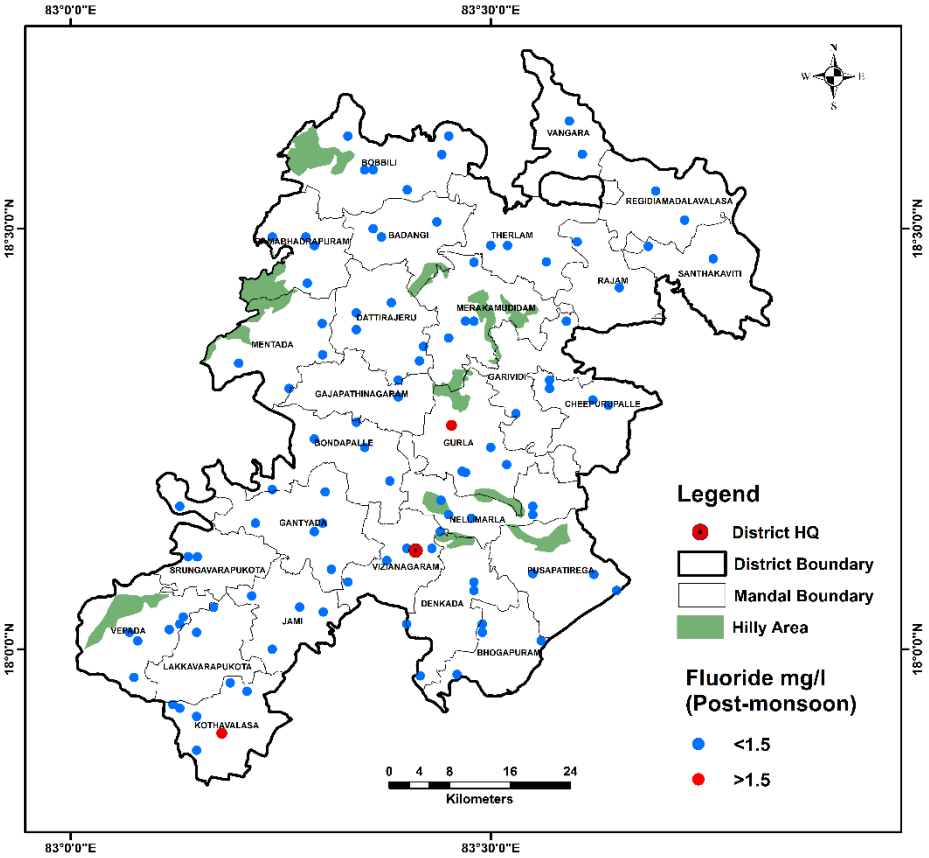
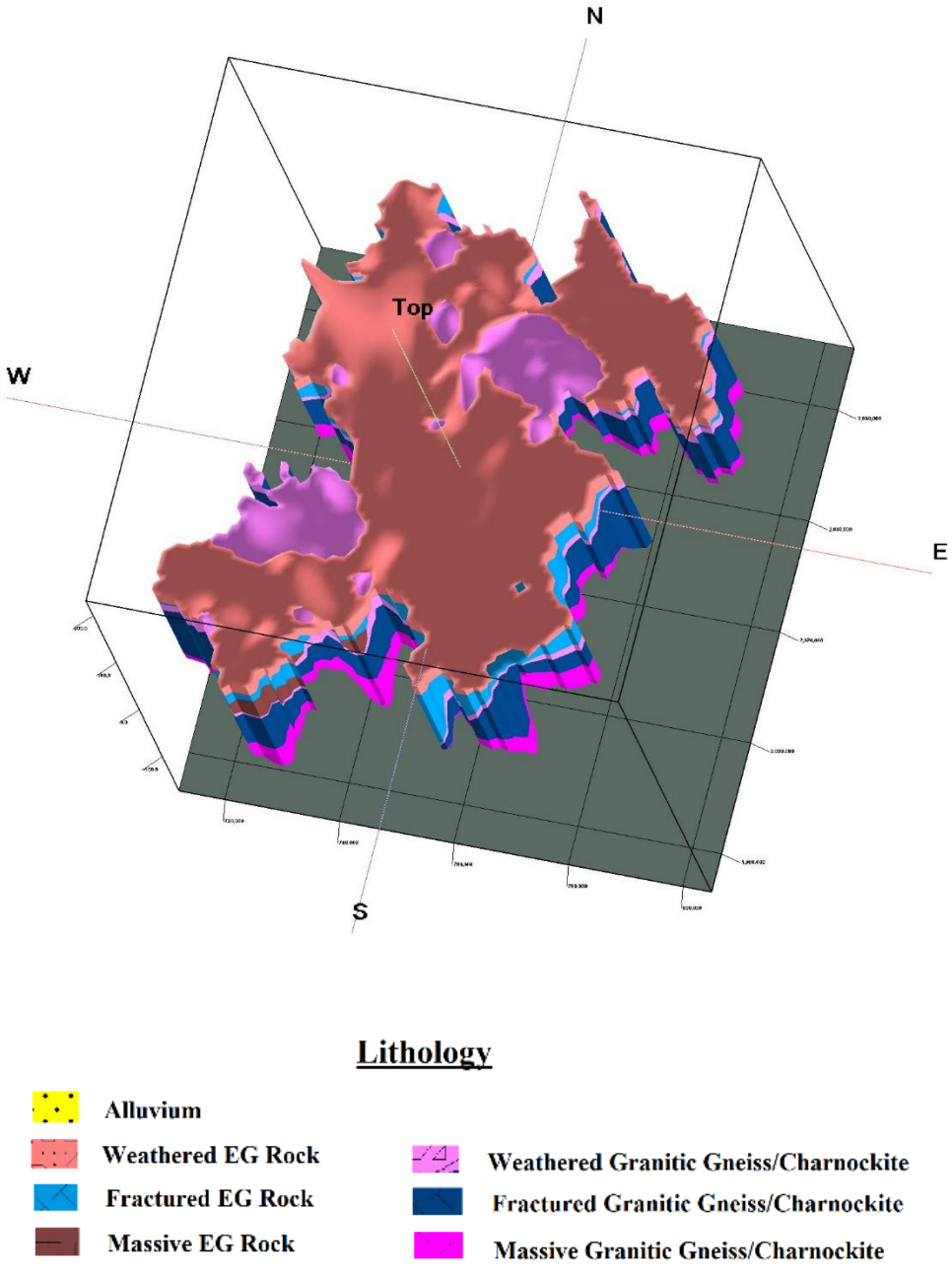


Fig.2.16: Distribution of Fluoride (Post-monsoon).

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

Conceptualization of 3-D hydrogeological model was carried out by interpreting and integrating representative 102 data points (both hydrogeological and geophysical down to 200 m) for preparation of 3-D map, panel diagram and hydrogeological sections. The data is calibrated for elevations with Shuttle Radar Topography Mission (SRTM) data. The lithological information was generated by using the Rock Works-17 software and generated 3-D aquifer disposition, Fence diagram (**Fig.3.1)** and hydrogeological sections of Vizianagaram district. **(Fig.3.3a-c)**



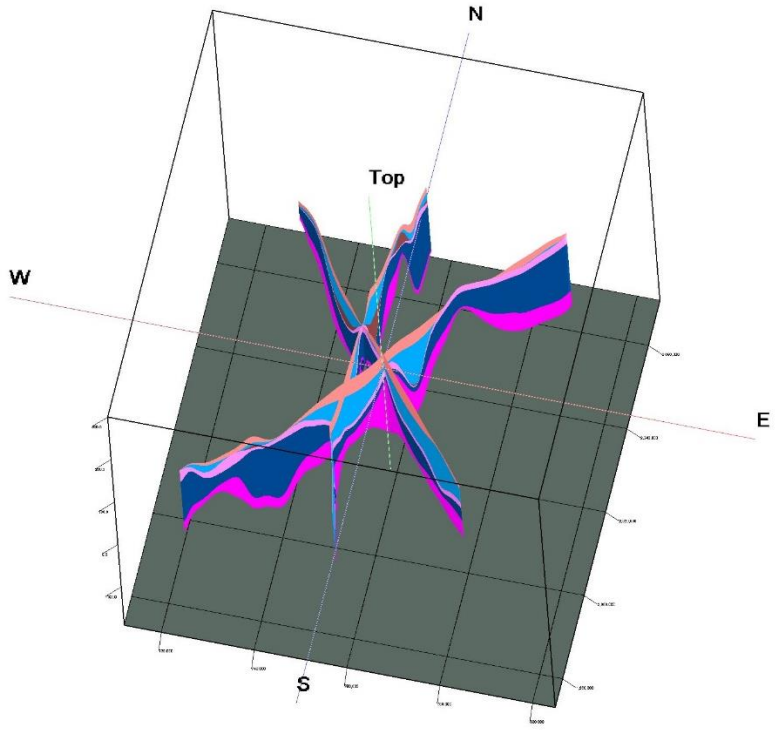


Fig.-3.1:3D Model and Fence Diagram for study area.

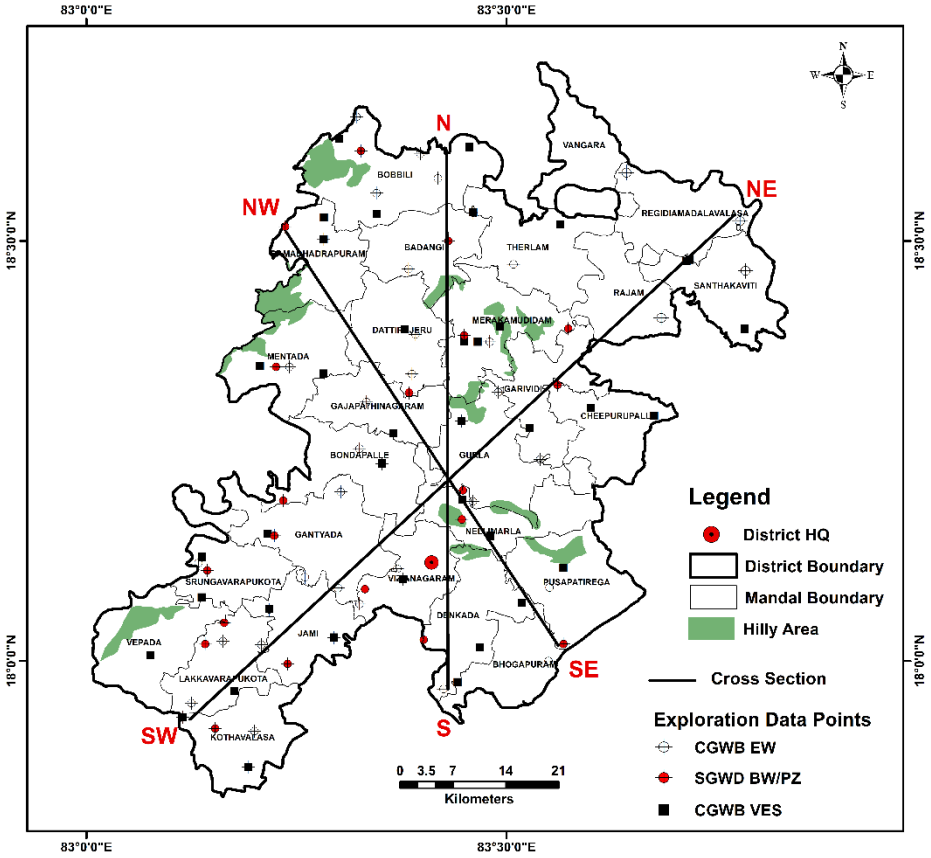


Fig.3.2: Map showing orientation of hydrogeological sections

3.1 Conceptualization of aquifer system in 3D:

Aquifers were characterized in terms of potential and quality based on integrated hydrogeological data and various thematic maps. Weathered zone is considered up to the maximum depth of weathering and first fracture encountered (below weathered depth) generally down to ~21 m depth and the fractured zone (fractured granite) is considered up to the depth of deepest fracture below weathered zone (~21 to 200 m).

3.2 Hydrogeological Sections:

Hydrogeological sections are prepared in N-S, SW-NE and NW-SE direction are shown in **Fig.3.2**.

3.2.1 Hydrogeological Cross Section (N-S): The section drawn along the N-S direction in central part of district covering distance of ~50 km (**Fig.3.3a**). It depicts khondalites are overlying Granitic gneisses in entire section. The deepest fracture occurs at Bondapalle village followed by massive granitic gneisses. At Dattirajeru, thick alluvium followed by fracture khondalite, then massive khondalite and again fracture encountered in granitic gneisses. The shallow depth of fracture encountered at Gotlam and with thick overlying alluvium.

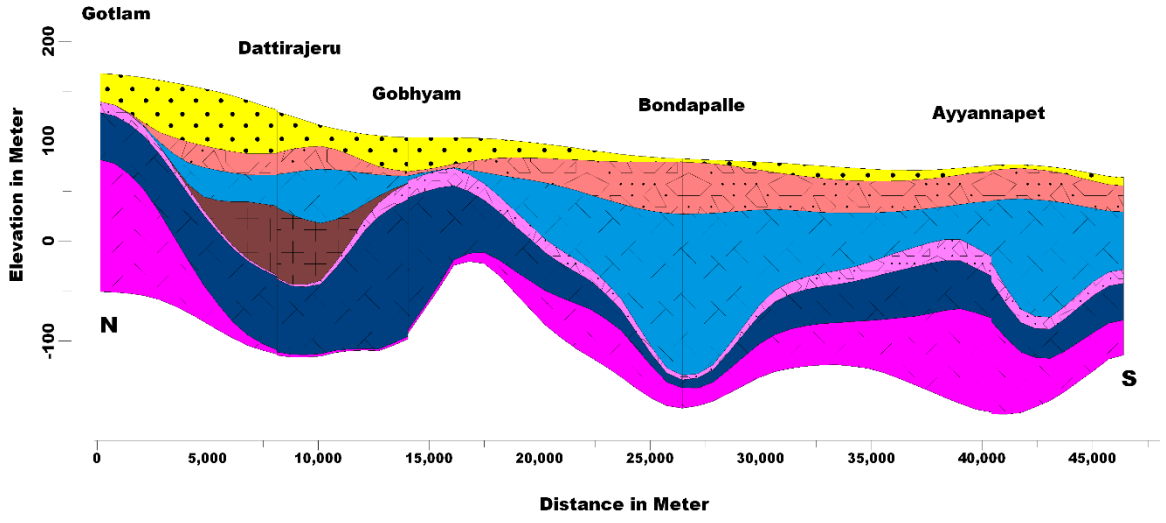


Fig.3.3a

3.2.2 Hydrogeological Cross Section (NW-SE): The section drawn along the NW-SE direction of the district covering distance of ~57 km (**Fig.3.3b**). It depicts weathered khondalite occur entire section with thin alluvium formation except at Pusapatirega and

Nikkalavalasa. At Puspatirega fracture occur at shallow depth in granite gneiss followed by massive granite gneiss/charnockite. The deepest fracture encountered at Bondapalle in khondalite followed by massive granitic gneiss/charnockite.

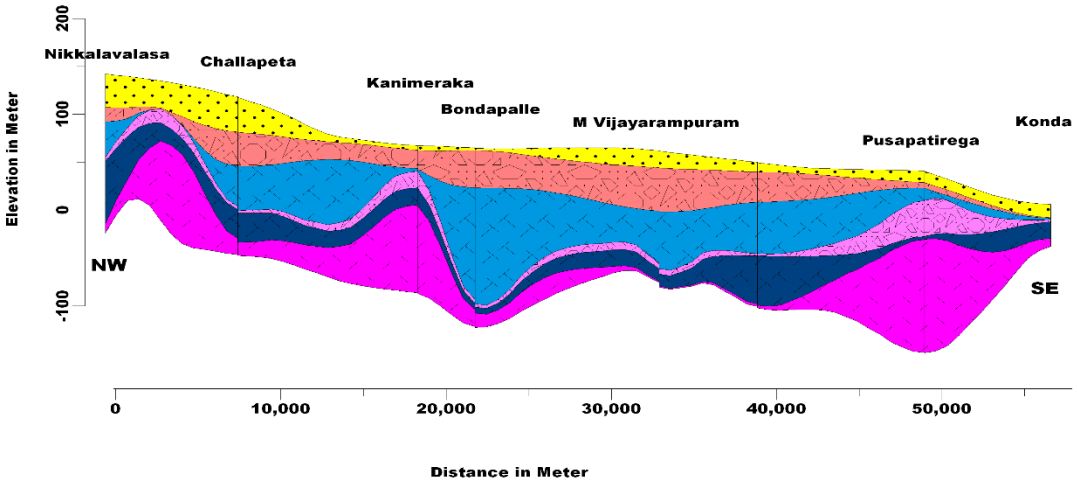


Fig.3.3b.

3.2.3 Hydrogeological Cross Section (SW-NE): The section drawn horizontally along the SW-NE direction of the district covering distance of ~70 km (**Fig.3.3c**). It depicts thick fractured khondalite overlain by weathered khondalite and occur in Bondapalle, P Bantupalle area (NE parts of section). At K.Gandredu weathered khondalite overlying massive granitic gneiss/charnockite rock. Weathered granitic gneiss/charnockite followed by thick fracture zone and massive granitic gneiss/charnockite occurs at S Kota. In south western part of section, fractured granitic gneisses form potential aquifer where as in north eastern part fractured Khondalite forming potential aquifer.

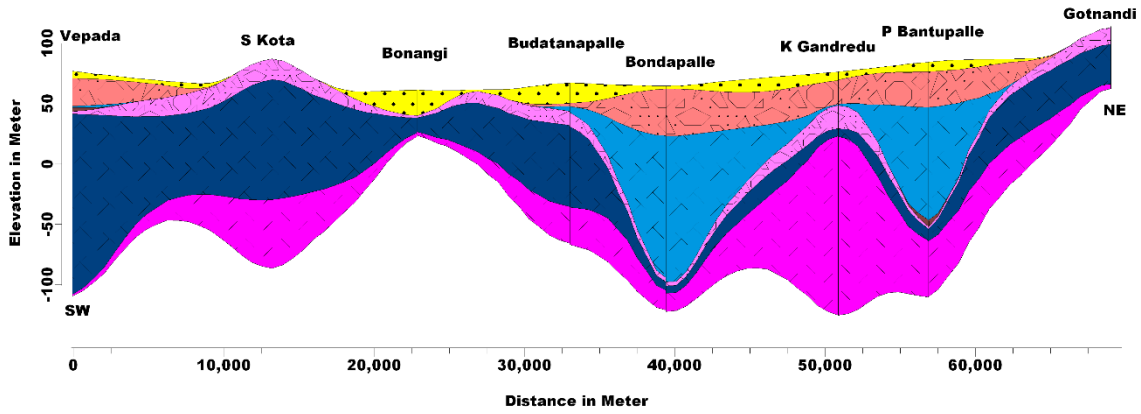


Fig.3.3c

3.3 Aquifer Characterization:

3.3.1 Weathered zone: The weathered zone (avg. ~21 m) varies from 6 to 48 m bgl in khondalitic formation and meagre to 57 m bgl in granitic gneiss formation. The spatial distribution of weathering depth zone map is given in **Fig.3.4**. The weathered zone is in the range of 20 to 30 m in most part of area covering ~65 % of area; <20 m occurs in ~29 % of the area; 30 to 40 m in most part of area covering ~5 % of are and deeper (>40 m) weathering occurs in rest of the area (**Fig.3.5**) The yield of the wells piercing the weathered zone vary from 0.03 to 3 lps depending on the location.

S.No.	Weathering Depth (m)	Area (Sq. Km)	% Area
1	<20	1142	29
2	20 to 30	2556	65
3	30 to 40	215	5
4	>40	34	1

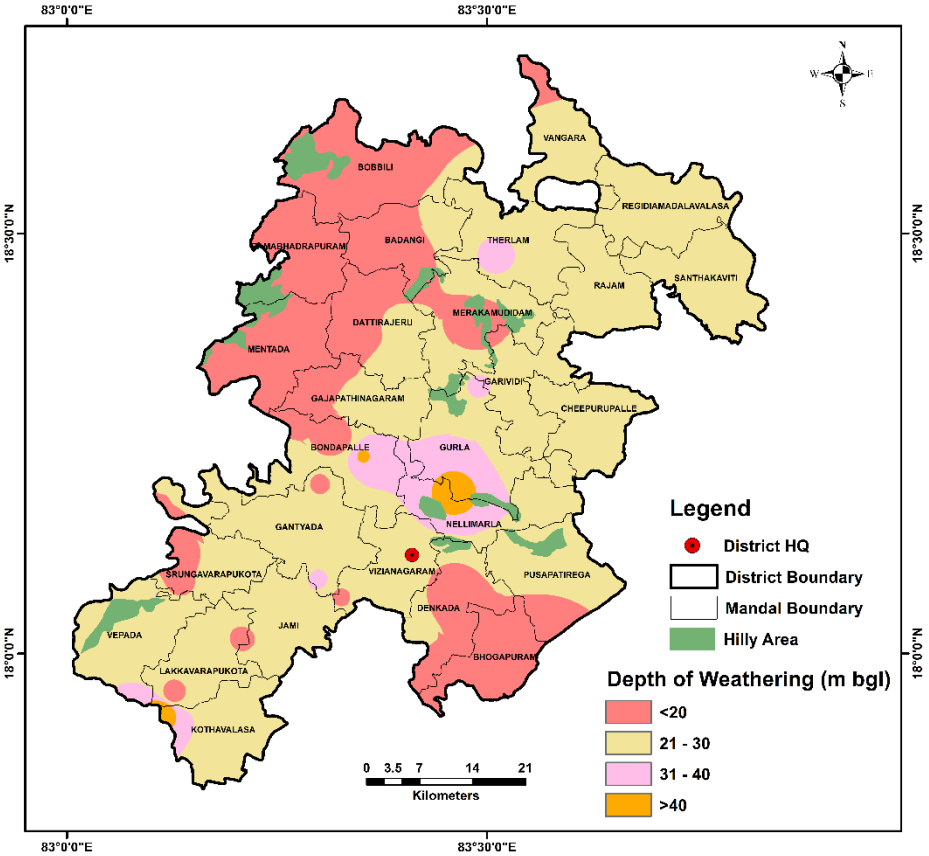


Fig.3.4: Depth to weathering

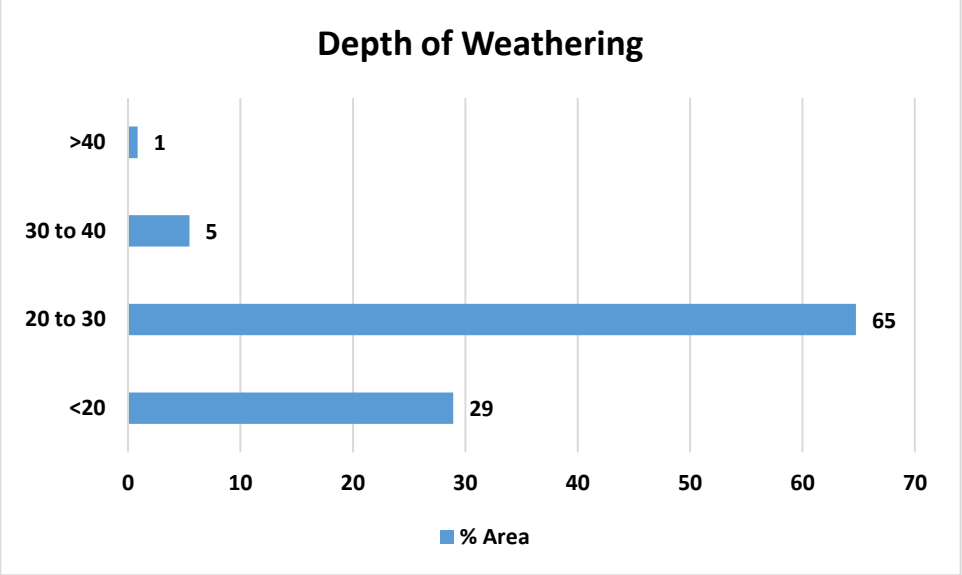


Fig.3.5: Depth wise weathered zone

3.3.2 Fractured zone: The groundwater is extracted mainly through bore wells of 30 to 200 m depth from fractured zone (~10 to 199 m). Based on CGWB and SGWD data, it is inferred that, fractures in the range of 100 to 150 m depth are more predominant (44 % of the area), 60 to 100 m fractures occur in 41 % area; 30 to 60 m and >150 m fractures occur in 9 % and 5 % of area respectively. The deep fractures > 150m occur in parts of Bobbili, Therlam, Bondapalli, Jami, Pusapatirega and Bhogapuram mandals. The shallow fracture (<30 m) occur in ~ 1% area (**Fig.3.6**). The depth ranges of bore wells are between 30 to 200 m bgl with yields varying from 0.5 to 5 lps. The depth wise distribution of fractures, Vizianagaram District shown in (**Fig. 3.7)**

S.No.	Fracturing Depth (m)	Area (Sq.Km)	% Area
1	<30	31	1
2	30 to 60	358	9
3	60 to 100	1606	41
4	100 to 150	1746	44
5	>150	206	5

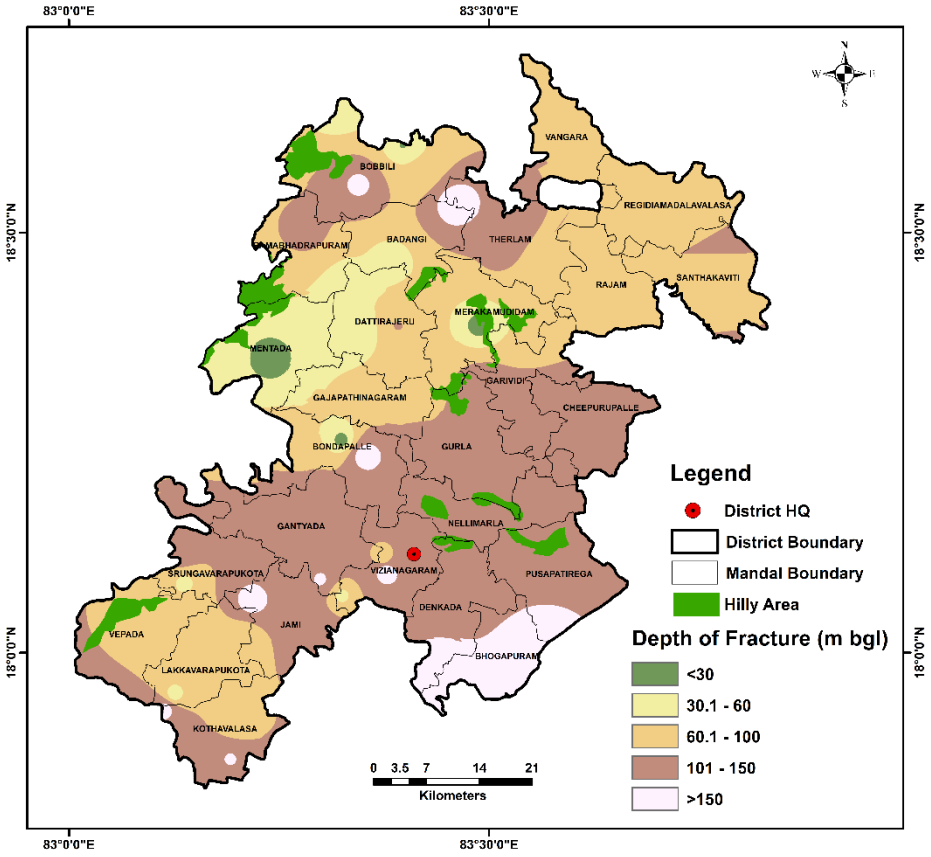


Fig.3.6: Depth of Fracture

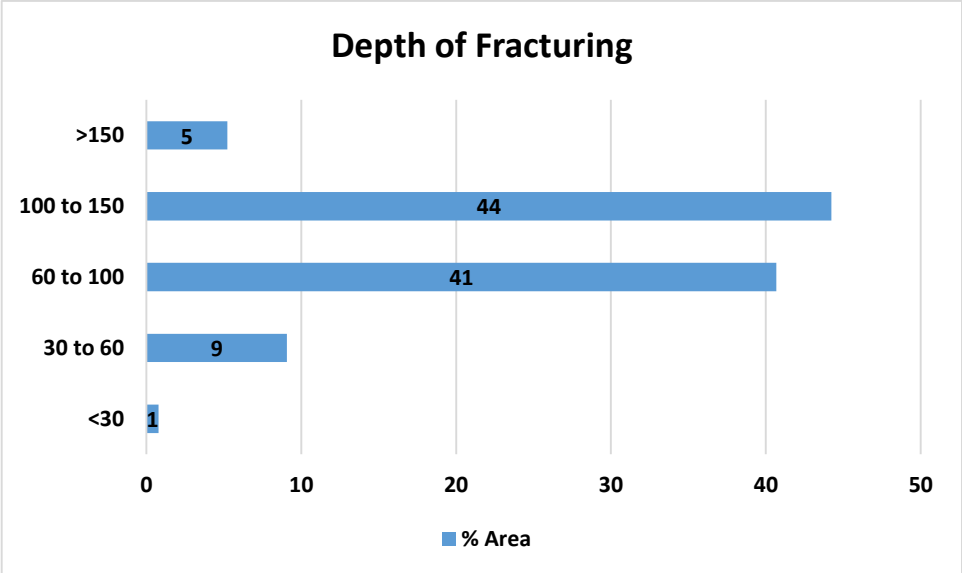


Fig.3.7: Depth wise distribution of fractures

4.0 GROUND WATER RESOURCES (2022)

In hard rocks, for practical purpose it is very difficult to compute zone wise (aquifer wise) ground water resources, because the weathered zone and fractured zone are inter-connected with fractures/joints and fractured zone gets recharged through weathered zone. Therefore, it is very difficult to demarcate the boundary between two aquifers; hence the resources are estimated considering entire area as a single aquifer system. The village wise dynamic and in-storage ground water resources are computed as per the guidelines laid down in GEC methodology.

While computing the in-storage resources, the general depth of deepest fractures in the area, pre-monsoon water levels and 2 % of granular zone (depth below pre-monsoon water level and down to deepest fracture depth in the village) is considered. Computed Dynamic ground water resources and assessment of mandal wise Dynamic Ground Water Resources of the Vizianagaram District, Andhra Pradesh (2022) are given in **Table-4.1 and Annexure-I, II & II**.

Table-4.1: Computed Dynamic ground water resources, Vizianagaram district

Ground Water Resource Assessment		
Year	**2020**	**2022**
Total Area (Sq.km)	4124	4143
Recharge worthy Area (Sq.km)	3998	4013
Resource	**MCM**	**MCM**
Recharge from Rainfall (Monsoon)	321	274
Recharge from Other Sources (Monsoon)	698	685
Recharge from Rainfall (Non-monsoon)	46	28
Recharge from Other Sources (Non-monsoon)	570	488
Total Annual Ground Water Recharge	1636	1474
Total Natural Discharges	82	74
Annual Extractable Ground Water Resource	**1554**	**1400**
Irrigation Use	314	304
Industrial Use	2	1
Domestic Use	19	22
Total Extraction	**335**	**328**
Annual GW Allocation for for Domestic Use as on 2025	50	32

Net Ground Water Availability for future use	**1208**	**1086**
Stage of Ground Water Extraction (%)	**23**	**26**
Categorization (OE/Critical/Semi-critical/Safe)	**Safe**	**Safe**

As per 2022 GEC report, the Annual Extractable Ground Water Resource availability is 1400 MCM, gross ground water draft for all uses 328 MCM, provision for domestic utilisation for the year 2025 is 32 MCM and net annual ground water potential available for future needs is 1086 MCM. Stage of ground water development varies from 4 % in Rajam mandal to 51 % in Gurla mandal (avg. 26 %). Based on present stage of ground water development, 27 mandals are falling under safe category **(Fig-4.1)**

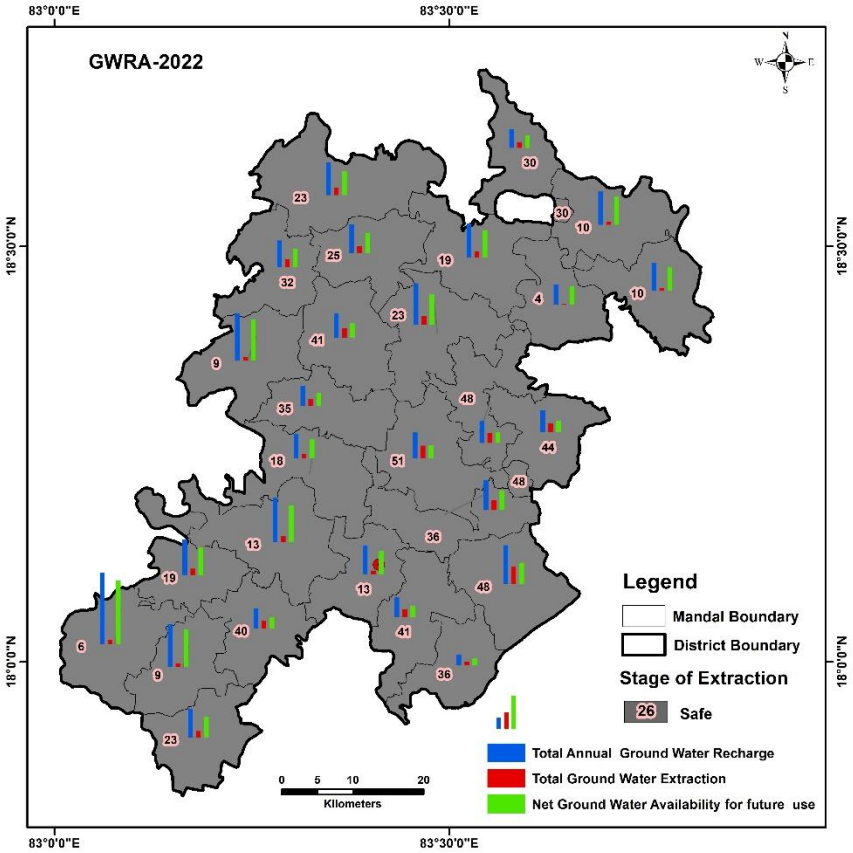


Fig-4.1: Categorization of Mandals (GWRA-2022)

5. GROUND WATER RELATED ISSUES AND REASONS

Groundwater Yield:

- The low yield (<1 lps) occurs in ~33 % of area and 1 to 2 lps yield occurs in ~51 % area of the district.
- The low yield is due to crystalline terrain and absence of primary and secondary porosity, poor interconnection of fractures and less recharge during rainy season. Among the crystalline formations granite gneiss/charnockite have developed moderate to highly fractured zones compared to khondalite formation. In khondalite formation, fractures after saturation gets highly weathered and form clay due to chemical decomposition and filled fracture zones. Hence, yielding very low or as dry fractures.

Deep water levels:

- Deep water levels (> 10 m bgl) are observed during pre as well as post-monsoon season in 32 sq.km and 6 sq.km of the area respectively.
- Out of 49 wells analysed, 11 wells during pre-monsoon and 9 wells during post-monsoon shown falling trend in the last 10 years (0.002 to 0.22 m/yrs and 0.007 to 0.88 m/yrs) respectively.

Water Logging:

- In Vizianagaram district, at present there is no water logging. However during post monsoon period in places around S.Kota, Jami, Gantyada, Vizianagaram, Nellimerla, Pusapatirega, Bobbili, Badangi, Vangara, Santhakaviti and Regidiamavalavasa mandals area, the water levels are < 2.0 m bgl (240 sq.km, 6% of area) indicating that these areas are prone to water logging. The water logging conditions may be due to surface water irrigation and can be overcome by conjunctive utilization of both surface and groundwater.

Pollution (Geogenic and Anthropogenic):

- In Vizianagaram, Fluoride concentration is within permissible limit. The Fluoride concentration beyond permissible limit found in Kothavalasa (1.72 mg/L), Darmapuri (2.31 mg/L) and S. Kota (1.52 mg/L) during pre-monsoon and in Kothavalasa (2.34

mg/L) and Palligantredu (2.49 mg/L) during post-monsoon period. The high concentration of fluoride is due to rock water interaction where fluoride bearing minerals (fluorite, fluoro-apatite) gets dissolved under alkaline condition and higher residence time of ground water in deeper aquifer.

- Nitrate concentration in the district is within the permissible limits except few locations. The Nitrate concentration >45 mg/L found in ground water at Tarapuram (68.22 mg/L), Almanda (73.72 mg/L), Bondapalli (68.23 mg/L), Agraharam (49.9 mg/L), Garbham (46.44 mg/L), Bobbili (99.55 mg/L) and Jannivalasa (51.54 mg/L) during pre-monsoon season. During post-monsoon, out of 96 samples, 14 sample nitrate concentration is >45 mg/L ranges from 69.61 to 588.14 mg/L which may be of local anthropogenic activity.

- The high concentration of EC (> 2000 µ Siemens/cm) occurring 143 sq.km and 404 sq.km area is observed during pre and post-monsoon period respectively along the coast line where fresh water is limited.

Ground water Development:

- The present stage, ground water development in the district varies from 4.0 to 51 percent and as a whole comes under safe category. The level of development is maximum in Gurla (51%), Garividhi (48%), Pusapatirega (48%) and while it is least in the mandals viz; Rajam (4%), Vepada (6 %), Mentada (9%) and Gantyada (10%).

6. GROUND WATER DEVELOPMENT AND MANAGEMENT STRATEGIES

6.1. Groundwater Development:

At present the ground water abstraction in the district is quiet low as the overall ground water development is only 26 % and there is a vast scope for further ground water development by construction of additional wells for irrigation. The total utilization of ground water is 328 MCM against the total ground water potential of 1086 MCM available for future use. A total area of 13,617 ha is net irrigated area through ground water, of which 73,932 ha with dug well sources and 9,685 ha by bore wells/ Tube wells.

Government of Andhra Pradesh was submitted estimates for drilling for ground water extraction structures under Pradhan Mantri Krishi Sinchayee Yojana- Her Khet Ko Pani (GW). In Vizianagaram district, 14,135 hectares' area to be irrigated by construction of 13,368 ground water extraction structures with estimated cost 62,941 lakhs and 732 villages will be benefited under PMKSY-HKKP (GW). By extracting more ground water through bore-wells / Tube wells, this will be generating more ayacut in irrigation sector and more subsurface ground water recharge potential for artificial recharge structure in future. **(Annexure-IV)**

While taking up the developmental schemes in the district, priority may be given to those mandals where level of groundwater development is less than 20 percent and there are 11 such mandals. Next priority may be given to those mandals where level of ground water development is 20 to 35 percent and there are 8 such mandals in the district. There is one mandal, Gurla where the groundwater development is 51 %.

The developmental activities of the district may be reviewed critically, once the level of groundwater development crosses 50 % in any mandal and this will enable to understand how the groundwater regime is getting adjusted both in space and time to the new stress conditions and also wherever the surface water irrigation conditions prevailing, the conjunctive use of surface and groundwater may be adopted.

The coastal parts of the district, in Bhogapuram and Pusapatirega electrical conductivity of groundwater is higher than other parts of the district. So, ground water development in these two mandals has to be taken up very judiciously to avoid any possibility of sea water ingress/intrusion. The groundwater development activities if planned

properly without disturbing ecological balance may bring the overall prosperity of this agrarian based district.

6.2. Groundwater Management Strategies:

6.2.1. Supply Side Measures:

6.2.1a. Artificial Recharge:

The area suitable for artificial recharge has been determined based on the analysis of average post-monsoon depth to water level data of the observation wells for the period 2013-2022. Accordingly, an area of 698 sq. kms is identified which is spread over in 216 villages in 7 mandals of the district. **(Fig.6.1)** The remaining area of 3138 sq. kms comprises of 739 villages in 27 mandals have water level less than 5 m bgl and forest/hilly area.

The availability of unsaturated sub surface volume of aquifers is computed as the product of area, thickness of aquifer zone between 5 m bgl and the average post-monsoon water level and specific yield of the aquifers. The unsaturated volume of the aquifers is calculated as 27 MCM. Out of the total run off available, only 20% is considered for recommendation of artificial recharge structures considering the riparian rights and other practical considerations for recommending the artificial recharge structures. The Check dams and Percolation Tanks are calculated by taking 5 fillings for Check dams and 2 fillings for Percolation Tanks and a total 1100 number of AR structures (569 number of PTs, 531 number of CDs) are feasible in the district. After considering the existing AR Structures and data gap, a total 354 number of AR structures (343 number of PTs, 11 number of CDs) are recommended for 698 sq. kms of the district.

Government of Andhra Pradesh had already created a total 4194 recharge structure (3538 check dams, 424 check walls, 146 PT's and 86 mini PT's) through MGNREGS and IWMP scheme (source: Department of Rural Development and Panchayat Raj, https://emms.ap.gov.in/nregs_ap/Reports/#) and their pin pointed location is shown in **Fig.6.2.** At present, @1 artificial recharge structure existed @per square km area in the district. The considering the SOP, it is also recommended that instead of planning for new artificial recharge structure, the existing CD's and PT's shall be desilted and maintained.

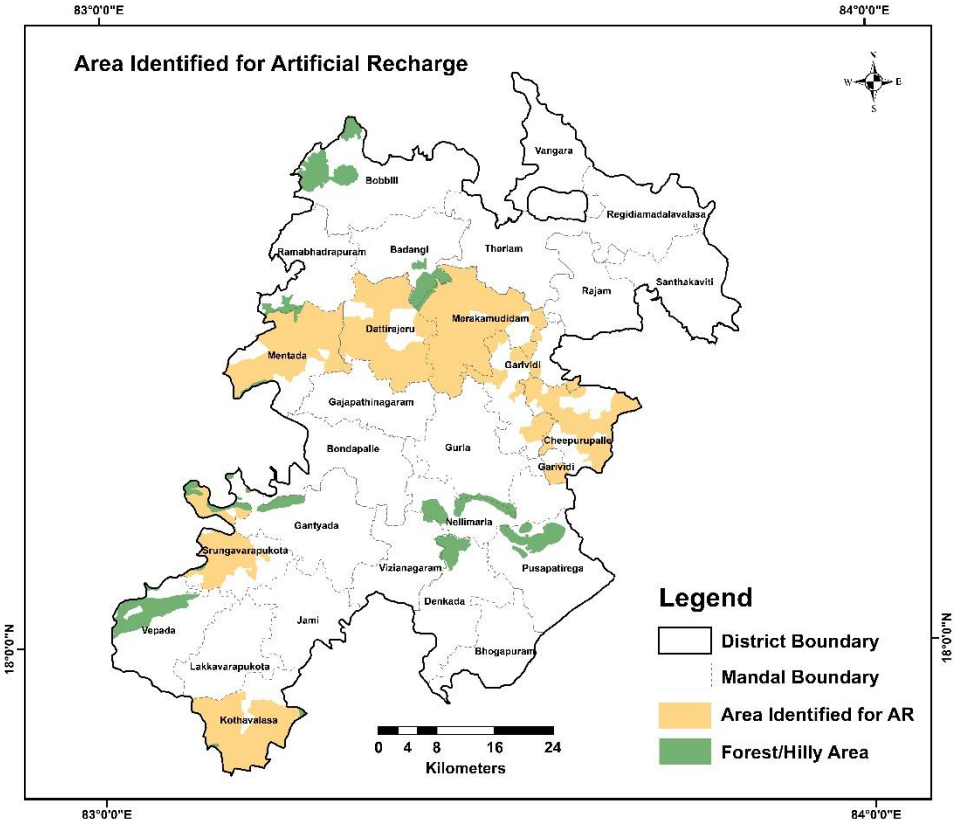


Fig.6.1. Area identified for Artificial Recharge Structures.

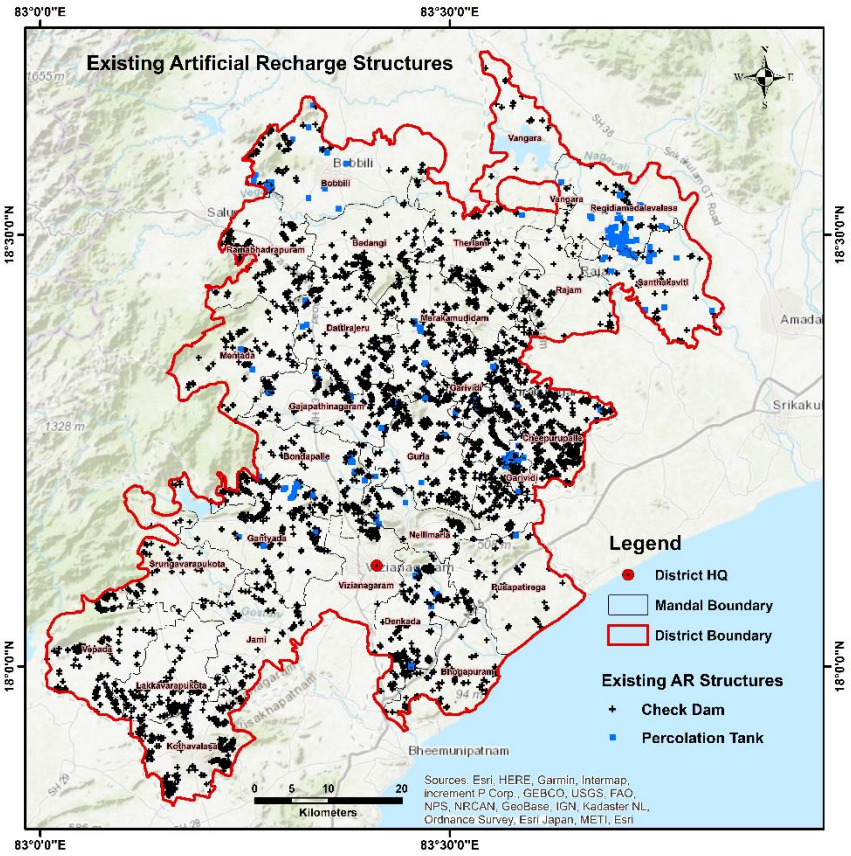


Fig.6.2. Existing Artificial Recharge Structures of the district.

6.2.2. Demand Side Measures:

6.2.2a. Micro-irrigation: The sustainability of bore well is low because of hard/crystalline rock. The yield of bore well is <1.0 lps identified in 33 % of area, and 1.0 to 2.0 lps in 51% of the area. This may be due to low interconnection among fractures or fracture becomes closed by clay due to chemical dissolution action of weathered portion in khondalite formation. A total 59615 ha actual area irrigated (Registered Ayacut 80638 ha) so far through 11821 nos. minor irrigation sources (Source: Directorate of Economics & Statistics, Govt. of A.P, Vijayawada). As sustainability of bore well is low, the sprinkler and drip irrigation system with suitable cropping pattern wherever feasible may be practiced as a measure for groundwater conservation, protection and management.

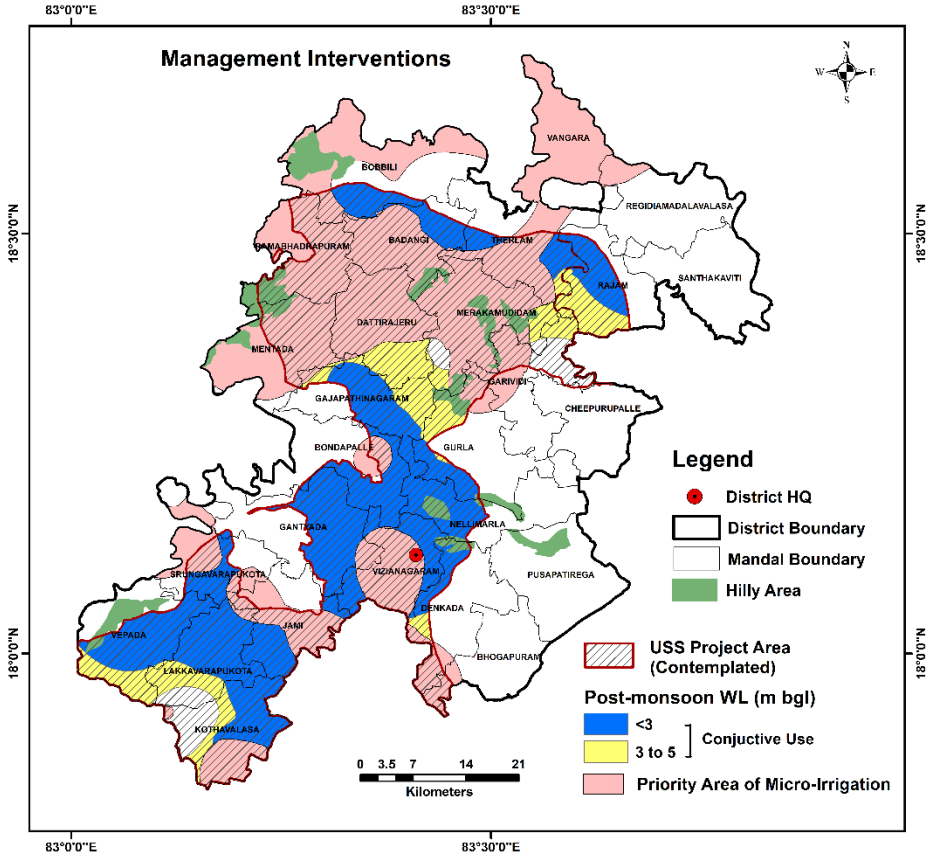


Fig.6.3. Management Intervention in Vizianagaram district.

6.2.3. Other Measures:

- Even though there is no immediate threat to the soil or crop due to water logging condition. It is recommended to follow the anti-water logging measures like

conjunctive use of surface and ground water in the feasible areas as the number of surface water irrigation projects are coming up in the district.

- The depth to ground water levels in the contemplated Uttarandhra Sujala Sravanthi project is <3 m in 1182 sq. kms and 3 to 5 m in 665 sq. kms. Upon completion of the project, there is likelihood of ~255 MCM of return irrigation which may result in water logging conditions. It is recommended for Conjunctive use of surface and ground water in the contemplated Uttandhra Sujala Sravanthi project areas (159446 ha) **(Fig.6.3)**

- Roof top rain water harvesting in 2 Municipalities (Bobbili and Vizianagaram) as per the existing post monsoon depth to water levels, provisions of AP WALTA and proper waste water management are other recommended measures in the district.

- In urban and rural area, the sewerage line should be constructed to arrest leaching of nitrate.

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Mandal wise recharge worthy and hilly area of the district **ANNEXURE-I**

S. No.	Assessment Unit (Mandal)	Recharge worthy area (Ha)	Hilly Area (Ha)	Total area of assessment unit (Ha)
1	Badangi	11963	40	12003
2	Bhogapuram	10324	32	10356
3	Bobbili	20426	279	20705
4	Bondapalle	16670	596	17266
5	Cheepurupalle	11954	270	12225
6	Dattirajeru	21132	333	21465
7	Denkada	11014	90	11104
8	Gajapathinagaram	15007	317	15324
9	Gantyada	16807	317	17123
10	Garividi	13680	298	13977
11	Gurla	16625	917	17542
12	Jami	14195	84	14279
13	Kothavalasa	13442	1448	14889
14	Lakkavarapukota	12429	129	12558
15	Mentada	26044	1556	27600
16	Merakamudidam	16609	897	17506
17	Nellimarla	15698	420	16118
18	Pusapatirega	12204	1177	13381
19	Rajam	12740	110	12850
20	Ramabhadrapuram	14486	293	14779
21	Regidiamadalavalasa	15110	490	15600
22	Santhakaviti	15374	985	16359
23	Srungavarapukota	14289	551	14840
24	Therlam	14903	171	15074
25	Vangara	11048	480	11528
26	Vepada	15027	371	15398
27	Vizianagaram	12136	301	12437
Total		401338	12949	414287

Mandal wise rainfall recharge and recharge due to different structures ANNEXURE-II

Sl.No	Mandal	Recharge from Rainfall-MON	Recharge from Other Sources-MON	Recharge from Rainfall-NM	Recharge from Other Sources-NM	Total Annual Ground Water (Ham) Recharge
1	Badangi	691	2161	109	2094	5055
2	Bhogapuram	716	769	44	483	2012
3	Bobbili	1939	2303	266	1322	5830
4	Bondapalle	1151	1580	128	1571	4431
5	Cheepurupalle	735	1730	43	1410	3918
6	Dattirajeru	1202	1433	132	1570	4337
7	Denkada	899	1395	59	1165	3518
8	Gajapathinagaram	911	1229	94	1394	3628
9	Gantyada	1893	3526	184	2388	7991
10	Garividi	1014	1692	53	1261	4021
11	Gurla	1246	2249	74	1074	4643
12	Jami	786	1718	130	957	3591
13	Kothavalasa	855	2103	109	2081	5148
14	Lakkavarapukota	767	4000	81	2851	7699
15	Mentada	1422	3623	129	3332	8507
16	Merakamudidam	951	3444	102	2965	7462
17	Nellimarla	691	2406	53	2249	5399
18	Pusapatirega	713	3279	32	2948	6972
19	Rajam	859	2161	90	434	3544
20	Ramabhadrapuram	1560	1439	140	1719	4857
21	Regidiamadalavalasa	901	4173	92	816	5982
22	Santhakaviti	631	3898	74	418	5021
23	Srungavarapukota	1160	3053	134	2085	6432
24	Therlam	899	2950	131	2069	6050
25	Vangara	689	1988	65	588	3331
26	Vepada	1458	5520	205	5652	12835
27	Vizianagaram	650	2635	46	1859	5190
Total		27392	68458	2798	48755	147403

Mandal wise GW Extraction and ground water categorization **ANNEXURE-III**

Sl.No	Mandal	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)	Irrigation Use (Ham)	Industrial Use (Ham)	Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (OE/Critical/Semicritical/Safe)
1	Badangi	253	4802	1231	0	0	1231	0	3591	26	safe
2	Bhogapuram	101	1911	680	0	0	680	0	1253	36	safe
3	Bobbili	292	5539	1177	7	96	1281	140	4305	23	safe
4	Bondapalle	222	4210	631	0	116	747	168	3411	18	safe
5	Cheepurupalle	196	3722	1507	0	145	1653	210	2079	44	safe
6	Dattirajeru	217	4120	1693	14	0	1707	0	2564	41	safe
7	Denkada	176	3342	1254	9	118	1381	171	1963	41	safe
8	Gajapathinagaram	181	3446	1124	3	90	1216	130	2283	35	safe
9	Gantyada	400	7592	839	0	149	989	218	6535	13	safe
10	Garividi	201	3820	1711	0	140	1850	203	1950	48	safe
11	Gurla	232	4411	2126	0	138	2264	200	2327	51	safe
12	Jami	180	3412	1236	0	136	1373	198	2099	40	safe
13	Kothavalasa	257	4890	994	0	150	1144	217	3689	23	safe
14	Lakkavarapukota	385	7314	652	0	0	652	0	6663	9	safe
15	Mentada	425	8082	596	62	46	705	67	7383	9	safe
16	Merakamudidam	373	7088	1515	14	66	1595	95	5507	23	safe
17	Nellimarla	270	5129	1664	0	177	1840	256	3524	36	safe
18	Pusapatirega	349	6624	3068	21	94	3183	137	3854	48	safe
19	Rajam	177	3367	118	0	19	138	28	3221	4	safe
20	Ramabhadrapuram	243	4614	1447	0	45	1492	65	3424	32	safe

21	Regidiamadalavalasa	299	5683	481	0	77	558	112	5133	10	safe
22	Santhakaviti	251	4770	391	0	97	488	140	4253	10	safe
23	Srungavarapukota	322	6110	1168	3	17	1188	24	4959	19	safe
24	Therlam	302	5748	1089	0	0	1089	0	4855	19	safe
25	Vangara	167	3164	881	0	66	947	96	2192	30	safe
26	Vepada	642	12193	633	3	121	757	176	11382	6	safe
27	Vizianagaram	260	4930	532	1	122	655	177	4220	13	safe
Total		**7370**	**140032**	**30437**	**138**	**2226**	**32801**	**3228**	**108618**	**26**	**safe**

Mandal wise tentative estimation for drilling of GW extraction structures under PMKSY-HKKP (GW) **ANNEXURE-IV**

S.No	District	Mandal Name	No. of Villages	No. of Bore Wells	No. of Shallow Tube Wells	No. of Deep Tube Wells	Total No. of Structures	No. of Feasible Structures	Area Proposed to be irrigated (Ha)	Total Cost of Drilling Component	Cost of Energization including Electric and Solar Structure	Total cost
1	Vizianagaram	BADANGI	21	178	8	0	186	186	194	171	630	874
2	Vizianagaram	BHOGHAPURAM	19	374	0	0	374	374	373	342	1270	1759
3	Vizianagaram	BOBBILI	40	505	117	0	622	622	738	581	2112	2937
4	Vizianagaram	BONDAPALLE	30	782	0	0	782	782	780	716	2656	3678
5	Vizianagaram	CHEEPURUPALLE	25	272	0	0	272	272	272	249	924	1280
6	Vizianagaram	DATTIRAJERU	32	386	0	0	386	386	388	353	1311	1815
7	Vizianagaram	DENKADA	26	530	0	0	530	530	528	485	1799	2492
8	Vizianagaram	GAJAPATHINAGARAM	34	845	0	0	845	845	846	773	2871	3975
9	Vizianagaram	GANTYADA	37	197	0	0	197	197	199	180	664	922
10	Vizianagaram	GARIVIDI	28	358	0	0	358	358	360	328	1216	1684
11	Vizianagaram	GURLA	38	723	161	0	884	884	1047	825	3005	4176
12	Vizianagaram	JAMI	26	382	0	0	382	382	384	350	1297	1796
13	Vizianagaram	KOTHAVALASA	16	206	0	0	206	206	207	189	700	969
14	Vizianagaram	LAKKAVARAPUKOTA	30	486	0	0	486	486	486	445	1648	2283
15	Vizianagaram	MENTADA	23	584	0	0	584	584	581	534	1985	2748
16	Vizianagaram	MERAKAMUDIDAM	33	586	0	0	586	586	586	536	1989	2755
17	Vizianagaram	NELLIMARLA	29	499	0	0	499	499	497	457	1694	2346
18	Vizianagaram	PUSAPATIREGA	33	1160	86	0	1246	1246	1333	1149	4233	5870
19	Vizianagaram	RAMABHADRAPURAM	19	182	0	0	182	182	182	167	617	854
20	Vizianagaram	REGIDIAMADALAVALASA	38	1289	149	0	1438	1438	1585	1331	4888	6782

21	Vizianagaram	SANTHAKAVITI	39	499	250	0	749	749	997	710	2545	3549
22	Vizianagaram	SRUNGAVARAPUKOTA	22	149	0	0	149	149	151	136	505	699
23	Vizianagaram	THERLAM	20	47	0	0	47	47	45	43	158	220
24	Vizianagaram	VANGARA	27	723	0	0	723	723	724	662	2456	3401
25	Vizianagaram	VEPADA	30	474	0	0	474	474	473	434	1609	2228
26	Vizianagaram	VIZIANAGARAM MANDAL	17	181	0	0	181	181	180	166	614	851
Total			732	12597	771	0	13368	13368	14135	12310	45397	62941

Exploratory well details of Vizianagaram district, Andhra Pradesh **ANNEXURE-V**

S.No.	Location	Mandal	Well Type	Deepest Fracture Depth (mbgl)	Weathered Depth (mbgl)	Yield (lps)	Drilled Depth (m)	Geology	Year
1	Venkataramanapeta	S.Kota	EW	51	19.1	1.3	120.5	Gneiss	2002
2	Kotyada	L.Kota	EW	64	17.5	1.37	123.5	Gneiss	2002
3	Kothavalasa	Kothavalasa	EW	67.5	28	1.33	123.5	Gneiss	2002
4	Korukondapalem	Vizianagaram	EW	49	18	1.22	129.7	Gneiss	2003
5	S.Gurjuvalasa	Dattirajeru	EW	31.5	16.5	0.45	200	Gneiss	2003
6	Kanimerka	Bondapalli	EW	19	13	2.2	155	Gneiss	2003
7	Tadivada	Denkada	EW	142	15	1.57	200	Gneiss	2003
8	Kondarajupalem	Bhogapuram	EW	158	11.5	3.82	200	Gneiss	2003
9	Kondarajupalem	Bhogapuram	OW	159.6	11.5	3.35	200	Gneiss	2003
10	Ramavaram	Ramavaram	EW	26	24	5.2	105	Gneiss	2001
11	Ramavaram	Ramavaram	OW	36	6	0.4	52	Gneiss	2001
12	Terlam	Terlam	EW	105	33.2	1	184	Gneiss	2001
13	Badangi	Badangi	EW	20	12.5	0.8	200	Gneiss	2001
14	Gutlam	Gutlam	EW	39	9.62	0.8	110	Gneiss	2001
15	Piridi	Bobbili	EW	64	17.7	1.41	200	Gneiss	2003
16	Komatipalli	Bobbili	EW	29	17.7	0.22	200	Gneiss	2003
17	Kallepalli	L.Kota	EW	40	9.8	5	120.2	Gneiss	2002
18	Kallepalli	L.Kota	OW	44.7	12	3.3	70	Gneiss	2002
19	Lakkavarapukota	L.Kota	EW	50.8	21	5.5	122	Gneiss	2002
20	Lakkavarapukota	L.Kota	OW	68	24	2.2	80.6	Gneiss	2002
21	Gobhyam	Dattirajeru	EW	62	30	3	178	Gniess	2003
22	Gobhyam	Dattirajeru	OW	38	24	0.45	55	Gneiss	2003
23	Kanchendavalasa	Makkuva	EW	32	5.6	0.21	200	Gneiss	2004

24	Vasanta	Gantyada	EW	120	25.3	1.71	200	Gneiss	2004
25	Bobbili	Bobbili	EW	164	11.6	1.37	200	Gneiss	2004
26	Lakshmipuram	Jami	EW	18	6.15	0.45	176	Gneiss	2001
27	Ayyannapeta	Vizianagaram	EW	68	24	0.4	190.6	Gneiss	2001
28	Pedavemali	Gantyada	EW	158	33	2	200	Gneiss	2001
29	Tondrangi	Garividi	EW	145	24.5	3.1	169	Gneiss	2001
30	Budatanapalli	Gantyada	EW	105	19	3.6	134.5	Gneiss	2001
31	Budatanapalli	Gantyada	OW	72	25.5	3	99.1	Gneiss	2001
32	Kotha Bheemsinghi	Jami	EW	132	25	0.31	200	Khondalite	2020-21
33	Bondapalle	Bondapalle	EW	181	42	0.03	200	Khondalite	2020-21
34	Duppada	Vizianagaram	EW	181	25	0.07	200	Khondalite	2020-21
35	Guchimi	Dattirajeru	EW	102	25	0.3	200	Khondalite	2020-21
36	Jagaram	Jami	EW	181	30	0.07	200	Khondalite	2020-21
37	Kotha Valasa	Kothavalasa	EW	153	21	0.21	200	Khondalite	2020-21
38	Musiram	Kothavalasa	EW	171	57	0.44	200	Granite	2020-21
39	Pedda Bantupalli	Gurla	EW	129	31	0.07	200	Khondalite	2020-21
40	Pinapenki	Badangi	EW	197	30	1.29	200	Khondalite	2020-21
41	Rajapulova	Bhogapuram	EW	186	18	0.44	200	Khondalite	2020-21
42	Ramabhadrapuram	Ramabhadrapuram	EW	116	12	0.76	200	Granite	2020-21
43	Srungavarapukota	Srungavarapukota	EW	131	18	0.07	200	Granite	2020-21
44	S S R Peta	Gurla	EW	143	47	3.3	200	Khondalite	2020-21