केंद्रीय भूमि जल बोर्ड

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विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,
Ministry of Jal Shakti
Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

JANGAON DISTRICT, TELANGANA

दक्षिणी क्षेत्र, हैदराबाद

Southern Region, Hyderabad

1. INTRODUCTION

National Aquifer Mapping (NAQUIM) had been taken up by CGWB to create robust database of hydrogeological information at 1:50,000 scale for sustainable groundwater. Aquifer mapping is a multidisciplinary and a holistic scientific approach wherein a combination of geological, geophysical, hydrological and chemical analysis is applied to characterize the quantity, quality and sustainability of ground water in aquifers. It had been taken up by CGWB to carry out detailed hydrogeological investigation on toposheet scale of 1:50,000. The vagaries of rainfall, inherent heterogeneity & unsustainable nature of hard rock aquifers, over exploitation of aquifers, insufficient regulation mechanism has a detrimental effect on ground water scenario of the country in last decade or so. Thus, prompting the paradigm shift from "**traditional groundwater development concept**" to "**modern groundwater management concept**".

Varied and diverse hydrogeological settings demand precise and comprehensive mapping of aquifers down to the optimum possible depth at appropriate scale to arrive at the robust and implementable ground water management plans. The proposed management plans will provide necessary inputs and recommendations for ensuring sustainable management of groundwater resources of district. The aquifer maps and management plans will be shared with the Administration of Jangaon district, TS for its effective implementation.

1.1 Objective and Scope of Study

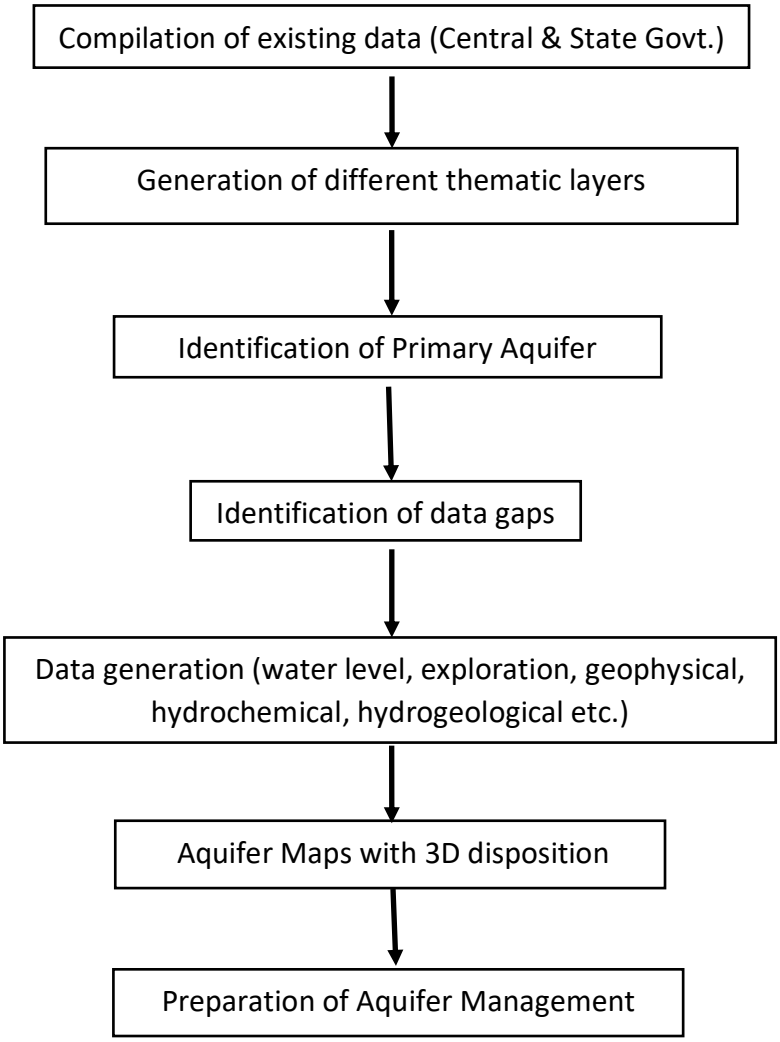
An integrated hydrogeological study was taken up to develop a reliable and comprehensive aquifer map and to suggest suitable groundwater management plan on 1: 50,000 scale. The activities under NAQUIM are aimed at:

- Identifying the aquifer geometry
- Aquifer characteristics and their yield potential
- Groundwater quality
- Aquifer wise assessment of ground water resources
- Preparation of aquifer maps in 3D and 2D
- Formulate ground water management plan

1.2 Approach and Methodology

The ongoing activities of NAQUIM include toposheet wise micro-level hydrogeological data acquisition supported by geophysical and hydro-chemical investigations supplemented with ground water exploration down to the depths of 200- 300 meters.

Considering the objectives of the NAQUIM, the data on various components was segregated, collected and brought on GIS platform by geo-referencing the available information for its utilization for preparation of various thematic maps. The approach and methodology followed for Aquifer mapping is as given below:



1.3 Study area

The Jangaon district, Telangana having geographical area of 2,188 km^2, lies between north latitude 17°26´ to 18°6´ and east longitude 78°47´ to 79°42´(**Fig.1.1**). Out of total area, the total cropped area is 86 %, wastelands is 18 %, land put to non-agricultural area is 2 %, barren and uncultivable area is 2 % and remaining are others. Administratively the district is governed by 12 revenue mandal and 175 revenue villages with a population of 5,66,376 (2011 Census) (urban: 13 %, rural: 87 %). The density of population is 258 persons/ km^2 and there is an increase in 4.22 % growth rate over last 10 years. (2011 census)

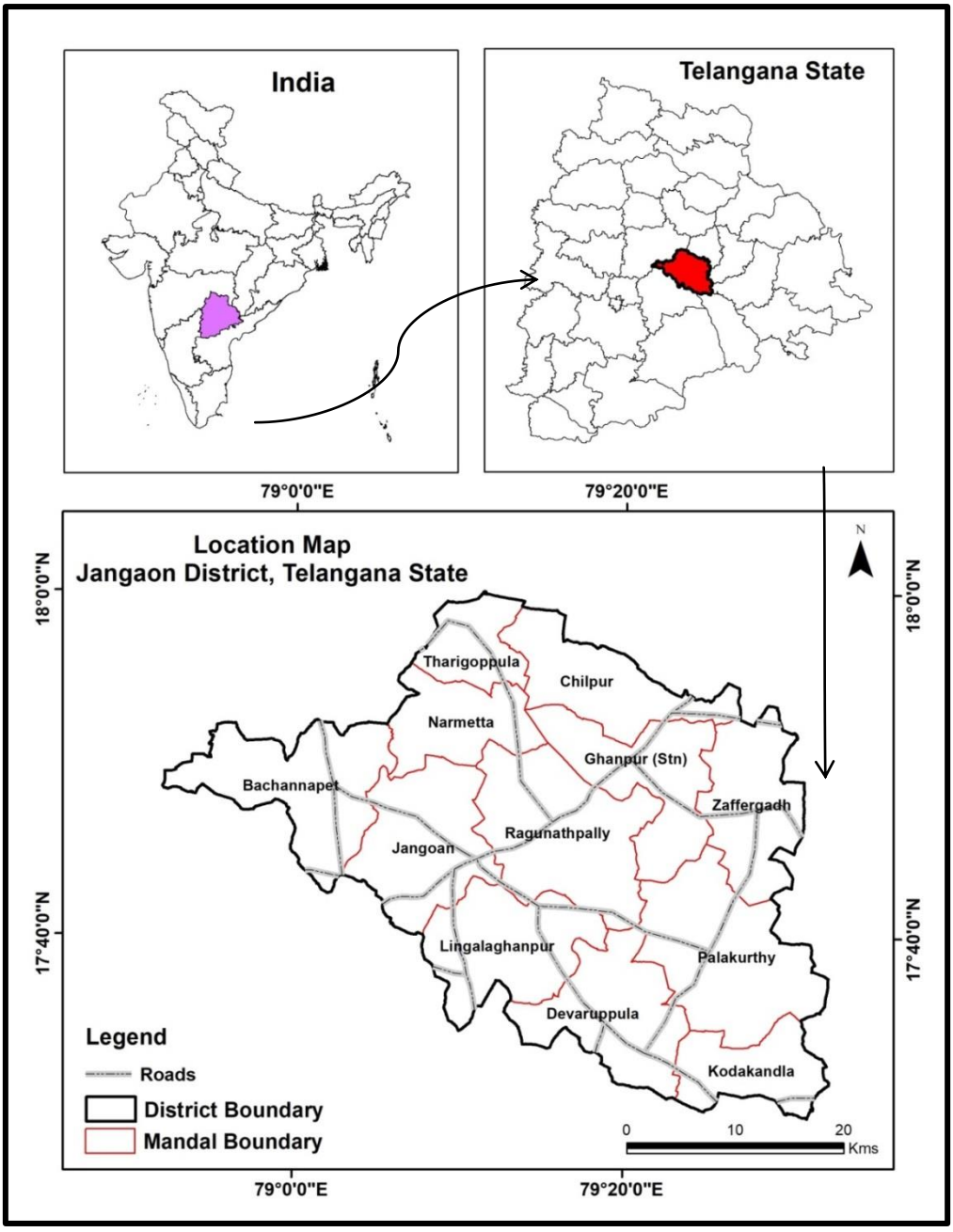


Fig.1.1: Location map of Jangaon district.

1.4 Climate and Rainfall

The district experiences very hot summers, moderate winters and less than the average precipitation. The normal mean daily minimum and maximum temperature is 7.7 °C and 48.2 °C. The annual normal rainfall of Jangaon district is 935.8 mm, which ranges from 650 mm at Devuruppala Mandal to 1150.2 mm at Ghanpur station Mandal. The South west monsoon (June to September) contributes ~80 %, North east monsoon (October toDecember) contributes ~11%, and remaining by winter and summer season. District received excess rainfall (+20% and above normal) in 2005, 2013 and 2021, deficient rainfall (-20% and below normal) in 2009, 2011, 2014 and 2018 and normal rainfall (-19% to +19%) in remaining years. The isohyetal map of study area is presented in **Fig.1.2a**

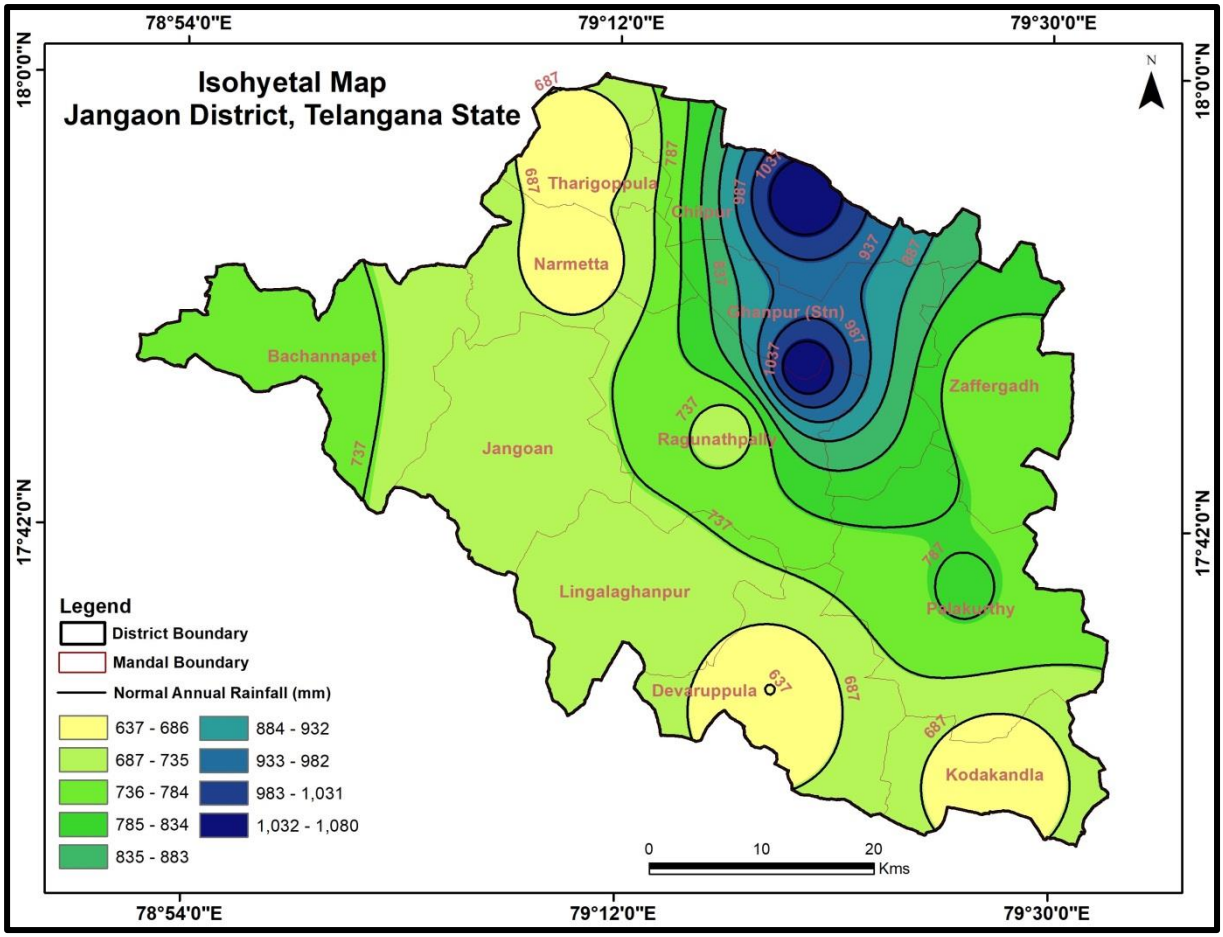


Fig.1.2a: Isohyetal map of Jangaon district.

Analysis of long term rainfall data of 17 years from 2005 to 2021 shows increasing trend in annual rainfall by 0.45 mm/year. District received excess rainfall (+20% & above normal) in 2005, 2013 & 2021, deficient rainfall (-20% & below normal) in 2009, 2011, 2014 & 2018 and normal rainfall (-19% to +19%) in remaining years. The average monthly rainfall distribution for 17 years from 2005 to 2021 shows maximum rainfall received in the month of June and least rainfall recorded in the month of December (**Fig.1.2b& 1.2c**).

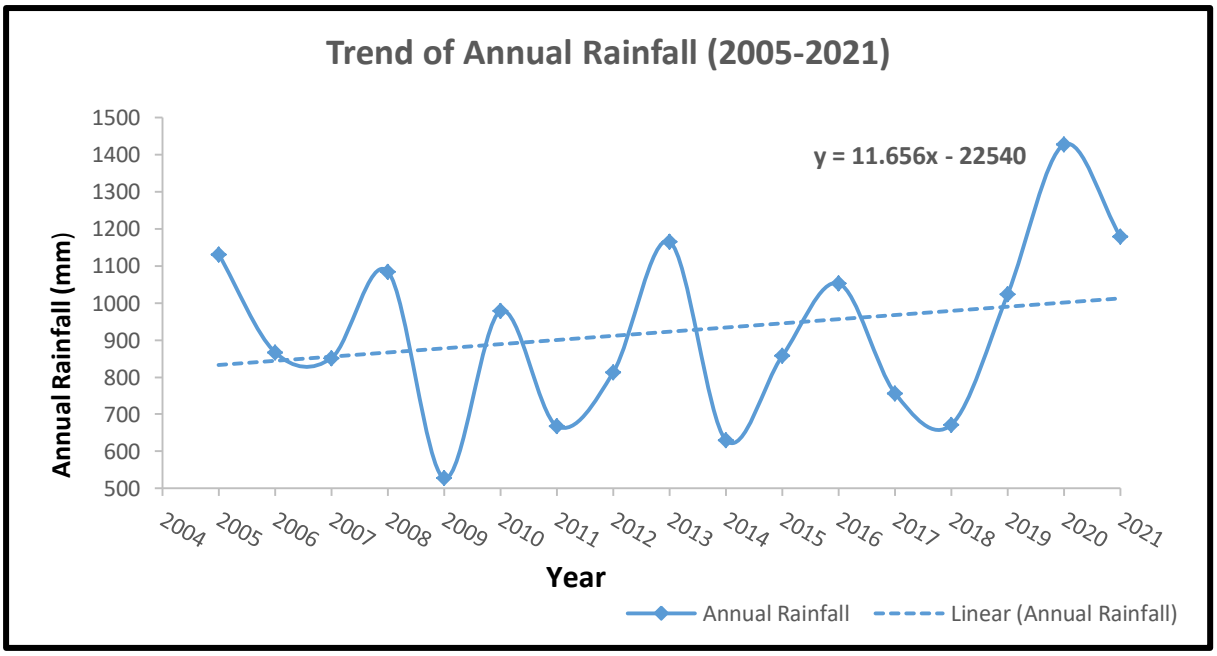


Fig.1.2b: Annual rainfall trend (2005-2021)

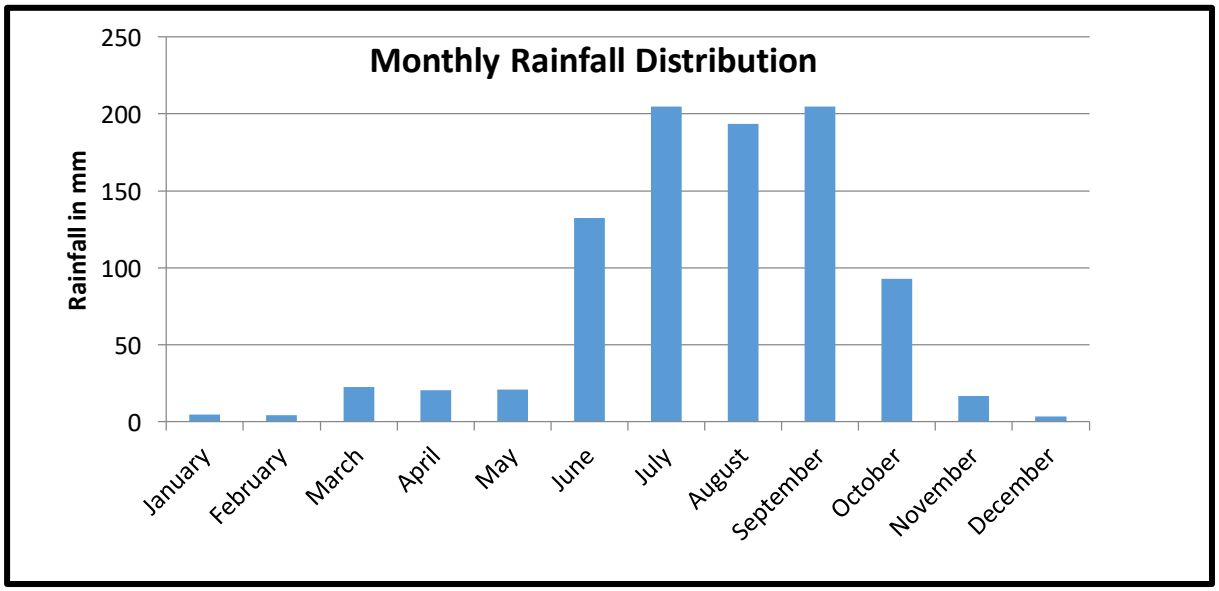


Fig.1.2c: Monthly rainfall trend (2005-2021)

1.5 Geomorphological Set up

Jangaon district is characterised by undulating topography with hill ranges, valleys and plains. Pedeplain is the major landform covering about 79% of the area. The other landforms observed are pediment (14%), flood plain (2%), channel Fill (1%), structural hills, residual hills, linear ridges etc .The geomorphology map of the study area is presented in **Fig.1.3**.

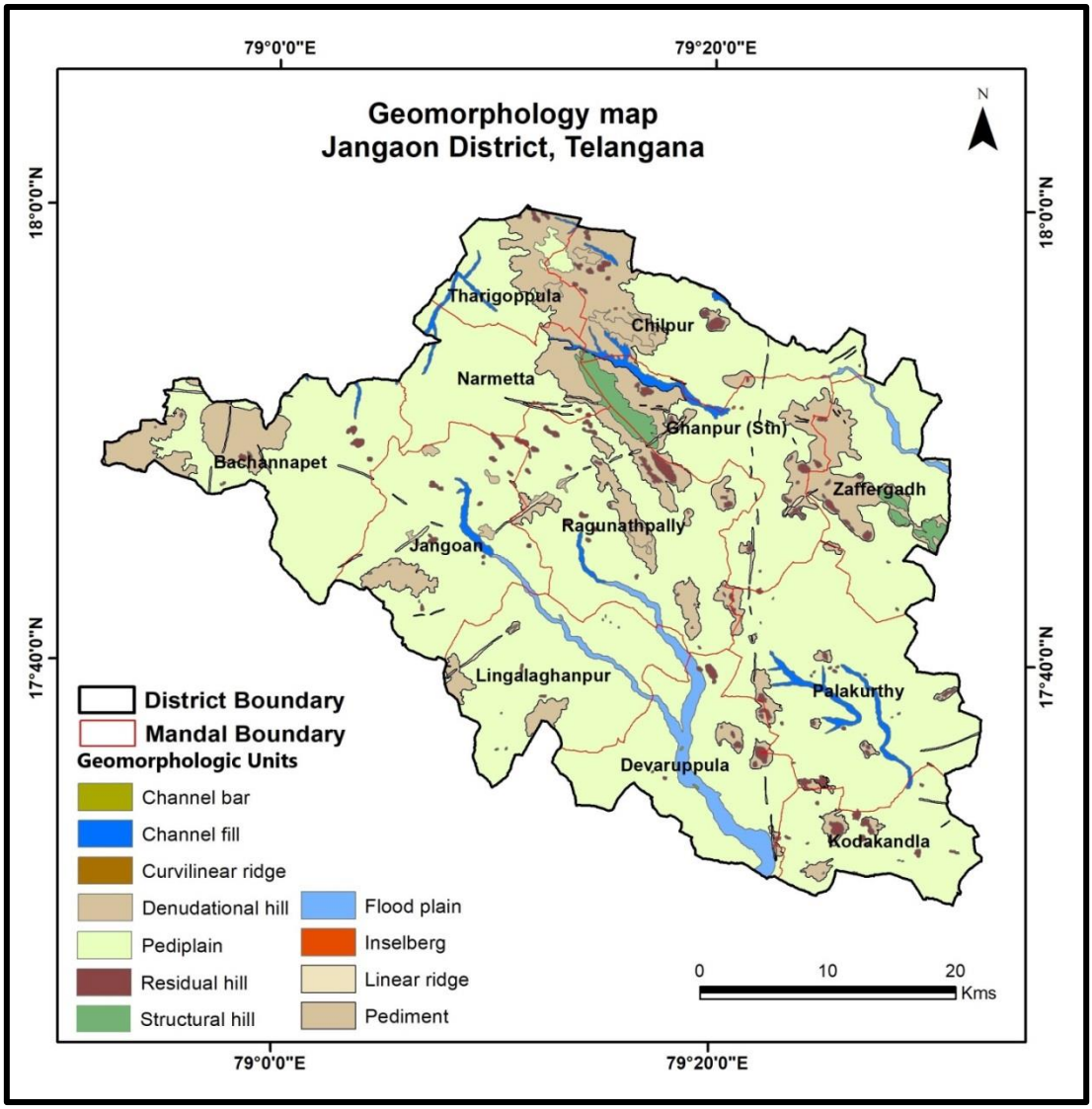


Fig.1.3: Geomorphology map of Jangaon district.

1.6 Drainage and Structures

In Jangaon District, there is no major rivers are flowing. Only small rivers and third order streams are observed viz Akkeru vagu, Pedda vagu, Thatikonda vagu, Chinnapendiyala vagu main tributary of Musi, Maneru Rivers. The drainage pattern in the area is dendritic to sub-dendritic in nature. Map depicting drainage, water bodies, and river is presented in **Fig.1.4.**

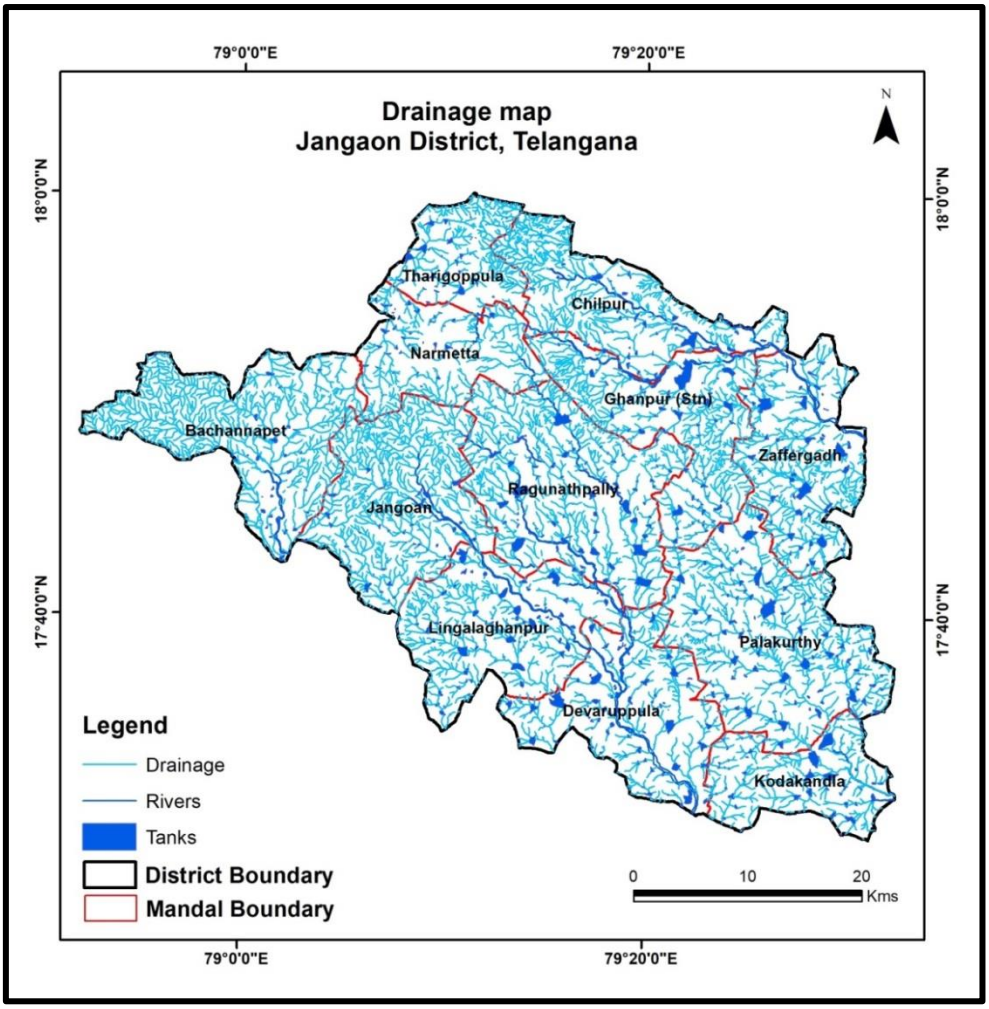


Fig.1.4: Drainage map of Jangaon district

1.7 Land use and cropping pattern

The land utilization of Jangaon district is as follows.

Table: 1.1 Land utilisation in Jangaon District

Land Utilisation	Area (in Sq.Km)	%age to Geographical Area
Forest	19.87	0.94 %
Barren and Uncultivable	59.81	2.83 %
Land put to Non-Agricultural uses	119.34	5.64 %
Culturable Waste	251.04	11.87 %
Permanent pasture and Other Grazing lands	10.77	0.51 %
Land under Miscellaneous Tree, Crops, Grovers (Not included in Net Sown Area)	3.93	0.19 %
Current Fallow Land	72.48	3.43 %
Other Fallow Land	0.25	0.01 %
Net Area sown	1650.51	78.01 %
Total Geographical Area	**2188**	**100 %**

Out of the total geographical area of 2,188 km2, agriculture and wastelands are the prominent land use aspects in Jangaon district and forms 86.06 % and 7.99 % of total area respectively. The spatial distribution of land use is presented in **Fig. 1.5.**

The net sown area of Khariff crops is 1472.43 km^2 and net sown area of Ravi Season is 644.10 km^2. There is wide variety of crops grown in the district. Major crops grown in the district during Khariff Season are mainly Paddy (52%) & Cotton (40%). While during the Ravi Season the major crop grown is Paddy (87%) and the remaining are distributed as Maize (5%), Groundnut (3%), Oil seeds (4%) and other crops.

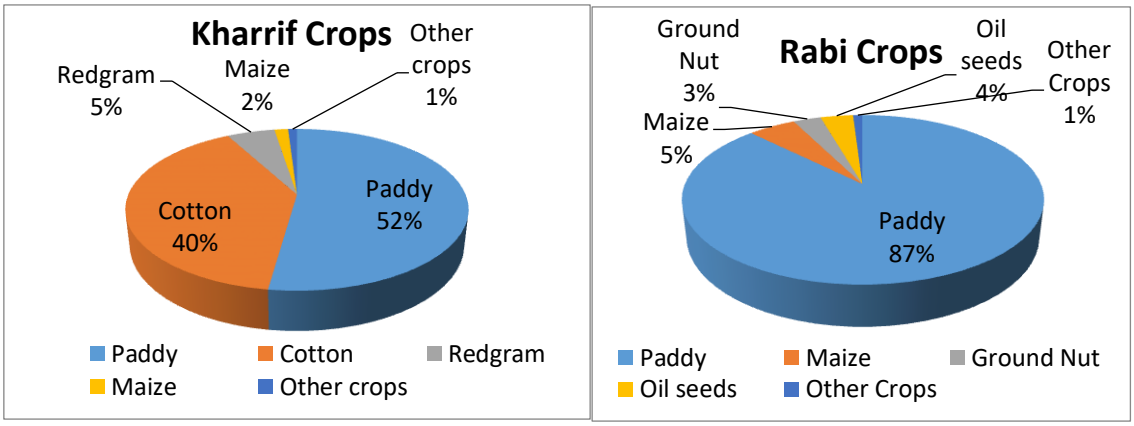


Table: 1.2 Crop distribution in Jangaon district

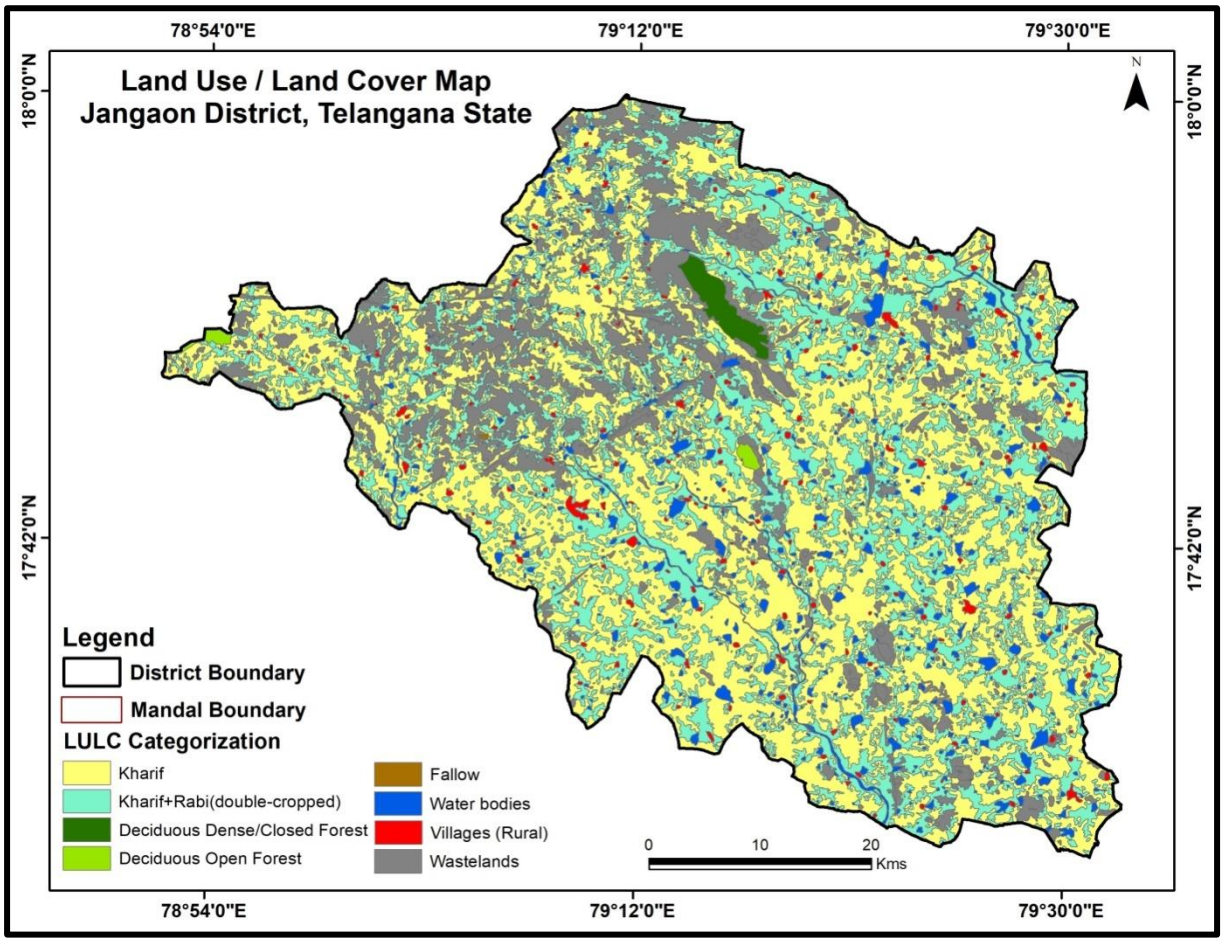


Fig.1.5: Land use and land cover of Jangaon district.

1.8 Soils

Jangaon district is endowed with a wide variety of soils ranging from red soils (acidic) and to some extent Black cotton soils. The soil types that comprise the district are clayey, cracking clay, calcareous, gravelly clay and gravelly loam. The total crop production area is 1,20,731 ha/year. The chief crops of the division are rice, cotton, groundnut, maize, redgram, jowar, chilli and Castor. The fine mixed and fine loamy mixed occupy nearly 36% of the land area while the fine montmorillonitic occupy about 28% of area. The loamy skeletal occupy around 32% of the land area and the rest of area is covered by clayey skeletal. The red soils are generally non-saline, non-alkaline and well drained. The black soils being calcareous, require the application of super phosphate. These soils are particularly suitable for the cultivation of cotton and paddy with a provision of surface drains and also rabi dry crops under rainfed conditions (**Fig.1.6**).

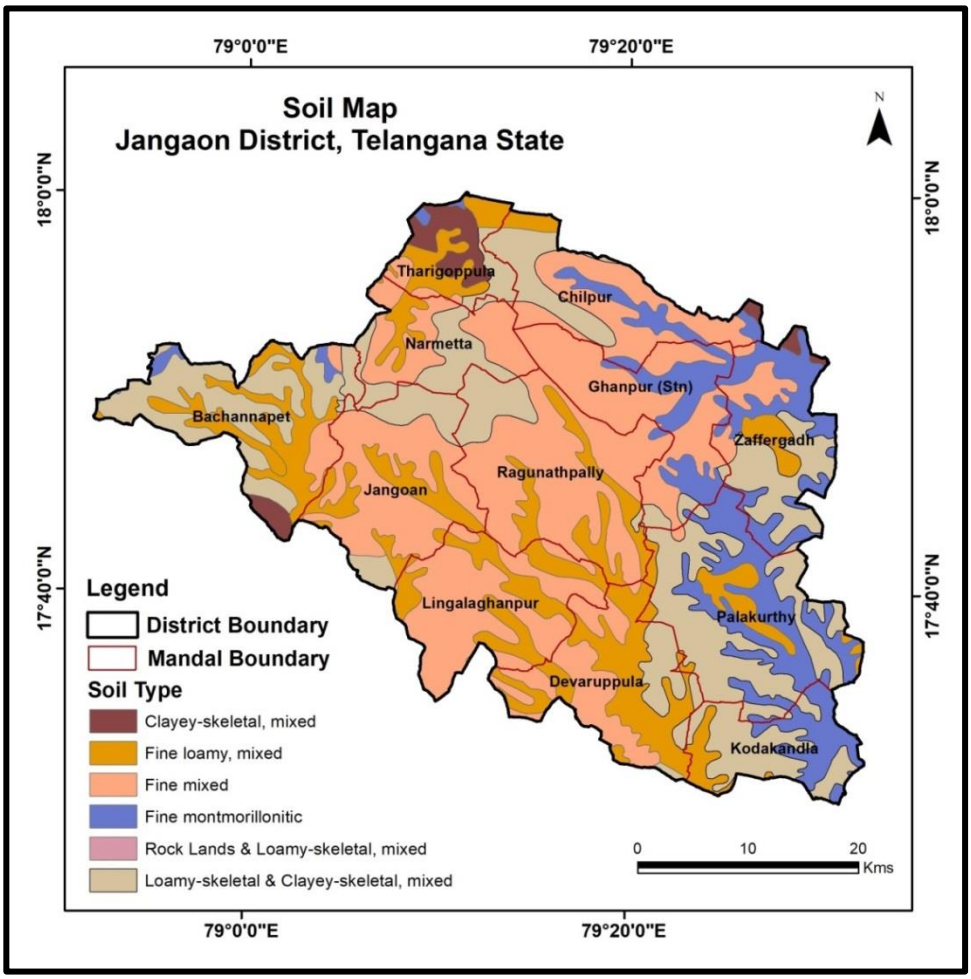


Fig.1.6: Soil map of Jangaon district

1.9 Irrigation

Major Irrigation:

An ayacut of about 242552 acres is met by the ongoing major irrigation projects. Project wise IP created is given below in table no: 1.3

Table: 1.3 Major Irrigation Project in the Jangaon district

Name of the Project	IP Created (in Acres)
Indiramma Flood Flow Canal from SRSP	22430
JCR Godavari Lift Irrigaiton Scheme	219130
Srirama Sagar Project Stage II	992

Minor Irrigation Tanks:

A total of 933 minor irrigation tanks exist in the district with an ayacut of 54,909 acres. In the district there are 53,154 irrigation wells (6751 dug wells and 46,403 tube wells). (Source: Telangana state statistical abstract-2021).

1.10 Prevailing Water Conservation/Recharge Practices

In the district there are 841 percolation tanks and 22 check dams exist. Under Mission Kakatiya (Phase 1 to 4), 72 tanks have been undertaken under RRR (Repairs, restoration and Rejuvenation) schemes.

1.11 Geology

The majority of district is underlain by oldest Archean formation. The general geological succession of the area is presented in the **Table-1.4.** 100% of the area is underlain by Banded Gneissic Complex (**Fig1.7**).

Table-1.4: Stratigraphic Succession of Jangaon district

Era	Period	Formation		Lithological Description
Unconformity				
Azoic	Archaeans	Archaeans		Granites and Gneisses

The basement gneisses and granites constitute the major rock types and found throughout the district. The granites are biotitic type.Veins of quartz and pegmatite traverse through most of the Archaean rocks and at places the Pakhals. A network of the basic dykes of dolerite traverse the granite country.

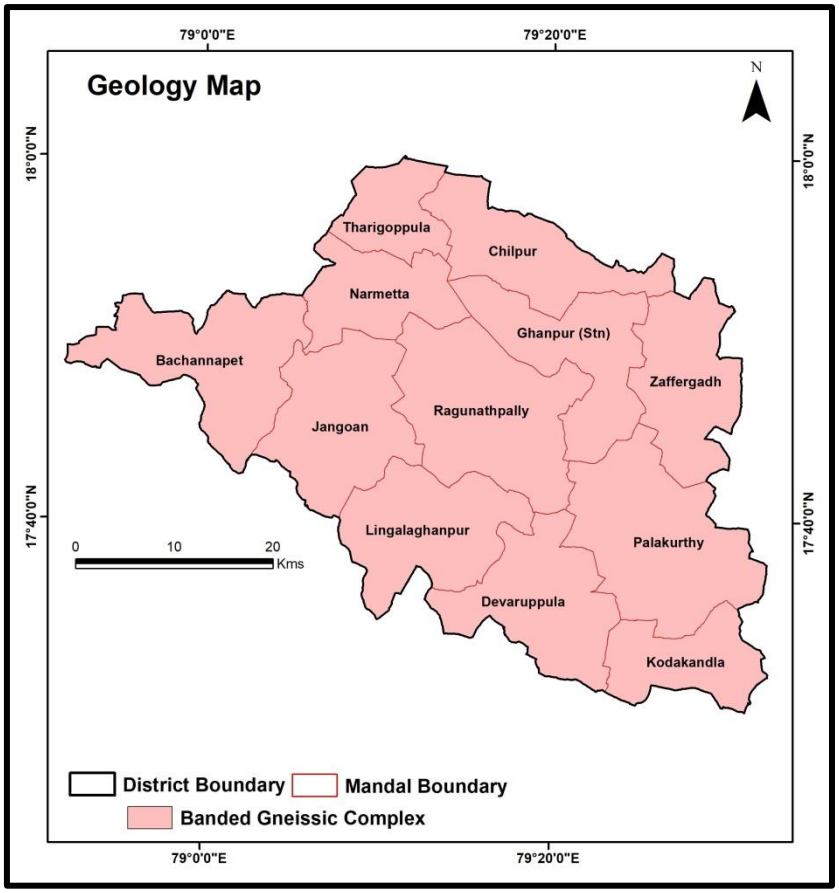


Fig.1.7: Geology map of Jangaon district.

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, Geo-chemical 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 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.

The aquifer geometry for shallow and deeper aquifer has been established through hydro geological studies, exploration, surface and subsurface geophysical studies in the district. The data used for the integration and interpretation includes:

2.1 Ground Water Exploration

So far, CGWB had constructed32 borewells at different depths in the Jangaon district. Data analysed from CGWB wells indicates that 12 well of shallow depth (<30 m), 7 nos (30-100 m),5 nos (100-150 m), 8 nos (150-200 m) depth. Deepest fracture was encountered at 163 m.bgl at Kannaipalle in consolidated banded gneissic formation. The locations of exploratory wells are shown in **Fig. 2.1**.

Table-2.2: Ground Water Exploration wells

Source	Exploratory wells	Observation wells
CGWB	29	3

2.2 Ground Water Monitoring Wells

Water level monitoring wells of 23CGWB and 21SGWD were utilized for the Aquifer mapping studies. Current and historical water levels along with water level trend data of 32borewells **(CGWB: 17, SGWD: 15).** Monitoring wells were utilized for pre-monsoon and post-monsoon season. CGWB wells are being monitored four times (January, April, August and November) in a year whereas; the monitoring wells of State Ground Water Department (SGWD) are being monitored every month. These groundwater monitoring wells were used in order to understand the spatio-temporal behaviour of the groundwater regime.The data is given in **Table-2.3** and locations of monitoring wells are shown in **Fig. 2.1.**

Table-2.3: Ground Monitoring wells

Source	**No. of wells**
CGWB	23
SGWD	21
Total	**44**

2.3 Ground Water Quality

To understand chemical nature of groundwater, 44(CGWB: 13, SGWD: 31) water sample data for premonsoon season and 31 (SGWD: 31) water sample data for postmonsoon season are utilized from ground water monitoring wells. The details are given in **Table 2.4**. Parameters namely pH, EC (in µS/cm at 25° C), TH, Ca, Mg, Na, K, CO3, HCO3, Cl, SO4, NO3 and F were analyzed. The data is given in **Table-2.4** and locations of monitoring wells are shown in **Fig. 2.1.**

Table-2.4: Ground Water Sampling wells

Source	Premonsoon	Postmonsoon
CGWB	13	-

SGWD	31	31

2.4 Geophysical Studies

Geophysical data on VES and profiling are used to extract information on the weathered thickness, fracture depth and thickness of fracture, etc of hard rock area. For the interpretation of the aquifer geometry geophysical data in conjunction with the available groundwater exploration data is utilised. The data from 7 Vertical Electrical Soundings (VES) employing the Schlumberger electrode configuration with the maximum electrode separation (AB) of 200 meters is used for the aquifer mapping studies (Fig. 2.1). The data was processed and interpreted by IPI2Win software enveloped by Moscow State University, after marginally modifying the manually interpreted results in corroboration with geology and hydrogeology. The details of resistivity with change in formation is given in **Table-2.5.**

Table-2.5: Ground Water Sampling wells

Formation	Resistivity range (ohm-m)	Thickness (m)
Weathered granite/Gneiss	22-100	4-38
Fractured/Jointed/Semiweathered Granite/Gneiss	100-400	38-90
Hard/compact granite/Gneiss	More than 500	

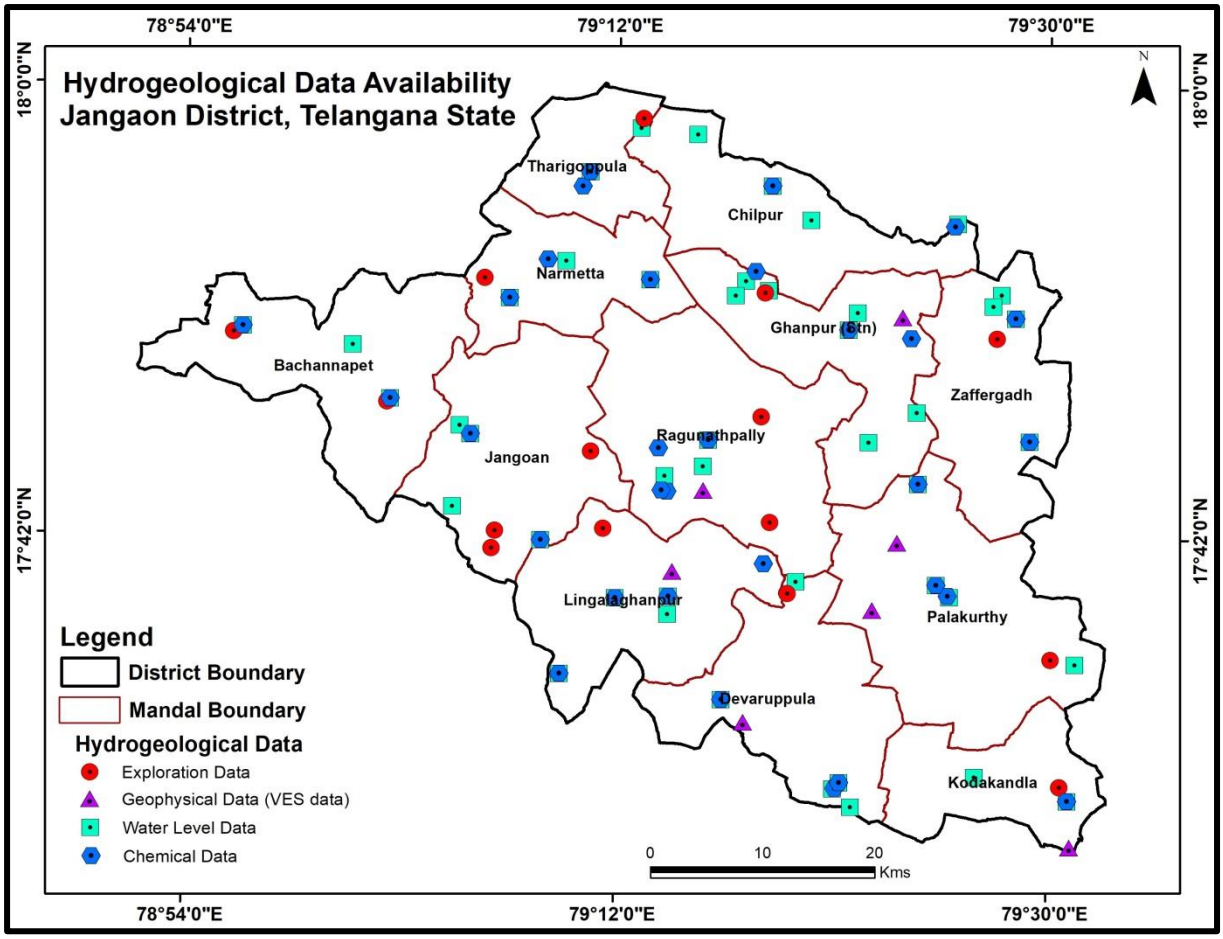


Fig.2.1: Hydrogeological Data availability

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

The data collected and generated on various parameters viz., water levels, water quality, exploration, aquifer parameters, geophysical, hydrology, hydrometeorology, irrigation, was interpreted and integrated. Based on this the various thematic layers hydrogeology, water level scenario of both current and long term scenarios, aquifer wise ground water quality, 2-D and 3-D sub surface disposition of aquifers by drawing fence and lithological sections, yield potential, groundwater resources, were generated and discussed in details.

3.1 Water Level Scenario

The present depth to water level scenario for premonsoon and postmonsoon season was generated by utilizing water level data of 58 (CGWB: 19, SGWD: 39) monitoring wells.

The premonsoon depth to water levels ranged between 5.80m bgl (Namiligonda) and 27.13mbgl (Raghunathapalli). The water levels of <10 m bgl are observed as isolated patches in parts of Ghanpur (Stn), Lingalaghanpur, Devaruppala, Palakurthy, Zaffergadh and Chilpurmandal (20 % of area). The water levels of 10-15 m bgl are observed in majority parts of the district (58 %).The deeper water levels of >15 m bgl are observed in parts of Bachannapet, Raghunathapalli, Narmetta, Kodakandla, Palakurthy, Jangaon and

Chilpurmandal (11.50 % of area). The pre-monsoon depth to water level map is given in **Fig.3.1.**

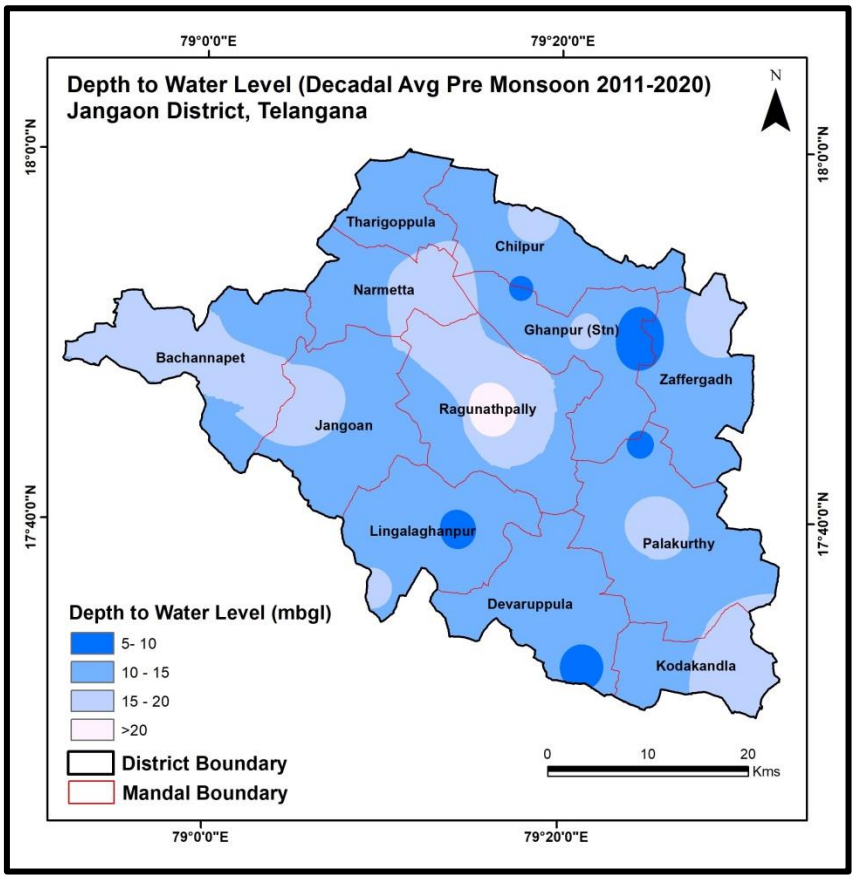


Fig.3.1: Depth to water level map of pre-monsoon season

The postmonsoon depth to water levels ranges between 4.19mbgl (Namiligonda) and 16.76mbgl (Raghunathapalli). The water levels of <5 mbgl are observed as isolated patch of Ghanpur (Stn) and Zaffergadhmandal of the district. The water levels between 5-10 m bgl are observed in majority part of the district (66% of area). The water levels between 10-15 m bgl are observed in Bachannapet, Raghunathapalli, Narmetta, Kodakandla, Palakurthy, Jangaon mandals of the district. The deeper water levels of >15 mbgl are observed as isolated patch in Raghunathapalli mandal (2% of area). The post-monsoon depth to water level map is given in **Fig.3.2.**

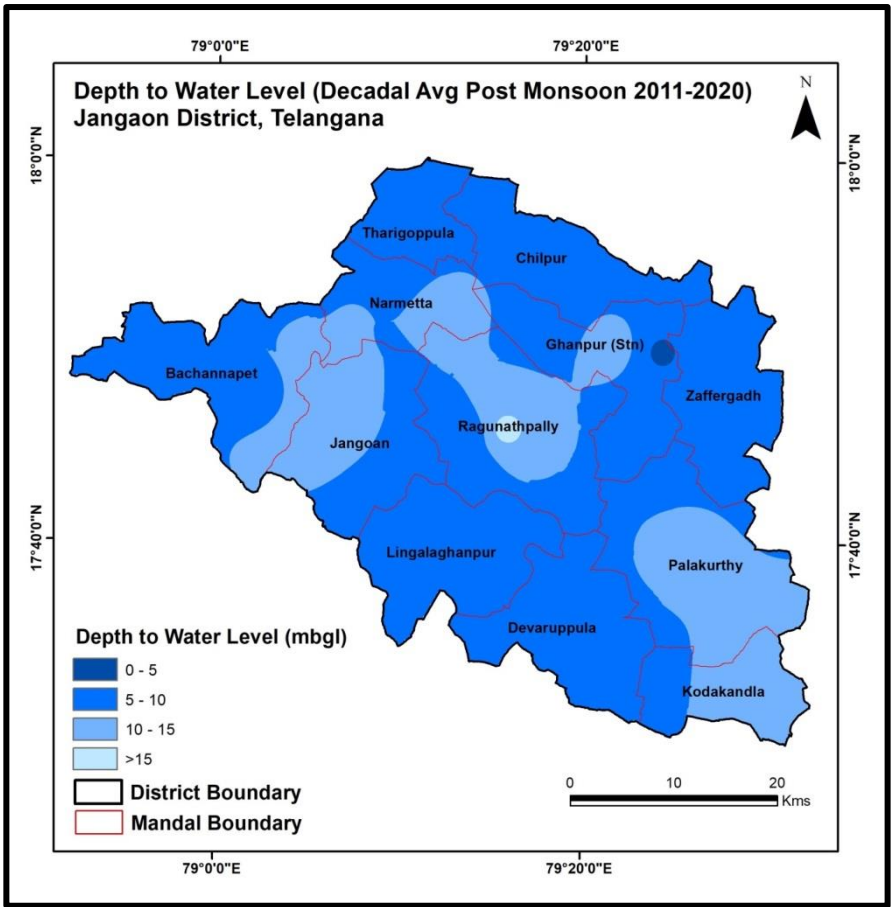


Fig.3.2: Depth to water level map of post-monsoon season

3.1.1 Water Level Fluctuation

The water level measured during pre and post monsoon period was used to compute the seasonal fluctuation. 100% (24 no's) of the wells show rise in water level and no wells show fall in water level. The analysis of water level fluctuation data indicates that minimum water level fluctuation was observed at Namiligonda(1.61m) while maximum water level fluctuation was observed at Ragunathapalli(10.37 m). The water level fluctuations were grouped under three categories i.e., less, moderate and high and the % of wells in each category was analysed (**Table-3.1**).

Table-3.1: Analysis of Water Level Fluctuation

S. No.	Category	Fluctuation Range	% of area
1.	Less water level fluctuation	0 to 5 m	67%
2.	Moderate water level fluctuation	5 to 10 m	29%
3.	High water level fluctuation	>10m	4%

The analysis indicates that majority of the area (67%) are falling in less fluctuation range indicating good aquifer storage, whereas moderate water level fluctuation are observed in 29 % area and high water level fluctuation were observed in 4 % area. The seasonal fluctuation map is presented as **Fig.3.3**

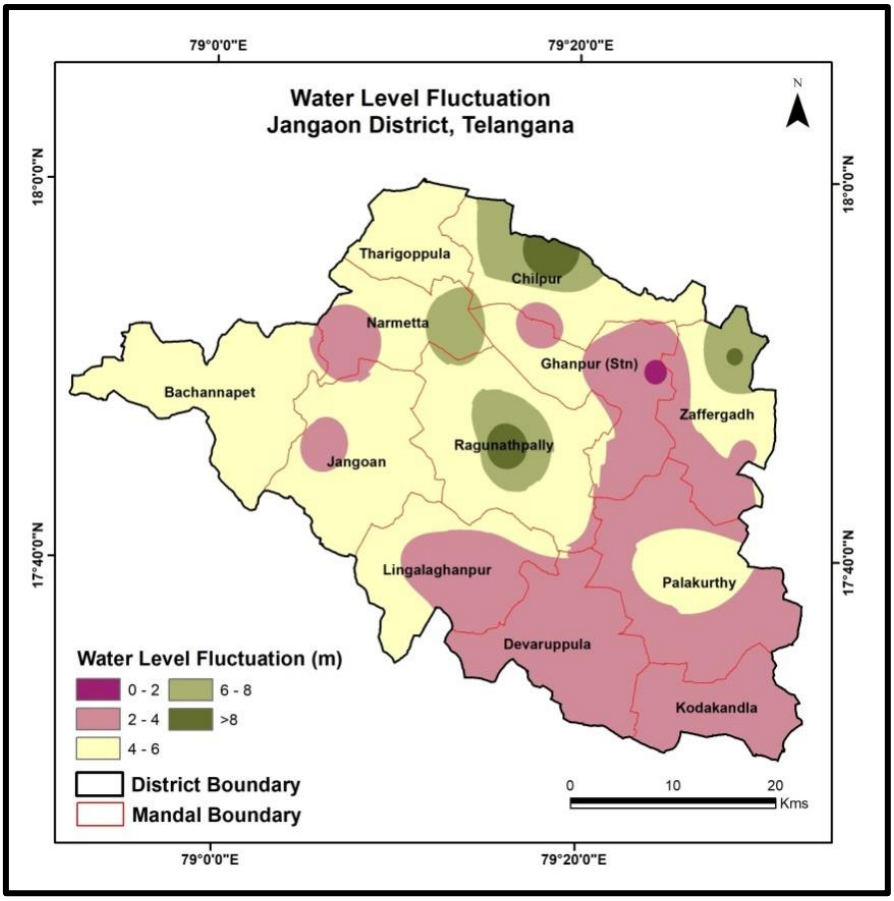


Fig.3.3: Water Level Fluctuations (m) (postmonsoon with respect to premonsoon)

3.1.2 Water Table Elevation

The water table elevation map for premonsoon and postmonsoon period was also prepared (**Fig.3.4(a),3.4(b)**) to understand the ground water flow directions. The water table elevation ranges from 226 to 500m amsl during pre-monsoon period and 229 to 505 m amsl during post monsoon period. The groundwater flow is mainly towards south-eastern direction.

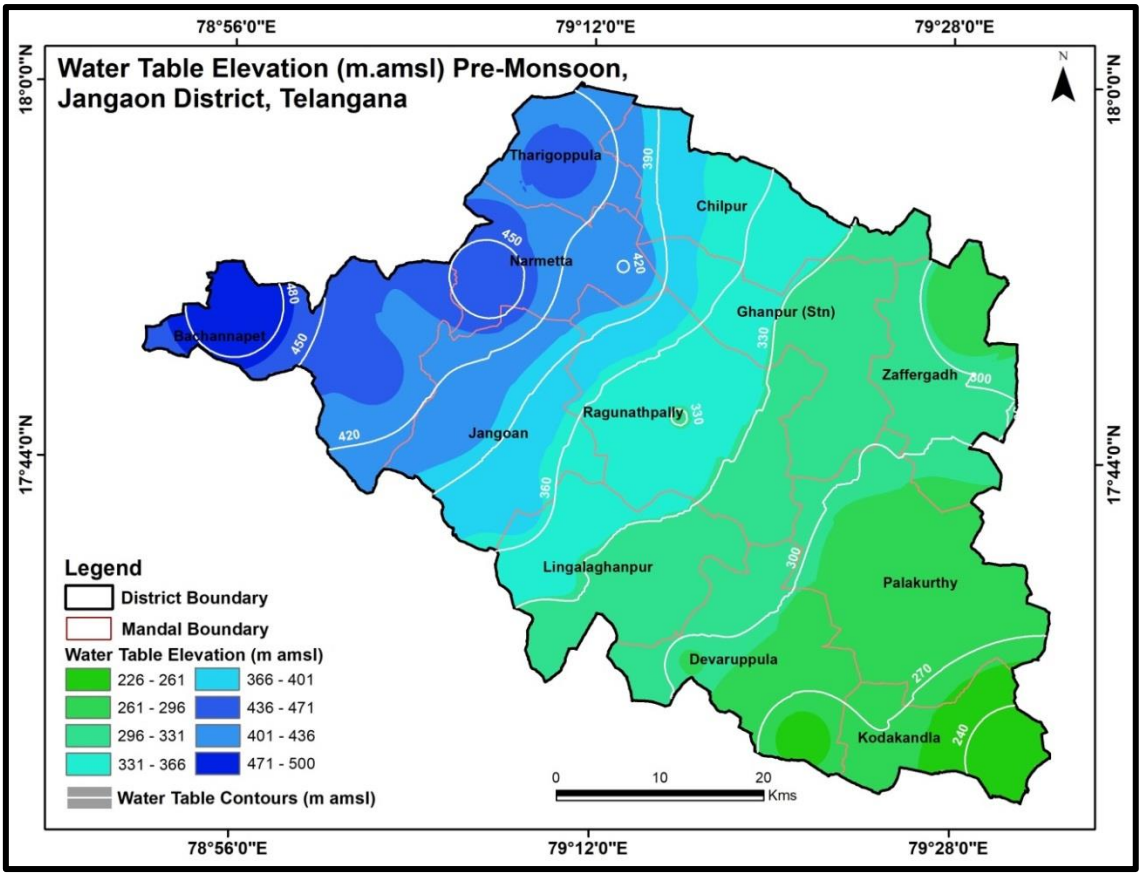


Fig.3.4(a): Water table elevations (m amsl) during pre-monsoon season

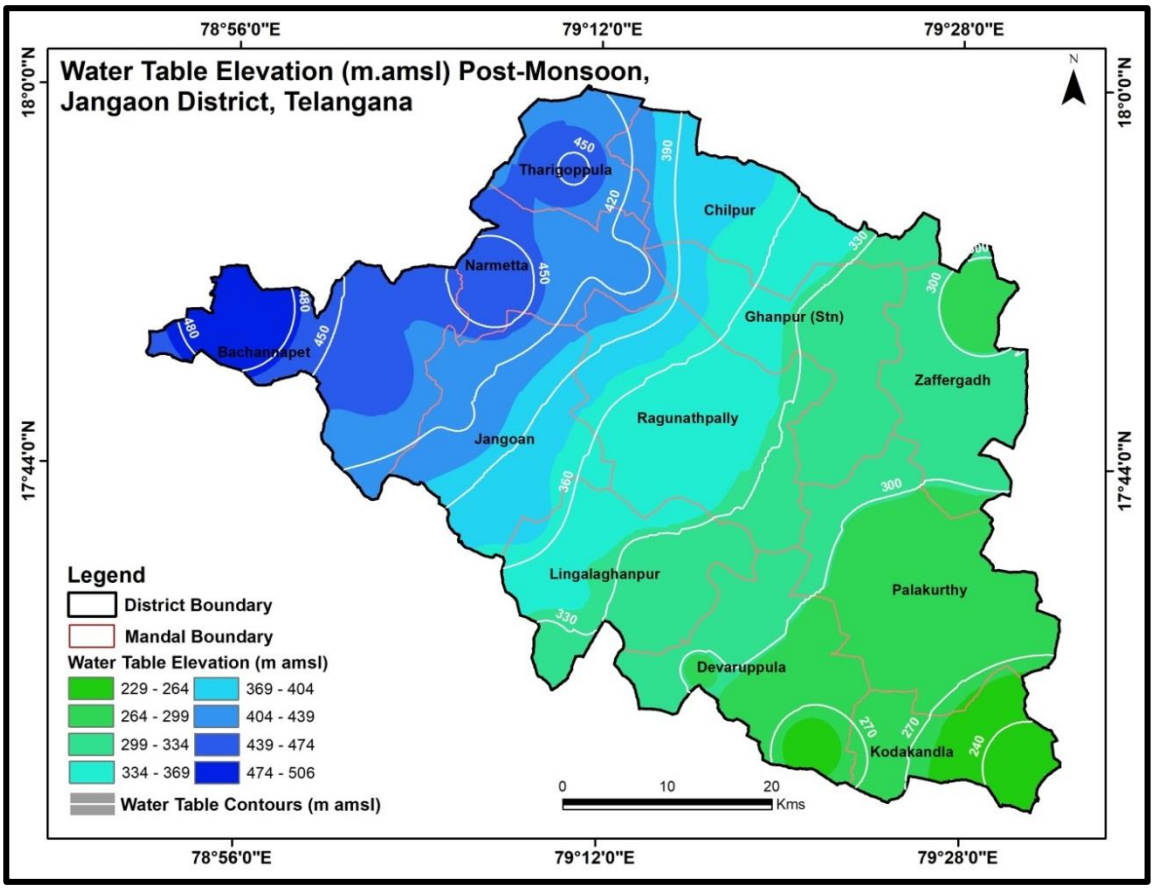


Fig.3.4(b): Water table elevations (m amsl) during post-monsoon season

3.1.3 Long Water Level Trend (2011-20)

Trend analysis for the last 10 years (2011-2020) is studied from 47 hydrograph stations of CGWB and SGWD. It is observed that during pre-monsoon season 21 wells shows rising trend ranging 0.02 to 1.41 m/yrs and 26 wells shows falling trends ranging 0.05 to 2.21 m/yrs. During post-monsoon season 40 wells shows rising trend ranging 0.08 to 3.13 m/yrs and 7 wells shows falling trends ranging 0.003 to 0.49 m/yrs. The graphical representation of fall and rise is shown in Fig.3.5 and spatial distribution map is shown in Fig.3.6 and 3.7.

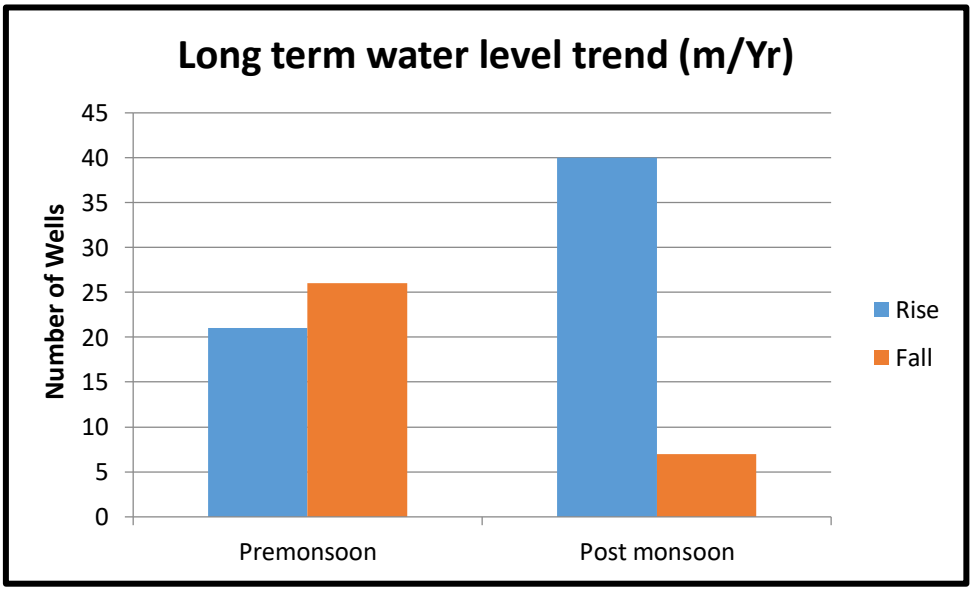


Fig. 3.5: Graphical representation of water level trends (2011-2020)

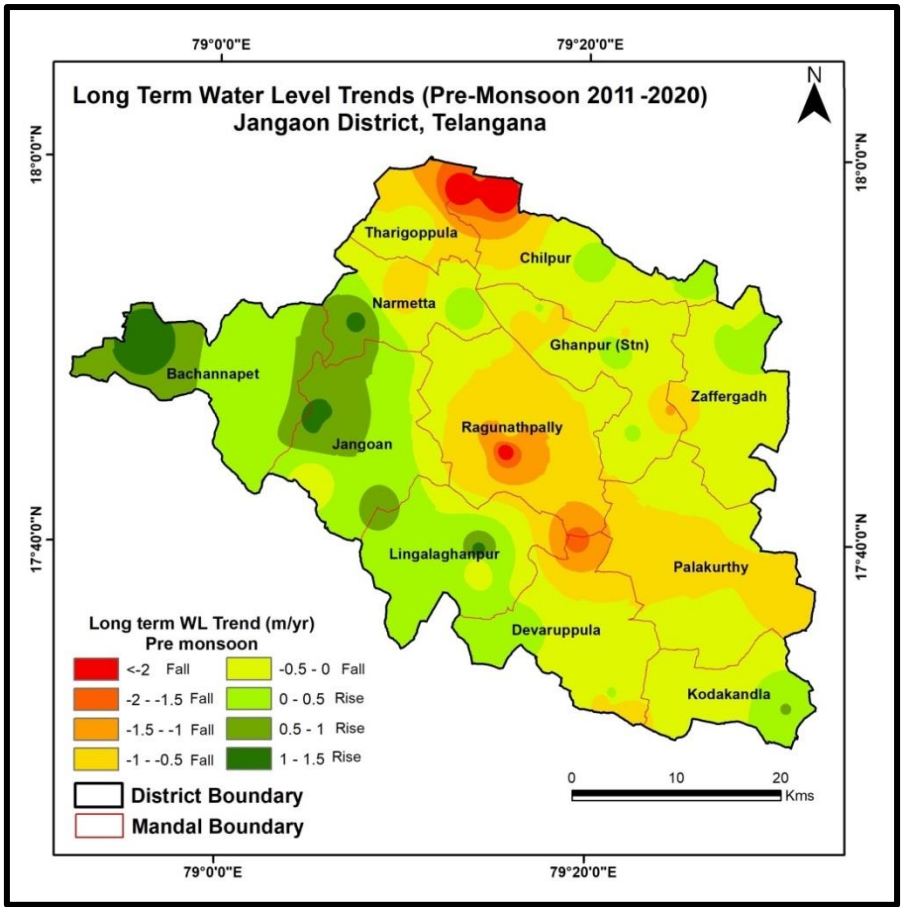


Fig. 3.6: Long-term water level trend-Premonsoon (2011-2020)

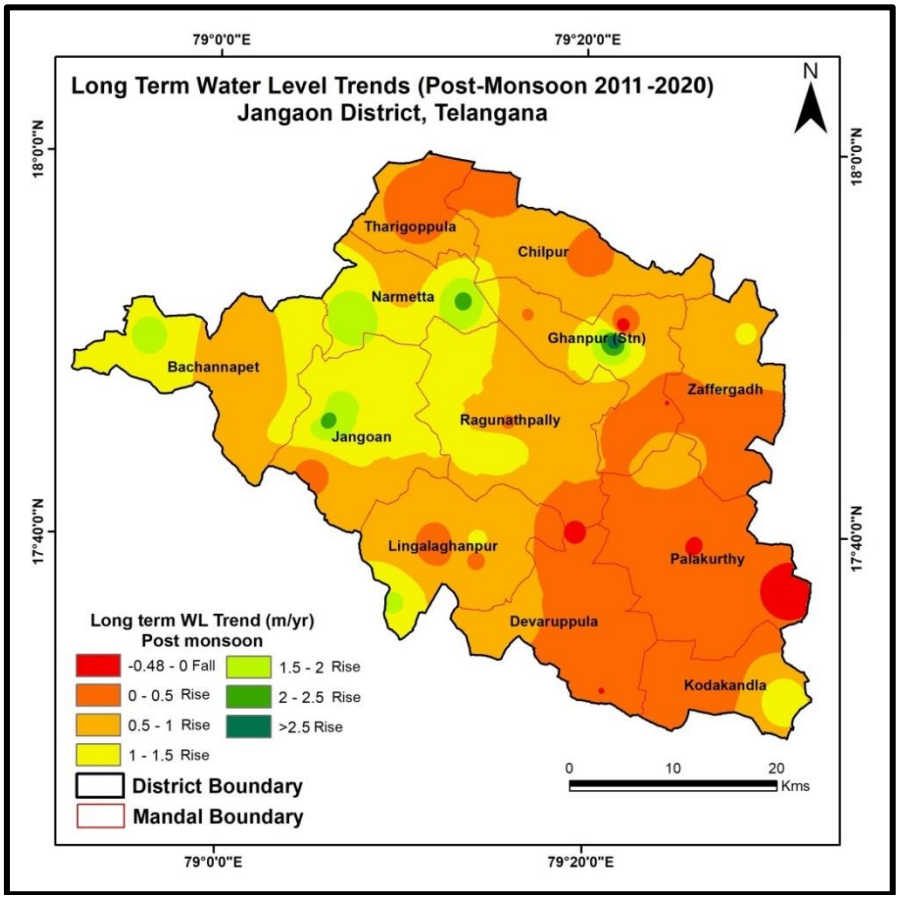


Fig. 3.7: Long-term water level trend-Postmonsoon (2011-2020)

3.2 Ground Water Quality

The suitability of ground water for drinking/irrigation/industrial purposes is determined keeping in view the effects of various chemical constituents present in water on the growth of human being, animals, various plants and also on industrial requirement. Though many ions are very essential for the growth of plants and human body but when present in excess, have an adverse effect on health and growth. For assessment of ground water quality, 75 samples (Pre-monsoon:44 and post-monsoon:31) were utilised from monitoring wells of CGWB and SGWD. The ground water samples were analysed for major chemical constituents. 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.

3.2.1 Pre-Monsoon

A total of 44 samples were analyzed (CGWB: 13, SGWD: 31).Groundwater from the area is mildly alkaline to alkaline in nature with pH in the range of 7.14-8.31 (Avg:7.99). Electrical conductivity varies from 336-2440 (avg: 1160) µ Siemens/cm. EC is within limit of3000 µ Siemens/cm (**Fig.3.8**). Nitrate concentration varies from 2.00-313 mg/L and 45 % of the samples is beyond permissible limits of BIS Standard (>45 mg/L) (**Fig.3.9**).High Nitrate concentration is observed in majority parts of the district. Fluoride concentration varies from 0.16 to 2.97 mg/L (**Fig 3.10**) and in 16 % of samples it is beyond permissible limits of BIS standard (>1.5 mg/L). High fluoride concentration is observed mainly in Bachannapet, Jangaon, Lingala ghanpur, Chilpur and Ragunathapalle.

3.2.2 Post-Monsoon

A total of 31 samples were analyzed (SGWD: 31). Groundwater from the area is mildly alkaline to alkaline in nature with pH in the range of 7.69-8.31 (Avg: 8.18). Electrical conductivity varies from 376-2744 (avg: 1280) µ Siemens/cm. EC is within limit of 3000 µ Siemens/cm (**Fig.3.11**). Nitrate concentration varies from 3.01-195 mg/L and in 54 % of the samples it is beyond permissible limits of BIS Standard (>45 mg/L) (**Fig.3.12**). High Nitrate concentration is observed in majority parts of the district. Fluoride concentration varies from 0.18-1.91 mg/L **(Fig 3.13**) and in 3 % of samples it is beyond permissible limits of BIS standard (>1.5 mg/L). High fluoride concentration is observed only in Chilpur mandal.

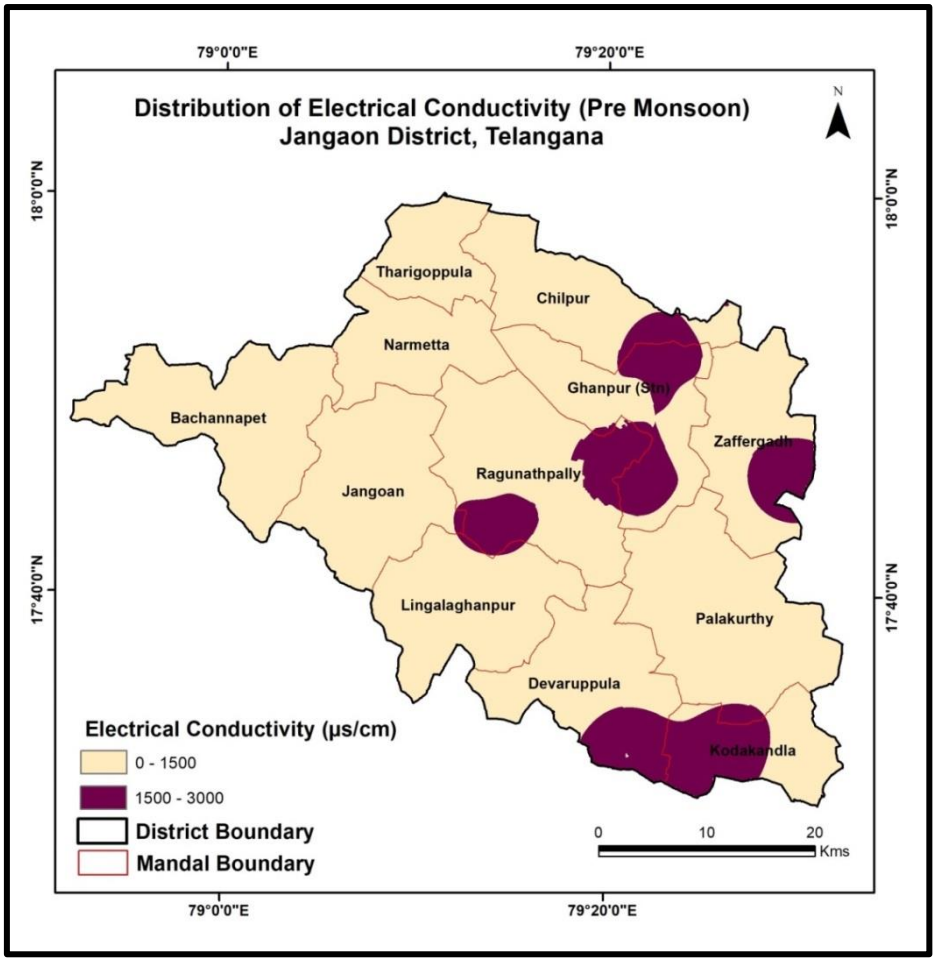


Fig.3.8: Distribution of Electrical conductivity (Pre-monsoon).

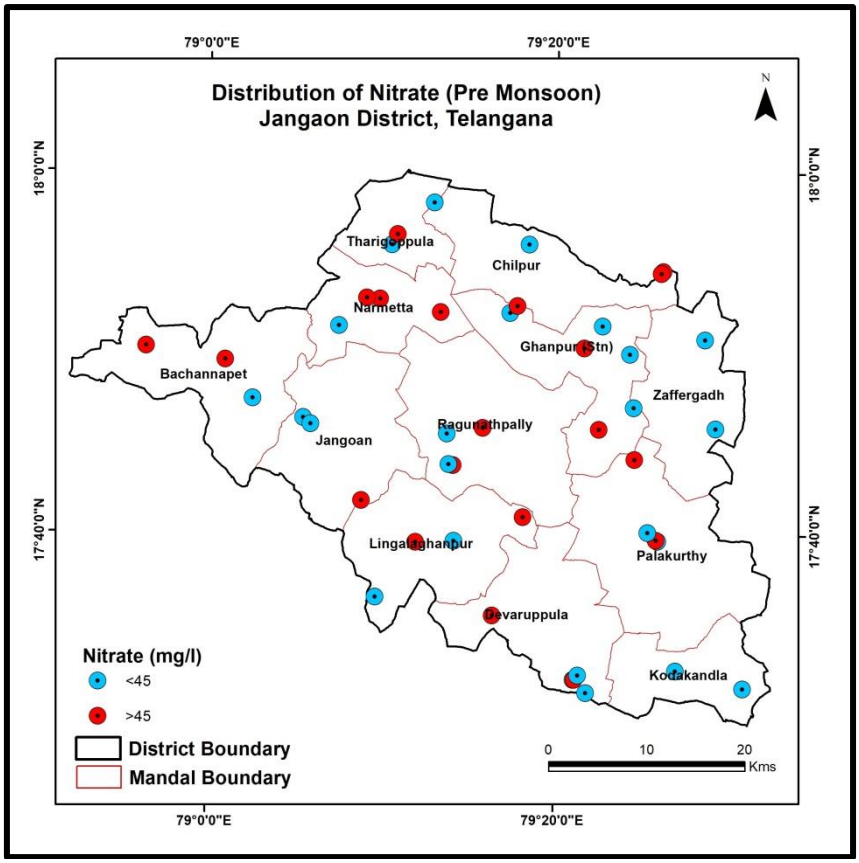


Fig.3.9: Distribution of Nitrate (Pre-monsoon)

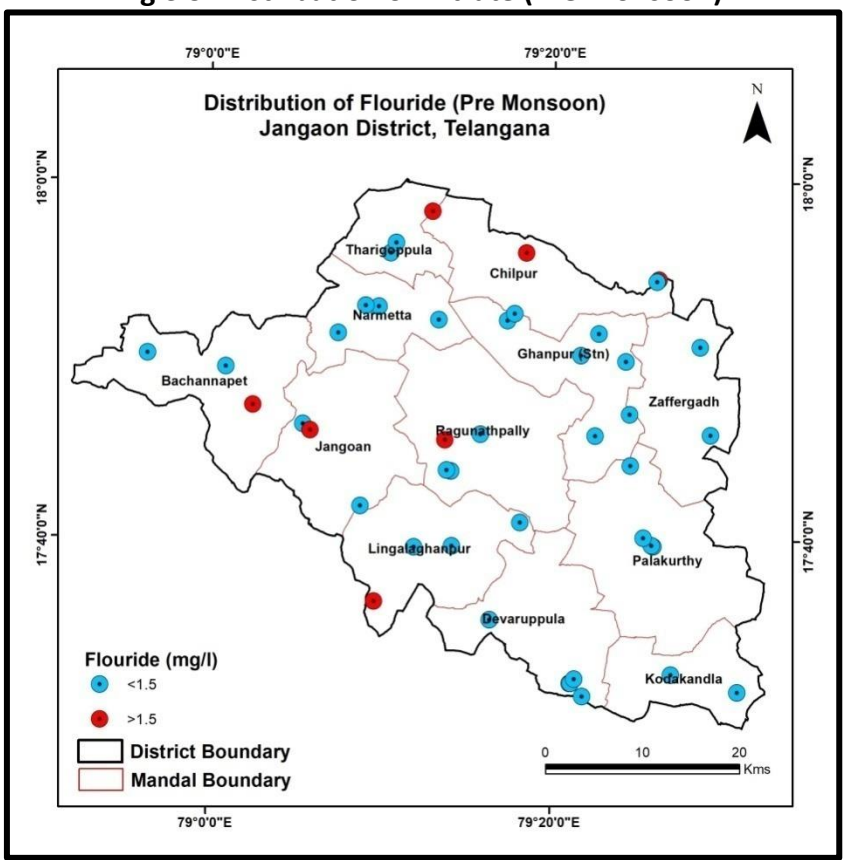


Fig.3.10: Distribution of Fluoride (Pre-monsoon)

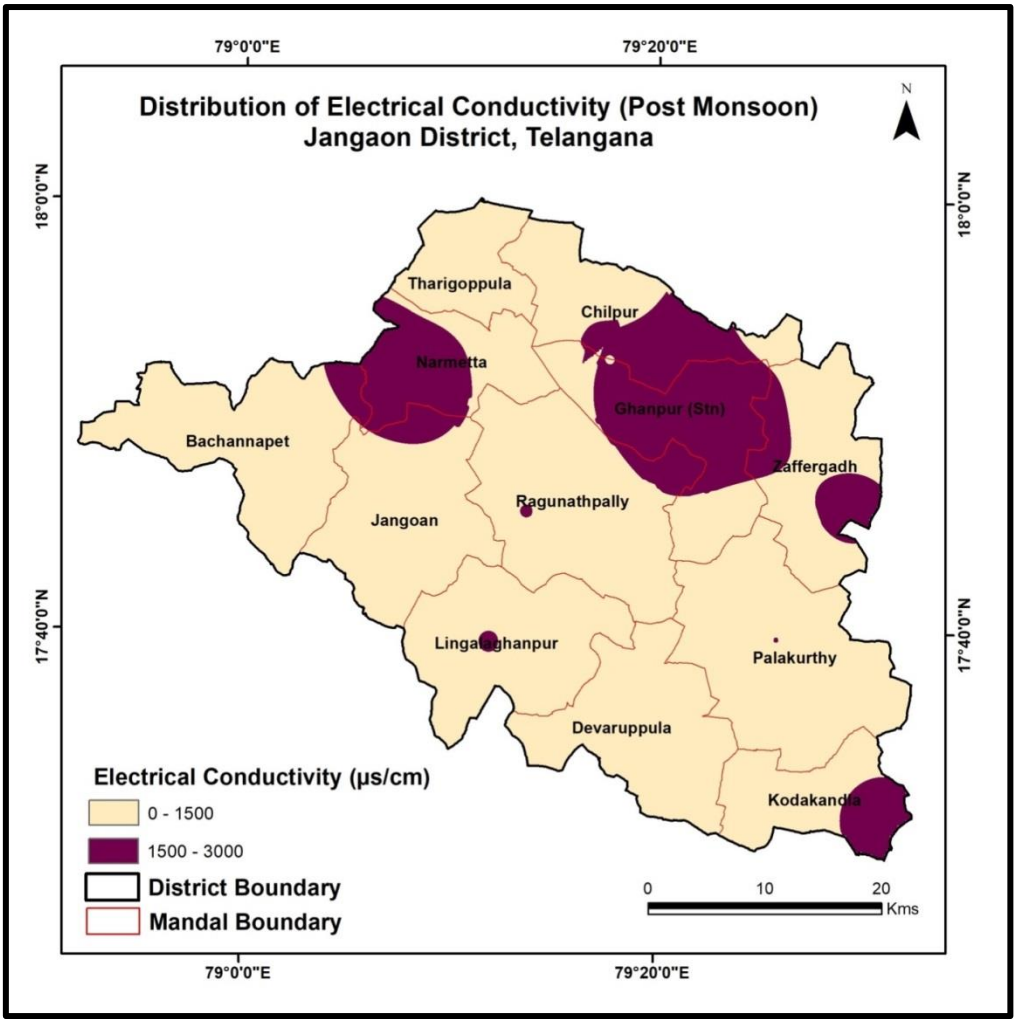


Fig.3.11: Distribution of Electrical conductivity (Post-monsoon)

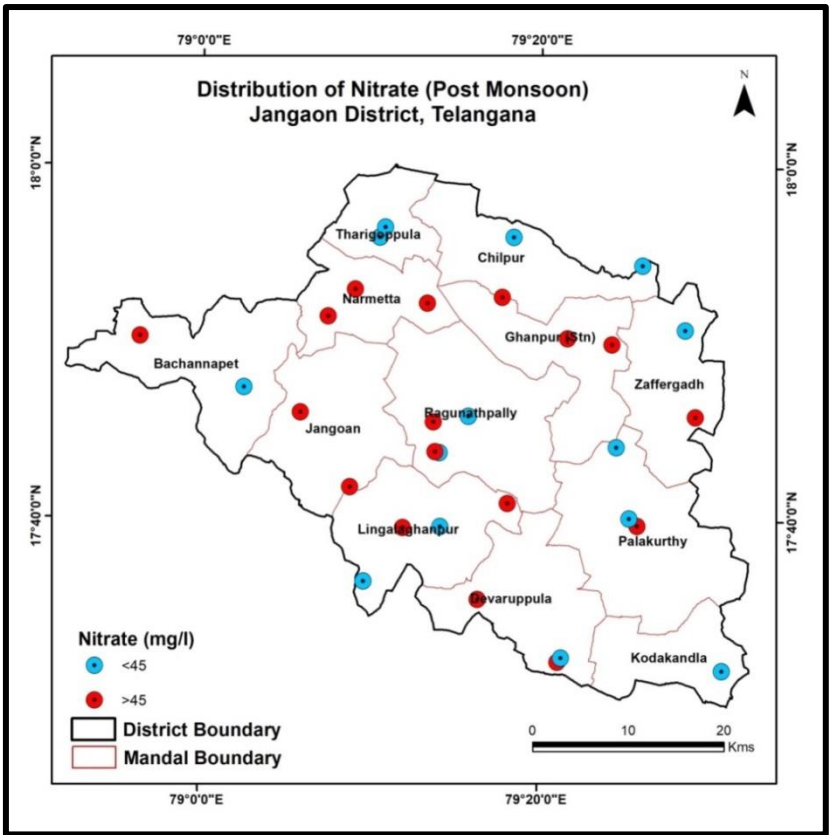


Fig.3.12: Distribution of Nitrate (Post-monsoon)

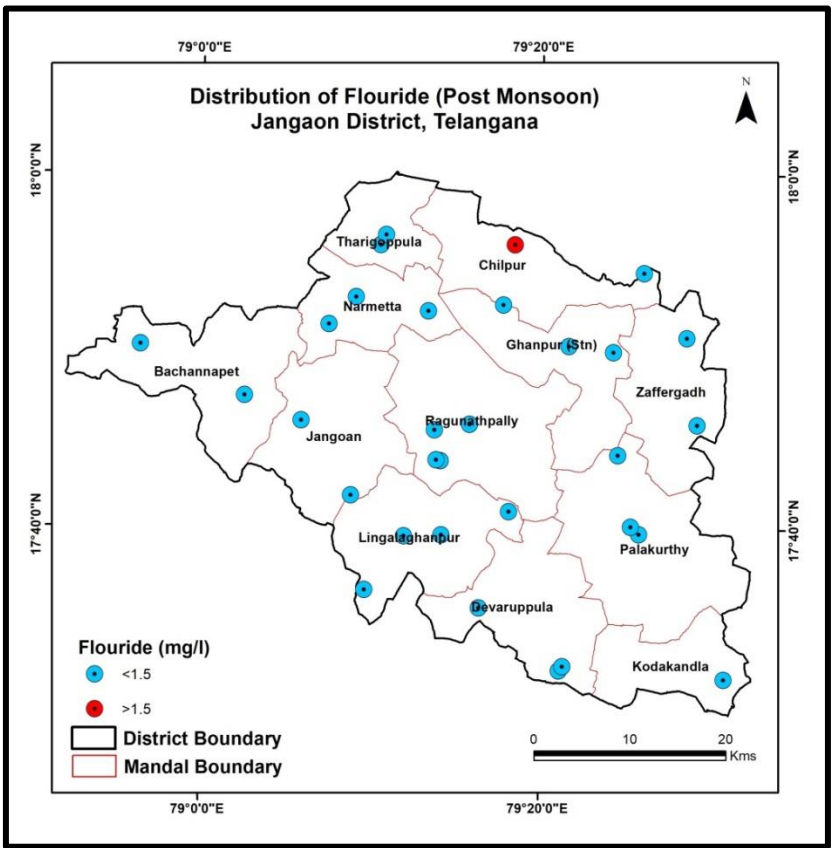


Fig.3.13: Distribution of Fluoride (Post-monsoon)

3.3 Aquifer Mapping

The aquifer geometry for shallow and deeper aquifer has been established through hydro geological studies, exploration, surface and subsurface geophysical studies in the district. The occurrence and movement of water in the subsurface is broadly governed by geological frameworks. It depends on rock type, depth of weathering and extension of weak zones like fractures, joints etc., in hard rocks, while in sedimentary rocks it depends on porosity, granularity, cementing matrix, permeability, bedding plains and faults etc. Based on 223 hydrogeological data points hydrogeological map is prepared and presented in **Fig 3.14**.

On the basis of occurrence and movement of ground water, rock units of the district can be broadly classified as consolidated formation (Archean crystalline and metasedimentary formation) which occupies approximately 100 % of the area.

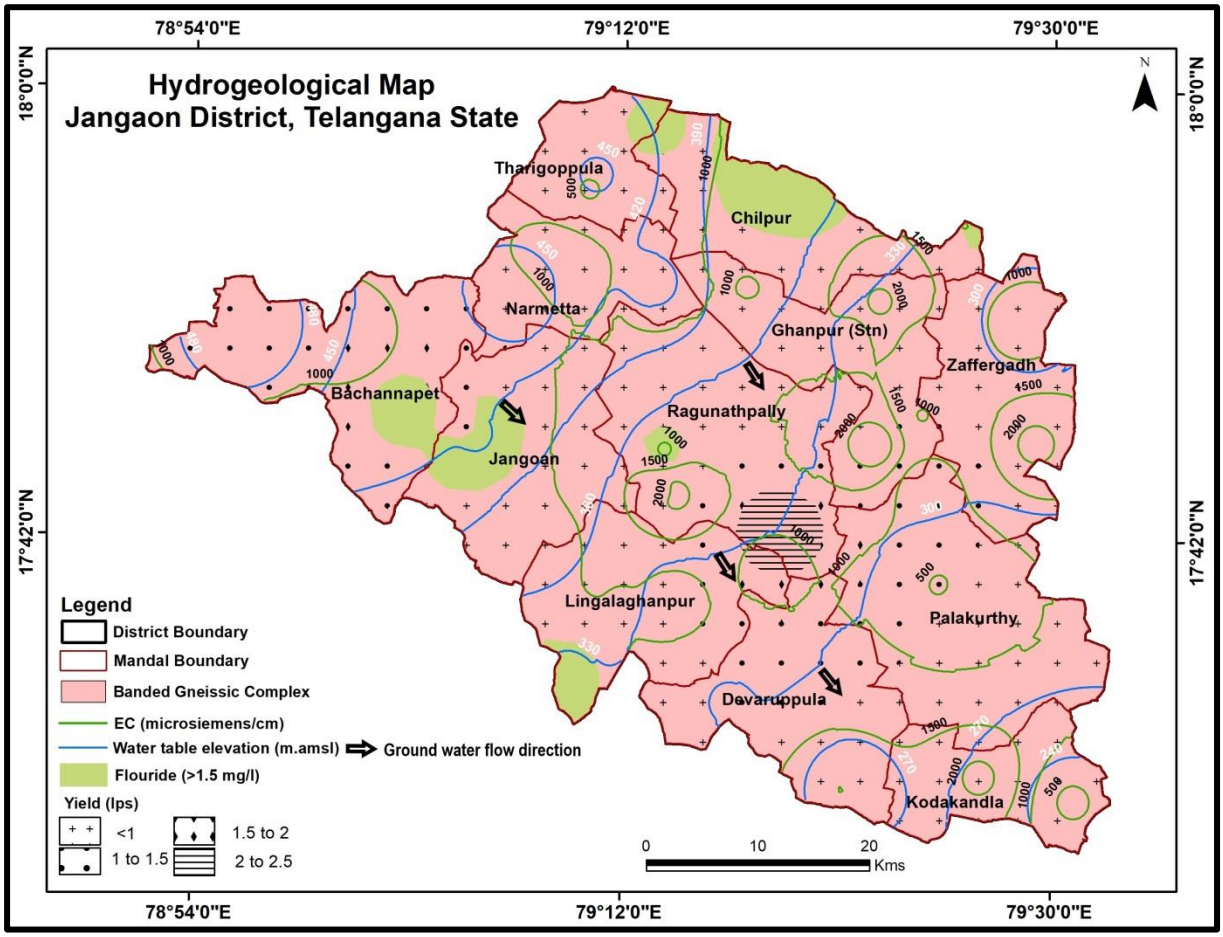


Fig.3.14: Hydrogeological map of Jangaon district

3.3.1 Aquifer system in consolidated formation

Consolidated formation consist of Archean crystalline formation. The crystalline granites and gneisses are devoid of primary porosity. However, subsequent weathering, fracturing and fissuring developed secondary porosity. 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.

3.3.1.1 Weathered Zone (Aquifer -I)

It consists of weathered residum where ground water occurs under unconfined conditions in the intergranular pore spaces of weathered mantle and is mainly developed by construction of dug wells or shallow bore wells as hand pumps.The storage in granite rocks is primarily confined to the weathered zone and it has been used mainly for irrigation purpose. It extends upto depth of 15m in Jangaon district.Thickness of weathered zone is in the range of 9-12 m in most part of area covering ~41 % of area, shallow weathering (<9 m) occurs in 35 % of the area and deep weathering (>12 m) occurs in 23% of the area(**Fig 3.15**).

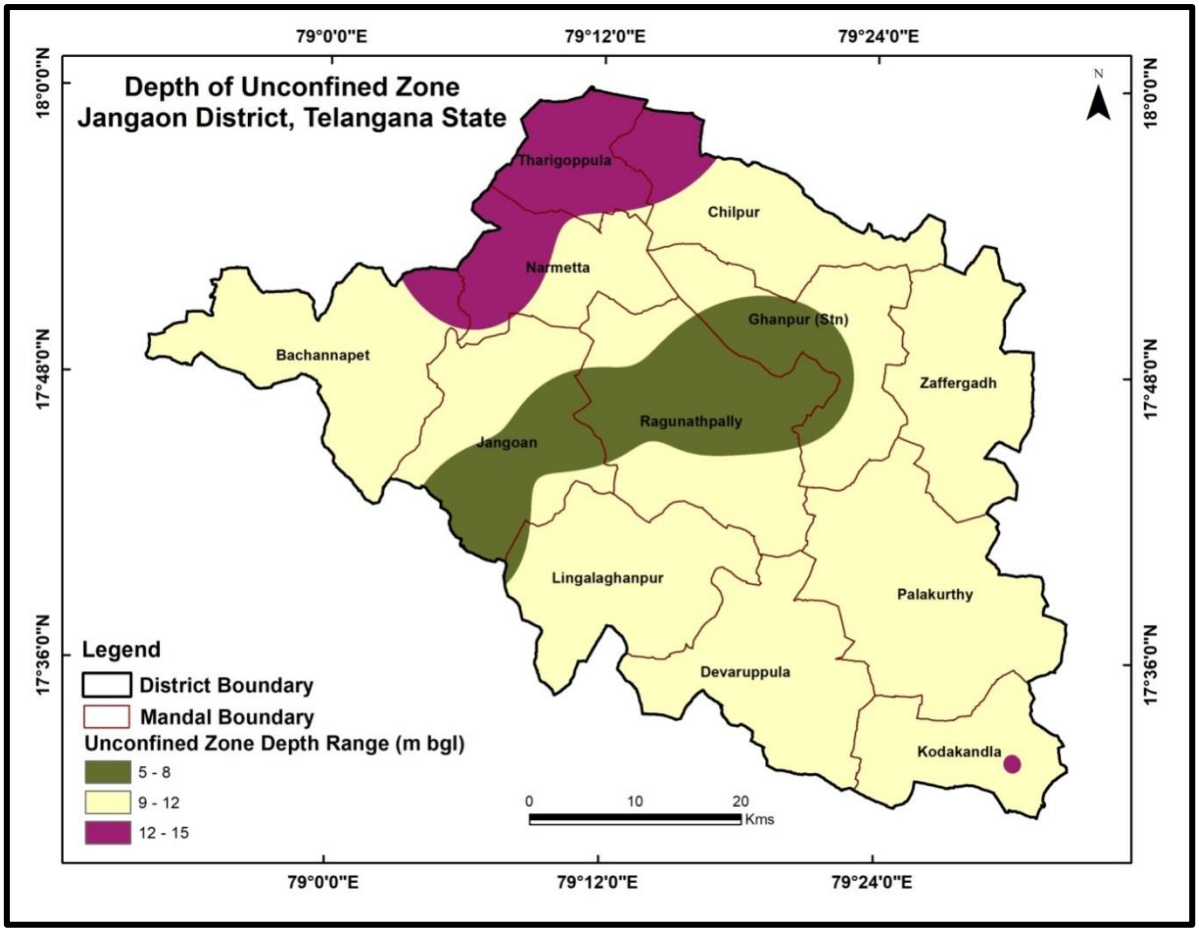


Fig.3.15: Unconfined zone map of Jangaon district

3.3.1.2 Fractured Zone (Aquifer -II)

In the fractured zone ground water occurs under semi-confined to confined conditions. The fractured zone is considered from bottom of weathered zoneto the top of deepest fracture. Ground water in fractured zone is developed through construction of shallow/deep bore wells and dug-cum borewells. The depth of fracturing varies from 12 m to 163m (deepest fracture encountered at Kannaipalle). Ground water yield from fractured granite/gneiss varies from <0.01 to 2.5lps. The transmissivity varies from 0.19-22.1 m2/day and storativity varies from 0.000001 to 0.001 (**Fig 3.16**).

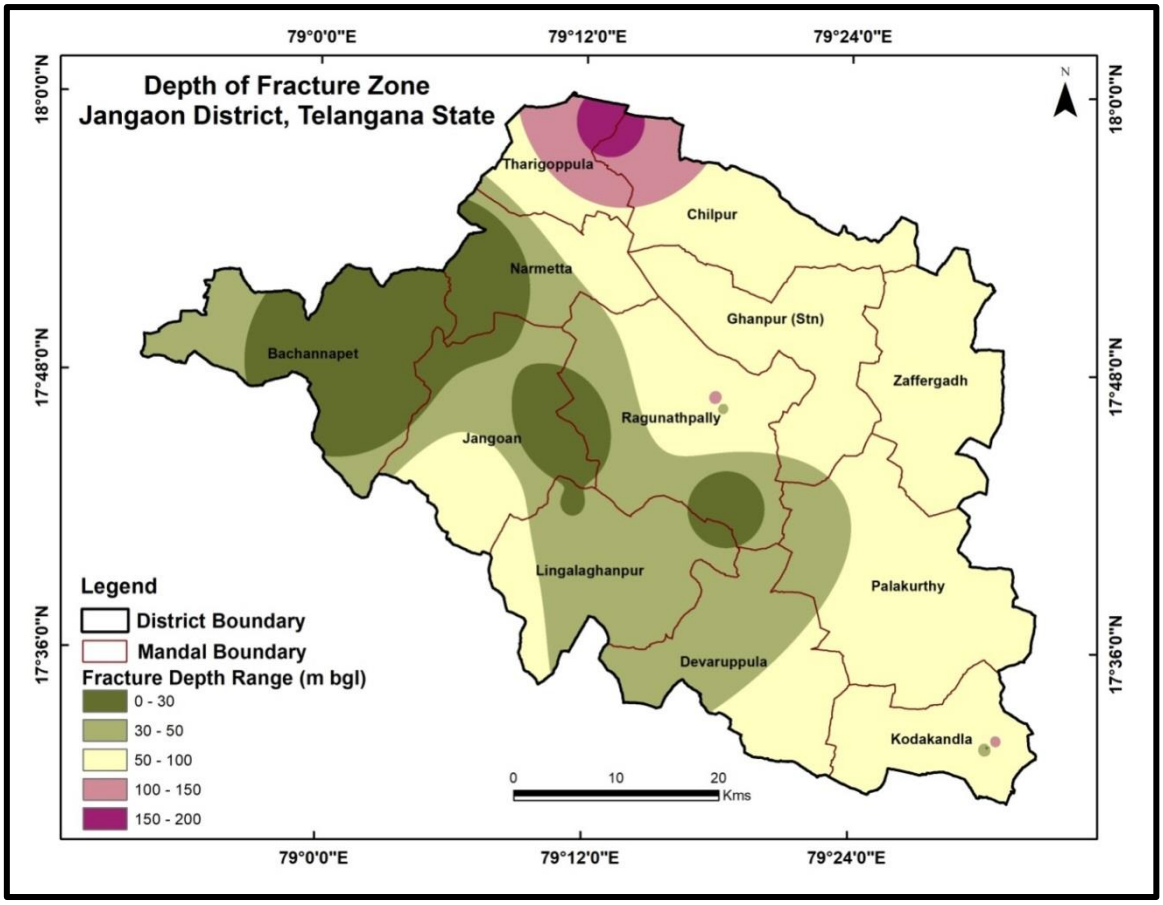


Fig.3.16: Fracture zone map of Jangaon district

Table 3.2 Salient features of Aquifer system in Jangaon district

	Archean Crystalline	
Prominent Lithology	Granite, Gneiss	
Aquifers	Weathered Zone (Aquifer-1)	Fracture Zone (Aquifer-2)
Thickness range	Upto 15 m	12-163 m
Range of yield potential	<0.01 to 2.5 lps	
Transmissivity (m^2/day)	0.19-22.1m^2/day	
Storativity	0.000001 to 0.001	
Specific Yield	2%	
Quality (Suitabilty of Irrigation)	Yes	Yes
Suitabilty of domestic purposes	Yes	Yes

3.4 3D and 2D Aquifer Disposition

The data generated from ground water monitoring wells, hydrogeological inventories, exploratory wells and geophysical studies, various thematic layers were utilized to decipher the aquifer disposition of the area. This particularly includes the information on 3D geometry of aquifers, panel diagram and hydrogeological information of these aquifers. RockWorks-17 software was used for this purpose. The data is calibrated for elevations with Shuttle Radar Topography Mission (SRTM) data. The 3-D representation of Aquifer disposition is presented in **Fig. 3.17**

The fence diagram indicating the disposition of various aquifers is presented in **Fig.3.18 and Fig.3.19**. In majority part of district, granites/gneiss can be seen. The disposition of weathered and fractured zone followed by massive granite/gneiss can be observed in the Fence.

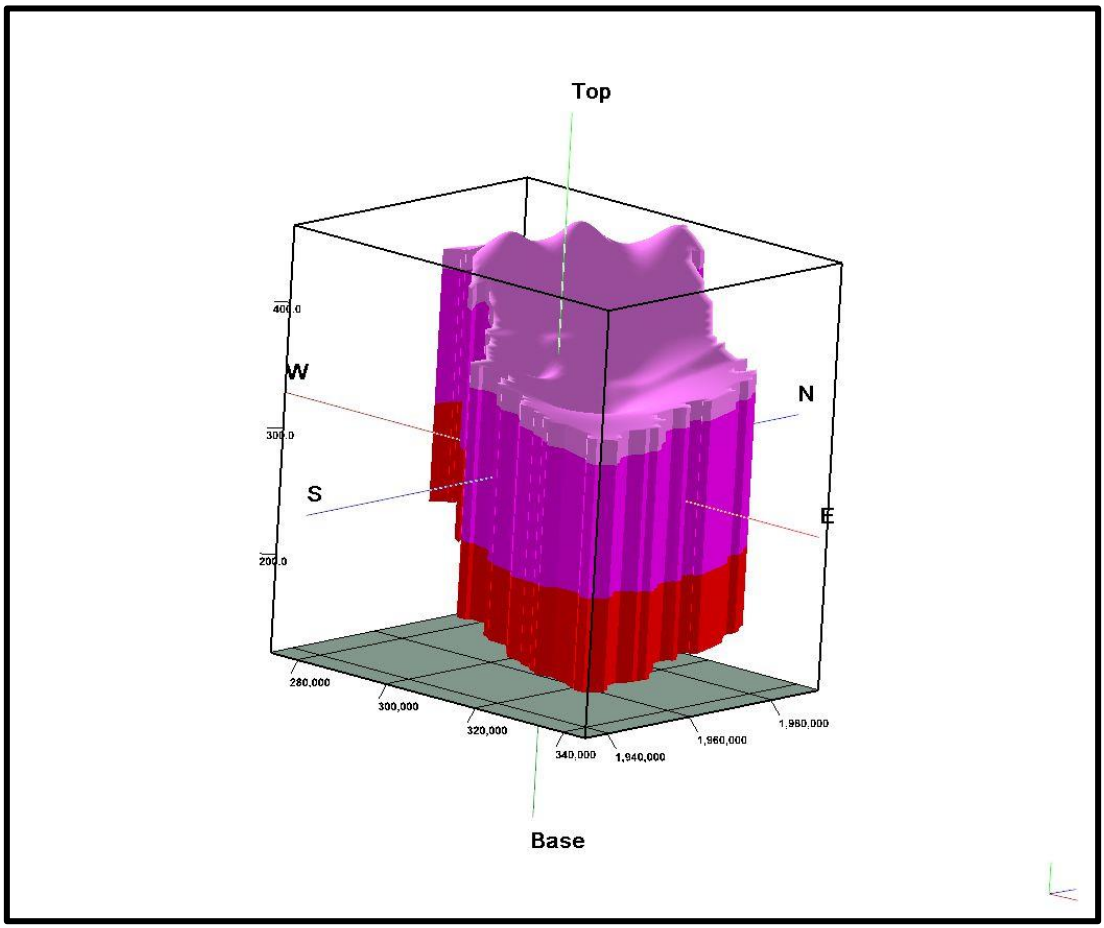


Fig.-3.17: 3-D disposition of Aquifers

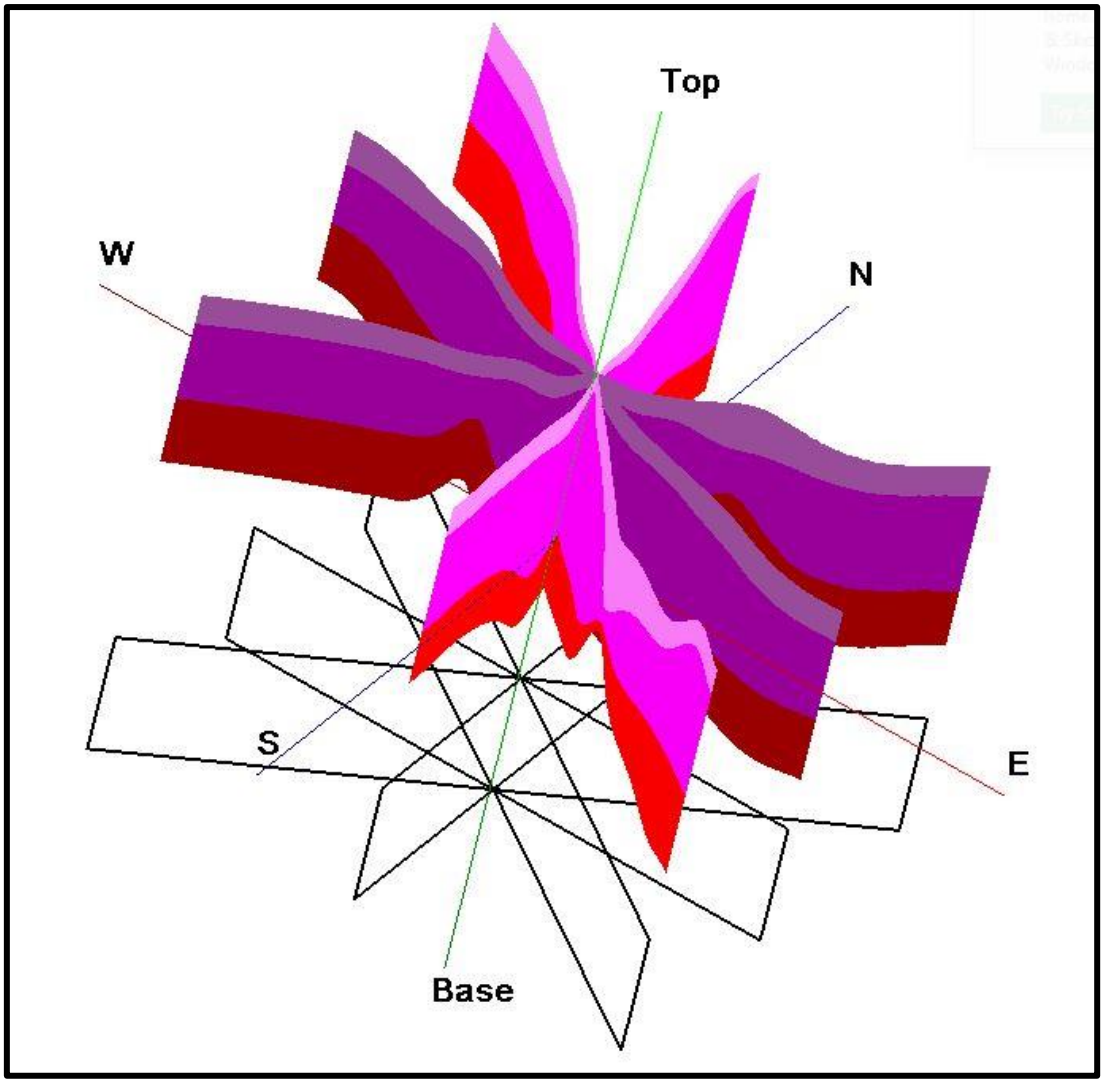
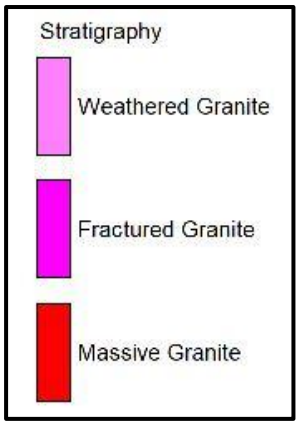


Fig.-3.18: Fence diagram-1



3.4.1 Hydrogeological Cross Sections

To study the aquifer disposition in detail, various hydrogeological cross section indicating aquifer geometry has been prepared viz.NE-SW, NW-SE direction in Granitic area (**Fig. 3.19**).

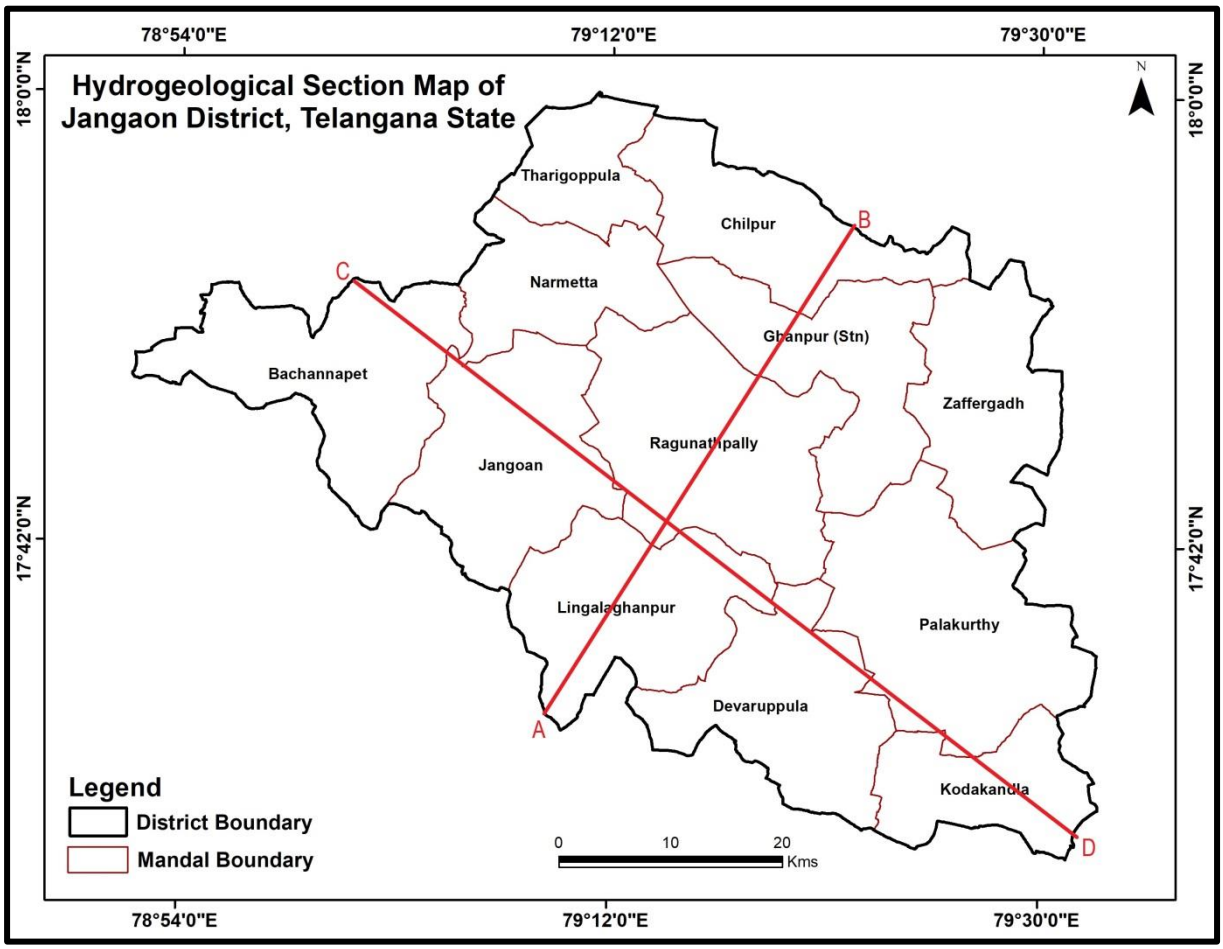


Fig.-3.19: Map showing orientation of hydrogeological sections

3.4.1.1 Hydrogeological Cross Section A-B

Hydrogeological cross section A-B (**Fig.3.20**) represents northeast-southwest direction covering a distance of ~40kms. It depicts thick fractured zone overlaid by thin weathered zone in granites. As we move from northeast to southwest direction, depth of fracture zone varies from 127.5 m bgl at Tammadapalle to 20 m bgl at Pembarti. The maximum depth of weathering ranging from 23.5 m bgl at Tammadapalle to 5.5 m bgl at Chowdaram.

3.4.1.2 Hydrogeological Cross Section C-D

Hydrogeological cross section C-D (**Fig.3.21**) represents northwest–southeast direction covering a distance of ~63 kms. It depicts thick fractured zone overlaid by thin weathered zone in granites. As we move from northwest to southeast direction, depth of fracture zone varies from 120 m bgl at Bachannapet to 24.5 m bgl at Vavilala. The maximum depth of weathering ranging from 17 m bgl at Bachannapet to 23.5 m bgl at Vavilala.

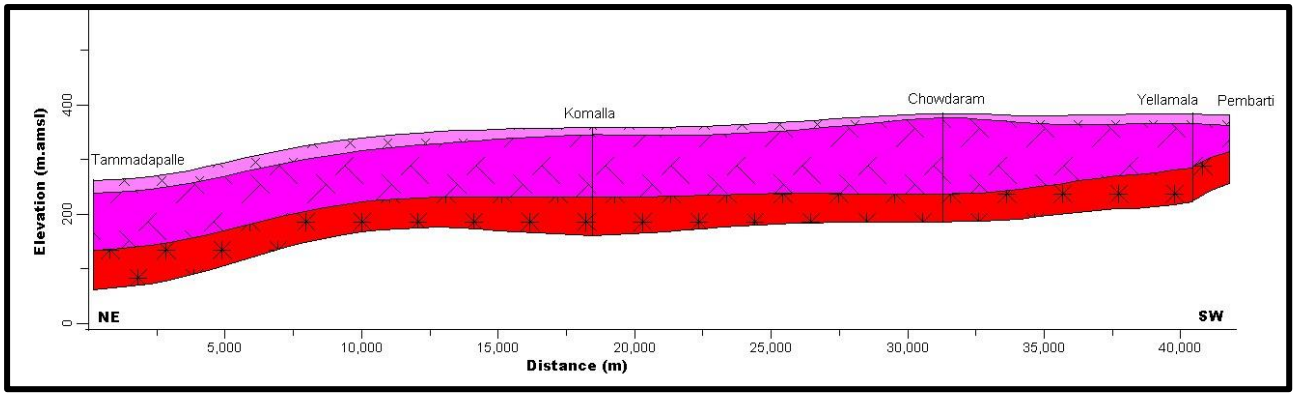


Fig.3.20: Hydrogeological cross section A-B

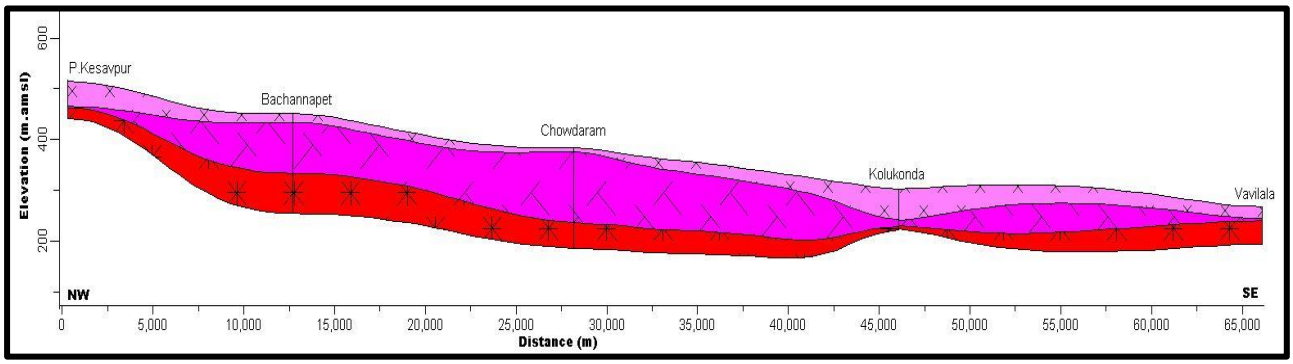


Fig.3.21: Hydrogeological cross section C-D

4. GROUND WATER RESOURCES

In hard rocks, for practical purpose it is very difficult to compute zone wise (aquifer wise) ground water resources, because the weathered zone (WZ) and fractured zone (FZ) 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. Village wise dynamic and in-storage ground water resources are computed as per the guidelines laid down in GEC methodology.

While computing the instorage 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. Dynamic ground water resources are computed as per the guidelines laid down in GEC-2020 methodology. As per 2020 GEC report, the net dynamic replenishable groundwater resources availability is 242.15 MCM, gross ground water draft for all uses is 212.58 MCM and net annual ground water potential available for future irrigation needs is 35.47MCM. Stage of ground water development varies from 61 % at Devaruppala to 106 % at Kodakandla. Out of 12 mandals, 5 are in Semicritical, 1 in Critical, 4 are in over exploited and 2 are in Safe categories. 90 % (MCM) of gross ground water draft is utilized for irrigation purpose only. Computed Dynamic ground water resources of the study area are given in **Fig 4.1** and **Table-4.1**.

Table-4.1: Computed Dynamic ground water resources.

As per GEC 2020	MCM
Dynamic (Net GWR Availability)	**242.15**
• Monsoon recharge from rainfall	156.17
• Monsoon recharge from other sources	24.36
• Non-Monsoon recharge from rainfall	24.85
• Non-monsoon recharge from other sources	63.67
• Natural Discharge	26.91
Gross GW Draft	**212.58**
• Irrigation	186.69
• Domestic and Industrial use	25.89
Provision for Drinking and Industrial use for the year 2025	22.22
Net GW availability for future irrigation	35.47
Stage of GW development (%)	**88.60%**

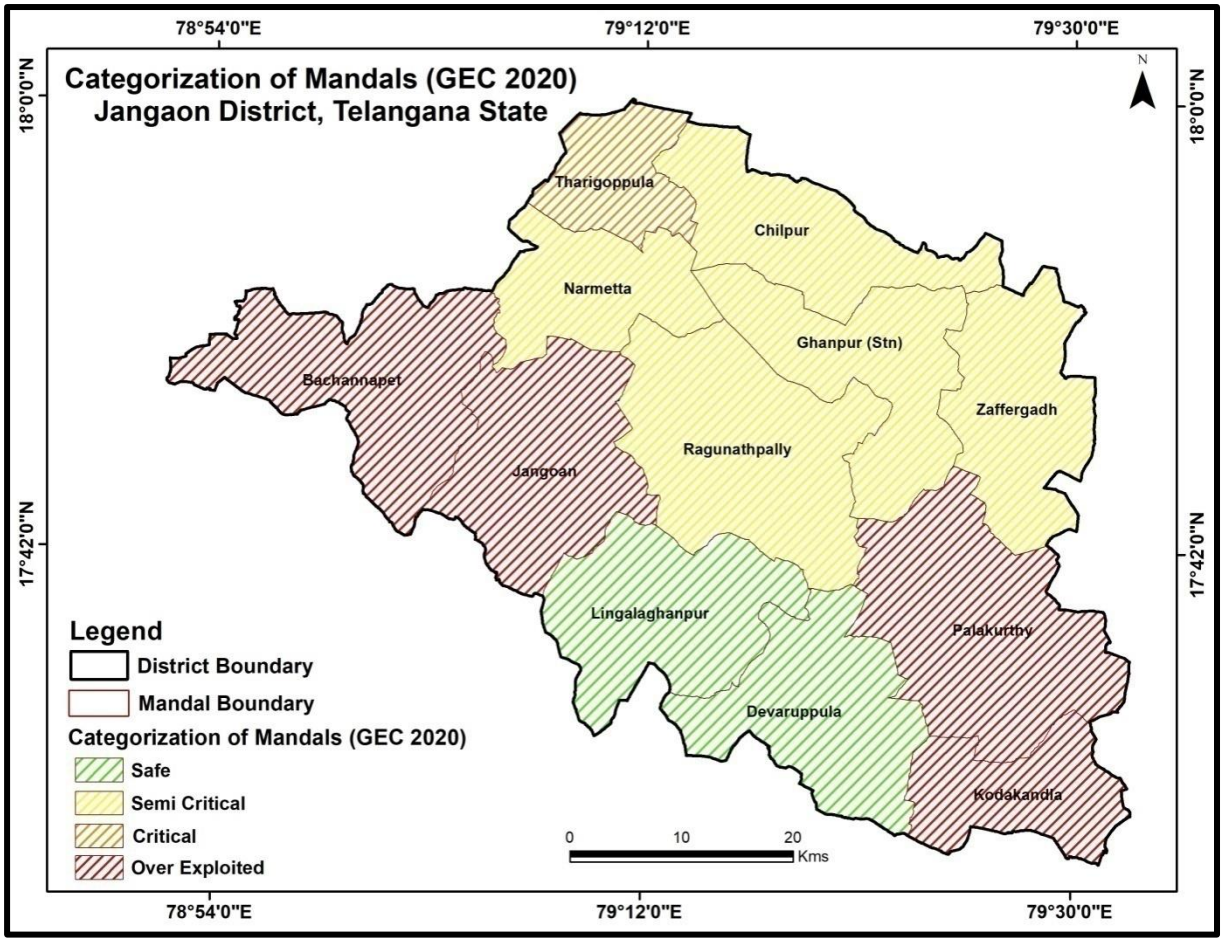


Fig.4.1: Categorization of mandals (GEC-2020)

5. GROUND WATER RELATED ISSUES

5.1 Low groundwater potential

In Jangaon district, low ground water potential (< 1 lps) have been identified in 45% of area in north-eastern parts mostly due to granitic terrain (absence of primary porosity, negligible development of secondary porosity) and restricted depth of weathering. The occurrence of less rainfall and urbanization also affects the potential. The yield from bore wells have reduced over a period of time and some bore wells which used to yield sufficient quantity of water have gone dry due to low rainfall. Sustainability of the aquifer is limited and the wells normally sustain pumping for 3 to 4 hours only.

5.2 Inferior groundwater quality

- Few mandals are fluorosis endemic where fluoride (geogenic) is as high as 2.97 mg/L during pre-monsoon and 1.91 mg/L during post-monsoon season. The high fluoride concentration (>1.5 mg/L) occur in 16 % and 3 % of the samples during pre-monsoon and post-monsoon season.

  Higher concentration of fluoride in ground water is attributed due to source rock water interaction where acid-soluble fluoride bearing minerals (fluorite, fluoro-

apatite) gets dissolved under alkaline conditions and higher residence time of ground water in deeper aquifer.

- High nitrate (> 45 mg/L) due to anthropogenic activities are observed in few mandals as moderately high as 313 mg/L during pre-monsoon and 195 mg/L during post-monsoon season. The high nitrate concentration (>45 mg/L) occur in 45 % and 54 % of the samples during pre-monsoon and post-monsoon season.

  Higher concentration is due to unscientific sewage disposal of treated and untreated effluents in urban and rural areas. Use of NPK fertilizers and nitrogen fixation by leguminous crops.

6. MANAGEMENT STRATEGY

The uneven distribution of groundwater availability and its utilization indicates that a single management strategy cannot be adopted and requires integrated hydrogeological aspects along with socio-economic conditions to develop appropriate management strategy.The management plan comprises two components namely supply side management and demand side management. The supply side management is proposed based on surplus surface water availability and the unsaturated thickness of aquifer whereas the demand side management is proposed by use of micro irrigation techniques.

6.1 Supply side management

The supply side management of ground water resources can be done through the artificial recharge of surplus runoff available within river sub basins and repairing, renovation & restoration of existing tanks.

6.1.1 Artificial Recharge Structures (To be taken up)

The areas feasible for construction of recharge structures has been demarcated based on the analysis of post-monsoon depth to water level data and existing data on artificial recharge structures constructed under various schemes of MGNREGA and IWMP by Rural Development department, Govt. of Telangana. The availability of unsaturated volume of aquifer was computed by multiplying the area feasible for recharge and unsaturated depth below 5 mbgl. The recharge potential of aquifer is calculated by multiplying the unsaturated volume with specific yield of the aquifers (0.02 for hard rock).

The source water availability is estimated from the rainfall and run off correlations. The runoff was calculated by taking into account of normal monsoon rainfall of the mandal and corresponding runoff yield from Strangers table for average catchment type. Out of the total run off available in the mandal, only 20% is considered for recommending artificial recharge structures in intermittent areas.

The storage required for existing artificial recharge structures by State Govt. departments under different IWMP and MNREGS schemes is deducted to find the available surplus run off for recommending the additional feasible artificial recharge structures.

50% of the available surplus runoff is considered for the recommendation of artificial recharge structures, as the remaining 50 % is recommended for implementing water conservation measures in recharge areas through MGNREGS. The **Table 6.1** gives the area feasible and volume available for the recharge.

The stage of ground water development in the district is 88.60% and only 2 out of 12 mandals are falling in safe category as per the GEC 2020 estimation. To control further increase in stage of ground water development, artificial recharge structures are recommended in 4 Over-exploited mandals (i.e., Bachannapet, Jangaon, Palakurthi, Kodakandla), 1 Critical mandal (Tharigoppula) and 5 Semi critical mandals (i.e, Chilpur, Ghanpur Station, Narmetta, Raghunathpally and Zaffergadh).

Table 6.1: Area feasible and volume available for artificial recharge

Total geographical area of district (Sq.km)	2,188
Area feasible for recharge (Sq.km) (in 6 mandals)	1718.26
Unsaturated Volume (MCM)	5898.90
Recharge Potential (MCM)	117.98
Surplus runoff available for recharge (MCM)	45.65
PROPOSED ARTIFICIAL RECHARGE STRUCTURES	
Percolation Tanks(@ Rs.20 lakh, Av. Gross Capacity=0.007 MCM*2 fillings = 0.0140 MCM) Volume of Water expected to be conserved / recharged (in MCM) Estimated Expenditure (in Crores)	223 2.51 44.60
Check Dams(@ Rs.15 lakh, Av. Gross Capacity=0.007 MCM* 5 fillings = 0.035 MCM) Volume of Water expected to be conserved / recharged (in MCM) Estimated Expenditure(in Crores)	333 15.75 49.95
Total volume of water expected to be recharged(in MCM)	18.26
Total Estimated Expenditure for Artificial Recharge (Rs. in Cr.)	**94.55**

The total unsaturated volume (below the depth of 5 m) available for artificial recharge is 5898.89MCM, having 117.98MCM of recharge potential (2%).The available surplus runoff can be utilized for artificial recharge through construction of percolation tanks, check dams with recharge shafts at suitable sites. The number of percolation tanks, and check dams are decided based on the number of suitable streams available in the district.

Thus, after taking into consideration all the factors, only 45.65 MCM of surplus water can be utilised for recharge, which is given in **Table 6.1**. This surplus water can be utilized for constructing 333 check dams with estimated expenditure of Rs.49.95 crores and 223 percolation tanks with estimated expenditure of Rs.44.60 crores at suitable sites. The amount of recharge from these artificial recharge structures was calculated by considering 0.0140 MCM per percolation tanks and 0.035 MCM per check dam. This intervention should lead to recharge of about 18.26 MCM/year. The details are given in **Annexure-1.**

In addition to this roof top rainwater harvesting structures should be made mandatory to all Government buildings.

6.1.2 State Government Projects

- **Mission Kakatiya (Repair, Renovation and Restoration of existing tanks):**

  De-silting of existing minor tanks (871 no.) was taken under state Govt. sponsored Mission Kakatiya (Phase-1 to 4) to remove silt and this has created additional surface storage and enhance ground water recharge.

- **Mission Bhagiratha**:

  Under this scheme the drinking water facility is provided for 610 habitations. Rs.840.00 crores has been sanctioned under main grid for construction of '21'no.'s Balancing Reservoirs and '1284.03 km' main grid pipe line had been laid all over the district for 'Bulk water supply'.

  Under Telangana Drinking Water Supply Project (TDWSP) also known as Mission Bhagiratha, all the villages and towns are proposed to be covered from the three water grids with intake from tributaries of Godavari river and Krishna river to provide protected water from surface reservoirs. Source of water being tapped @ Kondapaka from HMWSSB (Water being pumped by HMWSSB from Yellampally Reservoir) and from Lower Maneru Dam of Karimnagar. The scheme is to enhance the existing drinking water scheme and to provide safe drinking water 130010 no. of households.
  It is proposed to provide 100 litres per capita per day (LPCD) treated and piped water to every household in rural areas, 135 LPCD in municipalities and 150 LPCD in municipal corporations.

  Existing ARS like percolation tanks and check dams and dried dug wells can be de-silted involving people's participation through the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) (NREGA 2005). This will also help in sustainable management of groundwater resources.

6.2 Demand side management

In order to manage the available resources more effectively the following measures are recommended.

- In the district till date total number of 5032 no's drip and sprinklers are sanctioned which has irrigated ~5461.96 ha under ID crops saving ~8.19 MCM (considering 25% saving of 0.006 MCM/ha) of groundwater from the basin. Considering the current scenario of groundwater development, existing number of structures and shallow water levels, demand side intervention such as change in cropping pattern and micro irrigation has not been proposed.
- **~**3777 ha of additional land that can be brought under micro-irrigation (@1000 ha /mandal including existing area in 6 mandals) costing about 22.66 crores

(considering 1 unit/ha @0.6 lakh/ha). With this 5.67 MCM of ground water can be conserved over the traditional irrigation practices.

- Change in cropping pattern from water intensive paddy to irrigated dry crops like pulses and millets are recommended particularly in 4 mandals viz, Bachannapet, Jangaon, Palakurthi, Kodakandla where paddy cultivated area is ~ 80% of the Gross cropped area.
- To avoid the interference of cone of depression between the productive wells, intermittent pumping of bore wells is recommended through regulatory mechanism.
- Power supply should be regulated by giving power in 4 hour spells two times a day in the morning and evening by the concerned department so that pumping of the bore well is carried out in phased manner to allow recuperations of the aquifer and increase sustainability of the bore wells.

6.3 Other Recommendations

- A participatory groundwater management (PGWM) approach in sharing of groundwater and monitoring resources on a constant basis along with effective implementation of the existing 'Water, Land and Trees Act' of 2002 (WALTA-2002) are the other measures suggested. Subsidy/incentives on cost involved in sharing of groundwater may be given to the farmers involved.
- In urban and rural areas the sewerage line should be constructed to arrest leaching of nitrate.
- The other measure includes supplementary calcium and phosphorous rich food to the children in fluoride endemic mandals. Creating awareness about safe drinking water habits, side effects of high fluoride and nitrate rich groundwater, improving oral hygiene conditions are recommended.

6.4 Expected results and outcomes

With the above interventions costing Rs 117.21 crores (excluding the cost involved in Mission Kakatiya and Mission Bhagiratha), the likely benefit would be net saving of 29.67MCM of ground water. This will bring down the stage of groundwater development by 6.00% (from 88.60% to 82.60%)

Acknowledgment

The author express his thanks to Shri. Sunil Kumar, Chairman of CGWB, Govt. of India and Shri. J. Siddhardha Kumar, Regional Director (I/C), Smt. Rani V.R., Scientist-D for encouragement and support. The author acknowledge State Ground Water Department and Rural Water Supply department, Govt. of Telangana for making available of field data. Authors also thank the Executive Engineer and his drilling crew of CGWB, for carrying out the exploration activity.

Annexure-1

Proposed supply side interventions for ARS

Table-1: Village wise list of Artificial recharge structures recommended.						
S.no	**VILLAGE**	**Proposed CDs for intermittent area**	**Proposed PTs for intermittent area**	**Total cost CD @ 5 lakhs**	**Total cost PT @ 10 lakhs**	**Total lakhs cd +pts**
1	Abdulnagaram	1	0	15	0	15
2	Adivikeshvapur	1	0	15	0	15
3	Akkarajupalle	0	0	0	0	0
4	Alimpur	0	0	0	0	0
5	Aliyabad	0	0	0	0	0
6	Ammapur	1	0	15	0	15
7	Ankushapur	2	1	30	20	50
8	Aswaraopalle	2	2	30	40	70
9	Ayyangaripalle	0	0	0	0	0
10	Bachannapeta	3	3	45	60	105
11	Bandanagaram	1	0	15	0	15
12	Basireddipalle	1	0	15	0	15
13	Bhanjipeta	2	1	30	20	50
14	Bommanakur	0	0	0	0	0
15	Bommera	5	4	75	80	155
16	Bonthaghattunagaram	2	0	30	0	30
17	Chagal	7	5	105	100	205
18	Cheetakoduru	0	0	0	0	0
19	Chennur	3	1	45	20	65
20	Chilpur	4	3	60	60	120
21	Chinnapendyala	2	2	30	40	70
22	Chinnaramancherla	3	2	45	40	85
23	Chowdaram	0	0	0	0	0
24	Chowdarpalle	0	0	0	0	0
25	Dardepalle	5	4	75	80	155

26	Dubbakuntapalle	0	0	0	0	0
27	Edunuthula	2	1	30	20	50
28	Eravennu	3	2	45	40	85
29	Fathepur	6	0	90	0	90
30	Fatheshanagar	1	1	15	20	35
31	Gabbeta	1	1	15	20	35
32	Gandiramavaram	1	1	15	20	35
33	Gangapur	0	0	0	0	0
34	Gangupahad	2	1	30	20	50
35	Ghanpur_Stn	5	3	75	60	135
36	Goparajupalli	1	1	15	20	35
37	Govaradhanagiri	2	1	30	20	50
38	Gudur	0	0	0	0	0
39	Hanmanthapur	1	0	15	0	15
40	Ibrahimpur	1	1	15	20	35
41	Ippagudem	19	14	285	280	565
42	Itikalapalle	2	1	30	20	50
43	Jangaon	2	2	30	40	70
44	Kalvalapalle	0	0	0	0	0
45	Kanchanpalle	5	4	75	80	155
46	Kannaipalle	1	0	15	0	15
47	Katkoor	3	2	45	40	85
48	Kesireddipalle	3	1	45	20	65
49	Kistajigudem	5	4	75	80	155
50	Kodakandla	4	2	60	40	100
51	Kodavatoru	1	0	15	0	15
52	Kodur	2	2	30	40	70
53	Komalla	2	2	30	40	70
54	Konaichalam	1	1	15	20	35
55	Kondapur	2	0	30	0	30
56	Kondapur	2	0	30	0	30

57	Konne	2	3	30	60	90
58	Kothapalle	3	0	45	0	45
59	Kothulabad	1	0	15	0	15
60	Kunoor	2	1	30	20	50
61	Kuruchapalle	3	2	45	40	85
62	Lakshmakkapalle	3	2	45	40	85
63	Lakshminarayanapur	0	0	0	0	0
64	Lakshmipur	1	1	15	20	35
65	Lingam Palle	6	7	90	140	230
66	Lingampalle	2	0	30	0	30
67	Machupahad	2	2	30	40	70
68	Madharam	1	0	15	0	15
69	Mailaram	0	1	0	20	20
70	Malakpeta	0	0	0	0	0
71	Malkapur	5	2	75	40	115
72	Mallampalle	4	3	60	60	120
73	Manchuppula	3	2	45	40	85
74	Mansanpalle	0	0	0	0	0
75	Marigidi	0	0	0	0	0
76	Medikonda	6	3	90	60	150
77	Mekalagattu	2	1	30	20	50
78	Mondrai	2	1	30	20	50
79	Mutharam	4	3	60	60	120
80	Nagireddipaller	1	0	15	0	15
81	Nalimigonda	0	0	0	0	0
82	Narasapur	1	1	15	20	35
83	Narasingapur	0	0	0	0	0
84	Narayanapur	1	1	15	20	35
85	Narayanpur	2	2	30	40	70
86	Narmetta	6	3	90	60	150
87	Nashkal	1	1	15	20	35

88	Nidigonda	2	2	30	40	70
89	Obulakeshavapur	1	1	15	20	35
90	Obulapur	0	1	0	20	20
91	Padamatikeshvapur	3	2	45	40	85
92	Pakhala	1	1	15	20	35
93	Palakurthi	0	0	0	0	0
94	Pallagutta	10	8	150	160	310
95	Pamnoor	2	1	30	20	50
96	Pasarmadla	1	1	15	20	35
97	Peddapahad	3	2	45	40	85
98	Peddaramancherla	1	1	15	20	35
99	Pembarthy	0	0	0	0	0
100	Pochannapeta	7	6	105	120	225
101	Potharam	1	0	15	0	15
102	Pullaguda	0	0	0	0	0
103	Quileshapur	8	7	120	140	260
104	Raghavapur	4	3	60	60	120
105	Raghunathpalle	0	0	0	0	0
106	Raghunathpalle	0	0	0	0	0
107	Rajavaram	6	5	90	100	190
108	Ramachadrapur	1	0	15	0	15
109	Ramavaram	3	0	45	0	45
110	Rangapuram	0	0	0	0	0
111	Sagaram	1	0	15	0	15
112	Salvapur	2	1	30	20	50
113	Samudrala	9	5	135	100	235
114	Shameerpet	1	1	15	20	35
115	Shapalle	0	0	0	0	0
116	Shathapur	2	0	30	0	30
117	Shivunipalle	2	2	30	40	70
118	Siddenki	1	0	15	0	15

119	Solipur	0	1	0	20	20
120	Sreepathipalle	5	0	75	0	75
121	Suraram	0	0	0	0	0
122	Tammadapalle	1	1	15	20	35
123	Tarigoppula	4	2	60	40	100
124	Thanedarpalle	3	3	45	60	105
125	Thatikonda	19	14	285	280	565
126	Theegaram	0	0	0	0	0
127	Theegaram	0	0	0	0	0
128	Thidugu	1	1	15	20	35
129	Thimmampeta	1	1	15	20	35
130	Thimmapur	0	1	0	20	20
131	Thirmalagiri	0	0	0	0	0
132	Thorrur	1	0	15	0	15
133	Thummadapalle_G	1	0	15	0	15
134	Thummadapalle_I	1	1	15	20	35
135	Uppugal	5	4	75	80	155
136	Vadlakonda	2	2	30	40	70
137	Valmidi	3	2	45	40	85
138	Vavilala	5	4	75	80	155
139	Veldanda	5	2	75	40	115
140	Veldi	0	1	0	20	20
141	Venkatadripeta	1	1	15	20	35
142	Venkriyala	1	1	15	20	35
143	Vishwanathpur	2	2	30	40	70
144	Visnoor	5	4	75	80	155
145	Yellamala	1	1	15	20	35
146	Yerragollapahad	0	1	0	20	20
147	Yeswanthapur	1	0	15	0	15
148	Zaffargadh	4	5	60	100	160