केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

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

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

SURYAPET DISTRICT, TELANGANA

दक्षिणी क्षेत्र, हैदराबाद

Southern Region, Hyderabad

भारत सरकार
जल शक्ति मंत्रालय
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GOVERNMENT OF INDIA

MINISTRY OF JAL SHAKTI

DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT &

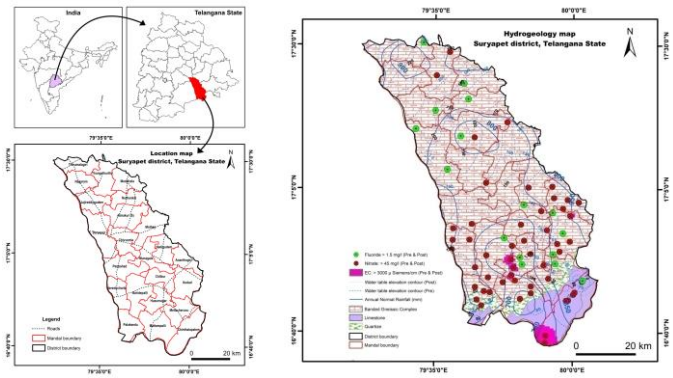
GANGA REJUVENATION

REPORT ON

AQUIFER MAPPING AND MANAGEMENT PLANS FOR

SUSTAINABLE GROUND WATER RESOURCES IN

SURYAPET DISTRICT, TELANGANA STATE



CENTRAL GROUND WATER BOARD

SOUTHERN REGION

HYDERABAD

MAY 2023

REPORT ON
AQUIFER MAPPING AND MANAGEMENT PLANS FOR SUSTAINABLE GROUND WATER RESOURCES IN SURYAPET DISTRICT, TELANGANA STATE
(AAP 2022-23)

CONTRIBUTORS' PAGE

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CENTRAL GROUND WATER BOARD
SOUTHERN REGION
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FOREWORD

India is the largest groundwater user in the world, with an annual groundwater withdrawal of 253 billion cubic meters (BCM). This represents about 25% of the world's groundwater withdrawals. India has about 112.3 BCM of water resources, of which 690 BCM is surface water and the remaining 433 BCM is groundwater. Out of the total available groundwater, 90% is used for irrigation purposes, mainly in agriculture. The remaining 10% is used for domestic and industrial purposes. According to the Composite Water Management Index (CWMI) report released by NITI Aayog in 2018, 21 major cities, including Delhi, Bengaluru, Chennai and Hyderabad, are at risk of running out of groundwater, affecting access for 100 million people. The CWMI report also states that the country's water demand is expected to be twice the available supply by 2030, which would mean serious water shortages for hundreds of millions of people and a 6% loss to the country's GDP.

In view of the above, it is necessary to scientifically plan the development of groundwater and its management in different hydrogeological environments, and develop effective management methods with the involvement of the community to better manage groundwater. The National Aquifer Mapping Project (NAQUIM) is being implemented by the Ministry of Jal Shakti, Department of Water Resources, River Development and Ganga Rejuvenation, Government of India and is being undertaken by the Central Ground Water Board (CGWB) The NAQUIM provides the mapping of aquifers (water-bearing formations), their characterization, and the development of aquifer management plans to enable sustainable management of groundwater resources to delineate and describe aquifers and develop groundwater management plans for their sustainable development with stakeholder participation.

The report titled " Report on Aquifer Mapping and Management Plans for Sustainable Ground Water Resources in Suryapet District, Telangana State" prepared from the extensive hydrogeological, geophysical and hydro chemical data generated by CGWB over the years and integrated with the data from various stake holder departments viz., ground water, irrigation, statistics, Rural Development, Mission Bhagiratha, Mission Kakatiya and Micro irrigation etc. The data has been analysed and interpreted using various software tools viz., ArcGIS and Rockworks for conceptualization of aquifers, their vertical and horizontal disposition and extent, assessment of ground water resources, quality of shallow and deeper aquifers and various aspects of ground water occurrence, distribution, and utilization in the district. The report identified specific groundwater related issues and recommended various supply and demand side management strategies for sustainable ground water development and management in the district.

This report has been prepared by Dr. S. S. Vittala, Scientist - B (Hydrogeology), and the effort made by the officer in preparation of this report is greatly appreciated. Due thanks to (i) Dr. Pandith Madhnure, then Scientist-D, CGWB, SR and presently serving as Director, State Ground Water Department, Telangana State (ii) Dr. G. Praveen Kumar, Scientist-C and (iii) Shri Ravi Kumar Gumma, Scientist-D who had prepared the reports on watershed basis (Phase – I to III) in the year 2015-16 for the erstwhile Nalgonda district during their service at SR, Hyderabad. These reports helped a lot to prepare the present report for the newly formed Suryapet district by incorporating latest data. Thanks are due to Smt. Rani, V.R, Scientist-D and Sh. Ravi Kumar Gumma, Scientist-D & OIC, CGWB, APSUO, Visakhapatnam for valuable suggestions in finalizing this document. Thanks are also due to various organizations of the Government of Telangana for providing data required for compiling this report. I hope this report will be of great help to District Administration and Stakeholder Departments for planning and sustainable management of groundwater resources in the district.

Sh. J. Siddhardha Kumar
Regional Director
CGWB, SR, Hyderabad

EXECUTIVE SUMMARY

The Suryapet district covering 3579 sq.km is carved from erstwhile Nalgonda district. Administratively, the area is governed by 3 revenue divisions, 23 mandals and 279 villages with a population of 10.99 lakhs (2011 census) (Rural: 84% and Urban: 16%) with average density of 307 persons/sq.km. The district is bounded on the north by Jangaon and Mahabubabad, on the east by Suryapet, on theKhammam, south by Guntur district of Andhra Pradesh state and on the west by Nalgonda and Yadadri Bhuvanagiri districts.

The annual normal rainfall of the district varies from 700 mm (Mattampalli mandal) to 950 mm in Ananthagiri mandal. The Southwest monsoon contributes 75%; Northeast monsoon contributes by 18.5% and remaining 7% by January to May months of normal annual rainfall. . The average normal rainfall in the district is 837 mm and received excess rainfall of 1006 mm (20% above normal) during the water year 2020-21.

The district falls under Krishna basin and Krishna Middle Sub-Basin. The major river Krishna is flowing in the district from west to east located southern boundary of the district. The tributaries viz., Musi and Palleru Rivers are also flows in the district and finally join to River Krishna. The Krishna river boundary acts as a district boundary towards south while Musi River acts as another boundary towards west. The major groundwater flow is towards E-W and NW-SE. Geologically, major part of the district is underlain by Gneisses. The pediplain is the major landform followed by pediment. The district is one of the agriculturally developed districts in the Telangana state.

The land use/land cover in the district indicates that out of the total area, majority of the area (>50%) falling under kharif category followed by double crop. The double cropped area has been noticed on either side of the river courses within the district. The forest occupied in about 3.5% area of the district. During kharif season, out of total gross cropped area, the is Paddy grown in 57% of the area followed by Cotton in 29% and other crops in 14% of the area while during rabi season, Paddy is grown in 98% of the area followed by others crops in 2% of the area. The majority of the soils are covered with loamy skeletal mixed, fine mixed and clayey skeletal mixed, fine montmorillonitic soils and very fine montmorillonitic soils.

Groundwater exploration carried out up to the depth 200 m bgl and reveals that weathered zone thickness varies from 0.5 to 30 m bgl. The data indicates 14% of the wells are shallow wells drilled up to a depth of <30 m bgl, 54% of the wells between the depth of 30-60 m bgl, 1% of the wells drilled between the depth range of 60 to 100 m bgl, 8% of the wells drilled between the depth range of 100 to 150 m bgl and the remaining 23% of the wells are drilled between the depth range of 150 to 200 m bgl. Further, the study revealed that majority of fracture (96%) occurs within 100 m depth. The yield of the wells varies from <1 to 6.73 lps with an average of 1 lps.

Water level data indicates that during pre-monsoon, majority of the water levels are in the range of 5 to 10 m bgl and distributed in 40% of the area, followed by the water levels ranging from 10 to 20 m bgl (32% of the area). The water level between 2 to 5 m bgl is noticed in 27% of the area while the deeper water levels of >20 m bgl is observed in 2% of the area. In none of the samples, the depth to water level shown <2 m bgl. During post-monsoon season, majority of the water levels are in the range of 2 to 5 m bgl and noticed in 51% of the area, followed by water levels of 5 to 10 m bgl distributed in 25% of the area. The water levels ranging from 10 to 20 m bgl is observed in 21% of the area and the deeper water levels >20 m bgl is noticed in 3% of the area. The shallow water levels <2 m bgl is noticed in 13% of the area while water levels ranging from 10 to 20 m bgl is distributed in 11% of the area. The deeper water levels >20 m bgl is noticed in none of the samples

The data analysed from the groundwater quality indicates that during pre-monsoon season, the electrical conductivity varies from 443 to 4970 µ Siemens/cm with an average 1592 µ Siemens/cm. The EC >3000 µ Siemens/cm is noticed in 9% of the samples. The NO_3 concentration ranges from 0.3 to 464 mg/l with an average of 65 mg/l. The NO3 more than permissible limit of >45 mg/l is noticed 39% of the samples. The Fluoride concentration varies from 0.14 to 4.95 mg/l with an average of 0.92 mg/l. The high fluoride concentration beyond permissible limit of >1.5 mg/l is observed in 11% of the samples. During post-monsoon season, the EC varies from 515 to 5111 µ Siemens/cm with an average of 1665 µ Siemens/cm and in about 7% of the samples, the EC is more than permissible limit of >3000 µ Siemens/cm. The NO_3 concentration ranges from 0.01 to 448 mg/l with an average of 90 mg/l. In about 54% of the samples, it is exceeding permissible limits >45 mg/l. The Fluoride

concentration varies from 0.15 to 4.29 mg/l with an average of 0.87 mg/l. In about 8% of the samples, the fluoride is noticed more than permissible of 1.5 mg/l.

Conceptualization of 3-D hydrogeological model was carried out by integrating and interpreting representative hydrogeological data points for preparation of 3-D map, panel diagram and hydrogeological sections. The lithological information was generated by using the RockWorks-16 software and generated various 3D map of the district along with panel diagram and hydrogeological sections and presented.

As per GEC 2022 estimation report, the net dynamic replenishable ground water availability for newly formed district is 1209MCM, the gross ground water draft for all uses 248 MCM, provision for drinking and industrial use for the year 2025 is 23 MCM and net annual ground water potential available for future irrigation needs is 1056 MCM. Out of 23 mandals, 21 mandals are falling under Safe (Ananthagiri (14%), Atmakur S (54%), Chilkur (10%), Chinthalapalem (6%), Chivvemla (47%), Garidepalle (11%), Huzur nagar (14%), Jajireddigudem (47%), Kodad (11%), Mattampalle (22%), Mellachervu (4%), Mothey (49%), Munagala (32%), Nadigudem (18%), Nagaram (66%), Neredcherla (6%), Noothankal (63%), Palakeedu (6%), Penpahad (54%), Suryapet (23%) and Thungathurthi (67%)), and the remaining 2 mandal (Maddirala (72%) and Thirumalagiri (71%)) is falling under Semi Critical category. The overall average stage of ground water extraction in the district is 33% falling under Safe category.

With respect to village wise groundwater management plans, the entire district is divided into two categories viz., Priority – I (Semi Critical/Critical/Over Exploited mandals) and Priority – II (Safe mandals) areas as per GEC 2022 estimation which help in sustainability of groundwater for sustainable development. In Priority – I area, 24 villages with an area of 254 sq.km the water conservation and management plan is prepared as the depth to water level in this area is >5 m bgl during post-monsoon season. About 153 artificial recharge structures have further recommended in these 24 villages (71 PTs with 2 fillings with a unit cost of Rs. 20 lakhs each and 82 CDs with recharge shafts with 6 fillings with a unit cost of Rs. 15 lakhs each) with a total cost of 26.5 Crores. In these villages, about 609 MCM of unsaturated volume (below 5 m depth is available during post-monsoon along with 12 MCM recharge potential and 7 MCM utilizable yield (uncommitted run-off) is available for

immediate intervention. After effective implementation of these recommended artificial recharge structures, there will be 4.44 MCM of groundwater recharge with 100% recharge efficacy. Whereas in Priority – II areas, out of 255 villages, for about 109 villages with an area of 1556 sq.km the water conservation and management plan is prepared as the depth to water level in this area is >5 m bgl during post-monsoon season. About 632 artificial recharge structures have further recommended in these 109 villages (297 PTs with 2 fillings with a unit cost of Rs. 20 lakhs each and 335 CDs with recharge shafts with 6 fillings with a unit cost of Rs. 15 lakhs each) with a total cost of 109.65 Crores. In these villages, about 3338 MCM of unsaturated volume (below 5 m depth is available during post-monsoon along with 67 MCM recharge potential and 67 MCM utilizable yield (uncommitted run-off) is available for immediate intervention. After the effective implementation of the recommended artificial recharge structures, there will be 18.23 MCM of groundwater recharge with 100% recharge efficacy.

To help the farmers for early sowing and to meet the needs for intermediate irrigation, it is suggested that, farm ponds construction may be taken up @20 structures per village. Thus, about 5580 farm ponds needs to be constructed at a unit cost of Rs. 25,000/- totalling to 13.95 Crores. This will create an additional storage capacity of 1.67 MCM.

As per the studies, it is estimated that 19195 ha. of additional land that can be brought under micro-irrigation (where actual area irrigated though MI is less than 1,000 ha.) costing about 115.17 Crores. By shifting from traditional to micro irrigation practices, 28.79 MCM of groundwater can be conserved.

The above interventions by investing about Rs. 265.27 Crores, a net saving of 53.13 MCM of groundwater can be achieved which will help in net reduction in groundwater extraction by 15% from the existing 72% to 56% in Priority – I area and by 13% from the existing 30% to 17% in Priority – II area. Where are in the entire district, net reduction in groundwater extraction is by 15% from the existing 33% to 18% it is This will help in arresting the groundwater deterioration and increase in its sustainability. The onetime cost will be 5 paisa/litre and the actual cost of invest will be 0.5 paisa/litre if considered the life of the artificial recharge structures and micro irrigation equipment as 10 year.

REPORT ON
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(AAP 2022-23)

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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.	:	Hector
ham	:	Hector meter
ID	:	Irrigated dry
IMD	:	Indian 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

1. INTRODUCTION

Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic, hydrogeological and chemical analyses is applied to characterize the quantity, quality and sustainability of ground water in aquifers. In recent past, there has been a paradigm shift from “ground water development” to “ground water management”. As large parts of India, particularly hard rock aquifers have become water stressed due to rapid growth in demand for water due to growth in population, irrigation, urbanization and changing life style. Therefore, in order to have an accurate and comprehensive micro-level picture of ground water in India, aquifer mapping in different hydrogeological settings at the appropriate scale is devised and implemented, to enable robust ground water 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 to meet climate change also. Thus, the crux of National Aquifer Mapping (NAQUIM) is not merely mapping, but reaching the goal-that of ground water management through community participation.

Hardrocks lack primary porosity, and ground water 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 lead to drying up at places and reducing the sustainability of structures. Besides these quantitative aspects, ground water 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 purposes. 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 ground water management plan on 1: 50,000 scale.

1.2 Scope of study

The main scope of study is summarised below.

a) Compilation of existing data (exploration, geophysical, ground water level and ground water quality) with geo-referencing information and identification of principal aquifer units.
b) 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.
c) Quantification of ground water availability and assessing its quality.
d) To delineate aquifer in 3-D along with its characterization on 1:50,000 scale.
e) Capacity building in all aspects of ground water development and management through information, education and communication (IEC) activities, information dissemination, education, awareness and training.
f) Enhancement of coordination with concerned central/state govt. organizations and academic/research institutions for sustainable ground water management.

1.3 Area Details

The Suryapet district covering 3579sq.km lies between north latitude of 79°21'27" - 80°04'41" and east longitude of 16°37'27" - 17°31'54" (Fig. 1.1). The district is bounded on the north by Jangaon and Mahabubabad, on the east by Suryapet, and Khammam, south by Guntur district of Andhra Pradesh state and on the west by Nalgonda and Yadadri Bhuvanagiri districts. The present district is carved out from erstwhile Nalgonda district. Administratively, the area is governed by 3Revenue Divisions, 23Revenue Mandals and 279Revenuevillages with a population of 10.99 lakhs (2011 census) (Rural: 84%, Urban: 16%) with average density of 307 persons/sq.km. The hilly and forest area occupying 3.5% of the total area located in different part of the district.

1.4 Climate and Rainfall

The district experiences tropical climate and is geographically located in semi-arid area. The district falls under South Telangana Agro-climatic zone based on the geographical characteristics such as rainfall, temperature, nature of soils etc. The wet season is oppressive and overcast; the dry season is humid and mostly clear and hot throughout the year. The temperature typically varies from 17°C to 40°C.

The hot season lasts for 3 months from April to June with an average daily high temperature above 38°C. The hottest month of the year in the district is May with an average high of 40°C and low of 28°C.

The southwest monsoon enters into the district in June and lasts until second week of October (as per IMD report) and northeast monsoon from October to December. The annual normal rainfall of the district varies from 700 mm (Mattampalli mandal) to 950 mm in Ananthagiri mandal. The Southwest monsoon contributes 75%, Northeast monsoon contributes by 18.5% and remaining 7% by January to May months of normal annual rainfall. The isohyetal map is prepared using annual normal rainfall in the district collected from DES, Govt. of Telangana is shown in Fig.1.2.The average normal rainfall in the district is 837 mm and received excess rainfall of 1006 mm (20% above normal) during the water year 2020-21.

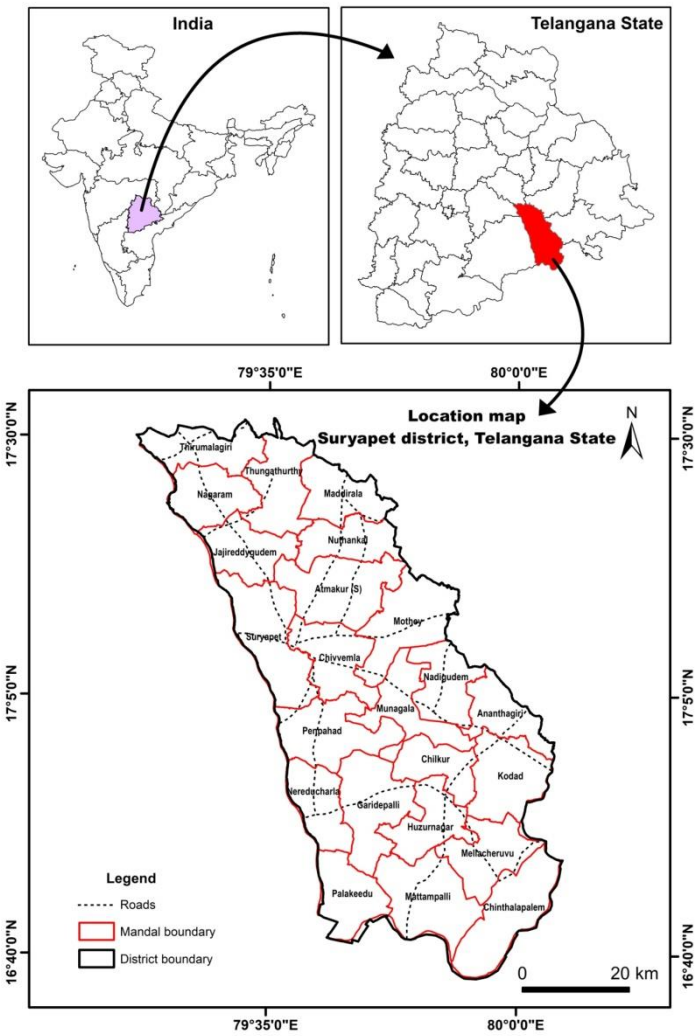

Fig. 1.1: Location map

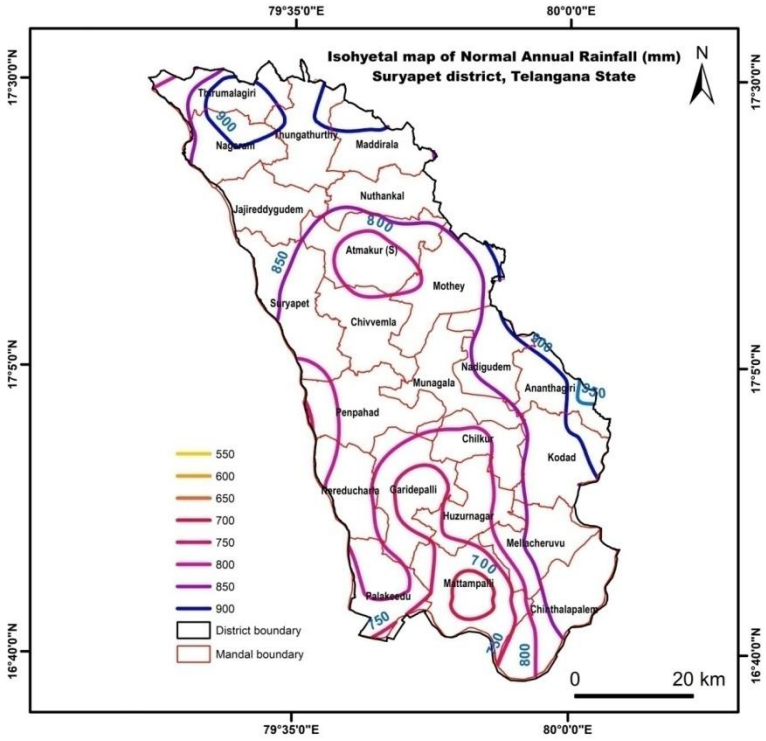

Fig. 1.2: Isohyetal map

1.5 Drainage

The district falls under Krishna basin and Krishna Middle Sub-Basin. The tributaries viz., Musi and Palleru Rivers are also flows in the district and finally join to River Krishna. The Krishna river boundary acts as a district boundary towards south while Musi river acts as another boundary towards west. The major ground water flow is towards E-W and NW-SE. The drainage map is presented in Fig. 1.3.

1.6 Geology

Geologically, most of the areas are underlain by crystalline rocks viz., Banded gneissic complex (80%) with basic intrusive rocks of Dolerites. The Limestone (12%) and Quaitize (8%), formation is also noticed at patches towards southern part of the district. The major lineaments in the area trend towards N-S, NW-SE directions. The geology map of the district is given in Fig. 1.4.

1.7 Geomorphological Set up

The district is contiguous part of Mysore Plateau and characterised by erosional topography with general slope from northwest to southeast. The pediplain (60%) is the major landform followed by pediment (12%), structural hills (10%), denudational hills (6%), residual hill (5%) dissected plateau (4%) and others geomorpholoical units (Fig. 1.5).

1.8 Land use/ land cover

Based on the land use study, several major classes have been delineated in the district viz., agricultural land (kharif and rabi), double crop, plantations, deciduous open forest, waste lands, water bodies. Out of the total area, majority of the area (>50%) falling under kharif category followed by double crop. The double cropped area is noticed on either side of the river courses within the district. About 3.5% of forest cover is noticed from the total area of the district. The land use / land cover map is given in Fig. 1.6.

1.9 Soils

The majority of the soils are covered with loamy skeletal mixed, fine mixed and clayey skeletal mixed, fine montmorillonitic soils and very fine montmorillonitic soils. They constitute >90% of the district. The other soils include rock lands and coarse loamy mixed soils. They are grouped into many classes (NBS & LUP) based on geomorphology and landscapes and further sub-divided based on physiography, relief and drainage (Fig. 1.7).

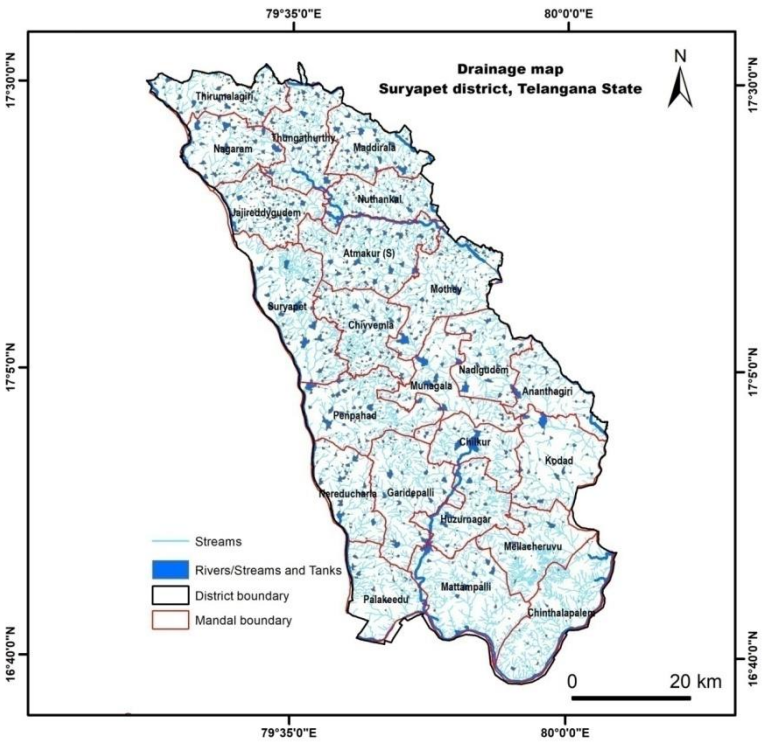

Fig 1.3: Drainage and water bodies map

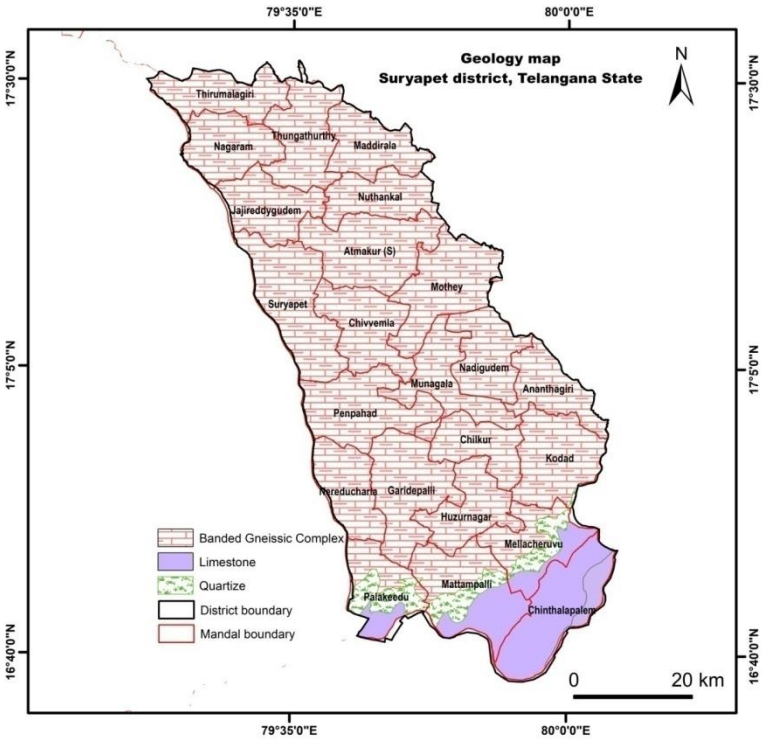

Fig.1.4: Geology map

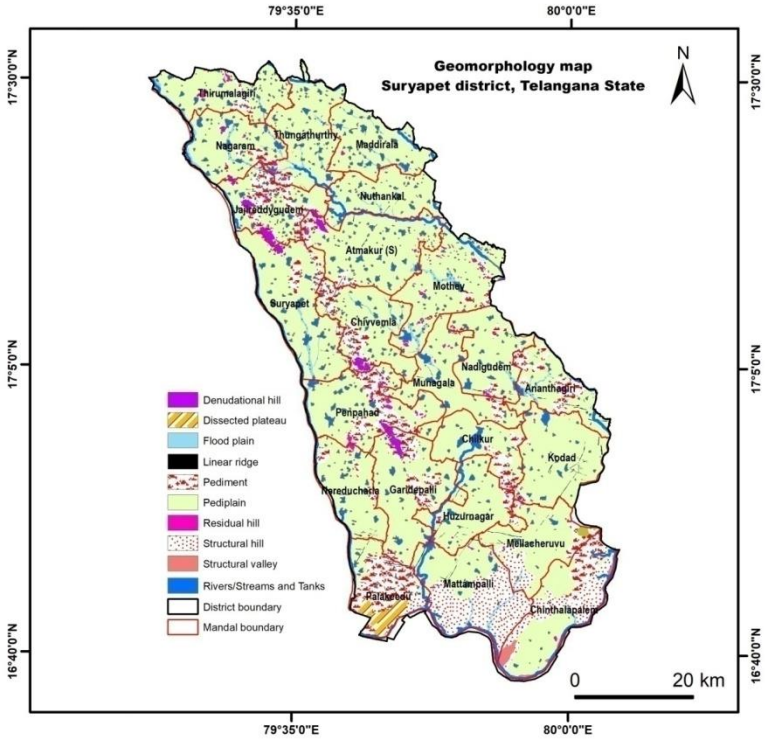

Fig. 1.5: Geomorphology map

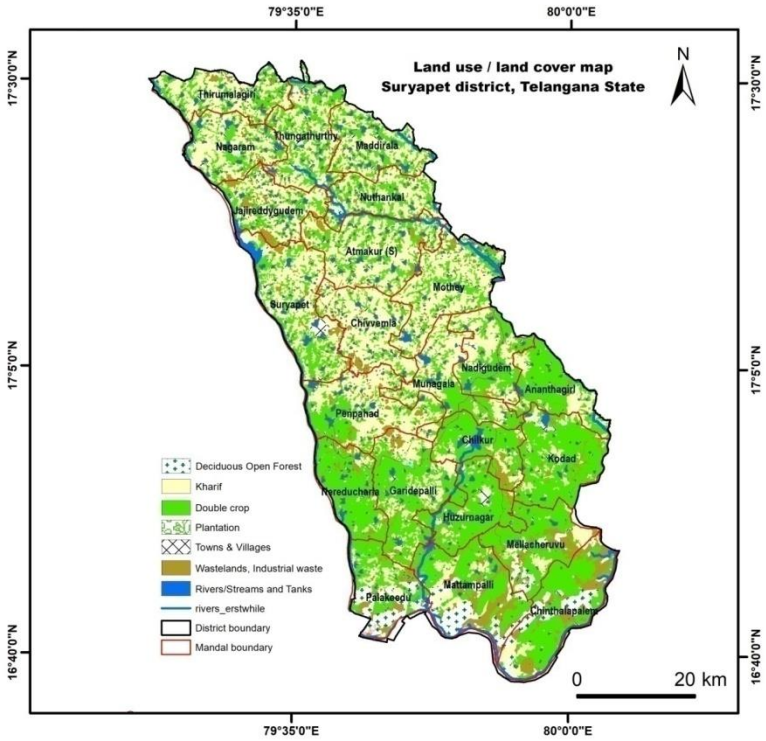

Fig. 1.6: Land use / land cover map

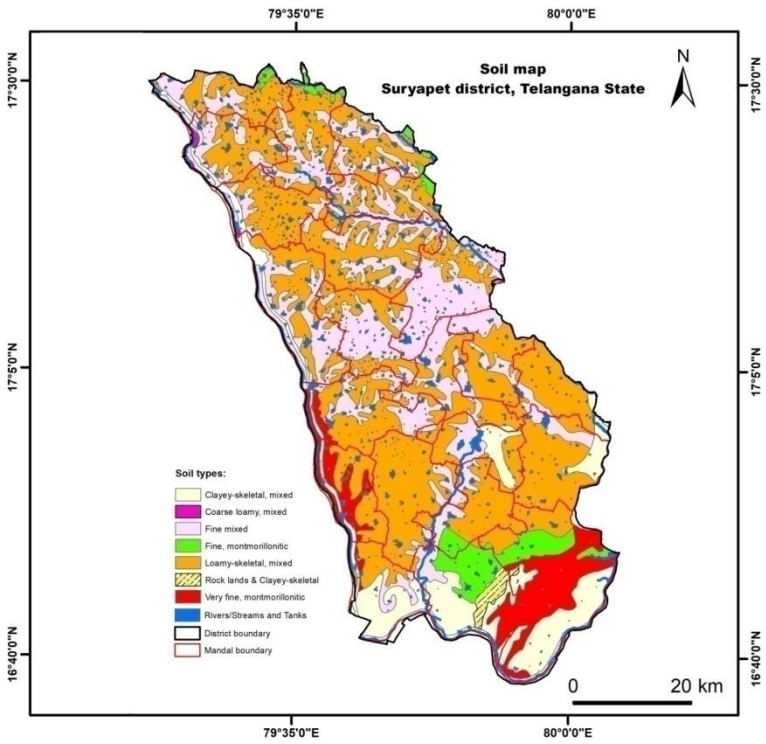

Fig. 1.7: Soil map

1.10 Cropping Pattern (2019-20 in ha.)

The forest occupies about 3.5% of the total geographical area, barren and uncultivable land occupies 9% of area; land put to non-agricultural use is 12%, cultivable wasteland is 2%. With respect to land utilization, out of total area, 11% of the area is falling under current fallows; 7% is under other fallows category. The net area sown is about 51% and area sown more than once is 23% which brings gross cropped area to 74%. During kharif season, out of total gross cropped area, Paddy is grown in 57% of the area followed by Cotton in 29% and other crops in 14% of the area while during rabi season, Paddy is grown in 98% of the area followed by others crops in 2% of the area (Fig. 1.8).

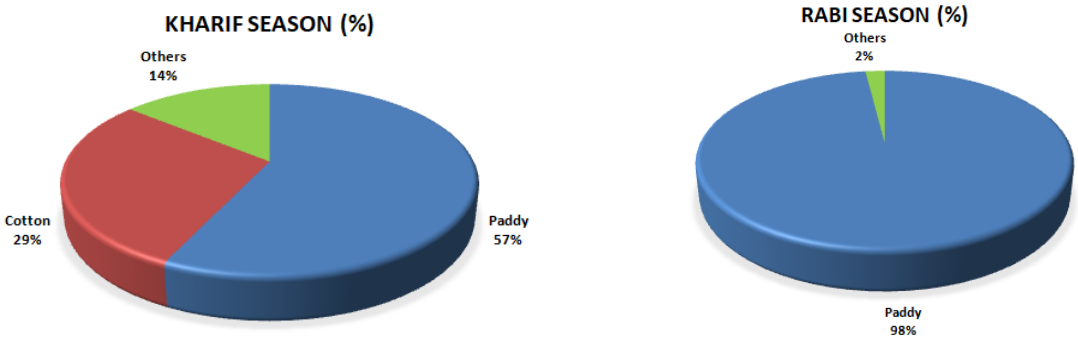

Fig. 1.8: Pie chart showing Cropping pattern trend during kharif and rabi seasons

1.11 Irrigation

In the district, there are 4 contemplated/completed Irrigation Potential (IP) projects viz.,JCR Godavari Lift Irrigaiton Scheme (4638 Ha.), Musi Project (5981 Ha.), Nagarjuna Sagar Project (86348 Ha.) and Srirama Sagar Project Stage II (88798 Ha.) (Fig. 1.9). In the district, about 1132 number of minor irrigation tanks covering 17099 ha. of ayacut. As per the latest GEC 2022 report, there are about more than 43,000numbers of bore wells (irrigation, domestic and industrial) and about more than nearly 29000 dug wells are being existed in the district.

1.12 Prevailing Water Conservation/Recharge Practices

In the district, 148 artificial recharge structures exists (PT's: 56, CD's: 92 and Farm Ponds: 456). Under Mission Kakatiya (Phase-1 to 4), out of 1132 minor irrigation tanks, 724 tanks (64%) of tanks are desilted.

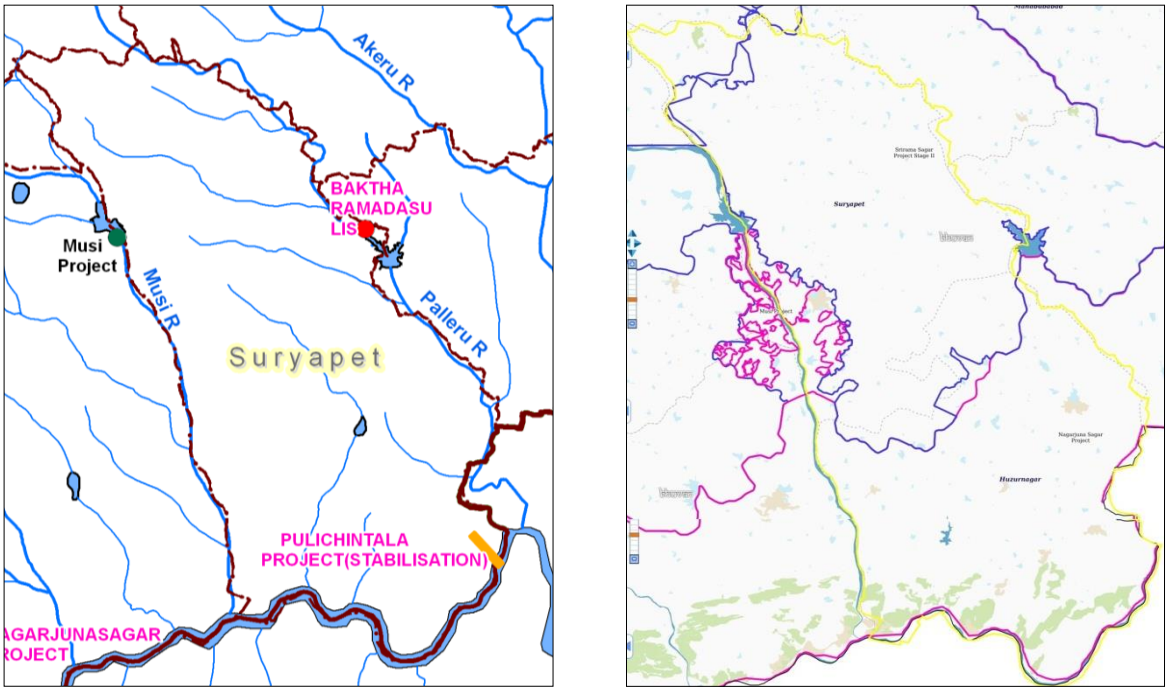

Fig. 1.9: Irrigation Projects and canal command areas in the district (Source: https://bhuvan-app1.nrsc.gov.in/twris/geoportal/twris.php)

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 (Table2.1).

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 ground water	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 ground water 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 ground water 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 of ground water occurring in the subsurface in relation to the geological environment. It 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 gneisses. 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 various hydrogeological data points collected through exploration, well inventory, VES, quality and other relevant data collected from state line departments, the hydrogeological map is prepared and presented in Fig. 2.1.

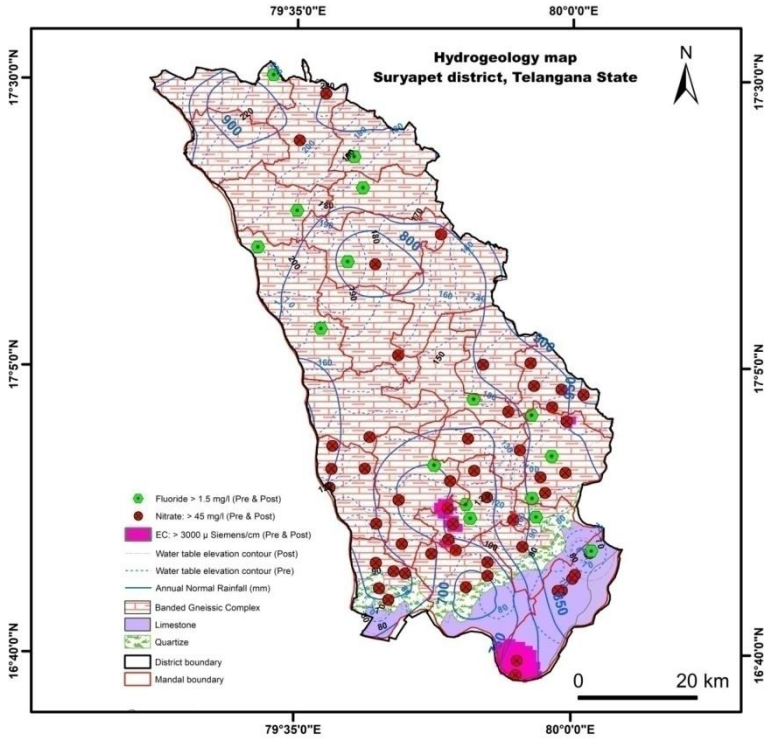

Fig. 2.1: Hydrogeology map

2.1.1 Ground water occurrences and movement

Ground water occurs under unconfined and semi-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 the depth of 200 m bgl. The storage in the aquifer formations is primarily confined to the weathered zone and its over-exploitation has resulted in desaturation at many places and reduced recharge to the underlying fractures.

Presently, the extraction of ground water is mainly through bore wells. The sustainability of the bore wells is dependent on the water availability in the weathered zone.

2.1.2 Exploratory Drilling

Ground water exploration started in the district in the year in four phases (1971-75, 1989-92, 1999-2004, 2014-16 and till date) in both shallow and deep aquifers. As on 31/03/2022, CGWB drilled 259 bore wells (EW-79, OW-15, PZ-24, HP (PZ)-136) and State Ground Water Department (SGWD) drilled 5 piezometers. The depth of the drilling ranges from 9 to 200 m bgl and weathering ranges from 0.5 to 30 m bgl. The data analysed from the above exploratory wells indicates that 14% of the wells drilled at shallow depth that are drilled up to a depth of <30 m bgl, 54% of the wells between the depth of 30 to 60 m bgl, 1% of the wells drilled between the depth of 60 to 100 m bgl, 8% of the wells drilled between the depth of 100 to 150 m bgl and the remaining 23% of the wells drilled between the depth of 150 to 200 m bgl (Fig. 2.2). The deeper wells of >100 m bgl are drilled in 14 mandals viz., Atmakur (S), Chilkur, Chivvemla, Jajireddygudem, Maddirala, Mothey, Munagala, Nagaram, Nuthankal, Palakeedu, Penpahad, Suryapet, Thirumalagiri and Thungathurthy mandals. Further, the study revealed that majority of fracture(96%) occurs within 100 m depth. The deepest fractures >100 m bgl is occurred in Jajireddygudem mandal. The yield of the wells varies from <1 to 6.73lps with an average of 1lps.

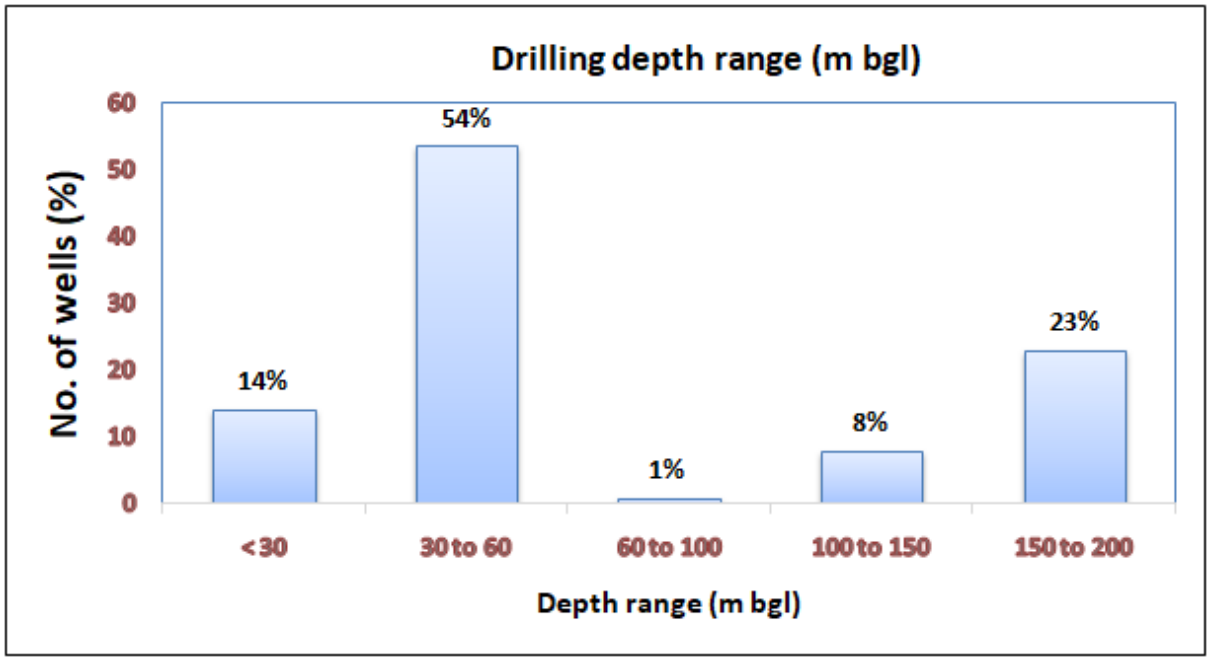

Fig. 2.2: Graph showing depth range under exploratory drilling programme

2.2 Water Levels (DTWL) (Average of 10 years: 2010 to 2019)

To study the behaviour of ground water in time and space, the wells were established and monitored at different places of the district by CGWB and SGWD. These data were utilized for preparation of depth to water level maps. The decadal average values of water levels measured from the year 2010 to 2019 during pre and post-monsoon season were analysed for better interpretation of the area. From the data, it is revealed that the depth to water level in the district varies from 3.03 to 21.44 m bgl (average: 8.62 m bgl) and 1.2to 13.94 m bgl (average: 5.05 m bgl) during pre-monsoon (May) and post-monsoon (November) seasons respectively.

2.2.1 Water Table Elevations (m amsl)

During pre and post-monsoon season of 2019, water-table elevation ranges from 53 to 239 and 61 to 243 m amsl respectively (Fig. 2.3).

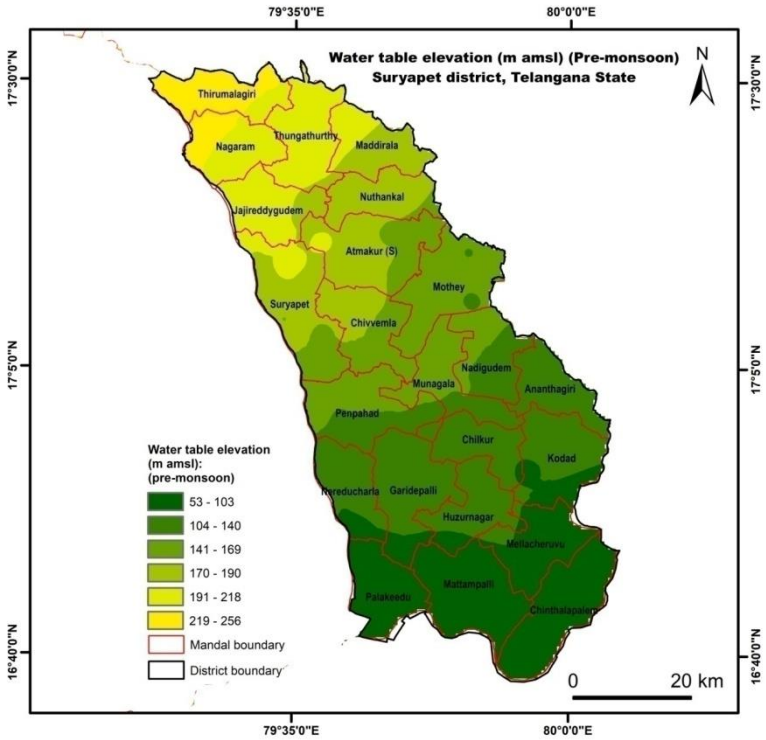

Fig. 2.3: Water table elevation (m amsl) map of pre-monsoon 2019

2.2.2 Pre-monsoon depth to water level (Decadal average 2010 to 2019)

The depth to water level during pre-monsoon season ranges from 3.03 to 21.44 m bgl with an average of 8.62 m bgl. Majority of the water levels during this season are in the range of 5 to 10m bgl and distributed in 40% of the area followed water levels ranging from 10 to 20 m bgl. The water levels of between 2 to 5 m bgl are observed in 27% of the area while water levels showing >20 m bgl is noticed in 2% of the area. In none of the samples, the depth to water level shown <2 m bgl (Fig. 2.4).

Table 2.2: Mandal wise distribution of water levels during pre-monsoon season

DTWL range	% of distribution	Mandals covered
0 to 2	Nil	-
2 to 5	27	Chilkur, Garidepalli, Huzurnagar, Kodad, Mothey, Munagala, Nereducharla, Penpahad, Suryapet and Thungathurthy
5 to 10	40	Ananthagiri, Atmakur (S), Chivvemla, Garidepalli, Jajireddygudem, Kodad, Mattampalli, Mothey, Munagala, Nereducharla, Palakeedu, Penpahad, Suryapet, Thirumalagiri and Thungathurthy
10 to 20	32	Atmakur (S), Chinthalapalem, Chivvemla, Jajireddygudem, Mattampalli, Mellacheruvu, Munagala, Nagaram, Nuthankal, Palakeedu, Suryapet, Thirumalagiri and Thungathurthy
>20	2	Chinthalapalem

2.2.3 Post-monsoon depth to water level (Decadal average 2010 to 2019)

The depth to water level during post-monsoon season ranges from 1.2 to 13.94 m bgl with an average of 5.05 m bgl. Majority of the water levels during this season are in the range of 2 to 5 m bgl followed by water levels of between 5 to 10 m bgl. The shallow water levels <2 m bgl is noticed in 13% of the area while the water levels ranging from 10 to 20 m bgl is noticed in 11% of the area. (Fig. 2.5).

Table 2.3: Mandal wise distribution of water levels during pre-monsoon season

DTWL range	% of distribution	Mandals covered
0 to 2	13	Huzurnagar, Kodad, Mothey, Munagala, Nereducharla and Suryapet
2 to 5	51	Ananthagiri, Atmakur (S), Chilkur, Chivvemla, Garidepalli, Kodad, Mattampalli, Mothey, Munagala, Nereducharla, Palakeedu, Penpahad, Suryapet and Thungathurthy
5 to 10	25	Atmakur (S), Chinthalapalem, Chivvemla, Jajireddygudem, Kodad, Mattampalli, Mellacheruvu, Nagaram, Nuthankal, Palakeedu, Thirumalagiri and Thungathurthy
10 to 20	11	Chinthalapalem, Jajireddygudem, Munagala, Suryapet and Thirumalagiri
>20	-	-

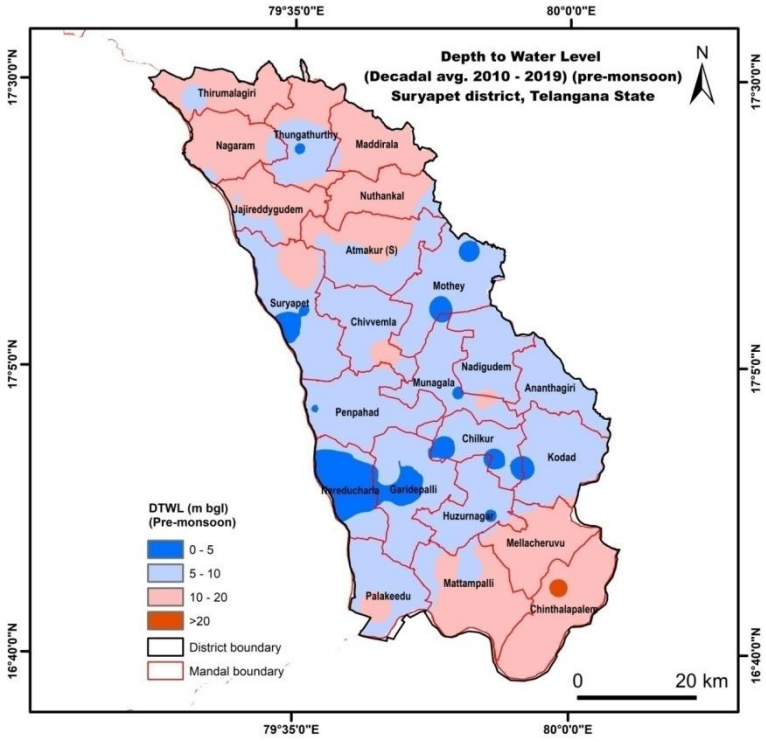

Fig. 2.4: Depth to water levels Pre-monsoon (avg. of 10 years: 2010 to 2019)

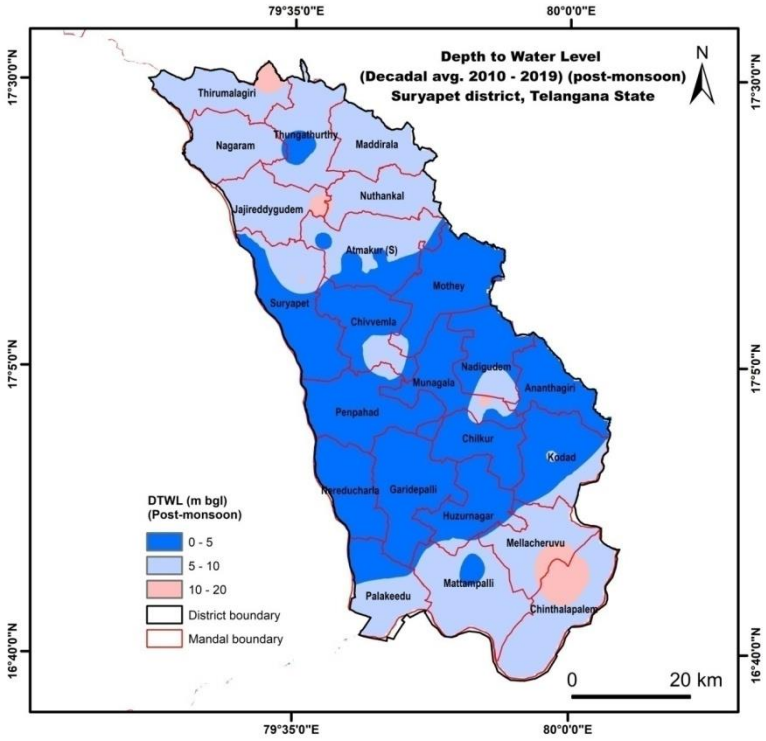

Fig. 2.5: Depth to water levels Post-monsoon (avg. of 10 years: 2010 to 2019)

2.2.4 Seasonal Water Level Fluctuations (November vs. May)

The entire district is showing rise in water level in the range of 0.75 to 10.94 m. Most of the wells (65% of the area) shows water level rise from 2 to 5 m and 17% of the area showing rise in water from 0 to 2 m. The water level rise between 5 to 10 m is noticed in 16% of the area. The water level rise of 10 to 20 m is noticed in 2% of the area(Fig. 2.6).

Table 2.4: Mandal wise distribution of seasonal water level fluctuation (November vs. May)

Seasonal fluctuation	% of distribution	Mandals covered
0 to 2	17	Chilkur, Kodad, Mothey, Munagala, Nereducharla, Palakeedu, Suryapet and Thungathurthy
2 to 5	65	Ananthagiri, Atmakur (S), Chinthalapalem, Chivvemla, Garidepalli, Huzurnagar, Jajireddygudem, Kodad, Mattampalli, Mothey, Munagala, Nagaram, Nereducharla, Nuthankal, Palakeedu, Penpahad, Suryapet, Thirumalagiri and Thungathurthy
5 to 10	16	Atmakur (S), Chinthalapalem, Chivvemla, Jajireddygudem, Mattampalli, Mellacheruvu and Thirumalagiri
10 to 20	2	Chinthalapalem

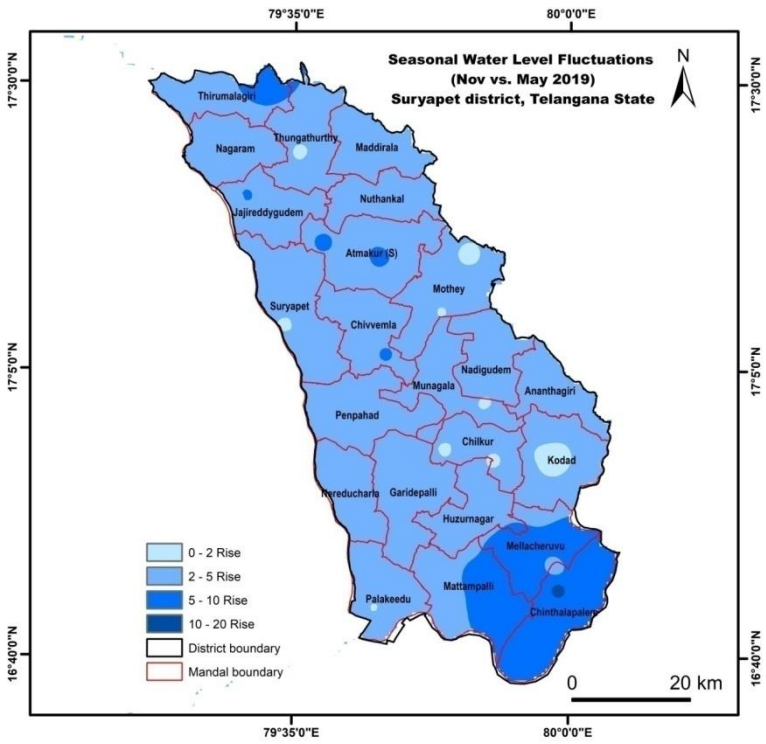

Fig. 2.6: Seasonal Water Level Fluctuations (m) (Nov vs. May2019)

2.2.5 Long term water level trends (2010-2019)

The trend analysis for last 10 years (2010-2019) is studied from the different hydrograph stations of CGWB and SGWD. During pre-monsoon season, 63% of the area shows rising trends and in remaining 37% of the area, it shows falling trend in the range of -0.01to -1.42 m/yr (Fig. 2.7). Whereas, during post-monsoon season, 83% of the area is showing rising trend ranging from 0.006 to 3.03m/yr and in remaining 17% of the area, it is showing the falling trend of from -0.03 to -0.21 m/yr) (Fig. 2.8).

Table 2.5: Mandal wise distribution of seasonal water level fluctuation (November vs. May)

Season		Range	% of Distri-bution	Mandals covered
Pre-mon	Rise	0.03 to 1.87	63	Ananthagiri, Atmakur (S), Chilkur, Chinthalapalem, Chivvemla, Jajireddygudem, Kodad, Mattampalli, Mothey, Munagala, Nagaram, Nereducharla, Nuthankal, Palakeedu, Suryapet and Thungathurthy
	Fall	0.01 to 1.42	37	Atmakur (S), Chivvemla, Garidepalli, Huzurnagar, Jajireddygudem, Kodad, Mattampalli, Mellacheruvu, Mothey, Munagala, Nereducharla, Nuthankal, Penpahad and Suryapet
Post-mon	Rise	0.006 to 3.03	83	Ananthagiri, Atmakur (S), Chilkur, Chinthalapalem, Chivvemla, Garidepalli, Jajireddygudem, Kodad, Mattampalli, Mellacheruvu, Mothey, Munagala, Nagaram, Nereducharla, Nuthankal, Palakeedu, Penpahad, Suryapet and Thungathurthy
	Fall	0.21	17	observed in Chilkur, Garidepalli, Huzurnagar, Jajireddygudem, Kodad, Mothey, Munagala, Nuthankal and Suryapet

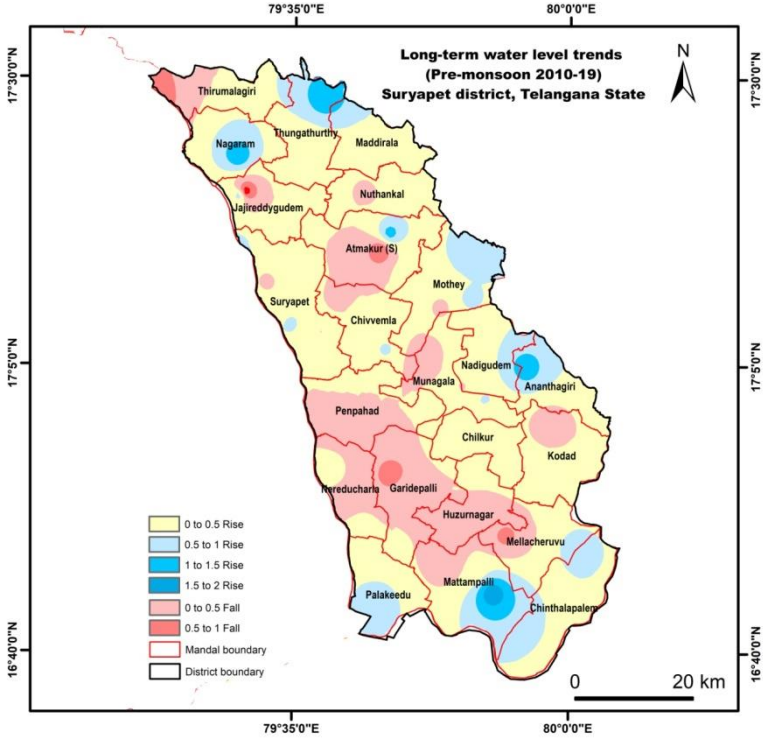

Fig. 2.7: Long-term water level trends (Pre-monsoon2010-19)

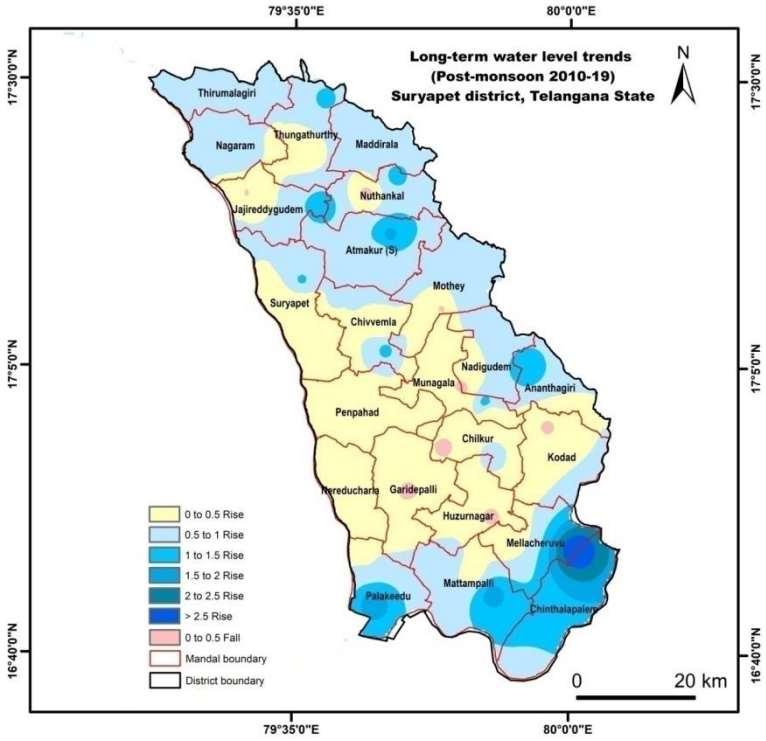

Fig. 2.8: Long-term water level trends (Post-monsoon2010-19)

2.3 Geophysical Studies

Under aquifer mapping studies, 118 VES were carried out in parts of the district covering 9 mandals viz., Ananthagiri, Chilkur, Garidepalle, Kodad, Mothey, Munagala, Nadigudem, Nagaram and Thirumalagiri. The interpreted results of VES indicated occurrence of thin top soil, weathered rock followed by fractured zone which is underlain by massive formation. The results of these studies in general have indicated that the top soil is characterized by the resistivity of 10 ohm-m to 135 ohm-m and the thickness is from 0.7 m to 4 m. The weathered zone is characterized by a resistivity of 20 ohm-m to 90 ohm-m and thickness varies from 3 m to 20 m. The fractured rock exhibits the resistivity between 90 ohm-m to 500 ohm-m. Based on the analysis of geophysical data for district the following resistivity ranges for different litho-units were arrived and given in Table 2.6.

Table 2.6: Resistivity ranges for different litho-units

Geological formation	Resistivity range Ohm (Ω) m	Depth range (m)
Top soil	10-135	0-4
Weathered formation	20-90	3-20
Fractured/jointed formation	90-500	40-50
Hard massive formation	More than 500	

2.4 Hydro-chemical Studies

To understand chemical quality of ground water, water samples collected from Aquifer-2 for both pre and post-monsoon seasons from SGWD during the year 2021 were utilized. Various chemical 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 analyzed. Out of which, five parameters namely pH, EC, TDS, NO_3 and F were interpreted for suitability for drinking purposes and is assessed as per BIS standards (2012) and irrigation suitability as per electrical conductivity.

2.4.1 Pre-monsoon

Ground water from the area is mildly alkaline in nature with pH in the range of 6.55 to 8.72(avg. 7.67). The Electrical conductivity varies from 443 to 4970 µ Siemens/cm (avg. 1592 µ Siemens/cm). In about 57% of the samples, the EC is within 1500 µ Siemens/cm, while in 34% of the samples it is in the range of 1500-3000 µ Siemens/cm. In about 9% of the samples from the EC is noticed >3000 µ Siemens/cm is observed (Fig. 2.9). The concentration of TDS varies from 284 to 3181mg/l (avg. 1021 mg/l) and found that in 92% of the samples, it falls within maximum permissible limits of BIS (<2000 mg/l) while in remaining 8% of the samples, it is falling >2000 mg/l. The NO_3 concentration ranges from 0.3 to 464mg/l (avg. 65 mg/l) and noticed that in about 61% of the samples falling within the permissible limits of <45 mg/l and in about 39% of the samples, the quality is not suitable and falling beyond permissible limit of >45 mg/l (Fig. 2.10). The Fluoride concentration varies from 0.14 to 4.95mg/l (avg. 0.92 mg/l) and in 89% of the samples, it is within the permissible limit of <1.5 mg/l and in remaining 11% of the samples, it is beyond permissible limit of >1.5 mg/l and not suitable for drinking water purpose (Fig. 2.11).

Table 2.7: Mandal wise distribution of water quality during pre-monsoon season

Para-meter	Range	% of distribution	Mandals covered
EC	<1500	57	Ananthagiri, Atmakur (S), Chilkur, Chinthalapalem, Chivvemla, Giridepalli, Huzurnagar, Jajireddygudem, Kodad, Maddirala, Mattampalli, Mellacheruvu, Mothey, Munagala, Nadigudem, Nagaram, Nereducharla, Nuthankal, Palakeedu, Suryapet, Thirumalagiri and Thungathurthy
	1500 to 3000	34	Ananthagiri, Atmakur (S), Chilkur, Chinthalapalem, Giridepalli, Huzurnagar, Kodad, Maddirala, Mattampalli, Mellacheruvu, Munagala, Nadigudem, Nereducharla, Nuthankal, Palakeedu and Suryapet
	>3000	9	Huzurnagar, Kodad, Mattampalli, Mellacheruvu, Mothey and Nadigudem
TDS	<2000	92	Ananthagiri, Atmakur (S), Chilkur, Chinthalapalem, Chivvemla, Giridepalli, Huzurnagar, Jajireddygudem, Kodad, Maddirala, Mattampalli, Mellacheruvu, Mothey, Munagala, Nadigudem, Nagaram, Nereducharla, Nuthankal, Palakeedu, Suryapet. Thirumalagiri and Thungathurthy
	>2000	8	Atmakur (S), Chilkur, Giridepalli, Huzurnagar, Kodad, Mattampalli, Mellacheruvu, Mothey, Nadigudem, Nereducharla and Suryapet
NO_3	<45	61	Ananthagiri, Atmakur (S), Chilkur, Giridepalli, Huzurnagar, Jajireddygudem, Kodad, Maddirala, Mattampalli, Mellacheruvu, Mothey, Munagala, Nadigudem, Nagaram, Nereducharla, Nuthankal, Palakeedu, Suryapet, Thirumalagiri and Thungathurthy
	>45	39	Ananthagiri, Atmakur (S), Chilkur, Chinthalapalem, Chivvemla, Giridepalli, Huzurnagar, Kodad, Maddirala, Mattampalli, Mellacheruvu, Nadigudem, Nereducharla, Palakeedu and Thungathurthy
Fluoride	<1.5	89	Ananthagiri, Atmakur (S), Chilkur, Chinthalapalem, Chivvemla, Giridepalli, Huzurnagar, Jajireddygudem, Kodad, Maddirala, Mattampalli, Mellacheruvu, Mothey, Munagala, Nadigudem, Nagaram, Nereducharla, Nuthankal, Palakeedu, Suryapet and Thungathurthy
	>1.5	11	Ananthagiri, Atmakur (S), Giridepalli, Kodad, Maddirala, Mellacheruvu, Munagala, Nereducharla, Suryapet and Thirumalagiri

2.4.2 Post-monsoon

During post-monsoon season, the ground water from the area is mildly alkaline in nature with pH in the range of 6.98 to 8.44 (avg. 7.7). The Electrical conductivity varies from 515 to 5111 µ Siemens/cm (avg. 1665 µ Siemens/cm). In 51% of the samples the EC is within 1500 µ Siemens/cm while in 42% of the samples it is in the range of 1500-3000 µ Siemens/cm. The EC >3000 µ Siemens/cm is observed in 7% of the samples (Fig. 2.12). The concentration of TDS varies from 330 to 3271 mg/l (avg. 1066 mg/l). In 94% of the samples, it is within the maximum permissible limits of BIS of <2000 mg/l, while in 6% of the samples, the EC is beyond permissible limit of >2000 mg/l. The NO_3 concentration ranges from 0.01to 448 mg/l (avg. 90 mg/l). It is noticed that in about 46% of the samples, it is within the permissible limit (<45 mg/l) while in 54% of the samples falling beyond permissible limit (>45 mg/l) and not suitable for drinking water purpose (Fig. 2.13). The Fluoride concentration varies from 0.15 to 4.29 mg/l (avg. 0.87 mg/l). In about 92% of the samples, it is falling within permissible limit of <1.5 mg/l while in 8% of the samples are having high fluoride concentration beyond permissible limits (>1.5 mg/l) and are not suitable for drinking water purpose (Fig. 2.14).

Table 2.8: Mandal wise distribution of water quality during pre-monsoon season

Para-meter	Range	% of distribution	Mandals covered
EC	<1500	51	Ananthagiri, Atmakur (S), Chilkur, Chinthalapalem, Chivvemla, Giridepalli, Huzurnagar, Jajireddygudem, Kodad, Maddirala, Mattampalli, Mellacheruvu, Mothey, Munagala, Nadigudem, Nagaram, Nereducharla, Nuthankal, Palakeedu, Suryapet, Thirumalagiri and Thungathurthy
	1500 to 3000	42	Ananthagiri, Atmakur (S), Chilkur, Giridepalli, Huzurnagar, Kodad, Mattampalli, Mellacheruvu, Munagala, Nadigudem, Nereducharla, Palakeedu, Suryapet and Thungathurthy
	>3000	7	Huzurnagar, Kodad, Mattampalli, Mellacheruvu and Mothey
TDS	<2000	94	Ananthagiri, Atmakur (S), Chilkur, Chinthalapalem, Chivvemla, Giridepalli, Huzurnagar, Jajireddygudem, Kodad, Maddirala, Mattampalli, Mellacheruvu, Mothey, Munagala, Nadigudem, Nagaram, Nereducharla, Nuthankal, Palakeedu, Suryapet, Thirumalagiri and Thungathurthy

	>2000	6	Huzurnagar, Kodad, Mattampalli, Mellacheruvu and Mothey
NO_3	<45	46	Ananthagiri, Atmakur (S), Chilkur, Giridepalli, Huzurnagar, Jajireddygudem, Kodad, Maddirala, Mattampalli, Mellacheruvu, Mothey, Munagala, Nadigudem, Nagaram, Nereducharla, Nuthankal, Palakeedu, Suryapet, Thirumalagiri and Thungathurthy
	>45	54	Ananthagiri, Atmakur (S), Chilkur, Chinthalapalem, Chivvemla, Giridepalli, Huzurnagar, Jajireddygudem, Kodad, Mattampalli, Mellacheruvu, Munagala, Nadigudem, Nereducharla, Palakeedu, Suryapet and Thungathurthy
Fluoride	<1.5	92	Ananthagiri, Atmakur (S), Chilkur, Chinthalapalem, Chivvemla, Giridepalli, Huzurnagar, Jajireddygudem, Kodad, Maddirala, Mattampalli, Mellacheruvu, Mothey, Munagala, Nadigudem, Nagaram, Nereducharla, Nuthankal, Palakeedu, Suryapet and Thungathurthy
	>1.5	8	Atmakur (S), Giridepalli, Huzurnagar, Kodad, Munagala, Nuthankal, Suryapet and Thirumalagiri

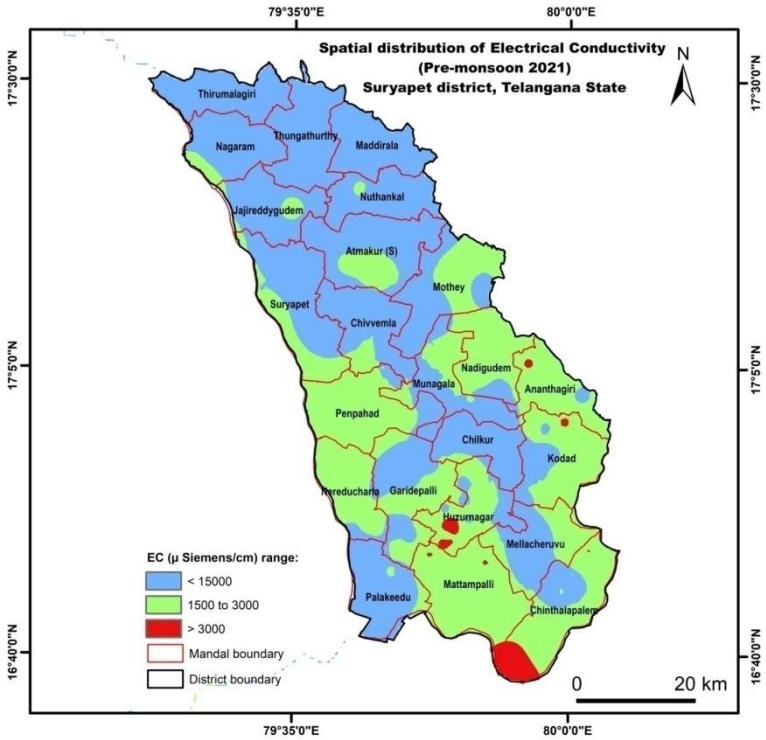

Fig.2.9: Spatial distribution of Electrical conductivity (Pre-monsoon2021)

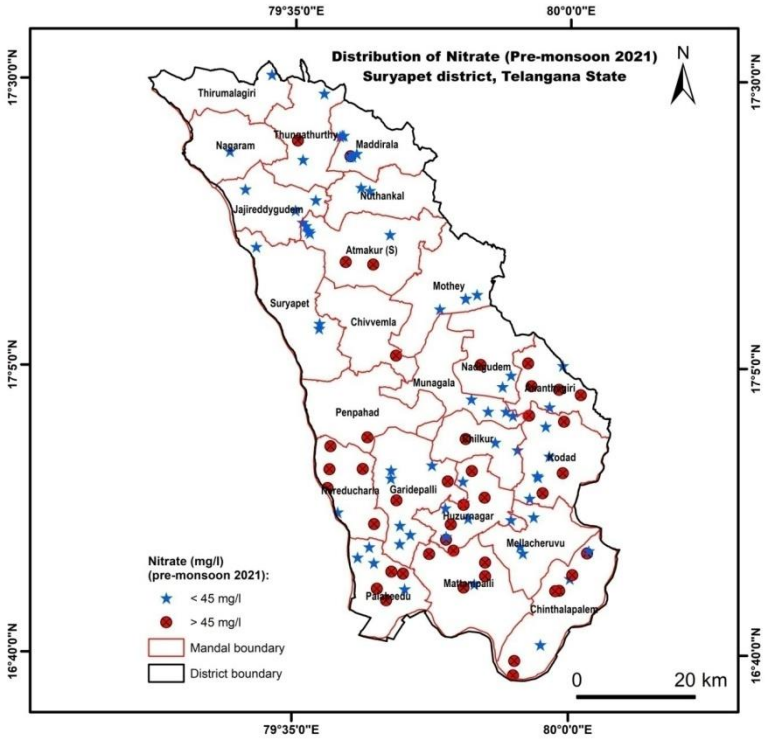

Fig. 2.10: Distribution of Nitrate (Pre-monsoon2021)

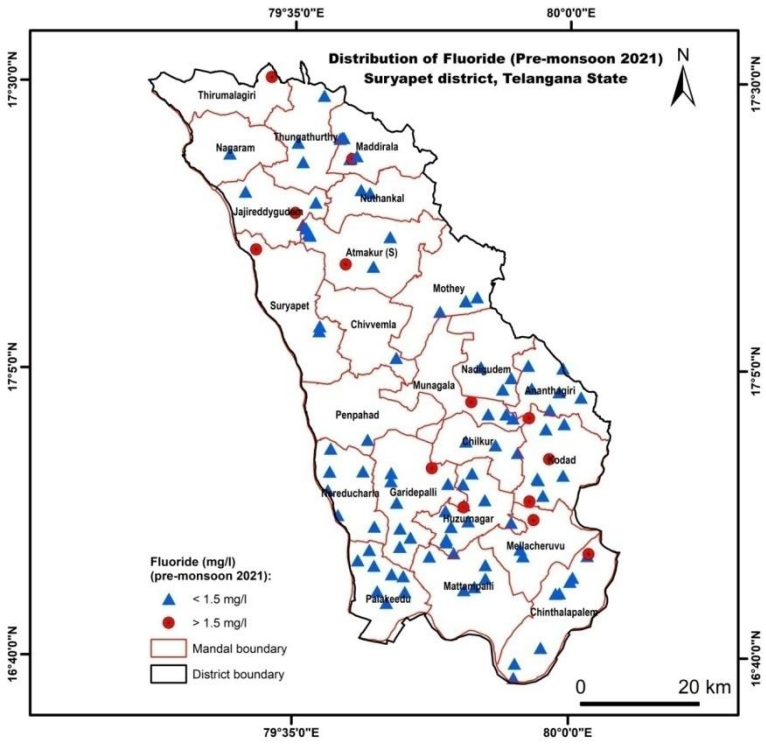

Fig. 2.11: Distribution of Fluoride (Pre-monsoon 2021)

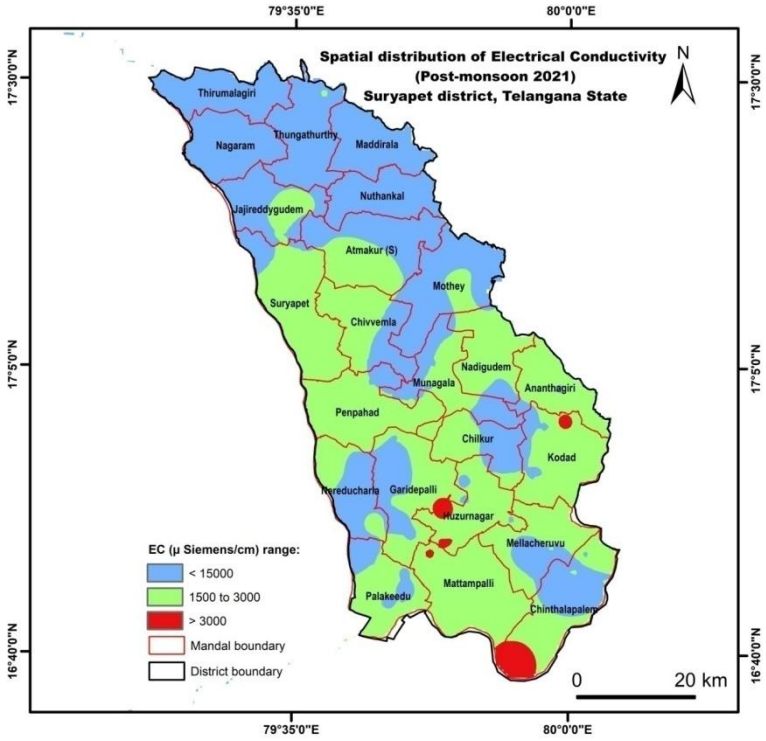

Fig.2.12: Distribution of Electrical conductivity (Post-monsoon 2021)

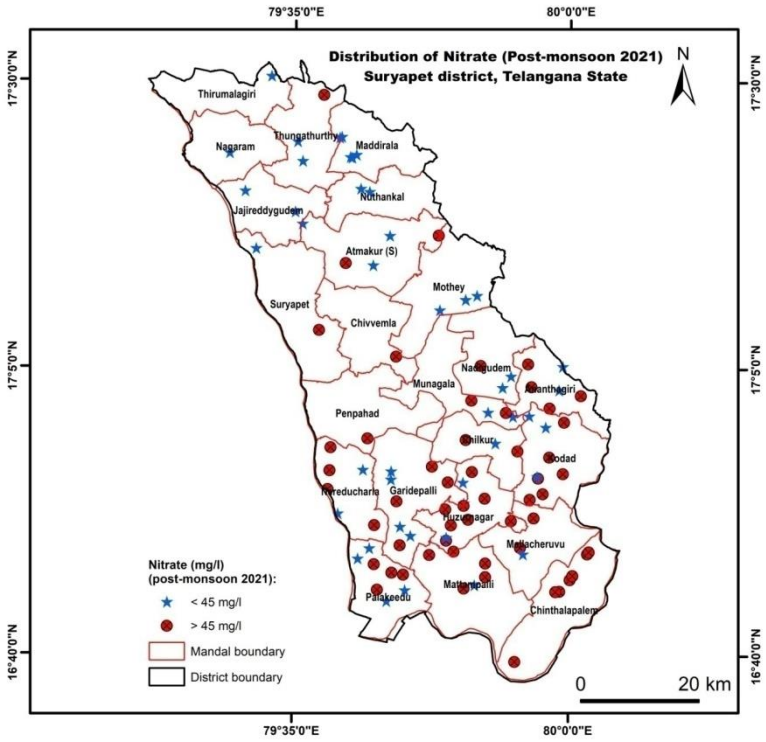

Fig.2.13: Distribution of Nitrate (Post-monsoon 2021)

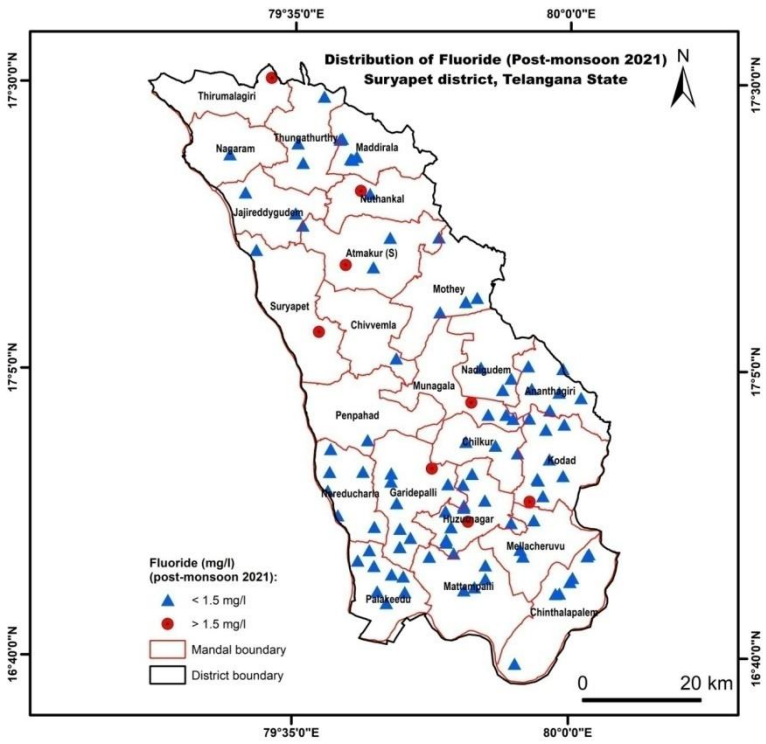

Fig. 2.14: Distribution of Fluoride (Post-monsoon 2021)

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

Conceptualization of 3-D hydrogeological model was carried out by integrating and interpreting data. A representative hydrogeological data collected from exploration, VES and well inventory carried out at different locations in the district down to the depth of 200 m bgl by CGWB and SGWD were utilized for preparation of 3D map, panel diagram and hydrogeological sections. The data is calibrated for elevations with SRTM data. The lithological information was generated by using the RockWorks-16 software and generated 3D map for district (Fig. 3.1) along with panel diagram (Fig. 3.2) and hydrogeological sections.

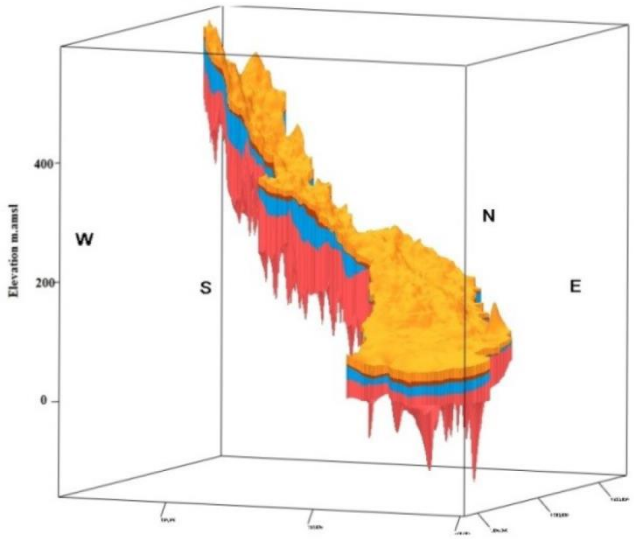

Fig. 3.1: 3D Model (Source: Erstwhile NAQUIM source report, Phase II)

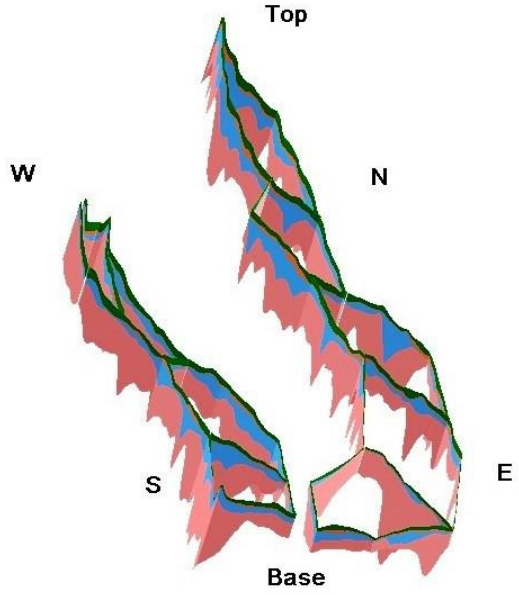

Fig. 3.2: Panel Diagram (Source: Erstwhile NAQUIM source report, Phase II)

3.1 Conceptualization of aquifer system in 3D

Aquifers were characterized in terms of their potential and quality based on integrated hydrogeological data and various thematic maps. The depth of investigation carried out was up to 200 m bgl. The weathered zone varies from 1.5 to 30 m bgl. The weathering >20 m bgl is observed in Jajireddygudem and Thungathurthy mandals. The fractured zone varies from 2.28 to 180m bgl with the yield ranging from <1 to 6.73lps with an average of 1lps. About 96% of the fractures were encountered within 100 m bgl depth in 20 mandals viz., Atmakur (S), Chilkur, Chinthalapalem, Chivvemla, Giridepalli, Huzurnagar, Jajireddygudem, Kodad,

Maddirala, Mattampalli, Mothey, Munagala, Nagaram, Nereducharla, Nuthankal, Palakeedu, Penpahad, Suryapet, Thirumalagiri and Thungathurthy mandals. The deeper fractures beyond 100 m bgl (4%) are encountered in Jajireddygudem, Thirumalagiri and Thungathurthy mandals.

3.2 Hydrogeological Sections

Two hydrogeological sections were prepared along NW-SE (a) and N-S (b) directions.

3.2.1 NW-SE Section (a)

The section drawn along the NW-SE direction, covering a distance of ~120 kms depicts uniform weathered zone thickness all along the section. The fracture thickness is more in NW parts in comparison to SE(Fig. 3.3a).

3.2.2 N-S Section (b)

Section drawn along N-S directions, covering a distance of ~85 kms, depicts almost uniform weathered zone thickness in most part. The thickness of fractured zone is more in northern part of section while it is negligible from the distance of 30 kms to 55 kms from N towards S directions (Fig. 3.3b) and again noticed fractured zone from 55 kms to 85 kms.

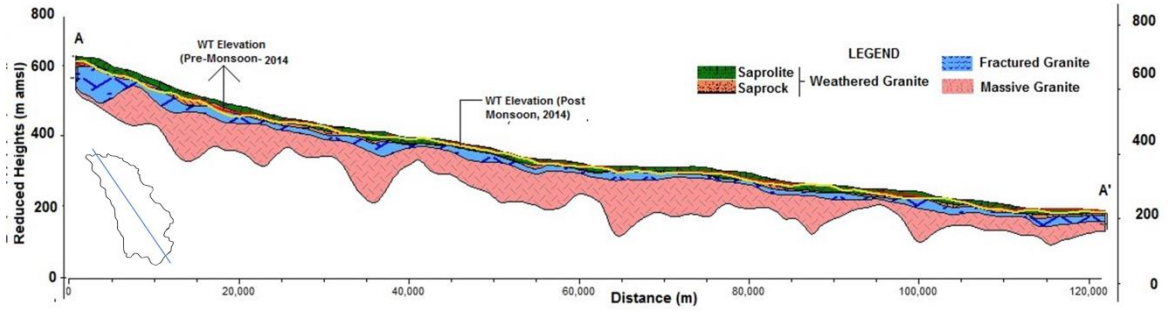

Fig. 3.3(a): NW-SE Section (Source: Erstwhile NAQUIM source report, Phase II)

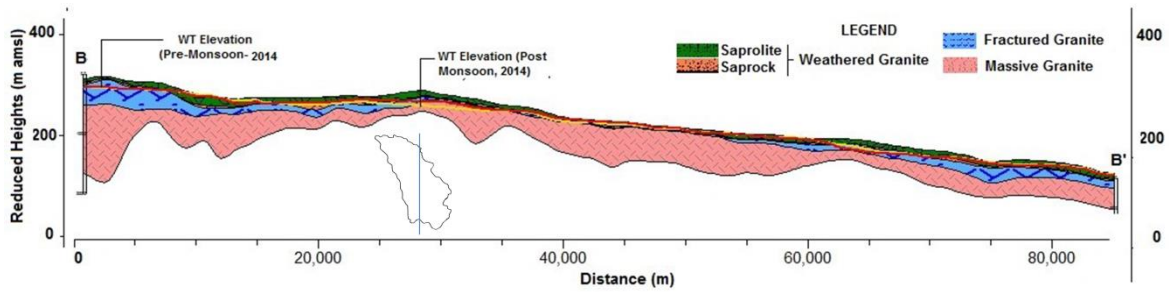

Fig. 3.3(b): N-S Section

Fig. 3.3: Hydrogeological sections along different directions

3.3 Aquifer Characterization

3.3.1 Weathered zone

The dug wells, which were in operational earlier, have gradually becoming dry and defunct due to over-exploitation particularly during pre-monsoon season at many places. The depth of weathering ranging from 1.5 to 30m bgl. In most part of the district (64% of the area), the depth of weathering ranges from 0 to 10 m bgl is mostly observed in Atmakur (S), Chivvemla, Giridepalli, Huzurnagar, Jajireddygudem, Kodad, Maddirala, Mothey, Munagala, Nagaram, Nereducharla, Nuthankal, Palakeedu, Penpahad, Suryapet, Thirumalagiri and Thungathurthy mandals, while the depth of weathering ranging from 10 to 20 m bgl (32% of the area) is observed in Atmakur (S), Chilkur, Chinthalapalem, Chivvemla, Jajireddygudem, Kodad, Mattampalli, Mothey, Munagala, Nagaram, Nereducharla, Nuthankal, Palakeedu, Penpahad, Suryapet and Thungathurthy mandals. The weathering depth >20 m bgl (4% of the area) is seen in Jajireddygudem, Kodad, Maddirala and Thungathurthy mandals (Fig. 3.4 and Fig. 3.5). Generally, the yield of weathered zone varies from up to 3 lps with average of 1 lps. The transmissivity varies from 8 to 633 m^2/day. The Specific yield varies from 0.001 to 0.01.

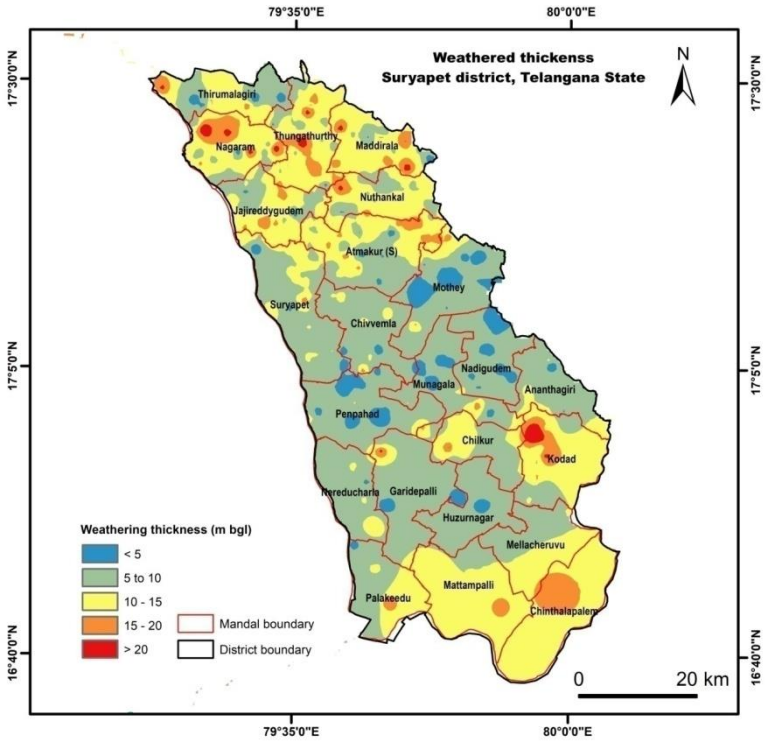

Fig. 3.4: Thickness of Weathered zone

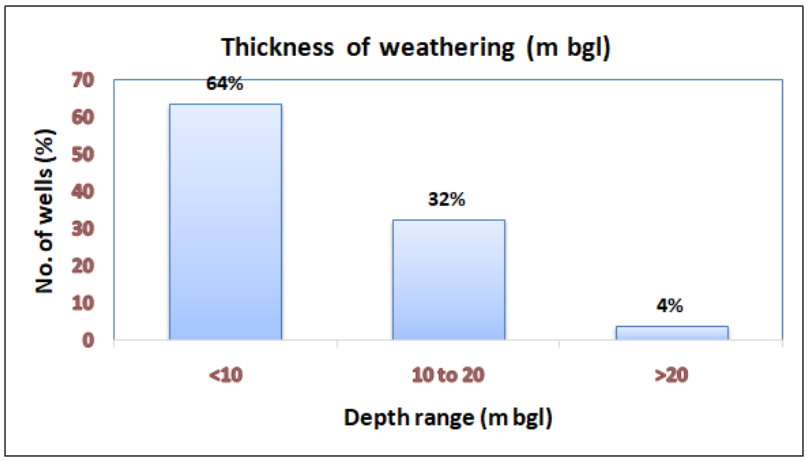

Fig. 3.5: Graph showing depth wise distribution of weathering zone

3.3.2 Fractured zone

Ground water is extracted mainly through bore wells tapping fractured zone till to the depth 200 m bgl. The detailed analysis based on exploratory well data, the fractures and yield corresponding with drilling and weathering depth have been analysed and given in Table 3.1. Based on this, it is inferred that 78% of the fractures occur within 30 m bgl with yield ranging from 0.02 to 6.73lpsobserved at Atmakur (S), Chilkur, Chinthalapalem, Chivvemla, Giridepalli, Huzurnagar, Jajireddygudem, Kodad, Maddirala, Mattampalli, Mothey, Munagala, Nagaram, Nereducharla, Nuthankal, Palakeedu, Penpahad, Suryapet, Thirumalagiri and Thungathurthy mandals. About 12% of the fractures occur within depth range of 30 to 60 m bgl with yields varying from 0.02to 3lps and are observed at Atmakur (S), Chilkur, Chinthalapalem, Chivvemla, Jajireddygudem, Kodad, Mattampalli, Munagala, Nagaram, Nuthankal, Palakeedu and Thungathurthy mandals. About 6% of the fractures occurring within the depth range of 60 to 100 m bgl with yield varying from 0.7 to 1.5lps (Atmakur (S), Chilkur, Mothey, Penpahad and Thungathurthy mandals) (Fig. 3.6 and 3.7). About 4% of the fractures have occurred beyond 100 m bgl with yield varying 2.5 to 4.3lps (Thirumalagiri mandal). The deepest fracture tapped at the depth of 179.90m bgl is encountered in the exploratory well drilled at Velchal village of Thirumalagiri mandals. Over all, the yield varies from 0.02 to 6.73lps in the terrain with an average of 1lps. The Transmissivity varies from 0.13 to 1392m^2/day. The Storativity varies from 0.000054 to 0.0108. From the fracture analysis, it is observed that in about 96% of fractures are encountered within the depth of 100 m bgl. Further exploitation is continued beyond 100 m bgl also in many parts of the district.

The yield wise data analysis shows that in about 92% of the wells, the yield is <1 lps (Atmakur (S), Chilkur, Chinthalapalem, Chivvemla, Giridepalli, Huzurnagar, Jajireddygudem, Kodad, Maddirala, Mattampalli, Mothey, Munagala, Nagaram, Nereducharla, Nuthankal, Palakeedu, Penpahad, Suryapet, Thirumalagiri and Thungathurthy mandals) while in 4% of the wells, the yield is ranges from 1 to 2 lps (Atmakur (S), Jajireddygudem, Mothey, Nagaram and Thungathurthy mandals). In about 2% of the wells, the yield is 2 to 3 lps (Chilkur, Jajireddygudem, Nagaram, Thirumalagiri and Thungathurthy mandals). The yield >3 lps is observed in 3% of the wells located in Atmakur (S), Chilkur, Mattampalli, Nagaram, Thirumalagiri and Thungathurthy mandals (Fig. 3.8).

Table 3.1: Analysis of fractures and yield corresponding with drilling and weathering depths

Fracture range (m bgl)	**% of fractures**	**Yield range (lps)**	**T (m2/day)**	**S**	**Drilling Depth Range (m bgl)**	**Weathering Depth Range (m bgl)**
<30	78	0.02 to 6.73	0.13 to 1392	0.000054 to 0.0108	9 to 203	1.5 to 30
30 to 60	12	0.02to 3	63.29 to 107.33	0.0010 to 0.00129	30 to 200	5.6 to 19.5
60 to 100	6	0.07 to1.5	0.38 to 16.47	0.000186 to 0.001	111.80 to 200	5.6 to 26
>100	4	2.5 to4.3	0.19 to 26.23	0.00030 to 0.0054	142.30 to 200	2 to 22

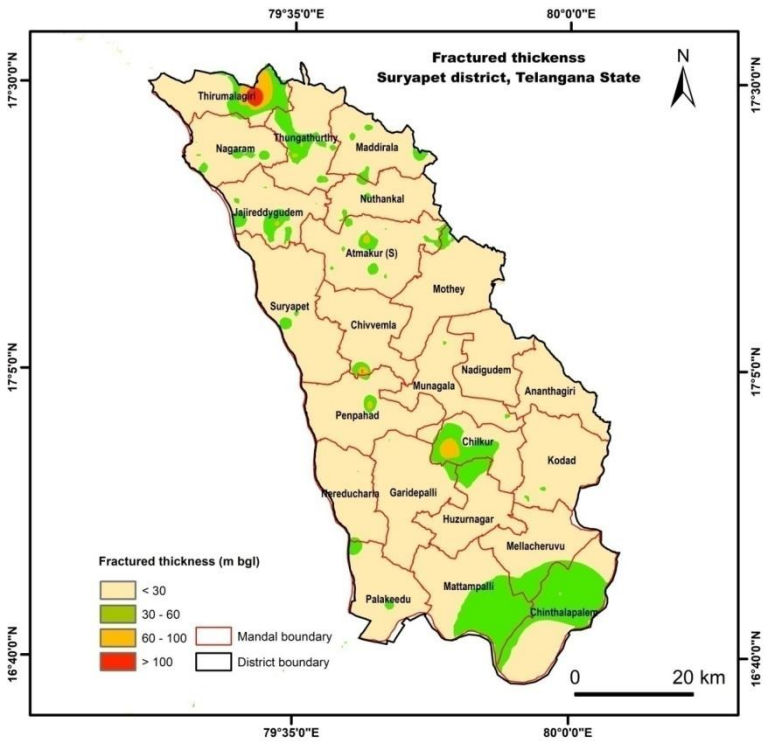

Fig.3.6: Depth of Fractured zone

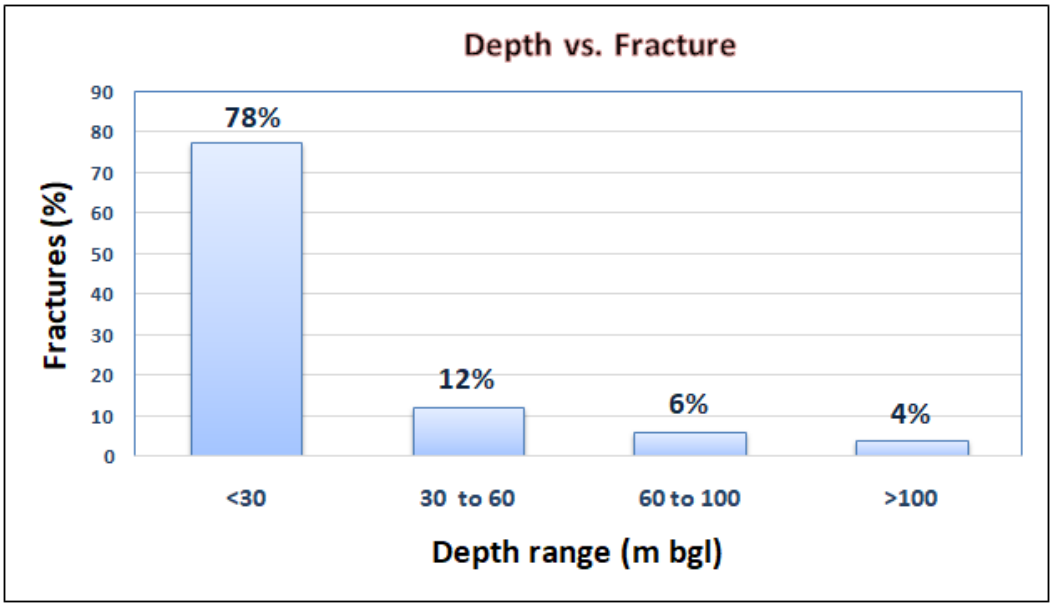

Fig. 3.7: Graph showing Depth vs. Fracture

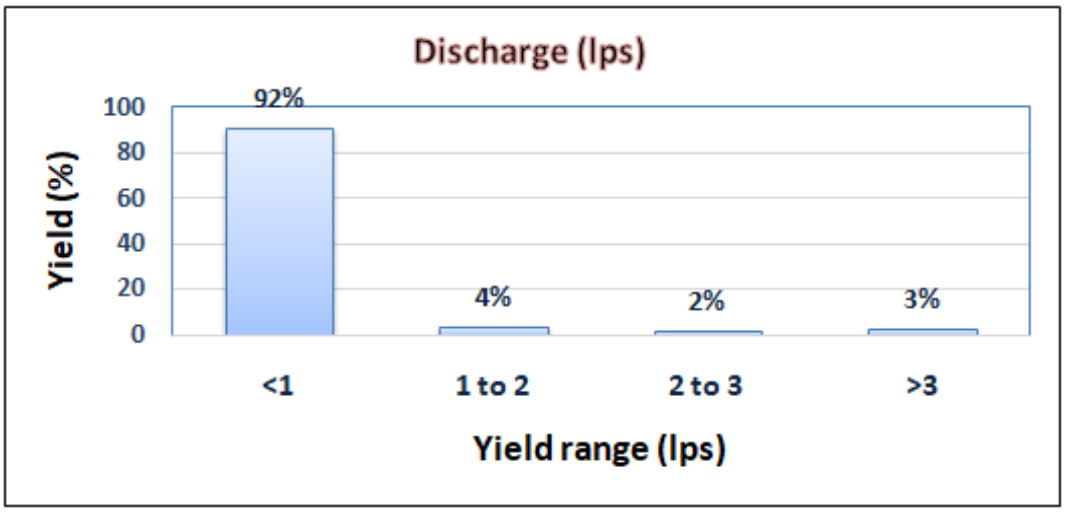

Fig. 3.8: Graph showing yield range

4. GROUND WATER RESOURCES (GEC 2022)

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. The mandal wise dynamic and in-storage ground water resources are computed as per the guidelines laid down in GEC methodology and the highlights of the district is given in Table 4.1.

As per GEC 2022 estimation report, the net dynamic replenishable ground water availability for newly formed district is 1209MCM, the gross ground water draft for all uses 248 MCM, provision for drinking and industrial use for the year 2025 is 23 MCM and net annual ground water potential available for future irrigation needs is 1056 MCM.

Out of 23 mandals, 21 mandals are falling under Safe (Ananthagiri (14%), Atmakur S (54%), Chilkur (10%), Chinthalapalem (6%), Chivvemla (47%), Garidepalle (11%), Huzur nagar (14%), Jajireddigudem (47%), Kodad (11%), Mattampalle (22%), Mellachervu (4%), Mothey (49%), Munagala (32%), Nadigudem (18%), Nagaram (66%), Neredcherla (6%), Noothankal (63%), Palakeedu (6%), Penpahad (54%), Suryapet (23%) and Thungathurthi (67%)), and the remaining 2 mandal (Maddirala (72%) and Thirumalagiri (71%)) is falling under Semi Critical category. The overall average stage of ground water extraction in the district is 33% falling under Safe category. The mandal wise categorisation based on GEC 2022 is given in Fig. 4.1.

Table 4.1: Computed dynamic ground water resources (GEC 2022)

Parameters	Resources (GEC 2022) in MCM
Dynamic (Net GWR Availability)	1304
• Monsoon recharge from rainfall	200
• Monsoon recharge from other sources	675
• Non-Monsoon recharge from rainfall	15
• Non-monsoon recharge from other sources	559
• Natural Discharge	144
Gross Recharge	1448
Gross GW Draft	248
• Irrigation	228
• Domestic and Industrial use	20
• Provision for Drinking and Industrial use for the year 2025	23
Net GW availability for future irrigation	1056
Average Stage of GW extraction (%)	33% (Safe)
Categorization of mandals	**Safe: 21, Semi-Critical: 2** **Safe:** (Ananthagiri (14%), Atmakur S (54%), Chilkur (10%), Chinthalapalem (6%), Chivvemla (47%), Garidepalle (11%), Huzur nagar (14%), Jajireddigudem (47%), Kodad (11%), Mattampalle (22%), Mellachervu (4%), Mothey (49%), Munagala (32%), Nadigudem (18%), Nagaram (66%), Neredcherla (6%), Noothankal (63%), Palakeedu (6%), Penpahad (54%), Suryapet (23%) and Thungathurthi (67%)) **Semi-Critical:** (Maddirala (72%) and Thirumalagiri (71%))

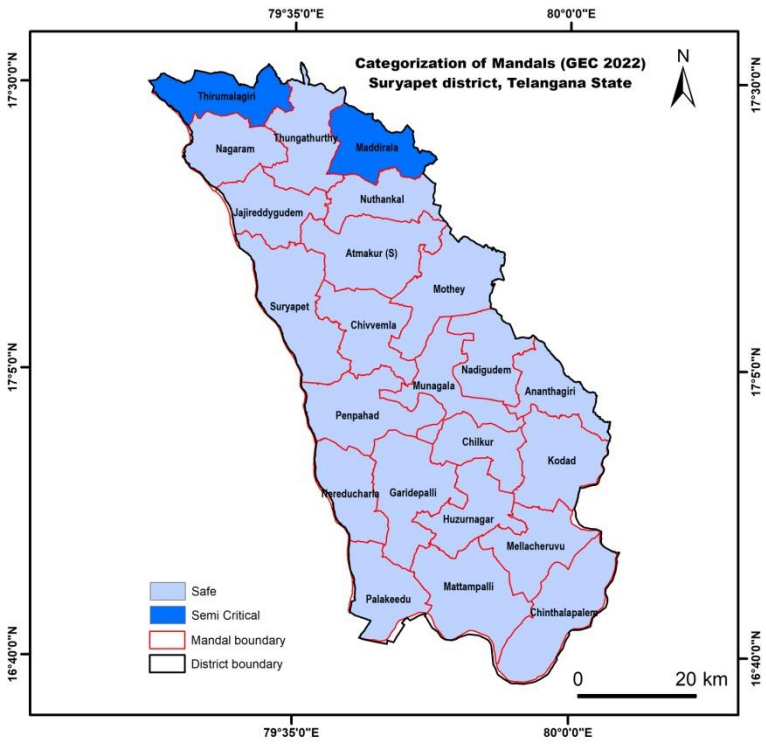

Fig. 4.1: Categorisation of mandals based on GEC 2022

5. GROUND WATER RELATED ISSUES

5.1 Issues

5.1.1 Ground water extraction based on GEC 2022

- Based on GEC 2022 report, the district noticed that in about 2 mandals viz., Maddirala (72%) and Thirumalagiri (71%) has been categorized under 'Semi Critical' where their stage of ground water extraction is between 70 % to 90%.

5.1.2 Inferior ground water Quality (Geogenic and Anthropogenic)

- **EC:** High Electrical Conductance (EC) (>3000 µ Siemens/cm) is noticed in 9% of the samples during pre-monsoon season (Huzurnagar, Kodad, Mattampalli, Mellacheruvu, Mothey and Nadigudem mandals), while it is noticed in 7% of the samples during post-monsoon season (Huzurnagar, Kodad, Mattampalli, Mellacheruvu and Mothey mandal).
- **Nitrate:** High nitrate contamination (>45 mg/l) due to anthropogenic activities is also observed in 39% of the samples during pre-monsoon season (Ananthagiri, Atmakur (S), Chilkur, Chinthalapalem, Chivvemla, Giridepalli, Huzurnagar, Kodad, Maddirala, Mattampalli, Mellacheruvu, Nadigudem, Nereducharla, Palakeedu and Thungathurthy mandals) and 54% during post-monsoon season (Ananthagiri, Atmakur (S), Chilkur, Chinthalapalem, Chivvemla, Giridepalli, Huzurnagar, Jajireddygudem, Kodad, Mattampalli, Mellacheruvu, Munagala, Nadigudem, Nereducharla, Palakeedu, Suryapet and Thungathurthy mandals). The higher concentration is due to unscientific sewage disposal of treated and untreated effluents in urban and rural areas. Use of fertilizers and nitrogen fixation by leguminous crops.
- **Fluoride:** The fluoride contamination (geogenic) in ground water is as high as 4.95 mg/l during pre-monsoon and 4.29mg/l during post-monsoon season. The high fluoride concentration (>1.5 mg/l) occurred in 11% of samples during pre-monsoon (Ananthagiri, Atmakur (S), Giridepalli, Kodad, Maddirala, Mellacheruvu, Munagala, Nereducharla, Suryapet and Thirumalagiri mandals) and 8% of the samples during post-monsoon season (Atmakur (S), Giridepalli, Huzurnagar, Kodad, Munagala, Nuthankal, Suryapet and Thirumalagiri mandals). Higher concentration of fluoride in ground water is attributed due to source rock (i.e., granite), rock water interaction where acid-soluble fluoride

bearing minerals (fluorite, fluoro-apatite) gets dissolved under alkaline conditions. It indicates higher residence time of ground water in deeper aquifer.

5.1.3 Deeper water levels (>20 m bgl)

- The deeper water levels (>20 m bgl) are observed in 2% of the area during pre-monsoon season (Chinthalapalem mandals). The Paddy cultivation during rabi season leads to more ground water extraction. The limited artificial measures might also be the main causes of deeper water levels in the area.

5.1.4 Ground water Sustainability

- The yield information from exploratory wells indicates that the low yield of <1 lps occurred in 92% of the wells observed in Atmakur (S), Chilkur, Chinthalapalem, Chivvemla, Giridepalli, Huzurnagar, Jajireddygudem, Kodad, Maddirala, Mattampalli, Mothey, Munagala, Nagaram, Nereducharla, Nuthankal, Palakeedu, Penpahad, Suryapet, Thirumalagiri and Thungathurthy mandals and shown low ground water potential.

- The yield from many 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 more exploitation of ground water. This is due to limited availability or absence of primary porosity, negligible development of secondary porosity, low rainfall and desaturation of weathered zone.

5.1.5 Shallow water levels (<2 m bgl)

- The shallow water levels (<2 m bgl) are observed in 13% of the area observed in Huzurnagar, Kodad, Mothey, Munagala, Nereducharla and Suryapet mandals during post-monsoon season.

5.1.6 Water Marketing and other Issues

- Water marketing is observed in almost all mandals and people are buying water can/bottled water from the market for drinking purposes.

- Change in land use from agricultural land to residential purposes and cropping pattern from traditional crops to cash crops (paddy) is observed.

- In non-command area, the paddy crop grown during rabi season is completely dependent on ground water which leads to heavy withdrawal of ground water during non-monsoon period.

6. MANAGEMENT STRATEGY

High dependence on ground water coupled with absence of augmentation measures has led to a steady fall in water levels and desaturation of weathered zone in some parts, raising questions on sustainability of existing ground water structures, food and drinking water security. The occurrence of fractures beyond weathered zone are very limited in extent, as the compression in the rock reduces the opening of fractures at depth and the majority of fractures normally occur within 100 m depth. In this district also, the most of the fractures encountered within 100 m bgl and further exploitation is happening till to the depth 200 m bgl. The higher NO_3concentrations (>45 mg/l) is due to over use of fertilizers in agriculture lands and other anthropogenic activities. The higher concentration of Fluoride (>1.5 mg/l) in weathered zone and fractured zone is due to local geology, high weathering, longer residence time and alkaline nature of ground water.

The uneven distribution of ground water 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 study suggests notable measures for sustainable ground water management, which involves a combination of 1) Supply side measures and 2) Demand side measures.

6.1Supply side management

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

6.1.1 Implementation of Artificial Recharge Structures

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 m bgl. 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. About 50% of the available surplus run-off is considered for the recommendation of artificial recharge structures and the remaining 50% needs to be recommended for implementing water conservation measures in recharge areas through MGNREGS by State Government.

As per the GEC 2022 estimation, Out of 23 mandals, 21 mandals are falling in Safe category and 2 mandals are falling under Semi Critical. The artificial recharge structures are proposed for entire district in two different classification as **Priority – I** (where mandals falling under Semi Critical/Critical/Over Exploited category with stage of ground water development is >70% as per GEC 2022 estimation) and **Priority – II** (where mandals falling under Safe category with stage of ground water development is <70% as per GEC 2022 estimation) (Fig. 6.1). The villages which are having unsaturated thickness to the depth below 5 m bgl during post-monsoon season water levels falling in both Priority – I and Priority – II categories were considered and recommended suitable artificial recharge structures.

The existing water conservation structures were also considered during formulation of water conservation management plan. The villages which are already having sufficient water conservation structures were not considered for recommending artificial recharge structures. The more importance is given to villages where there are no artificial recharge structures and also villages with less number of existing structures. The artificial recharge structures have not been recommended for those villages where the depth to water level is <5 m bgl during post-monsoon season. The highlights of the existing and proposed management plans for Priority – I & Priority– II areas is given in Table 6.1 and Table 6.2.The proposed artificial recharge intervention structures falling under Priority - I and Priority - II areas are given in Annexure - I and Annexure - II.

6.1.1.1 Priority-I (Semi Critical, Critical and Over Exploited mandals)

- Out of 23 mandals in the district, 2 mandals viz., Maddirala and Thirumalagiri are falling under Semi Critical category with stage of ground water development between 70% to 90% were classified under Priority – I category (Fig. 6.1).
- A total of 24 villages are falling in this category with an area 254 sq.km (7% of the area).
- Almost in all villages, the depth to water level is noticed >5 m bgl during post-monsoon season and for this area, the water conservation and management plan is prepared (Annexure – I).
- In these 24 villages, about 609 MCM of unsaturated volume (below 5 m depth) is available (in both weathered and fractured zones), 12 MCM recharge potential and 7 MCM utilizable yield (uncommitted run-off) is available for immediate intervention.
- No existing structures were noticed in these villages.
- About 153 artificial recharge structures have further recommended in these 24 villages (71 PTs with 2 fillings with a unit cost of Rs. 20 lakhs each and 82 CDs with recharge shafts with 6 fillings with a unit cost of Rs. 15 lakhs each) with a total cost of 26.5 Crores.
- After effective implementation of artificial recharge structures, there will be 4.44 MCM of ground water recharge with 100% recharge efficacy.
- Roof top rainwater harvesting structures should be made mandatory to all Government buildings (new and existing).

6.1.1.2 Priority - II (Safe mandals)

- Out of 23 mandals in the district, 21 mandals viz.,(Ananthagiri (14%), Atmakur S (54%), Chilkur (10%), Chinthalapalem (6%), Chivvemla (47%), Garidepalle (11%), Huzur nagar (14%), Jajireddigudem (47%), Kodad (11%), Mattampalle (22%), Mellachervu (4%), Mothey (49%), Munagala (32%), Nadigudem (18%), Nagaram (66%), Neredcherla (6%), Noothankal (63%), Palakeedu (6%), Penpahad (54%), Suryapet (23%) and Thungathurthi (67%))are falling under Safe category with stage of ground water extraction between <70% is classified under Priority – I category (Fig. 6.1).
- A total of 255 villages are falling in this category with an area 3325 sq.km (93% of the area).

- Out of which, 146 villages with an area of 1769 sq.km shown the depth to water level <5 m bgl during post-monsoon season. Hence, artificial recharge structures have not recommended for these villages.
- In the remaining 109 villages with an area of 1556 sq.km, the depth to water level is noticed >5 m bgl during post-monsoon season and for this area, the water conservation and management plan is prepared (Annexure – II).
- In these 109 villages, about 3338 MCM of unsaturated volume (below 5 m depth) is available (in both weathered and fractured zones), 67 MCM recharge potential and 67 MCM utilizable yield (uncommitted run-off) is available for immediate intervention.
- About 148 artificial recharge structures (Percolation Tanks (PTs): 56& Check Dams (CDs): 92) were already existing in 31 villages with storage capacity of 0.78 MCM.
- About 632 artificial recharge structures have further recommended in 109 villages (297 PTs with 2 fillings with a unit cost of Rs. 20 lakhs each and 335 CDs with recharge shafts with 6 fillings with a unit cost of Rs. 15 lakhs each) with a total cost of 109.65 Crores.
- After effective implementation of artificial recharge structures, there will be 18.23 MCM of ground water recharge with 100% recharge efficacy.
- Roof top rainwater harvesting structures should be made mandatory to all Government buildings (new and existing).

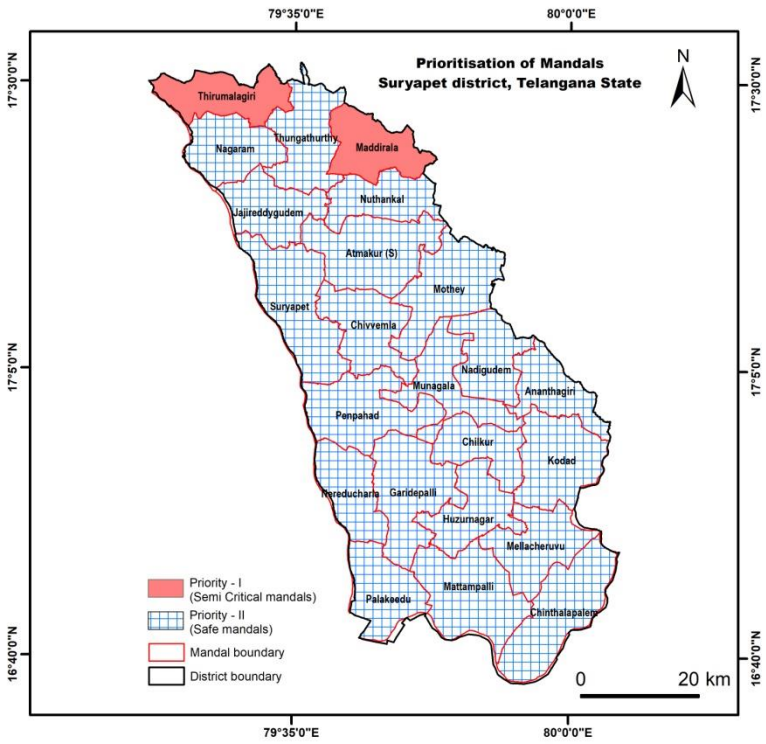

Fig. 6.1: Prioritisation of mandals for preparation of management plans

6.1.2 Water Conservation Measures through Farm Ponds (for both Priority – I & II mandals)

- The farm ponds are the ideal water conservation structures, which are constructed in the low lying areas of the farm. The size of form ponds can be 10 x 10 x 3 m. The total 5580 farm ponds are recommended (20 in each village in 279 villages for the entire district) at Rs 25,000/-each with total cost of 13.95 Crores. This can create an additional storage of 3.20 MCM. This may help the farmers for early sowing and to meet the needs for intermediate irrigation.

6.1.3 Other Supply Side Measures

- Existing artificial recharge structures viz., percolation tanks, check dams and dried natural water bodies 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 ground water resources.

6.1.4 State Government Projects

6.1.4.1 Mission Kakatiya (Repair, Renovation and Restoration of existing water bodies)

- Under Mission Kakatiya Programme taken up by State Government, out of 1132 minor irrigation tanks, 724 tanks were desilted during Phase-1 to Phase-4 and excavated 34.62 MCM quantity of silt. This helped in strengthening of water bodies and created additional surface storage thereby increased ground water augmentation in the district. This has indirectly saved 8.65 MCM of ground water (considering 25% of ground water savings) and with this about 1442 ha. of additional land that can be brought under ID crops under irrigation.
- There is a need to take remaining tanks in the next phases for de-siltation. This will greatly help in stabilisation of tank ayacut and further ground water augmentation.

6.1.4.2 Mission Bhagiratha

- Under Telangana Drinking Water Supply Project (TDWSP) also known as Mission Bhagiratha, all the villages are proposed to be covered (the schemes are at various stages of completion). The scheme is to enhance the existing drinking water scheme and to provide 100 lpd/persons in rural areas and 135 lpd/person in urban areas. Thus all habitations (including fluoride affected) will be covered with the implementation of this project.
- The water required to be imported to the tune of 42.32 MCM per annum from surface sources into the basins will reduce stress on ground water. Considering 60 lpcd at present utilization there will be net saving of 24.08 MCM of ground water, which can be effectively utilized to irrigate 4013 ha of additional land under ID crops.

6.2 Demand side management

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

6.2.1 Ongoing Micro-irrigation

Priority - I (Semi Critical, Critical and Over Exploited mandals):

- In Priority – I mandals till date, a total 218 ha. area is brought under micro-irrigation (Sprinklers: 46 ha. & Drip: 172 ha.) saving 0.3 MCM of ground water (considering 25% of saving to traditional practices).

Priority - II (Safe mandals):

- In Priority – II mandals till date, a total 3587 ha. area is brought under micro-irrigation (Sprinklers: 570 ha. & Drip: 3017 ha.) saving 5.4 MCM of ground water (considering 25% of saving to traditional practices).

6.2.2 Proposed Micro-irrigation

Priority - I (Semi Critical, Critical and Over Exploited mandals):

- In Priority – I mandals, additionally about 1782 ha. of additional land that can be brought under micro-irrigation (where actual area irrigated though micro-irrigation is less than 1,000 ha in one mandal) costing about 10.69 Crores (considering 1 unit/ha. @0.6 lakhs/ha.). With this, about 2.67 MCM of ground water can be conserved over the traditional irrigation practices (considering 25% of net saving for ID crops).

Priority - II (Safe mandals):

- In Priority – II mandals, additionally about 17413 ha. of additional land that can be brought under micro-irrigation (where actual area irrigated though micro-irrigation is less than 1,000 ha in one mandal) costing about 104.48 Crores (considering 1 unit/ha. @0.6 lakhs/ha.). With this, about 26.12 MCM of ground water can be conserved over the traditional irrigation practices (considering 25% of net saving for ID crops).

Table 6.1: Highlights of the existing management plans for Priority – I & Priority – II areas

Particulars	Priority – I	Priority - II	District
Total geographical area of district (Sq.km &%)	254 (7%)	2235 (62%)	3579
No. of mandals covered	2 (Semi Critical: 2)	21 (Safe: 21)	23
No. of villages covered	24	255	279
Unsaturated Volume (MCM) (below 5 m depth)	609	3338	3947
Recharge Potential (MCM)	12	67	79
Uncommitted Run-off (MCM) available	7	32	39
EXISTING			
Particulars	**Priority – I**	**Priority - II**	**District**
No. of villages where water levels <5 m bgl during post-monsoon season	Nil	146 (1769 sq.km)	146 (1769 sq.km)
No. of villages where water levels >5 m bgl during post-monsoon season	24 (254 sq.km)	109 (1556 sq.km)	133 (1810 kms)
No. of villages where artificial recharge structures exists	Nil	31	31
Existing artificial recharge structures	CDs: Nil, PTs: Nil, Storage Capacity (MCM): Nil	CDs: 92, PTs: 56, Storage Capacity (MCM): 0.78	CDs: 92, PTs: 56, Storage Capacity (MCM): 0.78
	Farm ponds: Nil, Storage Capacity (MCM): Nil	Farm ponds: 456, Storage Capacity (MCM): 1.94	Farm ponds: 456, Storage Capacity (MCM): 1.94
	Micro Irrigation: Sprinkler: No. 56, Ha: 46 Drip: No. 142, Ha: 172	Micro Irrigation: Sprinkler: No. 614, Ha: 570 Drip: No. 2557, Ha: 3017	Micro Irrigation: Sprinkler: No. 670, Ha: 616 Drip: No. 2699, Ha: 3189

Table 6.2: Highlights of the proposed management plans for Priority – I & Priority – II areas

PROPOSED			
Particulars	**Priority – I**	**Priority - II**	**District**
Villages considered to propose artificial recharge structures where unsaturated thickness below 5 m bgl	25 (272 sq.km)	107 (1525 sq.km)	132 (1797 kms)
Unsaturated Volume (MCM) (below 5 m depth)	609	3338	3947
Recharge Potential (MCM)	12	67	79
Uncommitted Run-off (MCM) available	7	32	39
Proposed artificial recharge structures	CDs: 82, PTs: 71, Storage Capacity (MCM): 4.44	CDs: 335, PTs: 297, Storage Capacity (MCM): 18.23	CDs: 417, PTs: 368, Storage Capacity (MCM):22.67
	Farm ponds: 20*24 villages=480, Storage Capacity (MCM): 0.14	Farm ponds: 20*255 villages=5100, Storage Capacity (MCM): 1.53	Farm ponds: 20*279 villages=5580, Storage Capacity (MCM): 1.67
	Micro Irrigation: Area to be covered: 1782 ha, Expected GW conservation (25% of net saving): 2.67 MCM	Micro Irrigation: Area to be covered: 17413 ha, Expected GW conservation (25% of net saving): 26.12 MCM	Micro Irrigation: Area to be covered: 19195 ha, Expected GW conservation (25% of net saving): 28.79 MCM
Cost estimation (Crores)	CDs: 12.30 Cr, PTs: 14.20 Cr	CDs: 50.25, PTs: 59.40	CDs: 62.55 Cr, PTs: 73.60 Cr
	Farm ponds: 1.20 Cr	Farm ponds: 12.75 Cr	Farm ponds: 13.95 Cr
	Micro Irrigation: 10.69 Cr	Micro Irrigation: 104.48 Cr	Micro Irrigation: 115.17 Cr
Present stage of GW extraction (%)	72%	30%	33%
Net reduction/ saving (%)	15%	13%	15%
Change stage of GW extraction (%)	56%	17%	18%

6.3 Other Recommendations

- Declaration of MSP in advance (before start of season) and improved facilities at procurement centres.
- As a mandatory measure, every ground water user should recharge rainwater through artificial recharge structures in proportionate to the extraction.
- Capacity building in power supply regulation (4 hour each in morning and evening) will increase the sustainability of wells.
- Participatory Ground Water Management (PGWM) approach in sharing of ground water and monitoring resources on a continuous basis along with effective implementation of the existing 'Water, Land and Trees Act' of 2002 (WALTA-2002).
- Subsidy/incentives on cost involved in sharing of ground water may be given to the concerned farmers
- In urban and rural areas the sewerage line should be constructed to arrest leaching of nitrate.
- Demand side measures include adaptation of micro irrigation practices which saves ~25 % water as compared to traditional flooding irrigation.
- Change in cropping pattern from water intensive paddy to other irrigated dry and drought resistant crops that have a short growing season is recommended, particularly in semi-critical mandals. If necessary some regulatory rules may be framed and implemented.
- To avoid the interference of cone of depression between two productive wells, intermittent pumping of bore wells is recommended through regulatory mechanism.
- Complete ban on paddy cultivation during rabi season under ground water irrigation in non-command areas and semi-critical mandals.
- Power supply should be regulated by giving power in 4 hour spells (two times a day, in the morning and evening)to increase the sustainability of structures.
- As mandatory measures power connection may be given to only those farmers who are adopting micro irrigation for all new bore well to be constructed.
- Compulsory rain water harvesting in proportionate to withdrawal.
- Roof top rainwater harvesting structures should be made mandatory to all Government/industrial buildings (new and existing).

6.4 Expected results and out come

Priority - I (Semi Critical, Critical and Over Exploited mandals):

- In Priority – I mandal, with the above interventions, the likely benefit would be increases in gross ground water availability with net saving of 7 MCM of ground water or net reduction of 15% in stage of ground water extraction, i.e., from the existing 72% to 56%. The onetime cost will be 5 paisa/litre and the actual cost of invest will be 0.5 paisa/litre if considered the life of the artificial recharge structures and micro irrigation equipment as 10 year.

Priority - II (Safe mandals):

- In Priority – II mandal, with the above interventions, the likely benefit would be increases in gross ground water availability with net saving of 46 MCM of ground water or net reduction of 13% in stage of ground water extraction, i.e., from the existing 30% to 17%. The onetime cost will be 5 paisa/litre and the actual cost of invest will be 0.5 paisa/litre if considered the life of the artificial recharge structures and micro irrigation equipment as 10 year.

Entire district:

- In the entire district, with the above, the likely benefit would be increases in gross ground water availability with net saving of 53 MCM of ground water or net reduction of 15% in stage of ground water extraction, i.e., from the existing 33% to 18%. The onetime cost will be 5 paisa/litre and the actual cost of invest will be 0.5 paisa/litre if considered the life of the artificial recharge structures and micro irrigation equipment as 10 year.

Acknowledgments

The first author expressed thanks to Chairman, Member (HQ) & Member (South) of the Central Ground Water Board (CGWB), Govt. of India, CHQ, Faridabad and Sh. J. Siddhardha Kumar, Regional Director, CGWB, Southern Region, Hyderabad for given me opportunity to work under NAQUIM Project and guidance. The author is also thankful to Smt. Rani, V.R, Sc-D and Shri Ravi Kumar Gumma, Sc-D & OIC (APSUO, Visakhapatnam) for encouragements and guidance. The author acknowledges with thanks to State Ground Water Department and Rural Water Supply Department, Govt. of Telangana for making the field data available.

Author is also thanks the Executive Engineer of CGWB, Div-IX and TS State Government's line departments for the relevant exploration data in the field area.

Annexure – I

Proposed interventions for Priority- I areas where villages falling under Semi Critical and Over Exploited mandals in Suryapet district.

Mandal	Village	Proposed Check Dams for intermittent areas	Proposed Percolation Tanks for Intermittent areas
Maddirala	Chandu Patla	2	2
Maddirala	Chinna Nemila	4	3
Maddirala	Ganjivari Kothapalle	2	2
Maddirala	Gorentla	5	4
Maddirala	Gummadavally	3	2
Maddirala	Kukkadam	5	4
Maddirala	Kunta Palle	3	2
Maddirala	Maddirala	3	3
Maddirala	Mamindla Madava	3	2
Maddirala	Mukundapuram	3	3
Maddirala	Polumalla	3	3
Maddirala	Ramachandrapur	1	1
Maddirala	Reddiguda	2	2
Thirumalagiri	Anantharam	1	1
Thirumalagiri	Bandla Palle	3	3
Thirumalagiri	Gundepuri	3	3
Thirumalagiri	Jalal Puram	4	3
Thirumalagiri	Mali Puram	4	3
Thirumalagiri	Mamidiyala	4	3
Thirumalagiri	Nanda Puram	2	2
Thirumalagiri	Sidda Samudram	2	2
Thirumalagiri	Thati Pamula	5	4
Thirumalagiri	Thirumalagiri	3	3
Thirumalagiri	Thonda	7	6
Thirumalagiri	Velchala	5	5

Annexure – II

Proposed interventions for Priority- II areas where villages falling under Safe mandals in Suryapet district.

Mandal	Village	Proposed Check Dams for intermittent areas	Proposed Percolation Tanks for Intermittent areas
Ananthagiri	Tellabali	3	2
Atmakur (S)	Aipur	5	4
Atmakur (S)	Bopparam	2	1
Atmakur (S)	Gattikal	1	1
Atmakur (S)	Isthalapur	1	1
Atmakur (S)	Maktha Kotha Gudem	1	1
Atmakur (S)	Midthan Palle	1	1
Atmakur (S)	Mukkudeu Devi Palle	2	2
Atmakur (S)	Patharla Pahad	3	2
Atmakur (S)	Venkatapur	1	1
Chinthalapalem	Adlur	5	4
Chinthalapalem	Chinthala Palem	9	8
Chinthalapalem	Chintriyala	7	6
Chinthalapalem	Donda Padu	9	8
Chinthalapalem	Gudimalkapuram	2	2
Chinthalapalem	Nemalipuri	5	4
Chinthalapalem	Reballe	4	3
Chinthalapalem	Thammaram	4	4
Chinthalapalem	Vajine Palli	4	3
Chinthalapalem	Vellatur	12	10
Chivvemla	Gumpula	2	2
Chivvemla	Thirumalagiri	1	1
Chivvemla	Tuljarao Pet	1	1
Chivvemla	Vallabhapur	1	1
Huzurnagar	Amara Varam	1	1
Huzurnagar	Yapala Singaram	1	1
Jajireddygudem	Adivemula	3	3
Jajireddygudem	Bollam Palle	2	1
Jajireddygudem	Jaji Reddi Gudem	8	7
Jajireddygudem	Kasarla Pahad	3	2
Jajireddygudem	Kesaram	1	1
Jajireddygudem	Kodur	3	3
Jajireddygudem	Kommala	4	3
Jajireddygudem	Kunchamarthi	2	2
Jajireddygudem	Parsai Palle	2	2
Jajireddygudem	Thimmapuram	3	3

Mandal	Village	Proposed Check Dams for intermittent areas	Proposed Percolation Tanks for Intermittent areas
Jajireddygudem	Uyyalawada	2	2
Jajireddygudem	Velpucherla	2	2
Kodad	Gudibanda	1	1
Kodad	Kuchipudi	4	4
Kodad	Redla Kunta	2	2
Mattampalli	Allipuram	1	1
Mattampalli	Channaya Palem	1	1
Mattampalli	Choutapalli	4	3
Mattampalli	Gundla Palli	3	2
Mattampalli	Mattam Palli	2	2
Mattampalli	Mattapalli	4	4
Mattampalli	Pedda Veedu	5	4
Mattampalli	Raghunadha Palem	7	6
Mattampalli	Vardha Puram	1	1
Mellacheruvu	Kandibanda	6	5
Mellacheruvu	Mella Chervu	13	11
Mellacheruvu	Revuru	12	10
Mellacheruvu	Yapala Madharam	6	5
Munagala	Akupamula	1	1
Munagala	Barakath Guda	1	1
Nadigudem	Eklashkhan Pet	1	1
Nadigudem	Rama Puram	3	3
Nadigudem	Ratna Varam	1	1
Nagaram	Chenna Puram	2	2
Nagaram	Devaraneni Kotha Palle	4	3
Nagaram	Etoor	4	4
Nagaram	Laxmapur	2	2
Nagaram	Mamidi Palle	2	2
Nagaram	Nagaram	3	3
Nagaram	Pasnur	2	2
Nagaram	Pasthala	4	3
Nagaram	Phanigiri	5	4
Nagaram	Wardhamanu Kota	9	8
Nuthankal	Bhikumalla	2	2
Nuthankal	Chilpa Kunta	4	3
Nuthankal	Dirisana Palle	1	1
Nuthankal	Gundla Singaram	1	1
Nuthankal	Lingam Palle	1	2
Nuthankal	Machan Palle	2	3
Nuthankal	Mediguda	2	2

Mandal	Village	Proposed Check Dams for intermittent areas	Proposed Percolation Tanks for Intermittent areas
Nuthankal	Miryala	3	4
Nuthankal	Nuthankal	3	3
Nuthankal	Pedanemila	1	2
Nuthankal	Talla Singaram	3	2
Nuthankal	Venke Palle	2	1
Nuthankal	Yadavalli	2	2
Nuthankal	Yerra Pahad	2	1
Palakeedu	Gundeboina Gudem	2	2
Palakeedu	Gundla Pahad	3	2
Palakeedu	Janapahad	6	5
Palakeedu	Komatikunta	2	2
Palakeedu	Mahankali Gudem	3	3
Palakeedu	Ravipahad	2	2
Palakeedu	Sunya Pahad	2	2
Penpahad	Dharmapuram	2	1
Suryapet	Balemla	6	5
Suryapet	Ramachandra Puram	2	1
Suryapet	Ramavaram	2	2
Suryapet	Solipet	2	2
Suryapet	Yerkaram	5	4
Thungathurthy	Annaram	2	2
Thungathurthy	Bandaramaram	3	2
Thungathurthy	Ganugubanda	2	2
Thungathurthy	Gottiparthi	5	4
Thungathurthy	Karivirala	1	1
Thungathurthy	Keshava Puram	2	2
Thungathurthy	Manapur	2	2
Thungathurthy	Ravula Palle	3	3
Thungathurthy	Sangem	2	2
Thungathurthy	Velug Palle		1
Thungathurthy	Vempati	6	6
