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

PEDDAPALLI DISTRICT, TELANGANA

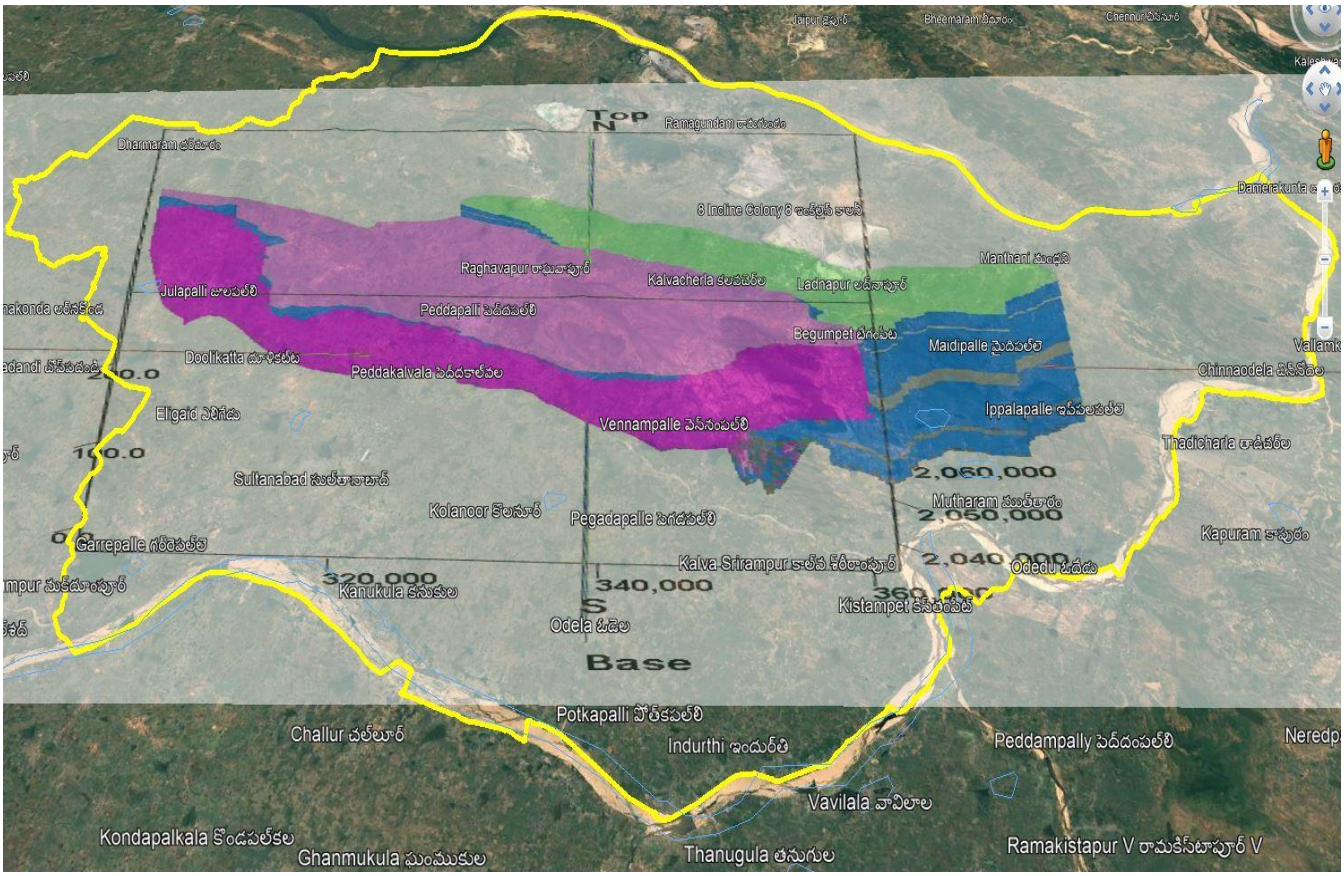
दक्षिणी क्षेत्र, हैदराबाद

Southern Region, Hyderabad

भारत सरकार
जल संसाधन नदी विकास एवम् गंगा संरक्षण मंत्रालय
केंद्रीय भूमिजल बोर्ड

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

REPORT ON
AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN HARD & SOFT ROCKS PEDDAPALLI DISTRICT, TELANGANA STATE



CENTRAL GROUND WATER BOARD
SOUTHERN REGION
HYDERABAD
MARCH-2023

REPORT ON
AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN HARD ROCK AREAS OF PEDDAPALLI DISTRICT, TELANGANA STATE

CONTRIBUTORS' PAGE

Name		Designation
Principal Authors		
Dr. M. Sudheer Kumar	**:**	**Scientist-D**

REPORT ON
AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN HARD & SOFT ROCKS PEDDAPALLI DISTRICT, TELANGANA STATE

Executive summary

Co n t e n t s

Figures

Table

REPORT ON
AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN HARD & SOFT ROCKS PEDDAPALLI DISTRICT, TELANGANA STATE

AT A GLANCE

S.No.	Item		Particulars
1	Districts	:	Peddapalli (Hard Rock & Soft Rock Area)
2	Revenue Divisions/ Mandals	:	14
3	Villages	:	215 Nos
4	Geographical area	:	2184 km^2
5	Population (2011 Census)	:	~7.95 lakh (urban: ~21 %, rural: ~79 %)
6	Density of population (2011 Census)	:	350 persons/km^2.
7	Locations	:	North latitude 18°20´58"-18°52´51" East longitude 79°17´26"-80°20´44"
8	Rainfall (Normal)	:	~1055 mm actual annual rainfall is 1292mm (SW: 20 % & NE: 20%) (During 2020 it received 1354 mm (28 % excess than normal rainfall)
9	Geomorphology	:	Pediplain (50 %, pediment (22 %), Denudation hills (15 %), flood plains (8 %) and channel fill (5 %).
10	Major Rivers	:	The Godavari and The Maner river
11	Watersheds	:	19 nos
12	Land Utilization (Ha)	:	Double cropped area occupies ~43% of the total geographical area, 49% of area is cultivated during kharif season. Forest: ~42%, wastelands ~ 9%, river sandy area is 3%, Water channel area 2%
13	Soils	:	Loamy soils (58 %) and Clayey soils (11 %)
14	Cropping Pattern (2019-2020) (Gross Area: 119763 Ha)	:	Khariff: 1,19,763 Ha paddy (36%), Oil seeds (3 Cereals & Millets are also grown in (36%) other non –food crops 2 % are grown Rabi: 36,930 ha Ha paddy (49 %), Cotton (25%) oil seeds (1%) and other non-food crops 2 % etc.
15	Irrigation	:	**Major project:** Sri Ram Sagar Project (Stage-1) (Registered ayacut:166397 ha) **Medium Projects:** Mannair Project (ayacut: 5463 ha), Shanigaram Project (ayacut: 2065 ha), Boggalavagu Project (ayacut: 2085 ha)

			MI Tanks: 405 minor irrigation tanks During 2020-2021 ground water contributed **44 %** of irrigation needs
16	Prevailing Water Conservation/Recharge Practices	:	PT: 53 and CD: 75 and Farm ponds:195 Micro irrigation: 32264 Ha. Under Mission Kakatiya (Phase 1 and 4) total ~0.25 MCM of silt is removed from 501 tanks.
17	Geology	:	Banded Gneissic complex (Gneisses & Granites: 70 %): and Sandstone/shale (20 %), and quartzite (3%) and ultramafic rocks.
18	Hydrogeological data points	:	31 hydrogeological data VES: 30 and Well inventory: 82)
19	Number of ground water structures	:	As on 31/03/2020, CGWB drilled 31 bore wells
20	Ground water yield (lps)	:	0.1 to 3 lps in hard rocks; 1 to 25 lps in soft rocks
21	Water Levels (2022) Depth to water levels (m bgl)	: :	31 piezometers (CGWB: 14 and SGWD: 17) The DTW varies during pre-monsoon from 2.65 to 20.79 meter below ground level (m bgl) (average: 9.19 m bgl) and during Post-monsoon varies from 1.04-17.49 m bgl (average: 5.9) seasons of 2021. Pre-monsoon water levels 2-10 m (71%) of the area, 10-20 m.bgl (25%). Deep water levels <25 mbgl (3%) and 2 to 5 mbgl occupy about 61% of the area. Post-monsoon: water levels 2-10m (87%) 10-20 m.bgl (10%). nil 20-40 m.bgl (< 2 mbgl) 3% and 2 to 5 m.bgl 48% of the area.
22	Water Level Fluctuations (May vs. November 2016)	:	fluctuations -2.27 to 8.96m average rise of 3.25m 1 well (3%) fall 30 wells (97%) rise.
23	Long term water level trends (2011-2020) (30 wells)	:	**Pre-monsoon:** Falling trends: 21 wells (70%) (0.01 to 2.69 m/Yr) and 9 wells (30%) shows rising trend (0.004-1.18 m/yr). **Post-monsoon:** Falling trends: 30 wells, 10 wells (33%) (0.01 to 0.75 m/Yr) and 19 wells (63%) rising trends (0.01 to 1.25 m/Yr)
24	Water level during **(2019-2020)** with average WL of last 10 years (2011-20)	:	**Pre-monsoon:** 21 wells show fall, 9 rise **Post-monsoon:** 10 wells shows fall and 19 shows rise.
25	Geophysical data (down to 200 m)	:	30 VES Top soil upto 3 m with resistivity of 10 to 50 ohm m, weathered zone from 4 m to 18 m with resistivity of 30 to 80 ohm m. The fractured rock existed upto 22 m with a resistivity of 150 ohm m.
26	Hydrochemistry (2020)	:	Total 227 data Pre-monsoon (CGWB:62 nos, SGWD:51)

			Post-monsoon (CGWB: 63; SGWD:51)	
26.1	Electrical Conductivity (µ Siemens/cm)	:	Pre: 192-2534 (avg: 818) µ Siemens/cm. In 72 % of area EC is within 1500 µ Siemens/cm, in 25% area, it is 1500-3000 µ Siemens/cm. Post: 142-2966 (avg: 1163) µ Siemens/cm. In 75% of area, EC is within 1500 µ Siemens/cm, in 25% of area EC is 1500 to 3000 µ Siemens/cm.	
26.2	Nitrate mg/l	:	Pre: 46% of samples is beyond permissible limits of 45mg/L are unfit for human consumption Post: 26% of samples is beyond permissible limits of 45 mg/L are unfit for human consumptions).	
26.3	Fluoride mg/l	:	Pre: 0.15-3.15, 94% of samples are within permissible limits and rest 6% are unfit for human consumptions. Post: 0.09-4.51 (Fig 2.13) and 92% of samples are within permissible limits and rest 8% are unfit for human consumptions.	
27	Conceptualization		Weathered zone (~30 m).	Fractured zone (30 -300) m
27.1	Aquifer Characterization	:	Saprolite (~10 m) and lower sap rock (10-30) 10-20 m weathering occurs in 68 % followed by < 10 m in 26% of area and deep weathering occurs in 6% of area.	Majority of fractures ~98% occurs within 100 m depth. Deepest fracture at 90-151 m
27.2	Aquifer wise Ground water yield	:	<0.1 to 10 lps. Lower yields (< 1 lps) occur in central part of study area and moderate yields (1-3 lps) occur in eastern part and higher yields (> 3 lps) occur in western,	0.01 to 5.8 lps.
27.3	Transmissivity (m^2/day)	:	28 to 668 m2/day	290 to 668 m2/day
27.4	Specific Yield	:	< 1 to 2.3 %.(avg: 1 %).	-
27.5	Storativity	:	-	0.00001 to 0.0001
28	Ground water Resources (2022) MCM	:	721.98 MCM	
28.1	Net Dynamic groundwater availability	:	**454.35**	
28.2	Gross GW Draft	:	650.98	
28.3	Provision for Domestic &Industrial (2025)	:	181.59	
28.4	Average Stage of Ground water development (%)		28.37	
28.5	Net GW Availability for future irrigation	:	454.35	
28.7	Categorization of mandals		Mandal wise 4 % to 44 % (Safe:14)	
29	Major Ground Water Issues Identified	:	• Ground water Pollution (Geogenic: Fluoride (8 % samples are unfit for human consumptions).(Anthropogenic: Nitrate	

			46 % samples are unfit for human consumptions). • Deep water levels (<10 m bgl) are observed during pre - monsoon season in 8 % of area. • Declining water levels: 67% wells during pre-monsoon, 33% wells during post-monsoon shown falling trend in the last 10 years.
30	Management Strategies	:	**Supply side measures:** 4508 MCM of unsaturated volume (below the 3 meter depth) is available during post-monsoon, having 122 MCM of recharge potential. **Ongoing Projects** **Mission Kakatiya: De-silting of Minor Tanks 501 under (**Phase-1 and 4): ~0.25 MCM of silt is removed contributing to ~ 0.20 MCM to groundwater. **Mission Bhagiratha:**~40.49 MCM of water will be imported from surface sources this will save ~24.29 MCM and from this ~4048.33 ha of additional land can be brought under ID crops. **To be taken up (Artificial Recharge Structure)** **Priority-1: recommended water levels below 6 to 10 m Villages** • 122 ARS (CD: 49 and PT: 73) • Cost Rs ~16.79 Crores Calculated by considering for Recharge • ~1.022 MCM percolation tanks and ~ 1.715 MCM per check dam **Water Conservation measures (WCM) Farm Ponds** • The size of form ponds can be 10 x 10 x 3 m. Total 5260 farm ponds are recommended (20 in each village in 263 villages) with total cost of **13.15** crores this can create an additional storage of 1.57 MCM. **Demand side measure** **Ongoing work:** In the area till date a total ~2864 ha area is brought under micro-irrigation (Sprinklers and drip) saving ~4.29 MCM of groundwater. **Other Recommendations** • ~11136 ha of additional land that can be brought under micro-

			irrigation (14 mandals) **Cost: 66.81** crores. With this ~16.70 MCM of ground water can be conserved over the traditional irrigation practices. • Declaration of MSP in advance (before start of season) and improved facilities at procurement centres. • As a mandatory measure, every groundwater user should recharge rainwater through artificial recharge structures in proportionate to the extraction • Roof top rainwater harvesting structures should be made mandatory to all Government/industrial buildings (new and existing). • Capacity building in power supply regulation (4 hour each in morning and evening) will increase the sustainability of wells • A participatory groundwater management (PGWM) approach in sharing of groundwater and monitoring resources on a constant basis along with effective implementation of the existing 'Water, Land and Trees Act' of 2002 (WALTA-2002). • Laser levelling of irrigated land. • Subsidy/incentives on cost involved in sharing of groundwater may be given to the concerned farmers. • In urban and rural areas the sewerage line should be constructed to arrest leaching of nitrate.
31	Expected Results and Out come	:	With the above interventions costing Rs **88.76** crores (**excluding the cost involved in Mission Kakatiya and Mission Bhagiratha**), the likely benefit would be net saving of 5.25 MCM of groundwater. This will bring down the stage of groundwater exploration by 0.5 % (from 50.80 % to 50.30 %).

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
Ha.m	:	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

EXECUTIVE SUMMARY

The hard & soft rocks of Peddapalli district covering 2184 Km^2 area (64 % hard & 36% soft of total district), receives an average annual normal rainfall of 1055 mm of which 80 % is contributed by SW monsoon and 20 % by north-east monsoon. During the year 2020, the district received 1354 mm (28% excess) rainfalls than normal annual rainfall. Administratively, the area is governed by 14 revenue mandals with 215 villages. The population of the district is ~ 7.95 lakhs (2011 census) with average density of 360 persons/km^2.

Area is underlain by, granitic gneisses (70%), Sandstone/Shale (20%) and Quartzite (3%). Pediplains are major geomorphic features (50% of area) followed by pediment (22%), denudation hills (15 %), flood plain (8%) and channel fill and residual hills (5 %). Most of the area is drained by river Godavari and its tributary Manner which were divided into 19 nos of watersheds. The gross cropped area (2019-20) during khariff season is 1,19,763 ha and during rabi season is 36,930 ha (Total 1,56,693 ha). Main crops grown are paddy 43,064 ha (36%) of net sown area and 35,741 ha (49%) during khariff and rabi season respectively. Cereals & Millets are also grown in 43,154 ha (36%) during Khariff and 36,059 ha (49%) during rabi, Cotton is grown in 30,009 ha (25%) during khariff season and Pulses are grown in 469 ha (1%) during rabi season. The other crops are spices and oil seeds.

The registered ayacut under Sri Ram Sagar major irrigation projects is 166397 ha and under medium irrigation project is 9613 ha. In the area there are 405 minor irrigation tanks. During the year 2020-2021 ground water contributes 48 % of irrigation and surface water 1 %. In the area there are ~53 PT and 75 CD and ~from 501 MI tanks ~0.25 MCM of silt is removed under Mission Kakatiya.

Exploratory results of CGWB (23 wells) suggest that 11 wells are drilled down 200 to 300m, 4 nos drilled in between 60-100m, 08 nos (20-40 m). Ground water yield varies from <0.1 to 3 lps in granite/gneisses. Majority of fractures occur within 100 m depth and deepest fracture is encountered >100 m depth.

Water levels are monitored through 31 wells during pre and post-monsoon season of 2021. The DTW varies during pre-monsoon from 2.65 to 20.79 meter below ground level (m bgl) (average: 9.19 m bgl) and during Post-monsoon varies from 1.04-17.49 m bgl (average: 5.9) seasons of 2021 respectively. During pre-monsoon season Major portion of

the water levels during this season are in the range of 2-10 m covering 71% of the area, followed by 10-20 m.bgl (25%). Deep water levels in the range of <25 mbgl occupy about < 3% of the area falling in parts of Manthani mandal (Fig.2.4a). Shallow water levels (<5mbgl) occupy about < 10% of the area in Ramagudam & Manthani mandals and 2 to 5 mbgl occupy about 61% of the area with isolated parts in West-North and Southern parts of the area. During post-monsoon season water levels 2-10m covering 87% of the area, followed by 10-20 m.bgl (10%). No deeper water levels in the range of 20-40 m.bgl (Fig.2.5a). Shallow water levels (< 2 mbgl) occupy about 3% of the area in Ramagundam mandal and 2 to 5 m.bgl occupy about 48% of the area in Western and North-Western parts of the area.

Geophysical data in 30 locations, including borehole logging and VES by CGWB indicates from top soil upto 3 m with resistivity of 10 to 50 ohm m, weathered zone from 4 m to 18 m with resistivity of 30 to 80 ohm m. The fractured rock existed upto 22 m with a resistivity of 150 ohm m. The typical sequence of Pakhal formations showed clay (6 ohm m) shale (42 ohm m) quartzite (324 ohm m), shaly dolomite (40 ohm m) dolomite (180 ohm m) Sullavai sandstone with several intercalations of quartzite and sandstone proportions.The sandstones have resistivity of 120 to 150 ohm m in Sri Rampur and Manthani areas.

Total 227 data is utilized from ground water monitoring wells of CGWB and SGWD wells (Pre-monsoon:113 and post-monsoon:114) were analysed for knowing the suitability of ground water for drinking purposes. In 72 % and 75 % of area EC is in the range of < 1500 µ Siemens/cm during pre and post-monsoon season respectively. During pre-monsoon season, concentration of NO_3 ranges from BDL 1.8to 350 mg/l and found that in 46 % samples nitrate is beyond maximum permissible limit of BIS (45 mg/l) and F concentration varies from 0.15 to 3.15 mg/l and 6 % is beyond maximum permissible limits of BIS (1.5 mg/l). During post-monsoon season, concentration of NO_3 ranges from BDL 1 to 279 mg/l and 26 % is beyond maximum permissible limit of BIS (45 mg/l). The F concentration varies from 0.09-4.51 mg/l and 8% is beyond maximum permissible limit of BIS.

Based on 68 hydrogeological data points, aquifers from the area can be conceptualized in to two nos namely, 1) weathered zone (~30 m) and 2) fractured zone (30- 167 m). Weathered zone ~ 20 m during pre-monsoon season. Weathered zone in the range of 6-20 m, and deep weathering (> 20 m) occurs in 3 % of area. Ground water yield of unconfined aquifer varies

from <1 to 2 lps (avg: 1 lps) with transmissivity of 25 to 50 m2/day. Ground water yield of weathered granite/gneiss aquifer varies from <0.1 to 2 lps (avg: 1 lps), The transmissivity of these aquifers vary from 28 m2/day to 668 m2/day with storativity ranging from 5x10-4 to 2.5x10-4. The Aquifer with 160m thickness encountered at Ramagundam and Manthani. The yields of exploratory wells drilled in Kamthi formation range from 700 lpm to 1200 lpm with transmissivity of 290 m2/day to 668 m2/day, where as the yields of Kota and Maleri sandstone range from 300 lpm to 350 lpm with transmissivity of 28 m2/day to 50 m2/day. The yields of exploratory wells drilled in Alluvial formation range up to 1250

The hydrogeology of Ramagundam Coal mine (637.94 sq.km) within 10 km radius as buffer zone around has been studied by SCCL. In buffer zone of 10 sqkm radius, there are 11 coal mines in operation, the water presently being pumped and its utility are given in table below. The total groundwater extracted from all the mines is 46,312 m^3/ day (16.9 MCM/yr), out of which ground water used for mine requirement is 14234 m^3/ day (5.2 MCM/yr), Domestic use is 4915 m^3/ day (1.8 MCM/yr), Plantation is 1519 m^3/ day (0.55 MCM/yr), and excess water let out into streams and water bodies is 25644 m^3/ day (9.3 MCM/yr). The phreatic water levels varies from 1.97m.bgl to 10.80m.bgl during pre-monsoon season and 0.95m.bgl to 8.10m.bgl during post-monsoon season. The water level fluctuation varies from 0.03 to 6.68m with an average water level fluctuation of 3.21m.The piezometric heads vary from 2.76 m.bgl to 26.15 m.bgl during pre-monsoon and 1.48m to 26.40m.bgl during post monsoon. The total groundwater draft in the buffer zone is about 15071.97 Ha.M/Year. Of this, draft from existing mines is about 1690.39 Ha.M/Year, while ground water used for irrigation is about 13017.59 (86% of total draft) Ha.M/Year.

As per GEC 2022, Net dynamic replenishable ground water availability is 721.98 MCM, gross ground water draft is 650.98MCM, provision for drinking and industrial use for the year 2025 is 181.59 MCM and net available balance for future irrigation use is 454.35 MCM. The stage of ground water development varies from 4% and 44 % (avg: 28 %).

Major issues identified are ground water pollution 4.51 mg/L (8%) and >45 mg/l (52%) (both anthropogenic (NO_3) and geo-genic (F), deep water levels are > 15 m bgl in 10 % of the area during pre-monsoon season and declining water levels in majority of hydrograph stations and sustainability in the area. Other issues identified are water marketing, change in cropping pattern from agricultural to residential colonies etc.

The management strategies mainly include both supply side and demand side. The supply side measure includes ongoing work under Mission Kakatiya where ~0.25 MCM of silt has been removed from existing 501 tanks. This will contribute ~0.20 MCM of ground water by recharge. There is immediate need to take remaining 60 % of tanks under Mission Kakatiya. Under Mission Bhagiratha, there is plan to import surface water ~40.49 MCM for drinking water purposes which will save the present ~24.29 MCM and creating additional ~4048.33 ha of land can be brought under ID crops.

Construction of 122 ARS with ~16.79 crores in **priority** area of 14 mandals having storage potential and are recommended as supply side measures. Under Water conservation measures include, construction of 5260 nos of farm ponds with 13.15 crores in all 20 in each 263 villages.

Demand side measure includes bringing ~11,136 ha of additional land that can be brought under micro-irrigation (@1000 ha /mandal proposed in all 14 mandals costing about 66.81 crores (considering 1 unit/ha @0.6 lakh/ha). With this 16.70 MCM of ground water can be conserved over the traditional irrigation practices.

Other measure includes providing good quality seeds, improved procurement facilities, mandatory artificial recharge at every Govt and industrial units. Capacity building in power supply regulation, application of laser levelling technology in irrigated land, providing proper sewerage system and participatory groundwater management (PGWM) are the other measures recommended.

With the above interventions costing Rs **88.76 Crores** (excluding the cost involved in Mission Kakatiya and Mission Bhagiratha), the likely benefit would be net saving of 5.25 MCM of groundwater. This will bring down the stage of groundwater exploration by 0.5 % (from 50.80 % to 50.30 %). The other benefits will be more distribution of income among farmers.

1. INTRODUCTION

Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic 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 rocks have become water stressed due to rapid growth in demand for water due to population growth, irrigation, urbanization and changing life style. Therefore, in order to have an accurate and comprehensive micro-level picture of 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.

The occurrence and movement of ground water in sedimentary rocks is controlled by the granular zones and their interconnectivity whereas in granites/hard rocks controlled by the degree of interconnection of secondary pores/voids developed by fracturing and weathering. Weathered zone is the potential recharge zone for deeper aquifers and excessive withdrawal from this zone leads to drying up of weathered zone in places and reducing the sustainability of deeper fractures. 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 Objective and Scope

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. The activities under NAQUIM are aimed at:

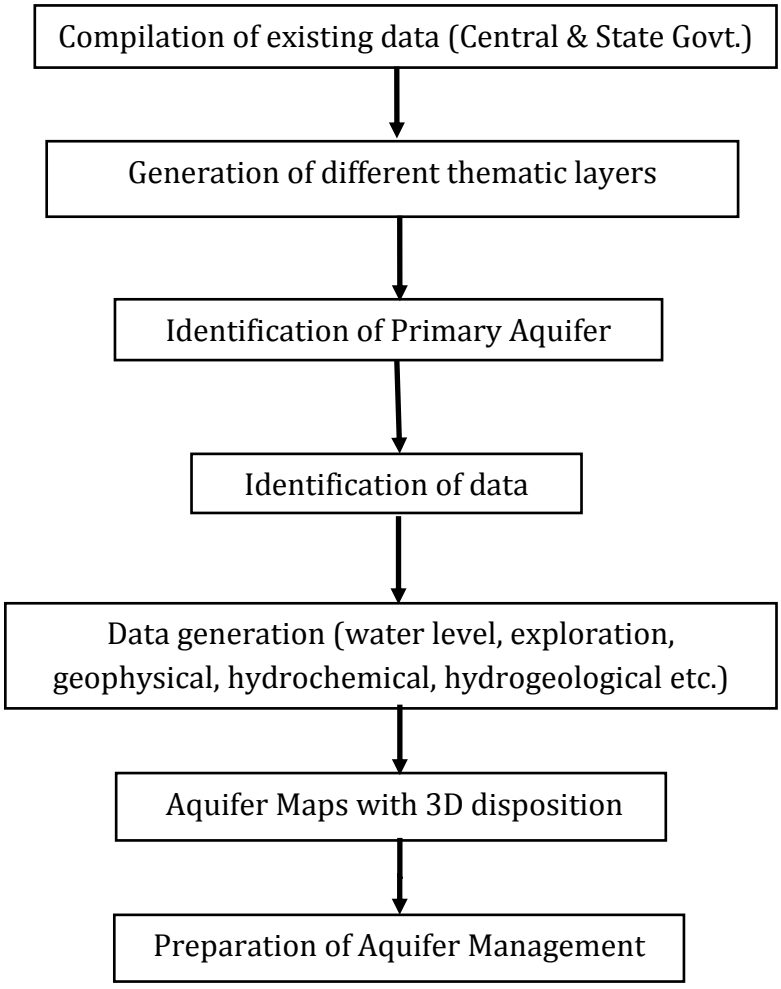
- Identifying the aquifer geometry
- Aquifer characteristics and their yield potential

- ❖ Ground water quality
- ❖ Aquifer wise assessment of ground water resources
- ❖ Preparation of aquifer maps in 3D and 2D
- ❖ Formulate ground water management plan

1.2 Approach and Methodology

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

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



1.3 Area Details: The District having geographical area of 2184 km^2, lies between north latitude 18°20´58"-18°52´51" and east longitude 79°17´26"-80°20´44". It is part of the Godavari River basin (**Fig.1.1**). The study area falls in newly carved two districts Peddapalli and Jayashanker Bhupalpalli. Administratively the area is governed by 14 revenue mandals with 215 villages, with a population of ~7.9 lakhs (2011 census) and average density of population is 360 persons/sq km. The Ramagunda mandal is densely Population among district with ~ 2,42,979.

1.4. Climate and Rainfall: The climate of the district is characterised by hot summer and cool winters with good amount of rainfall. May is the hottest month with daily mean temperatures ranging from 29.4°C to 42.7°C and December is the coldest month with daily mean temperatures ranging from 14.6°C to 29.9°C. Normal annual rainfall is 1055 mm and actual annual rainfall is 1292 with a 20% deviation with average of 1143 mm (**Fig. 1.2**). SW monsoon contributes 80% and 20% is contributed by retreating (NE) monsoon season, winter and summer rainfall. Rainfall increases from Southwest to Northeast. As per the IMD rainfall data, during the year 2020, the study area received average rainfall of 1354 mm (28% excess rainfall than normal rainfall).

1.5 Physiography: Physiographically, the area is represented by few hills in the western and southwestern parts near Ramagundam (420 m). The general surface elevation in the western parts is 223 m.amsl, at central parts it is 129 m and in eastern parts with 140 m.amsl. The raised plateau like structure in the eastern parts is occupied by thick forest cover. The low central part in the area is occupied with open cast coal mining and under ground coalmines.

1.6 Geomorphological Set up: Pediplain is the major landform covering about 1414 km^2 (50%) area. The other landforms observed are pediment (22%), Structural hills (15%), Flood plains (8%), residual hill, channel fill, etc. (5%) (**Fig.1.3**).

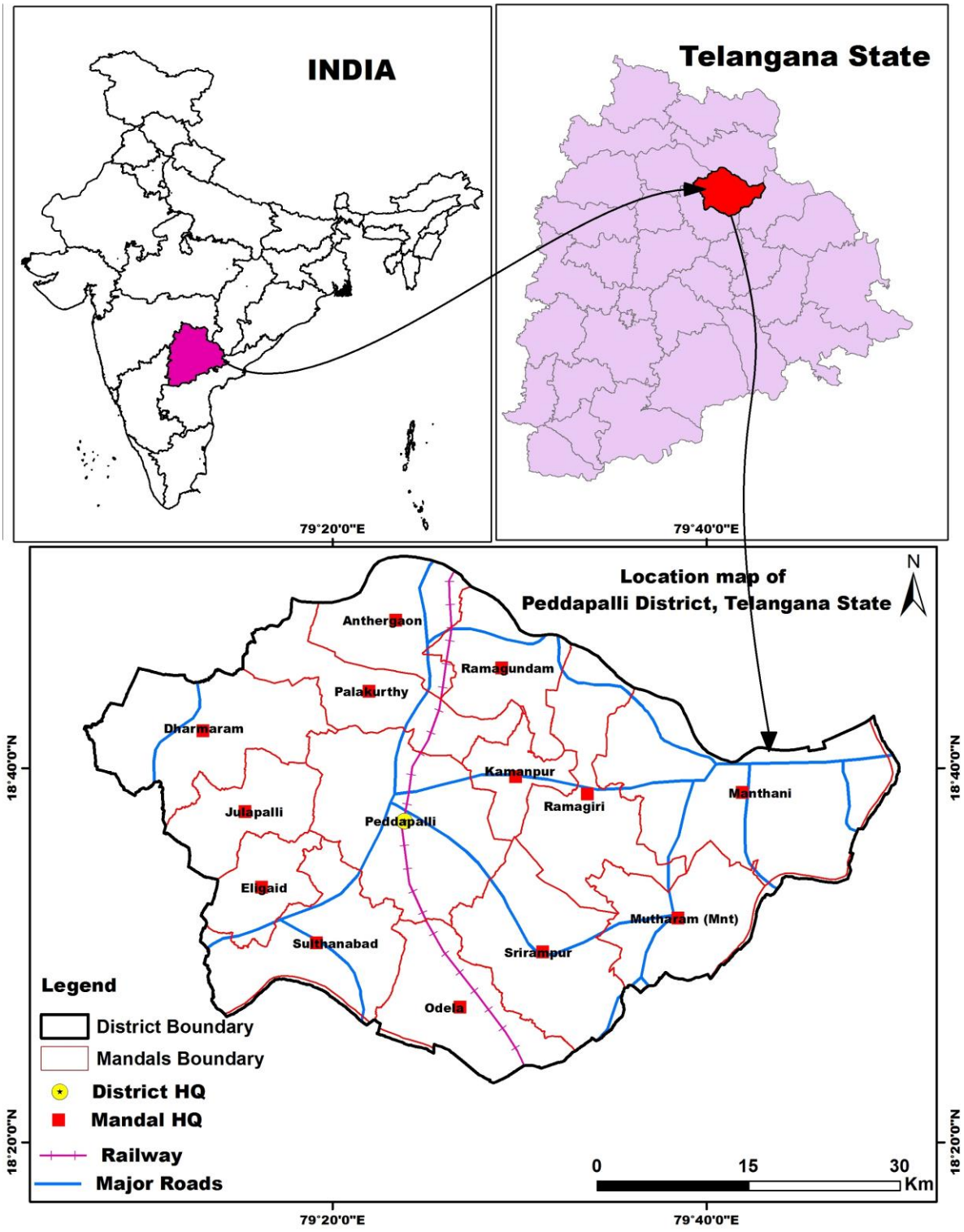


Fig.1.1: Location of Peddapalli District.

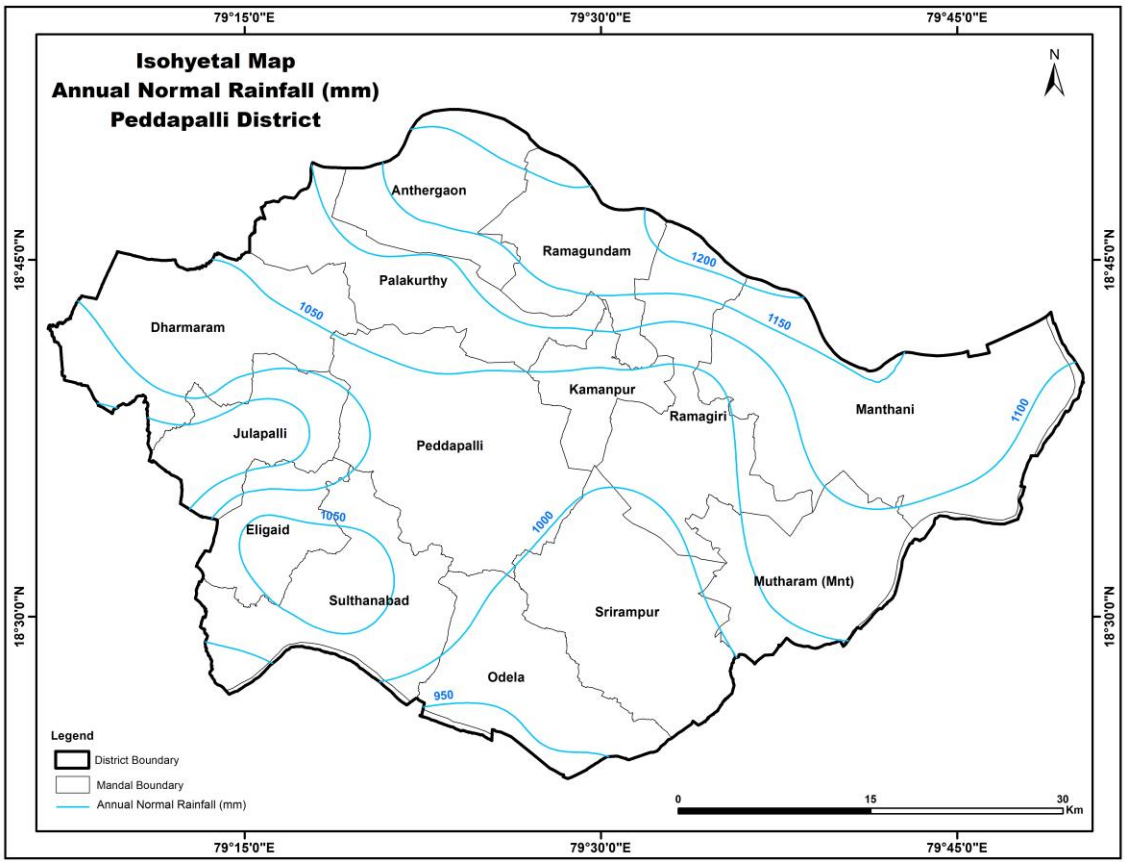


Fig.1.2: Isohyetal map of Peddapalli District.

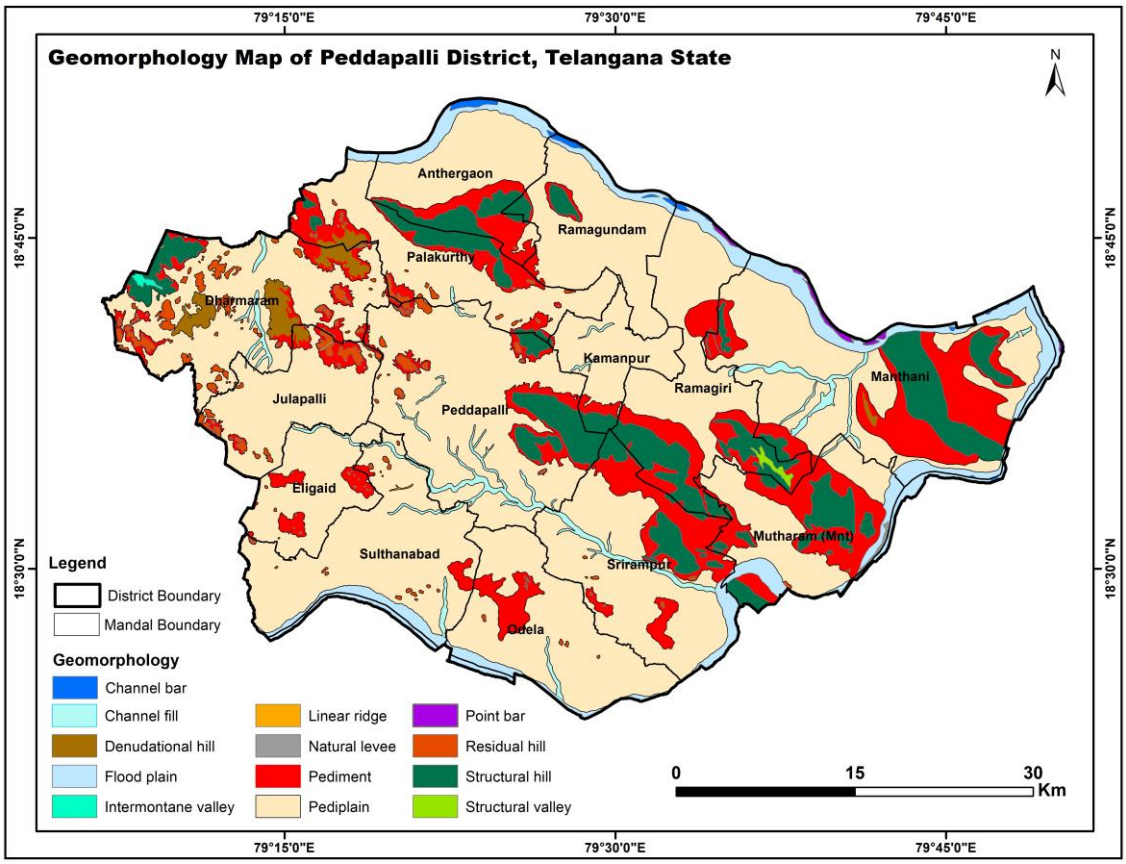


Fig.1.3: Geomorphology of Peddapalli District.

1.7 Drainage and Structures: The streams and smaller river in the area forms part of Pranahita sub-basin of the Godavari river basin. Northern part of the area is bordered by meandering Godavari river, whereas the Maner River a tributary of river Godavari and the flow direction is from south central part to Southeast into Godavari river. The Ramgiri hills and Kammampally reserve forest hills act as divide for streams originating from them to flow in to Godavari and Maner rivers. Bokkala vagu is other recognizable stream flowing in the central part through Manthani town ultimately joining Godavari River in downstream. The Maner river is a perennial except at times when draught-like conditions prevail then the river dries-up in summer months. The drainage pattern in the study area is sub-dendritic to dentritic and controlled by weathered formation and at places sub-parallel drainage is developed due to structural and jointing features.This sub-basin is further sub-divided into 19 watersheds in the district. Most of lineaments are trends along SW-NE, NW-SE and N-S directions. Map depicting drainage, water bodies is presented in **Fig.1.4**.

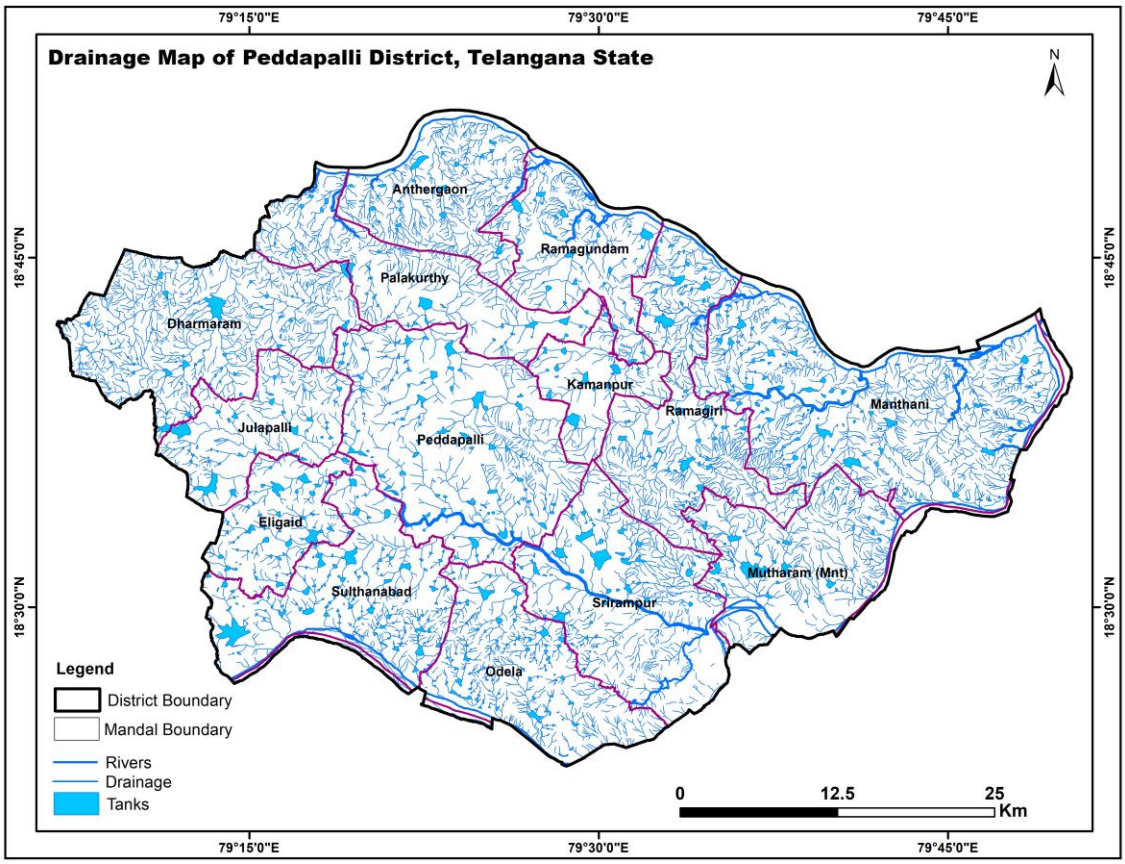


Fig.1.4: Drainage pattern of Peddapalli District.

1.8 Land use and cropping pattern:

In the area, the land use can be grouped into 06 main classes (**Fig.1.5**). Forest occupies ~42% of the total geographical area, waste lands 9%, agricultural land 43%, river sandy area is 3%, Water channel area 2%. The gross cropped area (2019-20) during khariff season is 1,19,763 ha and during rabi season is 36,930 ha (Total 1,56,693 ha). Main crops grown are paddy 43,064 ha (36%) of net sown area and 35,741 ha (49%) during khariff and rabi season respectively. Cereals & Millets are also grown in 43,154 ha (36%) during Khariff and 36,059 ha (49%) during rabi, Cotton is grown in 30,009 ha (25%) during khariff season and Pulses are grown in 469 ha (1%) during rabi season. The other crops are spices and oil seeds (Fig:1.6).

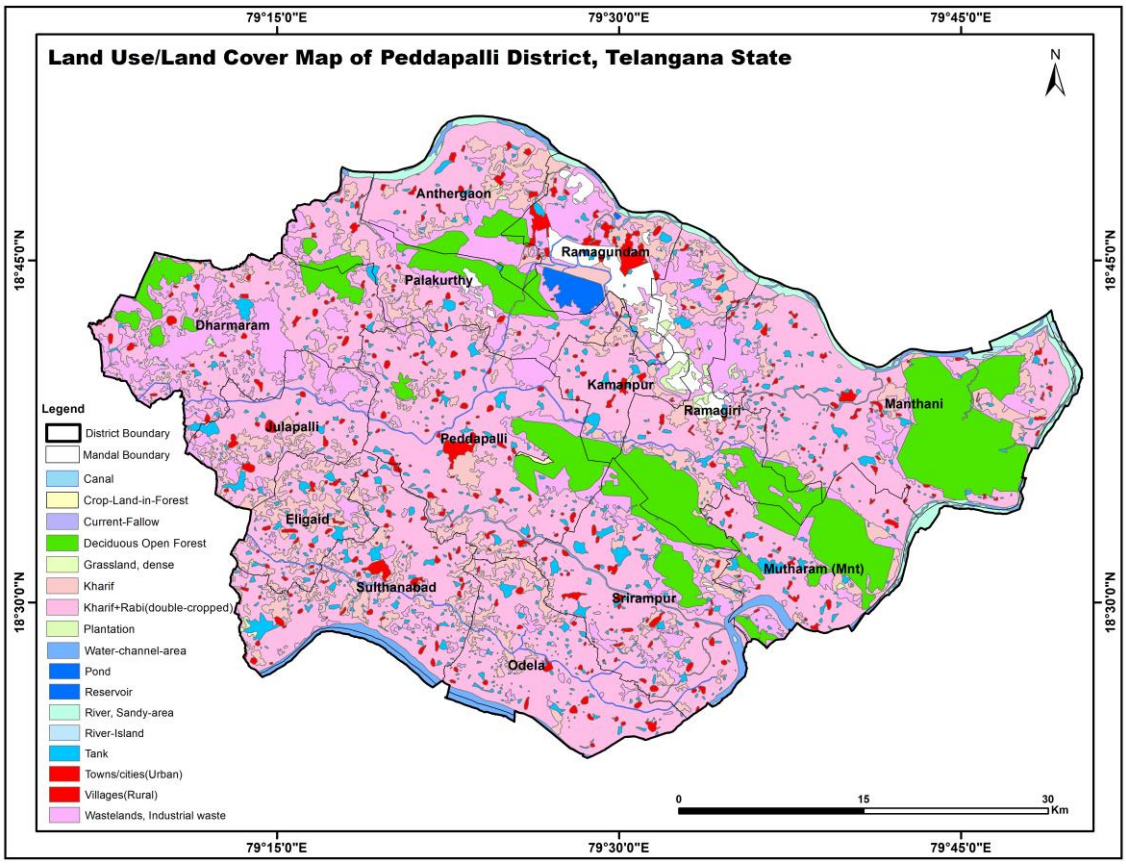


Fig.1.5: Land use and Cropping pattern of Peddapalli District

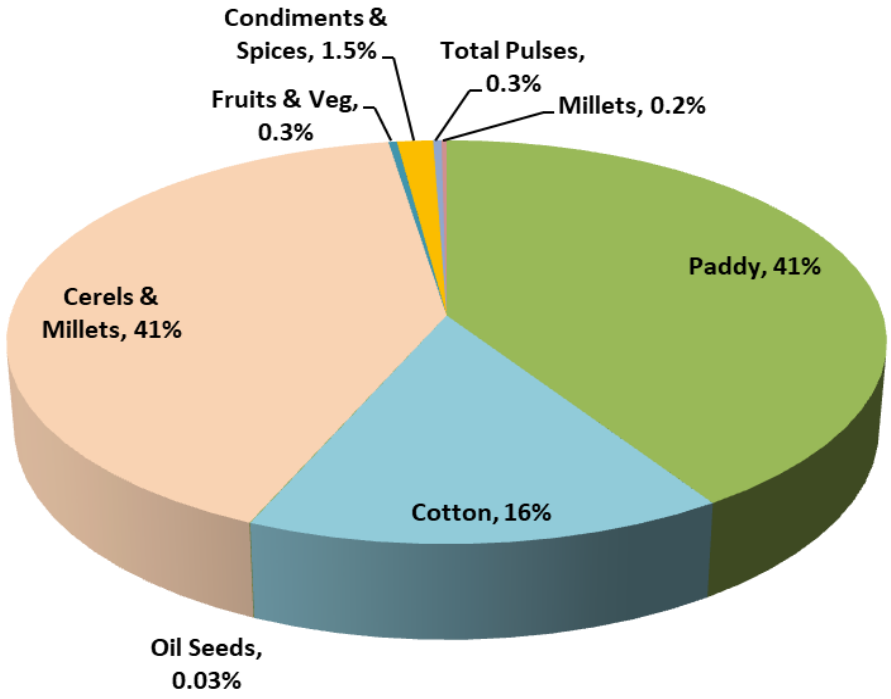


Fig.1.6: Cropping pattern of Peddapalli District

1.9 Soils: The area is mainly occupied by red earths and black soils. The red earths include sandy loams and sandy clay loams. The red earthy soils occur in southwestern parts where as sandy clayey loams occur in kamanpur, Manthani, Mutharam mandals located in the central part. Sandy loams occur in Tadicherla and Mutharam mandals. Black soils occupy parts of Manthani, Mahadevpur and Mahamutharam mandals. Loamy soils occupy 58% area, Rocky lands with clay occupy 11% area, Fine mixed soils occupy 30% of area. (**Fig.1.7**).

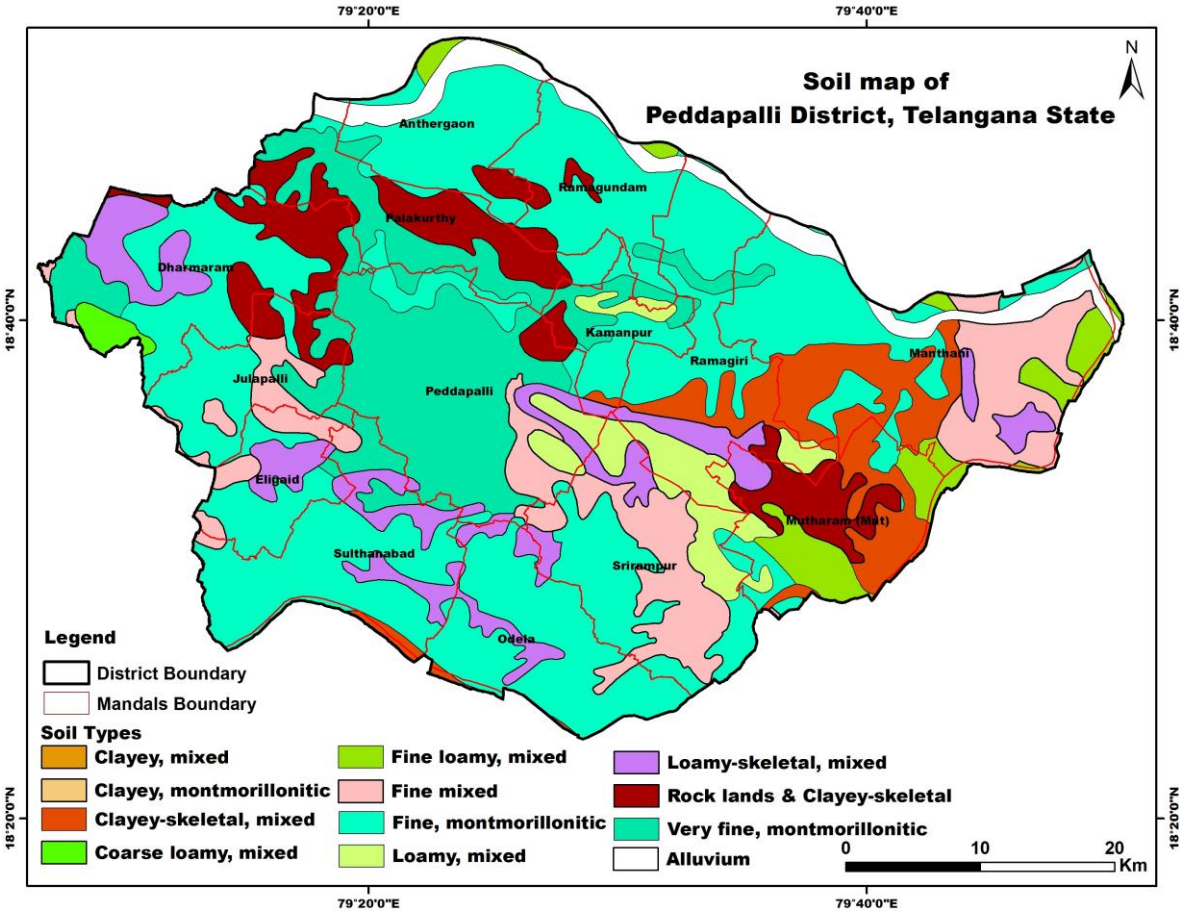


Fig.1.7: Soil map of Peddapalli District

1.10 Irrigation:

The area receives the canal water from Sri Ram Sagar Project (SRSP) through Kakathiya Canal and its distributaries. The Sri Ram Sagar Project is built across Godavari River. The D-83 distributary is the biggest distributary feeder canal of the project with a length of 82 km with discharge capacity of 57 cu Mecs, serving mandals of Ramagundam, Peddapally, Kamanpur, Manthani and Manthani Mutharam. The localized extent of area under D-83 feeder canal is 49,797 ha out of which 30,904 ha is for wet crops and 18,893 ha is for irrigated dry crops. The index map of Sri Ram Sagar Project canal system is given in

Fig-1.8. The details of discharges, bed width and full supply depth of the two distributaries is presented in Table-1.1

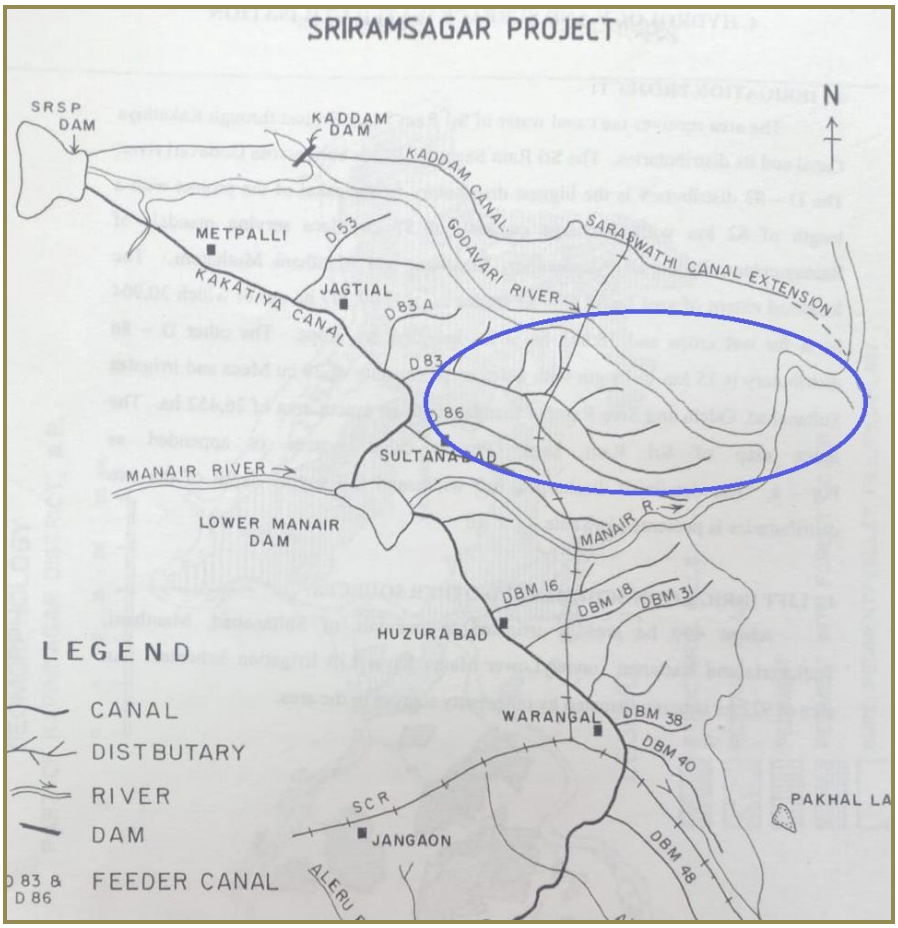


Fig-1.8 : Sri Ram Sagar Project canal system

Table-1.1 : Details of Distributary (D-83) of SRSP canal

Distributory	From Km to Km	Type of canal	Discharge (Cu mecs)	Bed width (BW)	Full Supply Depth
D-83	0.0 to 6.639	Lined	49.3583	6.09	3.11
			43.9236	5.49	3.04
	6.639 to 16.864	Lined	39.8084	16.15	2.37
	16.86 to 20.93	Lined	35.2105	15.54	2.215
	20.93 to 35.00	Lined	0	0	0
	35.00 to 43.20	Unlined	26.3028	10.62	2.155
RSB from Gundaram Tank	0.00 to 39.00	Unlined	11.9802	7.294	1.285
			5.8467	5.33	1.14
			3.7349	4.57	0.92

1.11 Prevailing Water Conservation/Recharge Practices: In the study area there are ~53 percolation tanks, 75 Check dams and 195 farm ponds. Under Mission Kakatiya (Phase-1 to

Phase-4) 405 tanks were desilted and renovated under RRR (Repairs, restoration and Rejuvenation) schemes.

1.12 Geology:

A part of the district is underlain by Gondwana formation. Recent to Archaean age formations can be seen in the area. The 70% of district is covered by granites of Archaean age and mostly occupied in the Western and Northern part of the district which is represented by pink and grey in colour and later intruded by younger formation dykes of dolerite rocks.

Pakhal Group of sediments, equivalent of upper Cuddapah rocks in age is represented by dolemitic limestones and conglomerates. These rocks occur in NW and west central parts of study area. The general strike of these rocks is NW-SE to NNW-SSE with dips of 5^0 to 20^0 to NE.

Sullavai formations belonging to Kurnool group of rocks are well represented in Eastern and NE part of the district, represented by sandstones and shales forming hills in the Ramagundam. These rocks are brown to brick red in colour, quartzite to felspathic with general strike direction of NW-SE to WNW-ESE diping 10^0 to 30^0 towards NE.

Gondwana formations overlie the Pakhal group of rocks in the area. These rocks are divisible in to two groups. The Talchir, Brakar, Barren measures and Kamthi constitute Lower Gondwana whereas Maleri, Kota and Chikiala formations comprise the Upper Gondwanas Group. The lower group is well represented by Barakar sandstones, which are grayish white, fine to coarse at times to gritty feldspathic. These are intercalates with grey clays and coal seams. The workable coal seams are located in Ramagundam, Godavari Khani and Kamanpur areas. The maximum thickness of these rocks is about 350 m as determined by boreholes data. The barren measures are represented by very coarse to coarse grained feldspathic sandstones with grey clays and carbonaceous clays without any coal deposits, these rocks are present below the Kamthi formations. The Kamthis are mainly ferrugineous sandstones and intermingled with clay zones, they are medium fine grained with cross bedding at places and form massive cliffs and escarpment of hills (east of Manthani). These rocks are covered by thick vegetations and often form raised mounds as in Maha Mutharam and Manthani areas. The thickness of these formations is stated to be about 300 metres.

Maleri formations form narrow bands between Kamthi and Kota formations and comprise of coarse to gritty, pale grey to reddish sandstones occurring in Maha Mutharam area. Kota

formations overlie Maleri formations. Their contact with Kamthis is structural and occurs as low relief areas comprising shales and clays intercalated with fine to medium grained sandstones. These are exposed in Maha Mutharam mandal. Chikialas form youngest formations of Gondwanas comprising light brown red buff coloured ferruginous sandstones and conglomerates intercalated with clays and shale beds. These rocks occur as narrow bands in eastern part of the area.

Gondwana formations represented by Barakar and Kamthi sandstones of Lower Gondwana age and Maleri and Kota formations of Upper Gondwana age are well represented in Kamanpur, Manthani and Ramagundam mandals.

Alluvial deposits of Recent age consist of sands and clays occur along banks of the Maner and the Godavari rivers in the district. The sand is fine to medium grained mixure of gravel, sand and silt. The general geological succession of the area is presented as ***Table-1.2.*** The Geology (Principal Aquifer) and Stratigraphy map of the district area is given in ***Fig- 1.9***.

Table-1.2: General Geological Succession

ERA/Age	Group/System	Series	Lithology
Lower Cretaceous to Upper Triassic	Upper Gondwana	Kota	Sandstones, clays and limestones
		Maleri	Red clays and calcareous sandstones
Lower Triassic to Upper Carboneferous	Lower Gondwana	Kamthi	Ferroginous sandstones, grits, clays and shales
		Barren Measures	Feldspathic sandstones, shales, carbonaceous clay
		Barakars	Feldspathic sandstones, siltstones and coal seams
		Talchirs	Boulder bed and fine grained sandstone
Unconformity			
Lower Palaeozoic to Upper Pre-Cambrian	Vindhyan	Sullavai	Orkosic quartzites and sandstones
Upper Pre-Cambrian	Pakhals	-	Shale, dolomite, basal conglomerates
Unconformity			
Lower Pre-Cambrian	Dharwarian		Schists, banded heamatites and quartzites
	Archaean		Pink and grey granites & gneisses

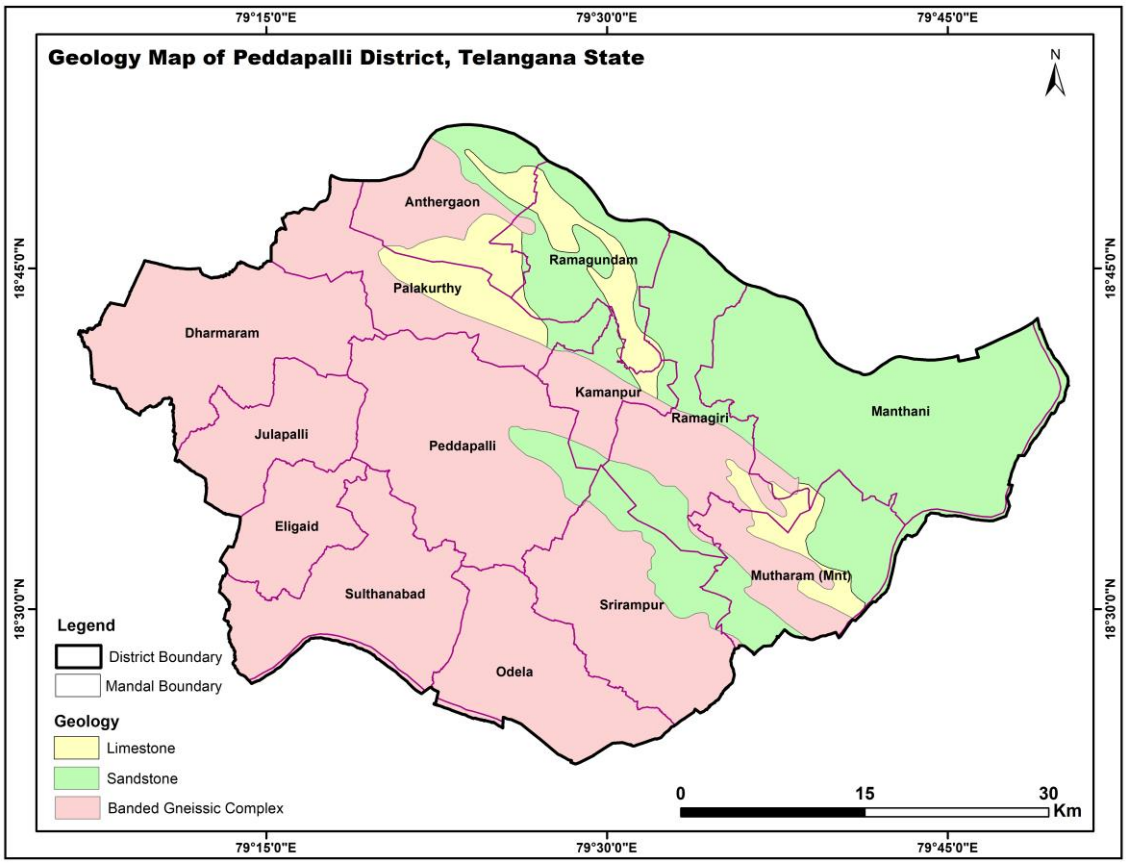


Fig.1.9: Geology of the Peddapalli District

2. Data Collection and Generation

Collection and compilation of data for aquifer mapping studies is carried out in conformity with Expenditure Finance Committee (EFC) document of XII plan of CGWB encompassing various data generation activities **(Table-2.1)**.

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

S. No.	Activity	Sub-activity	Task
1	Compilation of existing data/ Identification of Principal Aquifer Units and Data Gap	Compilation of Existing data on groundwater	Preparation of base map and various thematic layers, compilation of information on Hydrology, Geology, Geophysics, Hydrogeology, Geochemical etc. Creation of data base of Exploration Wells, delineation of Principal aquifers (vertical and lateral) and compilation of Aquifer wise water level and draft data etc.
		Identification of Data Gap	Data gap in thematic layers, sub-surface information and aquifer parameters, information on hydrology, geology, geophysics, hydrogeology, geochemical, in aquifer delineation (vertical and lateral) and gap in aquifer wise water level and draft data etc.
2.	Generation of Data	Generation of geological layers (1:50,000)	Preparation of sub-surface geology, geomorphologic analysis, analysis of land use pattern.
		Surface and sub-surface geo-electrical and gravity data generation	Vertical Electrical Sounding (VES), bore-hole logging, 2-D imaging etc.
		Hydrological Parameters on groundwater recharge	Soil infiltration studies, rainfall data analysis, canal flow and recharge structures.
		Preparation of Hydrogeological map (1:50, 000 scale)	Water level monitoring, exploratory drilling, pumping tests, preparation of sub-surface hydrogeological sections.
		Generation of additional water quality parameters	Analysis of groundwater for general parameters including fluoride.
3.	Aquifer Map Preparation (1:50,000 scale)	Analysis of data and preparation of GIS layers and preparation of aquifer maps	Integration of Hydrogeological, Geophysical, Geological and Hydro-chemical data.
4.	Aquifer Management Plan	Preparation of aquifer management plan	Information on aquifer through training to administrators, NGO's, progressive farmers and stakeholders etc. and putting in public domain.

2.1 Hydrogeological Studies

Hydrogeology is concerned primarily with mode of occurrence, distribution, movement and chemistry of ground water occurring in the subsurface in relation to the geological environment. The occurrence and movement of water in the subsurface is broadly governed by geological frameworks i.e., nature of rock formations including their porosity (primary and secondary) and permeability. The principal aquifers in the area are Sandstone, Granites and Limestone. The occurrence and movement of ground water in sedimentary rocks is controlled by the granular zones and their interconnectivity whereas in granites controlled by the degree of interconnection of secondary pores/voids developed by fracturing and weathering. Based on 31 hydrogeological data points (**Fig.2.1)** hydrogeological map is prepared.

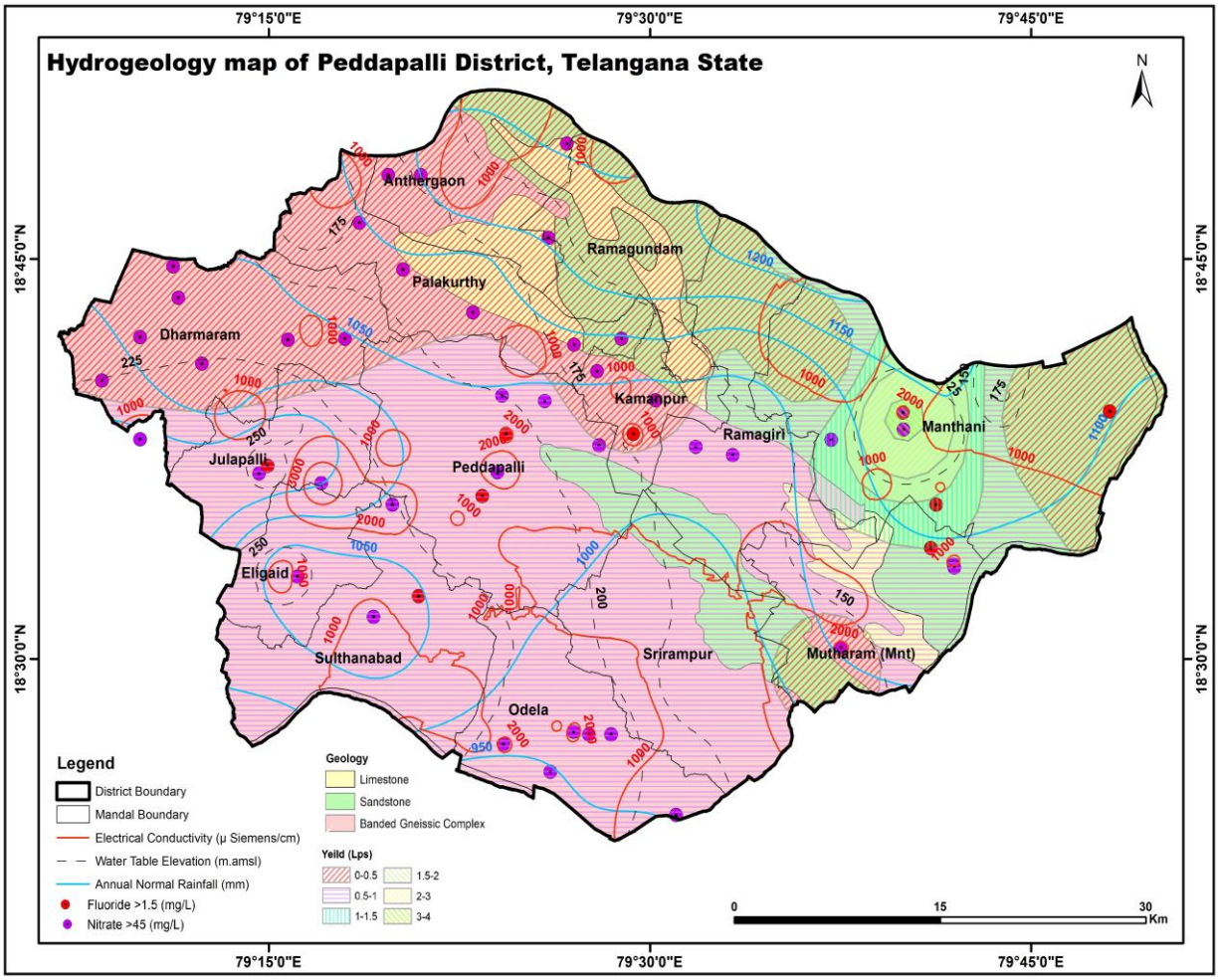


Fig. 2.1: Hydrogeological of the Peddapalli District.

2.1.1 Ground water occurrences and movement: Ground water occurs under unconfined and semi/confined conditions. On the basis of occurrence and movement of water in the subsurface, the aquifers in the district catagories into two types i) Consolidated formations (Igneous and Metamorphic rocks) and ii) Unconsolidated formation (Sedimentary rocks)

i. Consolidated formations: The consolidated aquifers include Granites and Quartzites of Precambrian age where the aquifers constitute the weathered zone at the top, followed by a discrete anisotropic fractured/fissured zone at the bottom, generally extending down to 200m depth.

ii. Unconsolidated formation (Sedimentary rocks): The Unconsolidated formations include the sedimentary formations of Gondwana and recent alluvium deposits. These aquifers constitute the unconfined zone at the top, followed by confined aquifers saperated by clay layers which act as aquitards (confining beds). In the area two confined aqufers are demarcated upto a depth of 300m. The hydrogeological map of the area is presented in **Fig. 2.2**.

2.1.2 Hydrogeology of Coal Mine area: Ramagundam Coal belt comprises of 16 nos of underground coal seams, they occur at 40 to 300m in mine inclines in the geological horizons of Barakar sandstones and Barren measures of lower Gondwana group. The estimated thickness of subsurface geological formations based on coal exploration is given below in table. The aquifer tests conducted at three borewells with depth of 200m. in Barakar sandstone shows ground water discharge of 126 to 560 lpm with a drawdown of 41.8 to 51.4m. The transmissivity varies from 2.19 m^2/day to 32.3m^2/day with a storativity of $1.1x10^{-3}$ to $3.38x10^{-4}$.

Table.2.2: Details of Subsurface Geological formations

Geological Formation	Thickness (m)
Kamthi Sandstones	1600
Barren Measures	500
Barakar Sandstones	275
Talchir formations	200

2.1.3 Exploratory Drilling: As on 31/03/2020, CGWB drilled 23 bore wells (exploratory, observation and piezometers) in the District, out of which 16 wells are drilled in sedimentary formations and 04 wells were were drilled in granitic terrain. Tube well depth analysis of 16 exploratory wells indicates, 06 well are in shallow depth (30 m), 03 wells are in the depth range of 30-100 m, 03 wells are in the depth range of 100-200 m and 04 wells are in the depth range of 200-300 m depth**.** 10 representative exploratory well data of SCCL were also utilized for the conceptualization of the Aquifer system in the area.

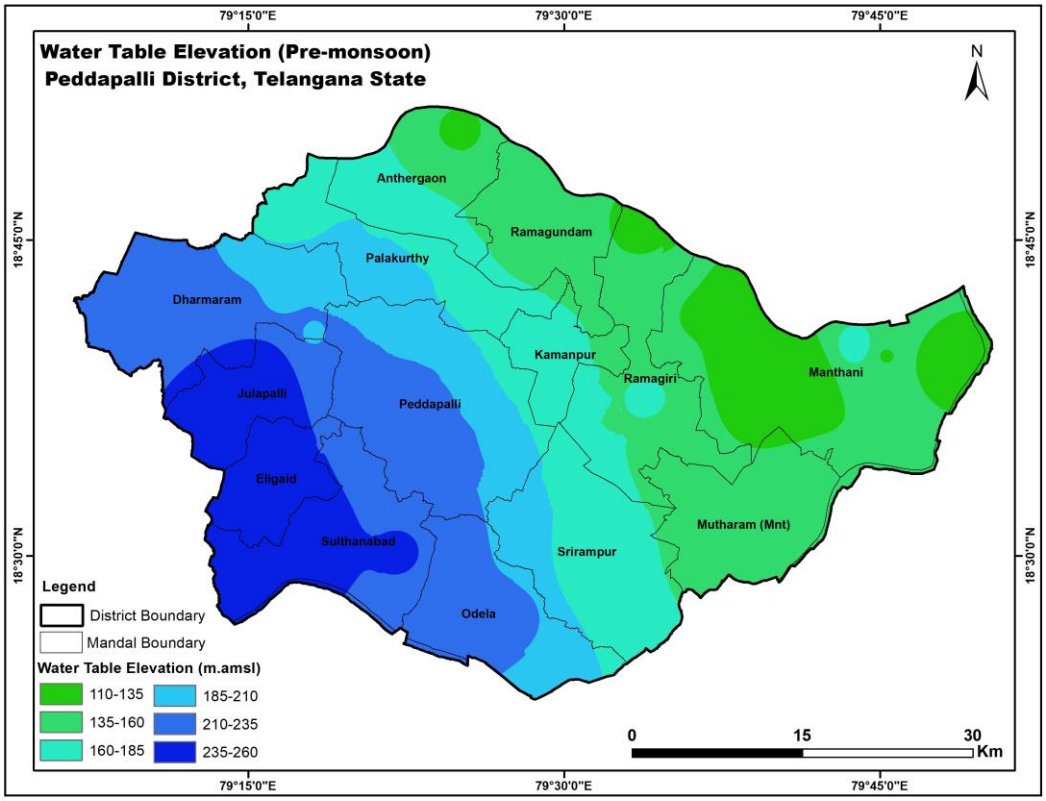
2.1.4 Ground water Yield: Ground water yield in granitic aquifers varies from <1 to 3 lps (avg: 1.5 lps). In soft rocks, the ground water yields vary from 1 to 25 lps. In Barren measures, Quartzites and Sandstone areas yield varies from 1 to 5 lps. In Maleri and Kota formations, Yield varies between 5 and 10 lps where as Kota and Kamthi formations show maximum yields varying between 10 and 25 lps.

Ground Water Levels of Peddapalli District (Soft and Hard Rocks):

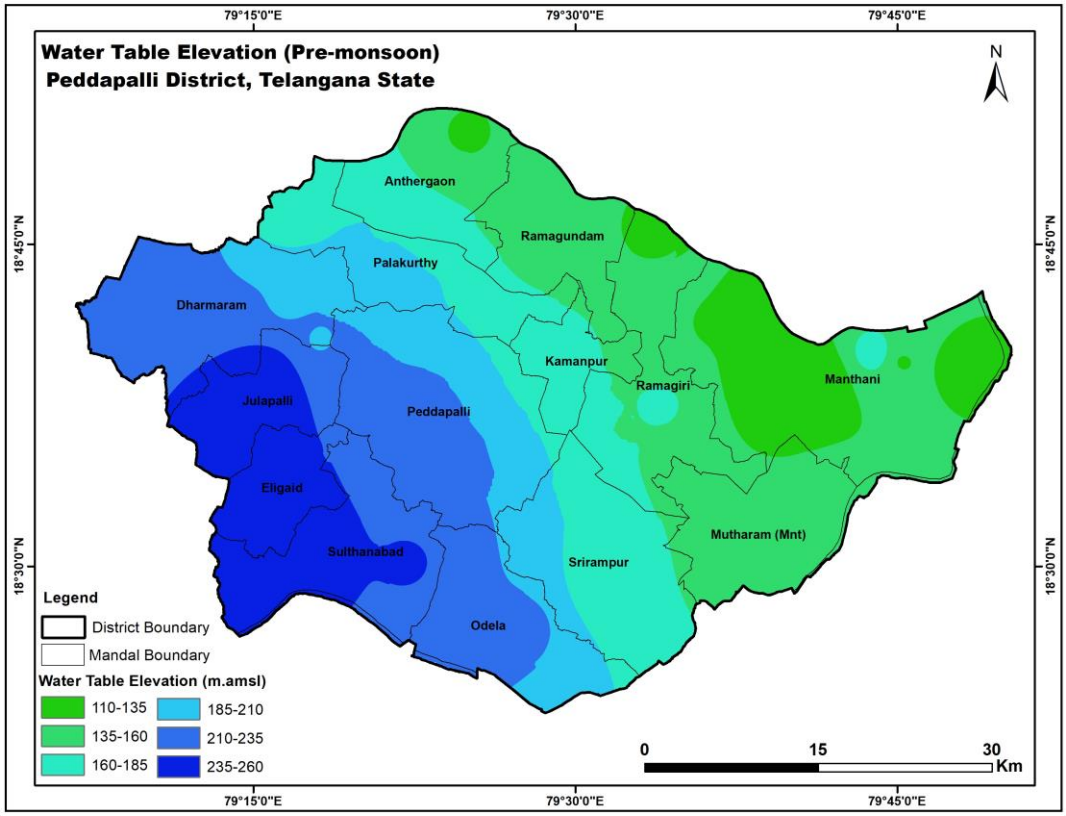
2.2.0 Water Levels (2022): Ground water levels from 31 piezometers (CGWB: 14 and SGWD: 17) were monitored for pre-monsoon and 31 piezometers (CGWB:14 and SGWD: 17) during post-monsoon season.

2.2.1 Water Table Elevations: During pre and post-monsoon season (May and November) of 2022, the water-table elevation ranges from 110-255 and 115-254 meters above mean sea level (m amsl) respectively. Ground water flow is towards Eastern direction from West, South-Western part and North Eastern part and central part in the river Godavari River. The groundwater divides, marked by the divergence of flow lines, almost coincide with the path of topographic divides and evelation.

2.2 a. Water Table Elevation (Pre-Monsoon) map during 2022 (m amsl)



2.2 b. Water Table Elevation (Post-Monsoon) map during 2022 (m amsl)



2.2.2 Depth to Water Levels (DTW): The DTW varies during pre-monsoon from 2.65 to 20.79 meter below ground level (m bgl) (average: 9.19 m bgl) and during Post-monsoon varies from 1.04-17.49 m bgl (average: 5.9) seasons of 2021 respectively.

2.2.3 Pre-monsoon season:

Major portion of the water levels during this season are in the range of 2-10 m covering 71% of the area, followed by 10-20 m.bgl (25%). Deep water levels in the range of <25 mbgl occupy about < 3% of the area falling in parts of Manthani mandal (**Fig.2.3a**). Shallow water levels (<5mbgl) occupy about < 10% of the area in Ramagudam & Manthani mandals and 2 to 5 mbgl occupy about 61% of the area with isolated parts in West-North and Southern parts of the area.

2.2.4 Post-monsoon season:

Major portion of the water levels during this season are in the range of 2-10m covering 87% of the area, followed by 10-20 m.bgl (10%). No deeper water levels in the range of 20-40 m.bgl (**Fig.2.3b**). Shallow water levels (< 2 mbgl) occupy about 3% of the area in Ramagundam mandal and 2 to 5 m.bgl occupy about 48% of the area in Western and North-Western parts of the area .

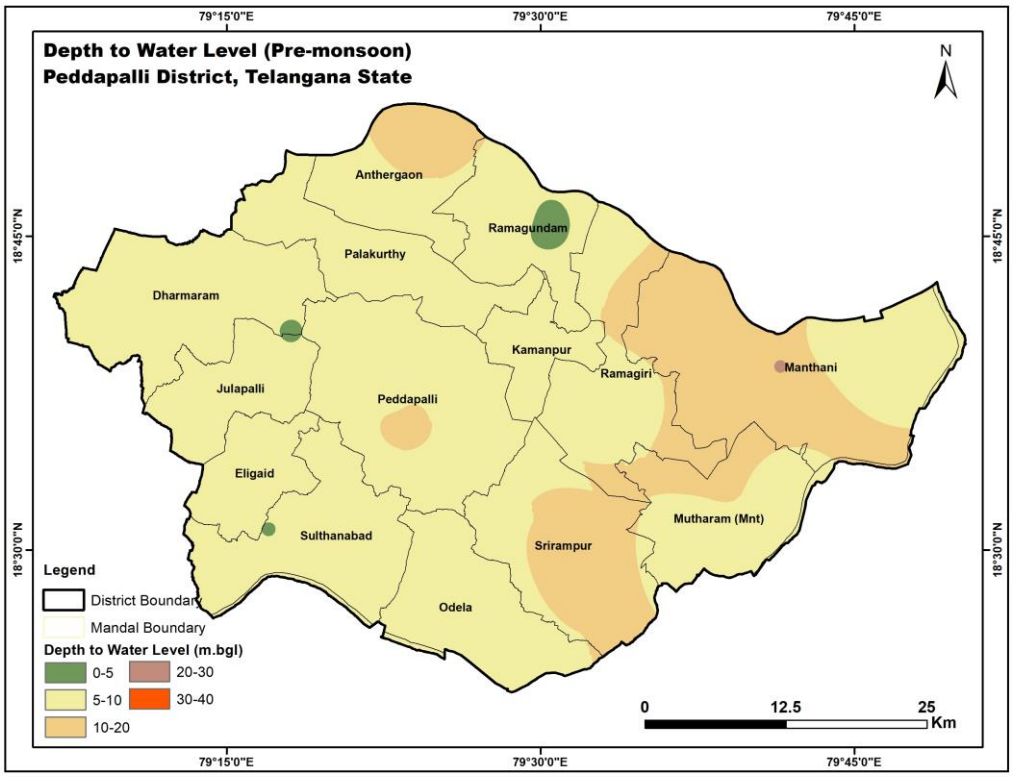


Fig.2.3a: Depth to water levels Pre-Monsoon (10 Yrs Average)

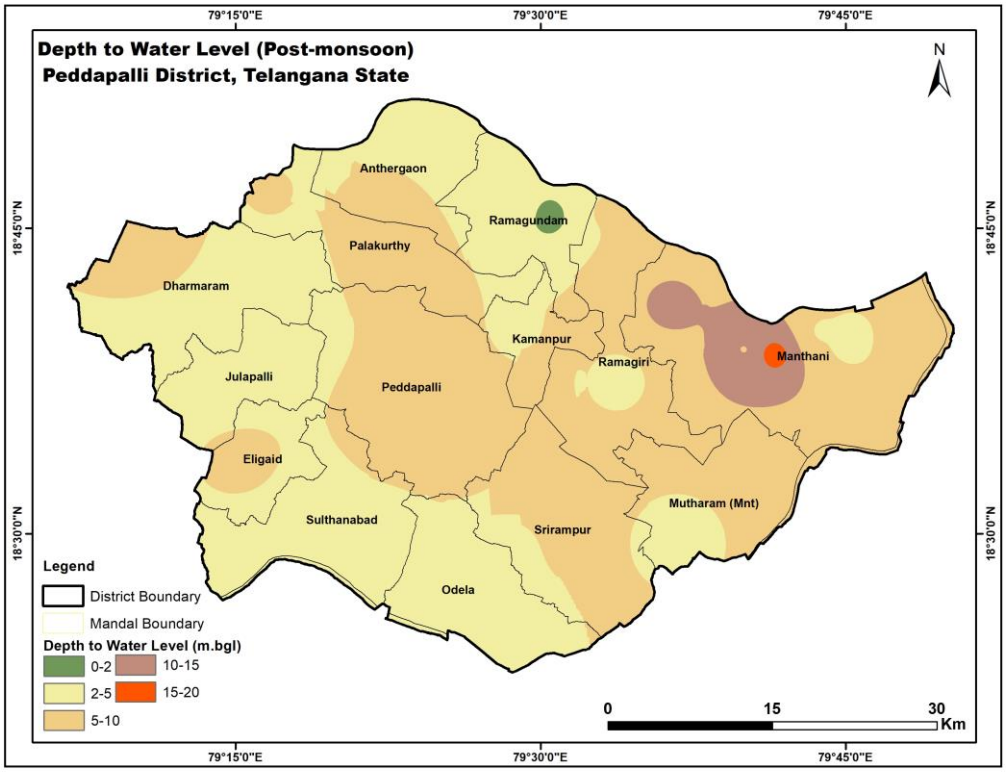
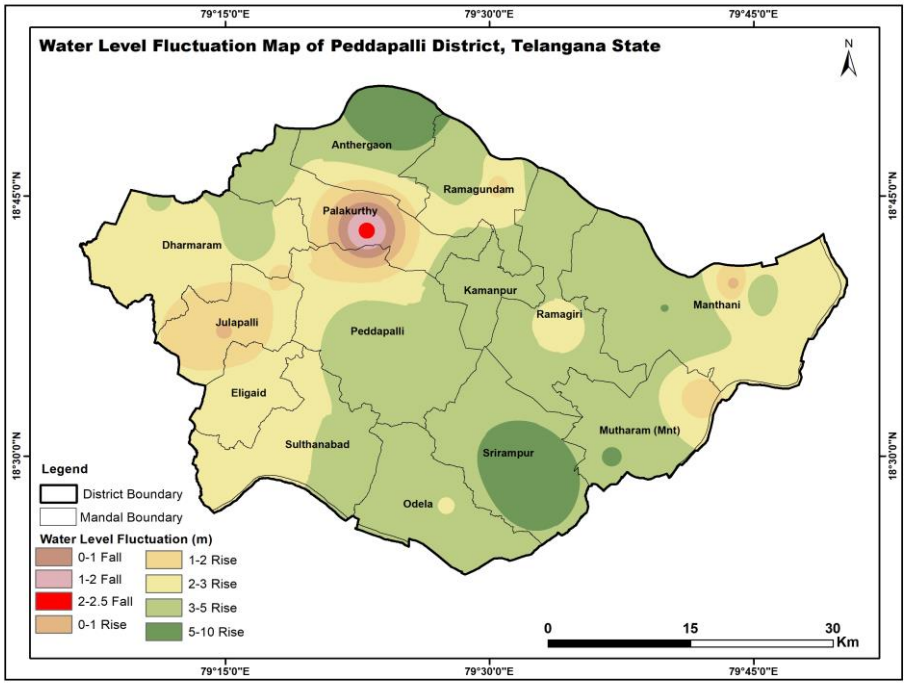


Fig.2.4b: Depth to water levels Post-monsoon (10 Yrs Average)

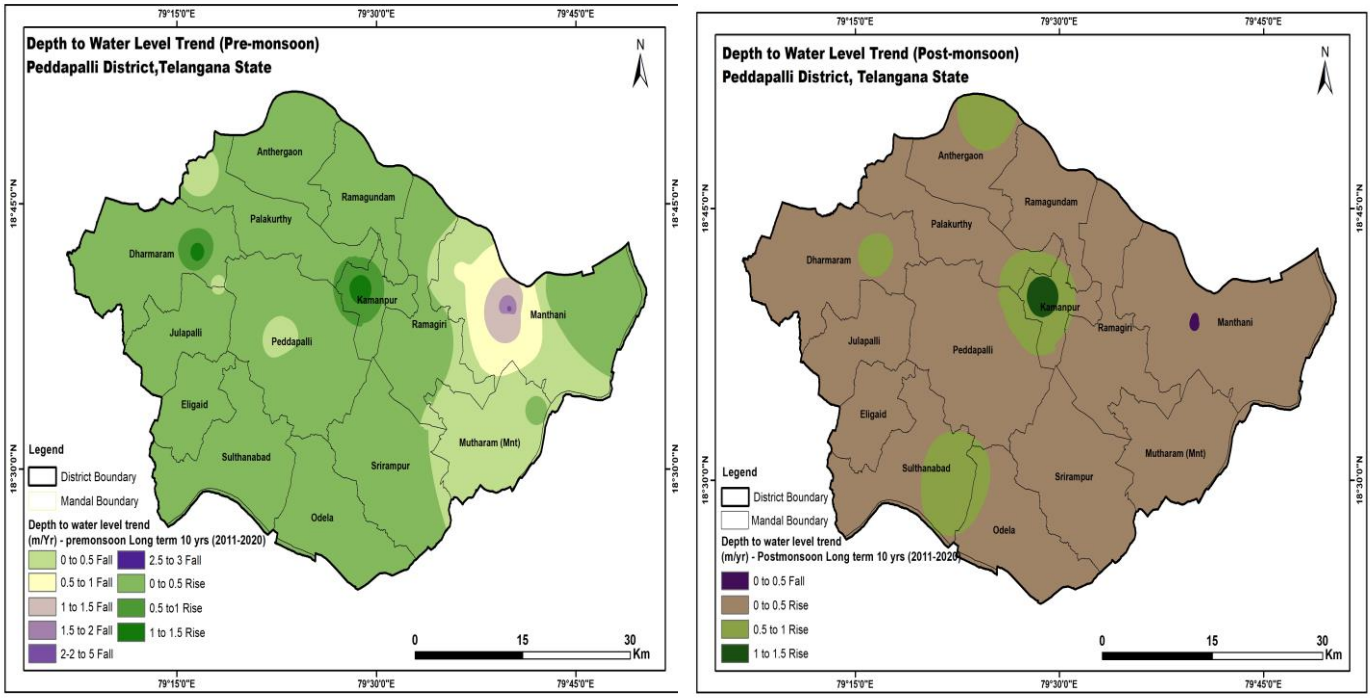
2.2.5 Water Level Fluctuations (May vs November): The water level fluctuations vary from -2.27 to 8.96m with average rise of 3.25m (**Fig.2.4**). One well (3%) registered fall in water levels and 30 wells (97%) show rise in water levels. Rise in water level in the range of 0 to 2m cover major part of area (23%) followed by 2 to 5 m covering 58% of area. Water level fall (4%) in between 0 to 2 m is observed in northern part of area.

Fig. 2.4. Water Level Fluctuations (May vs November)



2.2.6. Long term water level trends: Trend analysis for the last 10 years (2011-2020) is studied from hydrograph stations of CGWB and SGWD. It is observed during pre-monsoon season out of 30 wells, 21 wells (70%) shows falling trend (0.01 to 2.69 m/Yr) and 9 wells (30%) shows rising trend (0.004-1.18 m/yr). During post-monsoon season out of 30 wells, 10 wells (33%) shows falling trend (0.01 to 0.75 m/Yr) and 19 wells (63%) shows rising trends (0.01 to 1.25 m/Yr). The long term water level trend map of pre-monsoon and post-monsoon is given in **Fig 2.5a** and **Fig 2.5b**

Fig. 2.5a-b: Long-term water level trends Pre-Post-Monsoon (2011-2020)



2.3 Geophysical Studies

The Geophysical surveys are carried out by CGWB, SGWD and NGRI in the area. Geophysical surveys conducted in 30 locations, including borehole logging and VES by CGWB in the study area. Surveys indicated top soil upto 3 m with resistivity of 10 to 50 ohm m, weathered zone from 4 m to 18 m with resistivity of 30 to 80 ohm m. The fractured rock existed upto 22 m with a resistivity of 150 ohm m. The typical sequence of Pakhal formations showed clay (6 ohm m) shale (42 ohm m) quartzite (324 ohm m), shaly dolomite (40 ohm m) dolomite (180 ohm m) Sullavai sandstone with several intercalations of quartzite and sandstone proportions.The sandstones have resistivity of 120 to 150 ohm m in Sri Rampur and Manthani areas. When thickness of sandstone is greater than shale the resistivity is about 86 ohm m. Vertical electrical soundings (VES) at Yedlapalli, Rudraram and Medipalli in Kamthi sandstones showed a resistivity of 50 to 85 ohm m indicating productive aquifers. The Kamthi beds are found to occur at greater depths below clay horizons of Maleri and Kota formations at Medipally and Basavapuram villages. The sequences of formations at Nashtarpally, Dhanwada and Basvapuram showed the presence of clay stone with a resistivity of 6 to 20 ohm m and the resistive sandstone horizon with clay zone is well indicated as in Dhanwada village. The zones with greater than 100 ohm m resistivity are considered good aquifers for ground water development. The deep soundings conducted between Chintakani and Saranpalli revealed occurrence of thick sequence of clay zone down to 400 m depth.

2.4 Hydro Chemical Studies:

To understand chemical nature of ground water, total 227 data is utilized from ground water monitoring wells of CGWB and SGWD wells (Pre-monsoon:113 and post-monsoon:114) (mostly tapping combined aquifers Aq-1 and Aq-2) during the pre-monsoon and post-monsoon season of 2022. 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.

2.4.1 Pre-monsoon (Total 113 samples were analyzed):

Ground water from the area is mildly alkaline to alkaline in nature with pH in the range of 8.01-8.79 (Avg: 8.23). Electrical conductivity varies from 192-2534 (avg: 818) µ Siemens/cm**.** In 72 % of area EC is within 1500 µ Siemens/cm, in 25% area, it is 1500-3000 µSiemens/cm (**Fig.2.6).** Average concentration of TDS is 795 mg/L and NO_3 ranges from 1.8-350 mg/L. Nitate concentration in 46% of samples is beyond permissible limits of 45mg/L (**Fig.2.7**). Fluoride concentration varies from 0.15-3.15 (**Fig 2.8**), 94% of samples are within permissible limits of BIS and rest 6% is beyond permissible limit of 1.5 mg/L. High fluoride concentration is observed in eastern parts of the area. Over all 53 samples (47%) are unfit for human consumption in the study area.

2.4.2 Post-monsoon (Total 114 samples were analyzed):

Ground water from the area is mildly alkaline to alkaline in nature with pH in the range of 7.34-10.86 (Avg: 8.52). Electrical conductivity varies from 142-2966 (avg: 1163) µ Siemens/cm**.** In 75% of area, EC is within 1500 µ Siemens/cm, in 25% of area EC is 1500 to 3000 µ Siemens/cm (**Fig.2.9).** Average concentration of TDS is 745 mg/L and NO_3 ranges from 1-279 mg/L. Nitate concentration in 26% of samples is beyond permissible limits of 45 mg/L (**Fig.2.10**). Fluoride concentration varies from 0.09-4.51 (**Fig 2.11**) and 92% of samples are within permissible limits of BIS and rest 8% is beyond permissible limits of 1.5 mg/L. High fluoride concentration is observed in eastern and central parts of the area. Over all 51 samples (51%) of samples are unfit for human consumption in the study area.

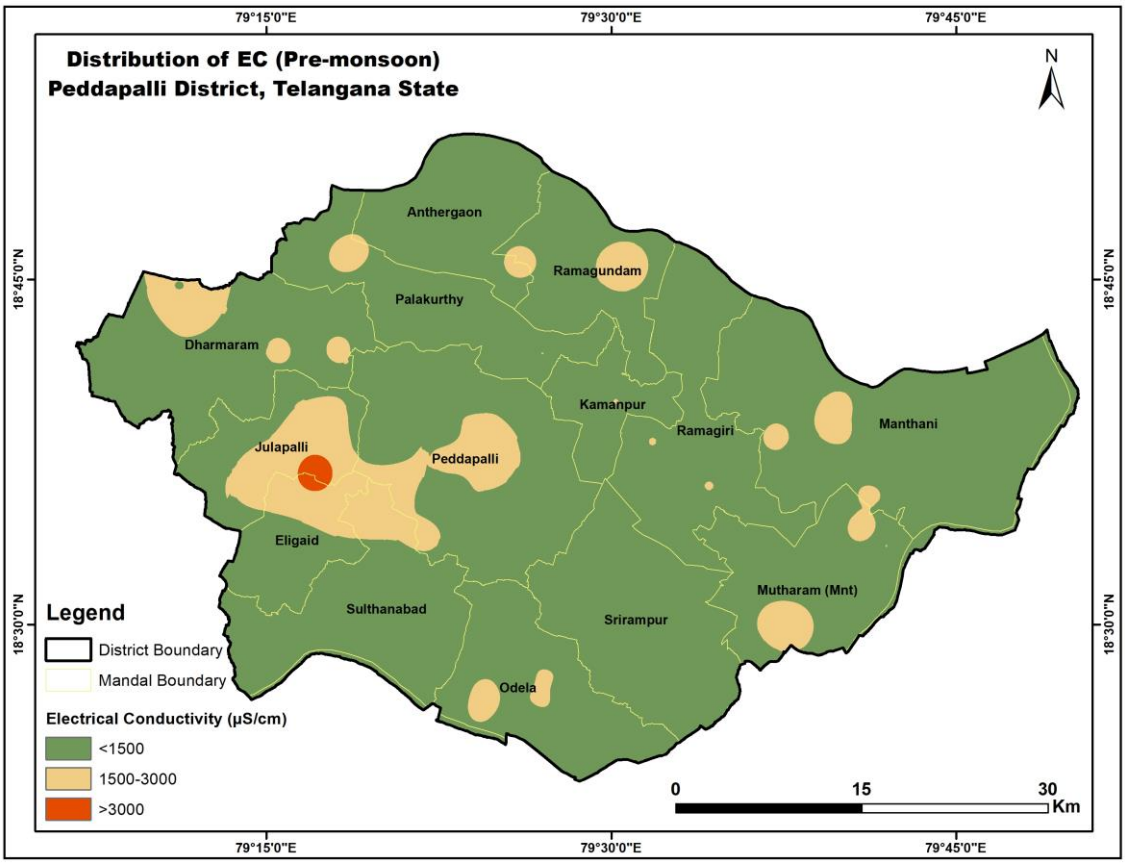


Fig.2.6: Distribution of Electrical conductivity (Pre-monsoon-2021).

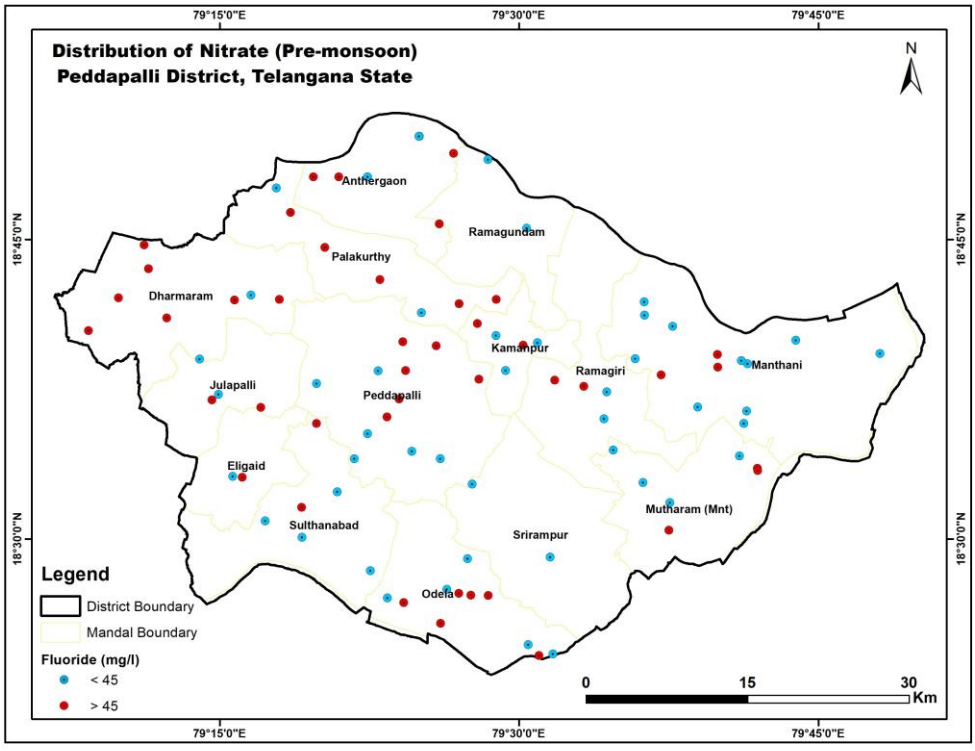


Fig.2.7: Distribution of Nitrate (Pre-monsoon-2021).

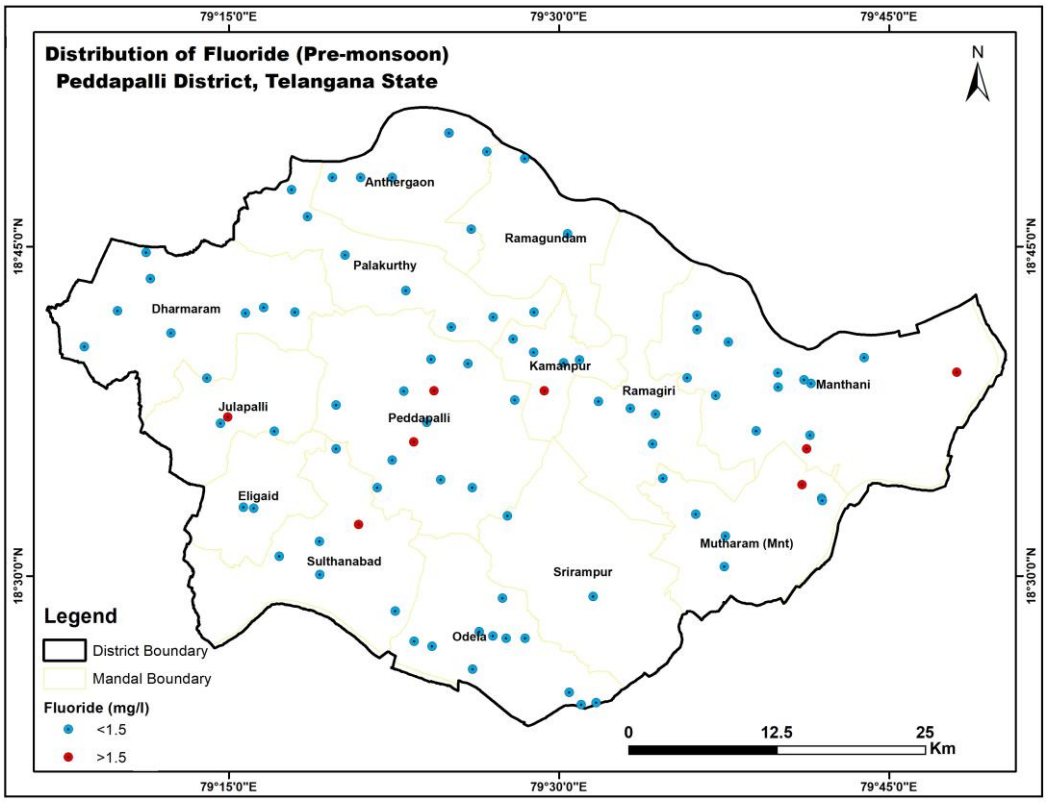


Fig.2.8: Distribution of Fluoride (Pre-monsoon-2021).

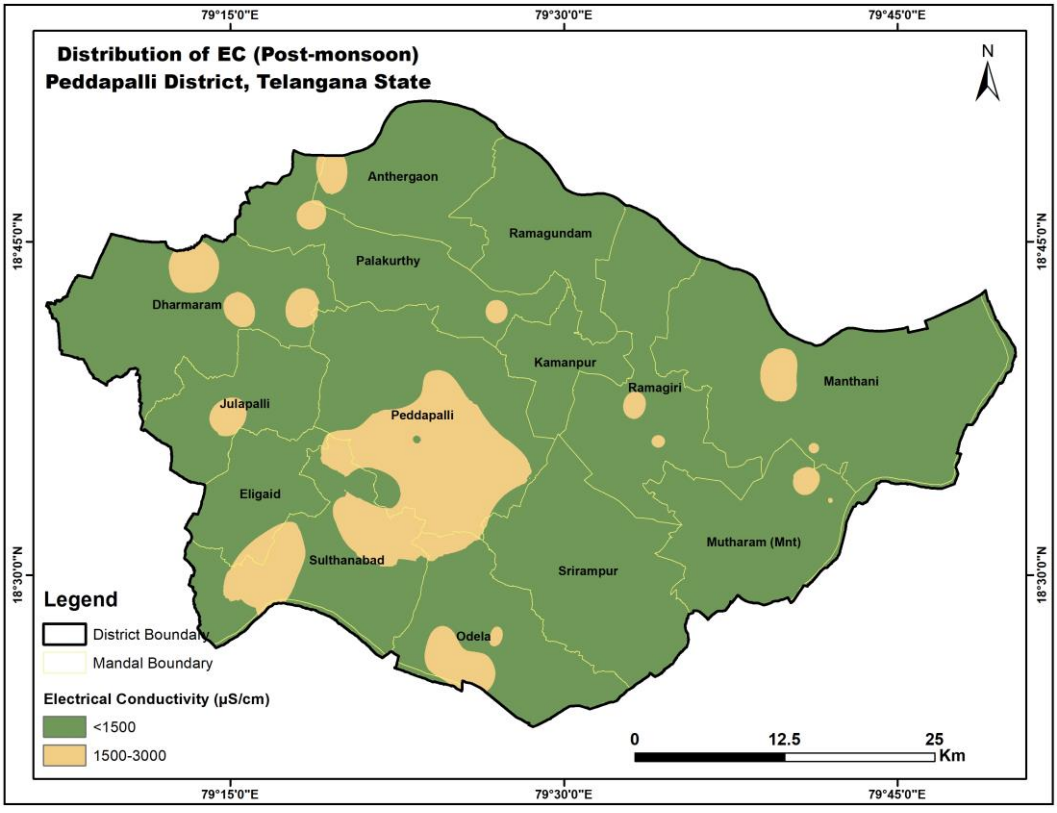


Fig.2.9: Distribution of Electrical conductivity (Post-monsoon-2021).

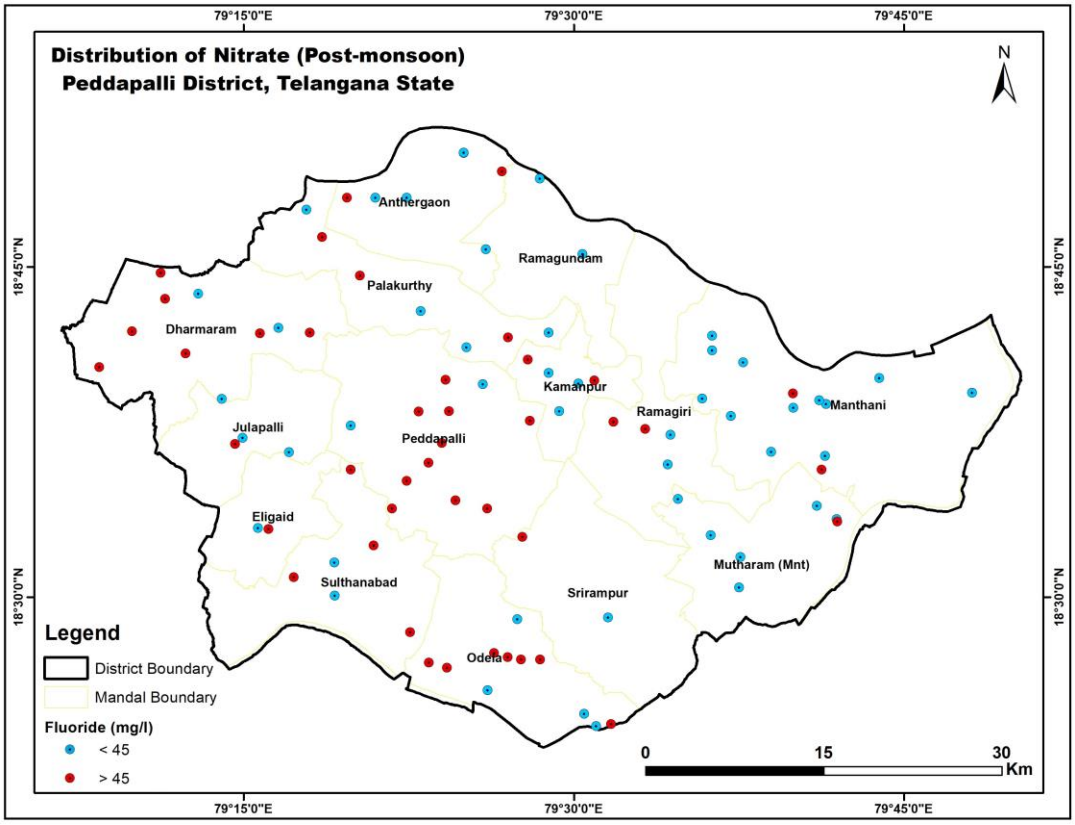


Fig.2.10: Distribution of Nitrate (Post-monsoon-2021).

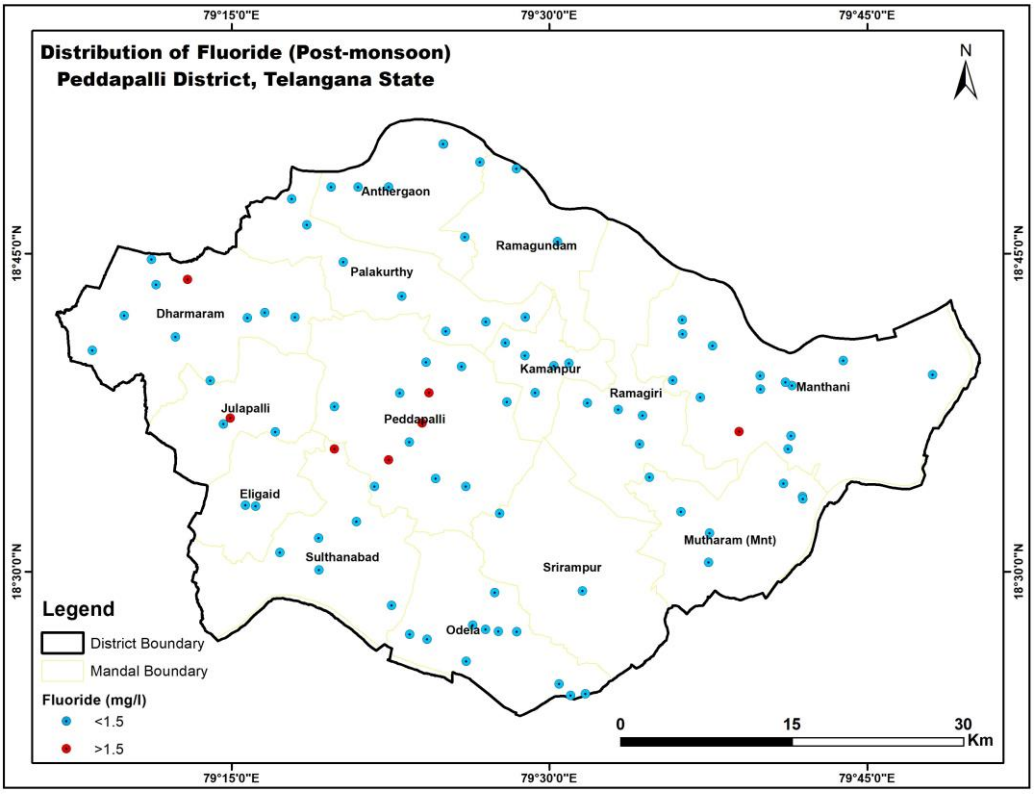


Fig.2.11: Distribution of Fluoride (Post-monsoon-2021).

3. DATA INTERPRETATION, INTEGRATION and AQUIFER MAPPING

Conceptualization of 3D hydrogeological model was carried out by interpreting and integrating representative 68 data points (both hydrogeological and geophysical data down to 300 m) for preparation of 3-D map, panel diagram and hydrogeological sections. The data (**Fig.2.1**) is calibrated for elevations with Shuttle Radar Topography Mission (SRTM) data. The perusal of the data indicates that there are multi aquifers in the area with intervening thick clay beds. Sandstone beds act as aquifers in the area and two to four distinct aquifers identified. Thin beds and pinched beds are neglected in making out the regional aquifer system. The lithological information was integrated by using the RockWorks-16 software and generated 3D map of the area (**Fig.3.1)** along with hydrogeological sections (**Fig.3.3a to 3.3d)**.

Type of Aquifer	Depth range (m.bgl)
Unconfined Aquifer (Aquifer-I)	4 to 50
Confined Aquifer (Aquifer-II)	33 to 150
Confined Aquifer (Aquifer group-III)	140 to 300

3.1 Conceptualization of aquifer system in 3D

Aquifers were characterized in terms of potential and quality based on integrated hydrogeological data and various thematic maps. In consolidated formation, Weathered zone is considered up to the maximum depth of weathering upto first fracture encountered (below weathered depth) generally down to ~20 m depth and the fractured zone (fractured granite) is considered up to the depth of deepest fracture encountered below weathered zone. In unconsolidated formation aquifers are classified into 3 Aquifer units, viz. Unconfined Aquifer (Aquifer-I), Confined/Semiconfined Aquifer (Aquifer-II) and Confined Aquifer group-III where the deeper aquifers are grouped into one unit due to inadequate aquifer wise data (**Fig.3.1)**.

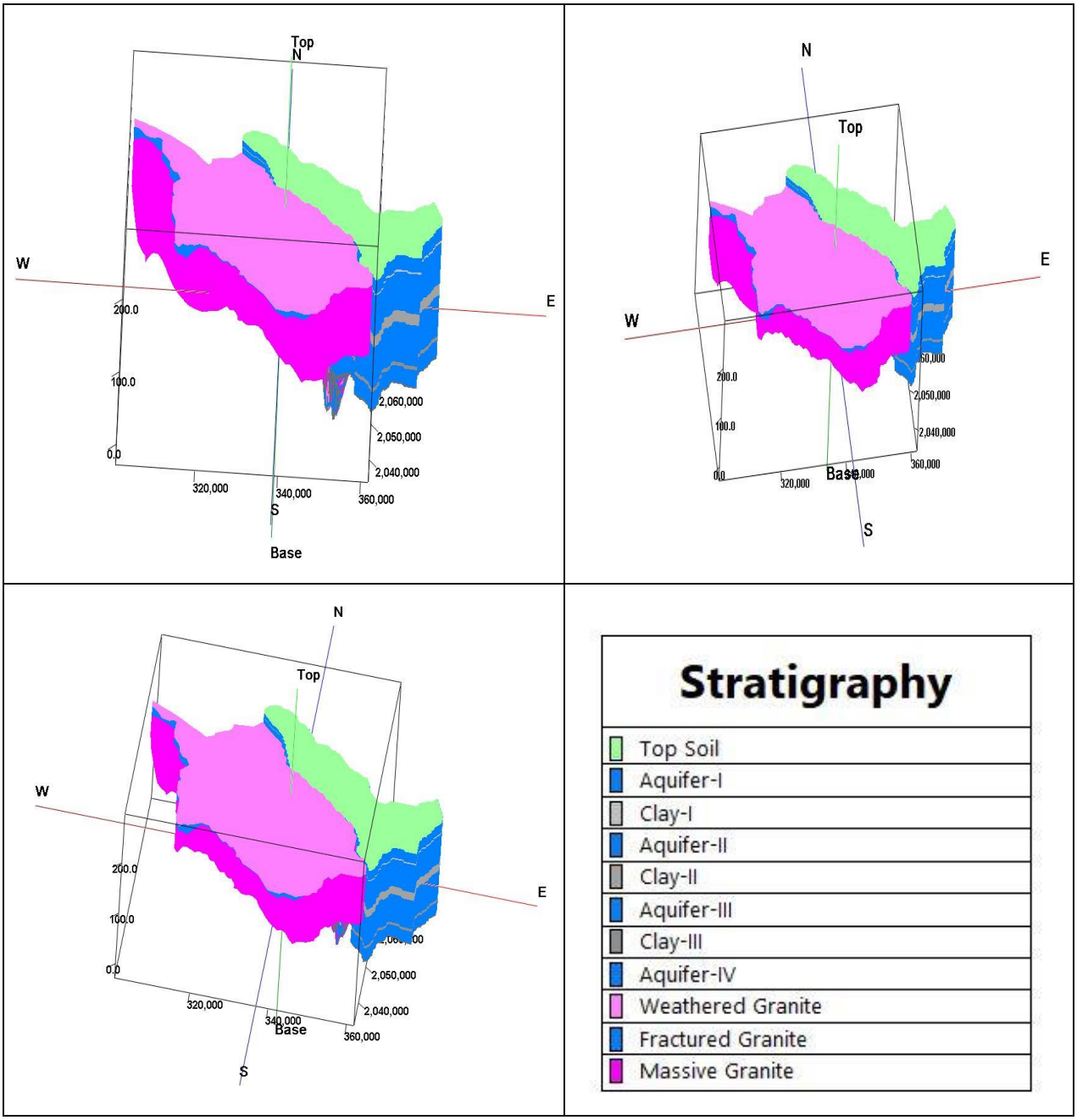


Fig.-3.1: 3-D Model of Peddapalli District

3.2 Hydrogeological Sections

4 Hydrogeological sections are prepared in NW-SE, SW-NE, W-E and N-S directions (**Fig. 3.2**).

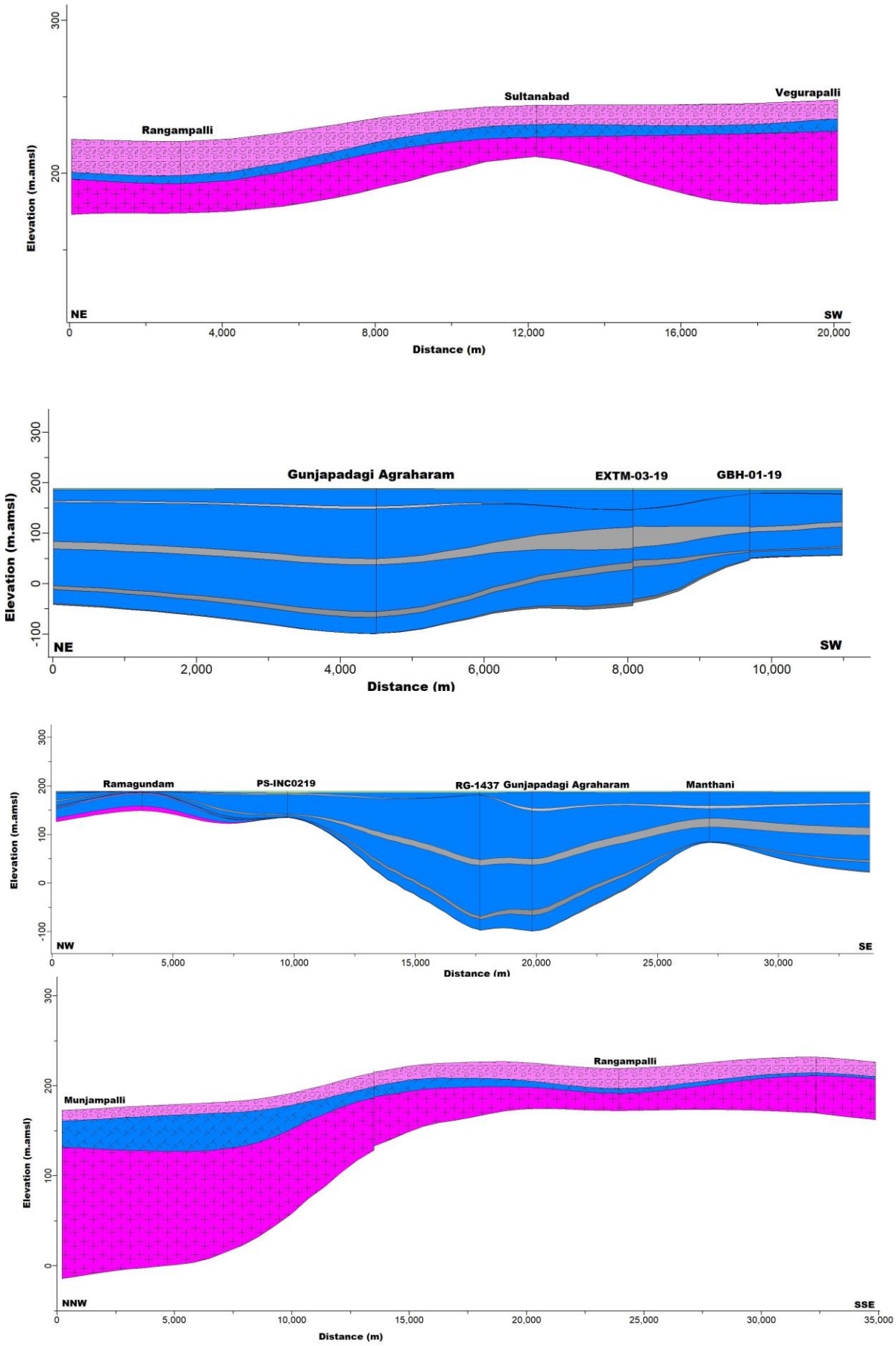


Fig.3.2. Hydrogeological profile in different directions.

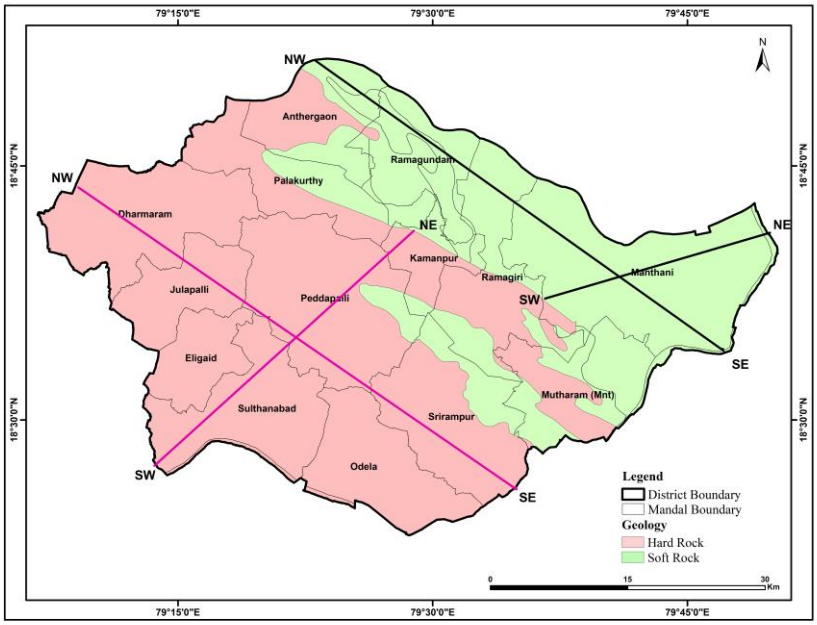


Fig.-3.3: Map showing orientation of various sections.

3.2.1 North-West and South-East Section: The section drawn along the NW-SE direction covering distance of ~200 kms (**Fig.3.3a**). It depicts weathered zone and fractured zone in Granites in north-western part extending from 0 to 25 km. and granular zones extend from 25 km to 90 km relatively thick clay beds are seen towards the southe-western parts. Thick Aquifer-II can be seen in central and southe-west of the section.

3.2.2 West-East Section: The section drawn along the W-E direction covering distance of ~90 kms (**Fig.3.3b**). It depicts weathered zone and fractured zone in Granites in north-western part extending from 0 to 25 km. and granular zones extend from 25 km to 90 km. relatively thick clay beds are seen towards the southe-western parts. Thick Aquifer-II is seen at Nashatarpalli, in the eastern side, relatively thin granular zones noticed in the central par of the section near Manthani and Gangaram villages.

3.2.3 South-West and North-East Section: The section drawn along the SW-NE direction covering distance of ~80 kms (**Fig.3.3c**). It depicts weathered zone and fractured zone in Granites in south-western part extending from 0 to 25 km and granular zones extend from 25 km to80 km relatively thick clay beds are seen in central part. Thickness of Aquifer-I & II is uniform through out the section except in central part near Medipalli village.

3.2.4 South-North Section: The section drawn along the S-N direction covering distance of ~22 kms (**Fig.3.3d**). It depicts the thickness of granular zones extending from south to north in the central part of the area. Relatively thick clay beds are seen in central part at Medipalli village, Aquifer-I & II is uniform through out the section except in the central part.

3.3 Aquifer Characterization

3.3.1 Aquifer-I/Unconfined Aquifer:

The unconfined aquifer thickness in unconsilodated (soft rock) formation range from 5 to 50 m. In hard rock area (Granitic formation) weathered zone (~20 m) varies from meagre to 15 m.bgl.

Ground water yield of unconfined aquifer varies from <1 to 2 lps (avg: 1 lps) with transmissivity of 25 to 50 m^2/day. Ground water yield of weathered granite/gneiss aquifer varies from <0.1 to 2 lps (avg: 1 lps).

3.3.2 Confined/ Semiconfined Aquifers (Aquifer-II and Aquifer group-III):

Aquifer-II and Aquifer group-III are confined/semiconfined aquifer. Aquifer-II present below unconfined aquifer in the depth range of 30 to 150m saperated by clay layer with considerable thickness of 5 to 30m and Aquifer group-III present below aquifer-II in the depth range of 140 to 300m saperated by clay layer with thickness of 5 to 30m. The transmissivity of these aquifers vary from 28 m^2/day to 668 m^2/day with storativity ranging from $5x10^{-4}$ to $2.5x10^{-4}$. The Aquifer with 160m thickness encountered at Ramagundam and Manthani. The yields of exploratory wells drilled in Kamthi formation range from 700 lpm to 1200 lpm with transmissivity of 290 m^2/day to 668 m^2/day, where as the yields of Kota and Maleri sandstone range from 300 lpm to 350 lpm with transmissivity of 28 m^2/day to 50 m^2/day. The yields of exploratory wells drilled in Alluvial formation range up to 1250 lpm.

3.3.3. Hydrogeology of Ramagundam Coal Mine Area (SCCL):

The Ramagundam Coal mine is located in the Northern part and extends into North-Eastern part of the district is known as Ramagundam coal belt, which is located in the Ramagiri and Kamanpur Mandals of Peddapalli district, Telangana State. The Project is bounded by N latitude 18°36’48” to 18°41’31” and E longitudes 79°31’41” to 79°36’42” in the Survey of India Topo sheet No.56 N/10.

The Ramagundam Coal Mine (RG Coal Mine) is formulated by amalgamating existing adjacent projects (viz., RG OC I Expansion Project, RG OC II Extension Project, Vakilpalli Mine, Adriyala Shaft Projects) and closed mines (i.e., Cluster of 10&10A) in Ramagundam area.

The hydrogeology of the area within 10 km radius buffer zone around Ramagundam Coal mine (637.94 sq.km) has been studied by SCCL, The salient features of the study is given below.

- The buffer zone area covers 69 villages falling Ramagundam, Kamanpur, Ramagiri, Manthani, Muttaram (mnt), Peddapalli, Srirampur (Kaluva) and Palakurthi Mandals of Peddapalli District.

- The main crops cultivated in this area are Paddy, Cotton, Maize, Chilies, and Vegetables etc. The total area irrigated during Kharif and Rabi seasons are 13427.6 ha, 8416.6 ha respectively. Out of 21,844 ha total irrigated area, 7895 ha (36%) was irrigated by surface water and 13949 ha (64 %) by ground water.

- In buffer zone, there are 11 coal mines in operation, the water presently being pumped and its utility are given in table below. The total groundwater extracted from all the mines is 46,312 m^3/ day (16.9 MCM/Yr), out of which ground water used for mine requirement is 14234 m^3/ day (5.2 MCM/yr), Domestic use is 4915 m^3/ day (1.8 MCM/yr), Plantation is 1519 m^3/ day (0.55 MCM/yr), and excess water let out into streams and water bodies is 25644 m^3/ day (9.3 MCM/yr).

- The phreatic water levels varies from 1.97m.bgl to 10.80m.bgl during pre-monsoon season and 0.95m.bgl to 8.10m.bgl during post-monsoon season. The water level fluctuation varies from 0.03 to 6.68m with an average water level fluctuation of 3.21m.

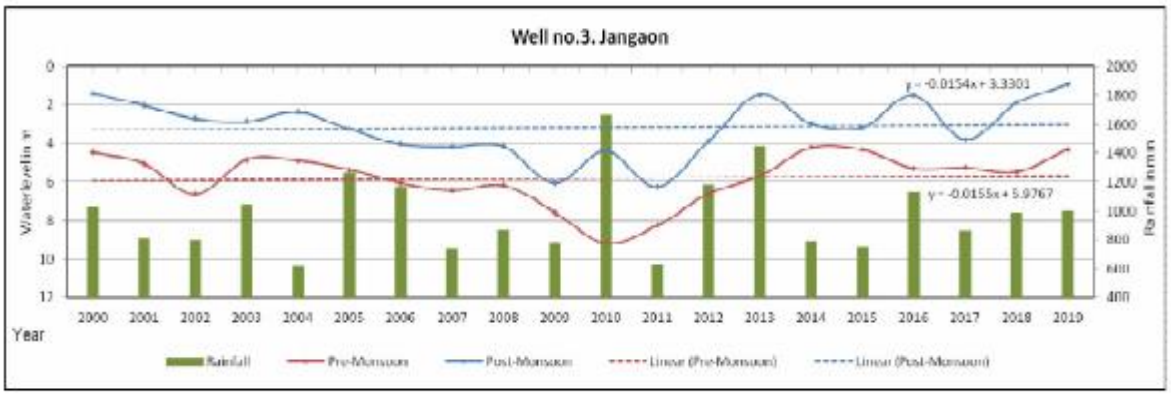
- The piezometric heads vary from 2.76 m.bgl to 26.15 m.bgl during pre-monsoon and 1.48m to 26.40m.bgl during post monsoon.

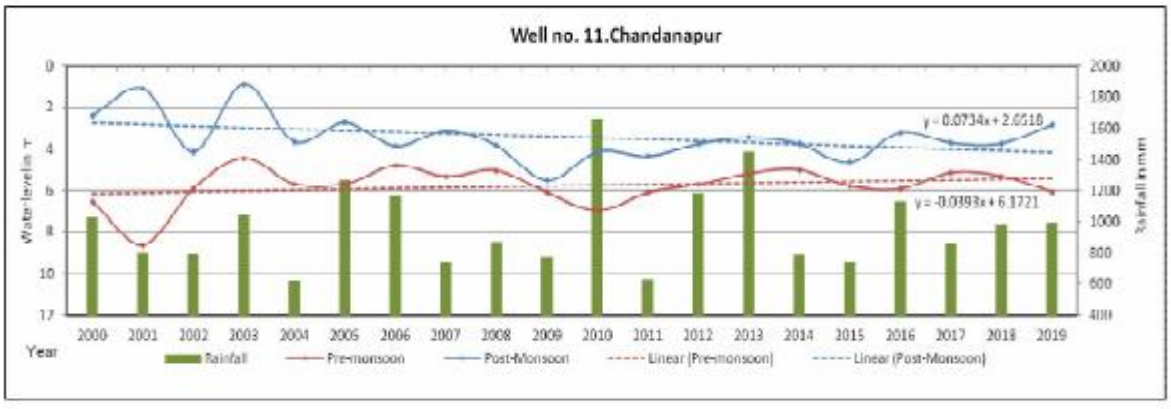
- The total groundwater draft in the buffer zone is about 15071.97 Ha.M/Year. Of this, draft from existing mines is about 1690.39 Ha.M/Year, while ground water used for irrigation is about 13017.59 (86% of total draft) Ha.M/Year.

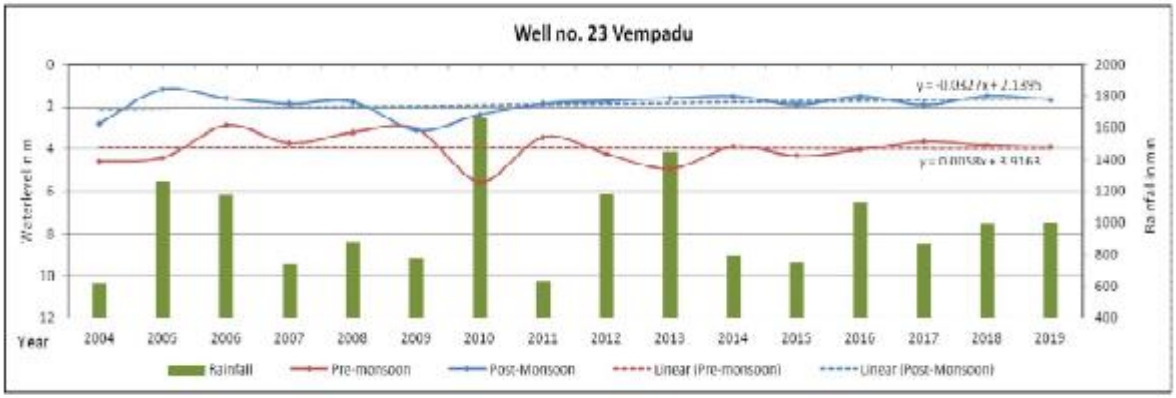
Mine-wise Ground water extraction and it's utility details in the buffer area

Sl. No.	Name of the Mine	Total quantity of water (m^3/day)				
		Pumped per day	Mine requirement	Domestic use	For plantation	Let out into streams
1	GDK 1&3	3067	1199	643	10	1215
2	GDK 2&2A	1800	1488	0	12	300
3	GDK 5	1100	700	0	400	0
4	GDK 7 LEP	3700	1200	500	200	1800
5	GDK 11	8360	3100	1500	20	3740
6	Vakilpalli	3250	750	500	200	1800
7	RGOCP-III	7896	1707	517	202	5470
8	GDK 10,10A	6834	3120	1200	400	2114
9	ALP	1605	20	30	5	1550
10	RGOCP-I	6900	700	20	50	6130
11	RG OC-II	1800	250	5	20	1525
	Total	46312	14234	4915	1519	25644

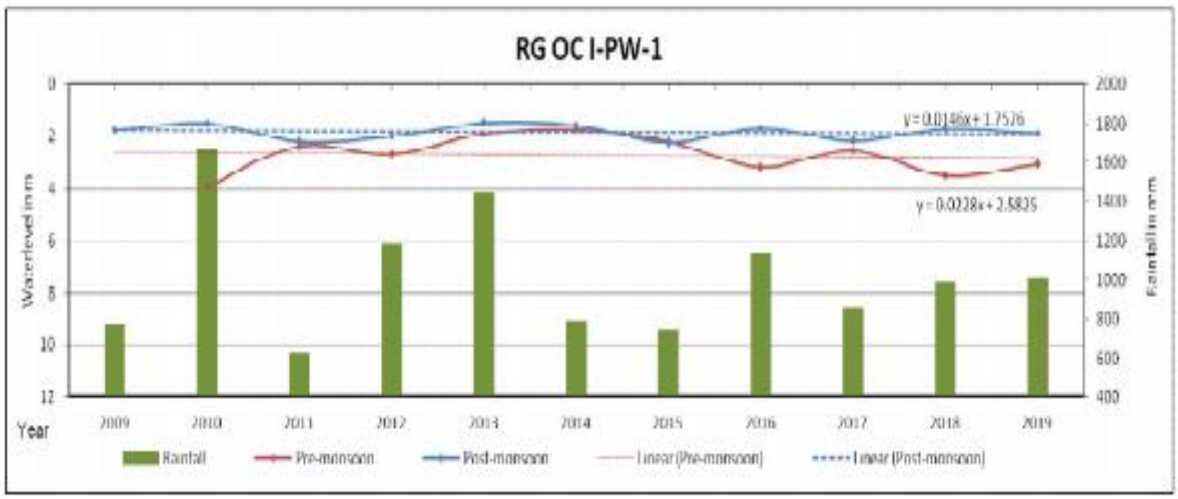
Hydrographs of Phreatic surface in the buffer area of RG Coal Mine

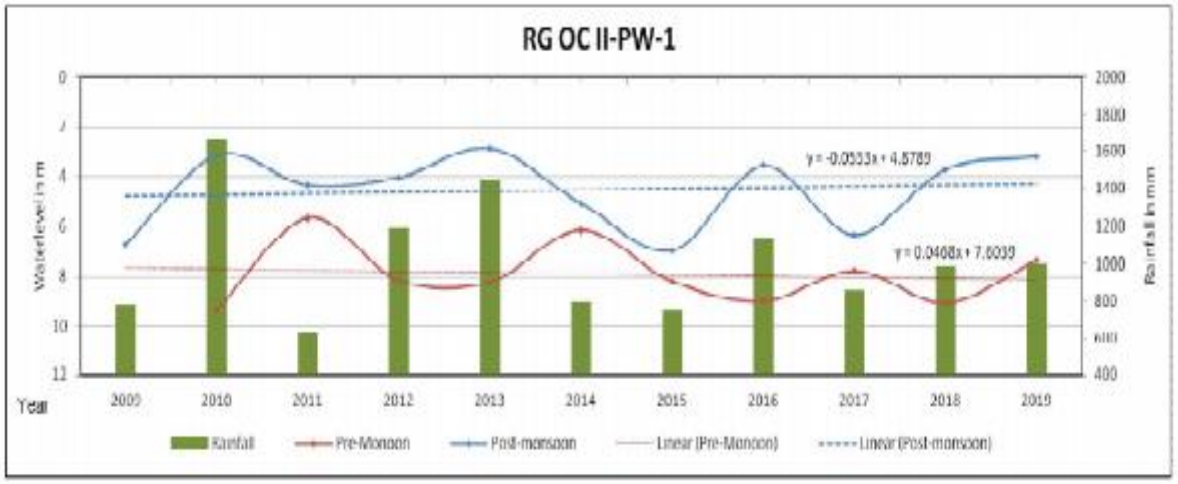


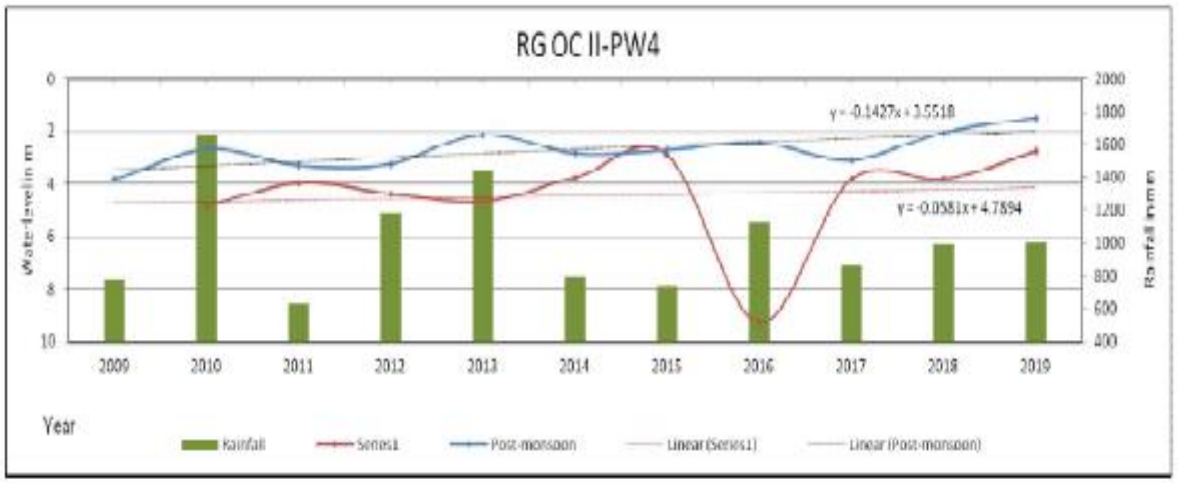




Hydrographs of Piezometric water levels in the buffer area of RG Coal Mine







4. GROUND WATER RESOURCES (2022)

Dynamic ground water resources are computed as per the guidelines laid down in GEC-15 methodology. As per 2022 GEC report, the net dynamic replenishable groundwater resources availability is 721.98 MCM, gross ground water draft for all uses 650.98 MCM and net annual ground water potential available for future use 454.358 MCM. Stage of ground water development varies from 4% and 44 % with average of 28 %. All the mandals fall under safe category, with highest stage of extraction of 4% to 44% seen in Srirampur and Manthani mandals respectively. Computed Dynamic ground water resources of the study area are given in **Table-4.1**.

Table-4.1: Computed Dynamic ground water resources.

As per GEC 2022	MCM
Dynamic (Net GWR Availability)	**454.35**
• Monsoon recharge from rainfall	161.18
• Monsoon recharge from other sources	328.73
• Non-Monsoon recharge from rainfall	115.15
• Non-monsoon recharge from other sources	220.51
Gross GW Draft	**650.98**
• Irrigation	175.45
• Domestic and Industrial use	154.28
Provision for Drinking and Industrial use for the year 2025	181.59
Net GW availability for future irrigation	454.35
Stage of GW development (%)	**28.37%** Min : 4% (Srirampur) Max : 44% (Manthani)

5. GROUND WATER RELATED ISSUES AND REASONS FOR ISSUES

5.1 Issues

Pollution (Geogenic and Anthropogenic)

1. 7 to 8 mandals are found to be fluorosis endemic where fluoride is geogenic and as high as 4.51 mg/L during pre-monsoon and 3.15 mg/L during post-monsoon season is found in groundwater. The high fluoride concentration (>1.5 mg/L) occur in 8% and 8 % of the samples during pre-monsoon and post-monsoon season of 2021 in 7 mandals viz. Sultanbad, Rangampalli, Adavisompalli, Gummunur, Peddapalli, Nittur, Julapalli and Raghavapuram.
2. High nitrate (> 45 mg/L) due to anthropogenic activities is observed in 52 samples (46%) and 50 samples (44%) during pre-monsoon and post-monsoon season 2022.

Deep water levels

3. Deep water levels (> 15 m bgl) are observed during pre as well as post-monsoon season in < 10% of the area.
4. 67% wells during pre-monsoon, 33% wells during post-monsoon shown falling trend in the last 10 years (@0.01 to 2.66 and 0.01 to 0.75 m/yr) respectively. Majority of the wells 33 to 67% show rising trend < 0.32 m/yr and falling tread <0.31 to 0.7 m/yr in both the seasons.

5.2 Reasons for Issues

Geo-genic pollution (Fluoride)

1. Higher concentration of fluoride in ground water is attributed due to source rock, rock water interaction where acid-soluble fluoride bearing minerals (fluorite, fluoro-apatite) gets dissolved under alkaline conditions.
2. Higher residence time of ground water in deeper aquifer.

Anthropogenic pollution (Nitrate)

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

Deep water levels

4. Over-extraction, paddy cultivation during rabi season (49% to total crops), ground water mining, limited artificial measures etc.

6. MANAGEMENT STRATEGY

Dependence on ground water coupled with absence of augmentation measures has led to a steady fall in water levels and de-saturation 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 is very limited in extent at depth and majority of fractures/sandstone normally occur within 100/200m depth.

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 management plan comprises two components namely supply-side management and demand-side management. The supply-side management is proposed based on surplus surface water availability and the unsaturated thickness of aquifer whereas the demand side management is proposed by use of micro irrigation techniques.

6.1. Supply side management:

The supply-side management of ground water resources can be done through artificial recharge by computing surplus runoff available within river sub-basins and also by repairing, renovation & restoration of existing tanks. In the district, 4508 MCM of unsaturated volume (below the 3 meter depth) is available during post-monsoon, having 122 MCM of recharge potential. This can be utilized for implementation of management strategy.

6.2 Artificial Recharge Structures (To be taken up):

The areas feasible for construction of recharge structures has been demarcated based on the analysis of post-monsoon depth to water level data and existing data on artificial recharge structures constructed under various schemes of MGNREGA and IWMP by Rural Development department, Govt. of Telangana. The availability of unsaturated volume of aquifer was computed by multiplying the area feasible for recharge and unsaturated depth below 3 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 and 0.03 for soft 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 government departments under different IWMP and MNREGS schemes is deducted to find the available surplus run-off for recommending the additional feasible artificial recharge structures.

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

As the stage of ground water extraction in the district is 28 % and 14 mandals are falling in safe category as per the GEC 2022 estimation, the artificial recharge structures are not proposed for entire district. To control further increase in stage of ground water extraction, artificial recharge structures are recommended in water levels below 6 to 10 m in safe category mandals.

Table 6.1: Area feasible and volume available for artificial recharge

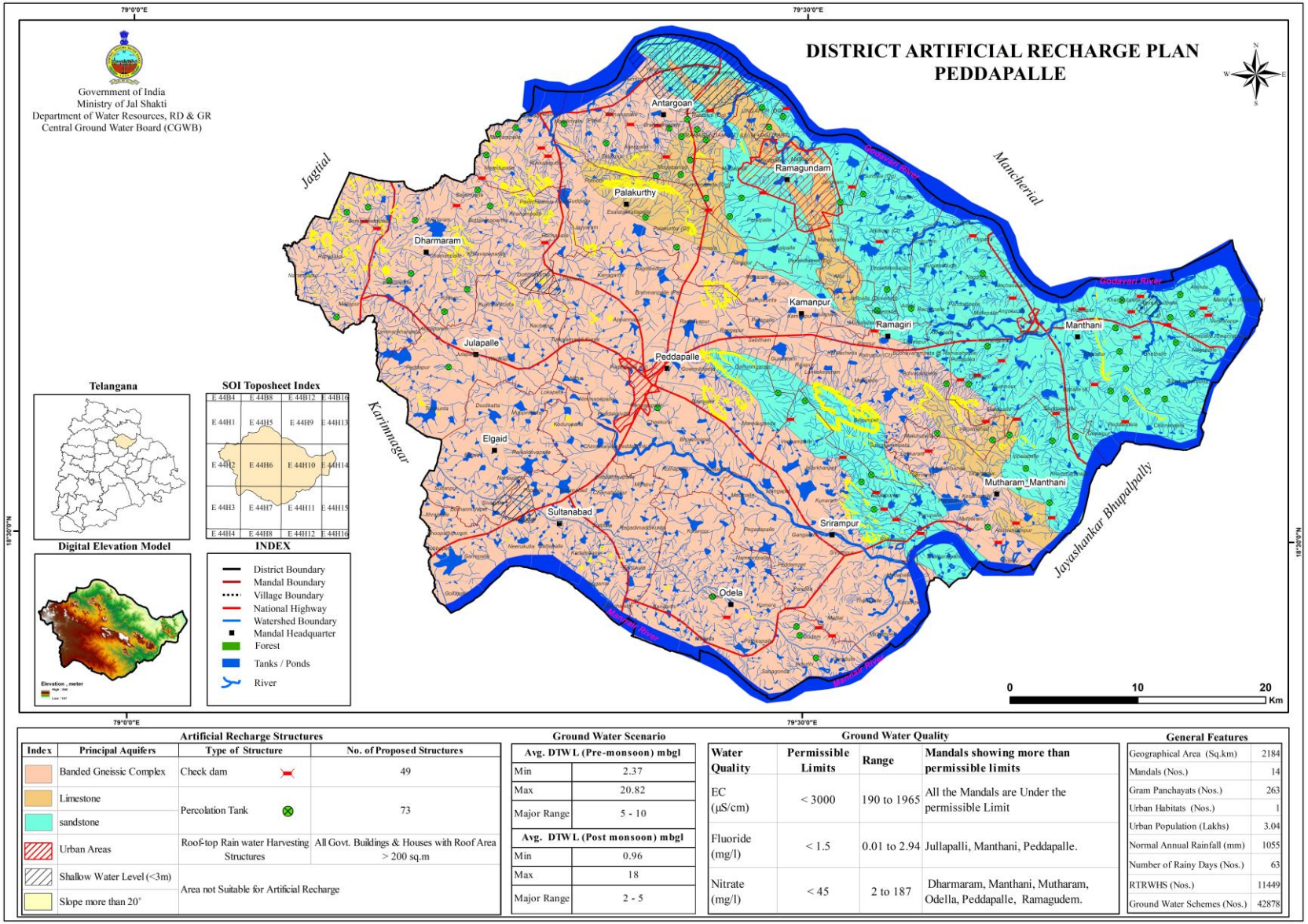
Total geographical area of district (Sq.km)	2184
Area feasible for recharge (Sq.km) (in 9 mandals)	1991
Unsaturated Volume (MCM)	4508
Recharge Potential (MCM)	121.50
Surplus run-off available for recharge (MCM)	73.42
PROPOSED ARTIFICIAL RECHARGE STRUCTURES	
Percolation Tanks (@ Rs.20 lakh, Av. Gross Capacity=0.007 MCM*2 fillings = 0.0140 MCM) Volume of Water expected to be conserved / recharged (in MCM) Estimated Expenditure (in lakhs)	73 1.022 1460
Check Dams (@ Rs.15 lakh, Av. Gross Capacity=0.007 MCM* 5 fillings = 0.035 MCM) Volume of Water expected to be conserved / recharged (in MCM) Estimated Expenditure (in Lakhs)	49 1.715 735
Total volume of water expected to be recharged (in MCM)	2.737
Total Estimated Expenditure for Artificial Recharge (Rs. in Cr.)	**21.95**

In the district, the total unsaturated volume (below the depth of 3 m) available for artificial recharge is 4508 MCM, having 121.50 MCM of recharge potential (2%). This available surplus run-off can be utilized for artificial recharge through construction of percolation tanks, check dams with recharge shafts at suitable sites. The number of percolation tanks, and check dams are decided based on the number of suitable streams available in the district.

Thus, after taking into consideration all the factors, only 73 MCM of surplus water can be utilised for recharge, which is given in **Table 6.1**. This surplus water can be utilized for constructing 49 check dams with estimated expenditure of Rs. 2.19 crores and 73 percolation tanks with estimated expenditure of Rs. 14.6 crores at suitable sites as shown in District Recharge Plan **(Fig-6.1).** The amount of recharge from these artificial recharge structures was calculated by considering 0.0140 MCM per percolation tanks and 0.035 MCM per check dam. This intervention would lead to recharge of about 2.343 MCM/year. The details are given in **Annexure-1.**

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

Fig-6.1. Proposed District Recharge Plan of Peddapalli district



Artificial Recharge Structures

Index	Principal Aquifers	Type of Structure	No. of Proposed Structures
	Banded Gneissic Complex	Check dam	49
	Limestone	Percolation Tank	73
	sandstone		
	Urban Areas	Roof-top Rain water Harvesting Structures	All Govt. Buildings & Houses with Roof Area > 200 sq.m
	Shallow Water Level (<3m)	Area not Suitable for Artificial Recharge	
	Slope more than 20°		

Ground Water Scenario

Avg. DTWL (Pre-monsoon) mbgl	
Min	2.37
Max	20.82
Major Range	5 - 10
Avg. DTWL (Post monsoon) mbgl	
Min	0.96
Max	18
Major Range	2 - 5

Ground Water Quality

Water Quality	Permissible Limits	Range	Mandals showing more than permissible limits
EC (µS/cm)	< 3000	190 to 1965	All the Mandals are Under the permissible Limit
Fluoride (mg/l)	< 1.5	0.01 to 2.94	Jullapalli, Manthani, Peddapalle.
Nitrate (mg/l)	< 45	2 to 187	Dharmaram, Manthani, Mutharam, Odella, Peddapalle, Ramagudem.

General Features

Geographical Area (Sq.km)	2184
Mandals (Nos.)	14
Gram Panchayats (Nos.)	263
Urban Habitats (Nos.)	1
Urban Population (Lakhs)	3.04
Normal Annual Rainfall (mm)	1055
Number of Rainy Days (Nos.)	63
RTRWHS (Nos.)	11449
Ground Water Schemes (Nos.)	42878

6.3. Water Conservation Measures (Farm Ponds)

The farm ponds are the ideal water conservation structures, which are constructed in the low lying areas of the farm. The size of farm ponds can be 10 x 10 x 3m. The total 5260 farm ponds are recommended (20 in each village in 263 villages of all mandals) at Rs.25000/- each with total cost of 13.15 Crores, this can create an additional storage of 1.57 MCM.

State Government ongoing Projects

- **6.3.1. Mission Kakatiya (Repair, Renovation and Restoration of existing tanks):** De-silting of existing minor tanks (501 no.) was taken under state Govt. sponsored Mission Kakatiya (Phase-1 to 4) to remove silt and this has created additional surface storage and enhance groundwater recharge.

- There is a need to take remaining tanks in the next phase for de-siltation; this will help greatly in stabilization of tank ayacuts and groundwater augmentation.

- **6.3.2. Mission Bhagiratha**: Under Telangana Drinking Water Supply Project (TDWSP), also known as Mission Bhagiratha, all the villages and towns are proposed to be covered from the three water grids with intake from 1) Medaram Balancing reservior, 2) Yellampally Reservoir (Segment-Manthani-Bhupalpally and Peddapalli-Ramagudem) to provide protected water from surface reservoirs. The scheme is to enhance the existing drinking water scheme and to provide safe drinking water to 142396 no. of households in the district.

- The total water requirement as per 2020 census is 40.49 MCM and this imported water from surface sources will reduce the present utilized ~24.29 MCM of ground water (considering 60 lpcd). This can be effectively utilized to irrigate ~4048.33 ha of additional land under ID crops.

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

6.4. Demand side management

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

- In the district, till date 2748 no's drip and sprinklers are sanctioned which has irrigated ~2864 ha in 14 mandals under ID crops saving ~4.29 MCM (considering 25% saving of 0.006 MCM/ha) of ground water from the basin. Considering the current scenario of ground water extraction, existing number of structures and shallow water levels, demand side intervention such as change in cropping pattern and micro irrigation has not been proposed.
- ~11,136 ha of additional land that can be brought under micro-irrigation (@1000 ha /mandal proposed in all 14 mandals costing about 66.81 crores (considering 1 unit/ha @0.6 lakh/ha). With this 16.70 MCM of ground water can be conserved over the traditional irrigation practices.

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

6.5. Other Recommendations

- A participatory ground water management (PGWM) approach in sharing of groundwater and monitoring resources on a constant basis along with effective implementation of the existing 'Water, Land and Trees Act' of 2002 (WALTA-2002) are the other measures suggested. Subsidy/incentives on cost involved in sharing of groundwater may be given to the farmers involved.
- In urban and rural areas, the sewerage line should be constructed to arrest leaching of nitrate.

- ❖ The other measures that are recommended include supplementary calcium and phosphorous rich food to the children in fluoride endemic mandals. Creating awareness about safe drinking water habits, side effects of high fluoride and nitrate rich groundwater, improving oral hygiene conditions.

6.6. Expected results and outcomes

With the above interventions costing Rs 88.76 Crores (excluding the cost involved in Mission Kakatiya and Mission Bhagiratha), the likely benefit would be net saving of 5.25 MCM of groundwater. This will bring down the stage of groundwater exploration by 0.5 % (from 50.80 % to 50.30 %).

Acknowledgment

The author expresses his sincere thanks to Sri. Sunil Kumar, Chairman, CGWB, Sri J.Siddhardha Kumar, Regional Director, for encouragement and support. Sri B.K. Mohanta, Scientist-C, Sri P. Vishnu, Young Professional and Mr. M. Sai Baba, Data Entry Operator for their support in preparation of maps. The author also acknowledge State Ground Water Department, Rural Water Supply Department, Singareni Collieries Company Ltd (SCCL), Government of Telangana for providing field data, and also thanks the Executive Engineer and his drilling crew of CGWB, Div-IX, Hyderabad for carrying out the exploration activity.