
# केन्द्रीय 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

## Guntur District
## Andhra Pradesh

दक्षिणी क्षेत्र, हैदराबाद
Sourthern Region, Hyderabad

भारत सरकार

जल शक्ति मंत्रालय

जल संसाधन नदी विकास एवम् गंगा संरक्षण विभाग

केंद्रीय भूमि जल बोर्ड

GOVERNMENT OF INDIA

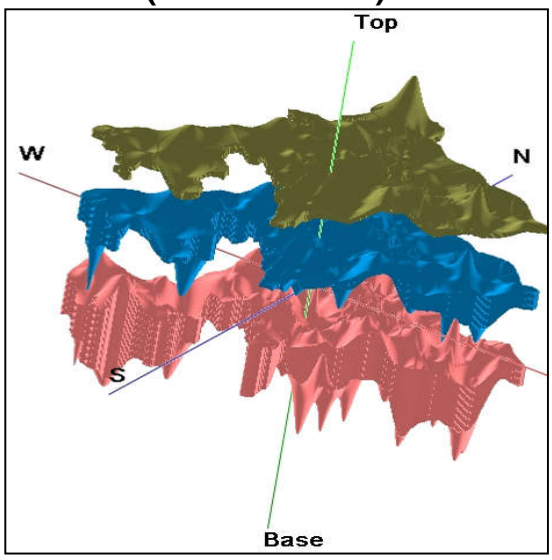
MINISTRY OF JAL SHAKTI

DEPARTMENT OF WATER RESOURCES, RD & GR

# REPORT ON

# AQUIFER MAPPING AND MANAGEMENT OF GUNTUR DISTRICT (PARTS), ANDHRA PRADESH STATE

## (AAP-2021-22)




**CENTRAL GROUND WATER BOARD**

**SOUTHERN REGION, HYDERABAD**

**JUNE, 2022**

**REPORT ON**

**AQUIFER MAPPING AND MANAGEMENT OF**

**GUNTUR DISTRICT (PARTS), ANDHRA PRADESH STATE**

**(AAP-2021-22)**

## CONTRIBUTORS' PAGE

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# AQUIFER MAPPING AND MANAGEMENT OF GUNTUR DISTRICT (PARTS), ANDHRA PRADESH STATE

## Executive summary

## Contents

**Figures**

**Tables**

# REPORT ON
# AQUIFER MAPPING AND MANAGEMENT OF
# GUNTUR DISTRICT (PARTS), ANDHRA PRADESH STATE
# (AAP-2021-22)
## At a Glance

| S.No. | Item | | Particulars |
|---|---|---|---|
| 1 | District | : | Guntur District (Parts), Hard Rock area |
| 2 | Revenue Divisions/ Mandals | : | 36 |
| 3 | Villages | : | 448 villages |
| 4 | Mappable area | : | 8125 $km^2$ |
| 5 | Population (2011 Census) | : | 27.5 lakhs |
| 6 | Density of population (2011 Census) | : | 152 persons/$km^2$ |
| 7 | Locations | : | North latitude 15°49′-16°49′and east longitude 79°12′-80°40’ |
| 8 | Rainfall (Normal) | : | The annual normal rainfall of the area varies from 659 mm (Macherla mandal) to 997 mm (Mangalagiri mandal) with normal average of 807 mm. |
| 9 | Geomorphology | : | Pediplain (60% of the area). Structural hills (11 % of the area), Pediment (10% of the area), Structural Valley (5% of the area), Dissected plateau (5% of the area) and channel fill (4% of the area). |
| 10 | Major River | : | Krishna and Gundlakamma |
| 11 | Land Utilization | : | Agricultural land occupies nearly 44% of the area, forest occupies nearly 18% of the area, 16% of the area is put to non agricultural uses and 12% of the area is fallow land. Remaining area is occupied by |

| | | | |
|---|---|---|---|
| | | | plantation, builtup, water bodies and barren land etc. |
| 12 | Soils | : | Based on the soil texture, the area is mainly occupied by Clayey skeletal mixed and clayey mixed (31%), Fine soil mixed (29%), fine montmorillonitic (23%), loamy skeletal (13%) and fine loamy mixed (4%) |
| 13 | Cropping Pattern (2019-20) (Ha) | : | The total gross cropped area during the year 2019-20 is 4,15,655 ha and net sown area is 3,76,212 ha. The gross area cropped during Khariff season is 3,55,438 ha and the major crops grown during khariff season is Paddy (18%), cotton (48%), chillies (18%) and total pulses (5%) and 11% remaining other crops. The gross area cropped during Rabi season is 60,217 ha and the major crops grown during the period are Paddy (40%), Pulses (33%), Maize (11%),Tobacco (3%) and remaining 13% by other crops |
| 14 | Irrigation | : | The Gross area irrigated is 235029 ha and the area irrigated more than once is 25291 ha. In which, 70% (166247 ha) of the irrigation is through surface irrigation and 29% (68782 ha) of the area is irrigated through ground water irrigation. |
| 16 | Prevailing Water Conservation/Recharge Practices | : | ~1259 percolation tanks, 606 Check dams,185 Percolation Tanks and 13552 Farm ponds. Also 73934 other water conservation structures. |
| 17 | Geology | : | The Archean Granitic Gneiss and granites covers 29% of the area and charnockites covers 17%. The Precambrian metasedimentary formation of Kurnool and Cuddapah system covers 54% of the area |
| 18 | Hydrogeological data points | | |
| | Exploratory drilling data points | : | CGWB Exploration: 138 |
| | Water Level data points | | 137 wells (CGWB:53, SGWD:84) |

| | | | |
|---|---|---|---|
| | **Hydrochemical Points** | | **Total 60**<br>• **Pre-monsoon:60(CGWB: 27, SGWD: 33)** |
| | **Geophysical** | | **VES: 55 (CGWB) and TEM (36)** |
| **19** | **DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING** | | |
| **20** | **Ground water Level Scenario** | | |
| | **Water Levels**<br>**Depth to water level**<br>**(m bgl)** | **:**<br>**:** | • **During Pre-Monsoon, water-table elevation ranges from 5-235 meter above mean sea level and in post-monsoon season 8-242 meter above mean sea level (m amsl).**<br>• **Depth to water level varies from <1 m to 52 m bgl with an average of 7.25 mbgl during pre monsoon. In Majority of the areas in pre monsoon water level is 5-10 m (46% of the area), followed by shallow water leve (<5 m bgl) in 30% of the area, 10 to 20 m bgl in 15% of the area and > 20 m bgl occupy about 9% of the area**<br>• **During post-monsoon season water level , <1 m - 35 m bgl with an average of 5.2 m bgl. and majority of the water level are in range of <5 m covering 46% of the area followed by 5 to 10 m bgl in 39% of the area 10 to 20 m bgl in 11 % of the area and < 20 mbgl occupy about 4% of the area.** |
| | **Water Level Fluctuations (May vs. November )** | **:** | • **Most of the wells in the state records water level rise. The seasonal water level fluctuations vary from <1 to 11.5m.** |
| | **Long term water level trends (2010-20)**<br>**(137 wells)** | **:** | **During pre-monsoon season 117 wells shows falling trend in the range of 0.01 m/yr to 1.9 m/yr and 20 wells shows rising trend 0.02-0.5 m/yr.**<br>**During post-monsoon season 57 wells show falling trend 0.01 to 1.5 m/yr and 80 wells shows rising** |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | trends 0.01-0.5 m/yr. | | | |
| 21 | Ground Water Quality | | | | | |
| | Electrical Conductivity (µ Siemens/cm) | : | Pre: 622-7210 (avg: 2697) micro Siemens/cm 65% of area EC is within 3000 µ Siemens/cm. | | | |
| | Nitrate mg/l | : | Pre: 1-560 mg/L and found 56% of samples are unfit for human consumption | | | |
| | Fluoride mg/l | : | Pre: 0.10-2.23 mg/L, 10% of sample are beyond permissible limit of 1.5 mg/L. | | | |
| 22 | Aquifer Mapping | | | | | |
| | Era | | Pre-Cambrian | | Archean Crystallines | |
| | Prominent Lithology | | Meta sedimentary Formation | | Granite Gneiss/Charnockite (Basement) | |
| | Aquifer types | | Aquifer-1 (Weathered Zone) | Aquifer-2 (Fracture Zone) | Aquifer-1 (Weathered Zone) | Aquifer-2 (Fracture Zone) |
| | Thickness range | | 1 - 30 m | up to 200m | 1 - 30 m | up to 200m |
| | Depth of range of occurrence of fractures | | - | 85% fracture encountered between Within 100 m | - | 80% fracture encountered between 30 - 90m |
| | Range of yield potential | | <1 to 3 | Avg 5 lps | <1 | Avg 3 lps |
| | Transmissivity (sqm/day) | | More than 1 to >100 sq.m/day | | | |
| 23 | Ground water Resources (2020) MCM | | | | | |
| | Net Dynamic groundwater availability | : | 1033 MCM | | | |

| | | | |
|---|---|---|---|
| | **Gross GW Draft** | **:** | **354 MCM** |
| | **Provision for Domestic &Industrial (2025)** | **:** | **104 MCM** |
| | **Average Stage of Ground water development (%)** | | **34%** |
| | **Net GW Availability for future irrigation** | **:** | **707MCM** |
| | **Categorization of mandals** | | **Stage of ground water development varies from 11% (Tadikonda mandal) to 137% (Veldurthi mandal). Out of 36 mandals in the study area, 2 mandals (Veldurthi and Bollapalle mandals) are over exploited, Piduguralla mandal is Critical and remaining 33 mandals are safe.** |
| **24** | **Major Ground Water Issues Identified** | **:** | • **The Over all stage of ground water development in the study area is 34%, except 3 mnadals, Viz., Piduguralla, Bollapalle and Veldurthy mandals. The Piduguralla mandal is known for its rich lime stone deposits and the industrial as well as mine dewatering may be the one of the reasons for high stage of ground water development.**<br>• **Low yield (<1 lps) occurs in most of the area of both in eastern as well as western parts of the study area.**<br>• **High nitrate (> 45 mg/L) due to anthropogenic activities is observed in 56% during pre-monsoon** |
| **25** | **Management Strategies** | **:** | **Supply side measures**<br>**To be taken up (Artificial Recharge Structures in the Study Area)**<br>**246 artificial recharge structures (152 CD's and 94 mini PT'in 85 villages)** |

| | | | |
|---|---|---|---|
| | | | **Water Conservation measures (WCM) Farm Ponds**<br><br>**The size of form ponds can be 10 x 10 x 3 m. Total 1352 farm ponds already exist in study area should be desilted and maintained so that it will greatly help in ground water augmentation.**<br><br>**Demand side measure**<br><br>**Micro irrigation: 30000 ha of land can be brought under micro-irrigation (@100 ha/village in 300 villages, considering 1 unit/ha @0.6 lakh/ha). With this ~54 MCM of ground water can be conserved over the traditional irrigation practices, considering @ 0.006 MCM/ha for ID crops with traditional irrigation methods).**<br>**Other Recommendations**<br><br>• **To avoid the interference of cone of depression between the productive wells, intermittent pumping of bore wells is recommended through regulatory mechanism.**<br><br>• **The western part of the study area is known for its rich lime stone deposits. As mandated by Central Ground Water Authority, the mine dewatered seepage can effectively be utilized by filling the tanks and supply to agriculture fields.**<br><br>• **As a mandatory measure, every groundwater user should recharge rainwater through artificial recharge structures in proportionate to the extraction**<br><br>• **Declaration of Minimum Support Price in advance (before start of season) and improved facilities at procurement centres.**<br><br>• **Capacity building in power supply regulation (4 hour each in morning and evening) will** |

| | | | |
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| | | | increase the sustainability of wells<br>• 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).<br>• Laser levelling of irrigated land. Subsidy/incentives on cost involved in sharing of groundwater may be given to the concerned farmers. |
| 26 | Expected Results and Out come | : | With the above interventions, the likely benefit would be the net saving of 63 MCM of ground water can be saved either through water conservation measures like adoption of drip and artificial recharge to ground water. |

## 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 Guntur district has a geographical area of 11,391 sq.kms, of which 8125 sq.kms is underlain by hard rock aquifer system, lies between north latitude 15°49′-16°49′and east longitude 79°12′- 80°40'. Administratively, the study area is governed by three revenue divisions – Narasaraopet, Guntur and Gurazala covering 36 mandals and 448 villages having a population of 27.5 lakhs (2011 census, population density of 152).

The study area is underlain by various geological formation from Archean to Recent. The Archean granitic gneiss and granites covers 29% of the area and charnockites covers 17% overlain by precambrian metasedimentary formation of Kurnool and Cuddapah system covering 54% of the area. Pediplains are the major landforms followed by structural hills and pediment. The major rivers draining the study area are Krishna and Gundlakamma.. Agricultural land occupies nearly 44% of the area, 18% of the area is forest, 16% of the area is put to non-agricultural uses and 12% of the area is fallow land. The total gross cropped area during the year 2019-20 is 4,15,655 ha and net sown area is 3,76,212 ha. The Gross area irrigated is 235029 ha. In which, 70% (166247 ha) of the irrigation is through surface irrigation and 29% (68782 ha) of the area is irrigated through ground water irrigation.

Water level is monitored through 137 wells during pre and post-monsoon seasons. During Pre-Monsoon, water-table elevation ranges from 5-235 meter above mean sea level and in post-monsoon season 8-242 meter above mean sea level (m amsl). Depth to water level varies from <1 m to 52 m bgl with an average of 7.25 mbgl during pre-monsoon and <1 m - 35 m bgl during post-monsoon season with an average of 5.2 m bgl. In

Majority of the areas in pre monsoon water level is 5-10 m (46% of the area), followed by shallow water level (<5 m bgl) in 30% of the area, 10 to 20 m bgl in 15% of the area and > 20 m bgl occupy about 9% of the area and during post monsoon season majority of the water level are in range of <5 m covering 46% of the area followed by 5 to 10 m bgl in 39% of the area 10 to 20 m bgl in 11 % of the area and < 20 mbgl occupy about 4% of the area. Most of the wells in the state records water level rise. The seasonal water level fluctuations vary from <1 to 11.5 m.

Trend analysis for the last 10 years (2011-2020) is studied from 137 hydrograph stations of CGWB and SGWD. It is observed that during pre-monsoon season 117 wells shows falling trend in the range of 0.01 m/yr to 1.9 m/yr and 20 wells shows rising trend 0.02 m/yr to 0.5 m/yr. During post-monsoon season 57 wells show falling trend 0.01 to 1.5 m/yr and 80 wells shows rising trends 0.01-0.5 m/yr

Total 60 ground water samples (CGWB:27 and SGWD:33) were analysed for knowing the suitability of ground water for drinking purposes. In 65 % of area EC is in the range of < 3000 µ Siemens/cm during pre-monsoon season. During pre-monsoon, average concentration of TDS is 1607 mg/L and $NO_3$ ranges from 1-560 mg/L. Nitrate concentration in 56% of samples is beyond permissible limits of 45 mg/L.Fluoride concentration varies from 0.10-2.23 with 10% of samples is beyond the permissible limits of BIS and rest is within the permissible limit.

On the basis of occurrence and movement of ground water, hard rock units of the study area are classified into two categories; Archean crystalline and Metasedimentary formations. Weathered and fractured Archean crystalline rocks (Charnockites and Granite Gneisses) form the archean aquifer system. Metasedimentary aquifer system overlies archean crystalline rocks aquifer system. Aquifers are conceptualized in to two namely, weathered zone (~30 m) and fractured zone (~200: 30 -192 m). The shallow aquifer is considered

up to the maximum depth of weathering and first fracture encountered (below weathered depth) generally down to ~30 m depth. Ground water yield varies from <1 to 3 lps in archean crystallines and <1 to 5 lps in metasedimentary formation. Transmissivity varies from 1 to >100 sq.m/day. The depth of fracturing varies from 30 m to 192 m

As per 2020 GEC report, the net dynamic replenishable groundwater availability is 1033 MCM, gross ground water draft for all uses 354 MCM, provision for drinking and industrial use for the year 2025 is 104 MCM and net annual ground water potential available for future irrigation needs is 278 MCM. Stage of ground water development varies from 11% (Tadikonda mandal) to 137% (Veldurthi mandal). Out of 36 mandals in the study area, 2 mandals (Veldurthi and Bollapalle mandals) are over exploited, Piduguralla mandal is Critical and remaining 33 mandals are safe.

Major issues identified are critical and over-exploited mandals such as Piduguralla, Bollapalle and Veldurthy are located in meta sedimentary formations comprising of Lime stones, Quartzites and Shales where the industrial as well as mine dewatering may be the one of the reasons for high stage of ground water development and in ground water quality, higher concentration of Nitrate is observed in 56% of samples.

The management strategies mainly include both supply side and demand side. The supply side management of ground water resources include artificial recharge of available surplus runoff in check dams and percolation tanks in rural areas and roof top and open space rain water harvesting in urban areas. In the study area, a total of 678 artificial recharge structures (534 CDs and 144 PTs) are already in existence. Considering 50% of the available left surplus runoff, a total of 246 AR structures (152 check dams and 94 percolation tanks) are recommended in the study area. After effective utilization of this yield, there will be 9.4 MCM of ground water recharge can be feasible. Under Water conservation measures include, desilting of

already existing 13552 numbers of farm ponds in the entire study area. Roof top and open space rain water harvesting for artificial recharge in urban areas.

Government of Andhra Pradesh had proposed to bring about 12423 ha of additional land under ground water irrigation in the district through construction of 11241 no. of bore wells in 268 villages of 24 mandals of study area with an estimated cost of 524 crores.

Demand side measure includes micro irrigation in ~30000 ha of additional land that can be brought under micro-irrigation (@100 ha/village in 300 villages) considering 1 unit/ha @0.6 lakh/ha. With this 54 MCM of ground water can be conserved over the traditional irrigation practices (considering 0.006 MCM/ha for ID crops against 0.008 MCM/ha).

Other measure includes capacity building in power supply regulation, effective utilization of mine dewatered seepage for filling the tanks and supply for irrigation, application of laser levelling technology in irrigated land, providing proper sewerage system, intermittent pumping of bore wells is recommended through regulatory mechanism, every groundwater user should recharge rainwater through artificial recharge structures in proportionate to the extraction and participatory groundwater management (PGWM) are the other measures recommended.

With the above interventions, the likely benefit would be the net saving of 63 MCM either through water conservation measures like adoption of drip and artificial recharge to ground water.

**NUMBER OF DATA POINTS USED FOR PREPARATION OF VARIOUS MAPS/FIGURES**

**GUNTUR DISTRICT HARD ROCKS (Parts)**

| S. No. | Data | Aquifer | Total data Points | Source |
|---|---|---|---|---|
| 1 | Panel Diagram | Combine | 185 | CGWB, GW & WAD |
| 2 | Hydrogeological Sections | 2nos | 185 | CGWB, GW & WAD |
| 4 | Depth of Weathering | 1no | 138 | CGWB ,GW & WAD |
| 5 | Depth of Fractures | 1no | 110 | CGWB, GW & WAD |
| 6 | GW Yield | Combine | 119 | CGWB , GW & WAD |
| 7 | Transmissivity | Combine | 80 | CGWB , GW & WAD |
| 8 | Depth to Water Level Maps | Combine | 137 | CGWB , GW & WAD |
| 9 | VES | Combine | 55 | CGWB |
| 10 | TEM | Combine | 36 | CGWB |
| 11 | Water Level Trend (Long Term) | Combine | 137 | CGWB , GW & WAD |
| 12 | Water Quality | Combine | 60 | CGWB , GW & WAD |

## 1. INTRODUCTION

Aquifer mapping is a multidisciplinary scientific approach wherein a combination of geologic, geophysical, hydrologic, and chemical analysis is applied to characterize the quantity, quality, and sustainability of groundwater in aquifers. In the recent past, there has been a paradigm shift from "**groundwater development**" to "**groundwater management**". As large parts of India particularly hard rock aquifers have become water stressed due to rapid growth in demand for water due to population growth, irrigation, urbanization, and changing lifestyle. Therefore, in order to have an accurate and comprehensive micro-level picture of groundwater in India, aquifer mapping in different hydrogeological settings at the appropriate scale is devised and implemented, to enable robust groundwater management plans. This will help in achieving drinking water security, improved irrigation facility, and sustainability in water resources development in large parts of rural and many parts of urban India. The aquifer mapping program is important for planning suitable adaptation strategies to meet climate change also. Thus, the crux of National Aquifer Mapping (NAQUIM) is not merely mapping, but reaching the goal-that of groundwater management through recommendation of appropriate management stratagies.

The Peninsular Shield consists mostly of crystalline rocks and consolidated sedimentary rocks. The occurrence and movement of groundwater in these formations are restricted to weathered residuum and interconnected fractures at deeper levels and have limited groundwater potential. The weathered zone is the potential recharge zone for deeper fractures and excessive withdrawal from this zone leads to drying up in places and reducing the sustainability of structures. Besides these quantitative aspects, groundwater quality also represents a major challenge, which is threatened by both geogenic and anthropogenic pollution.

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

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

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

**1.3 Area Details:** The Guntur district has a geographical area of 11,391 sq.kms, of which 8125 sq.kms is underlain by hard rock aquifer system, which is taken up in the NAQUIM in the AAP 2021-22. The study area lies between north latitude 15°49′-16°49′and east longitude 79°12′- 80°40' (**Fig.1.1**). Administratively the study area is governed by three revenue divisions – Narasaraopet, Guntur and Gurazala covering 36 mandals and 448 villages having a population of 27.5 lakhs (2011 census, population density of 152). Out of 36 mandals in the study area, 7 mandals (Chilakaluripeta, Edlapadu, Guntur, Mangalagiri, Nadendla, Pedakakani, Tadepalli) only parts are considered.

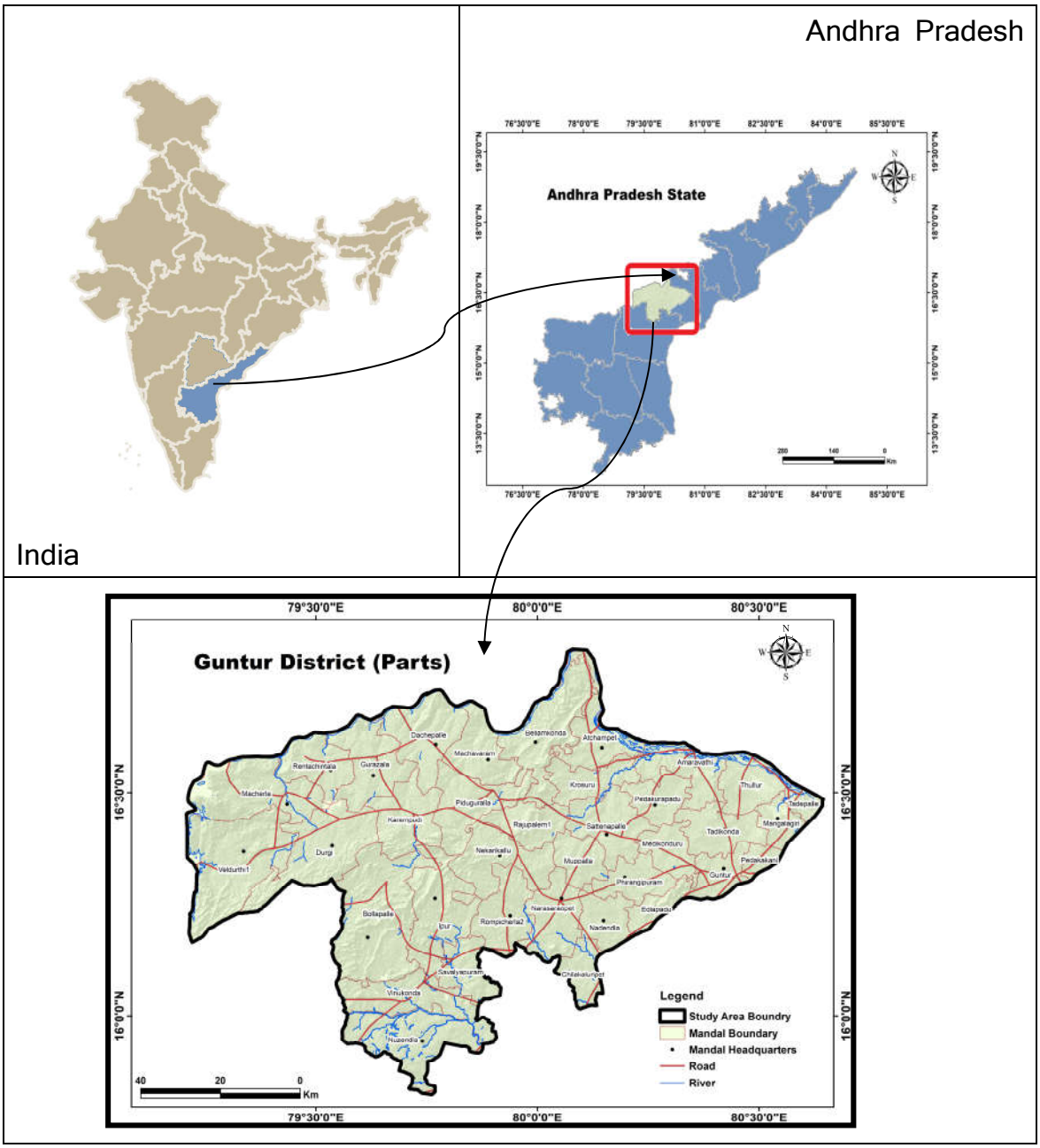



**Fig.1.1:** Location map of Guntur District (Parts)

**1.4 Climate and Rainfall:** The study area experiences tropical climate. Southwest monsoon enters into the district in June and lasts until the end of September and Northeast monsoon from October to December along with occasional cyclonic storms. Summer starts in the month of March and reaches peak in May with average highest temperature of 40°C and winter season starts in late November and lasts until early february with average lowest temperature of 18.6°C in January.

The annual normal rainfall of the area varies from 659 mm (Macherla mandal) to 997 mm (Mangalagiri mandal) with normal of 807 mm as per the data collected from IMD. Southwest monsoon normal rainfall (Avg: 512 mm) varies from 378 mm in Nuzendla to 640 mm in Tadepalle and during Northeast monsoon normal rainfall varies from 143 mm in Rentachintala to 282 mm in Vinukonda by (Avg:201 mm) and rest during winter period. Isohyetal map prepared using annual normal rainfall of mandals in the district collected from DES, Andrapradesh is shown in **Fig.1.2**.

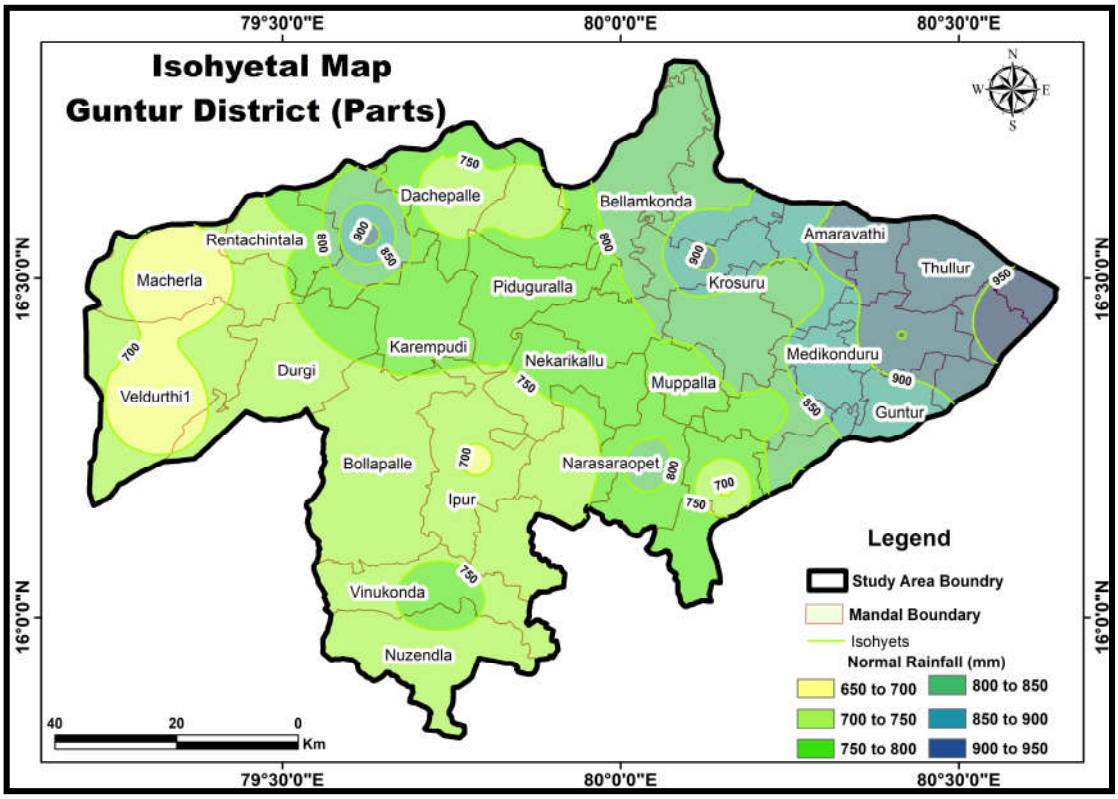



**Fig.1.2:** Isohyetal map Guntur District (Parts)

**1.5 Geomorphological Set up:** The study area predominantly consists of pediplain (60% of the area), structural hills (11 % of the area), pediment (10% of the area), structural valley (5% of the area), dissected plateau (5% of the area), channel fill (4% of the area) & remaining 5% of the area constitute other landforms. (**Fig:1.3**). The groundwater prospects are promising along valleys and foothills in the weathered and fractured zone.

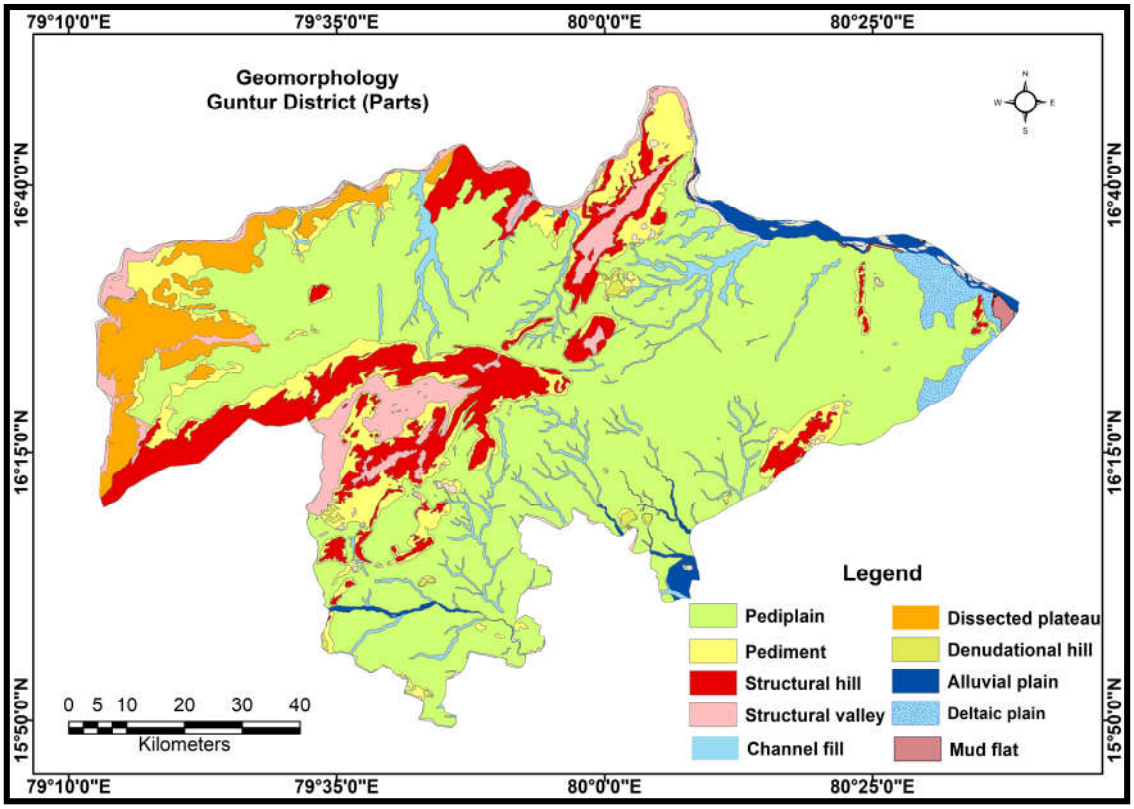



**Fig1.3:** Geomorphology Map

The shallow and moderately buried pediments are dissected pediments constitutes the pediplain unit in the area. They have gradational contact with each other and the thickness of the weathered residuum varies up to 30 m. The material comprises soil, gravel, clay, sand and silt. This unit is developed on crystalline rocks and metasedimentary formations (Koikuntla limestones, Paniam quartzites, Narji Limestones of Kurnool Group and Cumbum shales and phyllites of Cuddapah Super Group). The pediment area accelerates surface runoff with moderate to low infilteration along the jointed and weathered zone. The buried pediplains are suitable for construction of good yielding dug wells, dug cum bore well and shallow to deep bore wells.

## 1.6 Drainage

The major rivers draining the study area are Krishna and Gundlakamma. Other minor streams and rivulets flow into Gundlakamma and Krishna River. (**Fig.1.4**). The Krishna River forms the northern boundry of the district and flows to south between Guntur and Krishna district. Vogarru vagu flows from west to east. The general drainage pattern is sub parallel to sub-dendritic. The sub-parallel drainage in the area appears to be controlled by fractures and structures possibly of tectonic origin and the dendritic pattern in large controlled by erosional nature of terrain.

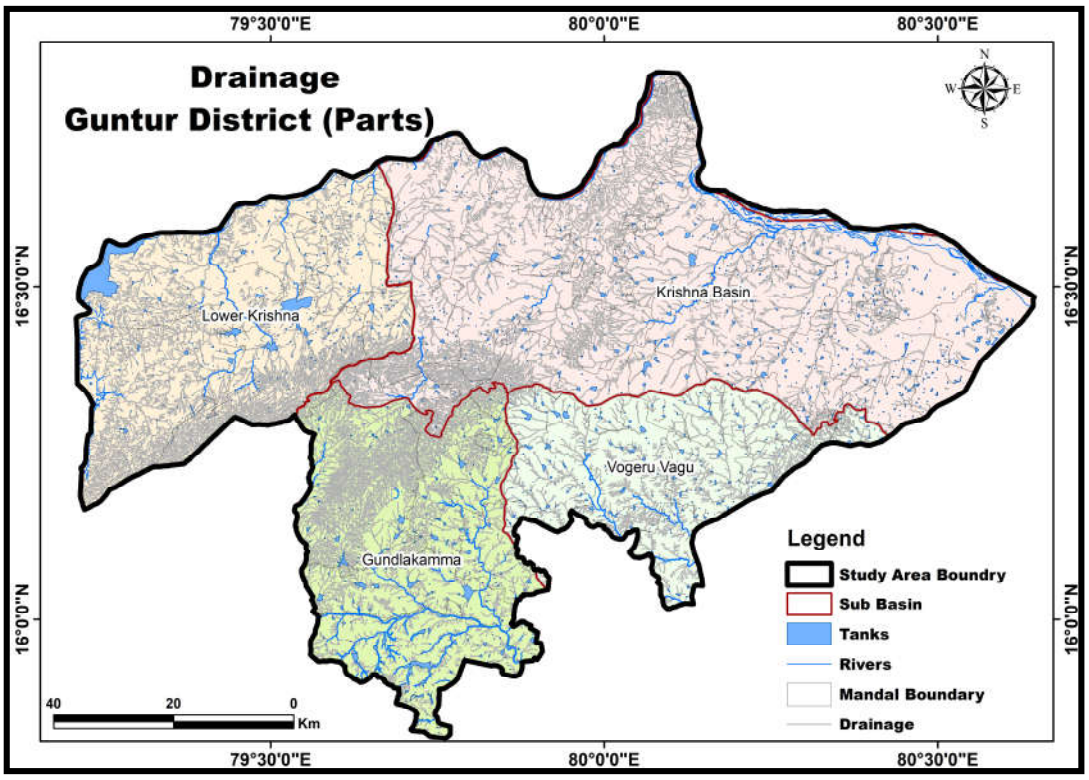



**Fig 1.4: Drainage Map**

**1.7 Soils:** Based on the soil texture, the area is mainly occupied by Clayey skeletal mixed and clayey mixed (31%), fine soil mixed (29%), fine montmorillonitic (23%), loamy skeletal (13%) and fine loamy mixed (4%) (**Fig.1.5**). Red sandy soils are seen in Vinukonda, Savalyapalem and Ipur mandals. Red gravelly soils are found in Achampeta and Krosur mandals. Black soils are found in Narasaraopeta areas. Red loamy and red gravelly soils are seen mostly in the upper reaches of hills, hillocks and also along hill slopes.

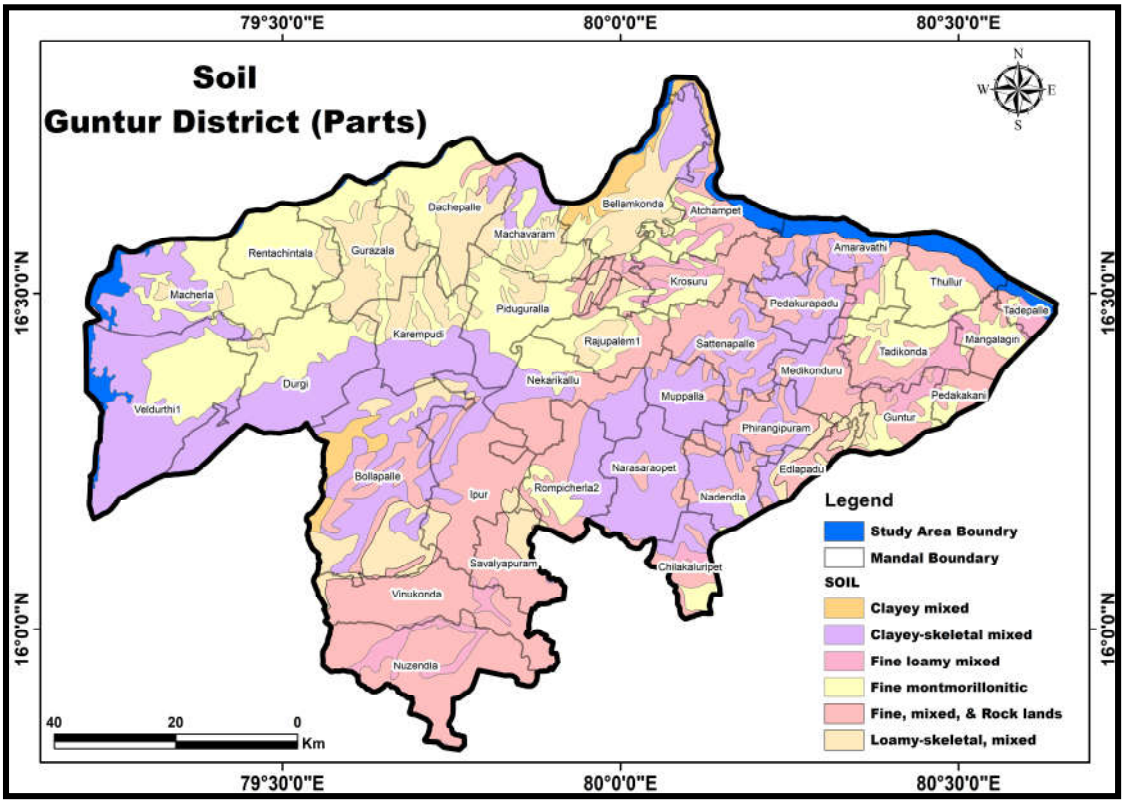



**Fig.1.5:** Soil map

**1.8 Land use and cropping pattern (2019-20):** Major part of the district is occupied by agricultural area (44%). In the district, forest occupies nearly 18% of the area, 16% of the area is put to non agricultural uses and 12% of the area is fallow land. Remaining area is occupied by plantation, builtup, water bodies and barren land etc (**Fig.1.6**). The total gross cropped area during the year 2019-20 is 4,15,655 ha and net sown area is 3,76,212 ha. The gross area cropped during Khariff season is 3,55,438 ha and the major crops grown during khariff season is Paddy (18%), cotton (48%), chillies (18%) and total pulses (5%) and 11% remaining other crops. The gross area cropped during Rabi season is 60,217 ha and the major crops grown during the period are Paddy (40%), Pulses (33%), Maize (11%), Tobacco (3%) and remaining 13% by other crops. Season wise cropping pattern is given in **Fig.1.6a and Fig.1.6b.**

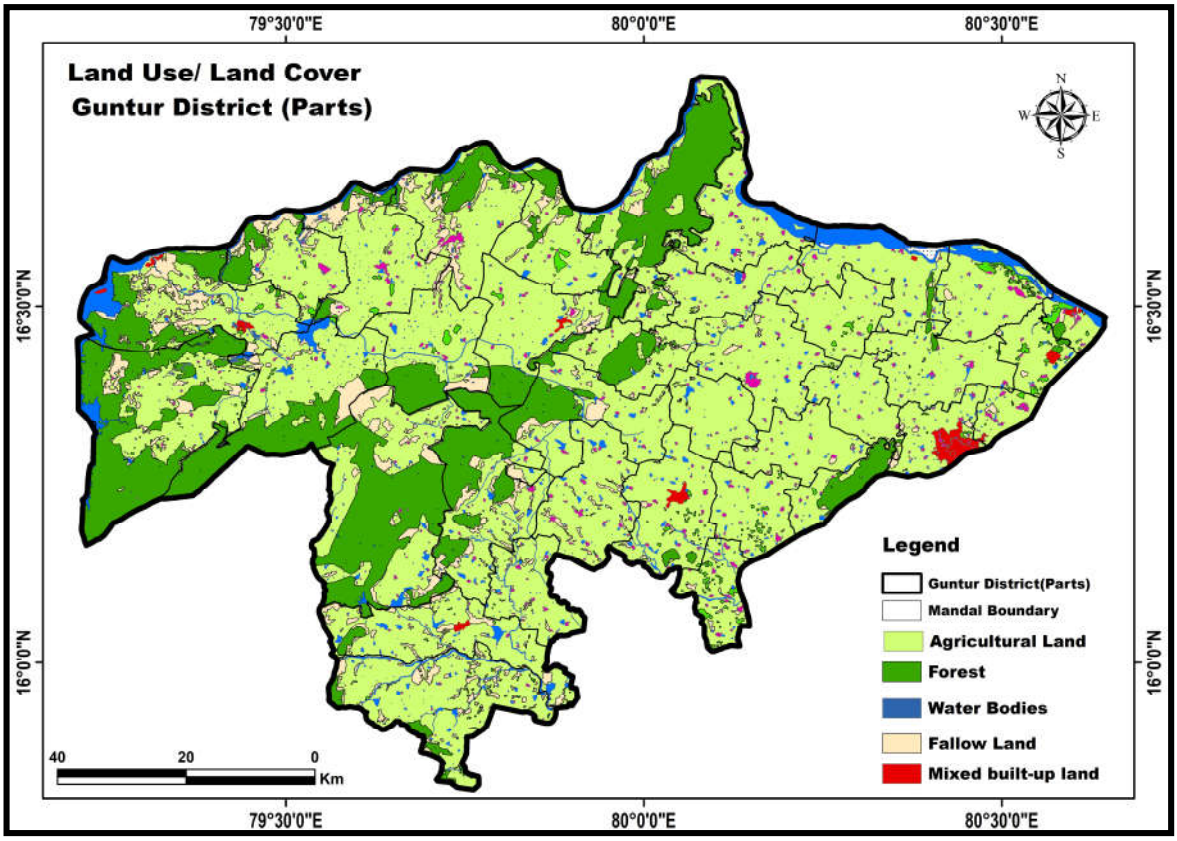



**Fig-1.6:** Land use pattern of Guntur District (Parts)

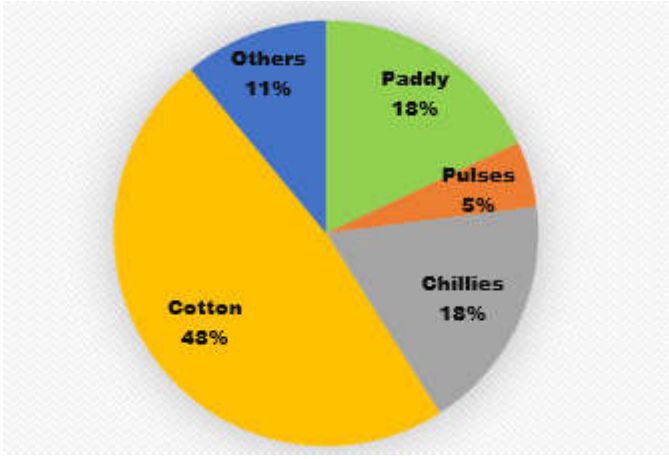



**Fig .1.6a:** Kharif Major Crops

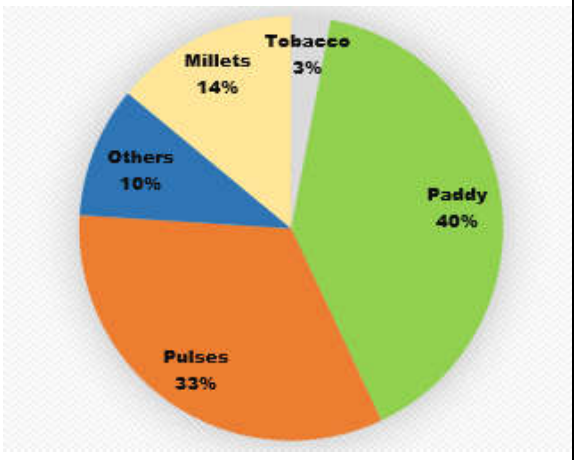



**Fig .1.6b:** Rabi Major Crops

## 1.9 Irrigation Projects:

The Nagarjuna Sagar multipurpose project was constructed on the river Krishna is located near the then Nandigonda (Village now Hill colony) in Nalgonda District is the pride of Independent India. The districts benefited under NSP are Guntur, Prakasam, Krishna, Nalgonda, Khammam and West Godavari **(Fig 1.7).** The localised ayacut of Nagarjuna Sagar Right (Jawahar) Canal in the study area is 2,40,998 ha.

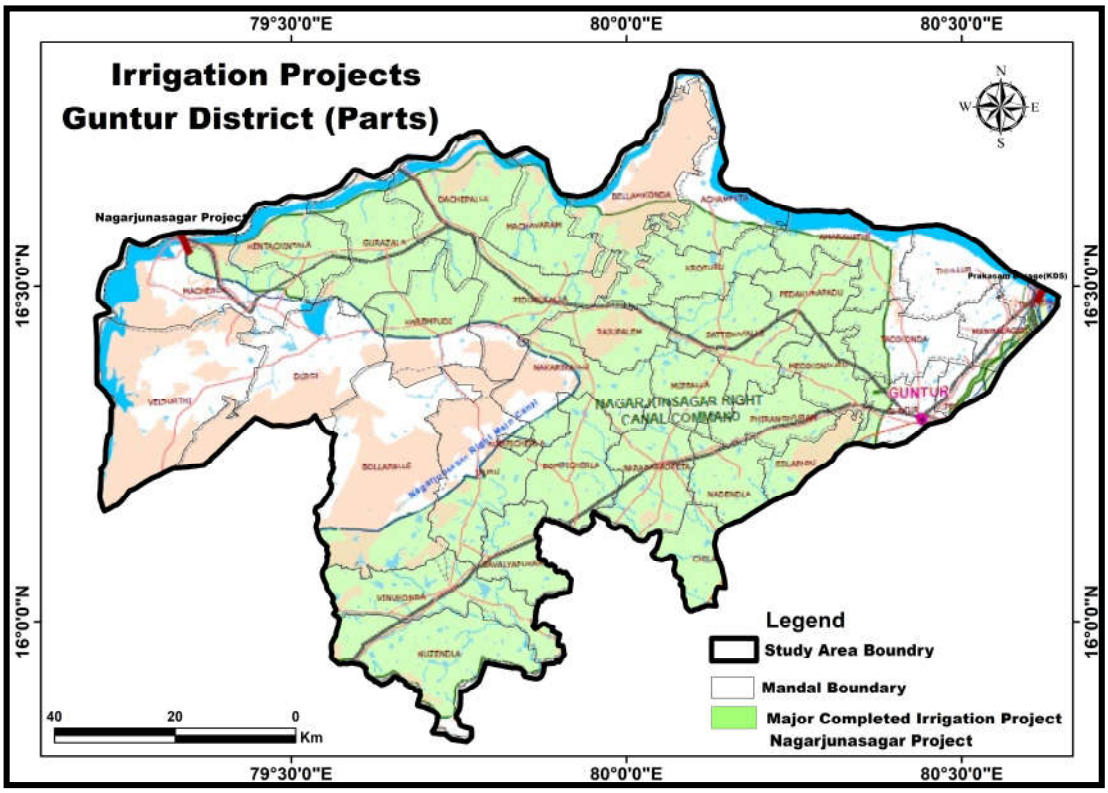



**Fig 1.7** Irrigation Projects in Guntur

**Table 1.1:** Area Irrigated

| AREA | No. of Mandals | Gross Area Irrigated (ha) | Area Irrigated More Than Once (ha) | Net Area Irrigated (ha) |
|---|---|---|---|---|
| Guntur (Parts) | 36 | 235029 | 25291 | 209738 |

**Table 1.2: Salient Features of Irrigation in Guntur District.**

| Source | | Numbers | Gross Area irrigated (ha) |
|---|---|---|---|
| Ground Water Irrigation | | | |
| Tube wells | Shallow | 6152 | 63680 |
| | Medium | 4935 | |
| | Deep | 11037 | |
| Dug wells | | 7910 | 5102 |
| Total | | | 68782 |
| Surface Water Irrigation | | | |
| Canals | | - | 155829 |
| Tanks | | - | 2342 |
| Lift Irrigation | | 1737 | 6812 |
| Other Sources | | - | 1264 |
| Total | | 1737 | 166247 |

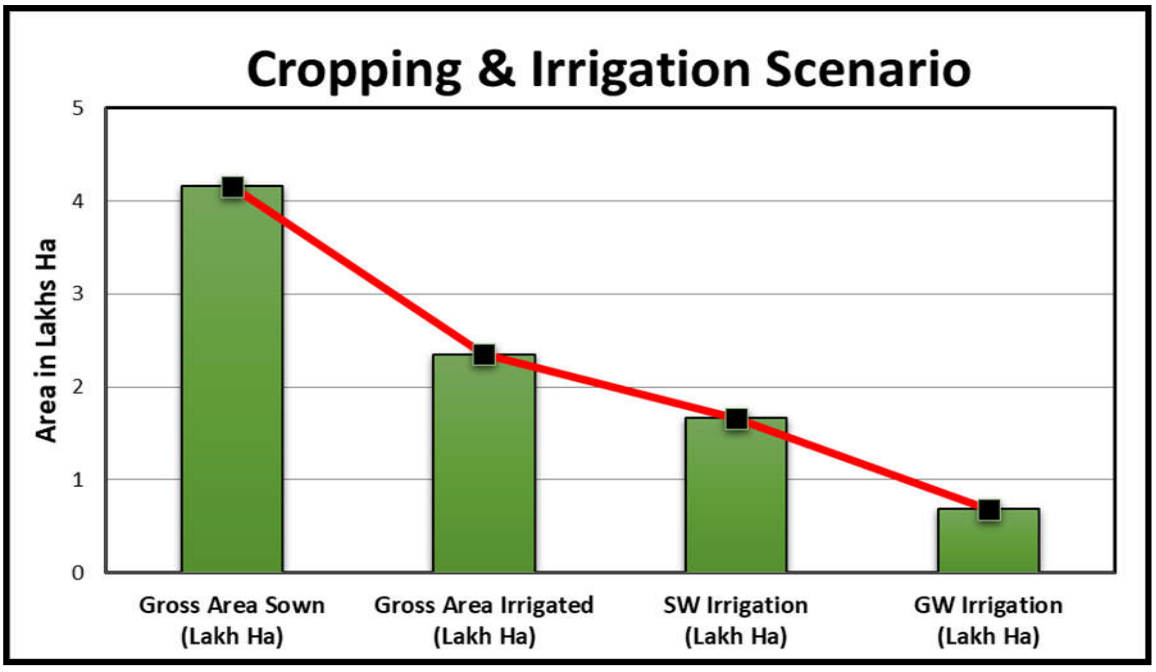



**Fig.1.8:** Cropping and Irrigation Scenario

Out of the total Gross area sown of 415655 ha, 57% of the cropped area is under irrigation (**Fig.1.8**) & (**Table 1.1**). In which, 70% of the irrigation is through surface irrigation and 29% of the area is irrigated through ground water irrigation (**Table 1.2**).

## 1.10 Geology:

The study area is underlain by various geological formation from Archean to Recent. (**Table:1.3**). The Archean basement complex comprising the granite gneisses, migmatites, schists and is followed by Cuddapah Super Group of rocks and Kurnool Group of rocks. The Archean Granitic Gneiss and granites covers 29% of the area and charnockites covers 17%. The Precambrian metasedimentary formation of Kurnool and Cuddapah system covers 54% of the area (**Fig1.9**) and (**Fig 1.10**).

**Table 1.3**: Stratigraphy of Guntur District (Parts)

| Era | Period | Formation |
|---|---|---|
| Quaternary | Sub-Recent to Recent | Alluvium |
| Pre-Cambrian | Kurnool System | Narji Limestone & Owk shales |
| | Cuddapah System | Quartzites & Phyllites, Cumbum shales |
| **……Unconformity……** | | |
| Archean | Dharwar (Basement Complex) | Veins of Pegmatite, dolerite dykes, Granite Gneisses, Charnockites khondalltes |

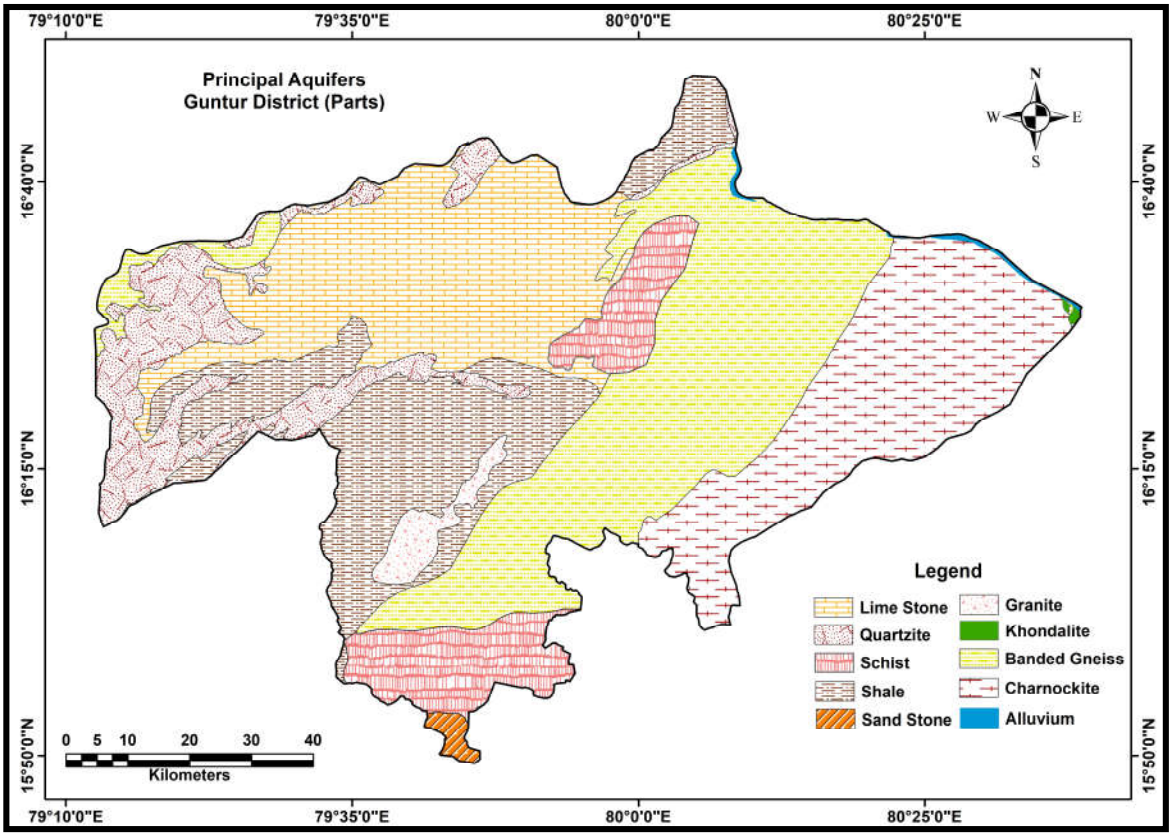



**Fig.1.9:** Principal Aquifers of Guntur District (Parts)

**Archean Rocks:**

The Archean rocks comprising of Charncokites, Granites, Granite Gneisses are intruded by basic rocks. Outcrops of Archeans are also seen as "Inliers" within the Cuddapah formations. The Granite Gneisses exhibit gneissosity trending NNE-SSW to ESE-WSW. They are light grey in colour and coarse grained with porphyritic texture at places. They are hard, compact and massive to jointed. The Khondalites are seen at Vinukonda, Narasaraopeta areas. The crystalline formation has developed secondary porosity with weathering, jointing and fracturing which enable these rocks to become water bearing and water yielding.

**Cuddapah Super Group of Rocks:**

The Cuddapah Super Groups of rocks consist of phyllites and slates belonging to Cumbum formation. The quartzites generally form the relief areas and phyllites occupy valleys and plains. Phyllites generally grades into slate and at places into shale. The bedding plane of phyllites generally strike

N10 E-S 19 W with easterly dip. Cumbum shales forming the core of the synclical folds. A typical feature in this is the domal upwards as seen near Nakrekallu and Achampeta areas.

**Kurnool Group of Rocks:**

Kurnool Group is also referred as Palnad series. The formation of this group occurring in the stratigraphic succession are Banganapalli Conglmerate/Quartzite, Narji limestone and owkshales. The important formation is the Narji limestone which are seen in and around Piduguralla, Dachepalli, Gurzala, Rentachinthala, and Macharla mandals. The Narji Limestone are good quality white, grey or buff coloured, compact limestones with conchoidal fractures whereas Banganapalli quartzites are hard, pebbly and white to black in colour.

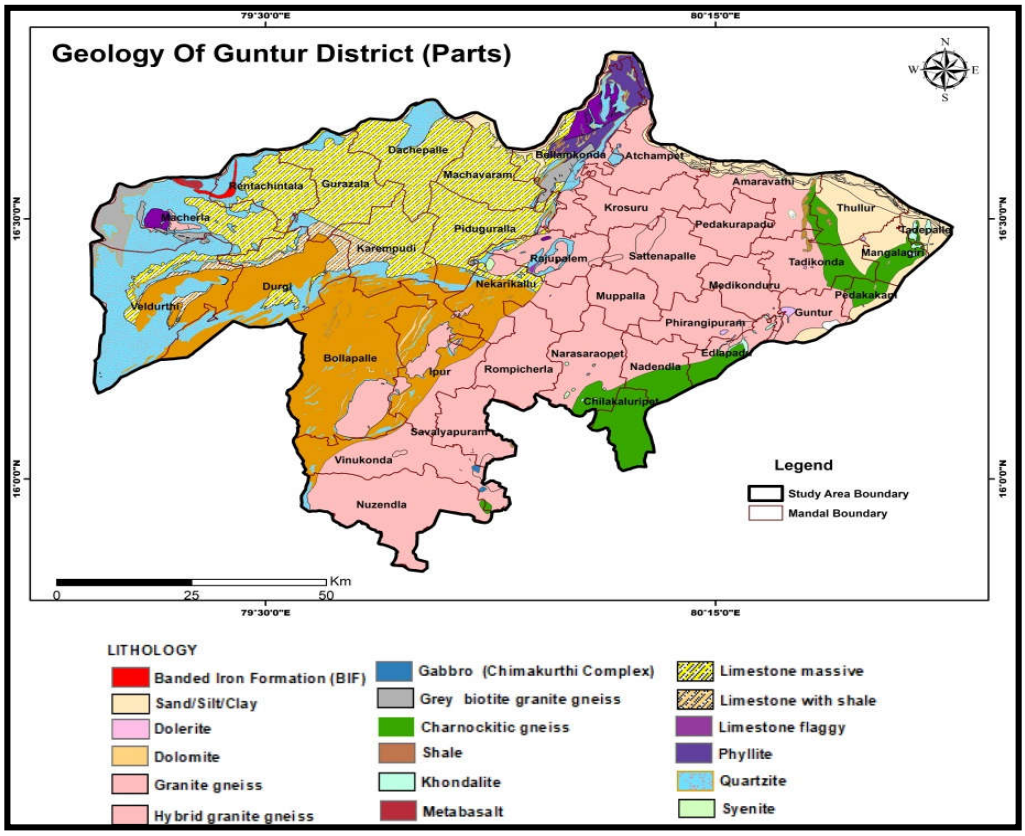



**Fig 1.10:** Geology of Guntur District (Parts)

## 2. DATA COLLECTION AND GENERATION

Collection and compilation of data for aquifer mapping studies are carried out in conformity with the Expenditure Finance Committee (EFC) document of XII plan of CGWB encompassing various data generation activities **(Table-2.1)**. The historically available data of Geology, Geophysics, Hydrogeology, and Hydrochemistry generated under various studies by the CGWB through Systematic Hydrogeological studies, Reappraisal Hydrogeological studies, Groundwater Management studies, Exploratory drilling, and special studies have been utilized for data gap analysis, along with the data collected from various State and Central government departments (**Fig 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- | Vertical Electrical Sounding (VES), bore- |

| | | | |
|---|---|---|---|
| | | surface geo-electrical and gravity data generation | hole logging, 2-D imaging etc. |
| | | Hydrological Parameters on groundwater recharge | Soil infiltration studies, rainfall data analysis, canal flow and recharge structures. |
| | | Preparation of Hydrogeological map (1:50, 000 scale) | Water level monitoring, exploratory drilling, pumping tests, preparation of sub-surface hydrogeological sections. |
| | | Generation of additional water quality parameters | Analysis of groundwater for general parameters including fluoride. |
| 3. | Aquifer Map Preparation (1:50,000 scale) | Analysis of data and preparation of GIS layers and preparation of aquifer maps | Integration of Hydrogeological, Geophysical, Geological and Hydro-chemical data. |
| 4. | Aquifer Management Plan | Preparation of aquifer management plan | Information on aquifer through training to administrators, NGO's, progressive farmers and stakeholders etc. and putting in public domain. |

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

**2.1 Exploratory Drilling:** Information on aquifer geometry, groundwater potential of various formations, fracture systems, their characterization is primarily inferred from the exploratory drilling data. CGWB has a total of 113 exploratory wells in the study area constructed between 1997 to 2021. Out of these, 91 wells were drilled before 2012 and 22 wells in 2021-22 based on the data gap analysis carried out in the study area as part of NAQUIM.

A total of 138 exploratory borewell data of CGWB (113) and SGWD (25) were used for the hydrogeological analysis. Out of these exploration, 61 exploratory wells are located in eastern parts of the study area mainly comprising of Charnockites and Granite gneisses, the remaining 72 exploratoin wells in meta sedimentary formations comprising of lime stone, quartzites and shales.

**2.2 Water Level:** Water level monitoring wells of CGWB and SGWD is utilized for the Aquifer Mapping studies. CGWB monitors 53 NHS stations in the study area out of which 41 are dug wells and 12 Piezometers and State Ground water department monitors 84 piezometers in the study area. CGWB wells are being monitored four times (January, April, August and November) in a year whereas; the monitoring wells of State Ground Water Department (SGWD) are being monitored every month. These 137 groundwater monitoring wells were used in order to understand the annual as well as decadal spatio-temporal behaviour of the groundwater regime.

**2.3 Hydro chemical Studies**: Water quality data of CGWB and SGWD is utilized for understanding the spatial variation of quality in the district. A total of 60 Pre monsoon (CGWB: 27, SGWD: 33) ground water monitoring well data of Central Ground Water Board and Andhra Pradesh State Ground Water Department (mostly tapping combined aquifers Aq-1 and Aq-2) is utilized to understand the chemical characteristics of groundwater. 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 Geophysical Studies**: Geophysical data on VES and profiling are used to extract information on the weathered thickness, fracture depth, thickness of fracture etc in the study area. For the interpretation of the aquifer geometry geophysical data in conjunction with the available groundwater exploration data is utilised. A total of 55 VES studies and 36 TEM studies have been carried out in the district as per data gap nalysis in the year 2021. Out of which 5 TEMS are carried out in western parts of the study area where meta sediments are predominant. Out of total 55 VES, 30 VES have been conducted in Meta Sedimantary formations of the study area. The

measurements were taken at the central part of the profile leaving 200 m on either side of the profile.

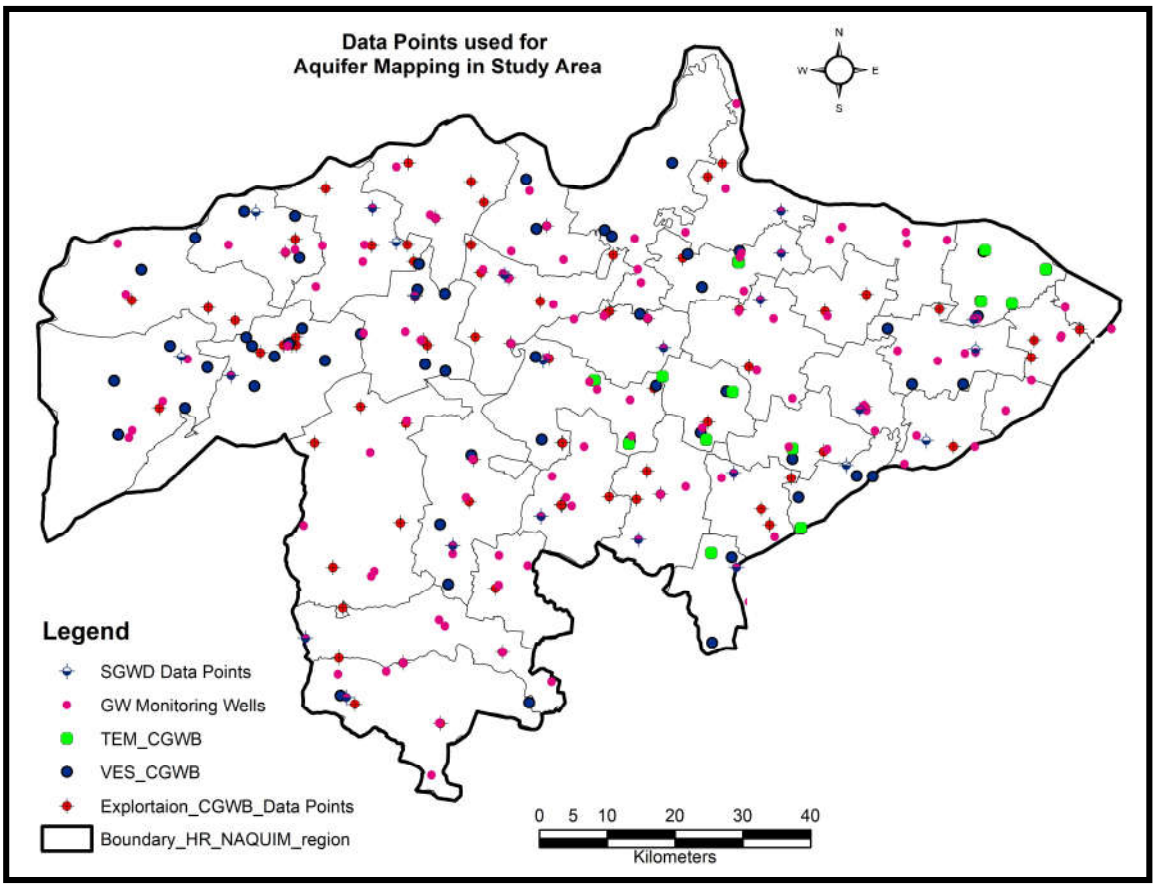



**Fig. 2.1:** Data availability of Guntur District (Parts)

## 3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

### 3.1. Ground Water Level Scenario

#### 3.1.1 Depth to Ground Water Levels

Analysis of the pre-monsoon and post-monsoon water level data from 137 (CGWB: 53, SGWD: 84 PZ) groundwater monitoring wells shows that depth to water level varies from <1 m to 52 m bgl with an average of 7.25 mbgl during pre monsoon and <1 m - 35 m bgl during post-monsoon season with an average of 5.2 m bgl.

**Pre-monsoon season:** In Majority of the areas, water level during this season is in the range of 5-10 m in 46% of the area, followed by shallow water level <5 m bgl in 30% of the area and 10 to 20 m bgl in 15% of the area. Deeper water levels in the range of > 20 m bgl occupy about 9% of the area falling in parts of Veldurthi, Macherla and Durgi mandals (**Fig.3.1**).

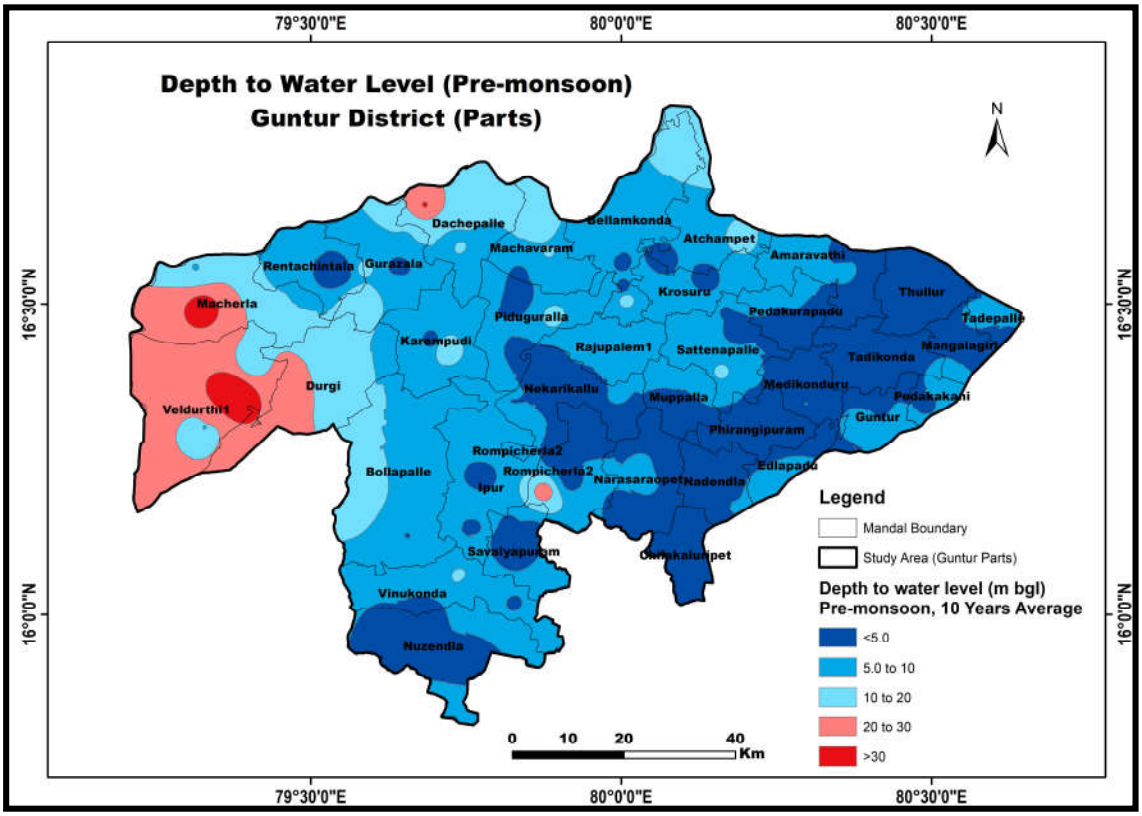



**Fig.3.1:** Depth to water levels Pre-monsoon

**Post-monsoon season:** Majority of the water level during this season are in the shallow water level range of <5 m covering 46% of the area followed by 5 to 10 m bgl in 39% of the area and 10 to 20 m bgl in 11 % of the area (**Fig.3.2**). Deeper water level < 20 mbgl occupy about 4% of the area in parts mainly in parts of Veldurthi, Macherla and Durgi mandals.

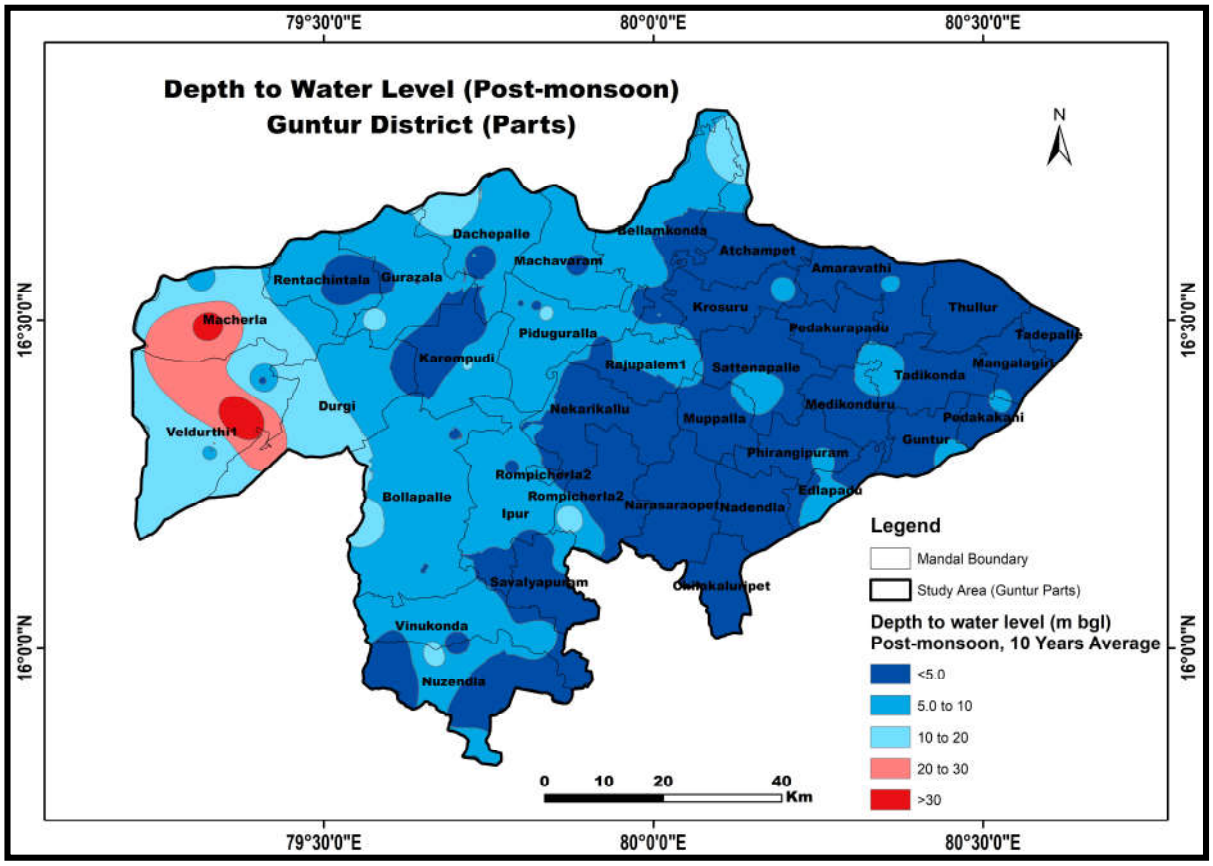



**Fig.3.2:** Depth to water levels post-monsoon

**3.1.2 Seasonal Water Level Fluctuations (May vs. November)**: Out of 137 wells, 109 wells records water level rise. The water level rise varies from <1 to 11.5 m in all the wells (**Fig.3.3**). Rise in water level between 0 to 3 m is observed in 72% of the area, 3 to 5 m rise is observed in 11% of the area. Rise in water level **>** 5 m is observed in 8% of area. Water level fall is recorded in 28 well.

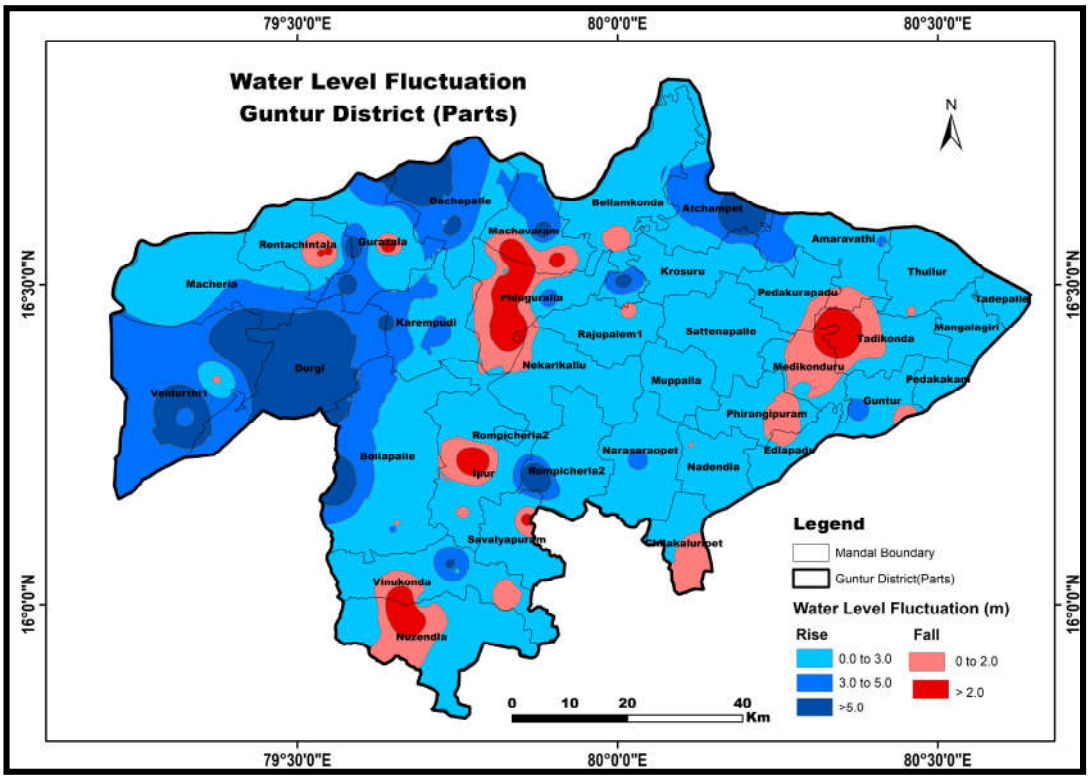



**Fig.3.3:** Water Level Fluctuation (m) (Nov with respect to May)

**3.1.3 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 that during pre-monsoon season, 117 wells shows falling trend in the range of 0.01 m/yr to 1.9 m/yr and 20 wells shows rising trend 0.02 m/yr to 0.5 m/yr. During post-monsoon season 57 wells show falling trend 0.01 to 1.5 m/yr and 80 wells shows rising trends 0.01-0.5 m/yr (**Fig. 3.4 a-b)**.

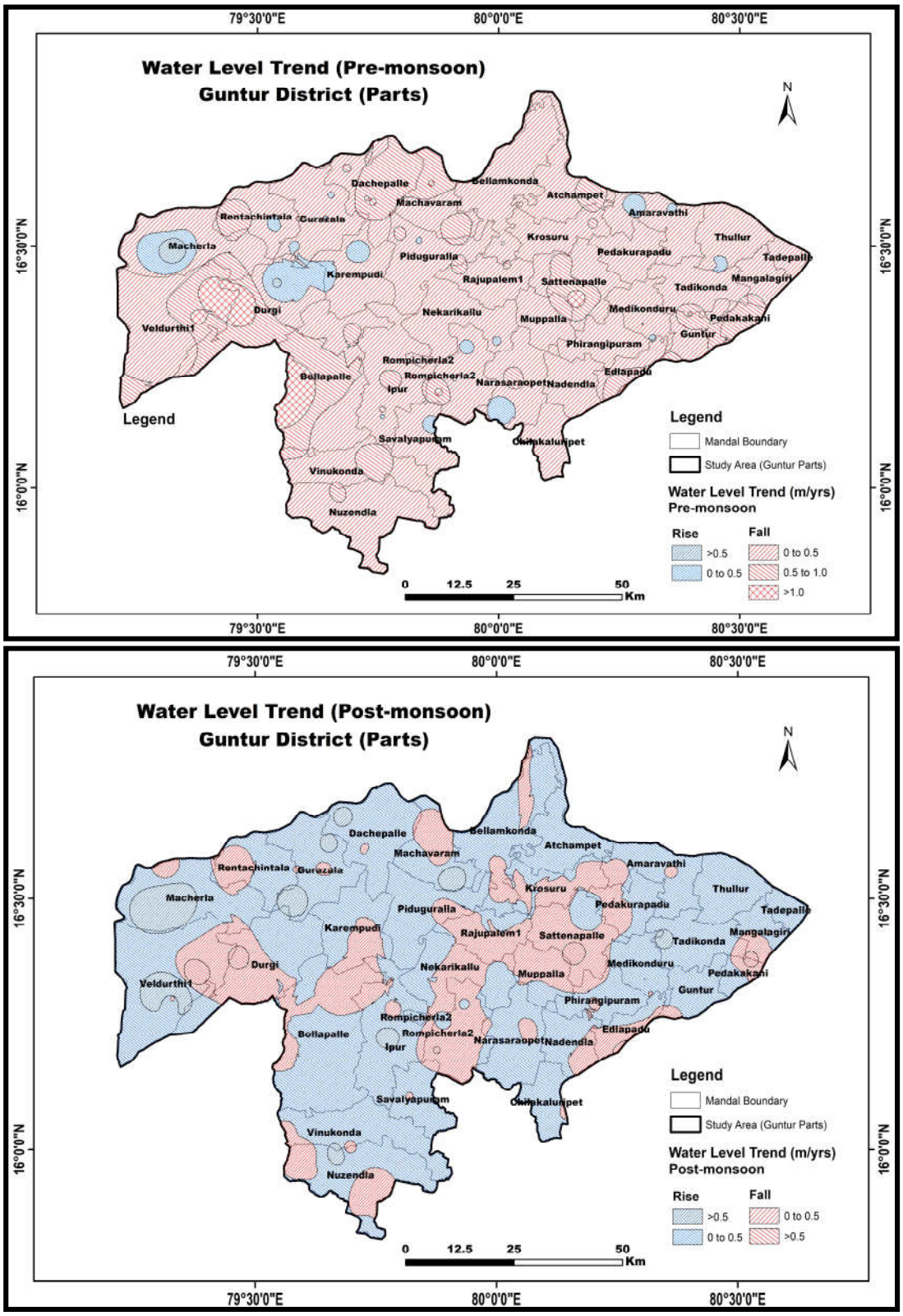



**Fig.3.4 a &b.** Long term water level trends (10 yrs)

**3.1.4 Water Table Elevation:** During Pre-Monsoon, water-table elevation ranges from 5-235 meter above mean sea level and in post-monsoon season 8-242 meter above mean sea level (m amsl). The ground water flow also has the same drainage flow direction. (**Fig.3.5**).

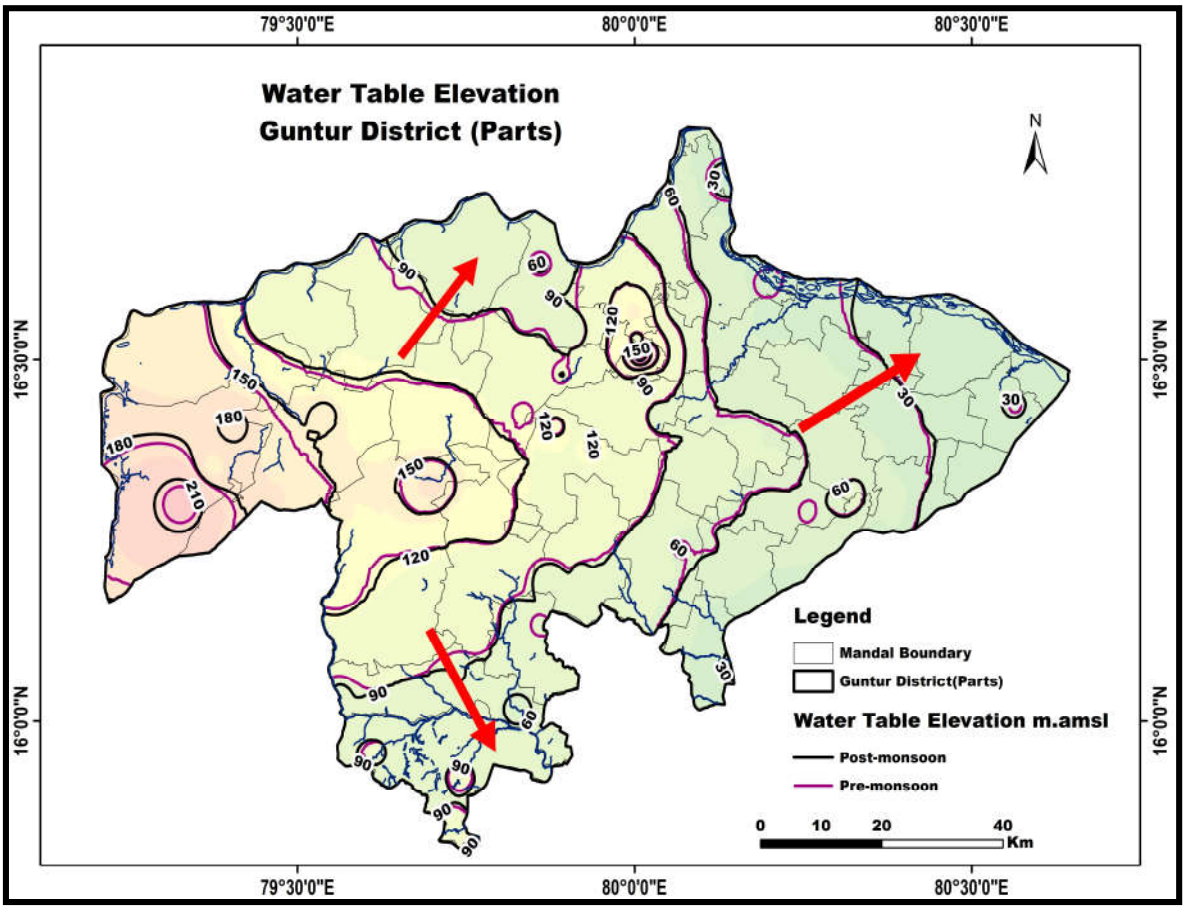



**Fig 3.5:** Water Table Elevation

## 3.2 Ground Water Quality

The groundwater quality in the area is generally good. In all the locations PH is within the acceptable limit and shows mildly alkaline nature.

**Pre-monsoon:** Groundwater is mildly alkaline with pH in the range of 6.90-8.07 (Avg: 7.6). Electrical conductivity varies from 622-7210 (avg: 2697) µ Siemens/cm. In 23 % of area, EC is within 1500 µ Siemens/cm, in 42 % area, it is between 1500-3000µ Siemens and in 35% of area it is beyond permissible limit. (**Fig.3.6**). Average concentration of TDS is 1607 mg/L and $NO_3$ ranges from 1-560 mg/L. Nitrate concentration in 56% of samples is beyond permissible limits of 45 mg/L (**Fig.3.7**). Fluoride concentration varies

from 0.10-2.23 (**Fig 3.8**) with 10% of samples is beyond the permissible limits of BIS and rest is within the permissible limit.

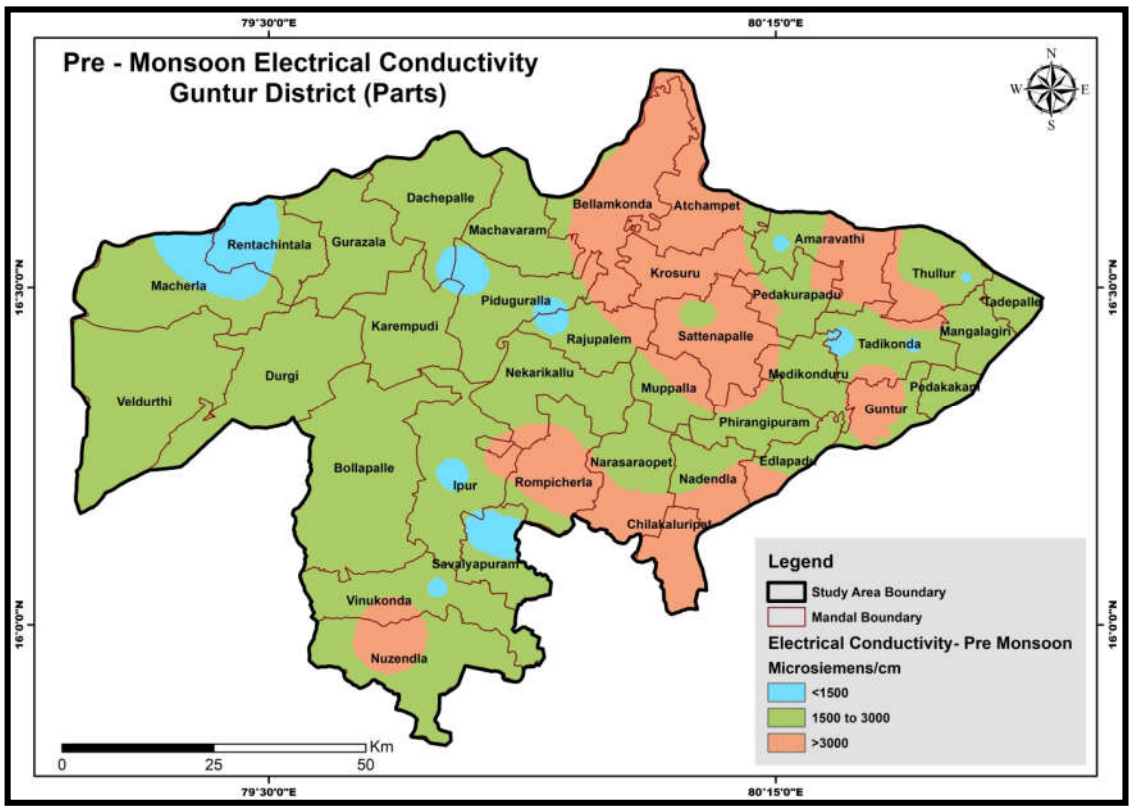



**Fig.3.6:** Pre monsoon EC distribution

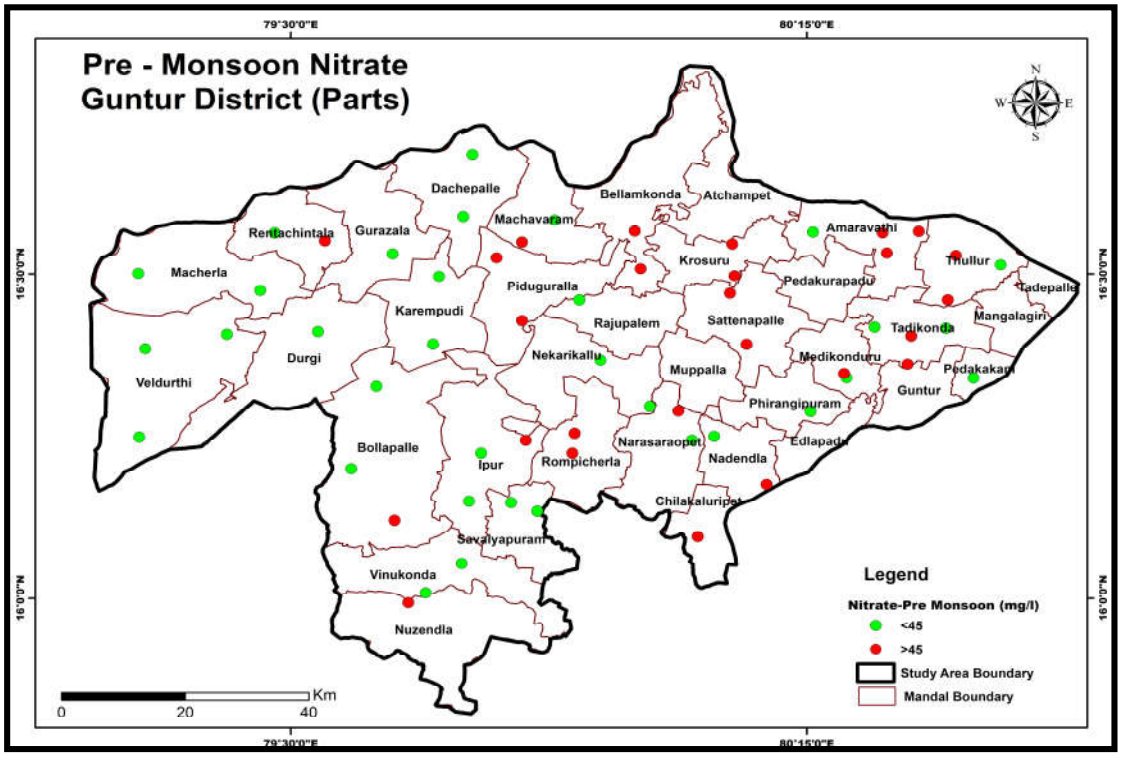



**Fig.3.7:** Pre monsoon Nitrate distribution

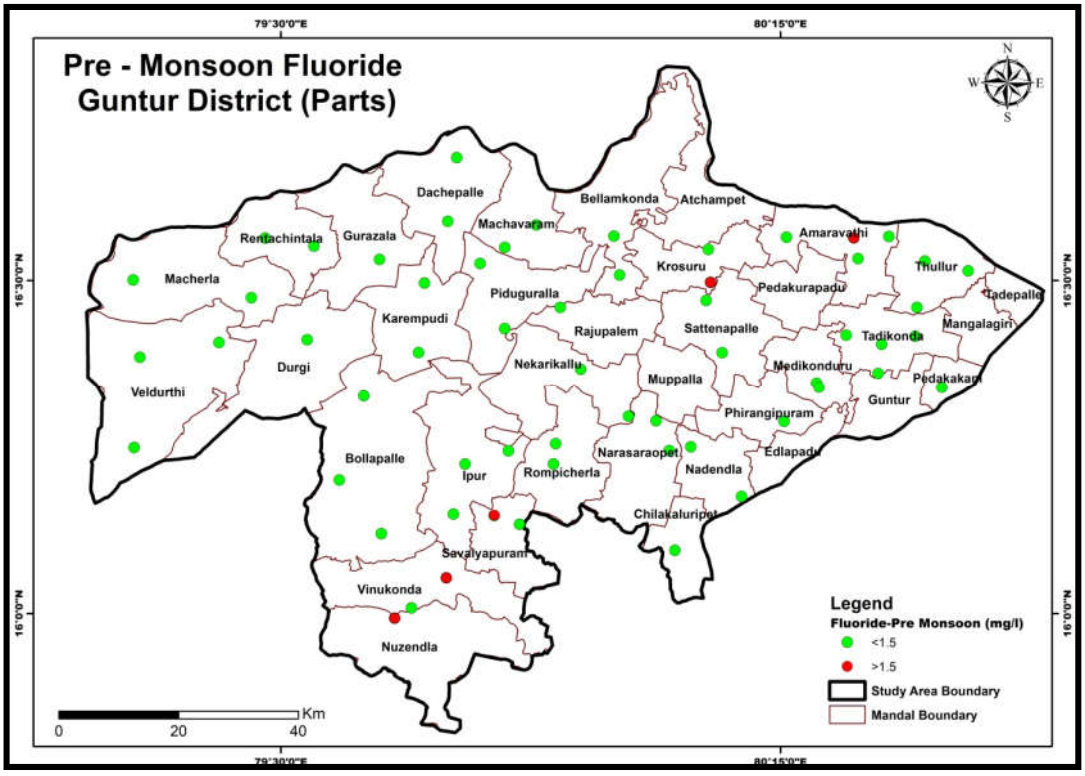



**Fig.3.8:** Premonsoon Fluoride distribution

## 3.3 AQUIFER MAPPING

The aquifer geometry for shallow and deeper aquifer has been established through hydrogeological studies, exploration, surface and subsurface geophysical studies in the district. Aquifers were characterized in terms of potential and quality. The aquifer wise characteristics have been delineated and are shown in **Table 3.1.** Hydrogeology map in the **Fig. 3.11**.

### 3.3.1 Aquifer System

**Aquifer Characterization:** On the basis of occurrence and movement of ground water, hard rock units of the study area are classified into two categories; Archean crystalline and Metasedimentary formations. Weathered and fractured Archean crystalline rocks (Charnockites and Granite Gneisses) form the archean aquifer system. Metasedimentary aquifer system overlies archean crystalline rocks aquifer system. The main aquifers constitute the weathered zone at the top, followed by a discrete anisotropic fractured zone at the bottom. Ground water occurs under unconfined and semi-confined conditions and flows downward from the weathered zone into the fracture

zone. The aquifer units identified includes **- Shallow Aquifer and Deeper Aquifer.**

**Weathered zone:**

Thickness of weathered zone in the range of 10 to 30 m in most part of area covering ~64 % of area, shallow weathering <10 m occurs in 28 % of the area, 20 to 30 m in 7% of the area and deep weathering (**>** 4 m) occurs in rest of the area (**Fig.3.9**).

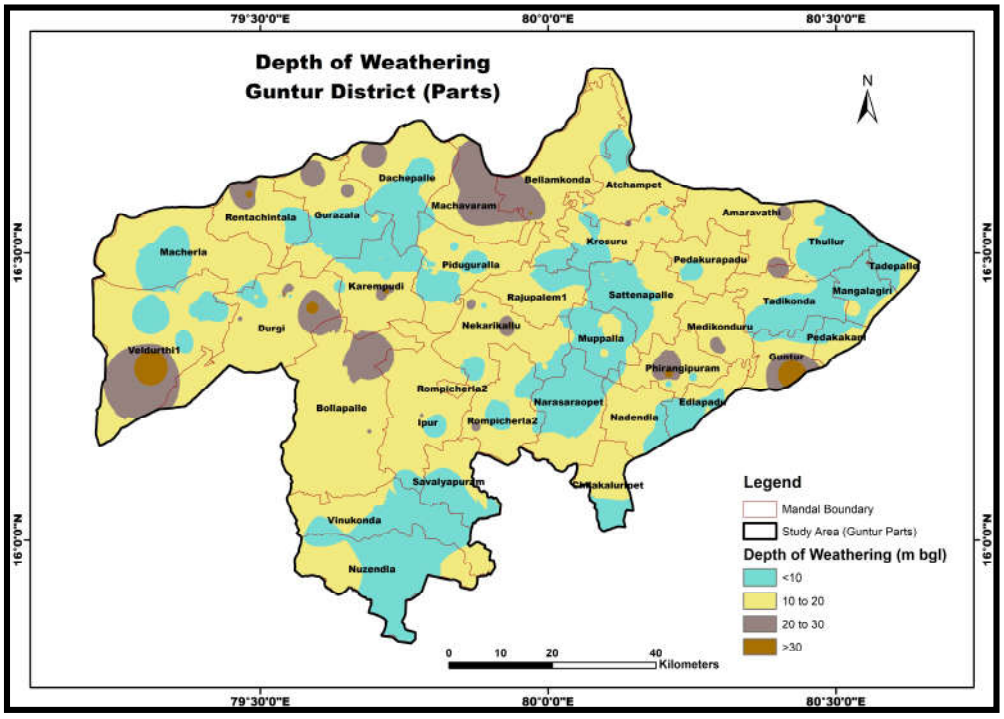



**Fig.3.9:** Weathered zone

**Aquifer Characterization of Shallow Aquifer: (Aquifer-1):** It consists of weathered residuum where ground water occurs under water table condition and is mainly developed by construction of dug wells or shallow bore wells as hand pump. The shallow aquifer is considered up to the maximum depth of weathering and first fracture encountered (below weathered depth) generally down to ~30 m depth. They are unconfined aquifers. Ground water yield varies from <1 lps (avg: 1.0 lps) in weathered granite/gneiss aquifer to 1 to 10 lps (avg: 5 lps) in metasedimentary aquifers.

**Fractured Zone:** Based on CGWB & SGWD data, it is inferred that fractures in the range of <60 m depth is more predominant (55 % of the area), 60-90

m in 30 % of the area and >100 m fractures occur in remaining areas. Deep fractures in the range of >180 m occur in Krosuru, Tadikonda, Piduguralla, Bellamkonda and Chilakaluripeta. The deepest fracture encountered is 192 m in Dodleru and Mothadka villages in Krosuru and Tadikonda mandals respectively. Analysis of occurence of fractures reveal that majority of fractures (~80 %) occur within 100 m depth (**Fig. 3.10)**

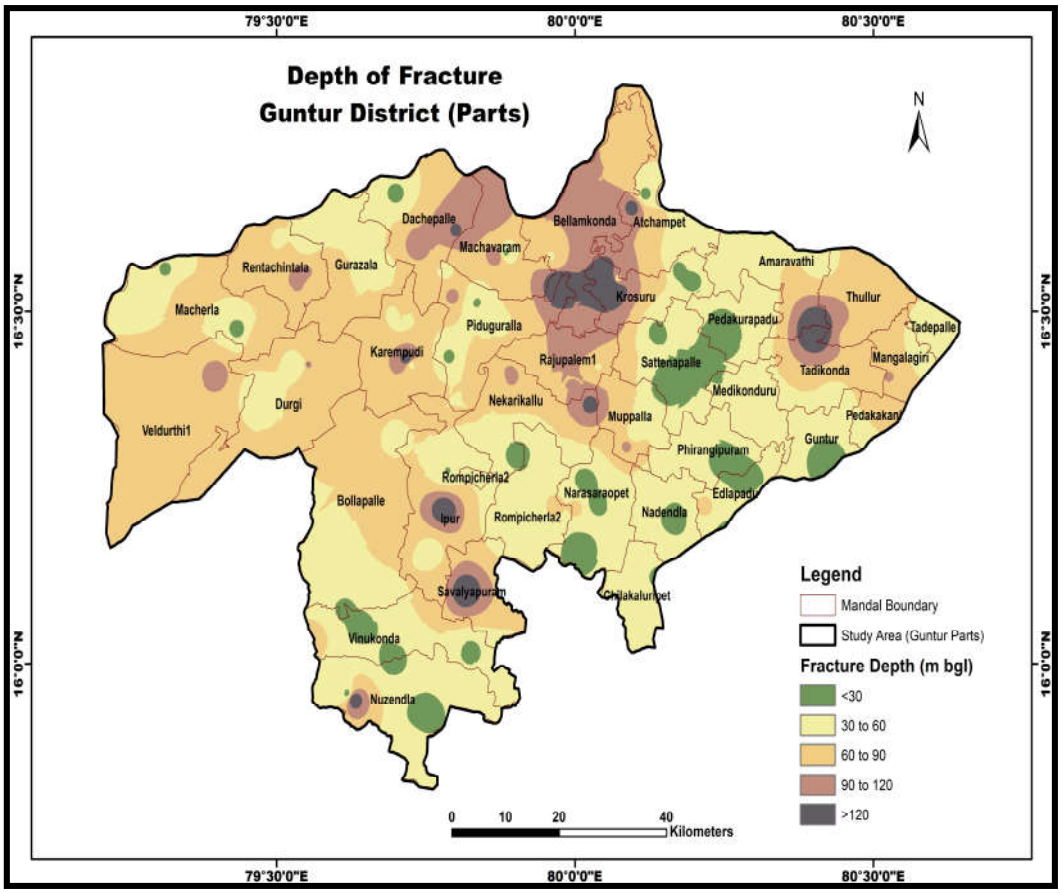



**Fig.3.10:** Depth of occurrence of fracture zone

**Aquifer Characterization of Deeper Aquifer (Aquifer II):** The aquifer-II is the deeper aquifer which tapped the fractured zone. Ground water in the second aquifer occurs under semi-confined to confined condition in the fractures upto the maximum depth of 192 m bgl (deepest fracture encountered). The deth of fracturing varies from 30 m to 192 m with yield of <1 to 3 lps. The transmissivity of consolidated formation varies from <1 to more than 100 sq.m/day. The storativity in granite gneisses and charnockites varies from 0.001 to 1 x $10^{-5.}$

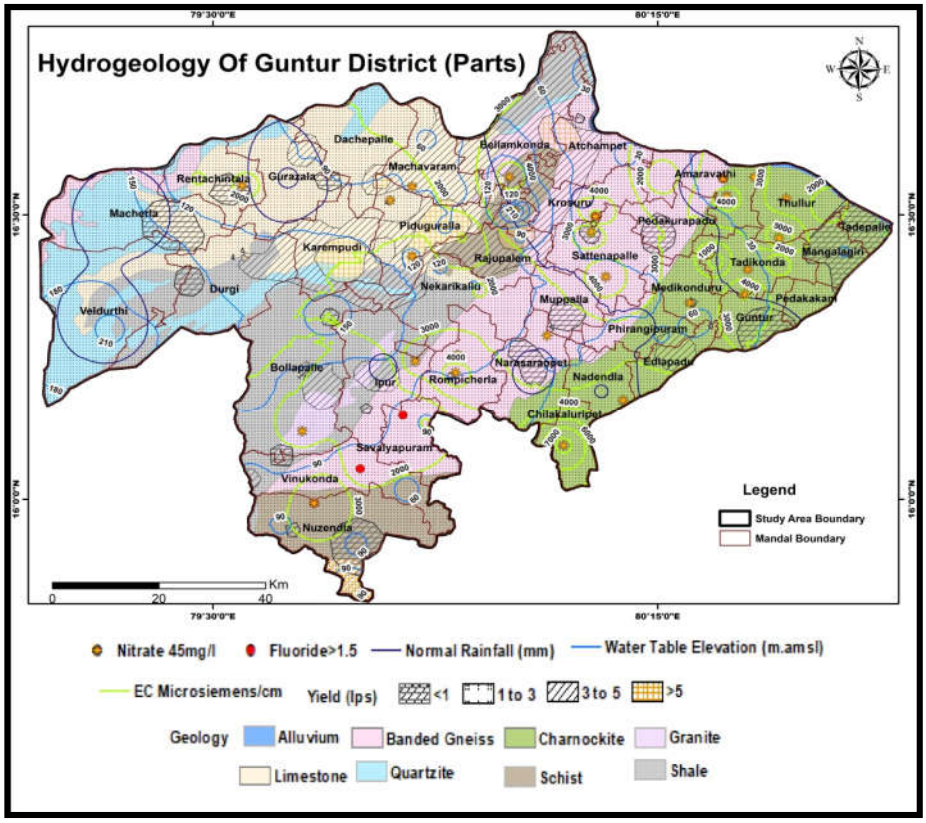



**Fig 3.11**: Hydrogeology of Guntur district (Parts)

**Table 3.1:** Hydrogeological Characteristics

| Era | Pre-Cambrian | | Archean Crystallines | |
|---|---|---|---|---|
| Prominent Lithology | Meta sedimentary Formation | | Granite Gneiss/Charnockite (Basement) | |
| Aquifer types | Aquifer-1 (Weathered Zone) | Aquifer-2 (Fracture Zone) | Aquifer-1 (Weathered Zone) | Aquifer-2 (Fracture Zone) |
| Thickness range | 1 - 30 m | up to 200m | 1 - 30 m | up to 200m |
| Depth of range of occurrence of fractures | - | 85% fracture encountered between Within 100 m | - | 80% fracture encountered between 30 - 100 m |
| Range of yield potential | <1 to 3 | Avg: 5 lps | <1 | Avg: 3 lps |
| Storativity | | | | 0.001 to 1 x $10^{-5}$ |
| Transmissivity (m2/day) | More than 1 to >100 sq.m/day | | | |

### 3.3.2 Aquifer Disposition 3D and 2D

Conceptualization of 3-D hydrogeological model was carried out by interpreting and integrating representative 185 data points (both hydrogeological and geophysical down to 200 m) for preparation of 3-D map, panel diagram and hydrogeological sections. The lithological information was generated by using the RockWorks-16 software and generated 3-D map of study area (**Fig.3.12& 3.14)** along with panel diagram and (**Fig. 3.13 & 3.15**) hydrogeological sections.

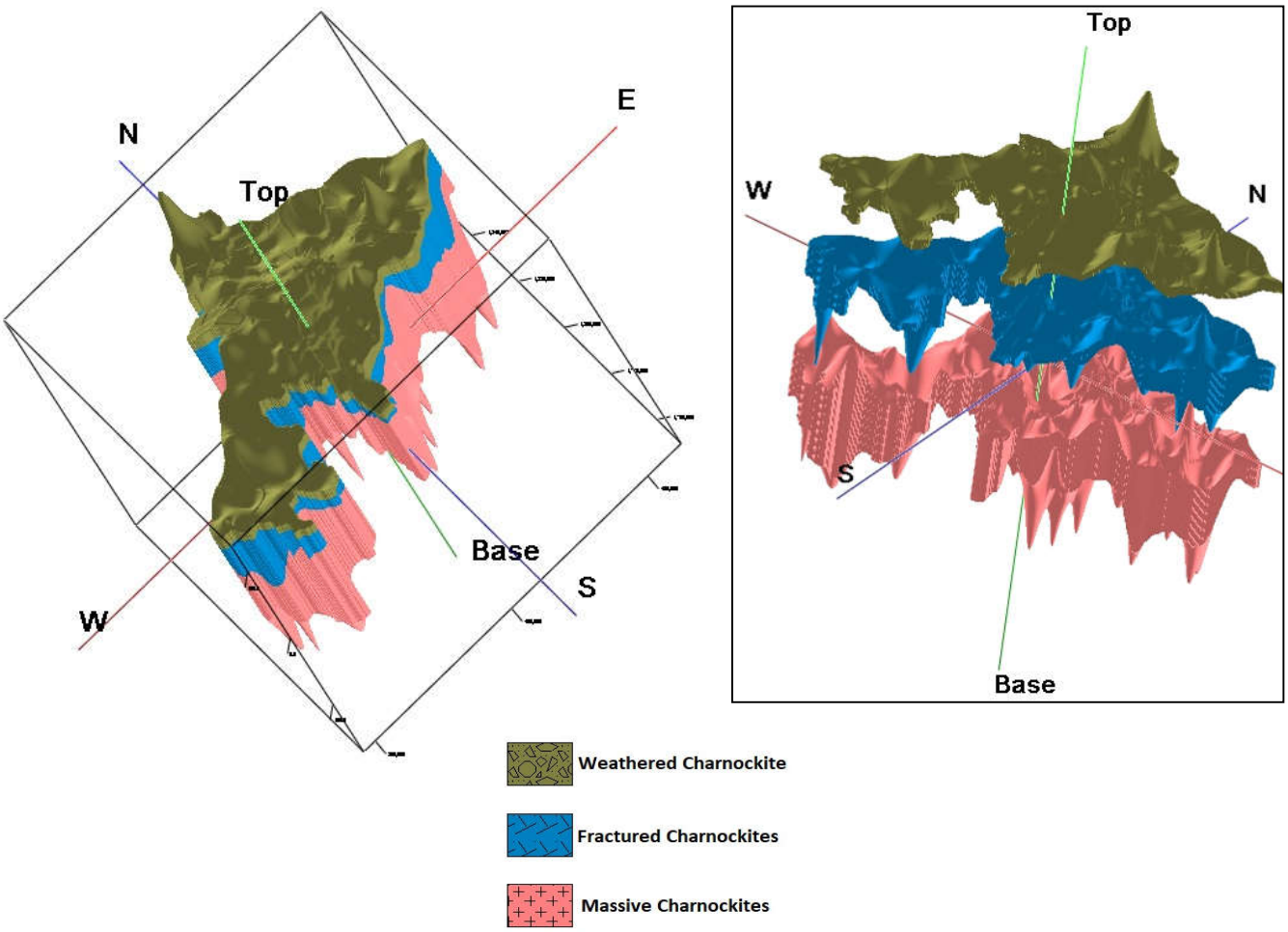
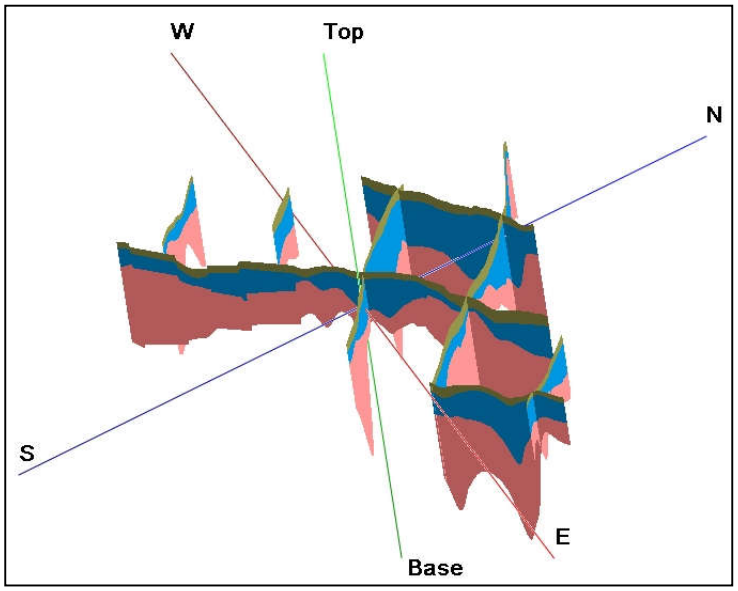
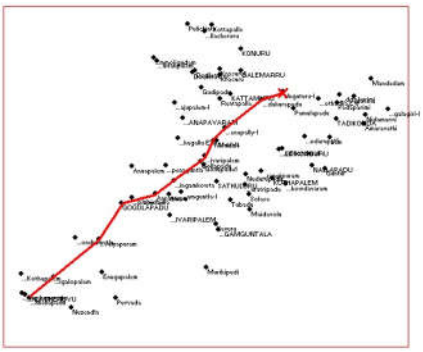



**Fig 3.12**: Aquifer Disposition of Charnockite Area

## Panel Diagram and 2D Section of Charnockite Area



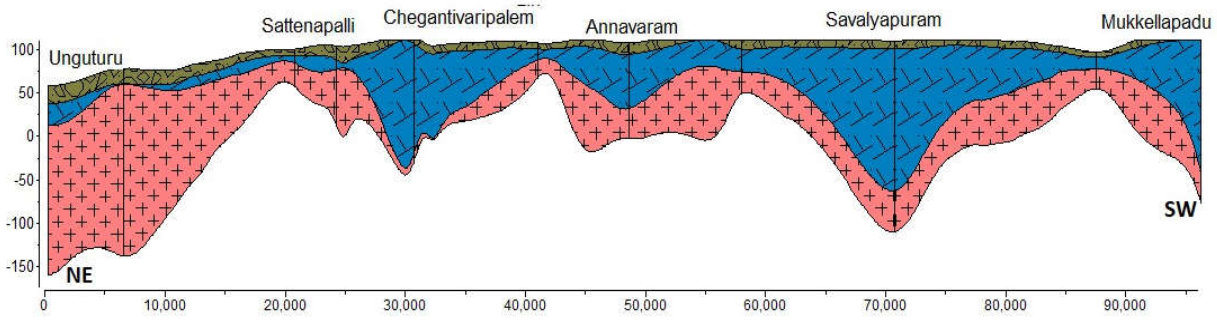



**Fig 3.13 a. Section: NE-SW Section**

## Aquifer Disposition in Meta Sedimantary Formation:

### Aquifer Disposition 2D

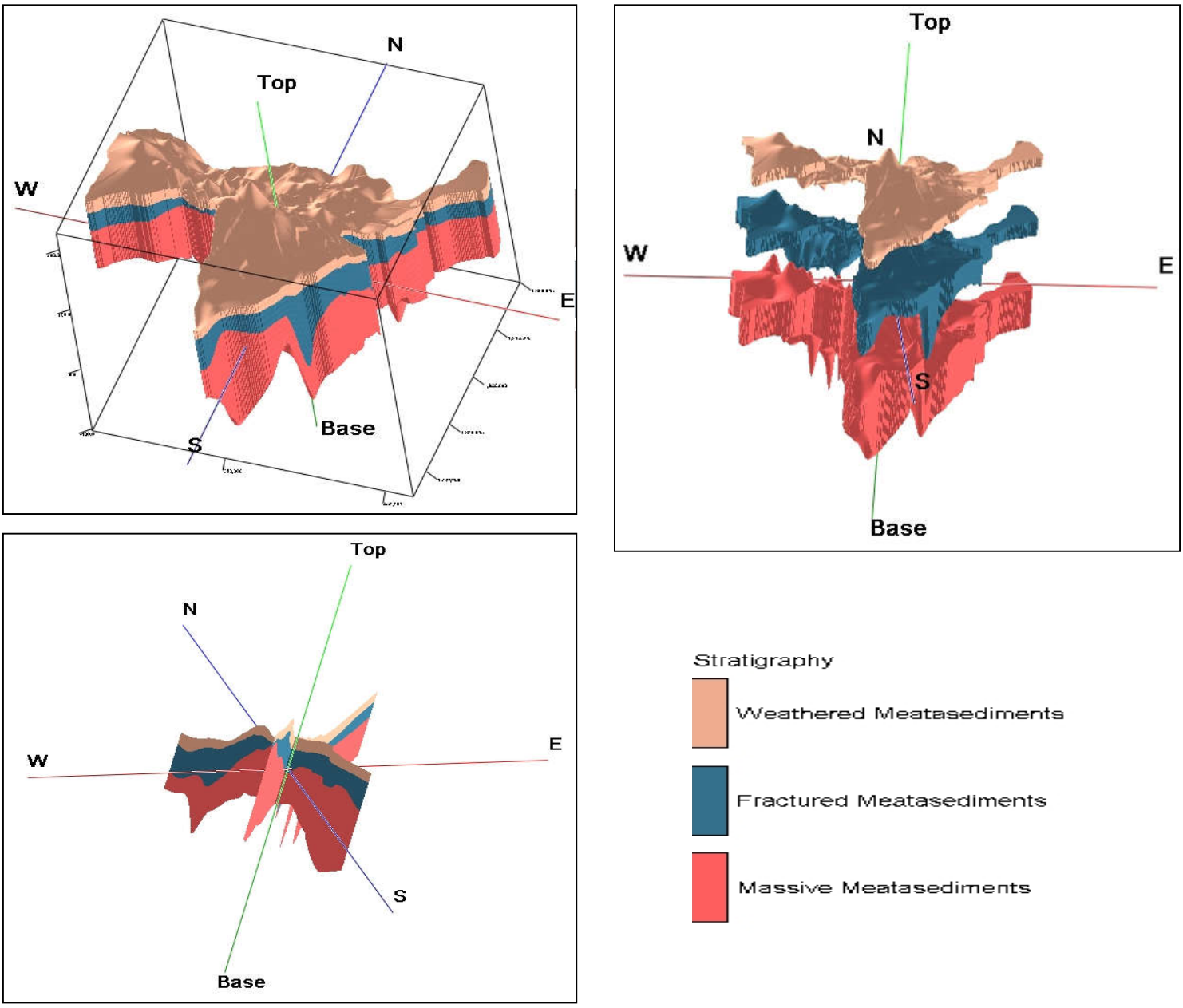



**Fig 3.14**: Aquifer Disposition of Metasedimentary Area

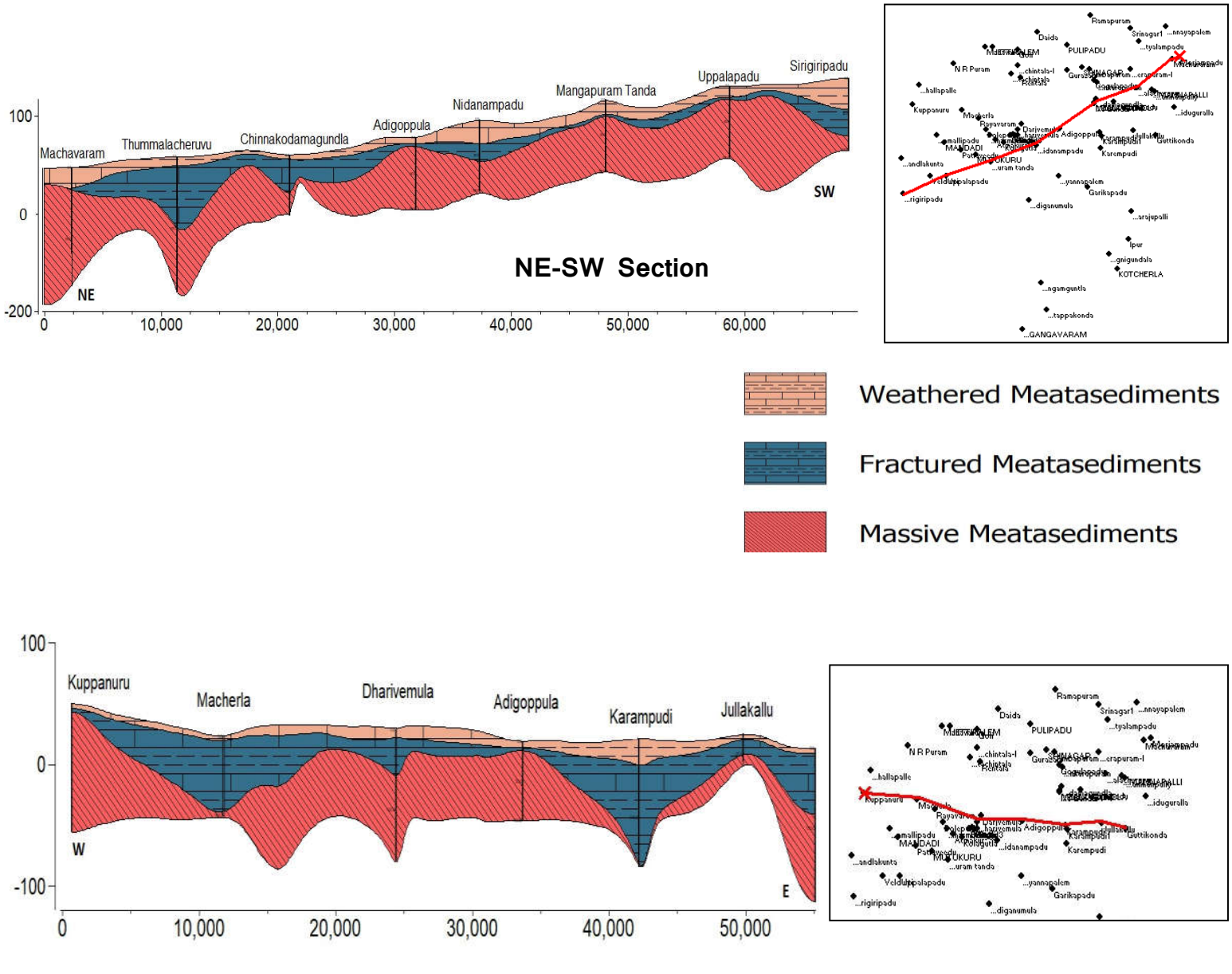



**Fig 3.15:** Hydrogeological profile of Metasedimentary Area

## 4. GROUND WATER RESOURCES (2020)

The dynamic ground water resources are computed as per the guidelines laid down in GEC methodology. As per 2020 Ground Water Resources Assessment, the net dynamic replenishable groundwater availability is 1033 MCM, gross ground water draft for all uses is 354 MCM, provision for drinking and industrial use for the year 2025 is 104 MCM and net annual ground water potential available for future use is 707 MCM. Stage of ground water development varies from 11% (Tadikonda mandal) to 137% (Veldurthi mandal). Out of 36 mandals in the study area, 2 mandals (Veldurthi and Bollapalle mandals) are over exploited, Piduguralla mandal is Critical and remaining 33 mandals are safe (**Fig 4.1**). The summarized dynamic ground water resources given in **Table-4.1**

**Table-4.1:** Computed Dynamic ground water resources

| **Parameters** | **Total** |
|---|---|
| **As per GEC 2020** | MCM |
| **Dynamic (Net GWR Availability)** | **1033** |
| • Monsoon recharge from rainfall | 307 |
| • Monsoon recharge from other sources | 490 |
| • Non-Monsoon recharge from rainfall | 11 |
| • Non-monsoon recharge from other sources | 279 |
| • Total Natural Discharges (Ham) | 54 |
| **Gross GW Draft** | **354** |
| • Irrigation | 278 |
| • Domestic and Industrial use | 73 |
| Provision for Drinking and Industrial use for the year 2025 | 104 |
| Net GW availability for future use | 707 |
| Stage of GW development (%) | 34% |

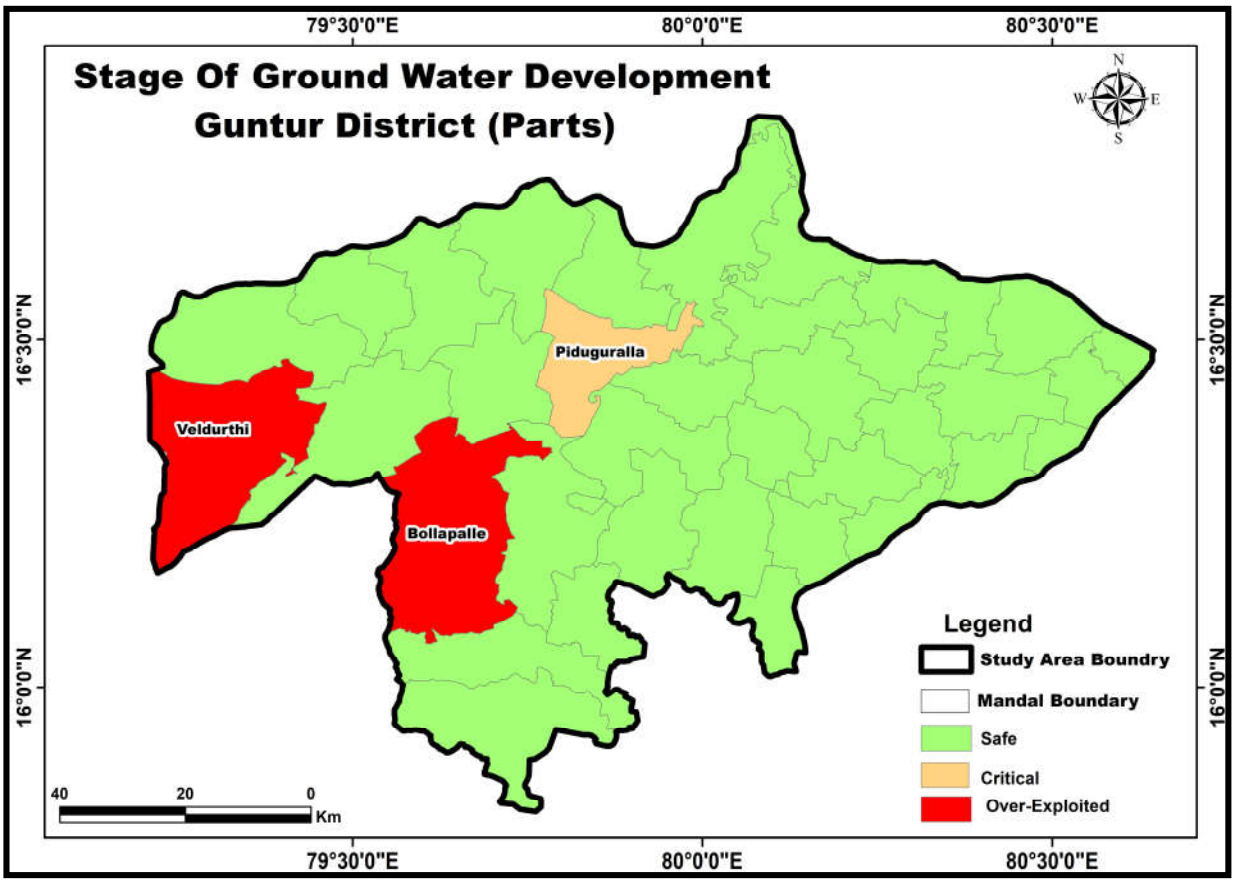



**Fig.4.1** Mandal wise stage of ground water development

**Scope for Ground Water Development for Irrigation:**

Government of Andhra Pradesh had submitted a detailed project report on PMKSY-HKKP- GWI (Ground Water Irrigation) in the year 2020 to Ministry of Jal Shakti, Govt. of India. The crietreion adopted for PMKSY-HKKP-GWI proposal is the area/mandal having more than 750 mm annual rainfall, less than 15 m of average ground water level and < 60% Stage of ground water development. Accordingly, in the study area, it is proposed to bring about 12423 ha of additional land under ground water irrigation by constructing 11241 no. of bore wells in 268 villages of 24 mandals with an estimated cost of 524 crores (**Table 4.2**).

**Table 4.2**- PMKSY-HKKP-GWI Proposal by Govt. of Andhra Pradesh

| S. No | Mandal Name | No. of Villages | Total No. of Structures | Area Proposed to be irrigated (Ha) | Cost of Drilling & others (In Lakhs) | Cost of Energization (75% Solar and 25% Electric) (In Lakhs) | Total Cost (In Lakhs) |
|---|---|---|---|---|---|---|---|
| 1 | ACHAMPETA | 12 | 407 | 404.37 | 512.85 | 1382.75 | 1895.60 |
| 2 | AMARAVATHI | 14 | 578 | 580.18 | 728.32 | 1963.70 | 2692.02 |
| 3 | BELLAMKONDA | 7 | 156 | 155.96 | 196.57 | 529.80 | 726.37 |
| 4 | CHILAKALURIPET | 15 | 451 | 680.14 | 590.92 | 1532.35 | 2123.27 |
| 5 | GUNTUR | 10 | 280 | 377.75 | 362.69 | 950.20 | 1312.89 |
| 6 | KROSURU | 11 | 270 | 270.02 | 340.22 | 916.50 | 1256.72 |
| 7 | MANGALAGIRI | 7 | 541 | 682.11 | 695.66 | 1839.25 | 2534.91 |
| 8 | MEDIKONDURU | 11 | 554 | 554.38 | 698.08 | 1883.30 | 2581.38 |
| 9 | MUPPALLA | 10 | 753 | 753.46 | 948.83 | 2560.65 | 3509.48 |
| 10 | NADENDLA | 9 | 136 | 135.99 | 171.37 | 460.60 | 631.97 |
| 11 | NAKARIKALLU | 7 | 455 | 455.10 | 573.33 | 1546.55 | 2119.88 |
| 12 | NARASARAOPETA | 14 | 433 | 433.45 | 545.61 | 1470.85 | 2016.46 |
| 13 | NUZENDLA | 20 | 1546 | 1545.43 | 1948.07 | 5255.50 | 7203.57 |
| 14 | PEDAKAKANI | 8 | 465 | 736.34 | 612.85 | 1580.85 | 2193.70 |
| 15 | PEDAKURAPADU | 14 | 499 | 498.02 | 628.78 | 1696.15 | 2324.93 |
| 16 | PHIRANGIPURAM | 11 | 502 | 501.89 | 632.56 | 1705.90 | 2338.46 |
| 17 | PIDUGURALLA | 5 | 194 | 193.77 | 244.45 | 659.30 | 903.75 |
| 18 | ROMPICHERLA | 14 | 323 | 322.31 | 407.00 | 1097.75 | 1504.75 |
| 19 | SATTENAPALLE | 16 | 539 | 538.32 | 679.18 | 1830.35 | 2509.53 |
| 20 | SAVALYAPURAM | 7 | 267 | 266.14 | 336.44 | 907.95 | 1244.39 |
| 21 | TADIKONDA | 10 | 622 | 621.12 | 783.76 | 2114.50 | 2898.26 |
| 22 | THADEPALLE | 6 | 200 | 382.47 | 270.36 | 680.00 | 950.36 |
| 23 | THULLUR | 19 | 428 | 693.04 | 566.03 | 1452.80 | 2018.83 |
| 24 | VINUKONDA | 11 | 642 | 641.96 | 808.97 | 2181.90 | 2990.87 |
| | | **268** | **11241** | **12423.73** | **14282.91** | **38199.45** | **52482.36** |

## 5. GROUND WATER RELATED ISSUES AND REASONS FOR ISSUES

### 5.1Issues

**Stage Of Groundwater Development:**

The Over all stage of ground ewater development in the study area is 34%, except 3 mnadals, Viz., Piduguralla, Bollapalle and Veldurthy mandals. All the mandals are located in meta sedimentary formations comprising of Lime stones, Quartzites and Shales. The Piduguralla mandal is known for its rich lime stone deposits and the industrial as well as mine dewatering may be the one of the reasons for high stage of ground water development.

**Sustainability**

Low yield (<1 lps) occurs in most of the area of both in eastern as well as western parts of the study area. The western parts of the study area are mainly comprising of Charnockites and as per ground water exploration data, the general yield of the charnockites is between 1 to 2 lps. The meta sedimentary parts of the western parts of the study area are also low in sustainability, owing to the massive nature of lime stone in the area.

### 5.2 Reasons for Issues

**Ground Water Quality**

**Anthropogenic pollution (Nitrate):** Higher concentration of Nitrate is observed in 56% of samples. This is due to unscientific sewage disposal of treated and untreated effluents in urban and rural areas. Use of NPK fertilizers and nitrogen fixation by leguminous crops.

# 6. MANAGEMENT STRATEGIES

The lacking of assured irrigation facilities in the rural areas, the demand and gap in water supply in urban areas, the dependency of ground water is increasing day by day. The ground water development in hard rock aquifer system may led to a steady fall in water levels, pose sustainability issues which may pose challenges to food and drinking water security in future. The occurrence of fractures in hard rock aquifers are are very limited in extent, as the compression in the rock reduces the opening of fractures at depth and the majority of fractures occur within 100 m depth. Though the general ground water scenario of the district is good, the uneven groundwater availability and its utilization indicates for requirement of integrated water resource management and sustainable practices for maintaining sustainable ground water scenario in the district.

## 6.1 Management plan

The management plan comprises of 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.

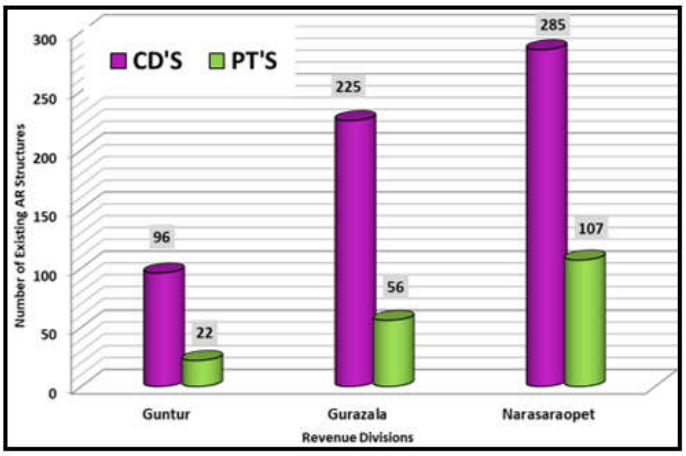
### 6.1.1 Supply side management

The supply side management of ground water resources include artificial recharge of available surplus runoff in check dams and percolation tanks. More over repair renovation & restoration of existing tanks will also help in ground water recharge.

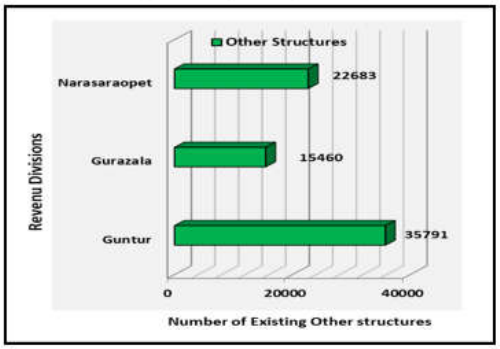
The area suitable for ground water augmentation through artificial recharge has been demarcated based on the analysis of average post-monsoon depth to water level data of the observation wells for the period of 2012-2021 and the existing data on artificial recharge structures constructed under various schemes of Mahatma Gandhi National Rural Employment Guarantee Scheme (MNREGS) and Integrated Watershed Management Programs (IWMP) by Rural Development department.

Government of Andhra Pradesh had already created a total 791 recharge structure (606 Check dams and 185 percolations tanks: source: APWRIMS) though MGNREGS and IWMP scheme **(Fig 6.1**).

**Existing AR & WC Structures of the Study Area**




| Divisions | Farm Ponds | CDs | PTs | Other Structures |
|---|---|---|---|---|
| Guntur | 4885 | 96 | 22 | 35791 |
| Gurazala | 3888 | 225 | 56 | 15460 |
| Narasaraopet | 4779 | 285 | 107 | 22683 |
| **Total** | **13552** | **606** | **185** | **73934** |




❖ Others Structures includes Cattle pond, Check wall, Mini Percolation Tank, Minor Drain, Rain Water Harvesting, Roof Water Harvesting, Feeder Channel and Field Channel Structures.

Source: APWRIMS

**Fig 6.1**: Existing Artifical Recharge Structures in the study Area

Considering the available run-off and recharge potential, there is a scope for construction of artificial recharge structures, which can be taken up as per requirement in the district. The availability of sub-surface storage volume of aquifers in each district is computed as the product of area, thickness of aquifer zone between 5 m. bgl and the average post-monsoon water level. The recharge potential/sub surface space of the aquifers is calculated by multiplying the sub surface storage volume with 2% specific yield. The source water availability is estimated from the rain fall 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, 20 % run off yield is considered as un-committed yield and 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. Recharge and Runoff available in the study area is given in **Table 6.1**.

**Table 6.1: Recharge and Runofff available in Study Area**

| | |
|---|---|
| Total geographical area of study area (Sq.km) | 8125 |
| Area feasible for recharge (Sq.km) | 6586 |
| Unsaturated Volume (MCM) | 13118 |
| Recharge Potential (MCM) | 282 |
| Runoff available (MCM) | 390 |
| Surplus runoff available for recharge (MCM) (20% of runoff) | 78 |

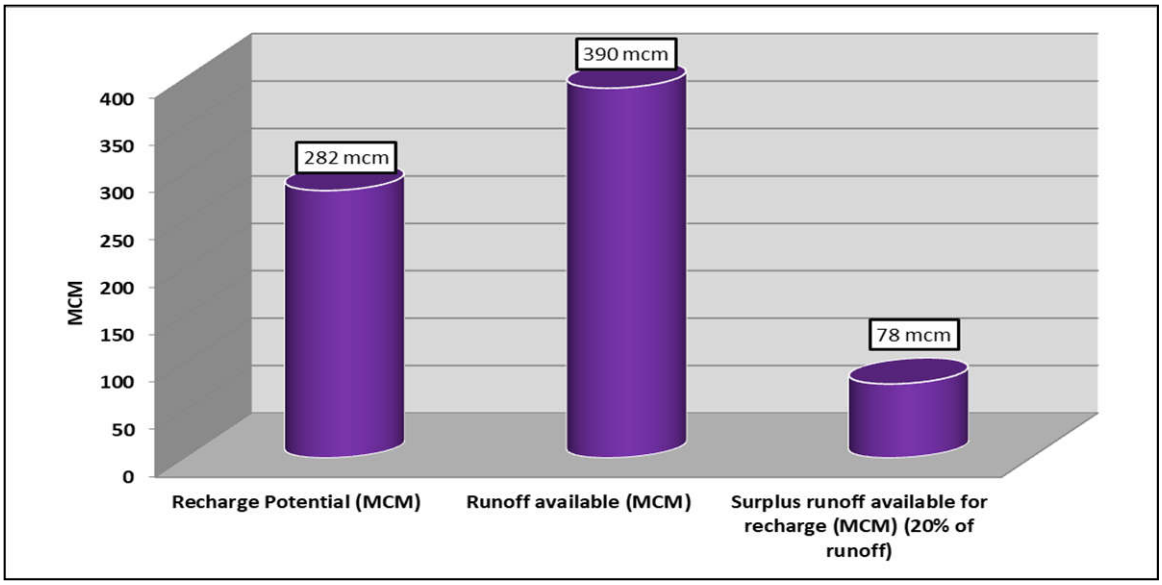



**Fig 6.2:** Recharge and Runofff available

### 6.1.1.1 Artificial Recharge Structures in study area:

The area feasible for artificial recharge is 6586 sq.kms. The recharge potential considering 2% of un saturated volume and the total run off 390 MCM. The surplus run off 78 MCM calculated as 20% of the total run off available in the study area. The study area details in this regard are provided in the **Table 6.2**.

**Table 6.2**: Study Area Details

| Guntur (Parts) covering 36 Mandals | |
|---|---|
| Area (Sq. Km) | 8125 |
| Recharge worthy area (Sq. Km) | 6586 |
| Average of Post Water Level (m bgl) | 5.3 |
| Runoff Village wise (MCM) | 390 |
| Uncommitted Runoff (20%) | 78 |
| Existing Check Dams | 534 |
| Existing Percolation Tanks | 144 |
| Runoff required for existing ARS(MCM) | 20.7 |
| Runoff considered for New ARS (MCM) (50% Of left Runoff) | 9.4 |
| Number of CDs Feasible | 152 |
| Number of PT feasible | 94 |

In the study area, a total of 678 artificial recharge structures (534 CDs and 144 PTs) are already in existence. Thus, out of 78 MCM surplus run off availability, 20.7 MCM is considered for existing ARS and only 50% of the available left surplus runoff considered for recommendantion of new artificial recharge strutcures and thus recommended for construction of total 246 AR structures (152 check dams and 94 percolation tanks) in the study area (**Annexure 1**). After effective utilization of this yield, there will be 9.4 MCM of ground water recharge can be feasible. In addition, roof top rainwater harvesting structures should be made mandatory to all Government buildings (new and existing).

#### 6.1.1.2 Other supply side measures:

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). This will also help in sustainable management of groundwater resources.

#### 6.1.1.3 Water Conservation Measures (WCM) (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 is 10 x 10 x 3 m. In the study area, a total 13552 farm ponds exist in 420 villages in the study area which may save 4.1 MCM. In mandals, where stage of ground water devolpment >50%, the existing farm ponds should be desilted and maintained so that it will greatly help in ground water augmentation.

### 6.1.2 Demand Side Measures:

#### 6.1.2.1. Micro-irrigation:

The area faces low sustainability in terms of ground water yield. The recharge potential is more than the total run off and surplus run off availability. Particulrly in meta sedimentary formations in western parts, the massive limestones making the ground water yield unpredictable and posing serious challenges to agriculture sustainability. Considering these, the sprinkler and drip irrigation system with suitable cropping pattern wherever feasible may be practiced as a measure for groundwater conservation, protection and management. An about 30000 ha of land can be brought under micro-irrigation (@100 ha/village in 300 villages, considering 1 unit/ha @0.6 lakh/ha). With adoption of micro irrigation practices, the total water requirement for irrigation can be reduced upto 60% to 70%. With this ~54 MCM of ground water can be conserved over the traditional irrigation practices, considering @ 0.006 MCM/ha for ID crops with traditional irrigation methods).

### 6.1.3 Other measures

- To avoid the interference of cone of depression between the productive wells, intermittent pumping of bore wells is recommended through regulatory mechanism.

- The western part of the study area is known for its rich lime stone deposits. As mandated by Central Ground Water Authority, the mine dewatered seepage can effectively be utilized by filling the tanks and supply to agriculture fields.
- 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.
- As a mandatory measure, every groundwater user should recharge rainwater through artificial recharge structures in proportionate to the extraction.
- A participatory groundwater management (PGWM) approach in sharing of groundwater and monitoring resources on a constant basis along with effective implementation of the existing 'Water, Land and Trees Act' of 2002 (WALTA-2002) are the other measures suggested. Subsidy/incentives on cost involved in sharing of groundwater may be given to the farmers involved.

### 6.2 Expected Results and Out come

With the above interventions, the likely benefit would be the net saving of 63 MCM of ground water either through water conservation measures like adoption of drip and artificial recharge to ground water.

### Acknowledgment

I would like to express my thanks to Shri Sunil Kumar, Chairman CGWB and Shri J. Siddhartha Kumar, Regional Director, CGWB, for encouragement, guidance and support. I am grateful to State Ground Water Department, Rural Development department, Rural Water Supply department, Directorate of Economics and Statistics, Minor Irrigation, Govt of Andhra Pradesh for providing the data for the preparation of report.

## Annexure-1: Proposed Supply side interventions

| SL NO | State | District | Mandal | Village | Check Dams | Percolation Tanks |
|---|---|---|---|---|---|---|
| 1 | Andhra Pradesh | Guntur | Bollapalle | Perurupadu | 1 | 0 |
| 2 | Andhra Pradesh | Guntur | Rompicherla (Guntur) | Alavala | 1 | 0 |
| 3 | Andhra Pradesh | Guntur | Bollapalle | Remidicherla | 1 | 0 |
| 4 | Andhra Pradesh | Guntur | Sattenapalle | Sattenapalle (M) | 1 | 0 |
| 5 | Andhra Pradesh | Guntur | Rompicherla (Guntur) | Gogulapadu-1 | 1 | 0 |
| 6 | Andhra Pradesh | Guntur | Bollapalle | Gandiganumala-1 | 1 | 0 |
| 7 | Andhra Pradesh | Guntur | Bellamkonda | Kolluru | 1 | 0 |
| 8 | Andhra Pradesh | Guntur | Bellamkonda | Chityala-2 | 1 | 0 |
| 9 | Andhra Pradesh | Guntur | Savalyapuram | Velupuru | 1 | 0 |
| 10 | Andhra Pradesh | Guntur | Macherla | Koppunur | 1 | 0 |
| 11 | Andhra Pradesh | Guntur | Macherla | Rayavaram-3 | 1 | 0 |
| 12 | Andhra Pradesh | Guntur | Durgi | Polepalle-2 | 1 | 0 |
| 13 | Andhra Pradesh | Guntur | Nuzendla | Khambhampadu | 1 | 0 |
| 14 | Andhra Pradesh | Guntur | Machavaram | Machavaram-4 | 1 | 0 |
| 15 | Andhra Pradesh | Guntur | Medikonduru | Varagani | 1 | 0 |
| 16 | Andhra Pradesh | Guntur | Vinukonda | Dondapadu-1 | 1 | 0 |
| 17 | Andhra Pradesh | Guntur | Bellamkonda | Bellamkonda-1 | 1 | 1 |
| 18 | Andhra Pradesh | Guntur | Ipuru | Chittapuram | 1 | 1 |
| 19 | Andhra Pradesh | Guntur | Rajupalem | Ganapavaram-1 | 1 | 1 |
| 20 | Andhra Pradesh | Guntur | Karempudi | Singarutla | 1 | 1 |
| 21 | Andhra Pradesh | Guntur | Durgi | Darivemula | 1 | 1 |
| 22 | Andhra Pradesh | Guntur | Dachepalle | Ramapuram-12 | 1 | 1 |
| 23 | Andhra Pradesh | Guntur | Durgi | Atmakur-5 | 1 | 1 |
| 24 | Andhra Pradesh | Guntur | Machavaram | Mallavolu | 1 | 1 |
| 25 | Andhra Pradesh | Guntur | Sattenapalle | Vaddavalli | 1 | 1 |
| 26 | Andhra Pradesh | Guntur | Phirangipuram | Phirangipuram-1 | 1 | 1 |
| 27 | Andhra Pradesh | Guntur | Rompicherla (Guntur) | Thurumella | 1 | 1 |
| 28 | Andhra Pradesh | Guntur | Rentachintala | Mallavaram-3 | 1 | 1 |
| 29 | Andhra Pradesh | Guntur | Phirangipuram | Repudi-1 | 1 | 1 |
| 30 | Andhra Pradesh | Guntur | Rajupalem | Reddigudem-1 | 1 | 1 |
| 31 | Andhra Pradesh | Guntur | Guntur Mandal | Guntur (M Corp.) | 1 | 1 |
| 32 | Andhra Pradesh | Guntur | Karempudi | Karempudi-1 | 1 | 1 |
| 33 | Andhra Pradesh | Guntur | Bellamkonda | Mannesultanpalem | 1 | 1 |
| 34 | Andhra Pradesh | Guntur | Piduguralla | Kamepalle | 1 | 1 |
| 35 | Andhra Pradesh | Guntur | Karempudi | Chinagarlapadu | 1 | 1 |
| 36 | Andhra Pradesh | Guntur | Bellamkonda | Emmajigudem | 1 | 1 |
| 37 | Andhra Pradesh | Guntur | Rentachintala | Rentala | 1 | 1 |
| 38 | Andhra Pradesh | Guntur | Rajupalem | Rajupalem-7 | 1 | 1 |
| 39 | Andhra Pradesh | Guntur | Ipuru | Muppalla-4 | 1 | 1 |
| 40 | Andhra Pradesh | Guntur | Dachepalle | Pedagarlapadu-1 | 1 | 1 |
| 41 | Andhra Pradesh | Guntur | Macherla | Pasuvemula | 1 | 1 |
| 42 | Andhra Pradesh | Guntur | Rentachintala | Manchikallu | 1 | 1 |
| 43 | Andhra Pradesh | Guntur | Amaravathi | Pondugala | 1 | 1 |
| 44 | Andhra Pradesh | Guntur | Dachepalle | Pondugula-2 | 1 | 1 |
| 45 | Andhra Pradesh | Guntur | Achampeta | Madipadu Agraharam | 1 | 1 |
| 46 | Andhra Pradesh | Guntur | Dachepalle | Gamalapadu | 2 | 1 |
| 47 | Andhra Pradesh | Guntur | Ipuru | Ipur | 2 | 1 |
| 48 | Andhra Pradesh | Guntur | Dachepalle | Madinapadu | 2 | 1 |
| 49 | Andhra Pradesh | Guntur | Rajupalem | Kubadpuram | 2 | 1 |
| 50 | Andhra Pradesh | Guntur | Bollapalle | Ayyannapalem | 2 | 1 |
| 51 | Andhra Pradesh | Guntur | Karempudi | Petasannigandla | 2 | 1 |
| 52 | Andhra Pradesh | Guntur | Gurazala | Cherlagudi Padu | 2 | 1 |
| 53 | Andhra Pradesh | Guntur | Machavaram | Vemavaram-1 | 2 | 1 |
| 54 | Andhra Pradesh | Guntur | Gurazala | Telukutla | 2 | 1 |
| 55 | Andhra Pradesh | Guntur | Karempudi | Chintapalle-2 | 2 | 1 |
| 56 | Andhra Pradesh | Guntur | Machavaram | Pinnelli | 2 | 1 |
| 57 | Andhra Pradesh | Guntur | Piduguralla | Janapadu | 2 | 1 |
| 58 | Andhra Pradesh | Guntur | Gurazala | Pallegunta | 2 | 1 |
| 59 | Andhra Pradesh | Guntur | Durgi | Durgi-1 | 2 | 1 |
| 60 | Andhra Pradesh | Guntur | Veldurthi | Kandlakunta | 2 | 1 |
| 61 | Andhra Pradesh | Guntur | Achampeta | Challagariga-1 | 2 | 1 |
| 62 | Andhra Pradesh | Guntur | Veldurthi | Gottipalla | 2 | 1 |
| 63 | Andhra Pradesh | Guntur | Bollapalle | Mellavagu | 2 | 1 |
| 64 | Andhra Pradesh | Guntur | Bellamkonda | Bodanam | 2 | 1 |
| 65 | Andhra Pradesh | Guntur | Macherla | Nagulavaram-3 | 2 | 1 |
| 66 | Andhra Pradesh | Guntur | Veldurthi | Srigiripadu | 2 | 1 |
| 67 | Andhra Pradesh | Guntur | Dachepalle | Bhatrupalem | 2 | 1 |
| 68 | Andhra Pradesh | Guntur | Piduguralla | Julakallu-1 | 2 | 1 |
| 69 | Andhra Pradesh | Guntur | Machavaram | Pillutla | 2 | 1 |
| 70 | Andhra Pradesh | Guntur | Tadikonda | Ravela | 2 | 2 |
| 71 | Andhra Pradesh | Guntur | Piduguralla | Karalapadu | 2 | 2 |
| 72 | Andhra Pradesh | Guntur | Tadikonda | Pamulapadu-3 | 3 | 2 |
| 73 | Andhra Pradesh | Guntur | Dachepalle | Tangeda | 3 | 2 |
| 74 | Andhra Pradesh | Guntur | Gurazala | Gottimukkala | 3 | 2 |
| 75 | Andhra Pradesh | Guntur | Achampeta | Taduvoy | 3 | 2 |
| 76 | Andhra Pradesh | Guntur | Gurazala | Pulipadu-1 | 3 | 2 |
| 77 | Andhra Pradesh | Guntur | Piduguralla | Piduguralla-1 | 3 | 2 |
| 78 | Andhra Pradesh | Guntur | Gurazala | Daida | 3 | 2 |
| 79 | Andhra Pradesh | Guntur | Macherla | Pullareddigudem | 3 | 2 |
| 80 | Andhra Pradesh | Guntur | Gurazala | Gangavaram-8 | 4 | 2 |
| 81 | Andhra Pradesh | Guntur | Achampeta | Chintapalle-1 | 4 | 3 |
| 82 | Andhra Pradesh | Guntur | Durgi | Kolagutla | 4 | 3 |
| 83 | Andhra Pradesh | Guntur | Piduguralla | Konanki-1 | 4 | 3 |
| 84 | Andhra Pradesh | Guntur | Gurazala | Madugula-1 | 5 | 3 |
| 85 | Andhra Pradesh | Guntur | Piduguralla | Guttikonda | 10 | 7 |