केंद्रीय भूमि जल बोर्ड

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विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

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

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

WARANGAL DISTRICT, TELANGANA

दक्षिणी क्षेत्र, हैदराबाद

Southern Region, Hyderabad

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

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REPORT ON
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AT A GLANCE

S.No.	Item		Particulars
1	Districts	:	Warangal
2	Revenue Divisions/ Mandals	:	38
3	Villages	:	700
4	Geographical area	:	8098 Km^2
5	Population (2011 Census)	:	26.6 lakhs (72 % Rural and 28 % urban)
6	Density of population (2011 Census)	:	328 persons/Km^2
7	Locations	:	North Latitude 17°19´26.5"-18°29´39.8" East Longitude 78°49´38"-80°10´2.5"
8	Rainfall (Normal)	:	~750-1130 mm (avg: 940) (SW: 78% & NE: 13%) (During 2014-15 it received 716 mm (-24 % less than normal rainfall)
9	Geomorphology	:	Pediplain (83%, pediment (10%), hills (3%) and flood plains (20%) and channel fill (2%).
10	Major Rivers	:	Munneru and Akeru tributaries of river Krishna
11	Watersheds	:	39
12	Land Utilization (Ha) (2014-15)	:	Gross area sown: 4,82,269 Ha (Khariff:3,71,583 ha and rabi:1,10,686 ha). Net sown area: 3, 71,610 (Khariff: 3,65,613 ha and rabi:5997 ha). Forest: ~11%, wastelands 10 % tanks 5 %.
13	Cropping Pattern (Ha) 2014-15	:	Khariff: Cotton (50%), paddy (17%), maize (16%), pulses (7%), chillies (3%), groundnut (1%) vegetables (1%) and others (5%). Rabi: paddy (33%), maize (32%), groundnut (16%), chilles (6%) pulses (5%), vegetables (3%) etc.
14	Soils	:	Loamy soils 69 % and clayey soils 31%.
15	Irrigation	:	**Major projetcs** Sri Ram Sagar Project (Stage-1 and Stage-2) with Registered ayacut of 8.64 lakh ha. Godavari Lift Irrigation scheme:18924 ha **Medium Projects:** Sali Vagu:Registered ayacut is 1232 ha **MI Tanks:** 3049 (Comand:1566 and Non-command:1483)

			During 2014-15 only 6700 ha was irrigated from surface water including tanks. Ground water contributes 97 % and Surface water 3 % (**2014-15**).
16	Prevailing water conservation/Recharge practices	:	PT: 1124, CD's:380 and mico-irrgation: 38680 ha land is under micro-irrigation (2014-15).
17	Geology	:	Banded Gneissic complex (Granites:82% and Gneisees:15%), Schist's (1%), Limestone (1%) and sandstone (1 %). Banded Iron ore formations occur in central part in NW-SE direction.
18	Hydrogeological data points	:	445 nos Exploration:114 (CGWB:66 and SGWD:48), VES:40 and well inventory:291
20	Number of ground water structures	:	Agricultural bore wells: 3.63 lakhs (IrrigatioBW:2.13 lakhs, Irrigation DW:1.33 lakhs and domestic wells:17544). As per Electricity Board there are 2.46 lakh agricultural bore wells
21	Ground water yield (lps)	:	Granites: < 0.1 to 8 lps. Sandstone:1.5 to 12.5 lps and Limestone:0.2 to 5.8 lps
22	Water Levels (2015) Depth to water levels (m bgl)	: :	368 Wells (DW:212 and Pz:156 nos) (CGWB:74 and SGWD:294) Pre-monsoon:0.96 to 39.5 (avg: 10.55) and majority is in the range of 10-20 m bgl (60% area followed by 5-10 m bgl (34 % of area). Post-monsoon:0.45 to 33.87 (avg: 7.45) and majority is in the range of 5-10 m bgl (45% area followed by 10-20 m bgl (31% of area).
23	Water Level Fluctuations (May vs. November 2015)	:	-9.7 to 19.1 (average rise of 3.15 m)
24	Long term water level trends (2006-15) (95 wells)	:	**Pre-monsoon:** Falling: 53 wells (0-1 m: 52, 1-2 m). Rising: 42 wells (0-1 m: 36, 1-2:4 and > 2 m: 2). **Post-monsoon:** Falling: 28 wells (all below 1 m). Rising: 67 wells (0-1m:57,1-2:8 and >2:2)
25	Water level during 2015 with average WL of last 10 years (2005-14)	:	**Pre-monsoon:** 71 wells shown fall and 23 wells shown rise and 1 well shown neither rise nor fall. **Post-monsoon:** 76 wells have shown fall and 18 wells shown rise and 1 well shown no change.
26	Geophysical data (down to 200 m)	:	40 no's (VES) weathered granite: < 90 ohm (Ω) m, semi-weathered granite: 90-180 Ω m, fractured granite 180-400 Ω m and massive granite > 400 Ω m
27	Hydrochemistry	:	461 samples pre-monsoon:219 (2015), post-monsoon-242 (2015)
27.1	Electrical Conductivity (µ Siemens/cm)	:	Pre: 348-5670 in majority it is <1500 (66 % samples), high EC >3000 in 6% of area (eastern part).

			Post: 453-5020 in majority it is <1500 (57 % samples), high EC >3000 in 6 % of area (north-eastern part).		
27.2	Nitrate mg/l	:	Pre: 5 to 461 (114 samples (52%) are unfit for human consumptions) Post: BDL to 478 (140 samples (58%) are unfit for human consumptions).		
27.3	Fluoride mg/l	:	Pre: 0.1-3.6 mg/L (37 samples (17%) unfit for human consumptions. Post: 0.1-6.4 (56 samples (23%) are unfit for human consumptions).		
28	Conceptualization		**Weathered zone (7-30 m)**	**Fractured zone (30-86 m)**	
28.1	Aquifer Characterization	:	Saprolite zone:~11 m and sap rock zone 11-30 m < 10 m weathering covers 24% area, 10-20 m covers 73 % area and > 20 m covers 3% of area.	Most of fractures occur within 100 m depth.	
28.2	Ground water yield	:	0.1 to 8 lps Lower yields (<1 lps) occur in central part, moderate (1-3 lps) in eastern and high yields > 3 lps in western part.	< 0.01-8 lps	
28.3	Transmissivity (m^2/day)	:	1-150 m^2/day but in majority it is in the range of 20 m^2/day.	1-150 m^2/day (average:20 m^2/day)	
28.4	Specific Yield	:	1 to 3 % (Avgerage: 1.5%)	-	
28.5	Storativity	:	-	0.0001 to 0.0345	
29	Ground water Resources (2013) MCM	:	Command	Non-Command	Total
29.1	Net dynamic groundwater availability	:	488.7	639.3	1128
29.2	Gross GW Draft	:	370.18	579.02	949.20
29.3	Provision for Domestic &Industrial (2025)	:	39.54	92.30	131.84
29.4	Average Stage of Ground water development (%)		76	91	84
29.5	Net GW Availability for future irrigation	:	104.21	6.44	110.65
29.6	In storage GW Resources	:	**80 MCM (May)** **94 MCM (November) net recharge of 14 MCM during post-monsoon season in storage resources.**		
29.7	Categorization of mandals		Mandal wise it varies from 55 % to 155 % (OE:10, C:3, SC:17 and Safe:7		
30	Major Ground Water Issues Identified	:	• Over-exploitation: 10 Mandals covering 265 villages. • Anthropogenic Pollution: 52 % and 58% ground water samples are unfit for human consumption (Nitrate is main anthropogenic contamination) during pre and post-monsoon season. • Fluoride as high 3.6 during pre and 6.4 during post-monsoon		

			season is detected. High F (> 1.5 mg/L) occupies 9% and 16% of area during pre and post-monsoon season of 2015. • Deep water levels (>20 m bgl) occupies 4% and 3% of area during pre and post-monsoon season resepctively. • Declining water level trends: Most of hydrographs are showing falling trends in both seasons. • Sustainability: Reduction in yield and low yields in ~27% area. • Water marketing and change in land use pattern from agriculture to residential purposes is noticed.
31	Management Strategies	:	**Supply side measures** **Ongoing Projects (Mission Kakatiya)** • De-silting of 16 MCM of silt from existing 40% minor irrigation tanks under Mission Kakatiya. This has created additional surface storage and this will contribute ~8 MCM of GW and with this additional ~1000 ha of land can be brought under ID crops. **To be taken up** • Remaining tanks will be taken up in phases 3, 4 and 5 (2017, 2018 and 2019). **Ongoing Projects (Mission Bhagiratha)** • ~125.16 MCM of water will be imported from surface sources this will save ~58 MCM and from this ~7250 ha of additional land can be brought under ID crops. **To be taken up (Artificial Recharge Structure)** **Priority-1:Over-exploited villages: 253(~2158 km^2)** • 850 ARS (CD:465 and PT:385) • Cost Rs ~70.3 Crores **Priority-2:Other remaining villages:406 (~5023 km^2)** • 2151 ARS (CD:1169 and PT:982) • Cost Rs ~170.4 Crores **Water Conservation measures (WCM) Farm Ponds** • Recommended 13960 nos farm ponds with total cost **34.90 crores** in ~698 villages (@ 20/village). **Demand side measure** **Ongoing work** • In the area till date a total ~38680 ha of land brought under MI, this might have saved 77 MCM of ground water.

			Proposed Work • Existing ~51868 of land irrigated through ground water during rabi season (50%) can be brought under MI costing **311.21 crores** (@0.6 lakhs/ha). With same unit additional same land during kharif season can be brought under MI. This will save ~104 MCM of ground water • MSP for crops should be declared in advance along with improved facilities at procurement centers. • 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. • Participatory groundwater management (PGWM) in sharing of groundwater and monitoring of 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 under horticulture. • 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.
32	Expected Results and Out come	:	With the above interventions costing Rs **586.34** crores (excluding the cost involved in Mission Kakatiya and Mission Bhagiratha), the likely benefit would be the net saving of 247 MCM of ground water or additional creation of ~41100 ha of irrigated land or the stage of ground water can be reduced by 15 % from present 84 % to 69 %. One time cost will be ~3ps/l or Rs 28.57/m3 of water.

ABBREVATION:

2D	:	2 Dimensional
3D	:	3 Dimensional
ARS	:	Artificial Recharge Structures
Avg	:	Average
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 rock areas of Warangal district covering ~8100 Km^2 area (63 % of total district), receives an average annual normal rainfall of 942 mm of which 78 % is contributed by SW monsoon and 13 % by north-east monsoon. During the year 2015, the district received 716 mm (24 % less) rainfalls than normal annual rainfall. Administratively, the area is governed by 38 revenue mandals with 700 villages. The population of the district is ~ 26.6 lakhs (2011 census) with average density of 328 persons/km2.

Area is underlain by granite (82%) and gneisses (15%), schists (1%), limestone and sandstone (1% each). Pediplains are major geomorphic features (83% of area) followed by pediment (10%), hills (3%), flood plain and channel fill (2 % each). The most of the area is drained by Munneru and Akeru rivers, tributaries of river Krishna and are divided into 39 watersheds. The gross cropped area during 2014-15 is 482269 ha (Khariff: 371583 ha and Rabi:110686 ha). Forest occupies 11% of the total geographical area, wasteland occupy 10 % and water bodies occupy 5% of area. Cotton (50%), paddy (17 %), maize (16%), pulses (7%) are main crops during kharif season. During rabi season paddy (33%), maize (32%), groundnut (16%), chillies (6%) and pulses (5%) are grown. The soils are loamy (69%) and clayey soils (31 %).

The registered ayacut under two major irrigation projects is 8.64 lakh ha and under Godavari lift irrigation project is 18924 ha. In the area there are 3049 minor irrigation tanks. During the year 2014-15 only 6700 ha area was irrigated from surface water. Ground water contributes 97 % of irrigation and surface water 3 %. In the area there are ~1124 PT and 380CD and ~38680 ha of land is brought under MI and ~16 MCM of silt is removed under Mission Kakatiya.

Exploratory results of CGWB (66 wells) suggest that 11 wells are drilled down to 150-200 m, 2 between 100-150 m, 30 nos (60-100 m),16 nos (30-60 m) and 4 are of shallow depth (< 30 m). There are ~3.63 agricultural bore wells (Irrigation BW: 2.13 lakhs, Irrigation DW: 1.33 lkahs and Domestic wells 17544). Ground water yield varies from <0.1 to 8 lps in granite/gneisses, 1.5-12.5 in sandstone and 0.2-5.8 lps in limestone area.

Water levels are monitored through 368 wells during pre and post-monsoon season of 2015. The DTW varies from 0.96 to 39.5 m bgl (average: 10.55) and 0.45 to 33.87 m bgl (average: 7.45) during pre and post-monsoon season of 2015 respectively. During pre-

monsoon season 10-20 m water levels is more predominant (60 % of area) followed by 5-10 m (34 % of area). During post-monsoon season 5-10 m water levels is more predominant (45 % of area) followed by 10-20 m (31 % of area). During the year water level fluctuation (Nov Vs. May of 2015) varies from -9.7 to 19.1 m with average rise of 3.15 m. Long-term water levels trends from 95 wells shows a falling trend in 53 wells (0-1m:52 and 1-2 m:1wells) (max fall: -1.36 m/yr) and 42 wells shows rising trend (0-1m:36, 1-2 m: 4 and >2 m: 2 well) (max rise: 2.83 m/yr). During post-monsoon season 28 shows falling trend (less than 1 m) (maximum fall: -0.92 m/Yr) and 67 wells shows rising trends (0-1 m: 57, 1-2 m: 8 and >2 m: 2wells) (max rise: 2.28 m/yr). Average water levels for the last 10 years (2005-14) were compared with 2015 data and it is found that during pre-monsoon season of 2015, 71 wells have shown fall, 23 shown rise and 1 well shown neither rise nor fall in water levels. During post monsoon season 76 wells shown fall, 18 shown rise in water levels and no change in 1 well.

Geophysical data from 40 VES data (CGWB) reveals resistivity < 90 Ohm (Ω) m for the weathered granite, 90-180 Ω m for underlying semi weathered granite, between 180-400 Ω m fractured granite and > 400 Ω m for massive granite.

Total 461 ground water samples (Pre-monsoon:219 and Post-monsoon:242) were analysed for knowing the suitability of ground water for drinking purposes. In 70 % and 59 % 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 5 to 461 mg/l and found that in 52 % it is beyond maximum permissible limit of BIS (45 mg/l) and F concentration varies from 0.1 to 3.6 mg/l and found that in 37 samples (17%) it is beyond maximum permissible limits of BIS (1.5 mg/l). During post-monsoon season, concentration of NO_3 ranges from 1-478 mg/l and found that in 140 samples (58 %) it is beyond maximum permissible limit of BIS (45 mg/l). The F concentration varies from 0.1 to 6.4 mg/l and found that in 56 samples (23%) it is beyond maximum permissible limit of BIS.

Based on 445 hydrogeological data points, aquifers from the area can be conceptualized in to two nos namely, 1) weathered zone (~30 m) and 2) fractured zone (30-86 m). Weathered zone in most of aquifers has gone dry in 10 mandals due to over-exploitation. Weathered zone in the range of < 10 m in 73% of area, 10-20 m occurs in 24 % of area and deep weathering (> 20 m) occurs in 3 % of area. Ground water yield of this zone varies from 0.1-8 lps, T varies from 1 to 150 m^2/day, specific yield ranges from 1-3 %.

Fracturing zone varies from 30 to 86 m (Muttojipet in Narsampet mandal) and data from drilled wells confirm that all fractures occur within 100 m depth. Ground water yield from fractured zone varies from <0.01 to 8 lps. Transmissivity (T) and storativity (S) varies from 1 to 150 m^2/day and 0.0001 to 0.0345 respectively.

Net dynamic replenishable ground water availability is 1128 MCM, gross ground water draft is 949.2 MCM, provision for drinking and industrial use for the year 2025 is 131.84 MCM and net available balance for future irrigation use is 110.65 MCM. The stage of ground water development varies from 55 to 155 % (avg: 84 %). The in-storage ground water resources down to the maximum fractured depth (85 m) are 80 MCM and there is net recharge of 14 MCM during 2015 post-monsoon season.

Major issues identified are over-exploitation (2214 km^2 area covering 10 mandals and 265 villages). Ground water pollution (both anthropogenic (NO_3) and geo-genic (F). Deep water levels are > 20 m bgl in 4 % and 3% of the area during pre and post-monsoon season respectively and declining water levels in majority of hydrograph stations and sustainability in 27 % of 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 ~16 MCM of silt have been removed from existing 40% tanks. This will contribute ~8 MCM of ground water by recharge, with this additional ~1000 ha land can be brought under irrigated dry (ID) crops in tank ayacut. There is need to take remaining 60 % of tanks during next phases. Under Mission Bhagiratha, there is plan to import ~125.16 MCM of water for drinking purposes which will save the present ~58 MCM of water for drinking and domestic purposes and with this additional ~7250 ha of land can be brought under ID crops.

Construction of 850 ARS with ~70.3 crores in **priority-1** area (over-exploited 253 villages having storage potential) and constructions of 2151 ARS with ~170.4 crores in **priority-2** area (other area) are recommended as supply side measures. Under Water conservation measures include, construction of 13960 nos of farm ponds with 34.90 crores in all villages.

Demand side measure includes bringing ~51868 ha of land (50 % ground water based irrigated area during rabi season) under micro-irrigation with total cost of **311.21** crores. With this 104 MCM of ground water will be saved in both seasons by utilizing same units.

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 **586.34** crores (excluding the cost involved in Mission Kakatiya and Mission Bhagiratha), the likely benefit would be increases in gross ground water irrigated area by ~41100 ha from ground water or net saving of **~247** MCM of ground water (net reduction of 15 % in stage of ground water development from 84 % to 69 %). The other benefits will be more distribution of income among farmers.

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

S. No.	Data	Aquifer	Total Data Points	Source		
				CGWB	SGWD	Well Inventory
1	Panel Diagram (3-D)	Combine	445	EW:66 VES:40	48	291
2	Hydrogeological Sections	4 no	445	EW:66 VES:40	48	291
3	Fence/panel Diagrams	1 no	445	EW:66 VES:40	48	291
4	Depth of weathering	1 no	445	EW:66 VES:40	48	291
5	Depth of fracturing	1 no	445	EW:66 VES:40	48	291
6	Groundwater Yield	Weathered zone	131	54	28	49
		Fractured zone	131	54	28	49
7	Transmissivity (m^2/day)	Weathered zone	15	15	-	-
		Fractured zone	7	7	-	-
8	Depth to Water Level Maps (2015)	Combine	368	74	294	-
9	Water Level Fluctuation	Combine	368	74	294	-
10	Long term water level trends	Combine	95	36	59	-
11	Water quality Pre-2015 Post-2014	Combine	Pre:219 Post:242 Total:	9 -	210 214 (SGWD and RWS)	-

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 "**groundwater development** " to " **groundwater 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 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 ground water management through community participation.

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

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

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

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

2.Periodic long term monitoring of ground water regime (for water levels and water quality) for creation of time series data base and ground water resource estimation.

3.Quantification of groundwater availability and assessing its quality.

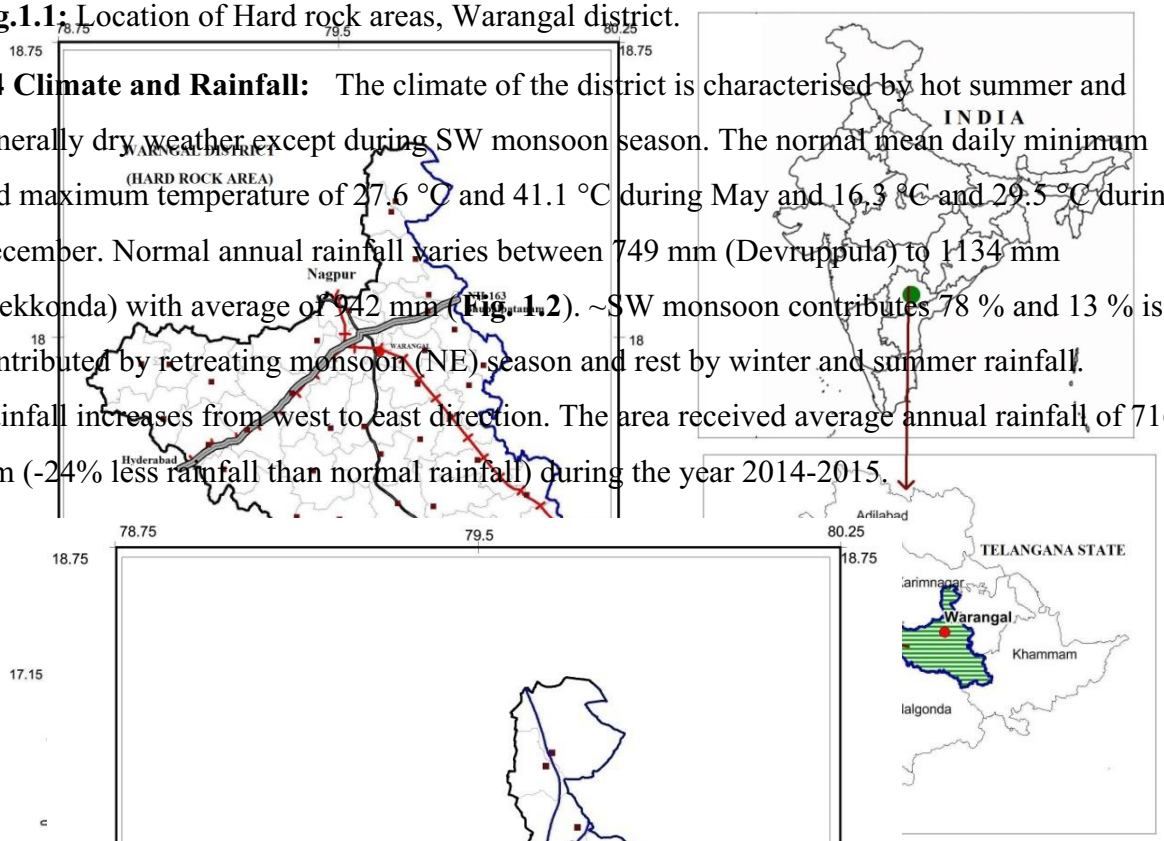
4.To delineate aquifer in 3-D along with their characterization on 1:50, 000 scale.

5.Capacity building in all aspects of ground water development and management through information, education and communication (IEC) activities, information dissemination, education, awareness and training.

6.Enhancement of coordination with concerned central/state govt. organizations and academic/research institutions for sustainable ground water management.

1.3 Area Details: The Warangal hard rock area covering ~8098 km ^{2} (63% area, Warangal district area: 12846 km ^{2}), lies between north latitude 17°19′26.5"-18°29′39.8" and east longitude 78°49′38"-80°10′2.5". It is part of the River Godavari and River Krishna basin (**Fig.1.1**) covering 39 watersheds with 7580 Km^2 mappable area and forests occupy ~ 11 % of study area. The non-command area is ~60 % and command area (~40 %). Administratively the area is governed by 38 revenue mandals covering 700 villages with a population of ~26.6 lakhs (2011 census) (urban: ~28%, rural: ~72 %) with average density of 328 persons/km^2.

Fig.1.1: Location of Hard rock areas, Warangal district.



1.4 Climate and Rainfall: The climate of the district is characterised by hot summer and generally dry weather except during SW monsoon season. The normal mean daily minimum and maximum temperature of 27.6 °C and 41.1 °C during May and 16.3 °C and 29.5 °C during December. Normal annual rainfall varies between 749 mm (Devruppula) to 1134 mm (Nekkonda) with average of 942 mm (**Fig. 1.2**). ~SW monsoon contributes 78 % and 13 % is contributed by retreating monsoon (NE) season and rest by winter and summer rainfall. Rainfall increases from west to east direction. The area received average annual rainfall of 716 mm (-24% less rainfall than normal rainfall) during the year 2014-2015.

Fig.1.2: Isohyetal map Hard rock areas, Warangal district.

1.5 Geomorphological Set up: Pediplain is the major landform covering about ~6700 km^2 (83 %) area. The other landforms observed are pediment (10%), hills (3 %), flood plain (2%), channel fill (2%), etc. (**Fig.1.3**).

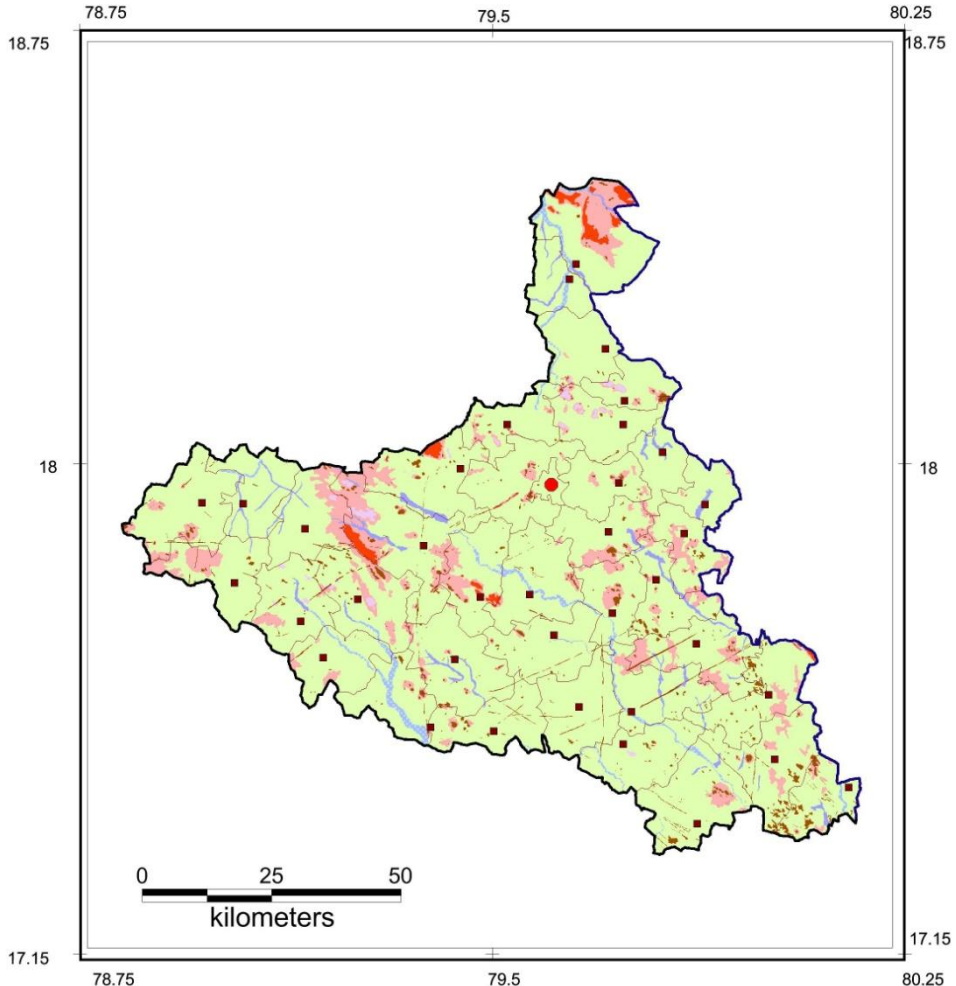


Fig.1.3: Geomorphology of Hard rock areas, Warangal district.

1.6 Drainage and Structures: The area is mainly drained by the river Muneru and river Akeru which are tributaries of river Krishna and divided into 39 watersheds. Map depicting drainage, hills and water bodies is presented in **Fig.1.4**.

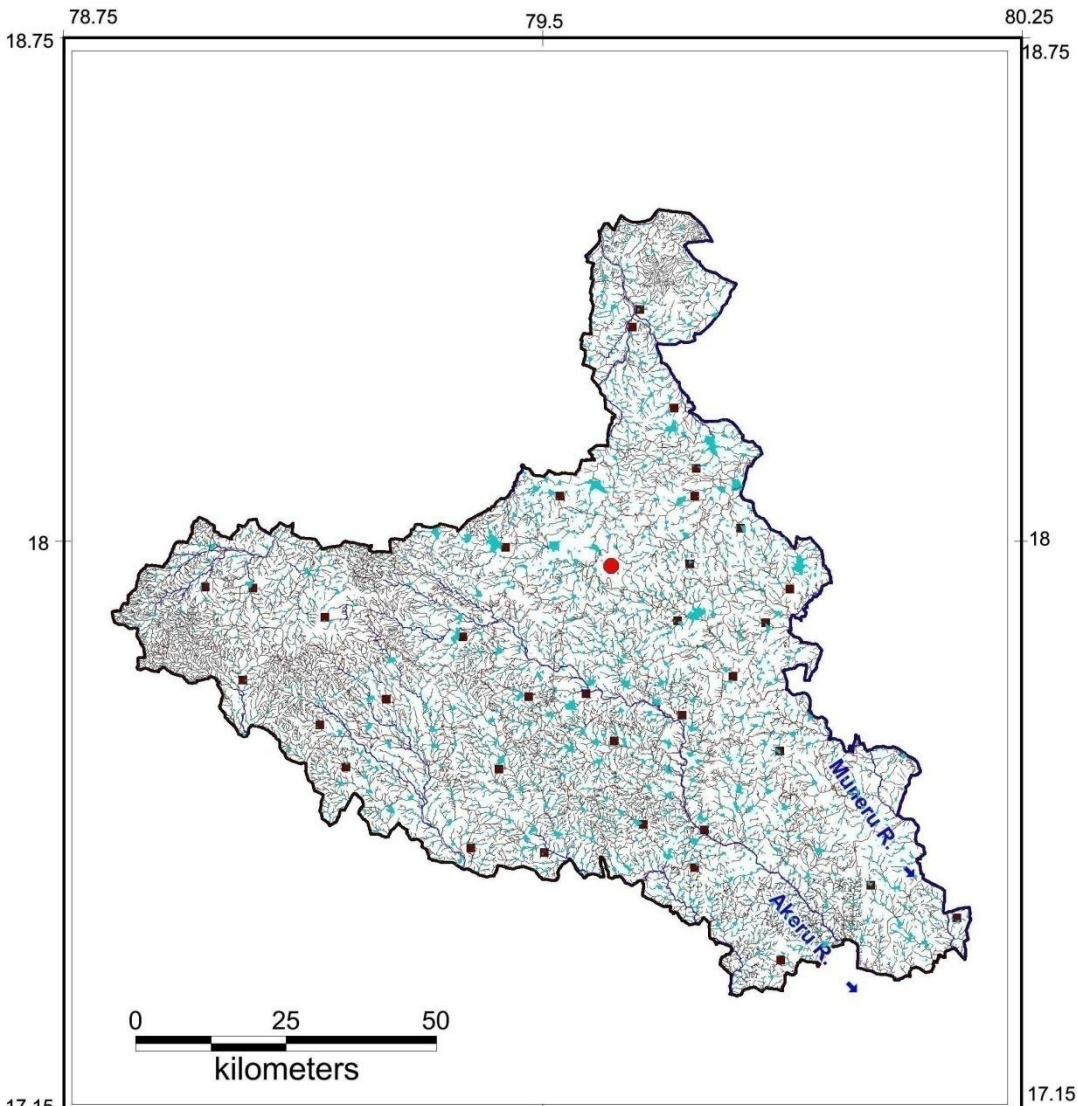


Fig.1.4: Drainage and water bodies map of Hard rock areas, Warangal district.

1.7 Land use and cropping pattern (2014-15): In the area, the land use can be grouped into 25 classes (**Fig.1.5**). Forest occupies ~11% of the total geographical area, wasteland (with and without shrub) occupy ~ 10 % of area; tanks occupy about 5 % of area. The gross area sown (2014-15) during kharif season is 371583 ha and during rabi season is 110686 ha (Total: 482269 ha). The net area sown (2014-15) during kharif season is 365613 ha and during rabi season is 5997 ha (Total: 371610 ha).

During kharif season cotton (50%), paddy, (17 %), maize (16%), pulses (7%), chillies (3%), groundnut 1%, vegetables 1% and others 5% are grown. During rabi season paddy (33 %), maize (32%), groundnut (16%), chillies (6%), pulses (5%) and vegetables 3 % etc are grown.

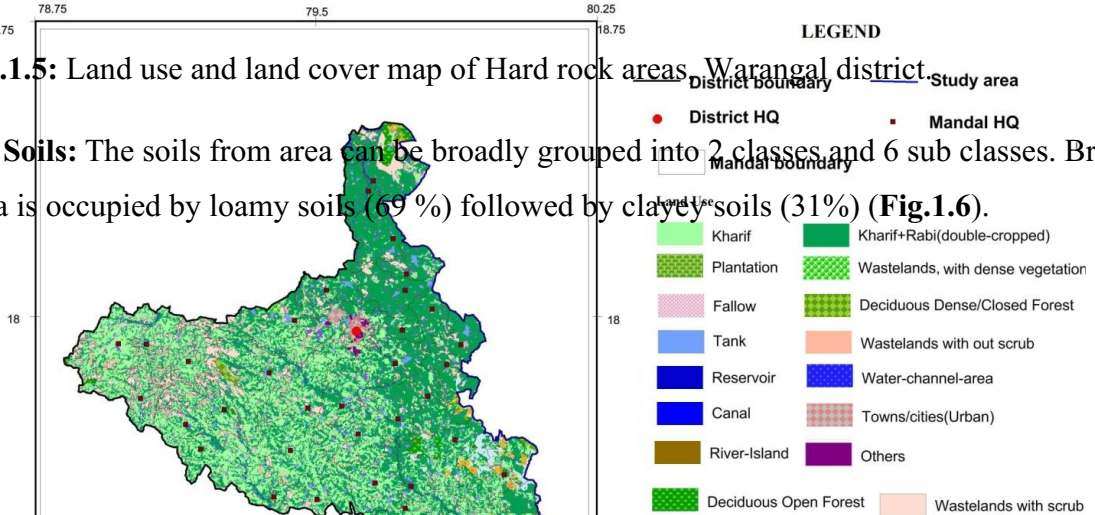


Fig.1.5: Land use and land cover map of Hard rock areas, Warangal district.

1.8 Soils: The soils from area can be broadly grouped into 2 classes and 6 sub classes. Broadly area is occupied by loamy soils (69 %) followed by clayey soils (31%) (**Fig.1.6**).

1.9 Irrigation: In the area, irrigation need is planned to be met from Sri Ram Sagar Project (Stage-1 and Stage-2) located on River Godavari (at Pochampad in Nizamabad district) with registered ayacut of these two projects is 8.64 lakhs ha in entire state but no gross or actual irrigation is taken place during the year 2014-15. ~18924 hectares of area is irrigated through Godavari Lift Irrigation scheme in the district (**Fig. 1.7**).

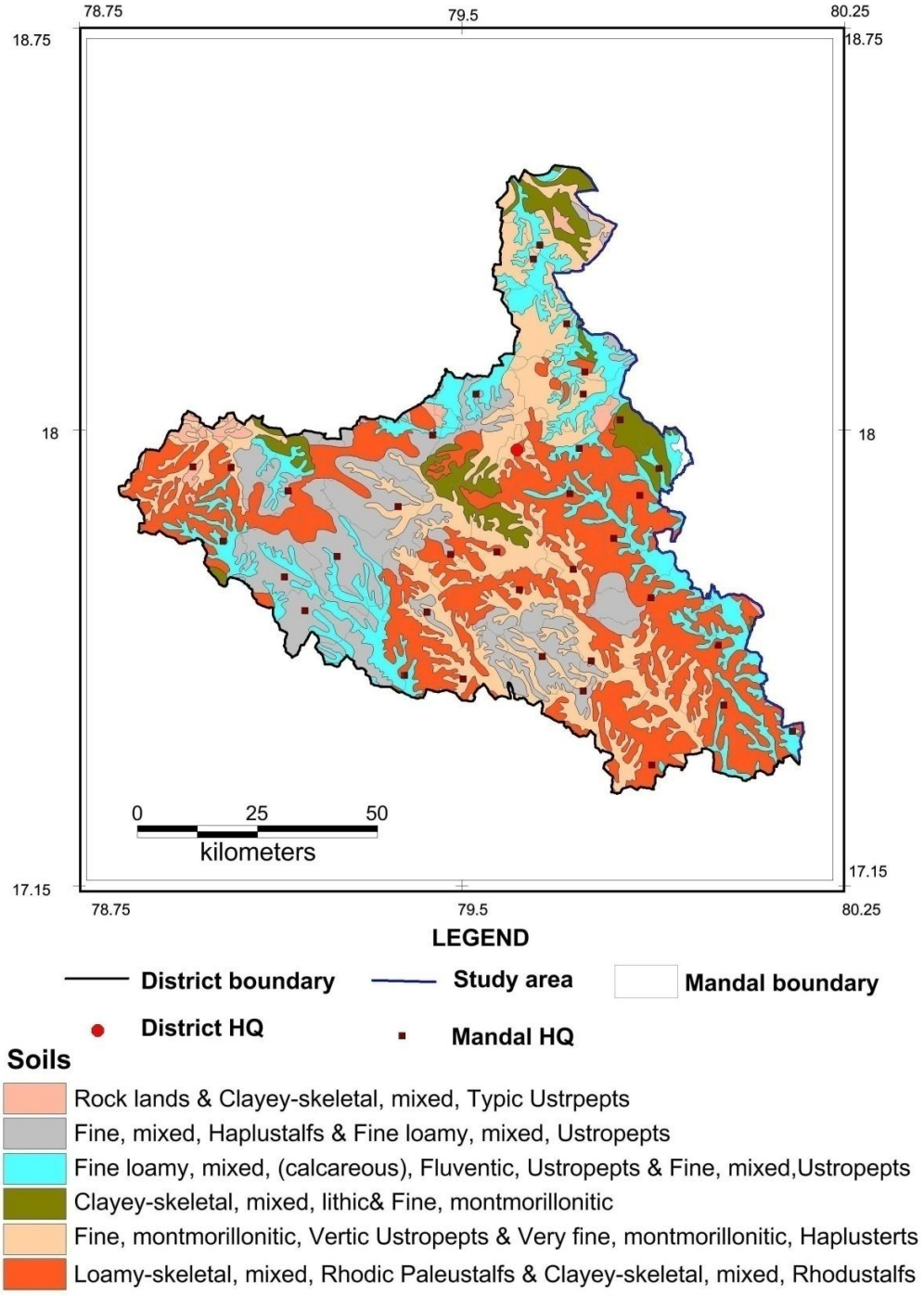


Fig.1.6: Soil map of hard rock areas, Warangal district.

The other medium project is Sali Vagu with registered ayacut of 1232 ha. In the area there are ~3049 MI Tanks (Command: 1566 and Non-command:1483) with 38900 hectare water spread (Command area: 22660 ham and Non-command area: 16259 ham). During the year 2014-15 only 6700 ha area was irrigated from surface sources (including tanks). The salient features of irrigation are given in **Table-1.1.**

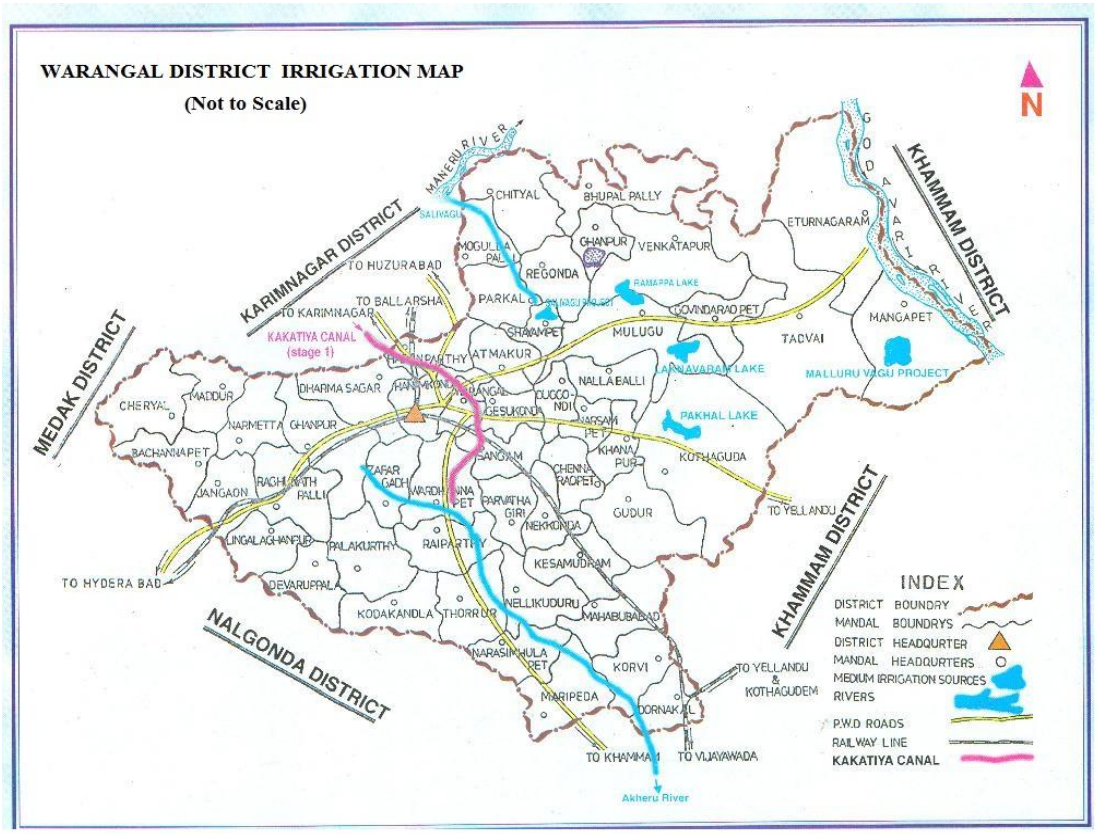


Fig.1.7: Irrigation map, Warangal district.

Table-1.1: Salient features of Irrigation in Warangal district (2014-15).

Irrigation	**Kharif**	**%**	**Rabi**	**%**
2014-15 (Ha)				
Ground water	**189137**	**97**	**103737**	**98**
• Bore wells	74237	38	50575	
• Dug wells	114900	59	53162	
Surface water	**4946**	**3**	**1751**	**2**
• Canals	106		305	
• Tanks	3913		1435	

• Lift	927		11	
Total				

1.10 Prevailing Water Conservation/Recharge Practices: In the area there are ~ 1124 percolation tanks (Command: 574 and Non-command:550) with 5622 ham storage capacity, 380 Check dams (Command: 215 and Non-command:165) with 942 ham storage capacity and very negligible farm ponds (3 in command area)In the district ~38680 ha of agricultural land is brought under micro irrigation (drip: 30917 ha and Sprinkler: 7763 ha) till December 2016. Under Mission Kakatiya (Phase 1 and 2) total ~16 MCM of silt is removed till March 2017.

1.11 Geology: ~ 82% of the area is underlain by crystalline rocks, namely granites, and 15% by Gneiss of Archaean to Proterozoic age and The other rocks namely schist (1%) occurs in patches in southern part, limestone (1%) and sandstone (1%) occurs in north-eastern part (**Fig1.8).** Banded iron formation occurs in central part in NW-SE direction.

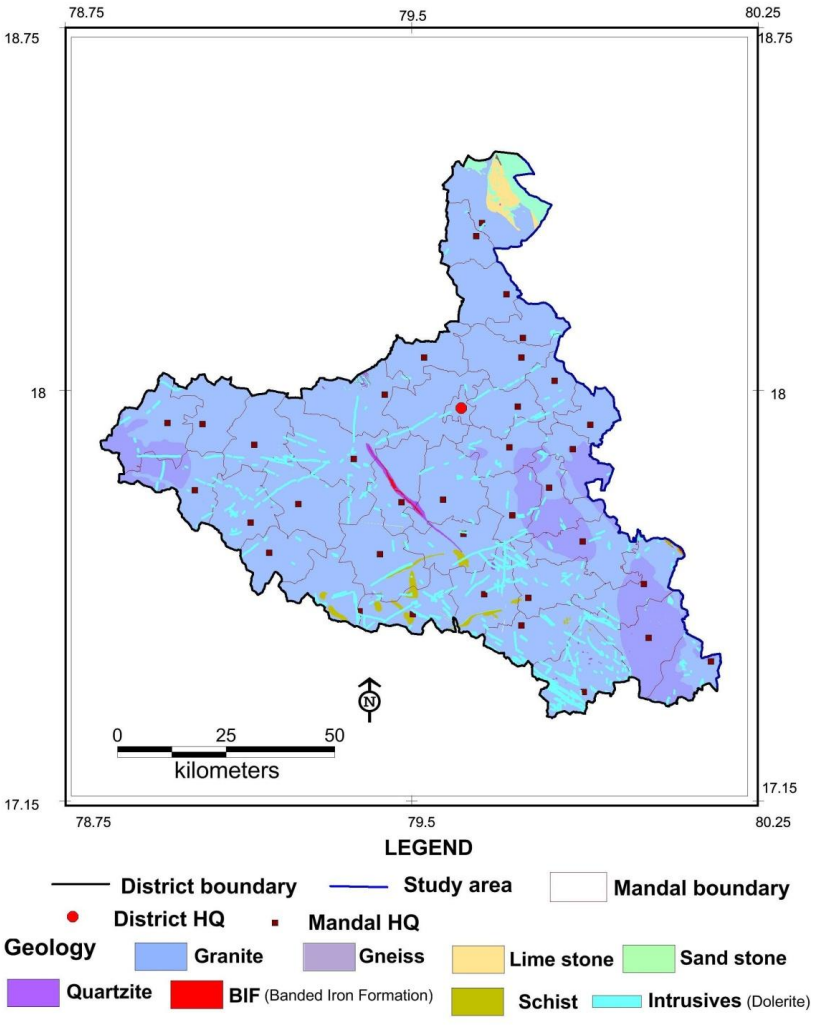


Fig.1.8: Geology map of Hard rock areas, Warangal district.

2. DATA COLLECTION and GENERATION

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

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

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

4.	Aquifer Management Plan	Preparation of aquifer management plan	Information on aquifer through training to administrators, NGO's, progressive farmers and stakeholders etc. and putting in public domain.

2.1 Hydrogeological Studies

Hydrogeology is concerned primarily with mode of occurrence, distribution, movement and chemistry of ground water occurring in the subsurface in relation to the geological environment. The occurrence and movement of water in the subsurface is broadly governed by geological frameworks i.e., nature of rock formations including their porosity (primary and secondary) and permeability. The principal aquifer in the area is granites and gneisses and the occurrence and movement of ground water in these rocks is controlled by the degree of interconnection of secondary pores/voids developed by fracturing and weathering. Based on 445 hydrogeological data points (Exploraton: 114 (CGWB: 66 and SGWD: 48), VES: 40 and Well inventory: 291) hydrogeological map is prepared (**Fig.2.1).**

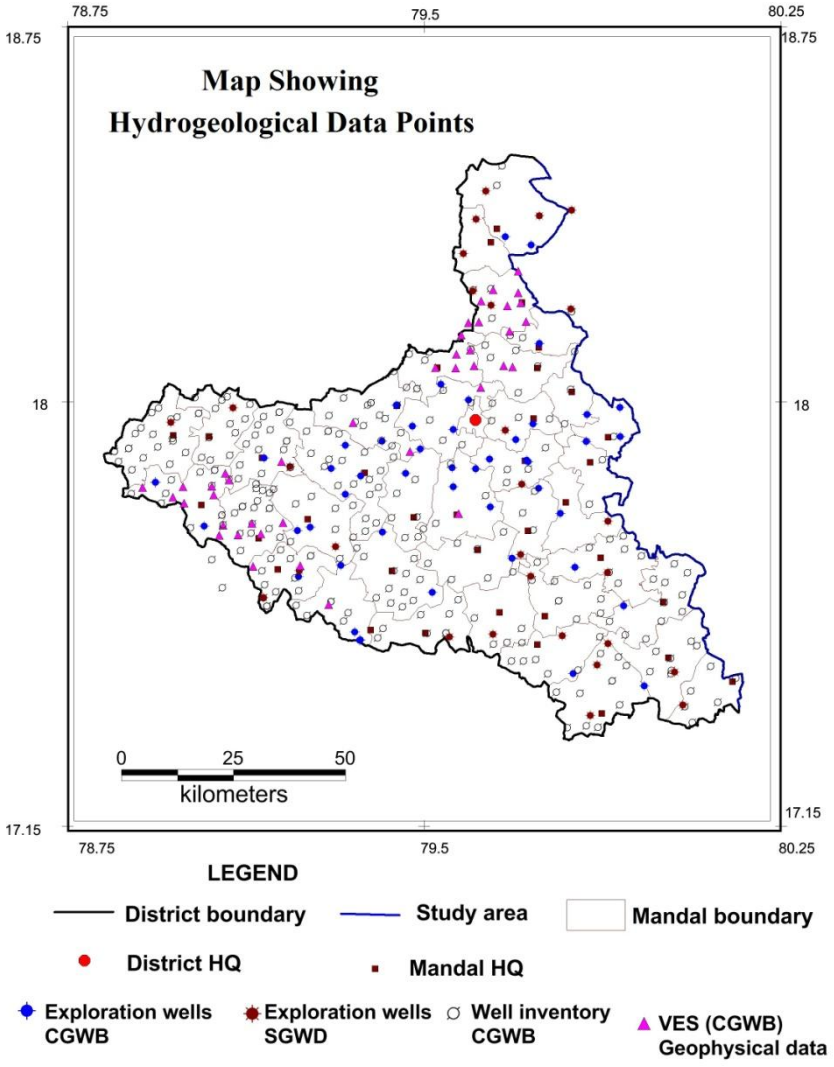


Fig. 2.1: Hydrogeological data availability, Hard rock areas, Warangal District.

2.1.1 Ground water occurrences and movement Ground water occurs under unconfined and semi-confined conditions and flows downward from the weathered zone (saprolite and sap rock) into the fracture zone. The main aquifers constitute the weathered zone at the top, followed by a discrete anisotropic fractured/fissured zone at the bottom, generally extending down to 130 m depth. The storage in granite rocks is primarily confined to the weathered zone and its overexploitation, mainly for irrigation purpose, has resulted in desaturation of weathered zone at many places. At present, extraction is mainly through boreholes of 60-130 m depth.

2.1.2 Exploratory Drilling: As on 31/03/2016, CGWB drilled 66 bore wells (exploratory, observation and piezometers) and SGWD drilled 48 wells in the hard rock areas of the district. Data analysed from CGWB wells indicates 4 wells are of shallow depth (30 m), 16 nos (30-60 m), 30 nos (60-100 m) 2 nos (100-150 m) 11 nos (150-200 m) depth**.**

In the district, there are ~3.63 lakhs existing wells (Irrigation BW: 2.13 lakhs, Irrigation DW: 1.33 lakhs and rest domestic wells 17544. As per electricity authority there are 2.46 lakhs electric connections. Various hydraulic properties of the aquifers are discussed in C**hapter -3**.

2.1.3 Ground water Yield: Yields from granite varies between <0.1 and 8 litres/second (lps), in sandstone from 1.5 to 12.5 lps (avg: 6.9 lps), in limestone it varies from 0.2 to 5.8 lps (avg: 1.6 lps). Studies from hydrogeological data reveal that all fractures occur within 100 m depth and deepest fracture is encountered at 86 m depth (Muttojipet in Narsampet mandal). The hydrogeological map of the area is presented in **Fig. 2.2**.

2.2 Water Levels (2015): Ground water levels from 368 wells (CGWB: 74 and SGWD: 294) consisting of dug wells (212) and piezometers (156) were monitored for pre-monsoon and post-monsoon season.

2.2.1 Water Table Elevations: During pre and post-monsoon season (May and November) of 2015, the water-table elevation ranges from < 150 to > 500 meter above mean sea level (m amsl) in both seasons and general ground water flow is towards river Akeru and river Muneru (**Fig.2.2**).

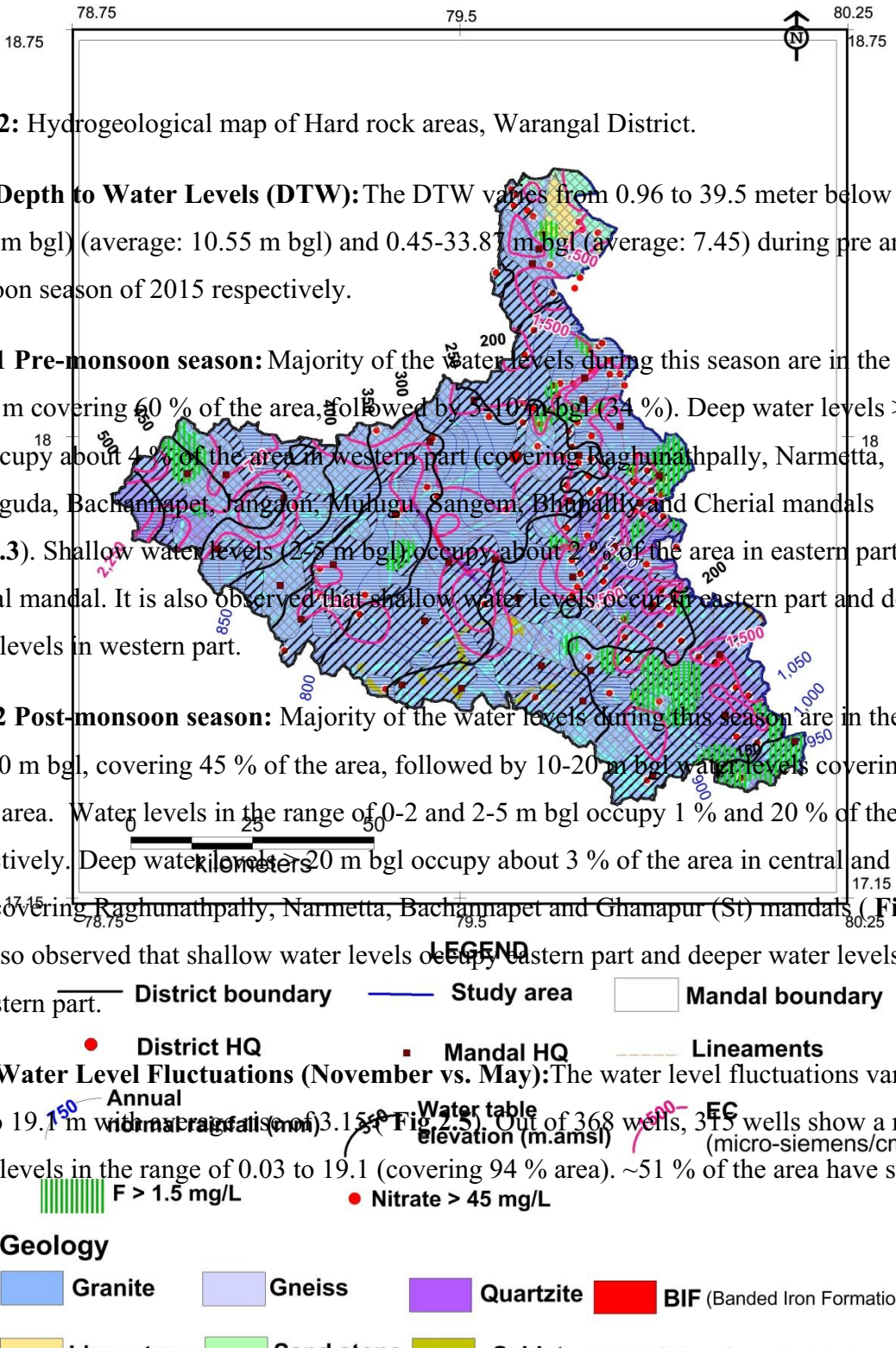


Fig.2.2: Hydrogeological map of Hard rock areas, Warangal District.

2.2.2 Depth to Water Levels (DTW): The DTW varies from 0.96 to 39.5 meter below ground level (m bgl) (average: 10.55 m bgl) and 0.45-33.87 m bgl (average: 7.45) during pre and post-monsoon season of 2015 respectively.

2.2.2.1 Pre-monsoon season: Majority of the water levels during this season are in the range of 10-20 m covering 60 % of the area, followed by 5-10 m bgl (34 %). Deep water levels > 20 m bgl occupy about 4 % of the area in western part (covering Raghunathpally, Narmetta, Kothaguda, Bachannapet, Jangaon, Mulugu, Sangem, Bhupalli and Cherial mandals (**Fig.2.3**). Shallow water levels (2-5 m bgl) occupy about 2 % of the area in eastern part of Chityal mandal. It is also observed that shallow water levels occur in eastern part and deeper water levels in western part.

2.2.2.2 Post-monsoon season: Majority of the water levels during this season are in the range of 5-10 m bgl, covering 45 % of the area, followed by 10-20 m bgl water levels covering 31 % of the area. Water levels in the range of 0-2 and 2-5 m bgl occupy 1 % and 20 % of the area respectively. Deep water levels > 20 m bgl occupy about 3 % of the area in central and western part (covering Raghunathpally, Narmetta, Bachannapet and Ghanapur (St) mandals (**Fig.2.4**). It is also observed that shallow water levels occupy eastern part and deeper water levels occur in western part.

2.2.3 Water Level Fluctuations (November vs. May): The water level fluctuations vary from -9.7 to 19.1 m with average rise of 3.15 m (**Fig.2.5**). Out of 368 wells, 315 wells show a rise in water levels in the range of 0.03 to 19.1 (covering 94 % area). ~51 % of the area have shown

water level rise in the range of 2-5 m, 0-2 m rise is observed in 27 % of area, 5-10 m in 14% and >10 m in 1% of the area. 26 wells shows fall in water levels in the range of -9.7 to -0.10 m. 17 wells have only 1 date (either pre or post-monsoon).

2.2.4 Long term water level trends (2006-2015): Trend analysis for the last 10 years (2006-2015) is studied from 95 hydrograph stations of CGWB (36 nos) and SGWD (59 nos). It is observed that during pre-monsoon season 53 wells shows a falling trend in the range of -1.36 m/yr to -0.004 m/yr (0 to 1 m: 52 wells and 1-2 m: 1 well) and 42 shows rising trend 0.003 m/yr to 2.83 m/yr (0 to 1 m: 36 wells, 1-2 m: 4 wells and > 2: 2 wells).

During post-monsoon season 28 wells shows a falling trend in the range of -0.92 m/yr to -0.004 m/yr (all below 0-1 m) and 67 wells shows rising trend in the range of 0.01 m/yr to 2.28 m/yr (0 to 1 m: 57 wells, 1-2 m: 8 wells and > 2: 2 wells).

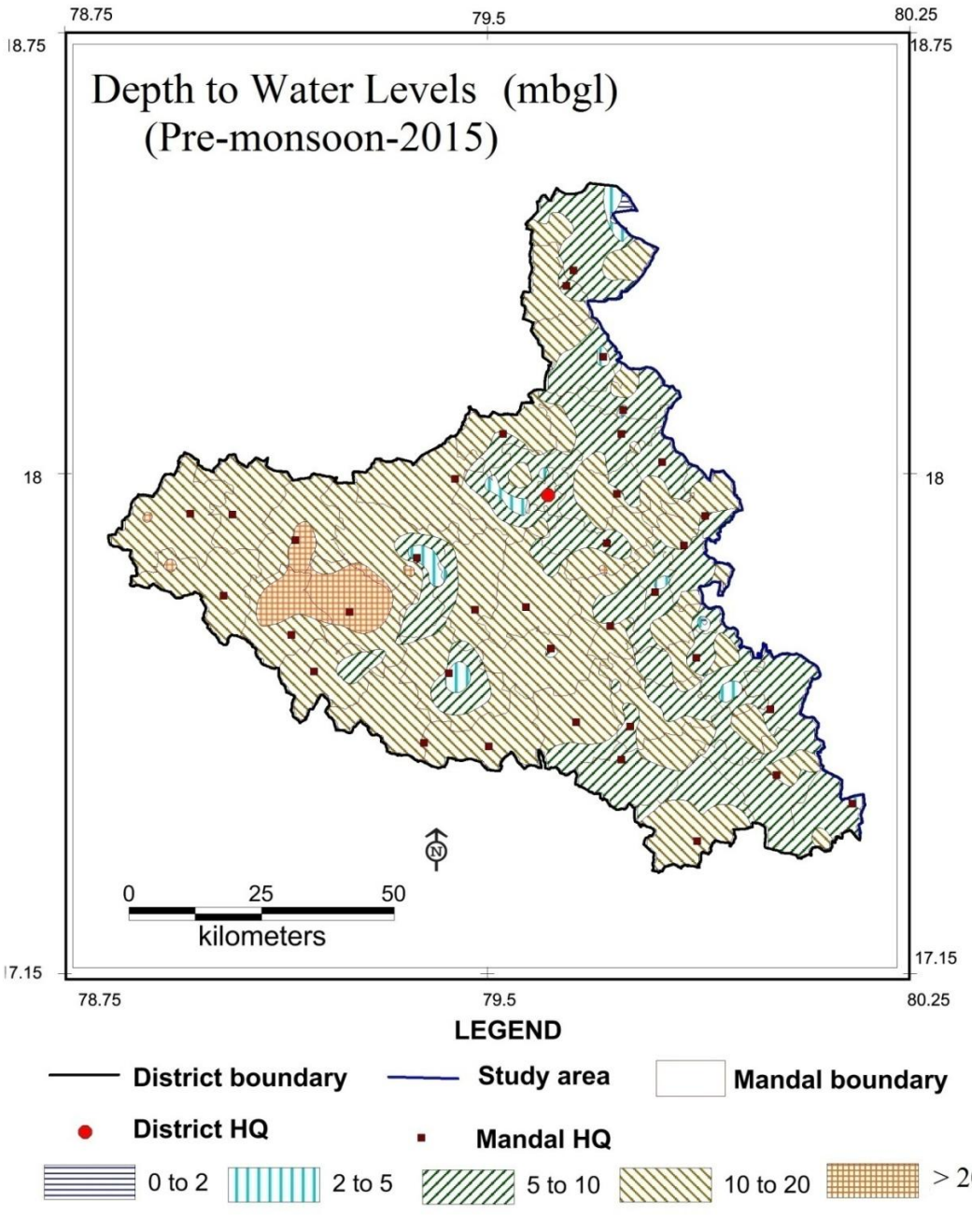


Fig.2.3: Depth to water levels Pre-monsoon (May-2015).

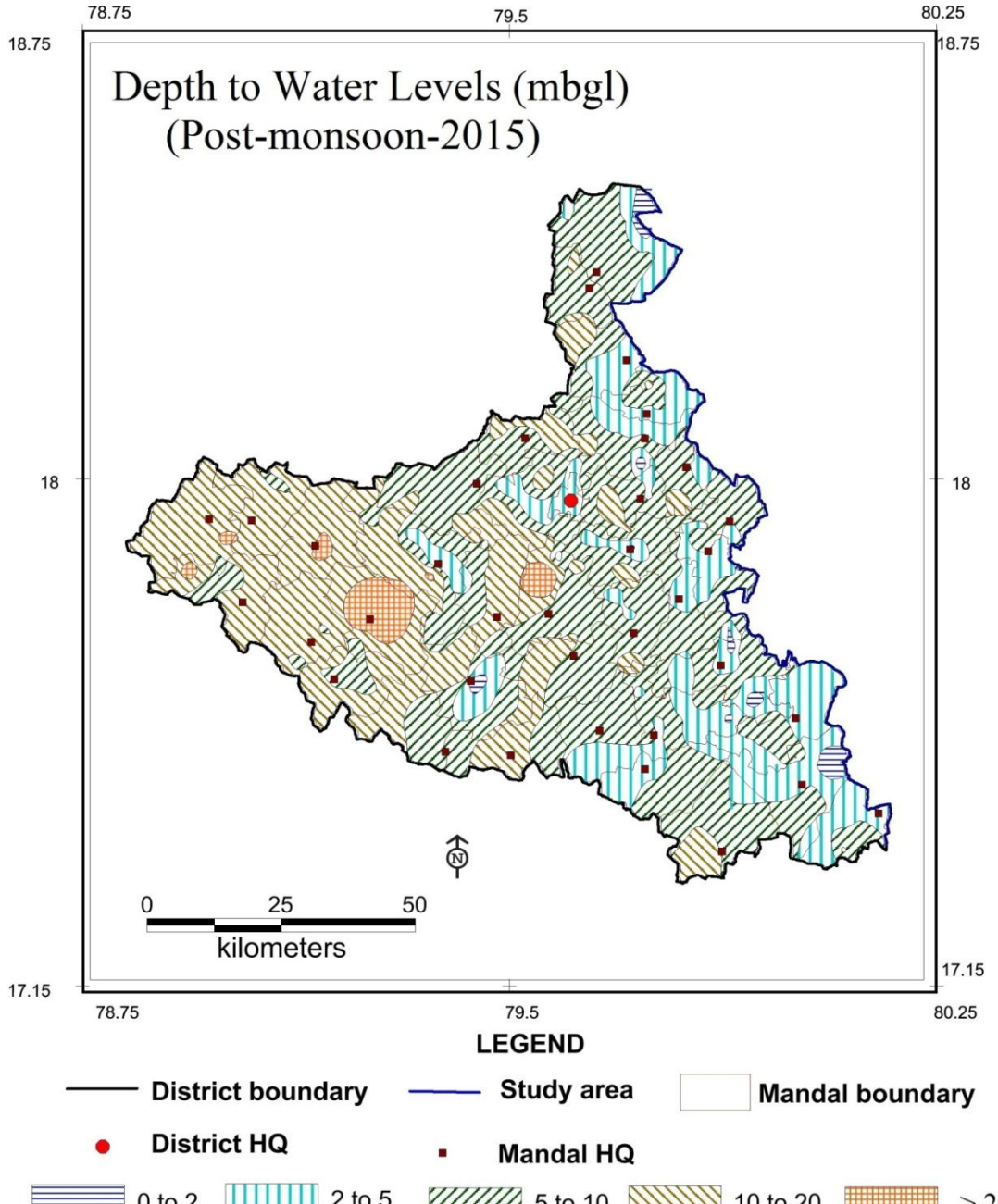


Fig.2.4: Depth to water levels Post-monsoon (Nov-2015).

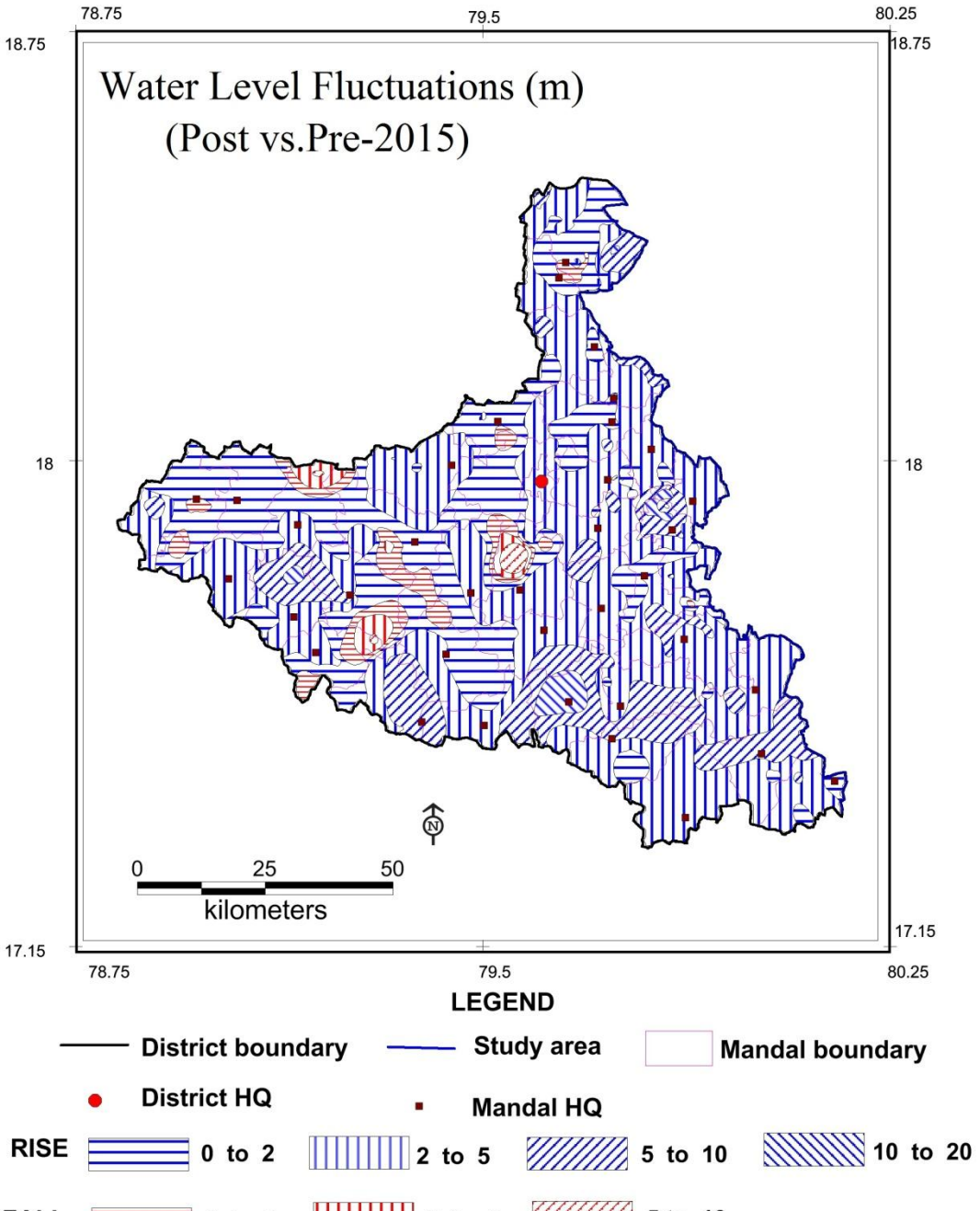


Fig.2.5: Water Level Fluctuations (m) (Nov vs. May-2015).

Average water levels for the last 10 years (2005-14) were compared with 2015 data and it is found that during 2015 pre-monsoon season 71 wells have shown fall and 23 shown rise and during post monsoon season 76 wells shown fall and 18 shown rise in water levels and 1 well shown neither rise nor fall in both seasons. Annual long term water level trends map is presented in **Fig 2.6.** Number of wells showing rise and fall during 2015 with respect to average of 2005-14 is presented graphically in **Fig 2.7**. From Fig.2.7 it is seen that in most of western part fall is observed and rise is observed in eastern part.

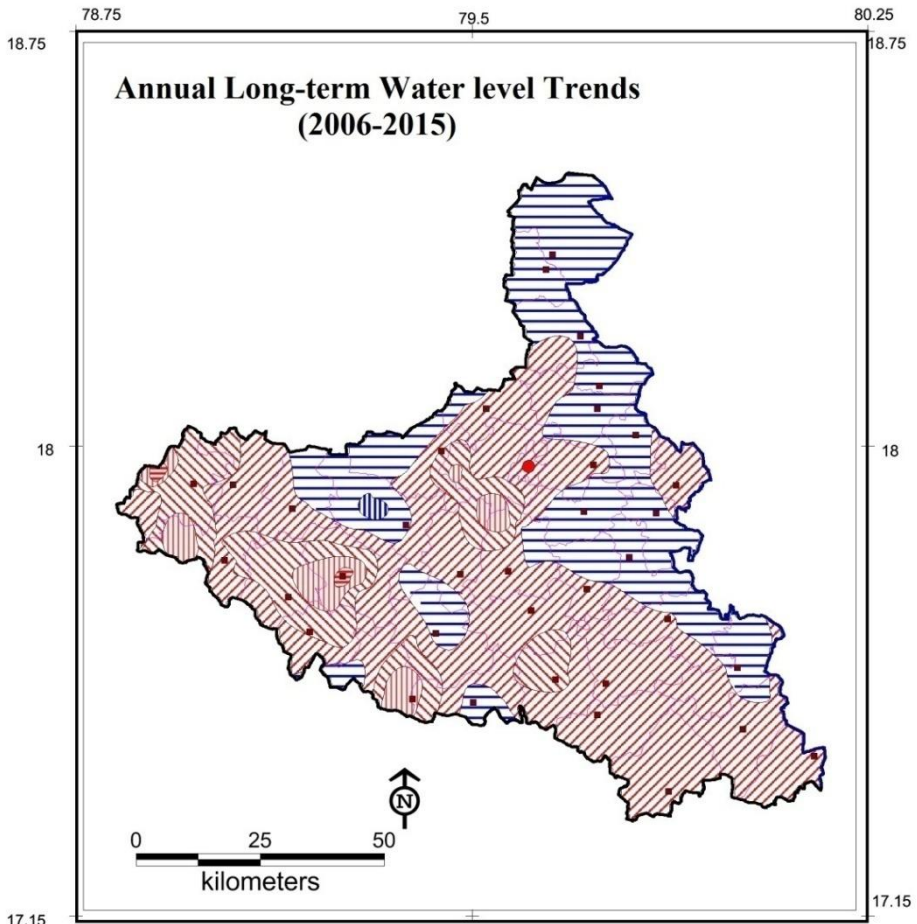


Fig. 2.6: Long-term water level trends (2006-2015).

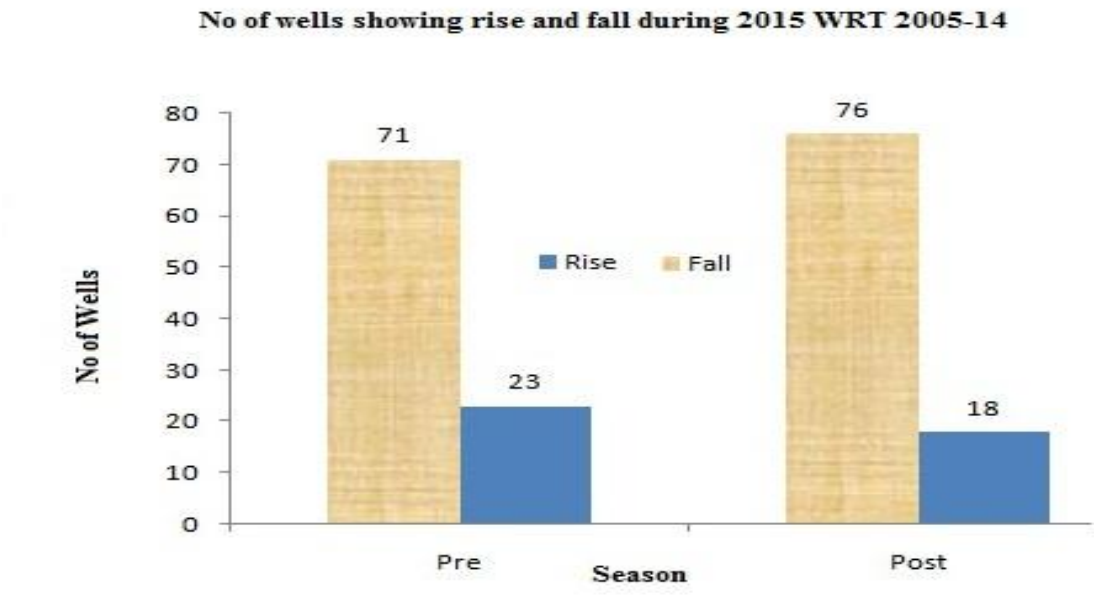


Fig. 2.7: No of wells showing rise/fall during 2015 WRT to 2005-14.

2.3 Geophysical Studies

A total of 40 VES data of CGWB is interpreted, which reveals resistivity < 90 Ohm (Ω) m for the weathered granite, 90-180 Ω m for underlying semi weathered granite, between 180-400 Ω m fractured granite and > 400 Ω m for massive granite.

2.4 Hydro chemical Studies

To understand chemical nature of groundwater, total 461 data is utilized from ground water monitoring wells of CGWB and SGWD wells (Pre-monsoon:219 and post-monsoon:242) (mostly tapping combined aquifers Aq-1 and aq-2) during the pre and post-monsoon season of 2015. Four parameters namely pH, TDS, NO_3 and F were analyzed and suitability for drinking purposes is assessed as per BIS standards (2012) and irrigation suitability as per electrical conductivity.

2.4.1 Pre-monsoon (May-2015) (219 samples-CGWB: 9 and SGWD & RWS: 210)

Groundwater from the area is mildly alkaline in nature with pH in the range of 7-8.9 (Avg: 8.1). Electrical conductivity varies from 348-5670 µ Siemens/cm . In 66 % of samples covering 70 % of area, EC is within 1500 µ Siemens/cm and in 61 samples covering 28 % area; it is in the range of 1500-3000 µ Siemens/cm. It is found that > 3000 EC is observed in 14 samples covering 6 % of area (mainly eastern part) and is not suitable for irrigation (**Fig.2.8).** TDS concentration of varies from 543 to 3629 (avg: 885 mg/l) and found that 95% of samples falls in maximum permissible limits of BIS (2000 mg/l). NO_3 concentration ranges from 5-461 mg/l and found 52 % of samples (114 nos) are unfit for human consumption (> 45 mg/l) (**Fig.2.9**). Fluoride concentration varies from 0.1-3.6 (**Fig 2.10**) and found that 37 samples (17%) covering 9 % area are unfit for human consumption (>1.5 mg/l). High fluoride concentration (>1.5 mg/l) is observed in mandals located in eastern part (Chityal, Shaympet, Atmakur, Narasampet, Parvatgiri, Nekkonda, Chennaraopet, Nellikodur, K.Samudram, Mahabubabad, Dornakal etc and mandals located in western part (Cherial) and central part (Ghanpur (Station)).

2.4.2 Post-monsoon (November-2015) (Total 242 samples all SGWD & RWS)

Groundwater from the area is mildly alkaline in nature with pH in the range of 7.5-9.1 (Avg: 8.3). Electrical conductivity varies from 453-5020 µ Siemens/cm . In 57 % of samples covering 59 % of area, EC is within 1500 µ Siemens/cm and in 90 samples covering 38 % area; it is in the range of 1500-3000 µ Siemens/cm. More than 3000 EC is observed in 15 samples covering 6 % of area (North eastern part) and is not suitable for irrigation (**Fig.2.11).** Comparatively high EC's are observed during post-monsoon season as compared to pre-monsoon season. TDS concentration of varies from 290 to 3213 (avg: 1017 mg/l) and found that 95% of samples falls in maximum permissible limit of BIS (2000 mg/l). NO_3 concentration ranges from 1-478 mg/l and found 58 % of samples (140 nos) are unfit for human consumption

(> 45 mg/l) (**Fig.2.12**). Fluoride concentration varies from 0.1-6.4 (**Fig 2.13**) and found that 56 samples (23 %) covering 16 % area are unfit for human consumption (>1.5 mg/l). High fluoride concentration (>1.5 mg/l) is observed in Bachannapet, Ghanpur (Station), Narmetta, Raghunathpalli, Dharamasagar, Narasampet, Duggondi, Parvatgiri, Wardhamanpet, Nekkonda, Chennaraopet, Nellikodur, K.Samudram, Mahabubabad, Dornakal etc. High concentration > 5 mg/l is observed in K.Samudram mandal (Thallapusalapalli village).

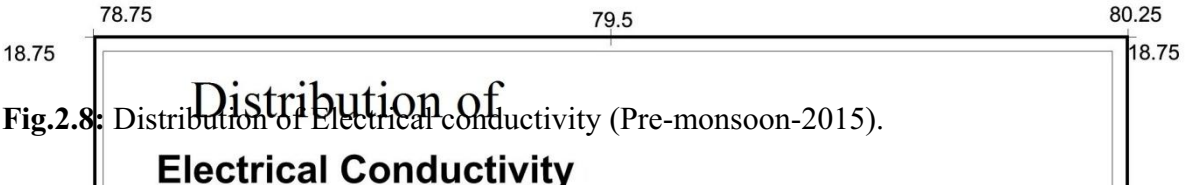


Fig.2.8: Distribution of Electrical conductivity (Pre-monsoon-2015).

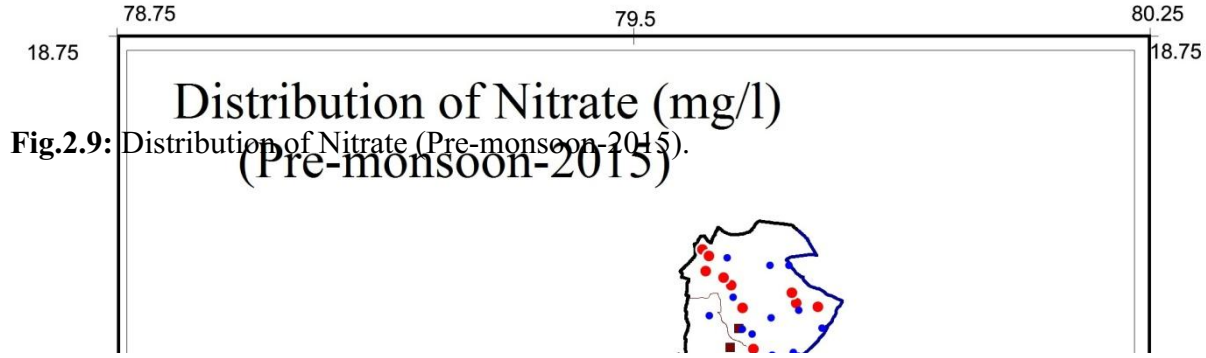


Fig.2.9: Distribution of Nitrate (Pre-monsoon-2015).

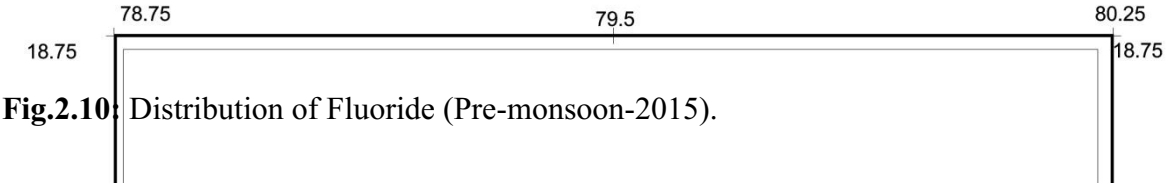


Fig.2.10: Distribution of Fluoride (Pre-monsoon-2015).

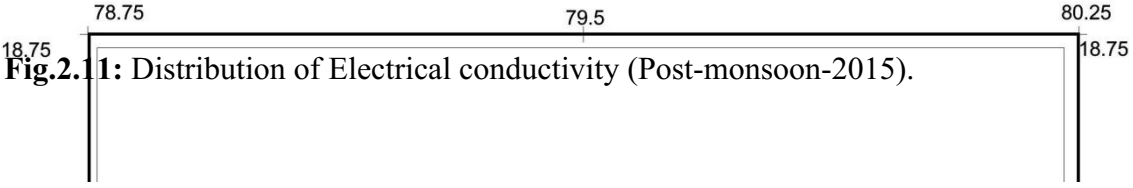


Fig.2.11: Distribution of Electrical conductivity (Post-monsoon-2015).

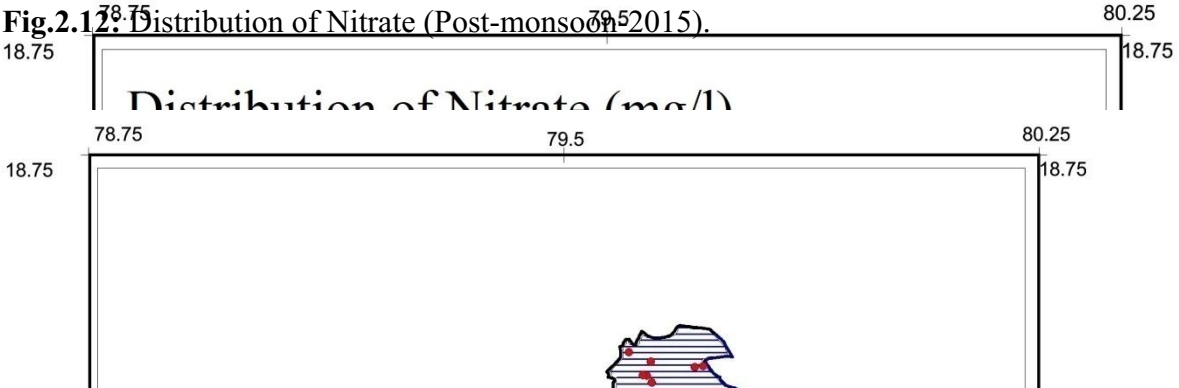


Fig.2.12: Distribution of Nitrate (Post-monsoon-2015).

Fig.2.13: Distribution of Fluoride (Post-monsoon-2015).

3. DATA INTERPRETATION, INTEGRATION and AQUIFER MAPPING

Conceptualization of 3-D hydrogeological model was carried out by interpreting and integrating representative 445 data points (both hydrogeological and geophysical down to 200 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 lithological information was generated by using the RockWorks-16 software and generated 3-D map for hard rock areas of Warangal district (**Fig.3.1)** along with panel diagram (**Fig. 3.2**) and hydrogeological sections.

Fig.-3.1:3-D Model for study area.

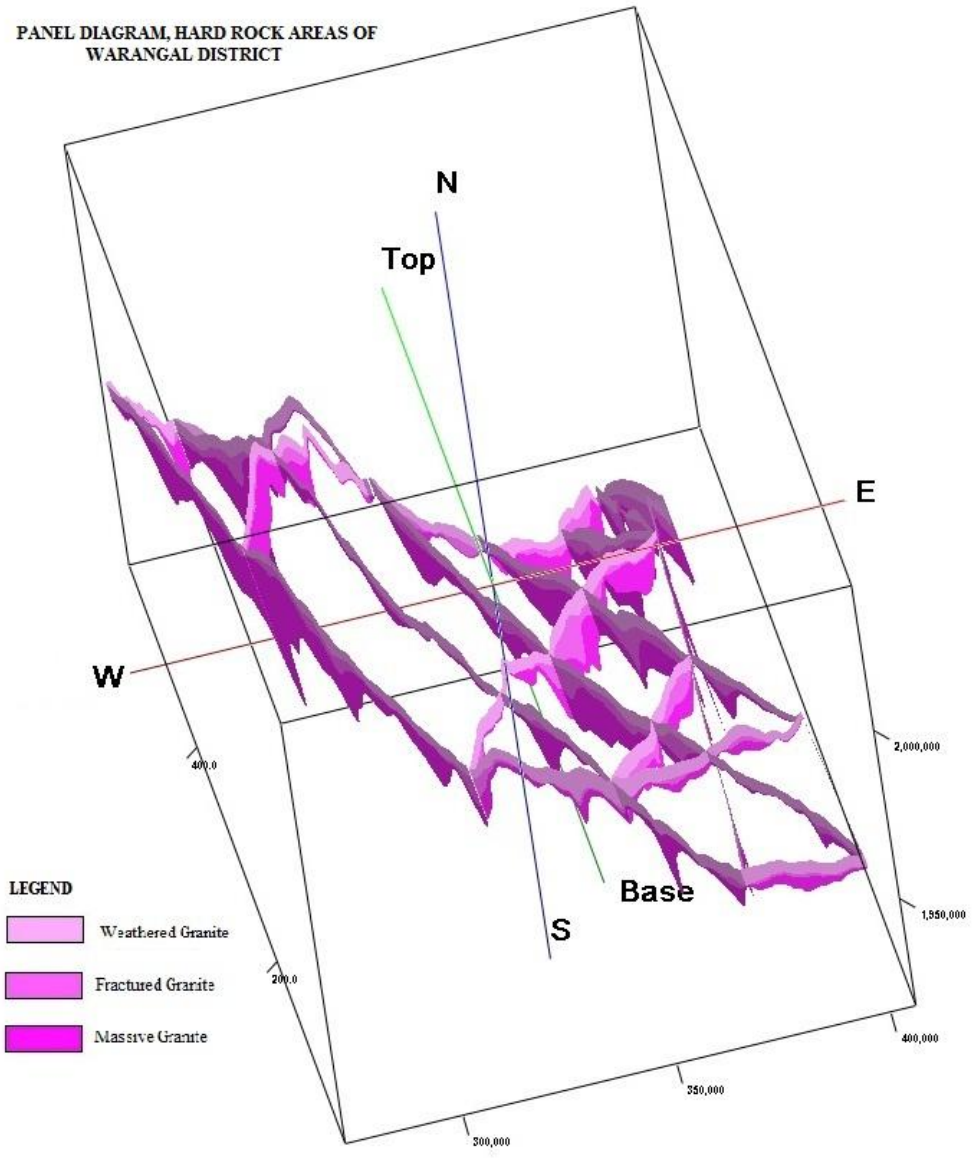


Fig.-3.2: Panel Diagram, Hard rock areas,Warangal district.

3.1 Conceptualization of aquifer system in 3D

Aquifers were characterized in terms of potential and quality based on integrated hydrogeological data and various thematic maps. Weathered zone is considered up to the maximum depth of weathering and first fracture encountered (below weathered depth) generally down to ~30 m depth (avg depth 12 m) and the fractured zone is considered up to the depth of deepest fracture below weathered zone (~30-86 m). Out of 445 data points ~93 % of data points have information down to 100 m only (**Fig3.3**). Only 2 % of data have information down to 200 m.

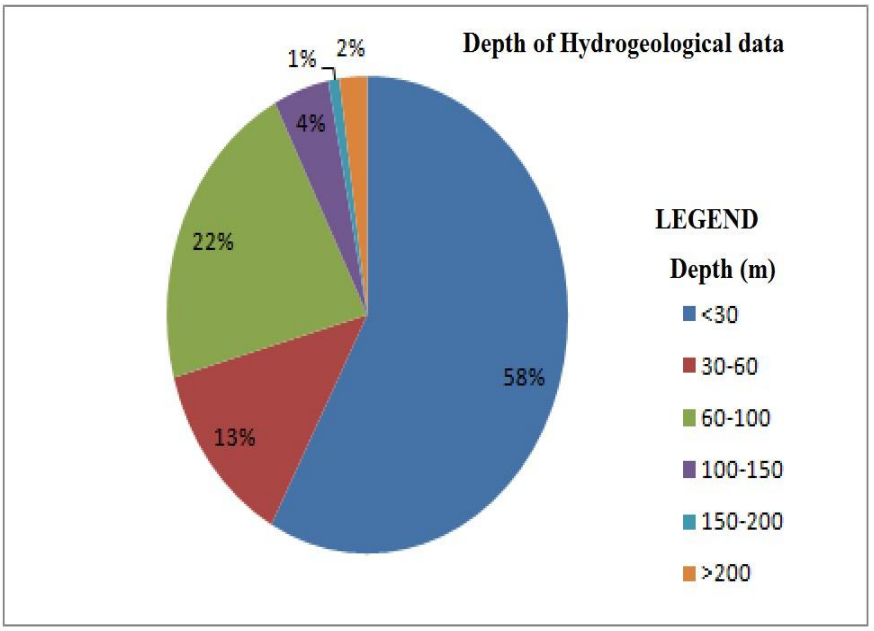


Fig.3.3: Depth range of Hydrogeological data.

3.2 Hydrogeological Sections

Four hydrogeological sections are prepared in N-S, NW-SE and 2 section covering E-W direction (1 and 2) (**Fig. 3.5a-d**).

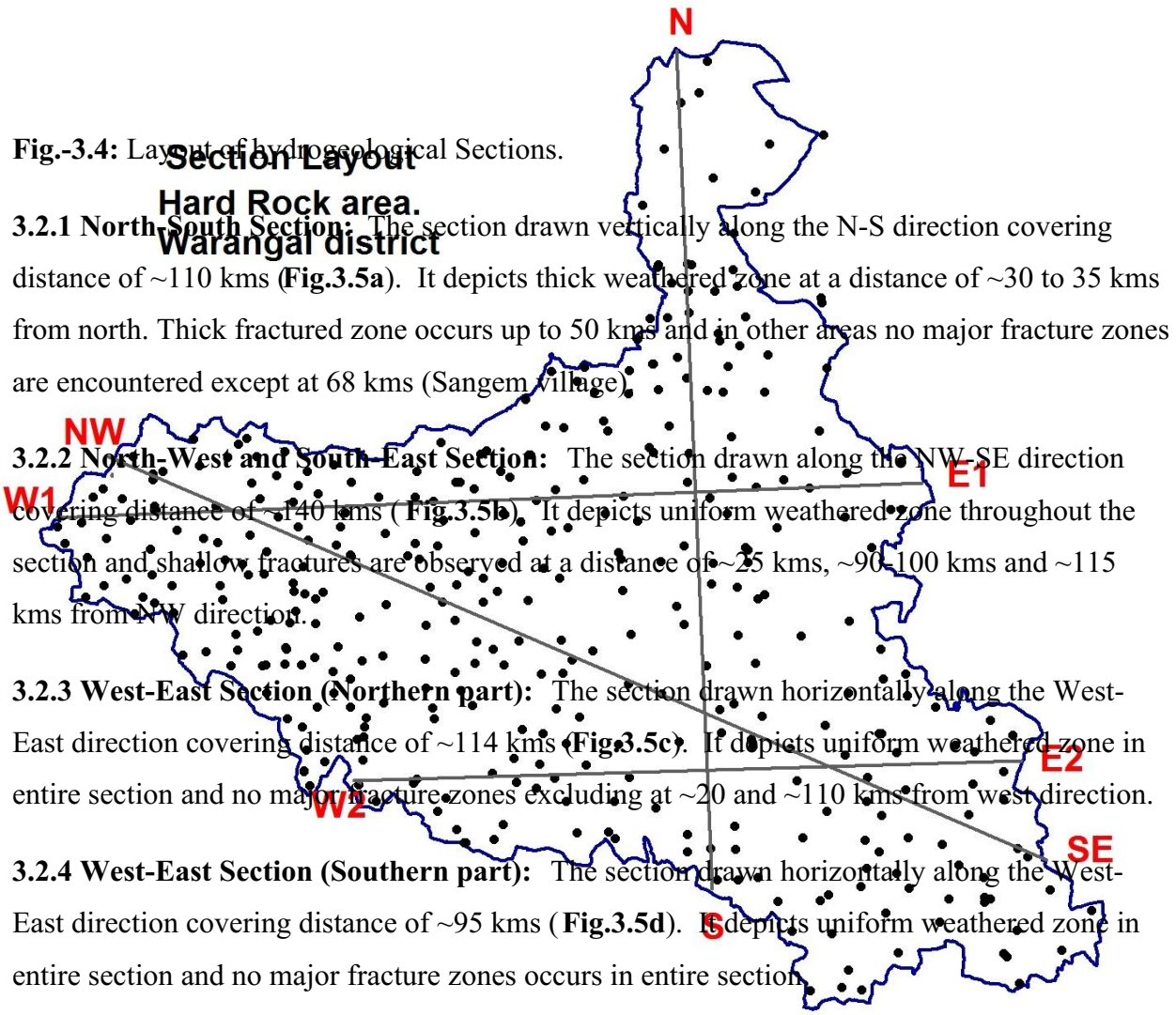


Fig.-3.4: Layout of hydrogeological Sections.

3.2.1 North-South Section: The section drawn vertically along the N-S direction covering distance of ~110 kms (**Fig.3.5a**). It depicts thick weathered zone at a distance of ~30 to 35 kms from north. Thick fractured zone occurs up to 50 kms and in other areas no major fracture zones are encountered except at 68 kms (Sangem village).

3.2.2 North-West and South-East Section: The section drawn along the NW-SE direction covering distance of ~140 kms (**Fig.3.5b**). It depicts uniform weathered zone throughout the section and shallow fractures are observed at a distance of ~25 kms, ~90-100 kms and ~115 kms from NW direction.

3.2.3 West-East Section (Northern part): The section drawn horizontally along the West-East direction covering distance of ~114 kms (**Fig.3.5c**). It depicts uniform weathered zone in entire section and no major fracture zones excluding at ~20 and ~110 kms from west direction.

3.2.4 West-East Section (Southern part): The section drawn horizontally along the West-East direction covering distance of ~95 kms (**Fig.3.5d**). It depicts uniform weathered zone in entire section and no major fracture zones occurs in entire section.

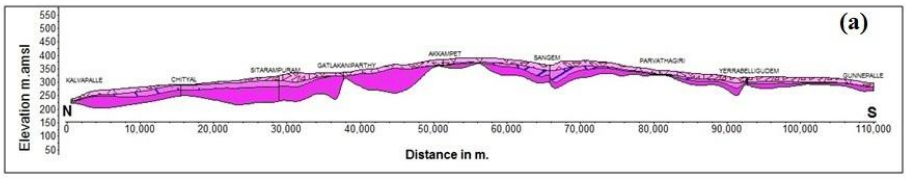


Fig.3.5 (a-d): Hydrogeological sections in different directions, Hard rock areas, Warangal district.

3.3 Aquifer Characterization

3.3.1 Weathered zone: The weathered zone (~30 m) consisting of upper saprolite (~11 m) and lower sap rock (11-30) has gone dry in considerable part due to over-exploitation (excluding command area). Dug wells, which are in existence, have become defunct. In most of the area 10-20 m (73%) weathering is most common followed by < 10 m (24 %). Deep weathering (20-30 m) occurs in 3% of area (**Fig.3.6**).

Ground water yield from weathered granite/gneiss aquifer varies from <0.1 to 8 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 part of study area. The transmissivity varies from 1-150 m^2/day and in majority of wells it is ~20 m^2/day, specific yield (Sy) ranges from < 1 to 3 %.(avg: 1.5%).

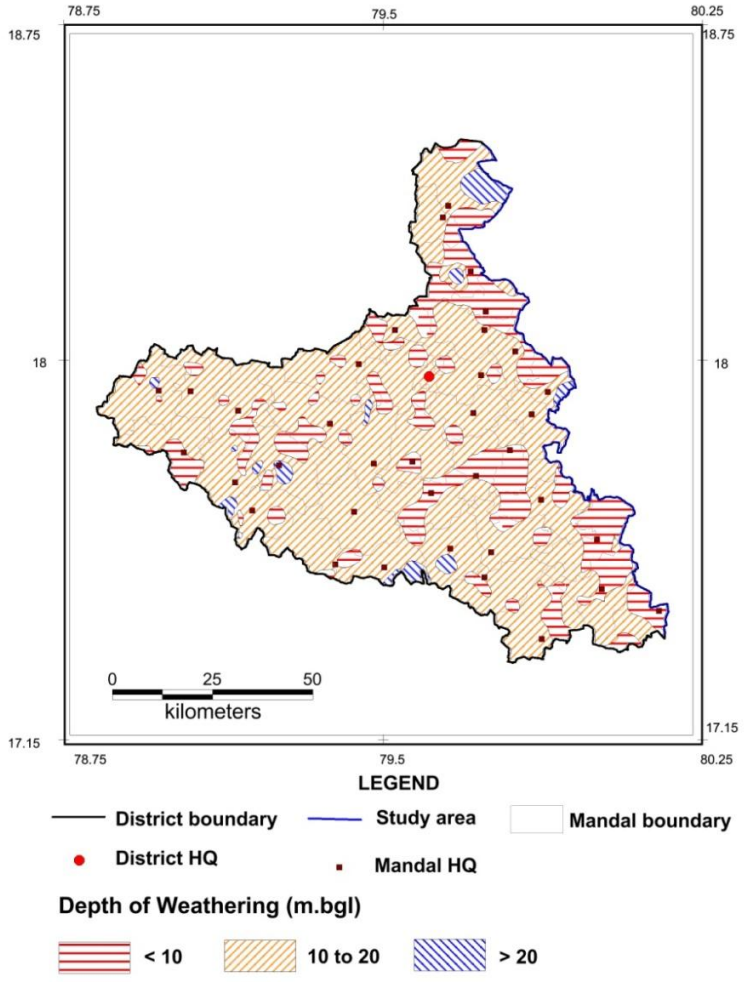


Fig.3.6: Thickness of Weathered zone, Hard rock areas, Warangal district.

3.3.2 Fractured zone: Ground water is extracted mainly through bore wells of 60 to 100 m depth from fractured zone (~30 to 86 m) (deepest fracture at Muttojipet in Narasampet mandal). Based on CGWB data, it is inferred that fractures in the range of < 30 m depth are more predominant (59 % of the area); 30-60 m and 60-86 fractures occur in 39 % and 2 % of area respectively and deep fractures are not observed as only 2 % of wells have sub-surface information down to 200 m depth (**Fig.3.7**). Ground water yield in this zone varies from 0.01 to 8 lps. The transmissivity (T) varies from 1 to 150 m^2/day (avg: 20 m^2/day) and storativity varies from 0.0001 to 0.0345.

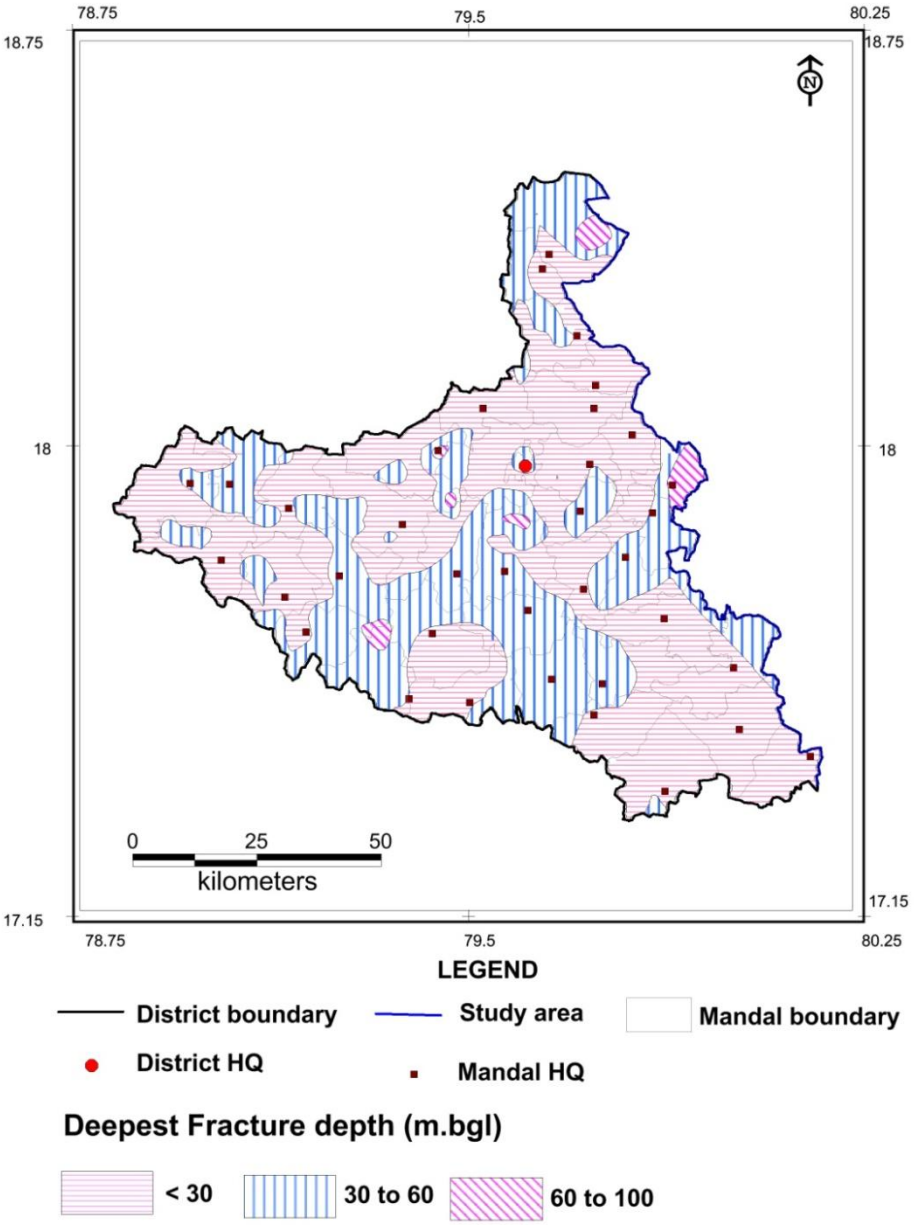


Fig.-3.7: Depth of Fractured zone, Hard rock areas, Warangal district.

4. GROUND WATER RESOURCES (2013)

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

While computing the in-storage resources, the general depth of deepest fractures in the area, pre-monsoon water levels and 2 % of granular zone (depth below pre-monsoon water level and down to deepest fracture depth in the village) and 3 % as specific yield is considered. Summarized command/non-command area wise and mandal wise resources for 37 mandals (Warangal mandal is considered as part of Hanmakonda mandal) are given in **Table-4.1 and Table-4.2** respectively.

As per 2013 GEC report, the net dynamic replenishable groundwater availability is 1128 MCM, gross ground water draft for all uses 949.2 MCM, provision for drinking and industrial use for the year 2025 is 131.84 MCM and net annual ground water potential available for future irrigation needs is 110.65 MCM. The stage of ground water development varies from 76 % in command area and 91 % in non-command area with average of 84 %. 10 mandals falls in over-exploited category, 3 in critical category, 17 in semi critical category and others in safe category. Mandal wise stage of ground water development varies from 55 % (Chityal mandal)

to 155 % (Maddur mandal). Based on 2013 resources, village wise utilizable ground water resource map is prepared and presented in **Fig. 4.1.**

Computed total in-storage ground water resources from hard rock areas down to the maximum depth of fracture are estimated at 80 MCM. During the post monsoon season there is net recharge of 14 MCM.

Table-4.1: Computed Dynamic, In-storage ground water resources, Hard rock areas, Warangal district.

Parameters	Command	Non-command	**Total**
As per GEC 2013	MCM	MCM	MCM
Dynamic (Net GWR Availability)	**488.7**	**639.3**	**1128.0**
• Monsoon recharge from rainfall	254.76	386.54	641.3
• Monsoon recharge from other sources	78.97	81.71	160.68
• Non-Monsoon recharge from rainfall	63.25	104.07	167.32
• Non-monsoon recharge from other sources	134.85	134.87	269.72
Gross GW Draft	**370.18**	**579.02**	**949.20**
• Irrigation	344.97	540.54	885.51
• Domestic and Industrial use	25.21	38.48	63.69
Provision for Drinking and Industrial use for the year 2025	39.54	92.30	131.84
Net GW availability for future irrigation	104.21	6.44	110.65
Average Stage of GW development (%)	76	91	84
Categorization of mandals	Mandal wise it varies from 55 % to 155 % (OE:10, C:3, SC:17 and Safe:7		
In-storage GW Resources (down to the maximum depth of fractures)	**80 MCM (May) 94 MCM (November)**		

Table-4.2: Administrative Unit Wise Assessment of Dynamic Groundwater Resources, Hard Rock Areas, Warangal District [2012-2013] [in ham.]

S. No.	Administrative unit/District	Net annual ground water availability	Gross ground water draft (Irr)	Gross ground water draft (Domestic and Industrial)	Total draft	Provision for domestic and industrial requirement (for the year 2025)	Net ground water availability for future irrigation	Stage of ground water development %	Category
1	Atmakur	3566	2385	142	2527	246	935	71	S.C
2	Bachannapet	2869	2884	182	3066	197	-212	107	O.E.
3	Chennaraopet	2851	3021	93	3114	229	-399	109	O.E.
4	Cherial	3376	2507	197	2704	304	565	80	S.C
5	Chityal	5299	2576	144	2720	245	2478	51	Safe
6	Devaruppula	2650	1910	166	2076	186	554	78	S.C
7	Dharmasagar	3262	2512	151	2663	312	438	82	S.C
8	Dornakal	2392	1552	148	1700	187	653	71	S.C
9	Duggondi	1775	2159	138	2297	192	-576	129	O.E.
10	Geesugonda	2123	2223	149	2372	247	-347	112	O.E.
11	Hanamakonda	3836	1830	468	2298	3897	-1891	60	Safe
12	Hasanparthy	2299	1567	136	1703	272	460	74	S.C
13	Jangaon	2510	2595	253	2848	577	-662	113	O.E.
14	K.Samudram	3849	1884	169	2053	288	1677	53	Safe
15	Kodakandla	2587	2679	171	2850	223	-315	110	O.E.
16	Korivi	3405	1764	239	2003	328	1313	59	Safe
17	Lingala Ghanpur	2522	2206	77	2283	178	138	91	Critical
18	Maddur	2157	3159	187	3346	176	-1178	155	O.E.
19	Mahabubabad	3770	2368	304	2672	473	929	71	S.C
20	Maripeda	3744	2599	301	2900	359	786	77	S.C
21	Mogullapally	2610	2013	65	2078	113	484	80	S.C
22	Narmetta	3088	2703	121	2824	188	197	91	Critical
23	Narsampet	1978	1732	105	1837	150	96	93	S.C
24	Narsimhulapet	2925	1704	131	1835	255	966	63	Safe
25	Nekkonda	3357	2131	161	2292	185	1041	68	Safe

26	Nellikudur	3668	3337	272	3609	272	59	98	S.C
27	Palakurthy	3499	2749	166	2915	245	505	83	S.C
28	Parkal	3160	2043	143	2186	320	797	69	Safe
29	Parvatagiri	2499	1963	142	2105	202	334	84	S.C
30	Raghunathpally	3289	3149	142	3291	239	-99	100	O.E.
31	Rayaparthy	3465	3180	152	3332	235	50	96	Critical
32	Sangem	2886	2086	160	2246	238	562	78	S.C
33	Shayampet	2040	1452	85	1537	187	401	75	S.C
34	Stn Ghanpur	4296	3058	195	3253	396	842	76	S.C
35	Thorrur	2997	3184	259	3443	312	-499	115	O.E.
36	Wardhannapet	3915	3893	151	4044	327	-305	103	O.E.
37	Zaffergadh	2286	1794	104	1898	204	288	83	S.C
	Total	**112800**	**88551**	**6369**	**94920**	**13184**	**11065**	**84**	

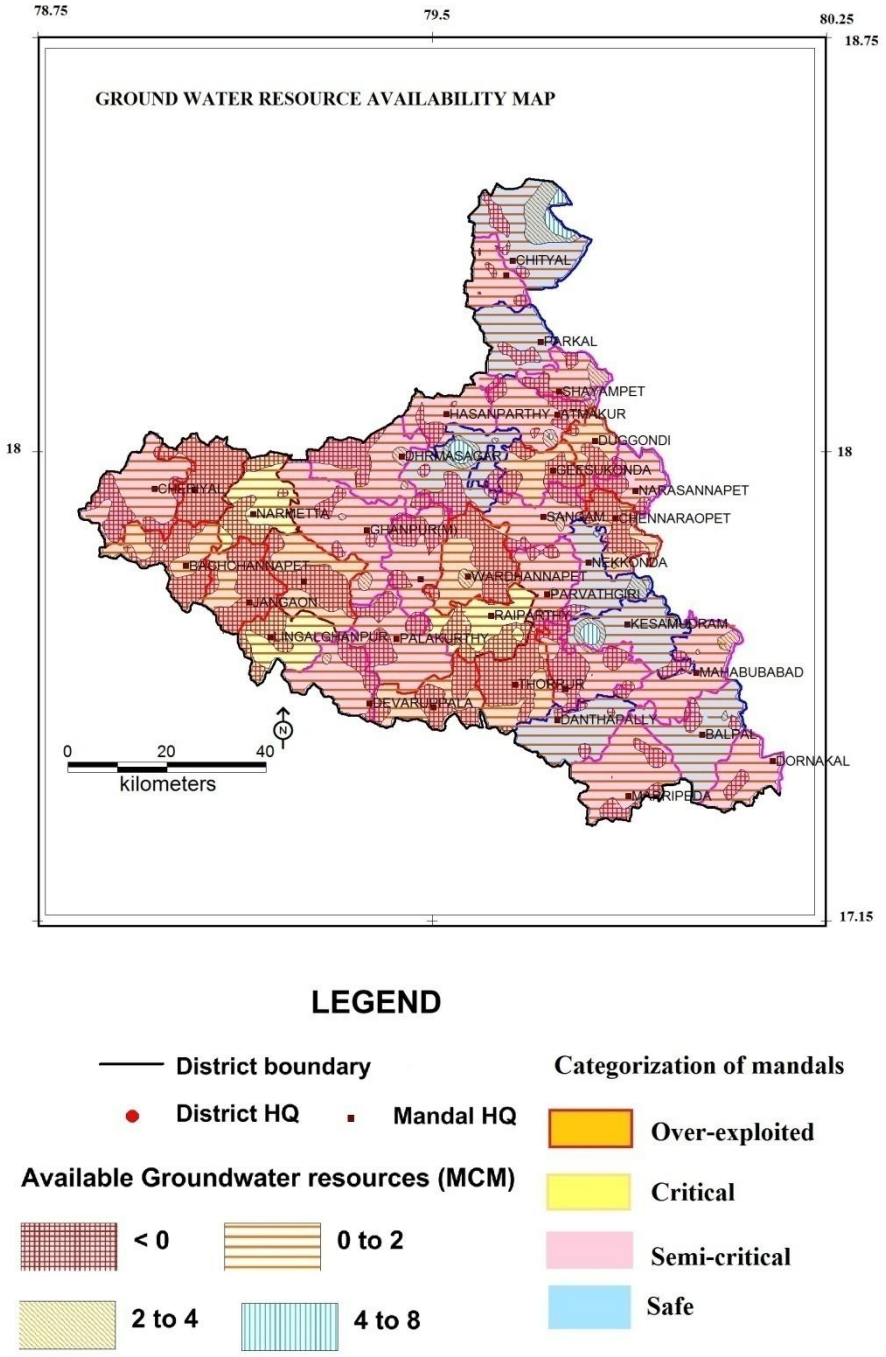


Fig.4.1: Utilizable ground water resources, Hard rock areas, Warangal district (2013).

5. GROUND WATER RELATED ISSUES and REASONS FOR ISSUES

5.1 Issues

Over-exploitation

- ~ 2214 Km^2 area covering 265 villages are categorized as over-exploited where ground water balance for future irrigation is zero or negative.

Pollution (Geogenic and Anthropogenic)

- Few mandals are fluorosis endemic where fluoride (geogenic) as high as 3.6 mg/l during pre-monsoon and 6.4 mg/l during post-monsoon season is found in groundwater. The high fluoride concentration (>1.5 mg/l) occur in 9 % and 16 % of the area during pre and post-monsoon season of 2015.

- High nitrate (> 45 mg/l) due to anthropogenic activities is observed in 114 samples (52 %) and 140 samples (58 %) during pre and post-monsoon season respectively covering mostly eastern part (command area) and urban areas.

- The high concentrations of EC (> 3000 micro-Siemens/cm) covering 6 % of area during pre as well as post-monsoon season (mostly in canal command area) are observed. Comparatively high EC is observed in during post-monsoon season.

Deep water levels

- Deep water levels (> 20 m bgl) are observed during pre as well as post-monsoon season in 4 % and 3 % of the area respectively.

Declining water level trends

- Out of 95 wells analyzed, 53 wells shown falling trend in pre-monsoon and 28 during post-monsoon season (@-1.36 to -0.004 and -0.92 to -0.004 m/yr) respectively.

- Water levels of 2015, compared to average of 2005-14 have shown fall in 71 and 76 wells (total wells: 95) during pre and post-monsoon season respectively.

Sustainability

- Low yield (<1 lps) occurs in ~27 % of area and yields covering central part. The yield from bore wells have reduced over a period of time and some bore wells which used to yield sufficient quantity of water have gone dry due to more exploitation.

Water Marketing and other Issues

- Water marketing is present in almost all over the area and people are buying bottled water from the market for drinking purposes as there is no sufficient supply of potable water.

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

- Based on ground water paddy is grown during rabi season in non-command area also leading to heavy withdrawal of ground water during non-monsoon period.

5.2 Reasons for Issues

Geo-genic pollution (Fluoride)

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

Anthropogenic pollution (Nitrate)

- 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.

Over-exploitation and Deep water levels

- Over-extraction, paddy cultivation during rabi season (33 % to total crops) more ground water extraction in proportion to recharge, limited artificial measures etc.

6. MANAGEMENT STRATEGIES

High dependence on groundwater coupled with absence of augmentation measures has led to a steady fall in water levels and desaturation of weathered zone in some parts, raising questions on sustainability of existing groundwater structures, food and drinking water security. The occurrence of fractures in fractured zone 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. Higher NO_3^- concentrations (> 45 mg/L) in weathered zone is due to sewage contamination and higher concentration of F^- (>1.5 mg/L) in weathered zone and fractured zone is due to local geology (granite/gneiss rock), high weathering, longer residence time and alkaline nature of groundwater.

6.1 Management plan

The uneven distribution of groundwater availability and its utilization indicates that a single management strategy cannot be adopted and requires integrated hydrogeological aspects along with socio-economic conditions to develop appropriate management strategy. The study suggests notable measures for sustainable groundwater management, which involves a combination of 1) Supply side measures and 2) Demand side measures.

6.1.1 Supply side measures:

In the district 45,348 MCM of unsaturated volume (below the depth of 3 m) is available during post-monsoon season of 2015, having 952 MCM of recharge potential (2%). This can be utilized for implementing management strategy.

Ongoing Projects

6.1.1.1 Mission Kakatiya (Repair Renovation and Restoration of existing tanks):

- Under state Govt. sponsored Mission Kaktiya-Phase-1 and Phase-2, ~16 MCM of silt has removed from 40% of excising tanks and this has created additional surface storage. This will contribute ~ 8 MCM to groundwater and with this additional ~1333 ha land can be brought under irrigated dry (ID) crops in tank ayacut.

- There is need to take remaining tanks in next phases for de-silting, this will greatly help in stabilisation of tank ayacut and ground water augmentation.

6.1.1.2 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 Palair, Jogampally reservoir and Lower Manair Dam.
- The total water import will be 125.16 MCM (drinking and industrial needs) and this imported water from surface sources will reduce the present utilized ~58 MCM of ground water (considering 60 lpcd). This can be effectively utilized to irrigate ~7250 ha of additional land under ID crops.

To be taken up

6.1.1.3 Artificial Recharge structures:

While formulating the village wise groundwater management plan, the unsaturated volume of aquifer is estimated by multiplying the area with specific yield and unsaturated thickness (post-monsoon water levels below 3 m). Initially village wise dynamic groundwater resources of 2013 are considered (**Fig.4.1**). Potential surface run off is estimated by following standard procedures. Initailly, 20 % run off yield is considered as non-committed yield and for recommending artificial recharge structures in intermittent areas 50 % of yield is considered and remaining 50 % is recommended for implementing water conservation measures in recharge areas through MGNREGS.

The pre-monsoon groundwater quality is considered for categorising contaminated area (F >1.5 mg/l & EC >3000 µ S/cm). Nitrate is not considered here because it is point source pollution and localized. Based on above criteria, the area can be prioritized into **Priority-1(over-exploited)** which needs immediate intervention **and Priority-2** . Based on hydrogeological characteristics, the area is further sub-divided into following 8 categories (**Table-6.1**).

Priority-1 (Area where groundwater development > 100 %)

Area consisting of 253 villages covering ~2158 Km^2 (**Fig.6.1**) is considered as Priority-1 where 322 MCM recharge potential and ~31.83 MCM utilizable yield is available for taking ARS in intermediate area and immediate intervention is required because, here, the stage of groundwater development is > 100 % (**Annexure-1**). The area is again sub-divided into 8 categories based on hydrogeological conditions as mentioned above.

Table-6.1: Hydrogeological characteristics of area.

Category	Hydrogeological characterizations
1	High EC with additional scope for artificial recharge.
2	High EC with no additional scope for artificial recharge.
3	High F with additional scope for artificial recharge.
4	High F with no additional scope for artificial recharge.
5	High EC and F with additional scope for artificial recharge.
6	High EC and F with no additional scope for artificial recharge.
7	Groundwater quality within permissible limits for drinking and irrigation with scope for artificial recharge.
8	Groundwater quality within permissible limits for drinking and irrigation with no scope for artificial recharge.

- 850 artificial recharge structures (465 CD's with 6 filling and 385 mini PT's with 1.5 fillings) with a total cost of **70.3** crores can be taken up.
- After effective utilization of this yield, there will be 15.93 MCM of ground water recharge (50 % of total utilizable yield).
- Roof top rainwater harvesting structures should be made mandatory to all Government buildings (new and existing).

Priority-2 (A**rea where groundwater development <100 %)**

- Area consisting of 406 villages with ~5023 km^2 chargeable area (**Fig.6.2**) is considered as Priority-2, where ~624.5 MCM recharge potential and ~66.6 MCM utilizable yield is available (**Annexure-2**). The area is again further divided into 8 categories based on hydrogeological characteristics as mentioned above.

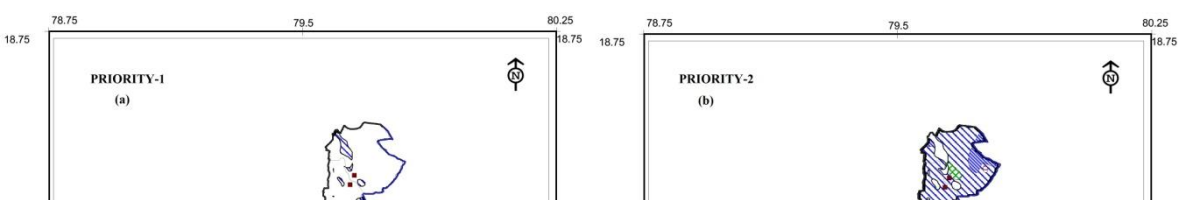


Fig.6.1 (a-b): Priority-1 and Priority-2 area, for sustainable management of ground water Resources, Hard rock areas, Warangal district.

- 2151 Artificial recharge structures (ARS) (1169 CD's with 6 fillings and 982 mini PT's with 1.5 fillings) can be taken up with a cost estimate of **170.4** crores.
- After effective utilization of this yield, there will be 33.3 MCM of ground water recharge (50 % of total utilizable yield).
- Roof top rainwater harvesting structures should be made mandatory to all Government buildings.

6.1.1.4 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 form ponds can be 10 x 10 x 3 m. Total 13960 farm ponds are recommended (20 in each village in 698 villages) with total cost of **34.90** crores.

Other supply side measures:

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

6.1.2 Demand side measures: In order to manage the available resources more effectively the following measures are recommended.

6.1.2.1 Ongoing Micro-irrigation

- In the area till date a total ~38680 ha area is brought under mico-irrigation saving ~77 MCM of groundwater.

6.1.2.2 Proposed Micro-irrigation

- ~51868 ha of additional land that can be brought under micro-irrigation (considering 50 % of rabi irrigation based on GW) costing about **311.21** crores (considering 1 unit/ha @0.6 lakhs/ha). With this 104 MCM of ground water can be conserved over the traditional irrigation practices (considering 0.006 MCM/ha for ID crops).

6.1.3 Other Recommendations

- 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.

6.2 Expected results and out come

With the above interventions costing Rs **586.34** crores (**excluding the cost involved in Mission Kakatiya and Mission Bhagiratha**), the likely benefit would be increases in gross groundwater based irrigation from ~2.93 lakhs ha to 3.34 lakhs ha or net saving of **247** MCM of ground water (net reduction of 15 % in stage of ground water, i.e., from 84 % to 69 %) or additional ~41100 ha of additional agricultural land will be brought under irrigation. The other

benefits will be more distribution of income among farmers. The onetime cost will be ~3 paisa/litre (Rs 28.57 /m^3 of water).

Acknowledgment

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Annexure-1

S. No	Mandal	Village	Area	Ec	F	Unsaturated Volume	Village Recharge Potential (Sy 2%)	20% Of Runoff Yield	Proposed CDs	Proposed PTs	Total Cost CD @ 5	Total Cost PT @ 10	Total Lakhs CD +PTs
			Km^2	Ω Siemens/cm	Mg/l	MCM	MCM	MCM	Nos	Nos	lakhs	lakhs	lakhs
1	Atmakur	Agrampad	4.87	2875	1.8	29.2	0.58	0.22	4	4	20	40	60
2	Atmakur	Brahmanapalli	3.91	4150	0.8	7.8	0.16	0.18	3	3	15	30	45
3	Atmakur	Kamaram	4.84	3475	1.2	19.4	0.39	0.22	4	4	20	40	60
4	Atmakur	Kogilvai	6.73	875	0.6	40.4	0.81	0.31	6	6	30	60	90
5	Atmakur	Singarajupalli	3.74	875	0.6	18.7	0.37	0.17	3	3	15	30	45
6	Bachannap	Alimpur	10.41	1800	1	62.5	1.25	0.25	5	3	25	30	55
7	Bachannap	Bandanagaram	3.92	1825	0.8	47.1	0.94	0.09	2	2	10	20	30
8	Bachannap	Dubbakuntapall	3.14	2325	0.4	22.0	0.44	0.07	0	1	0	10	10
9	Bachannap	Itikalapalli	7.95	1825	0.6	63.6	1.27	0.19	4	4	20	40	60
10	Bachannap	Katkuru	12.71	1650	1.4	101.7	2.03	0.30	6	6	30	60	90
11	Bachannap	Lingampalli	8.57	2450	0.4	120.0	2.40	0.20	0	4	0	40	40
12	Bachannap	Nagireddypalli	8.06	2350	0.8	80.6	1.61	0.19	2	0	10	0	10
13	Bachannap	Narayanapur	6.22	1325	0.6	74.6	1.49	0.15	3	3	15	30	45
14	Bachannap	Pochannapet	12.19	1150	0.8	158.5	3.17	0.29	6	6	30	60	90
15	Bachannap	Pullaguda (D)	1.40	2425	0.4	9.8	0.20	0.03	1	1	5	10	15
16	Bachannap	Ramchandrapur	5.23	2225	0.6	31.4	0.63	0.12	2	0	10	0	10
17	Bachannap	Thammadapalli	4.76	1025	0.8	61.8	1.24	0.11	2	2	10	20	30
18	Chennarao	Akkalchedu	4.36	1450	1.2	8.7	0.17	0.17	3	3	15	30	45
19	Chennarao	Aminabad	13.96	775	1.8	27.9	0.56	0.56	11	11	55	110	165
20	Chennarao	Chennaraopet	5.56	1575	1.4	5.6	0.11	0.22	2	2	10	20	30
21	Chennarao	Gurijala	15.50	1450	1.4	31.0	0.62	0.62	12	12	60	120	180
22	Chennarao	Jalli	5.24	1175	1.6	10.5	0.21	0.21	4	2	20	20	40

	S. No	Mandal	Village	Area	Ec		F	Unsaturated Volume	Village Recharge Potential (Sy 2%)	20% Of Runoff Yield	Proposed CDs	Proposed PTs		Total Cost CD @ 5	Total Cost PT @ 10	Total Lakhs CD +PTs
23	Chennarao	Konapuram	9.04	1675	1.2	27.1	0.54	0.36	7	7	35	70	105			
24	Chennarao	Lingapuram	4.18	2400	1	12.5	0.25	0.17	3	3	15	30	45			
25	Chennarao	Upparapalli	11.09	2575	0.6	22.2	0.44	0.45	8	8	40	80	120			
26	Chennarao	Yellaigudem	9.81	1450	1.2	29.4	0.59	0.39	6	7	30	70	100			
27	Cherial	Chunchukota	8.03	1275	1.2	96.3	1.93	0.16	3	3	15	30	45			
28	Cherial	Komaravelli	11.78	2250	0.6	141.3	2.83	0.23	4	4	20	40	60			
29	Cherial	Nagapuri	16.26	900	1.2	130.0	2.60	0.32	6	6	30	60	90			
30	Cherial	Peddarajupeta	2.45	950	1.2	26.9	0.54	0.05	1	0	5	0	5			
31	Cherial	Ramsagar	3.74	1200	1.2	37.4	0.75	0.07	1	1	5	10	15			
32	Cherial	Tapaspalli	2.34	1050	1.2	21.1	0.42	0.05	1	1	5	10	15			
33	Chityal	Ankushapur	3.72	475	1.2	26.0	0.52	0.15	1	1	5	10	15			
34	Chityal	Chityal	9.83	1150	1.4	59.0	1.18	0.39	7	2	35	20	55			
35	Chityal	Garimillpalli	8.30	1025	0.8	33.2	0.66	0.33	3	1	15	10	25			
36	Chityal	Ramkistapur	3.03	1075	0.6	18.2	0.36	0.12	2	2	10	20	30			
37	Chityal	Somanpalli	3.27	575	0.8	16.4	0.33	0.13	0	2	0	20	20			
38	Devaruppu	Chowdur	6.57	1875	0.6	52.5	1.05	0.10	2	0	10	0	10			
39	Devaruppu	Dharmapur	9.92	875	0.6	39.7	0.79	0.14	3	0	15	0	15			
40	Devaruppu	Gollapalli	2.92	0	0	8.8	0.18	0.04	1	1	5	10	15			
41	Devaruppu	Madhapur	14.89	1225	0.6	89.3	1.79	0.22	3	0	15	0	15			
42	Devaruppu	Manphad	3.27	1400	0.4	13.1	0.26	0.05	1	0	5	0	5			
43	Dharmasag	Mallakapalli	2.61	1525	1.2	23.5	0.47	0.04	1	1	5	10	15			
44	Dharmasag	Mallikudurla	8.46	1575	0.6	59.2	1.18	0.14	0	1	0	10	10			
45	Dharmasag	Narayanagiri	13.45	2000	0.8	94.1	1.88	0.22	1	4	5	40	45			
46	Dharmasag	Velair	29.90	2500	0.8	179.4	3.59	0.48	7	7	35	70	105			
47	Dornakal	Kannegudla	14.39	1125	1.4	57.6	1.15	0.44	8	3	40	30	70			
48	Dornakal	Ravigudem	7.71	900	2.8	7.7	0.15	0.23	2	0	10	0	10			

	S. No	Mandal	Village	Area	Ec	F	Unsaturated Volume	Village Recharge Potential (Sy 2%)	20% Of Runoff Yield	Proposed CDs	Proposed PTs		Total Cost CD @ 5	Total Cost PT @ 10	Total Lakhs CD +PTs
49	Duggondi	Adavirangapur	6.92	1650	1	34.6	0.69	0.28	5	1	25	10	35		
50	Duggondi	Chalaparthy	4.56	1275	1.4	18.2	0.36	0.18	3	1	15	10	25		
51	Duggondi	Keshavapuram	3.23	1500	1.6	16.1	0.32	0.13	2	2	10	20	30		
52	Duggondi	Madiramandap	1.15	1350	0.8	5.7	0.12	0.05	1	1	5	10	15		
53	Duggondi	Mandapalli	4.61	1175	1	46.1	0.92	0.18	4	2	20	20	40		
54	Duggondi	Polaram	2.04	3525	1	4.1	0.08	0.08	2	1	10	10	20		
55	Duggondi	Rebelli	4.98	875	1	19.9	0.40	0.20	4	1	20	10	30		
56	Duggondi	Rekampalli	3.31	1300	0.8	19.9	0.40	0.13	3	1	15	10	25		
57	Duggondi	Thimmampet	9.83	1425	0.6	29.5	0.59	0.39	8	3	40	30	70		
58	Duggondi	Thogarrai	3.51	1150	1	35.1	0.70	0.14	3	3	15	30	45		
59	Duggondi	Venkatapur	10.00	900	1	40.0	0.80	0.40	8	5	40	50	90		
60	Geesugond	Anantharam	4.69	2275	1.2	14.1	0.28	0.16	2	3	10	30	40		
61	Geesugond	Boddduchinthal	5.37	2100	1	37.6	0.75	0.19	4	4	20	40	60		
62	Geesugond	Dharmaram	7.80	1450	0.8	70.2	1.40	0.27	5	5	25	50	75		
63	Geesugond	Elkurthy	12.22	3125	1	24.4	0.49	0.43	8	8	40	80	120		
64	Geesugond	Kommala	4.59	1975	1.2	23.0	0.46	0.16	3	3	15	30	45		
65	Geesugond	Machapur	8.39	1650	0.4	25.2	0.50	0.29	6	6	30	60	90		
66	Geesugond	Mogilicherla	10.04	1400	1.8	70.3	1.41	0.35	7	7	35	70	105		
67	Geesugond	Vasanthapur	4.27	1500	0.8	17.1	0.34	0.15	2	3	10	30	40		
68	Geesugond	Vishwanathapu	10.13	1750	1	30.4	0.61	0.35	7	7	35	70	105		
69	Hanamkon	Allipur	2.18	1575	0.6	6.5	0.13	0.07	1	1	5	10	15		
70	Hanamkon	Battupally	2.45	1650	0.8	2.5	0.05	0.08	1	1	5	10	15		
71	Hanamkon	Kondaparthy	25.81	1600	0.6	129.1	2.58	0.84	16	16	80	160	240		
72	Hanamkon	Kothaplli (H)	4.14	1650	0.8	4.1	0.08	0.13	2	2	10	20	30		
73	Hanamkon	Madikonda	42.31	1650	1.2	338.4	6.77	1.38	26	26	130	260	390		

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74	Hanamkon	Thralapally	5.44	1625	1	38.1	0.76	0.18	3	3	15	30	45	
75	Hanamkon	Wanamalakanp	6.99	1550	1	76.9	1.54	0.23	4	4	20	40	60	
76	Hasanparth	Devannapeta	6.77	1650	1	33.9	0.68	0.22	4	4	20	40	60	
77	Hasanparth	Jayagiri	5.72	1550	1	40.0	0.80	0.19	4	2	20	20	40	
78	Hasanparth	Laknavaram	2.23	1575	1	17.8	0.36	0.07	1	1	5	10	15	
79	Hasanparth	Pembarthy	9.34	1200	1	74.7	1.49	0.30	6	6	30	60	90	
80	Jangaon	Adavikeshapur	6.75	2600	0.4	74.3	1.49	0.11	2	2	10	20	30	
81	Jangaon	Cheetakodur	8.08	1000	0.8	56.5	1.13	0.13	1	2	5	20	25	
82	Jangaon	Chowadram	7.95	900	0.8	71.6	1.43	0.13	0	2	0	20	20	
83	Jangaon	Ganugupahad	11.32	1225	0.8	113.2	2.26	0.18	3	3	15	30	45	
84	Jangaon	Goparajupalli	7.47	2325	0.6	74.7	1.49	0.12	2	2	10	20	30	
85	Jangaon	Jangaon(town)	5.70	1075	0.8	57.0	1.14	0.09	2	2	10	20	30	
86	Jangaon	Marigidi	10.57	1025	0.8	105.7	2.11	0.17	1	1	5	10	15	
87	Jangaon	Obulakeshavap	7.28	1875	0.6	72.8	1.46	0.12	2	2	10	20	30	
88	Jangaon	Peddapahad	17.79	1500	0.6	177.9	3.56	0.29	5	5	25	50	75	
89	Jangaon	Pembarthy	12.56	1050	0.6	87.9	1.76	0.20	4	4	20	40	60	
90	Jangaon	Venkiryal	10.21	1850	0.6	102.1	2.04	0.17	3	3	15	30	45	
91	Jangaon	Wadlakonda	6.39	975	0.8	63.9	1.28	0.10	2	2	10	20	30	
92	Jangaon	Yerragollapaha	10.42	1425	0.6	114.7	2.29	0.17	0	3	0	30	30	
93	Jangaon	Yeshawanthapu	6.62	1200	1	59.5	1.19	0.11	2	2	10	20	30	
94	Kodakandl	Authapuram	12.48	1575	0.6	87.4	1.75	0.18	3	0	15	0	15	
95	Kodakandl	Kodakandla	22.90	1225	0.6	274.8	5.50	0.33	6	5	30	50	80	
96	Kodakandl	Mondrai	13.80	1350	0.4	69.0	1.38	0.20	4	4	20	40	60	
97	Kodakandl	Narshinghapur	3.31	1225	0.6	36.5	0.73	0.05	1	0	5	0	5	
98	Kodakandl	Phakala	7.77	1225	0.6	85.5	1.71	0.11	2	1	10	10	20	

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99	Kodakandl	Pochampally	8.78	1325	0.6	61.4	1.23	0.13	2	0	10	0	10		
100	Kodakandl	Pocharam	3.44	1175	0.6	13.8	0.28	0.05	1	1	5	10	15		
101	Kodakandl	Veddekothapall	10.51	1200	0.6	42.1	0.84	0.15	3	0	15	0	15		
102	Kodakandl	Yedunuthula	13.49	1200	0.6	134.9	2.70	0.20	2	0	10	0	10		
103	Korivi	Ayyagaripalli	5.66	1225	1.2	5.7	0.11	0.21	2	0	10	0	10		
104	Korivi	Korivi	14.97	600	0.4	15.0	0.30	0.56	6	4	30	40	70		
105	Lingala	Jeedikal	9.95	1525	0.4	129.4	2.59	0.16	3	0	15	0	15		
106	Lingala	Kothaplli	7.11	1225	1.4	49.8	1.00	0.12	2	0	10	0	10		
107	Lingala	Lingala	21.23	1500	0.8	148.6	2.97	0.34	7	7	35	70	105		
108	Lingala	Nagaram	4.99	1425	0.6	39.9	0.80	0.08	2	2	10	20	30		
109	Lingala	Nellutla	20.14	1500	0.8	161.1	3.22	0.33	6	5	30	50	80		
110	Maddur	Arjunapatla	5.90	825	1.4	53.1	1.06	0.10	2	0	10	0	10		
111	Maddur	Bairanpalli	7.85	650	0.6	62.8	1.26	0.13	2	1	10	10	20		
112	Maddur	Bekkal	10.87	650	0.6	76.1	1.52	0.18	3	3	15	30	45		
113	Maddur	Dharmaram	3.80	1050	0.6	60.9	1.22	0.06	1	1	5	10	15		
114	Maddur	Dhulmitta	12.25	650	0.6	85.7	1.71	0.20	4	4	20	40	60		
115	Maddur	Gagillapur	10.53	725	0.8	147.5	2.95	0.17	2	0	10	0	10		
116	Maddur	Kamalaipalli	5.37	850	1.6	53.7	1.07	0.09	2	1	10	10	20		
117	Maddur	Kondapur	8.62	725	0.6	86.2	1.72	0.14	3	3	15	30	45		
118	Maddur	Kutigal	12.06	850	0.6	96.4	1.93	0.20	4	4	20	40	60		
119	Maddur	Ladnur	15.97	2375	0.6	255.6	5.11	0.26	5	5	25	50	75		
120	Maddur	Lakkapalli	2.93	1150	0.6	43.9	0.88	0.05	1	1	5	10	15		
121	Maddur	Lingapur	5.75	675	0.8	46.0	0.92	0.09	2	2	10	20	30		
122	Maddur	Madduru	11.29	750	0.8	169.3	3.39	0.18	3	3	15	30	45		
123	Maddur	Marmamula	10.58	1225	0.8	148.1	2.96	0.17	3	3	15	30	45		
124	Maddur	Narsaipalli	3.36	775	1.2	43.7	0.87	0.05	1	1	5	10	15		

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125	Maddur	Rebarthi	9.34	875	0.6	121.4	2.43	0.15	3	2	15	20	35		
126	Maddur	Salakpur	9.09	825	0.8	136.3	2.73	0.15	3	0	15	0	15		
127	Maddur	Thornala	2.51	650	0.6	20.1	0.40	0.04	1	0	5	0	5		
128	Maddur	Vallampatla	8.16	725	0.6	81.6	1.63	0.13	1	0	5	0	5		
129	Maddur	Vangapalli	7.23	1150	0.6	86.8	1.74	0.12	2	2	10	20	30		
130	Mahabuba	Jangiligonda	7.65	950	2.8	7.7	0.15	0.31	3	3	15	30	45		
131	Mahabuba	Mudupugal	6.05	1475	1	6.1	0.12	0.24	2	2	10	20	30		
132	Mahabuba	Shanigapur	10.64	1400	0.6	42.5	0.85	0.43	8	8	40	80	120		
133	Mahabuba	Singaram	3.61	1325	0.6	7.2	0.14	0.14	3	3	15	30	45		
134	Mahabuba	V.S.	8.35	975	3.2	16.7	0.33	0.34	6	6	30	60	90		
135	Maripeda	Anepur	11.38	1200	0.6	91.0	1.82	0.22	4	1	20	10	30		
136	Maripeda	Burahanpur	5.13	1425	0.6	46.1	0.92	0.10	2	0	10	0	10		
137	Maripeda	Galivarigudem	4.17	825	1.2	20.9	0.42	0.08	2	0	10	0	10		
138	Maripeda	Gundipudi	13.03	1200	0.6	104.2	2.08	0.26	5	5	25	50	75		
139	Maripeda	Ullepally	8.36	1100	1.2	25.1	0.50	0.17	3	0	15	0	15		
140	Maripeda	Veesampally	8.72	775	1.4	17.4	0.35	0.17	3	0	15	0	15		
141	Mogullapal	Akenepally	6.73	975	1	40.4	0.81	0.24	4	4	20	40	60		
142	Mogullapal	Gundlakurthy	2.07	1400	0.8	12.4	0.25	0.07	1	1	5	10	15		
143	Mogullapal	Mulkalapalli	5.38	1175	1	32.3	0.65	0.19	4	1	20	10	30		
144	Mogullapal	Peddakomatipa	6.20	725	1	43.4	0.87	0.22	0	1	0	10	10		
145	Mogullapal	Rangapur	8.39	2925	0.8	50.3	1.01	0.29	6	5	30	50	80		
146	Narmetta	Abdulnagaram	9.81	1325	1	117.8	2.36	0.16	3	0	15	0	15		
147	Narmetta	Akkarajupalli	3.50	2375	0.4	49.1	0.98	0.06	1	0	5	0	5		
148	Narmetta	Ankushapur	13.68	900	0.6	177.8	3.56	0.22	4	4	20	40	60		
149	Narmetta	Bommakur	5.79	2975	0.4	75.2	1.50	0.09	2	0	10	0	10		

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150	Narmetta	Bonthagattunag	15.38	1125	0.8	261.5	5.23	0.25	5	1	25	10	35		
151	Narmetta	Hanmanthapur	14.47	2300	0.4	217.1	4.34	0.23	4	2	20	20	40		
152	Narmetta	Malakpet	1.98	1500	0.6	27.7	0.55	0.03	1	0	5	0	5		
153	Narsampet	Kammepally	3.31	1225	1	9.9	0.20	0.15	3	0	15	0	15		
154	Narsampet	Lakenepally	4.59	1200	2.2	13.8	0.28	0.21	4	0	20	0	20		
155	Narsampet	Madire	2.64	1375	1.6	5.3	0.11	0.12	1	2	5	20	25		
156	Narsampet	Maheswaram	9.00	2575	1	45.0	0.90	0.41	7	8	35	80	115		
157	Narsampet	Pasupunuru	6.64	0	0	19.9	0.40	0.30	6	6	30	60	90		
158	Narsampet	Ramavaram	3.07	1975	1	9.2	0.18	0.14	3	0	15	0	15		
159	Narsimhul	Kommalavanch	8.22	950	1	24.6	0.49	0.16	3	3	15	30	45		
160	Narsimhul	Kwshelyadevia	4.90	1000	2.2	14.7	0.29	0.10	2	2	10	20	30		
161	Narsimhul	Vanthadupula	7.26	1000	0.8	29.0	0.58	0.14	3	3	15	30	45		
162	Nekkonda	Gotlakonda	7.63	1775	1	30.5	0.61	0.33	5	5	25	50	75		
163	Nellikudur	Bodlada	4.99	1000	0.8	5.0	0.10	0.19	2	0	10	0	10		
164	Nellikudur	Chinna	23.17	1650	1	92.7	1.85	0.87	17	17	85	170	255		
165	Nellikudur	Chinna	9.19	850	0.8	55.1	1.10	0.34	7	7	35	70	105		
166	Nellikudur	Kachikal	7.28	1150	1.4	43.7	0.87	0.27	5	4	25	40	65		
167	Nellikudur	Mecharajpally	4.87	850	1.4	34.1	0.68	0.18	3	3	15	30	45		
168	Nellikudur	Nainala	19.00	1175	2.2	76.0	1.52	0.71	14	14	70	140	210		
169	Nellikudur	Nellikudur	19.52	1375	1.2	58.6	1.17	0.73	14	14	70	140	210		
170	Nellikudur	Ramanjapuram	1.70	1175	1.8	8.5	0.17	0.06	1	1	5	10	15		
171	Nellikudur	Vavilala	8.50	1475	1.2	25.5	0.51	0.32	6	4	30	40	70		
172	Palakurthy	Gudur	21.87	850	0.4	218.7	4.37	0.52	10	5	50	50	100		
173	Palakurthy	Kondapur	6.06	1875	0.4	6.1	0.12	0.14	2	0	10	0	10		
174	Palakurthy	Kothulabad	4.22	1000	1	33.8	0.68	0.10	2	2	10	20	30		

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175	Palakurthy	Laxminarayana	3.07	925	0.6	21.5	0.43	0.07	1	1	5	10	15		
176	Palakurthy	Thigaram	3.51	850	0.6	3.5	0.07	0.08	1	1	5	10	15		
177	Palakurthy	Thirmalagiri	3.41	850	0.6	30.7	0.61	0.08	2	2	10	20	30		
178	Palakurthy	Visnur	19.63	850	0.6	39.3	0.79	0.47	9	9	45	90	135		
179	Parkal	Laxmipur	5.81	2925	0.6	29.0	0.58	0.23	4	4	20	40	60		
180	Parkal	Nadikuda	8.81	775	0.2	17.6	0.35	0.35	7	7	35	70	105		
181	Parkal	Rajipet	3.28	1200	1	3.3	0.07	0.13	1	1	5	10	15		
182	Parkal	Sarvapoor	2.25	1700	0.8	11.3	0.23	0.09	2	2	10	20	30		
183	Parkal	Vallampalli	8.62	925	0.6	17.2	0.34	0.35	7	5	35	50	85		
184	Parvathagir	Annaramsharee	10.98	1100	0.8	87.8	1.76	0.26	5	5	25	50	75		
185	Parvathagir	Bhurgumadla	1.89	1275	1.4	13.2	0.26	0.04	1	1	5	10	15		
186	Parvathagir	Enugal	17.25	1875	1	120.8	2.42	0.41	8	8	40	80	120		
187	Parvathagir	Konkapaka	11.00	1075	1.8	22.0	0.44	0.26	5	5	25	50	75		
188	Raghunath	Fatheshapur	10.57	725	0.8	200.8	4.02	0.19	4	4	20	40	60		
189	Raghunath	Ibrahimpuram	7.60	775	0.8	174.7	3.49	0.14	3	3	15	30	45		
190	Raghunath	Kanchnpalle	26.22	825	1.4	472.0	9.44	0.47	9	9	45	90	135		
191	Raghunath	Komalla	11.44	825	1	297.3	5.95	0.21	4	4	20	40	60		
192	Raghunath	Madharam	5.17	800	0.8	124.1	2.48	0.09	2	2	10	20	30		
193	Raghunath	Mekalagattu	12.34	1325	0.6	160.5	3.21	0.22	4	4	20	40	60		
194	Raghunath	Raghunathpally	11.80	775	1	364.0	7.28	0.21	1	3	5	30	35		
195	Raghunath	Veldi	6.71	825	0.8	201.2	4.02	0.12	0	2	0	20	20		
196	Rayaparthy	Burahanpally	5.57	2625	0.4	55.7	1.11	0.14	0	3	0	30	30		
197	Rayaparthy	Gannaram	4.69	2725	0.4	46.9	0.94	0.12	1	0	5	0	5		
198	Rayaparthy	Gattikal	6.01	1150	0.8	36.0	0.72	0.15	3	2	15	20	35		
199	Rayaparthy	Jagannathpally	5.04	1150	0.8	20.2	0.40	0.13	2	0	10	0	10		
200	Rayaparthy	Keshwapur	7.00	1475	0.8	42.0	0.84	0.18	1	0	5	0	5		

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201	Rayaparthy	Kondapur	3.74	1000	1	26.2	0.52	0.10	2	2	10	20	30		
202	Rayaparthy	Kondur	18.87	2950	0.4	226.4	4.53	0.49	9	3	45	30	75		
203	Rayaparthy	Pothireddypally	8.45	2200	0.4	67.6	1.35	0.22	3	0	15	0	15		
204	Rayaparthy	Sannur	14.18	1175	0.8	56.7	1.13	0.37	7	5	35	50	85		
205	Sangem	Gadepalli	6.05	1325	0.8	18.2	0.36	0.18	3	0	15	0	15		
206	Sangem	Lohitha	6.33	1150	1.2	31.7	0.63	0.19	2	1	10	10	20		
207	Sangem	Mondrai	9.10	2100	0.8	63.7	1.27	0.28	5	5	25	50	75		
208	Sangem	Narlavai	3.04	2150	1.2	21.3	0.43	0.09	2	2	10	20	30		
209	Sangem	Pallarigudem	8.89	2275	1.2	62.2	1.24	0.27	5	5	25	50	75		
210	Sangem	Shapur	7.20	1250	1.2	43.2	0.86	0.22	2	3	10	30	40		
211	Shayampet	Gatlakanaparth	10.21	900	0.6	20.4	0.41	0.47	8	8	40	80	120		
212	Shayampet	Kippula	11.65	2550	1	11.7	0.23	0.53	4	2	20	20	40		
213	Shayampet	Kothagattusing	5.79	1200	1.2	5.8	0.12	0.26	2	2	10	20	30		
214	Shayampet	Thaharapur	6.78	1000	0.6	20.3	0.41	0.31	6	4	30	40	70		
215	St Ghanpur	Chelpur	14.81	1050	1	29.6	0.59	0.29	6	2	30	20	50		
216	St Ghanpur	Krishnagigude	10.90	1000	0.8	98.1	1.96	0.22	4	4	20	40	60		
217	St Ghanpur	Meedikonda	9.85	900	0.6	157.6	3.15	0.19	4	1	20	10	30		
218	St Ghanpur	Raghavapuram	7.22	825	0.6	115.6	2.31	0.14	3	3	15	30	45		
219	St Ghanpur	Shivunipalli	6.04	1800	0.4	18.1	0.36	0.12	0	2	0	20	20		
220	St Ghanpur	Venkatadripet	7.24	1350	1	50.7	1.01	0.14	3	3	15	30	45		
221	Thorrur	Ammapur	8.73	1100	1	34.9	0.70	0.21	4	4	20	40	60		
222	Thorrur	Cherlapalem	4.66	1075	0.6	4.7	0.09	0.11	2	2	10	20	30		
223	Thorrur	Chikataipalem	7.79	1050	0.6	7.8	0.16	0.18	3	3	15	30	45		
224	Thorrur	Chinnavangara	14.09	1150	0.6	56.3	1.13	0.33	6	2	30	20	50		
225	Thorrur	Chintalapalli	8.38	1150	1.2	33.5	0.67	0.20	4	4	20	40	60		
226	Thorrur	Fathepur	7.31	1125	0.8	21.9	0.44	0.17	3	3	15	30	45		

	S. No	Mandal	Village	Area	Ec	F	Unsaturated Volume	Village Recharge Potential (Sy 2%)	20% Of Runoff Yield	Proposed CDs	Proposed PTs		Total Cost CD @ 5	Total Cost PT @ 10	Total Lakhs CD +PTs
227	Thorrur	Gurtur	5.83	975	1.2	35.0	0.70	0.14	3	3	15	30	45		
228	Thorrur	Kantaipalam	11.89	1150	1.4	47.6	0.95	0.28	5	5	25	50	75		
229	Thorrur	Khanapur	5.24	1050	1.2	26.2	0.52	0.12	2	2	10	20	30		
230	Thorrur	Kommanepalli	2.67	1150	1	10.7	0.21	0.06	1	1	5	10	15		
231	Thorrur	Nancharimadur	13.09	1375	0.6	65.4	1.31	0.31	6	6	30	60	90		
232	Thorrur	Somaram	7.68	925	1	53.7	1.07	0.18	3	3	15	30	45		
233	Thorrur	Thorrur	18.04	1125	1	72.2	1.44	0.43	8	8	40	80	120		
234	Thorrur	Velikatta	13.81	1175	0.8	55.2	1.10	0.33	4	6	20	60	80		
235	Thorrur	Venkatapur	4.73	1100	0.8	14.2	0.28	0.11	2	1	10	10	20		
236	Wardhanna	Bandawathapur	5.57	1550	0.6	61.3	1.23	0.12	2	0	10	0	10		
237	Wardhanna	Divitipally	4.78	2175	0.4	33.4	0.67	0.10	2	2	10	20	30		
238	Wardhanna	Ellanda	21.71	1325	0.6	86.8	1.74	0.47	9	8	45	80	125		
239	Wardhanna	Inavolu	18.40	1475	0.6	276.0	5.52	0.40	6	0	30	0	30		
240	Wardhanna	Katrial	7.38	1225	0.8	29.5	0.59	0.16	3	2	15	20	35		
241	Wardhanna	Kothapalli	4.14	1225	0.8	20.7	0.41	0.09	2	0	10	0	10		
242	Wardhanna	Lyabarthy	13.59	1275	0.8	81.5	1.63	0.29	6	5	30	50	80		
243	Wardhanna	Nallabelli	20.62	1175	1	61.9	1.24	0.45	7	4	35	40	75		
244	Wardhanna	Panthini	14.32	1250	0.6	100.2	2.00	0.31	2	5	10	50	60		
245	Wardhanna	Punnelu	10.89	1525	0.6	21.8	0.44	0.24	4	0	20	0	20		
246	Wardhanna	Singaram	8.13	1550	0.6	73.2	1.46	0.18	3	2	15	20	35		
247	Wardhanna	Upparapalli	7.07	1175	0.8	28.3	0.57	0.15	2	3	10	30	40		
248	Zaffergadh	Garmillapalli	12.80	800	0.6	179.1	3.58	0.25	5	5	25	50	75		
249	Zaffergadh	Suraram	4.70	950	0.6	32.9	0.66	0.09	0	1	0	10	10		
250	Zaffergadh	Thammadapalli	5.88	700	0.6	58.8	1.18	0.12	2	2	10	20	30		
251	Zaffergadh	Thidugu	6.16	850	0.6	73.9	1.48	0.12	2	2	10	20	30		
252	Zaffergadh	Thimmapur	5.05	1325	0.6	40.4	0.81	0.10	0	2	0	20	20		

	S. No	Mandal	Village	Area	Ec		F	Unsaturated Volume	Village Recharge Potential (Sy 2%)	20% Of Runoff Yield	Proposed CDs	Proposed PTs		Total Cost CD @ 5	Total Cost PT @ 10	Total Lakhs CD +PTs
253	Zaffergadh	Uppugal	6.03	975	0.8	30.2	0.60	0.12	2	2	10	20	30			
	Total		**2157.60**			**16096.22**	**321.93**	**54.76**	**929**	**769**	**4645**	**7690**	**12335**			

Annexure-2

S. No	Mandal	Village	Area	Ec	F	Unsaturated Volume	Village Recharge Potential (Sy 2%)	20% Of Runoff Yield	Proposed CDs	Proposed PTs	Total Cost CD @ 5	Total Cost PT @ 10	Total Lakhs CD +PTs
			Km2	Ω Siemens/cm	Mg/l	MCM	MCM	MCM	Nos	Nos	lakhs	lakhs	lakhs
1	Atmakur	Athmakur	16.22	4700	0.8	48.7	0.97	0.74	14	14	70	140	210
2	Atmakur	Chowllapalli	6.16	1375	3.5428	18.5	0.37	0.28	5	5	25	50	75
3	Atmakur	Damera	10.29	1250	1	113.2	2.26	0.47	9	7	45	70	115
4	Atmakur	Housebuzurgu	5.03	4025	0.8	10.1	0.20	0.23	4	0	20	0	20
5	Atmakur	Katakshapuram	20.24	5225	0.6	40.5	0.81	0.92	15	15	75	150	225
6	Atmakur	Kothagattu	6.69	1675	1	6.7	0.13	0.30	3	3	15	30	45
7	Atmakur	Ladella	11.77	900	0.8	58.9	1.18	0.54	10	8	50	80	130
8	Atmakur	Malakapeta	4.04	1050	1.2	4.0	0.08	0.18	2	2	10	20	30
9	Atmakur	Mustyalapalli	8.75	2500	1.4	61.3	1.23	0.40	8	8	40	80	120
10	Atmakur	Neerukulla	13.60	1775	1.6	13.6	0.27	0.62	5	5	25	50	75
11	Atmakur	Obulapuram	4.84	1400	1.6	19.4	0.39	0.22	4	4	20	40	60
12	Atmakur	Oorugonda	18.17	1875	0.6	54.5	1.09	0.83	16	15	80	150	230
13	Atmakur	Pasaragonda	7.11	1250	2	14.2	0.28	0.32	5	3	25	30	55
14	Atmakur	Penchikalapeta	5.76	1625	1.6	5.8	0.12	0.26	2	2	10	20	30
15	Atmakur	Pulukurthi	11.36	850	0.8	11.4	0.23	0.52	4	0	20	0	20
16	Atmakur	Venkatapuram	4.43	900	0.6	31.0	0.62	0.20	4	4	20	40	60
17	Bachannapet	Bachannapet (	20.38	1325	0.8	224.1	4.48	0.48	6	7	30	70	100
18	Bachannapet	Basireddypalli	4.53	1375	1	49.9	1.00	0.11	2	2	10	20	30
19	Bachannapet	Chinnaramcherla	12.30	1000	0.8	184.5	3.69	0.29	6	6	30	60	90
20	Bachannapet	Kesireddypally	12.28	2700	0.6	147.3	2.95	0.29	6	4	30	40	70
21	Bachannapet	Kodavatur	10.00	1625	1	100.0	2.00	0.24	2	1	10	10	20
22	Bachannapet	Konne	16.06	2375	0.4	96.3	1.93	0.38	3	7	15	70	85

	S. No	Mandal	Village	Area	Ec		F	Unsaturated Volume	Village Recharge Potential (Sy 2%)	20% Of Runoff Yield	Proposed CDs	Proposed PTs	Total Cost CD @ 5	Total Cost PT @ 10	Total Lakhs CD +PTs
23		Bachannapet	Laxmipur	6.65	2575	0.6	86.5	1.73	0.16	3	3	15	30	45	
24		Bachannapet	Mansanpalli	2.80	2175	0.6	33.6	0.67	0.07	1	0	5	0	5	
25		Bachannapet	Padamatikeshavapur	14.56	2475	0.4	276.6	5.53	0.34	7	6	35	60	95	
26		Bachannapet	Salvapur	9.34	1925	0.6	84.0	1.68	0.22	4	2	20	20	40	
27		Chennaraopet	Lingagiri	5.73	1150	1.4	11.5	0.23	0.23	4	2	20	20	40	
28		Chennaraopet	Makdoompuram	5.44	1400	1.2	16.3	0.33	0.22	4	3	20	30	50	
29		Chennaraopet	Papaiahpet	16.76	1000	2	83.8	1.68	0.67	13	9	65	90	155	
30		Chennaraopet	Surpelli	16.52	1350	1.2	49.6	0.99	0.66	13	13	65	130	195	
31		Chennaraopet	Thimmarainipadu	5.83	1950	0.8	11.7	0.23	0.23	4	4	20	40	60	
32		Cherial	Ainapur	20.51	1100	1	184.6	3.69	0.40	8	8	40	80	120	
33		Cherial	Akunuru	30.29	775	1.4	272.6	5.45	0.60	11	11	55	110	165	
34		Cherial	Cheriyal	45.26	925	1.8	543.1	10.86	0.89	17	17	85	170	255	
35		Cherial	Chityal	9.42	950	2	94.2	1.88	0.19	4	4	20	40	60	
36		Cherial	Danampalli	8.43	875	1.6	75.8	1.52	0.17	3	3	15	30	45	
37		Cherial	Dommatta	13.21	900	2	132.1	2.64	0.26	5	5	25	50	75	
38		Cherial	Goiraipalli	6.65	2450	0.4	93.1	1.86	0.13	2	2	10	20	30	
39		Cherial	Guruvannapeta	8.85	850	1.2	70.8	1.42	0.17	3	3	15	30	45	
40		Cherial	Kadaverugu	22.89	1000	1.4	251.8	5.04	0.45	9	9	45	90	135	
41		Cherial	Kistampeta	11.68	1550	1.2	140.2	2.80	0.23	4	4	20	40	60	
42		Cherial	Marrimuchala	4.27	1325	1.6	46.9	0.94	0.08	2	2	10	20	30	
43		Cherial	Mutyala	22.69	850	1	431.1	8.62	0.45	9	9	45	90	135	
44		Cherial	Posanpalli	4.58	850	1.2	36.6	0.73	0.09	2	2	10	20	30	
45		Cherial	Tadur	8.66	1050	1.8	86.6	1.73	0.17	3	3	15	30	45	
46		Cherial	Vechrani (Yasareni)	9.03	1175	1.6	99.4	1.99	0.18	3	3	15	30	45	
47		Chityal	Chainpaka	22.24	875	0.4	44.5	0.89	0.89	15	10	75	100	175	
48		Chityal	Duthpalli	5.19	2700	0.4	5.2	0.10	0.21	2	0	10	0	10	

	S. No	Mandal	Village	Area	Ec		F	Unsaturated Volume	Village Recharge Potential (Sy 2%)	20% Of Runoff Yield	Proposed CDs	Proposed PTs	Total Cost CD @ 5	Total Cost PT @ 10	Total Lakhs CD +PTs
49		Chityal	Guddemuttaram	7.58	775	0.4	37.9	0.76	0.30	5	0	25	0	25	
50		Chityal	Gummadavelli	3.37	625	1	23.6	0.47	0.14	3	3	15	30	45	
51		Chityal	Jadalpeta	15.06	2375	0.6	30.1	0.60	0.60	12	10	60	100	160	
52		Chityal	Kalavapalli	3.85	800	0.4	15.4	0.31	0.15	3	3	15	30	45	
53		Chityal	Kalikota	11.49	750	0.6	46.0	0.92	0.46	9	9	45	90	135	
54		Chityal	Khylapur	8.83	1075	1.6	35.3	0.71	0.35	7	7	35	70	105	
55		Chityal	Kundanpalli	6.45	2275	0.4	12.9	0.26	0.26	0	4	0	40	40	
56		Chityal	Muchiniparthy	15.00	1125	1.2	60.0	1.20	0.60	8	8	40	80	120	
57		Chityal	Nainpaka	20.33	1125	1.2	81.3	1.63	0.82	16	7	80	70	150	
58		Chityal	Nawabepta	16.57	525	0.4	82.9	1.66	0.66	5	9	25	90	115	
59		Chityal	Raghavapur	6.33	825	0.4	31.7	0.63	0.25	1	0	5	0	5	
60		Chityal	Tekumatla	13.66	850	0.8	82.0	1.64	0.55	8	9	40	90	130	
61		Chityal	Thirmalapur	11.06	2425	0.6	55.3	1.11	0.44	6	8	30	80	110	
62		Chityal	Velishal	11.34	1075	0.6	56.7	1.13	0.46	4	8	20	80	100	
63		Chityal	Vellampalli	7.59	900	1	38.0	0.76	0.30	0	3	0	30	30	
64		Chityal	Wadithyal	9.03	3375	0.4	9.0	0.18	0.36	3	2	15	20	35	
65		Chityal	Yemped	7.45	900	1	22.4	0.45	0.30	6	4	30	40	70	
66		Chityal	Zookal	12.34	875	0.4	61.7	1.23	0.50	9	6	45	60	105	
67		Devaruppula	Chinnamadur	51.00	1500	0.8	408.0	6.19	0.56	11	0	55	0	55	
68		Devaruppula	Devaruppula	28.08	850	0.6	112.3	2.25	0.41	8	6	40	60	100	
69		Devaruppula	Kadvendi	49.06	925	0.6	245.3	3.99	0.58	9	7	45	70	115	
70		Devaruppula	Neermal	12.55	1250	0.6	125.5	2.51	0.18	1	0	5	0	5	
71		Devaruppula	Peddamadur	21.81	1200	0.8	174.5	3.49	0.32	6	0	30	0	30	
72		Devaruppula	Ramarajupalli	5.28	1325	0.8	58.0	1.16	0.08	1	0	5	0	5	
73		Devaruppula	Singarajupally	7.07	1225	0.8	63.6	1.27	0.10	2	0	10	0	10	
74		Dharmasagar	Devunur	14.18	2125	0.8	85.1	1.70	0.23	2	4	10	40	50	

	S. No	Mandal	Village	Area	Ec		F	Unsaturated Volume	Village Recharge Potential (Sy 2%)	20% Of Runoff Yield	Proposed CDs	Proposed PTs	Total Cost CD @ 5	Total Cost PT @ 10	Total Lakhs CD +PTs
75		Dharmasagar	Dharmapur	8.75	1475	1.2	70.0	1.40	0.14	1	3	5	30	35	
76		Dharmasagar	Dharmasagar	21.41	1650	1.2	64.2	1.28	0.35	7	5	35	50	85	
77		Dharmasagar	Gundlasgar	10.79	1700	0.8	75.5	1.51	0.17	0	2	0	20	20	
78		Dharmasagar	Mupparam	17.57	2025	0.8	105.4	2.11	0.28	5	5	25	50	75	
79		Dharmasagar	Peddapendyala	19.89	450	0.4	159.2	3.18	0.32	6	5	30	50	80	
80		Dharmasagar	Peesara	21.57	1900	1.2	129.4	2.59	0.35	1	0	5	0	5	
81		Dharmasagar	Rampur	16.67	1475	1.2	166.7	3.33	0.27	3	3	15	30	45	
82		Dharmasagar	Sodashapally	7.81	1800	0.6	54.6	1.09	0.13	0	1	0	10	10	
83		Dharmasagar	Sopmadevarapalli	4.69	2075	0.8	32.8	0.66	0.08	1	1	5	10	15	
84		Dharmasagar	Tatikayala	15.94	525	0.4	95.7	1.91	0.26	1	3	5	30	35	
85		Dharmasagar	Unikicherla	11.01	1675	1.2	55.0	1.10	0.18	3	3	15	30	45	
86		Dharmasagar	Yelkurthi	20.79	825	0.6	124.8	2.50	0.34	1	1	5	10	15	
87		Dornakal	Ammapalam	11.89	975	2.2	23.8	0.48	0.36	7	7	35	70	105	
88		Dornakal	Burguphad	2.95	1175	0.8	3.0	0.06	0.09	1	0	5	0	5	
89		Dornakal	Chilkudu	15.46	1225	0.4	15.5	0.31	0.47	5	0	25	0	25	
90		Dornakal	Dornakal	10.36	950	2	10.4	0.21	0.31	4	0	20	0	20	
91		Dornakal	Gollacherla	19.89	925	1.8	19.9	0.40	0.60	6	0	30	0	30	
92		Dornakal	Gurralakunta	4.31	975	2.2	12.9	0.26	0.13	2	2	10	20	30	
93		Dornakal	Mannegudem	20.22	875	3.4	20.2	0.40	0.61	8	8	40	80	120	
94		Dornakal	Mulkalapally	7.42	725	0.4	7.4	0.15	0.22	0	2	0	20	20	
95		Dornakal	Permandlasankeesa	16.20	1200	1.2	16.2	0.32	0.49	6	0	30	0	30	
96		Dornakal	Uyalawada	12.71	975	2	25.4	0.51	0.38	7	5	35	50	85	
97		Dornakal	Vennaram	18.26	975	2.2	73.0	1.46	0.55	7	11	35	110	145	
98		Duggondi	Duggondi	8.98	700	0.8	27.0	0.54	0.36	7	7	35	70	105	
99		Duggondi	Laxmipuram	10.61	1250	1	31.8	0.64	0.43	8	8	40	80	120	
100		Duggondi	Mahamadapuram	7.24	1200	0.6	14.5	0.29	0.29	6	1	30	10	40	

	S. No	Mandal	Village	Area	Ec		F	Unsaturated Volume	Village Recharge Potential (Sy 2%)	20% Of Runoff Yield	Proposed CDs	Proposed PTs	Total Cost CD @ 5	Total Cost PT @ 10	Total Lakhs CD +PTs
101	Duggondi	Mallampalli	13.42	1025	0.6	26.8	0.54	0.54	10	6	50	60	110		
102	Duggondi	Muddunur	11.78	1100	1	47.1	0.94	0.47	9	8	45	80	125		
103	Duggondi	Nachenepalli	7.66	1125	1.2	61.3	1.23	0.31	6	0	30	0	30		
104	Duggondi	Ponkal	3.99	1225	1.2	19.9	0.40	0.16	3	1	15	10	25		
105	Geesugonda	Geesugonda	15.99	2200	1	95.9	1.92	0.56	11	11	55	110	165		
106	Geesugonda	Gorrekunta	14.41	1700	0.8	86.5	1.73	0.50	10	10	50	100	150		
107	Geesugonda	Manugonda	9.19	3025	0.2	36.8	0.74	0.32	6	6	30	60	90		
108	Geesugonda	Ookal	6.31	1200	1.2	37.9	0.76	0.22	4	4	20	40	60		
109	Geesugonda	Potharajupalli	19.12	1575	0.8	172.1	3.44	0.67	13	13	65	130	195		
110	Geesugonda	Ramchandrapuram	2.68	2450	1.2	10.7	0.21	0.09	2	2	10	20	30		
111	Geesugonda	Shayampet(H)	13.86	1075	0.6	110.9	2.22	0.48	9	9	45	90	135		
112	Geesugonda	Vanchanagiri	9.56	950	0.8	86.0	1.72	0.33	6	6	30	60	90		
113	Hanamkonda	Desaipeta	3.12	2000	0.8	3.1	0.06	0.10	1	1	5	10	15		
114	Hanamkonda	Hanamkonda(town)	68.00	1700	0.6	680.0	13.60	2.21	42	42	210	420	630		
115	Hanamkonda	Kadipikonda	4.67	1675	0.8	14.0	0.28	0.15	3	3	15	30	45		
116	Hanamkonda	Kothapet	15.77	1025	2.2	94.6	1.89	0.51	10	10	50	100	150		
117	Hanamkonda	Kumarpally	3.11	1675	0.6	18.6	0.37	0.10	2	2	10	20	30		
118	Hanamkonda	Mamnoor	10.03	1575	0.6	50.2	1.00	0.33	6	6	30	60	90		
119	Hanamkonda	Nakkalapalli	2.76	1575	0.6	11.0	0.22	0.09	2	2	10	20	30		
120	Hanamkonda	Paidipally	27.51	2375	0.8	55.0	1.10	0.90	17	17	85	170	255		
121	Hanamkonda	Palivelpula	5.80	1600	0.6	23.2	0.46	0.19	4	4	20	40	60		
122	Hanamkonda	Somidi	3.34	1700	1	3.3	0.07	0.11	1	1	5	10	15		
123	Hanamkonda	Thimmapur (H)	8.67	1575	0.6	26.0	0.52	0.28	5	5	25	50	75		
124	Hanamkonda	Waddepally	13.03	1625	1	91.2	1.82	0.42	8	8	40	80	120		
125	Hanamkonda	Warangal(town)	30.00	1825	0.6	60.0	1.20	0.98	19	19	95	190	285		
126	Hanamkonda	Yenumamula	15.97	2125	0.8	16.0	0.32	0.52	6	6	30	60	90		

	S. No	Mandal	Village	Area	Ec		F	Unsaturated Volume	Village Recharge Potential (Sy 2%)	20% Of Runoff Yield	Proposed CDs	Proposed PTs	Total Cost CD @ 5	Total Cost PT @ 10	Total Lakhs CD +PTs
127	Hasanparthy	Ananthasagar	10.24	1750	1	81.9	1.64	0.33	6	6	30	60	90		
128	Hasanparthy	Arvapalli	5.23	1125	0.8	36.6	0.73	0.17	3	3	15	30	45		
129	Hasanparthy	Bheemaram	7.59	1675	1.2	37.9	0.76	0.25	5	5	25	50	75		
130	Hasanparthy	Chinthagattu	12.83	1400	1	89.8	1.80	0.42	8	8	40	80	120		
131	Hasanparthy	Hasanparthy	11.23	1250	1	56.2	1.12	0.37	7	5	35	50	85		
132	Hasanparthy	Madipalli	12.18	1850	1	85.2	1.70	0.40	8	8	40	80	120		
133	Hasanparthy	Mallareddypalli	6.77	1650	0.8	33.9	0.68	0.22	4	4	20	40	60		
134	Hasanparthy	Mucherla	13.76	1350	0.8	110.1	2.20	0.45	9	9	45	90	135		
135	Hasanparthy	Nagaram	11.73	1200	1	93.8	1.88	0.38	7	7	35	70	105		
136	Hasanparthy	Pegadapalli	7.91	1650	0.6	63.3	1.27	0.26	5	5	25	50	75		
137	Hasanparthy	Siddapur	9.83	1125	0.8	88.5	1.77	0.32	6	4	30	40	70		
138	Hasanparthy	Sudanpalli	4.15	1425	0.8	29.0	0.58	0.13	3	3	15	30	45		
139	Hasanparthy	Vangapahad	11.69	1525	0.6	105.2	2.10	0.38	7	7	35	70	105		
140	Hasanparthy	Yellapur	7.38	1350	1	51.7	1.03	0.24	5	5	25	50	75		
141	Jangaon	Pasarmadla	10.13	1000	0.8	111.4	2.23	0.16	3	3	15	30	45		
142	Jangaon	Peddaramancherla	10.74	1325	0.8	107.4	2.15	0.17	3	3	15	30	45		
143	Jangaon	Shameerpeta	10.98	1000	0.8	120.8	2.42	0.18	3	3	15	30	45		
144	Jangaon	Siddenki	8.34	1050	0.8	100.0	2.00	0.14	3	3	15	30	45		
145	Jangaon	Yellamal	9.93	975	0.8	149.0	2.98	0.16	3	3	15	30	45		
146	Kesamudram	Arpanapally	4.32	1000	1.4	21.6	0.43	0.16	3	3	15	30	45		
147	Kesamudram	Beruwada	8.06	1150	1.4	24.2	0.48	0.30	6	6	30	60	90		
148	Kesamudram	Dhansari	17.01	1425	1.8	85.1	1.70	0.64	12	8	60	80	140		
149	Kesamudram	Ingurthy	38.01	925	0.8	38.0	0.76	1.42	14	14	70	140	210		
150	Kesamudram	Intikanne	9.74	1850	0.8	9.7	0.19	0.36	4	4	20	40	60		
151	Kesamudram	Kalwala	14.39	1125	1	57.5	1.15	0.54	10	10	50	100	150		
152	Kesamudram	Katrapally	11.43	1975	0.4	57.2	1.14	0.43	8	8	40	80	120		

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153		Kesamudram	Kesamudram	16.79	1900	0.6	16.8	0.34	0.63	6	6	30	60	90	
154		Kesamudram	Komatipalli	10.85	1400	1.2	43.4	0.87	0.41	8	8	40	80	120	
155		Kesamudram	Korkondapalli	6.71	1325	1.2	33.6	0.67	0.25	5	5	25	50	75	
156		Kesamudram	Mohammadpatnam	13.00	1300	1.4	39.0	0.78	0.49	9	9	45	90	135	
157		Kesamudram	Penugonda	20.34	1100	1.2	81.4	1.63	0.76	14	9	70	90	160	
158		Kesamudram	Tallapusapally	15.07	1250	0.6	15.1	0.30	0.56	5	6	25	60	85	
159		Kesamudram	Upparapally	4.89	1425	2.2	29.3	0.59	0.18	3	2	15	20	35	
160		Kodakandla	Gantlakunta	14.45	1300	0.6	115.6	2.31	0.21	3	2	15	20	35	
161		Kodakandla	Koripally	5.47	1225	0.6	27.3	0.55	0.08	1	1	5	10	15	
162		Kodakandla	Laxmakkapally	20.08	1125	0.6	100.4	2.01	0.29	6	6	30	60	90	
163		Kodakandla	Peddavangara	17.20	1225	0.6	68.8	1.38	0.25	5	0	25	0	25	
164		Kodakandla	Ramavaram	22.07	1250	0.6	242.7	4.85	0.32	6	0	30	0	30	
165		Kodakandla	Rangapur	5.75	1225	0.6	46.0	0.92	0.08	2	0	10	0	10	
166		Korivi	Chintapalli	14.19	1275	1.2	42.6	0.85	0.53	10	10	50	100	150	
167		Korivi	Kampalli	14.97	1475	0.8	44.9	0.90	0.56	11	11	55	110	165	
168		Korivi	Kancharlagudem	14.19	725	0.6	14.2	0.28	0.53	5	5	25	50	75	
169		Korivi	Kandikonda	13.64	1225	1.4	13.6	0.27	0.51	5	5	25	50	75	
170		Korivi	Modugulagudem	17.40	1200	0.8	34.8	0.70	0.65	12	12	60	120	180	
171		Korivi	Nallela	20.22	650	0.6	20.2	0.40	0.76	8	8	40	80	120	
172		Korivi	Seerole	17.40	1025	2.6	52.2	1.04	0.65	12	12	60	120	180	
173		Korivi	Sudanpalli	7.08	1200	1.4	14.2	0.28	0.26	5	0	25	0	25	
174		Korivi	Tattupally	5.59	1475	0.8	16.8	0.34	0.21	4	0	20	0	20	
175		Korivi	Thallasankeesa	16.20	1050	2.4	16.2	0.32	0.61	6	6	30	60	90	
176		Korivi	Tirumalapuram	2.95	725	0.6	3.0	0.06	0.11	1	0	5	0	5	
177		Korivi	Upparigudem	12.74	1450	0.8	38.2	0.76	0.48	9	9	45	90	135	

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178	Lingala	Cheetur	9.51	2200	0.6	114.1	2.28	0.15	3	1	15	10	25		
179	Lingala	Gummadavelli	9.39	1450	0.6	122.1	2.44	0.15	3	0	15	0	15		
180	Lingala	Kallem (	20.18	1400	0.4	181.6	3.63	0.33	6	4	30	40	70		
181	Lingala	Kundaram	24.36	1725	1	219.2	4.38	0.39	8	6	40	60	100		
182	Lingala	Nelapogula	11.07	1375	1.2	88.5	1.77	0.18	3	3	15	30	45		
183	Lingala	Siripuram	9.57	1500	0.4	114.8	2.30	0.16	0	1	0	10	10		
184	Lingala	Vaddicherla(Nawabp	17.64	1250	1.6	123.5	2.47	0.29	5	5	25	50	75		
185	Lingala	wanaparthi	16.87	1275	1	151.8	3.04	0.27	5	5	25	50	75		
186	Mahabubaba	Amanagal	8.90	700	0.8	26.7	0.53	0.36	7	7	35	70	105		
187	Mahabubaba	Bethole	7.27	1200	0.8	36.3	0.73	0.29	6	6	30	60	90		
188	Mahabubaba	Edulapusapally	16.58	1500	1.2	33.2	0.66	0.67	13	13	65	130	195		
189	Mahabubaba	Gummadur	9.27	1525	1.2	9.3	0.19	0.37	4	4	20	40	60		
190	Mahabubaba	Jamandlapally	9.09	1550	1.2	9.1	0.18	0.36	3	3	15	30	45		
191	Mahabubaba	Kambalapalli	21.08	1450	1.2	42.2	0.84	0.85	16	15	80	150	230		
192	Mahabubaba	Laxmipuram	10.68	1350	1	21.4	0.43	0.43	8	8	40	80	120		
193	Mahabubaba	Malyala	17.20	1050	2	86.0	1.72	0.69	13	13	65	130	195		
194	Mahabubaba	Mdapuram	11.74	975	1.6	23.5	0.47	0.47	9	9	45	90	135		
195	Mahabubaba	Nadiwada	11.72	1500	1.2	23.4	0.47	0.47	9	9	45	90	135		
196	Mahabubaba	Parvathagiri	10.93	925	2.6	21.9	0.44	0.44	8	8	40	80	120		
197	Mahabubaba	Redyala	10.76	1350	1	21.5	0.43	0.43	8	5	40	50	90		
198	Mahabubaba	Vemnoor	13.12	1425	1.2	26.2	0.52	0.53	10	10	50	100	150		
199	Maripeda	Abbaipelam	8.94	825	0.8	44.7	0.89	0.18	3	1	15	10	25		
200	Maripeda	Beechrajpally	7.28	925	1	36.4	0.73	0.14	3	0	15	0	15		
201	Maripeda	Chillamcherla	11.89	1125	0.6	71.3	1.43	0.23	4	0	20	0	20		
202	Maripeda	Chinnagudur	15.00	875	1.8	45.0	0.90	0.30	6	1	30	10	40		
203	Maripeda	Dharmaram	12.74	1150	1.4	51.0	1.02	0.25	5	1	25	10	35		

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204	Maripeda	Edjarla	10.34	1075	1.8	20.7	0.41	0.20	4	2	20	20	40		
205	Maripeda	Giripuram	5.79	1375	0.6	52.1	1.04	0.11	2	0	10	0	10		
206	Maripeda	Jayyaram	21.82	925	2.2	43.6	0.87	0.43	8	7	40	70	110		
207	Maripeda	Maripeda	32.06	950	0.6	224.4	4.49	0.63	12	6	60	60	120		
208	Maripeda	Neelakurthy	10.40	1175	0.6	83.2	1.66	0.21	4	4	20	40	60		
209	Maripeda	Purusothamaigudem	8.33	950	1.6	33.3	0.67	0.16	3	0	15	0	15		
210	Maripeda	Rampur	12.38	1175	0.6	74.3	1.49	0.24	5	3	25	30	55		
211	Maripeda	Tanamcherla	17.98	1400	0.6	161.8	3.24	0.35	7	2	35	20	55		
212	Maripeda	Thallaookal	16.84	1375	0.6	151.6	3.03	0.33	6	1	30	10	40		
213	Maripeda	Uggampally	7.95	775	2	23.9	0.48	0.16	3	0	15	0	15		
214	Maripeda	Veeraram	16.84	700	0.8	50.5	1.01	0.33	6	0	30	0	30		
215	Maripeda	Yellampeta	17.56	475	0.4	52.7	1.05	0.35	7	4	35	40	75		
216	Mogullapally	Ankushapur	1.73	1600	1	10.4	0.21	0.06	1	1	5	10	15		
217	Mogullapally	Dubbyal	7.55	975	1	45.3	0.91	0.26	4	4	20	40	60		
218	Mogullapally	Gudipahad	3.74	1625	0.8	22.5	0.45	0.13	2	1	10	10	20		
219	Mogullapally	Issipet	13.38	2175	0.8	93.7	1.87	0.47	9	6	45	60	105		
220	Mogullapally	Kurukshal	3.31	800	0.8	16.6	0.33	0.12	1	0	5	0	5		
221	Mogullapally	Medarmatla	4.84	2425	1	29.0	0.58	0.17	3	1	15	10	25		
222	Mogullapally	Metpalli	7.49	1375	1	44.9	0.90	0.26	5	2	25	20	45		
223	Mogullapally	Mogullapalli	11.98	1225	0.8	59.9	1.20	0.42	4	1	20	10	30		
224	Mogullapally	Motlapalli	7.44	1375	1	44.7	0.89	0.26	5	1	25	10	35		
225	Mogullapally	Parlapally	7.81	1125	1	46.8	0.94	0.27	1	2	5	20	25		
226	Mogullapally	Pidisilla	8.44	1350	1	50.7	1.01	0.30	6	6	30	60	90		
227	Mogullapally	Pothugal	7.22	400	1.2	57.8	1.16	0.25	3	5	15	50	65		
228	Mogullapally	Vemulapalli	8.62	1525	0.6	69.0	1.38	0.30	6	4	30	40	70		
229	Narmetta	Ammapur	9.41	2300	0.4	131.7	2.63	0.15	3	0	15	0	15		

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230	Narmetta	Gandiramavaram	20.37	1425	0.8	285.1	5.70	0.33	6	6	30	60	90		
231	Narmetta	Machupahad	19.09	1375	0.6	248.2	4.96	0.31	4	6	20	60	80		
232	Narmetta	Narmetta	36.70	2100	0.4	770.7	15.41	0.60	11	8	55	80	135		
233	Narmetta	Narsapur	11.05	1425	0.8	154.7	3.09	0.18	3	3	15	30	45		
234	Narmetta	Potharam	7.22	1675	0.4	101.1	2.02	0.12	2	1	10	10	20		
235	Narmetta	Solipur	8.22	1200	0.4	98.6	1.97	0.13	2	3	10	30	40		
236	Narmetta	Tharigoppula (	23.61	1325	0.6	307.0	6.14	0.38	7	5	35	50	85		
237	Narmetta	Veldanda	28.16	3325	0.4	309.8	6.20	0.46	9	5	45	50	95		
238	Narsampet	Banjipeta	11.35	1100	1.2	34.0	0.68	0.52	10	6	50	60	110		
239	Narsampet	Etukalapally	13.13	1150	2	52.5	1.05	0.60	11	3	55	30	85		
240	Narsampet	Madannapeta	11.50	1200	2.4	57.5	1.15	0.52	10	9	50	90	140		
241	Narsampet	Muthogipeta	8.62	1175	2.8	34.5	0.69	0.39	7	0	35	0	35		
242	Narsampet	Narsampet	4.59	1200	3.2	18.4	0.37	0.21	4	4	20	40	60		
243	Narsampet	Rajupeta	9.74	1175	3	38.9	0.78	0.44	8	0	40	0	40		
244	Narsampet	Sarvapur	4.51	1175	3	18.0	0.36	0.21	4	0	20	0	20		
245	Narsimhulap	Agapet	6.16	1075	0.6	12.3	0.25	0.12	2	2	10	20	30		
246	Narsimhulap	Akkerala (D)	5.03	1100	0.6	15.1	0.30	0.10	2	2	10	20	30		
247	Narsimhulap	Bojjannapet	4.90	1250	1	9.8	0.20	0.10	2	2	10	20	30		
248	Narsimhulap	Dantalapalli	12.71	1050	0.6	12.7	0.25	0.25	5	5	25	50	75		
249	Narsimhulap	Datla	21.15	1075	0.8	84.6	1.69	0.42	8	8	40	80	120		
250	Narsimhulap	Gundamrajpalli	8.11	1000	3.4	24.3	0.49	0.16	3	3	15	30	45		
251	Narsimhulap	Gunnepalli	10.31	1050	0.8	30.9	0.62	0.20	4	4	20	40	60		
252	Narsimhulap	Jayapuram	7.36	1025	1.2	22.1	0.44	0.15	3	3	15	30	45		
253	Narsimhulap	Kalvapalli	2.24	1050	0.6	2.2	0.04	0.04	1	1	5	10	15		
254	Narsimhulap	Kummarikunta	9.24	1075	0.6	27.7	0.55	0.18	3	3	15	30	45		

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255		Narsimhulap	Mungimadugu	13.40	850	2	40.2	0.80	0.26	5	5	25	50	75	
256		Narsimhulap	Narshimullapet	29.32	875	1	88.0	1.76	0.58	11	11	55	110	165	
257		Narsimhulap	Peddamupparam	19.49	1050	0.6	19.5	0.39	0.38	7	7	35	70	105	
258		Narsimhulap	Peddanagaram	20.04	825	0.6	80.2	1.60	0.40	8	8	40	80	120	
259		Narsimhulap	Ramavaram	5.52	1050	0.6	5.5	0.11	0.11	2	2	10	20	30	
260		Narsimhulap	Reponi	7.06	1075	0.6	21.2	0.42	0.14	3	3	15	30	45	
261		Narsimhulap	Vemulapalli	9.01	1075	0.6	18.0	0.36	0.18	3	3	15	30	45	
262		Nekkonda	Alamkhanpet	10.33	1550	0.8	41.3	0.83	0.44	6	3	30	30	60	
263		Nekkonda	Appalraopet	12.33	1950	0.8	49.3	0.99	0.53	3	6	15	60	75	
264		Nekkonda	Bollikonda	4.97	1125	0.8	14.9	0.30	0.21	4	4	20	40	60	
265		Nekkonda	Chandrugonda	19.66	1200	1	98.3	1.97	0.84	16	16	80	160	240	
266		Nekkonda	Chinna korpole	5.56	1900	0.4	38.9	0.78	0.24	3	2	15	20	35	
267		Nekkonda	Deekshakunta	21.36	2525	0.4	42.7	0.85	0.91	16	16	80	160	240	
268		Nekkonda	Gundrapalli	4.67	1475	2.4	9.3	0.19	0.20	4	3	20	30	50	
269		Nekkonda	Mudigonda	7.07	3475	0.4	21.2	0.42	0.30	4	6	20	60	80	
270		Nekkonda	Nekkonda	8.96	2900	0.4	26.9	0.54	0.38	7	4	35	40	75	
271		Nekkonda	Pathipaka	4.92	2075	1.2	19.7	0.39	0.21	4	4	20	40	60	
272		Nekkonda	Peddakorpole	9.09	1725	0.6	54.5	1.09	0.39	2	5	10	50	60	
273		Nekkonda	Phanikara	8.89	1750	1	17.8	0.36	0.38	6	6	30	60	90	
274		Nekkonda	Redlawada	18.82	1975	0.8	94.1	1.88	0.81	13	11	65	110	175	
275		Nekkonda	Topanpalli	4.44	1125	0.8	13.3	0.27	0.19	4	0	20	0	20	
276		Nekkonda	Venkatapur	9.87	1675	0.6	39.5	0.79	0.42	3	7	15	70	85	
277		Nellikudur	Brahmankothapalli	8.33	1150	1	16.7	0.33	0.31	6	6	30	60	90	
278		Nellikudur	Errabelligudem	16.37	1050	1.6	16.4	0.33	0.61	6	6	30	60	90	
279		Nellikudur	Madanthurthy	20.46	1175	1.4	61.4	1.23	0.77	15	15	75	150	225	
280		Nellikudur	Munegalaveedu	14.22	1425	0.8	28.4	0.57	0.53	10	10	50	100	150	

	S. No	Mandal	Village	Area	Ec		F	Unsaturated Volume	Village Recharge Potential (Sy 2%)	20% Of Runoff Yield	Proposed CDs	Proposed PTs	Total Cost CD @ 5	Total Cost PT @ 10	Total Lakhs CD +PTs
281	Nellikudur	Narsimulagudem	10.28	1725	1.8	10.3	0.21	0.38	4	4	20	40	60		
282	Nellikudur	Rajulakothapalli	14.04	1850	1	28.1	0.56	0.53	10	10	50	100	150		
283	Nellikudur	Ravirala	14.37	1775	1.6	28.7	0.57	0.54	10	10	50	100	150		
284	Nellikudur	Sriramgiri	10.69	2375	1.2	10.7	0.21	0.40	4	0	20	0	20		
285	Palakurthy	Ayyangaripalli	3.39	925	0.6	37.3	0.75	0.08	2	2	10	20	30		
286	Palakurthy	Bommera	22.80	850	0.6	205.2	4.10	0.54	10	10	50	100	150		
287	Palakurthy	Chennur	15.07	925	0.6	45.2	0.90	0.36	7	7	35	70	105		
288	Palakurthy	Iravennu	12.64	1175	0.8	113.7	2.27	0.30	6	6	30	60	90		
289	Palakurthy	Mailaram	5.59	850	0.6	16.8	0.34	0.13	0	3	0	30	30		
290	Palakurthy	Mallampalli	17.09	1500	0.6	68.4	1.37	0.41	8	8	40	80	120		
291	Palakurthy	Manchippula	12.20	1025	0.6	61.0	1.22	0.29	6	6	30	60	90		
292	Palakurthy	Mutharam	22.35	1100	0.6	134.1	2.68	0.53	10	10	50	100	150		
293	Palakurthy	Shathapur	7.30	1500	0.6	58.4	1.17	0.17	3	0	15	0	15		
294	Palakurthy	Thorrur	6.92	1150	0.6	62.3	1.25	0.16	3	1	15	10	25		
295	Palakurthy	Valmidi	12.72	975	0.6	25.4	0.51	0.30	6	6	30	60	90		
296	Palakurthy	Vavilala	20.41	1600	0.6	163.3	3.27	0.48	9	9	45	90	135		
297	Parkal	Cherlapalli	6.09	1425	0.2	67.0	1.34	0.24	5	4	25	40	65		
298	Parkal	Choutaparthy	5.29	1400	0.4	37.1	0.74	0.21	4	4	20	40	60		
299	Parkal	Dharmaram	4.20	1100	0.4	12.6	0.25	0.17	3	3	15	30	45		
300	Parkal	Kamareddypalli	3.48	1225	1.2	13.9	0.28	0.14	3	1	15	10	25		
301	Parkal	Kantathmakur	13.11	1850	0.6	65.6	1.31	0.53	10	10	50	100	150		
302	Parkal	Kowkonda	4.77	1075	0.6	9.5	0.19	0.19	4	0	20	0	20		
303	Parkal	Madharam	8.37	1425	0.8	16.7	0.33	0.34	6	2	30	20	50		
304	Parkal	Malakpet	5.66	1775	0.6	17.0	0.34	0.23	3	0	15	0	15		
305	Parkal	Mustyalapalli	4.84	1500	0.4	43.6	0.87	0.19	4	4	20	40	60		
306	Parkal	Nagaram	8.00	2450	0.6	32.0	0.64	0.32	6	6	30	60	90		

	S. No	Mandal	Village	Area	Ec		F	Unsaturated Volume	Village Recharge Potential (Sy 2%)	20% Of Runoff Yield	Proposed CDs	Proposed PTs	Total Cost CD @ 5	Total Cost PT @ 10	Total Lakhs CD +PTs
307	Parkal	Narlapuram	13.87	1425	0.2	152.6	3.05	0.56	11	7	55	70	125		
308	Parkal	Paidipalli	8.82	1975	0.8	8.8	0.18	0.35	3	3	15	30	45		
309	Parkal	Pocharam	11.14	900	0.6	22.3	0.45	0.45	6	9	30	90	120		
310	Parkal	Puligilla	6.71	1375	0.4	53.6	1.07	0.27	5	5	25	50	75		
311	Parkal	Rayaparthy	14.16	1525	0.6	56.6	1.13	0.57	11	11	55	110	165		
312	Parkal	Varikolu	10.63	1650	0.4	106.3	2.13	0.43	8	3	40	30	70		
313	Parkal	Venkatapur	7.43	2550	0.6	37.2	0.74	0.30	6	6	30	60	90		
314	Parvathagiri	Chintha nekkonda	18.95	2550	1	75.8	1.52	0.45	9	9	45	90	135		
315	Parvathagiri	choutapalli	12.14	1875	2.2	60.7	1.21	0.29	5	5	25	50	75		
316	Parvathagiri	Gopanpalli	8.42	1100	1.6	16.8	0.34	0.20	4	4	20	40	60		
317	Parvathagiri	Kalleda	15.12	2575	1.2	90.7	1.81	0.36	7	7	35	70	105		
318	Parvathagiri	Parvathagiri	23.60	2850	0.8	118.0	2.36	0.56	9	11	45	110	155		
319	Parvathagiri	Ravuru	6.95	2475	1	41.7	0.83	0.16	2	3	10	30	40		
320	Parvathagiri	Rollakal	8.50	2225	1.2	42.5	0.85	0.20	4	4	20	40	60		
321	Parvathagiri	Somaram	9.40	3225	1.2	18.8	0.38	0.22	0	4	0	40	40		
322	Parvathagiri	Wadlakonda	10.99	1875	1.4	44.0	0.88	0.26	5	4	25	40	65		
323	Raghunathpal	Ashwaraopally	18.52	925	0.8	481.4	9.63	0.33	6	6	30	60	90		
324	Raghunathpal	Bhanjipeta	10.67	900	1.2	160.0	3.20	0.19	4	4	20	40	60		
325	Raghunathpal	Gabbeta	7.88	850	1.4	86.7	1.73	0.14	3	3	15	30	45		
326	Raghunathpal	Govardhanagiri	12.46	850	1	298.9	5.98	0.22	4	4	20	40	60		
327	Raghunathpal	Kalvalapalli	3.84	925	1.2	53.8	1.08	0.07	1	1	5	10	15		
328	Raghunathpal	Kannaipalle	5.35	1125	1.2	64.2	1.28	0.10	2	2	10	20	30		
329	Raghunathpal	Kodur	12.30	1975	0.8	135.3	2.71	0.22	4	4	20	40	60		
330	Raghunathpal	Kurchapalle	16.40	950	1.2	196.8	3.94	0.29	6	6	30	60	90		
331	Raghunathpal	Narayanapur	11.89	800	1.2	107.0	2.14	0.21	4	4	20	40	60		

	S. No	Mandal	Village	Area	Ec		F	Unsaturated Volume	Village Recharge Potential (Sy 2%)	20% Of Runoff Yield	Proposed CDs	Proposed PTs	Total Cost CD @ 5	Total Cost PT @ 10	Total Lakhs CD +PTs
332	Raghunathpal	Nidigonda	14.32	500	1.2	100.3	2.01	0.26	5	5	25	50	75		
333	Raghunathpal	Qilashapuram	47.91	850	0.8	1150.0	23.00	0.86	16	16	80	160	240		
334	Rayaparthy	Katrapally	9.94	2400	0.4	79.5	1.59	0.26	3	2	15	20	35		
335	Rayaparthy	Kolanpaly	14.63	2475	0.4	73.1	1.46	0.38	5	0	25	0	25		
336	Rayaparthy	Kothur	19.64	1700	1	117.9	2.36	0.51	10	7	50	70	120		
337	Rayaparthy	Muripirala	14.75	1825	0.6	88.5	1.77	0.38	7	4	35	40	75		
338	Rayaparthy	Mylaram	14.03	1250	0.6	56.1	1.12	0.36	7	7	35	70	105		
339	Rayaparthy	Ookal	11.47	1050	1	68.8	1.38	0.30	6	6	30	60	90		
340	Rayaparthy	Perkedu	18.29	1250	0.8	109.8	2.20	0.47	6	6	30	60	90		
341	Rayaparthy	Rayaparthy	30.00	1200	0.6	120.0	2.40	0.77	15	15	75	150	225		
342	Rayaparthy	Thirmalaipally	8.68	2125	0.6	95.5	1.91	0.22	4	2	20	20	40		
343	Sangem	Bollikunta	11.99	1425	0.6	36.0	0.72	0.36	7	6	35	60	95		
344	Sangem	Chintalapalli	10.80	1550	0.6	75.6	1.51	0.33	6	6	30	60	90		
345	Sangem	Elgur rangampet	25.25	1625	0.6	50.5	1.01	0.76	15	14	75	140	215		
346	Sangem	Gavicherla	11.48	1275	0.8	68.9	1.38	0.35	4	3	20	30	50		
347	Sangem	Kapulakanaparthy	10.93	1125	0.8	21.9	0.44	0.33	5	5	25	50	75		
348	Sangem	Katrepally	8.91	1100	0.8	17.8	0.36	0.27	4	1	20	10	30		
349	Sangem	Mummadivaram	7.93	2000	0.6	47.6	0.95	0.24	5	5	25	50	75		
350	Sangem	Nallabelly	7.81	2275	1	54.7	1.09	0.24	4	4	20	40	60		
351	Sangem	Ramchandrapuram	12.01	1200	1	72.1	1.44	0.36	7	1	35	10	45		
352	Sangem	Teegarajupalli	11.37	1775	0.4	136.4	2.73	0.34	7	7	35	70	105		
353	Sangem	Timmapur	6.47	1650	0.4	19.4	0.39	0.20	4	4	20	40	60		
354	Sangem	Venkatapur	4.27	1075	0.8	17.1	0.34	0.13	2	1	10	10	20		
355	Shayampet	Dongalasingaram	5.81	3100	0.4	11.6	0.23	0.26	4	0	20	0	20		
356	Shayampet	Hyssainpally	2.56	1225	1.2	7.7	0.15	0.12	2	0	10	0	10		
357	Shayampet	Katrepally	20.24	2175	0.8	40.5	0.81	0.92	15	4	75	40	115		

	S. No	Mandal	Village	Area	Ec		F	Unsaturated Volume	Village Recharge Potential (Sy 2%)	20% Of Runoff Yield	Proposed CDs	Proposed PTs	Total Cost CD @ 5	Total Cost PT @ 10	Total Lakhs CD +PTs
358	Shayampet	Mylaram	7.49	1250	1.4	37.5	0.75	0.34	6	0	30	0	30		
359	Shayampet	Neredupalli	4.84	5600	0.4	9.7	0.19	0.22	3	2	15	20	35		
360	Shayampet	Pathipaka	9.85	1425	1.2	29.6	0.59	0.45	8	0	40	0	40		
361	Shayampet	Peddakodepaka	18.30	1400	1.8	128.1	2.56	0.83	16	16	80	160	240		
362	Shayampet	Vasanthapur	6.87	1800	0.4	13.7	0.27	0.31	5	5	25	50	75		
363	St Ghanpur	Chagal	12.38	725	0.4	210.4	4.21	0.24	5	3	25	30	55		
364	St Ghanpur	Chinnapendyala	8.59	600	0.6	51.5	1.03	0.17	2	3	10	30	40		
365	St Ghanpur	Fathepur	12.66	1075	1	114.0	2.28	0.25	2	0	10	0	10		
366	St Ghanpur	Ghanpur	20.24	2475	0.4	20.2	0.40	0.40	8	5	40	50	90		
367	St Ghanpur	Ippagudem	30.55	1150	2	122.2	2.44	0.60	11	8	55	80	135		
368	St Ghanpur	Kondapur	14.20	1675	1.2	142.0	2.84	0.28	5	1	25	10	35		
369	St Ghanpur	Kothapalli	5.64	900	0.6	73.3	1.47	0.11	2	0	10	0	10		
370	St Ghanpur	Lingampalli	15.36	1250	1.6	107.5	2.15	0.30	6	0	30	0	30		
371	St Ghanpur	Malkapur	15.36	1400	1.2	138.2	2.76	0.30	6	2	30	20	50		
372	St Ghanpur	Namiligonda	12.30	1750	0.8	12.3	0.25	0.24	4	5	20	50	70		
373	St Ghanpur	Nashkal	10.03	1325	1.2	70.2	1.40	0.20	4	4	20	40	60		
374	St Ghanpur	Pallagutta	21.40	1050	0.8	128.4	2.57	0.42	8	8	40	80	120		
375	St Ghanpur	Pamnur	7.81	1150	0.6	15.6	0.31	0.15	0	1	0	10	10		
376	St Ghanpur	Rajavaram	17.28	750	0.6	69.1	1.38	0.34	6	6	30	60	90		
377	St Ghanpur	Samudrala	16.05	1000	1.2	96.3	1.93	0.32	6	1	30	10	40		
378	St Ghanpur	Sreepathipalli	8.78	1200	1	105.3	2.11	0.17	3	0	15	0	15		
379	St Ghanpur	Thanedarpalli	7.48	1400	2.2	29.9	0.60	0.15	0	2	0	20	20		
380	St Ghanpur	Thatikonda	32.17	1025	0.8	289.6	5.79	0.63	11	7	55	70	125		
381	St Ghanpur	Vishawathanapuram	4.27	1325	1.6	25.6	0.51	0.08	2	2	10	20	30		
382	Thorrur	Bommakal	7.43	1050	0.6	7.4	0.15	0.18	3	2	15	20	35		
383	Thorrur	Bontupalli	6.09	1075	0.8	6.1	0.12	0.14	2	2	10	20	30		

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384		Thorrur	Chityal	11.45	1075	0.6	22.9	0.46	0.27	5	5	25	50	75	
385		Thorrur	Gopalagiri	6.33	1100	0.8	12.7	0.25	0.15	3	3	15	30	45	
386		Thorrur	Haripirala	15.48	1025	0.6	15.5	0.31	0.37	6	6	30	60	90	
387		Thorrur	Jamastanpur	2.76	1050	0.8	22.1	0.44	0.07	1	1	5	10	15	
388		Thorrur	Madipalli	11.97	1200	1.6	59.9	1.20	0.28	5	5	25	50	75	
389		Thorrur	Matedu	7.51	1100	0.8	15.0	0.30	0.18	3	3	15	30	45	
390		Thorrur	Polepalli	5.52	1125	0.8	11.0	0.22	0.13	2	2	10	20	30	
391		Wardhannape	Chennaram	10.03	1325	0.6	70.2	1.40	0.22	3	3	15	30	45	
392		Wardhannape	Dammannapeta	14.83	2225	0.4	103.8	2.08	0.32	4	2	20	20	40	
393		Wardhannape	Kakkiralapalli	15.24	1275	0.6	381.0	7.62	0.33	4	1	20	10	30	
394		Wardhannape	Nandanam	26.29	1200	0.6	525.8	10.52	0.57	11	9	55	90	145	
395		Wardhannape	Ramavaram	7.59	2900	0.4	38.0	0.76	0.16	3	3	15	30	45	
396		Wardhannape	Wardhannapeta	41.44	1600	0.6	207.2	4.14	0.90	16	13	80	130	210	
397		Zaffergadh	Konaichelam	7.05	850	0.6	77.6	1.55	0.14	3	3	15	30	45	
398		Zaffergadh	Kunur	11.11	700	0.6	122.2	2.44	0.22	4	2	20	20	40	
399		Zaffergadh	Obulapuram	14.01	2175	0.4	70.0	1.40	0.28	0	2	0	20	20	
400		Zaffergadh	Sagaram	5.57	1025	0.6	55.7	1.11	0.11	2	2	10	20	30	
401		Zaffergadh	Shampalli	2.72	950	0.4	21.8	0.44	0.05	1	0	5	0	5	
402		Zaffergadh	Thammadapalli (G)	10.08	1450	0.4	70.6	1.41	0.20	2	0	10	0	10	
403		Zaffergadh	Theegaram	8.60	1250	1.6	34.4	0.69	0.17	0	3	0	30	30	
404		Zaffergadh	Thimmampeta	10.95	875	0.8	43.8	0.88	0.22	3	4	15	40	55	
405		Zaffergadh	Venkatapur	15.10	1375	0.8	211.4	4.23	0.30	6	6	30	60	90	
406		Zaffergadh	Zaffargadh	33.55	1550	0.4	268.4	5.37	0.66	8	13	40	130	170	
	Total			**5022.98**			**31371.79**	**624.55**	**140.11**	**2338**	**1964**	**11690**	**19640**	**31330**	