केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

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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

RAJANN SIRCILLA DISTRICT, TELANGANA

दक्षिणी क्षेत्र, हैदराबाद

Southern Region, Hyderabad

भारतसरकार

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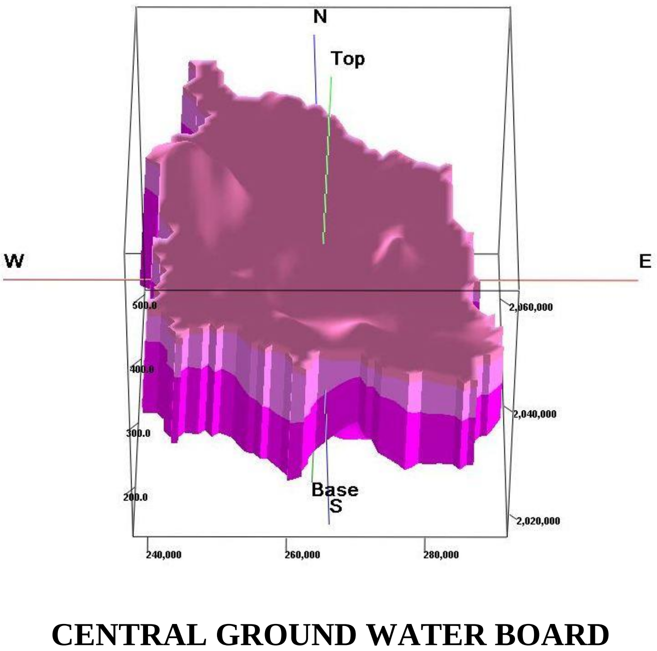
GOVERNMENT OF INDIA
MINISTRY OF JAL SHAKTI
DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION

REPORT ON AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN RAJANNA SIRCILLA DISTRICT, TELANGANA STATE



CENTRAL GROUND WATER BOARD
SOUTHERN REGION
HYDERABAD
AUGUST 2022

REPORT ON
AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN RAJANNA SIRCILLA DISTRICT, TELANGANA STATE

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REPORT ON
AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN RAJANNA SIRCILLA DISTRICT, TELANGANA STATE

Executive summary

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ABBREVATIONS

2D	:	2 Dimensional
3D	:	3 Dimensional
ARS	:	Artificial Recharge Structures
Avg	:	Average
BDL	:	Below Detection Level
BW	:	Bore Well
CD	:	Check dam
CGWB	:	Central Ground Water Board
Cr	:	Crore
DTW	:	Depth to water
DW	:	Dug well
EC	:	Electrical conductivity
EL	:	East Longitude
F	:	Fluoride
FP	:	Farm Pond
GEC	:	Ground Water Estimation committee
GW	:	Ground Water
ha.	:	Hector
ham	:	Hector meter
ID	:	Irrigated dry
IMD	:	Indian Meteorological Department
km^2	:	square kilometre
LPS	:	Litres per second
M	:	Meter
M^3	:	Cubic meter
m bgl	:	Metres below ground level
MCM	:	Million cubic meter
mg/l	:	Milligram per litre
MI	:	Micro irrigation
Min	:	Minimum
max	:	Maximum
MPT	:	Mini percolation tank
MSP	:	Minimum Support price
NL	:	North Latitude
NO_3	:	Nitrate
OE	:	Over Exploited
PGWM	:	Participatory ground water management
PT	:	Percolation tank
SGWD	:	State Ground Water Department
S	:	Storativity
Sy	:	Specific Yield
T	:	Transmissivity
WCM	:	Water conservation measures

EXECUTIVE SUMMARY

The Rajanna Sircilla district covering about 1896 km^2 lies between north latitude 18°12’52” - 18°41’5.0” and east longitude 78°31’31” - 79°01’15”. The district is bounded on the north by Jagitial and Nizamabad district, on the east by Karimnagar district, on the south by Siddipet district and on the west by Kamareddy and Nizamabad districs. The present district is carved from erstwhile Karimnager district. Administratively, the area is governed by 2 Revenue Divisions, 13 Revenue Mandals and 171 revenue villages with a population of 5.52 lakhs (2011 census) (Rural: 79%, Urban: 21%) with average density of 291 persons/km^2.

The annual normal rainfall of the district varies from 718 mm (Mustabad mandal) to 1027mm (Chendurthy mandal) with district normal of 913 mm. Southwest monsoon contributes 78 %, Northeast monsoon by 14 % and rest 8 % by winter and summer rainfall. The district received excess rainfall of 1566 mm (71% above normal) during the water year 2021-22.

The area is underlain by various geological formation from the oldest Archaean rocks to upper cretaceous to lower Eocene age. About 93% of the area is underlain by Gneisses and Granite(4%) of Archaean age and Basalt (3%) of Upper creatoceous to lower Eocene age. Pediplain is the major landform covering about 62 % area. The other landforms observed are pediment (17 %), denudation hills (6 %), dissected plateau (5%), flood plain (4 %), channel fill (3%) and residual hills (1 %). The district falls under Godavari basin and Mannair sub basin. During 2020-21, the net area sown is about 56% and area sown more than once is 36%, which brings gross swon area to 92% for two seasons. During kharif season, out of total gross swon area, the paddy is grown in 55% of the area followed by cotton 37% , pulses 4%, of the area and other crops in 4% of the area while during rabi season, paddy is grown in 97% of the area and others in 3% of the area. Forest occupies nearly 20 % of the area. The soils are mainly fine montmorillonitic, clayey skeletal, loamy skeletal, fine mixed, rock land & clayey skeletal soils. Majority of soils are occupied by fine montmorillonitic and fine mixed.

Groundwater exploration data revealed that the depth drilled varies from 23 to 200 m bgl and weathering varies from 7 to 35 m bgl. The data indicates that 27% of the wells are shallow wells that are drilled up to a depth of <30 m bgl, 40% of the wells between the depth of 30-60 m bgl, 13% of the wells drilled between the depth range of 60 to 100 m bgl and around

20% of the wells are drilled between the depth range of 150 to 200 m bgl. The deeper wells of >150 m bgl are located in Mustabad mandals. Further, the study reveal that majority of fractures (79%) occur within 100 m depth. The deepest fractures >100 m bgl is noticed in Mustabad Konaraopeta, Sircilla and Vemulawada mandals.

Water level data indicates that during pre-monsoon, majority of the water levels are in the range of 10 to 20 m bgl distributed in 72% of the wells located in Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Rudrangi, Sircilla, Thangallapalli, Veernapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals followed by water levels >20 m bgl (13% of the wells) noticed in Gambhiraopet, Illanthakunta, Mustabad, Rudrangi, Veernapalli, Vemulawada, Yellareddipet mandals. The water levels in the range of 5 to 10 m bgl is noticed in 16% of the wells falling in Boinpalli, Chendurthi, Illanthakunta,Sircilla, Vemulawada and Vemulawada Rural mandals. During post-monsoon season**,** majority of the water levels during this season are in the range of 5 to 10 m bgl and noticed in 53% of the wells located in Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Rudrangi, Sircilla, Thangallapalli, Veernapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals followed by water levels from 10 to 20 m bgl distributed in 41% of the wells falling in Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Rudrangi, Sircilla, Thangallapalli, Veernapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals. The shallow water levels of <5 m bgl (6% of the wells) is observed in Sircilla, Illanthakunta and Thangallapalli, mandals.

The data analysed from the groundwater quality indicate that during pre-monsoon season, the electrical conductivity varies from 402 to 4700 µ Siemens/cm. The EC >3000 µ Siemens/cm is observed in 1% of the samples (Mustabad, Illanthakunta, Thangallapalli, Vemulawada mandals). The NO_3 concentration ranges from 0.20 to 467 mg/l and noticed that in about 46% of the samples quality is not suitable for drinking water purpose (>45 mg/l). The Fluoride concentration varies from 0.09 to 4.4 mg/l and found that high fluoride concentration >1.5 mg/l is observed in 24% of the samples (Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Rudrangi, Sircilla, Thangallapalli, Veernapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals).

During post-monsoon season, the EC varies from 310 to 2624 µ Siemens/cm and in none of the samples, the EC >3000 µ Siemens/cm is observed. The NO_3 concentration ranges from 0.40 to 298 mg/l. In about 48% of the samples (Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Rudrangi, Sircilla, Thangallapalli, Veernapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals), it is exceeding permissible limits. The Fluoride concentration varies from 0.05 to 4.34 mg/l and in about 20% of the samples (Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Sircilla, Thangallapalli, Veernapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals), the fluoride concentration is beyond permissible limit.

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

As per GEC 2020 report, the net dynamic replenishable groundwater availability for newly formed Rajanna Sircilla district is 328 MCM. The gross groundwater draft for all uses 261 MCM, provision for drinking and industrial use till the year 2025 is 18 MCM and net annual groundwater potential available for future irrigation needs is 57 MCM. Out of 13 mandals, 2 mandals are falling under Safe (Boinpalli (69%), Vemulawada Rural (69%)) and 9 mandals falling under Semi-Critical (Chendurthi (73%), Illanthakunta (83%), Konaraopet (78%), Rudrangi (80%), Sircilla (73%), Thangallapalli (79%), Veernapalli (75%), Vemulawada (72%) and Yellareddipet (85%)) and the remaining remaining 2 mandals falling under Critical catetory (Gambhiraopet (91%) and Mustabad (96%)). The overall average stage of ground water extraction in the district is 79%.

The village wise groundwater management plan was also prepared. As per village wise GEC 2020 estimates, the areas spread over 34 villages covering 315 km^2 falls under Priority-1, where the stage of groundwater extraction is >90% and required an immediate intervention. In this area, 36 MCM recharge potential and 06 MCM utilizable yield (uncommitted run-off) is available. Around 29 artificial recharge structures viz., 16 mini PT's and 13 CD's with recharge shafts with a total cost of 5.15 crores recommended. By constructing these structures, there will be additional groundwater recharge of 1 MCM which will help in sustainability of the groundwater.

Area consisting of 134 villages having 1485 km^2 covered under Priority-2, where the stage of groundwater extraction is <90%. In the area, 142 MCM recharge potential and 41 MCM utilizable yield is available. About 546 artificial recharge structures viz.,323 mini PT's and 223 CD's with recharge shafts with a total cost of 98.05 crores are recommended. By constructing these structures, there will be additional groundwater recharge of 13 MCM which will help in sustainability of the groundwater.

To help the farmers for early sowing and to meet the needs for intermediate irrigation, it is suggested that, farm ponds construction may be taken up @20 structures per village. Thus, about 3420 farm ponds needs to be constructed at a unit cost of Rs. 25,000/- totalling to 8.5 Crores. This will create an additional storage capacity of 1.03 MCM.

As per the studies, it is estimated that 8550 ha. of additional land that can be brought under micro-irrigation (@50 ha/village in 171 villages) costing about 51 Crores. By shifting from traditional to micro irrigation practices, 12.83MCM of groundwater can be conserved.

The above interventions by investing about Rs. 163 Crores, a net saving of 27.32 MCM of groundwater can be achieved which will help in net reduction in groundwater extraction by 6% i.e., from the existing 79% to 76%. This will help in arresting the groundwater deterioration and its sustainability. The onetime cost will be 5.97paisa/litre and the actual cost of invest will be 0.59paisa/litre if considered the life of the artificial recharge structures and micro irrigation equipment as 10 year.

NUMBER OF DATA POINTS USED FOR PREPARATION OF VARIOUS MAPS/FIGS-RAJANNA SIRCILLA DISTRICT, TELANGANA STATE

S. No.	Data	Aquifer	Total Data Points	Source	
				CGWB	SGWD
1	Panel Diagram (3-D)	Combine	72	Expl:06 VES:57	Expl:09
2	Hydrogeological Sections	Combine	72	Expl:06 VES:57	Expl:09
3	Fence/panel Diagrams	1 no	72	Expl:06 VES:57	Expl:09
4	Depth of weathering	1 no	72	Expl:06 VES:57	Expl:09
5	Depth of fracturing	1 no	72	Expl:06 VES:57	Expl:09
6	Groundwater Yield	Weathered zone Fractured zone	72	Expl:06 VES:57	Expl:09
7	Transmissivity (m^2/day)	Weathered zone Fractured zone	72	Expl:06 VES:57	Expl:09
8	Depth to Water Level Maps	Combine	32 Piezometers (10 Years data)	05	27
9	Water Level Fluctuation	Combine	32 Piezometers (10 Years data)	05	27
10	Long term water level trends	Combine	31 Hygrograph Station (10 Years data)	06	25
11	Water quality Pre-2021 Post-2021	Combine	921 Pre:457 Post:464	0 0	457 464

1. INTRODUCTION

Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic, hydrogeological and chemical analyses is applied to characterize the quantity, quality and sustainability of groundwater in aquifers. In recent past, there has been a paradigm shift from "groundwater development" to "groundwater management". As large parts of India, particularly hard rock aquifers have become water stressed due to rapid growth in demand for water due to growth in population, 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 groundwater management through community participation.

Major part of the Peninsular India is underlain by hard rocks which lack primary porosity, and groundwater occurrence is limited to secondary porosity, developed by weathering and fracturing. Weathered zoneoccuring at the top is the potential recharge zone for deeper fractures and excessive withdrawal from this zone lead to drying up at places and reducing the sustainability of structures. Besides these quantitative aspects, 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.

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

1.3 Area Details

The Rajanna Sircilla district covering about 1896 km^2 lies between north latitude 18°12'52" - 18°41'5" and east longitude 78°31'31" - 79°01'15" (Fig. 1.1). The district is bounded on the north by Jagitial and Nizamabad district, on the east by Karimnagar district, on the south by Siddipet district and on the west by Kamareddy and Nizamabad districs. The present district is carved from erstwhile Karimnager district. Administratively, the area is governed by 2 Revenue Divisions, 13 Revenue Mandals and 171 revenue villages with a population of 5.52 lakhs (2011 census) (Rural: 79%, Urban: 21%) with average density of 291 persons/km^2.

1.4 Climate and Rainfall

The district experiences tropical climate and is geographically located in semi-arid area. The district falls under Northan Telangana Agro-climatic zone based on the geographical characteristics such as rainfall, temperature, nature of soils etc. The mean temperature during summer is 34.2°C and highest temperature 47.8°C (Yellaredipeta mandal recoreded), mean temperatur in winter is 24°C and lowest temeratur is 5°C (Mustabad mandal recoreded) (as per TSDPS,Januar 2021 report). The normal annual rainfall varies between 718 mm (Mustabad) and 1027 mm (Chendurthi) with average of 913 mm. SW monsoon contributes 78 % and 14 % is contributed by retreating monsoon (NE) season and rest by winter and summer rainfall. Rainfall increases from southwest to northeast direction.

Isohyetal map prepared using annual normal rainfall of mandals in the district collected from DPS, Govt. of Telangana is shown in Fig.1.2. The area received average annual rainfall of 1566 mm (71% excess rainfall than normal rainfall) during the year 2021-2022.

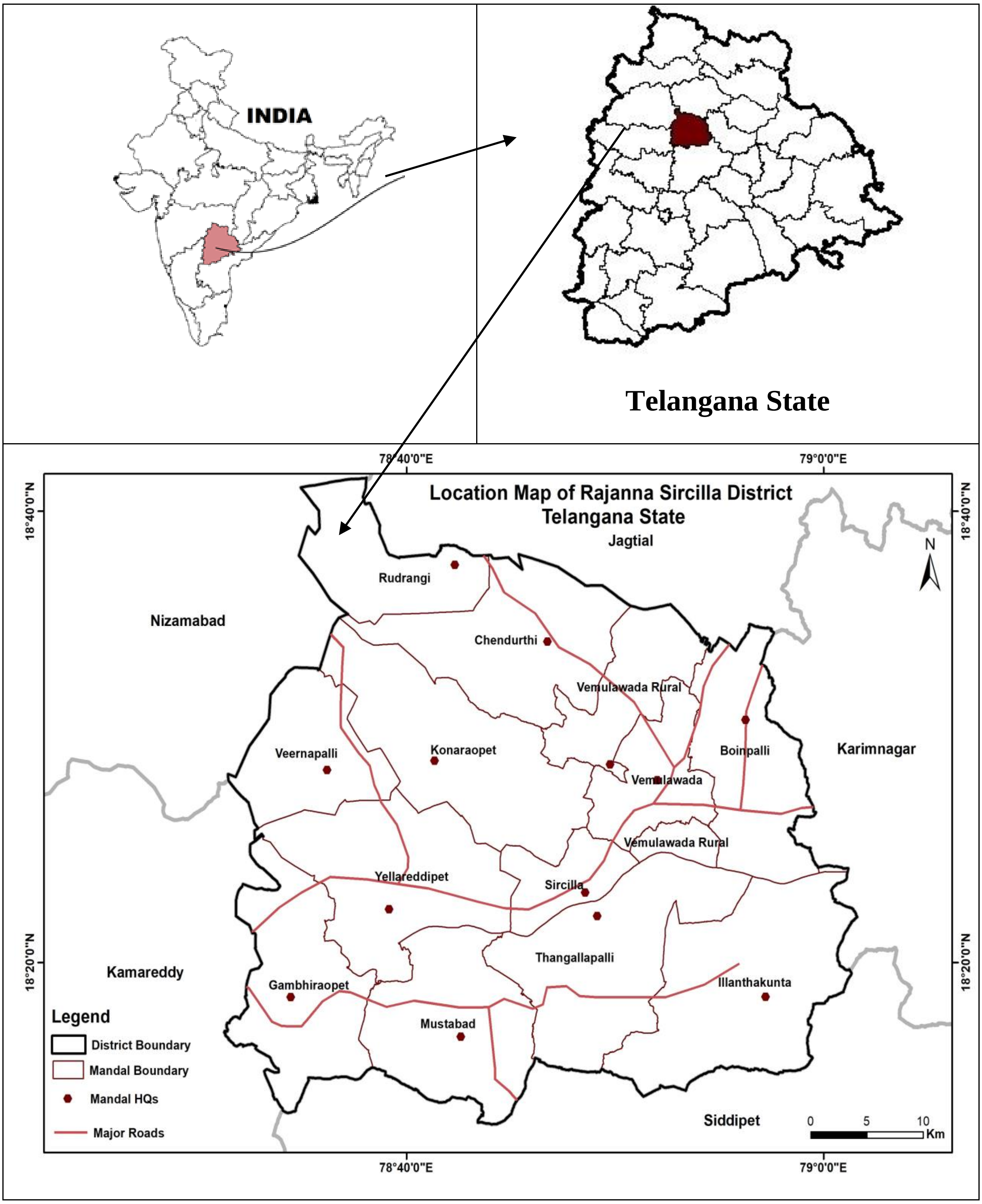


Fig. 1.1: Location map.

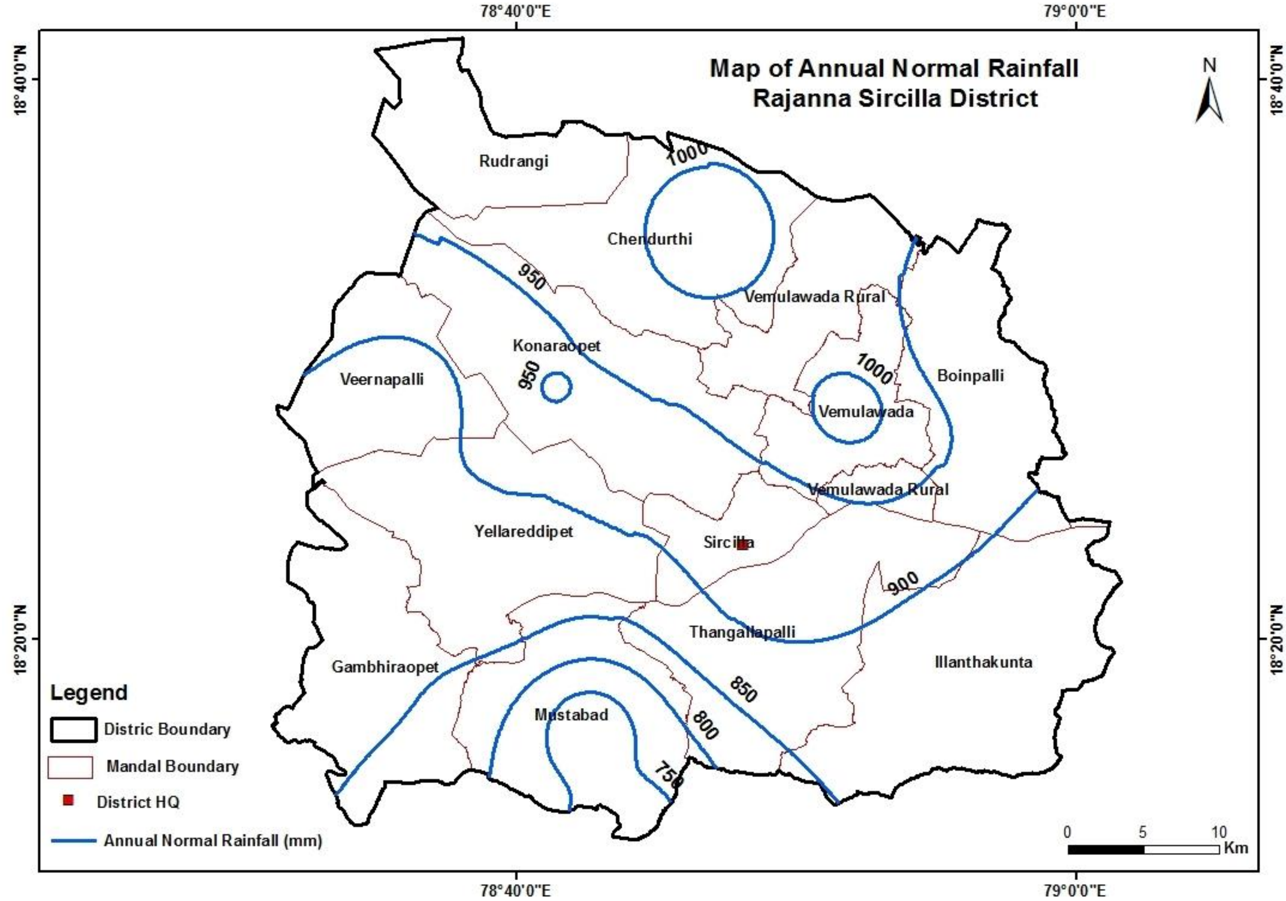


Fig. 1.2: Isohyetal map.

1.5 Geomorphological Set up

Pediplain is the major landform covering about 62 % area. The other landforms observed are pediment (17 %), denudation hills (6 %), dissected Plateau (5%), flood plain (4 %), channel fill (3%) and residual hills (1 %) etc. (**Fig.1.3**).

1.6 Drainage

The district falls under Godavari basin and Mannair sub basins. The river “Mannair” which is a tributary of Godavari River, it is flowing through Medak & Kamareddy district and enters the district from western direction. Map depicting drainage and water bodies is presented in Fig. 1.4.

1.7 Land use/ land cover

Based on the land use study, several classes have been delineated in the district viz., kharif, double crop, forest plantation, waste lands, waterbodies, etc. Out of the total area, majority of the area falling under kharif category followed by rabi. Some of the double cropped area also noticed on either side of the stream/river courses with in the district. The land use / land cover map is given in Fig. 1.5.

1.8 Soils

The soils from the district are mainly fine montmorillonitic, clayey skeletal, loamy skeletal, fine mixed, rock land & clayey skeletal soils. Majority of soils are occupied by fine montmorillonitic and fine mixed. They are grouped into many classes (NBS & LUP) based on geomorphology and landscapes and further sub-divided based on physiography, relief and drainage (Fig. 1.6).

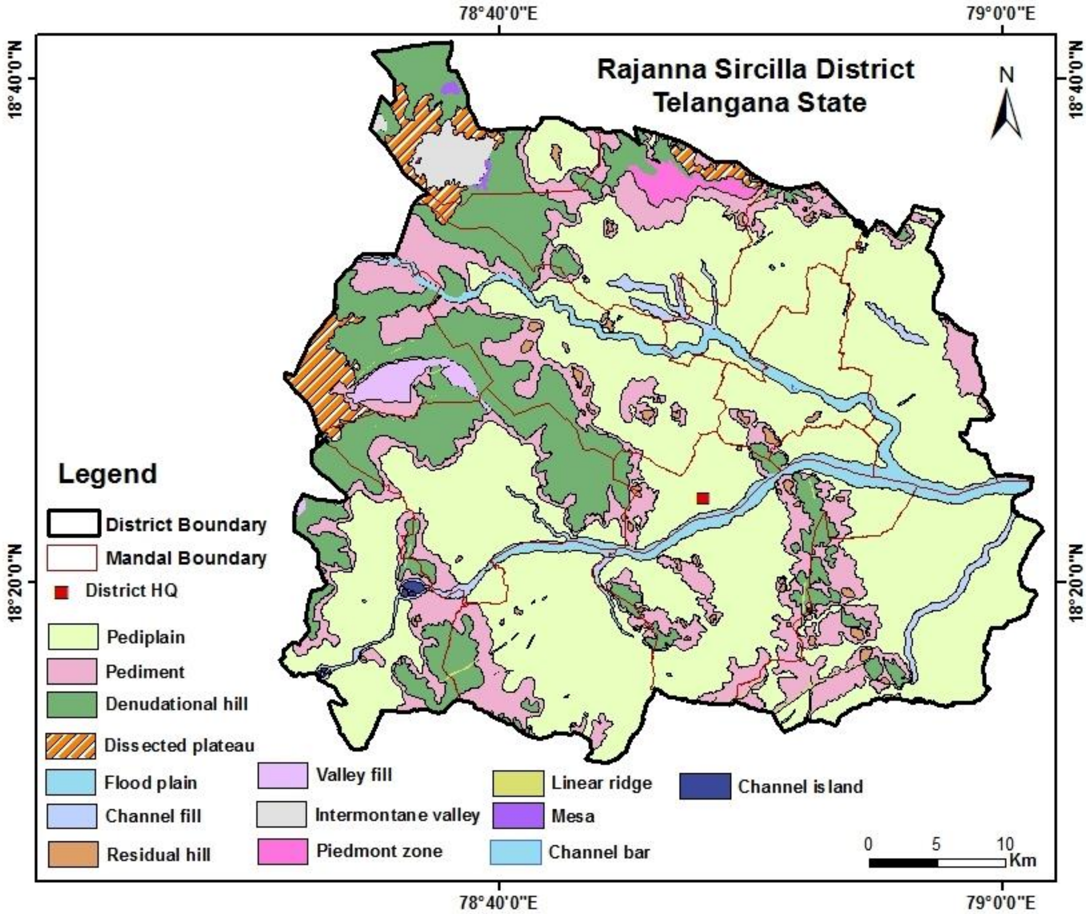


Fig. 1.3: Geomorphology map.

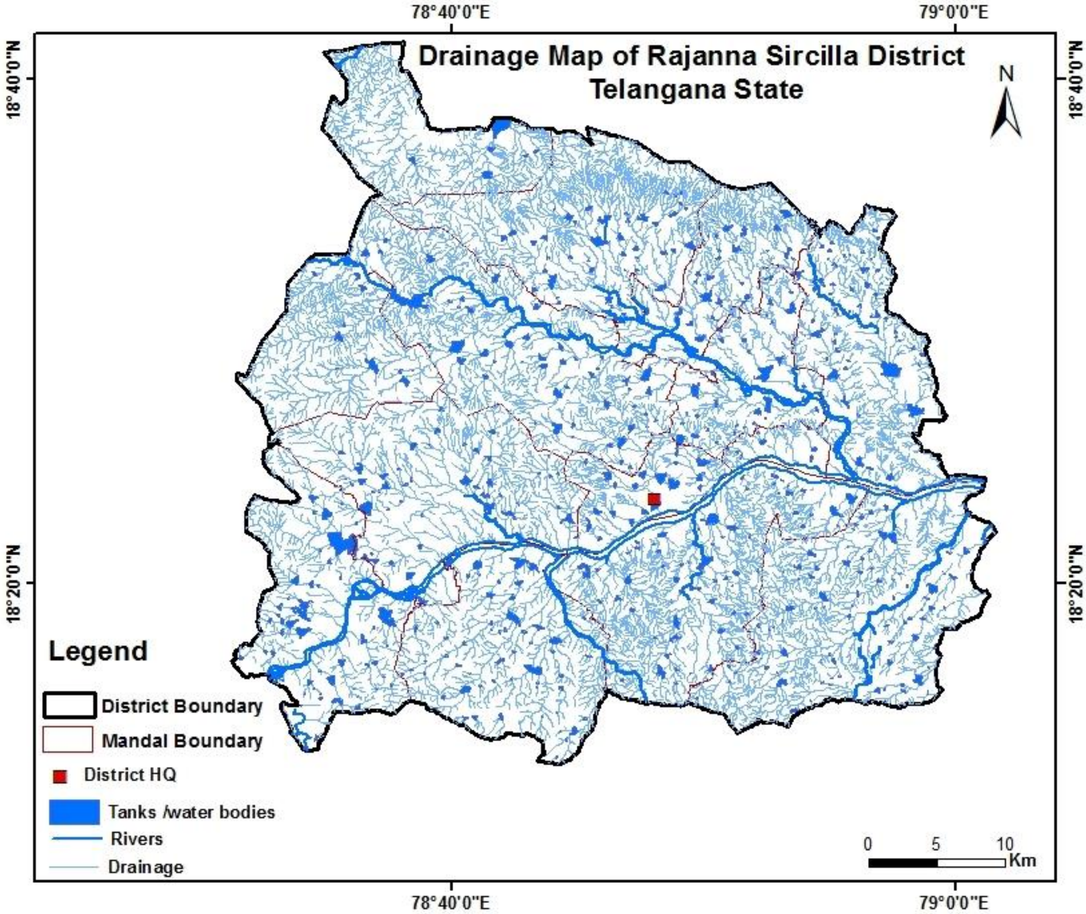


Fig 1.4: Drainage and water bodies map.

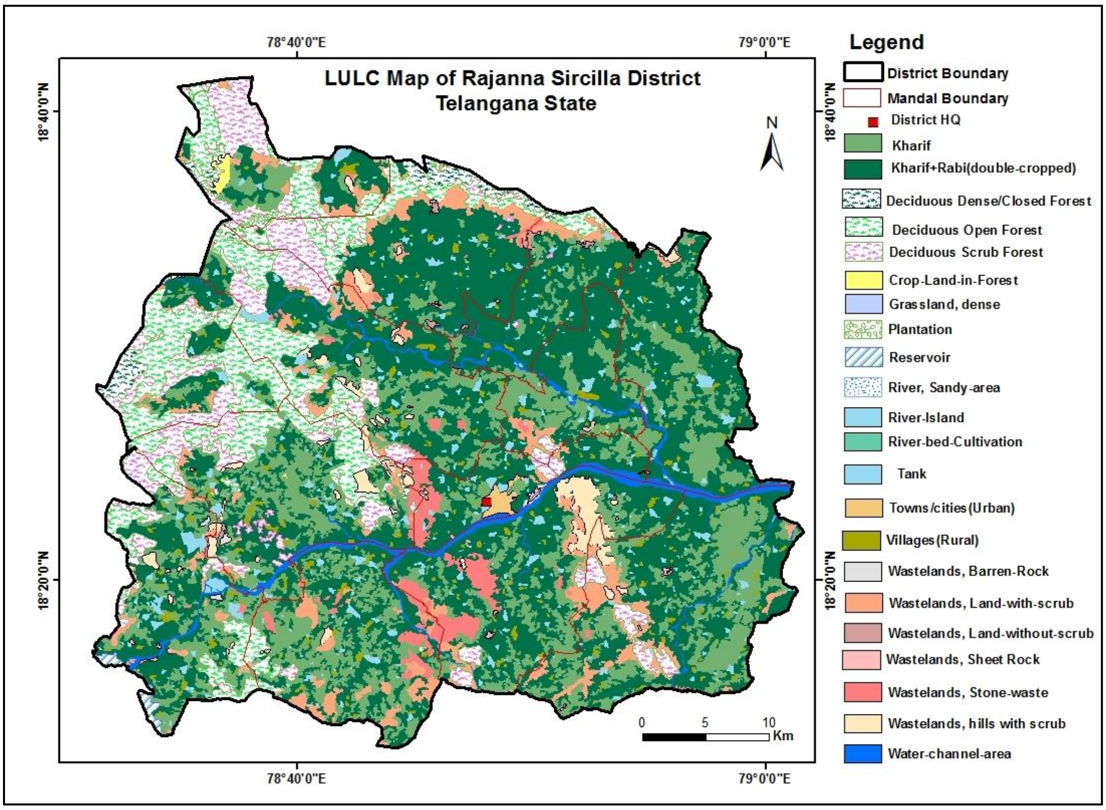


Fig. 1.5: Land use / land cover map

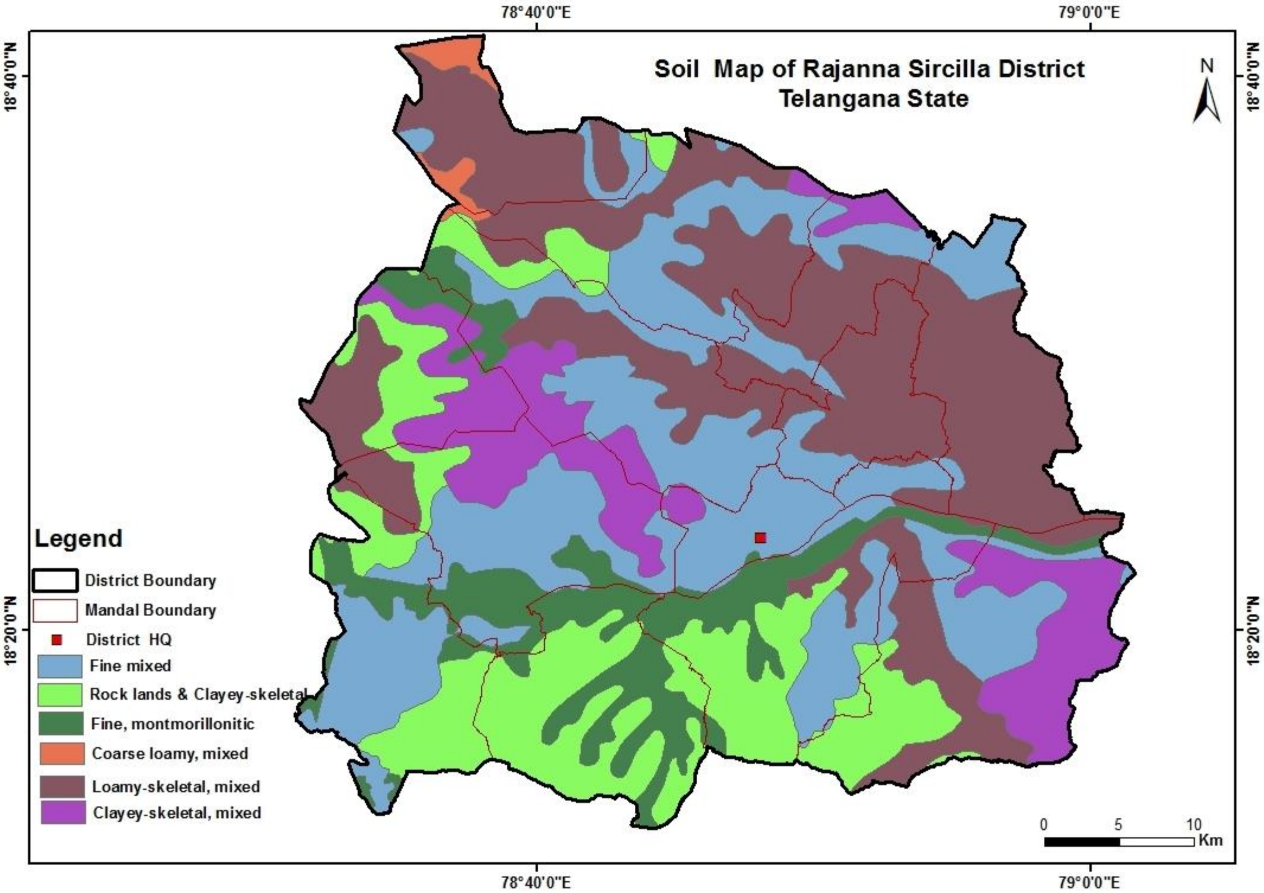
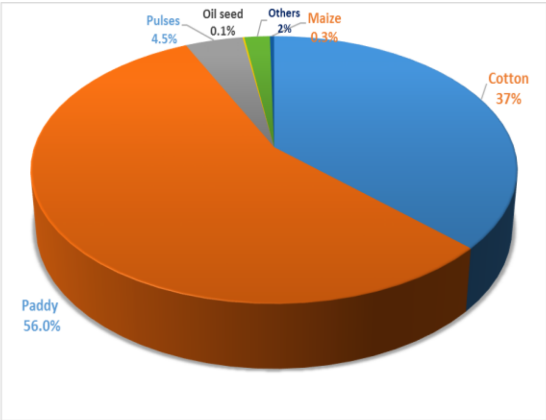


Fig. 1.6: Soil map.

1.9 Cropping Pattern (2020-21 in ha.)

The forest occupies about 17% of the total geographical area, barren and uncultivable land occupies 6% of area; land put to non-agricultural use is 9%, cultivable wasteland is 2%. With respect to land utilization, out of total area, 3.2% of the area is falling under current fallows; 2.8% is under other fallows. During 2020-21 the net area sown is about 56% and area sown more than once is 36%, which brings gross swon area to 92% for two seasons. During kharif season, out of total gross swon area, the Paddy is grown in 55% of the area followed by cotton 37% , pulses 4%, of the area and other crops in 4% of the area while during rabi season, Paddy is grown in 97% of the area and others in 3% of the area (Fig. 1.7).

KHARIFF SEASON



RABI SEASON

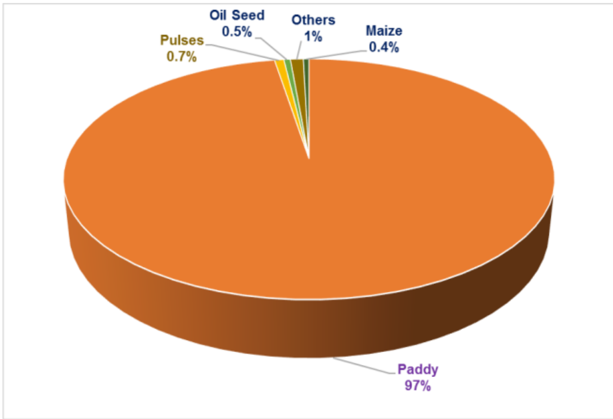


Fig. 1.7: Cropping pattern.

1.10 Irrigation

In the district, major irrigation project is Upper Manair Dam with 5297 ha ayacut. The other sources of irrigation are Mid Manair reservoir, Annapurna reservoir and Singasamudram tanks. Location map of irrigation projects is given in **Fig. 1.8**. In the area there are 47049 minor irrigation sources and during the year 2020-21 only 7629 ha area was irrigated from surface sources (including tanks). The salient features of irrigation during 2020-21 are given in **Table-1.1.** It is observed that during 2020-21 ground water contributed 94 % of irrigation needs (Kharif: 99% and Rabi: 89%).

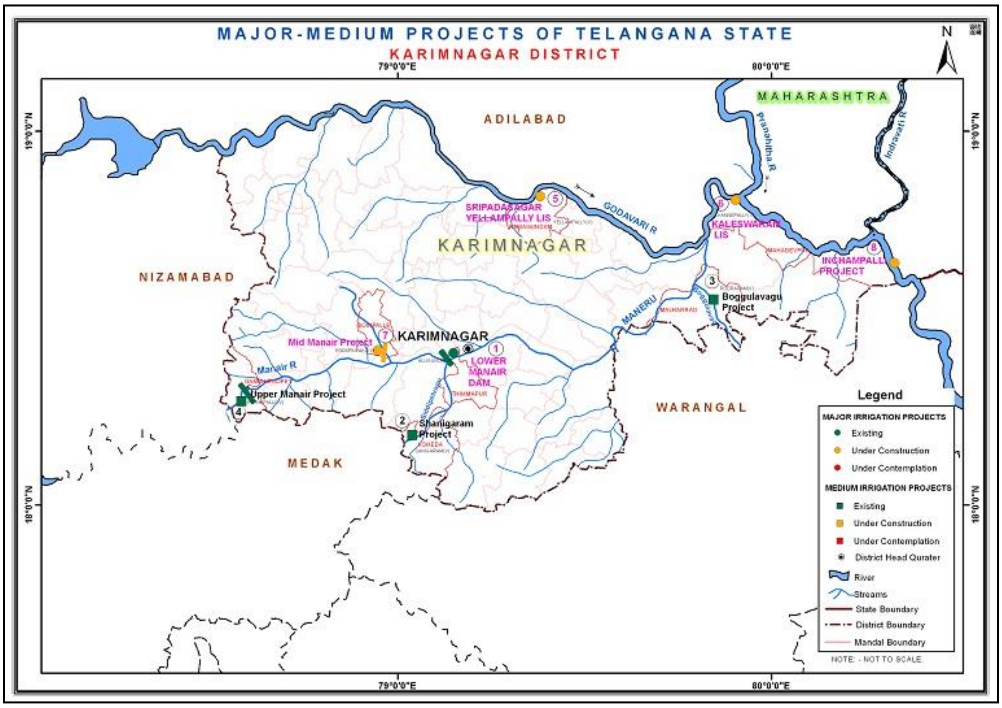


Fig. 1.8: Irrigation Projects in the erstwhile Karimnagar district.

Table-1.1: Salient features of Irrigation Rajanna Sircilla district (2020-21).

Source of Irrigation	**Kharif**	**%**	**Rabi**	**%**	**Total**	**%**
2020-21	**(Ha)**		**(Ha)**		**(Ha)**	
• Bore wells	41211		42297		83508	
• Dug wells	23426		19782		43208	
Total Ground water	**64637**	**99**	**62079**	**89**	**126716**	94
• Canals	0		2257		2257	
• Tanks	321		5050		5371	
• Lift	0		0		0	
Total Surface water	**321**	**1**	**7307**	**11**	**7628**	**6**
Gross Total Area	**64958**		**69386**		**134344**	

1.11 Prevailing Water Conservation/Recharge Practices

In the district, there are 592 artificial recharge structures (PT's: 300 and CD's: 292) are existing with combine storage capacity of 15 MCM. Under Mission Kakatiya (Phase-1 to 4), out of 2074 minor irrigation tanks, 753 tanks are desilted.

1.12 Geology

The area is underlain by various geological formation from the oldest Archaean rocks to upper cretaceous to lower Eocene age. About 93% of the area is underlain by Gneisses and Granite (4%) of Archaean age and Basalt (3%) of Upper creatoceous to lower Eocene age. (Fig.1.9).

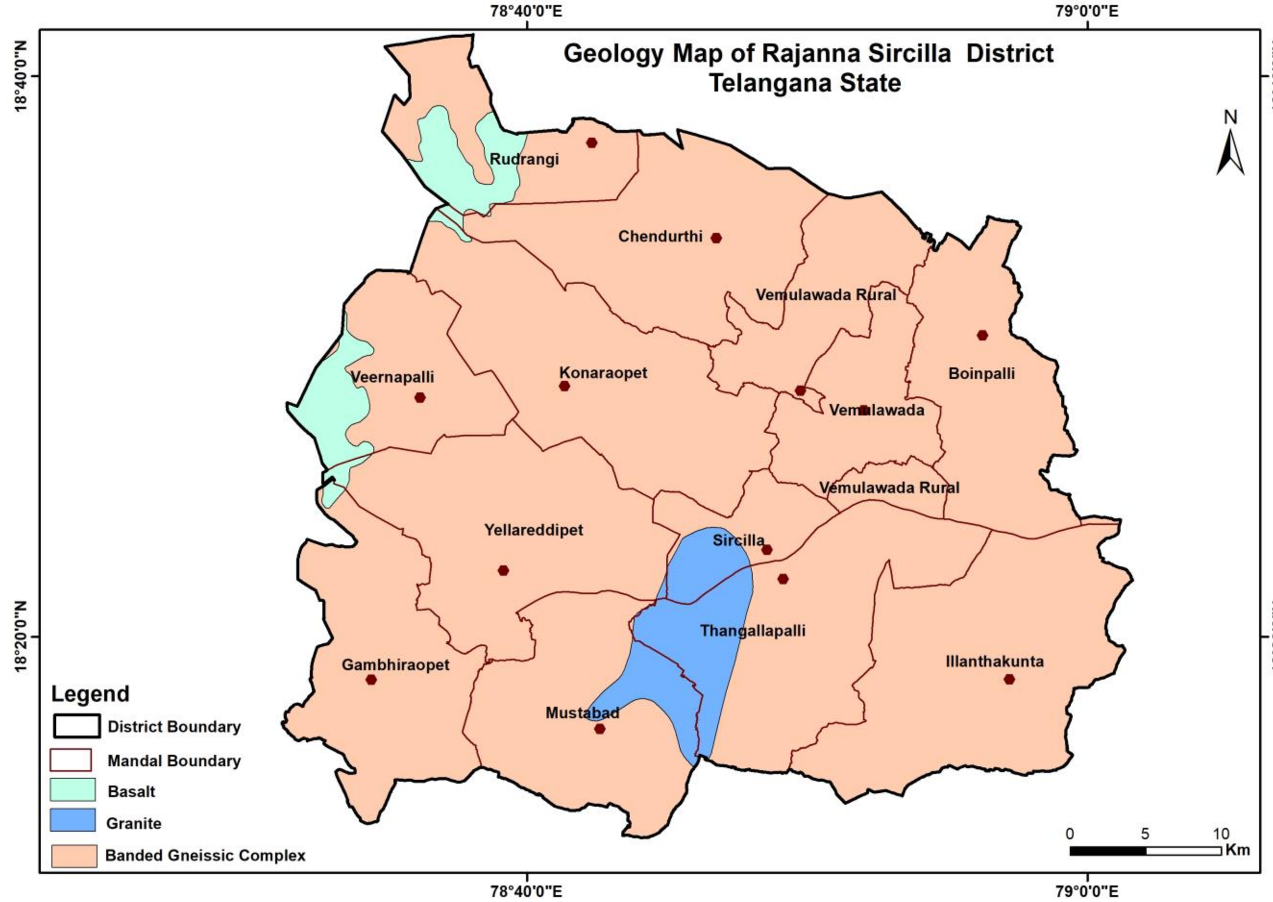


Fig. 1.9: Geology map.

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 of groundwater occurring in the subsurface in relation to the geological environment. It is broadly governed by geological frameworks i.e., nature of rock formations including their porosity (primary and secondary) and permeability. The principal aquifer in the area is Gneisses, Granite and Basalt 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 various hydrogeological data points collected through exploration, well inventory, VES, quality and other relevant data collected from state line departments, the hydrogeological map is prepared (Fig. 2.1 and 2.2).

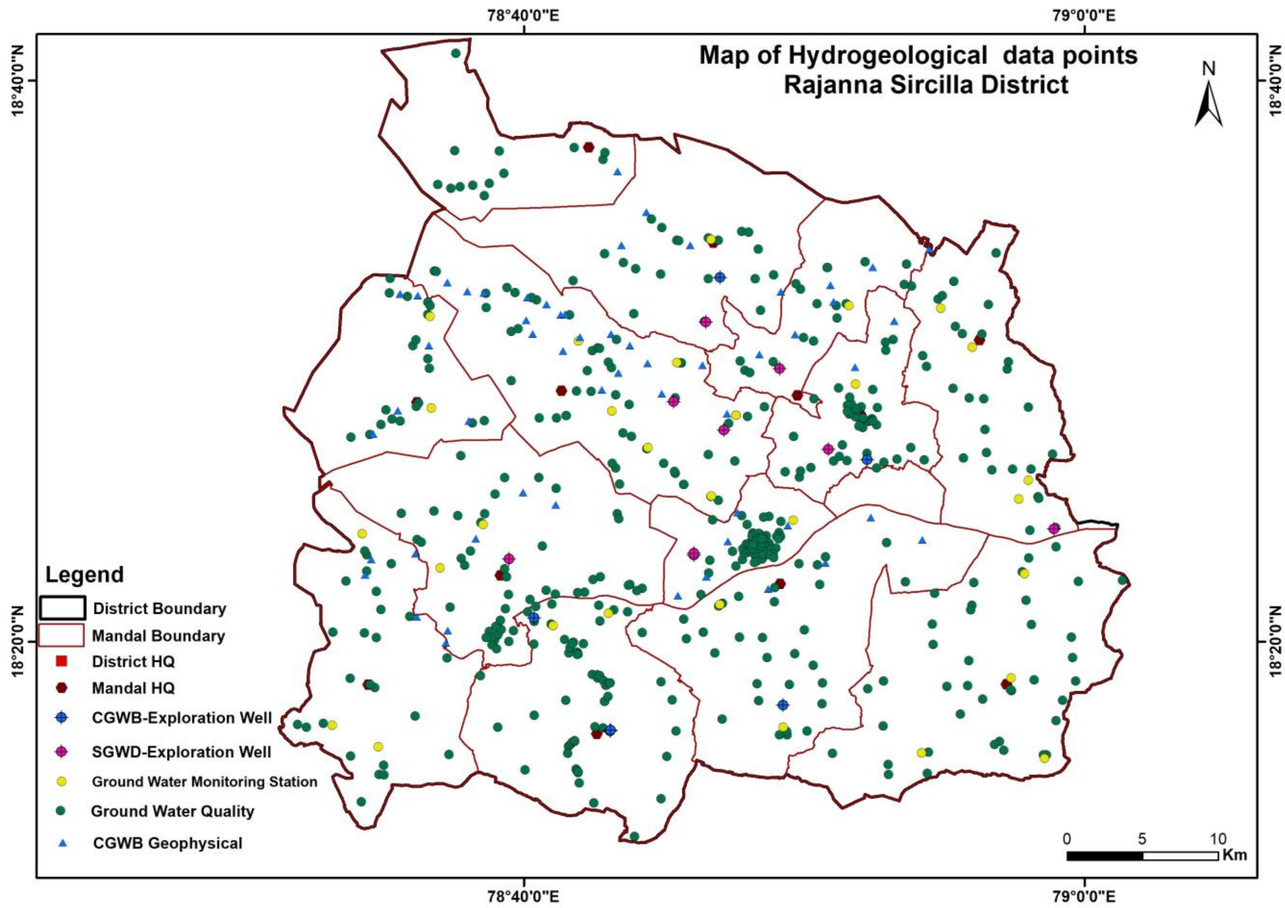


Fig. 2.1: Hydrogeologcal data availibity map.

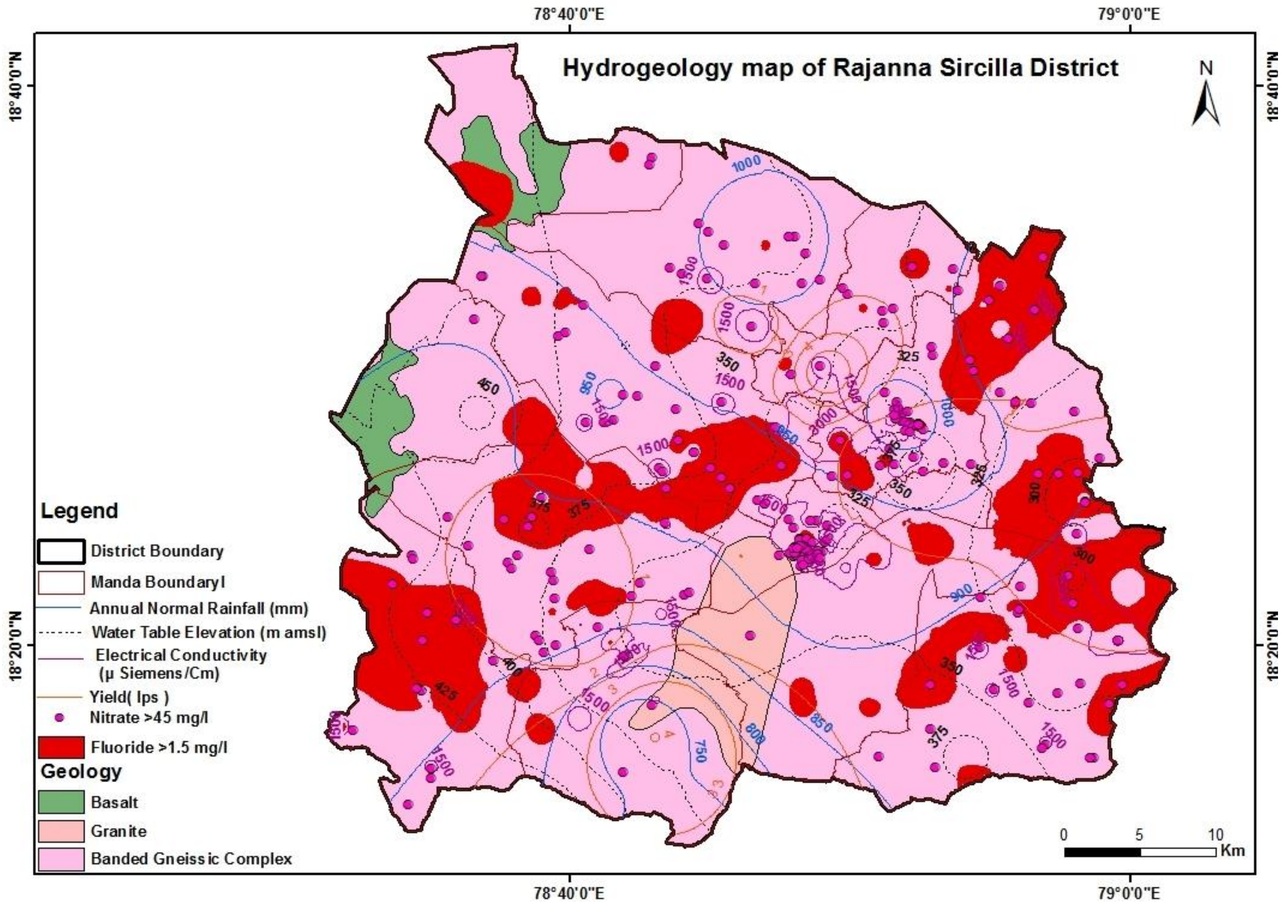


Fig. 2.2: Hydrogeology map.

2.1.1 Ground water occurrence and movement

Ground water occurs under unconfined and semi-confined conditions in the weathered zone into the fracture zone. The main aquifers constitute the weathered zone at the top, followed by a discrete anisotropic fractured/fissured zone at the bottom, generally extending down to the depth of 150 m bgl. The storage in gneissic formation is primarily confined to the weathered zone and its over-exploitation has resulted in desaturation at many places and reduced recharge to the underlying fractures. Presently, the extraction of groundwater is mainly through bore wells. The sustainability of the bore wells is dependent on the water availability in the weathered zone.

2.1.2 Exploratory Drilling

CGWB drilled 06 bore wells (exploratory, observation, piezometers) and SGWD drilled 09 wells (piezometers) in the district. The depth drilled varies from 23 to 200 m bgl and weathering varies from 7 to 35 m bgl. The data analysed from the exploratory wells indicates 27% of the wells are shallow wells that are drilled up to a depth of <30 m bgl, 40% of the wells between the depth of 30-60 m bgl, 13% of the wells drilled between the depth range of 60 to 100 m bgl, 20% of the wells drilled between the depth of 150 to 200 m bgl. The deeper wells of >150 m bgl are located in Mustabad mandal. Further, the study reveal that majority of fractures (79%) occur within 100 m depth. The deepest fractures of >100 m bgl is noticed in Mustabad, Konaraopeta, Sircilla, Vemulawada mandals.

2.2 Decadal Average Depth to Water Level (DTWL) (Average of 10 years: 2011 to 2020)

To study the behaviour of ground water in time and space, the wells were established and monitored at different places of the district by CGWB and State Ground Water Department (SGWD). These data were utilized for preparation of depth to water level maps. From the data, it is revealed that the depth to water level in the district varies from 5.41 to 33.65 m bgl (average: 14.97 m bgl) and 2.25 to 18.24 m bgl (average: 9.62 m bgl) during pre-monsoon (May) and post-monsoon (November) seasons respectively.

2.2.1 Water Table Elevations (m amsl)

During pre and post-monsoon season, water-table elevation ranges from 294.87 to 456.34 and 298.79 to 475.13 m amsl respectively. The general ground water flow is towards SW-NE and NW-SE (Fig.2.3).

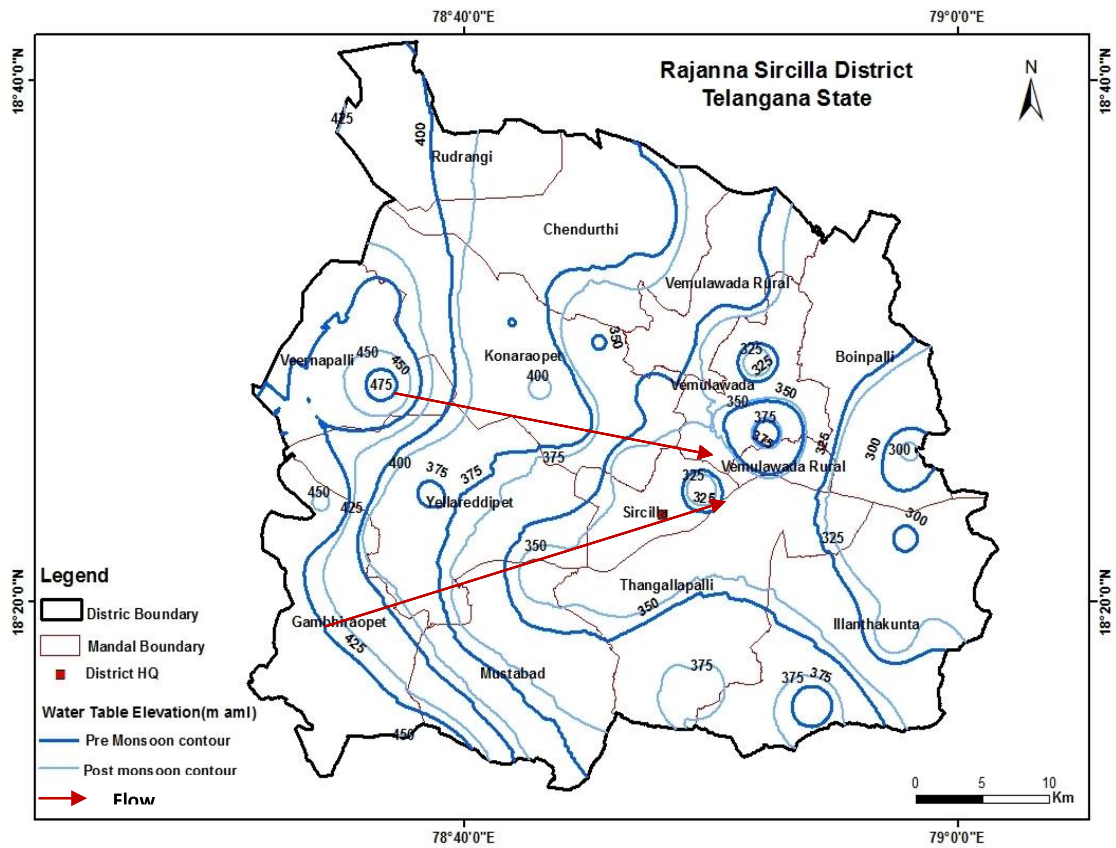


Fig. 2.3: Water table elevation (m amsl) map.

2.2.2 Depth to Water levels- Pre-monsoon Season

Majority of the water levels during this season are in the range of 10 to 20 m bgl and represented by 72% of the wells that are located in Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Rudrangi, Sircilla, Thangallapalli, Veernapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals followed by water levels of >20 m bgl (13% of the wells) noticed from Gambhiraopet, Illanthakunta, Mustabad, Rudrangi, Veernapalli, Vemulawada, Yellareddipet mandals. The water levels in the range of 5 to 10 m bgl is noticed in 16% of the wells falling in Boinpalli, Chendurthi, Illanthakunta,Sircilla, Vemulawada and Vemulawada Rural mandals**. (Fig. 2.4).**

2.2.3 Depth to water Level- Post-monsoon Season

The majority of the water levels during this season are in the range of 5 to 10 m bgl and noticed in 53% of the wells located in Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Rudrangi, Sircilla, Thangallapalli, Veernapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals followed by water levels from 10 to 20 m bgl distributed in 41% of the wells falling in Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Rudrangi, Sircilla, Thangallapalli, Veernapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals. The shallow water levels of <5 m bgl (06% of the wells) is observed in Sircilla, Illanthakunta and Thangallapalli mandals (Fig. 2.5).

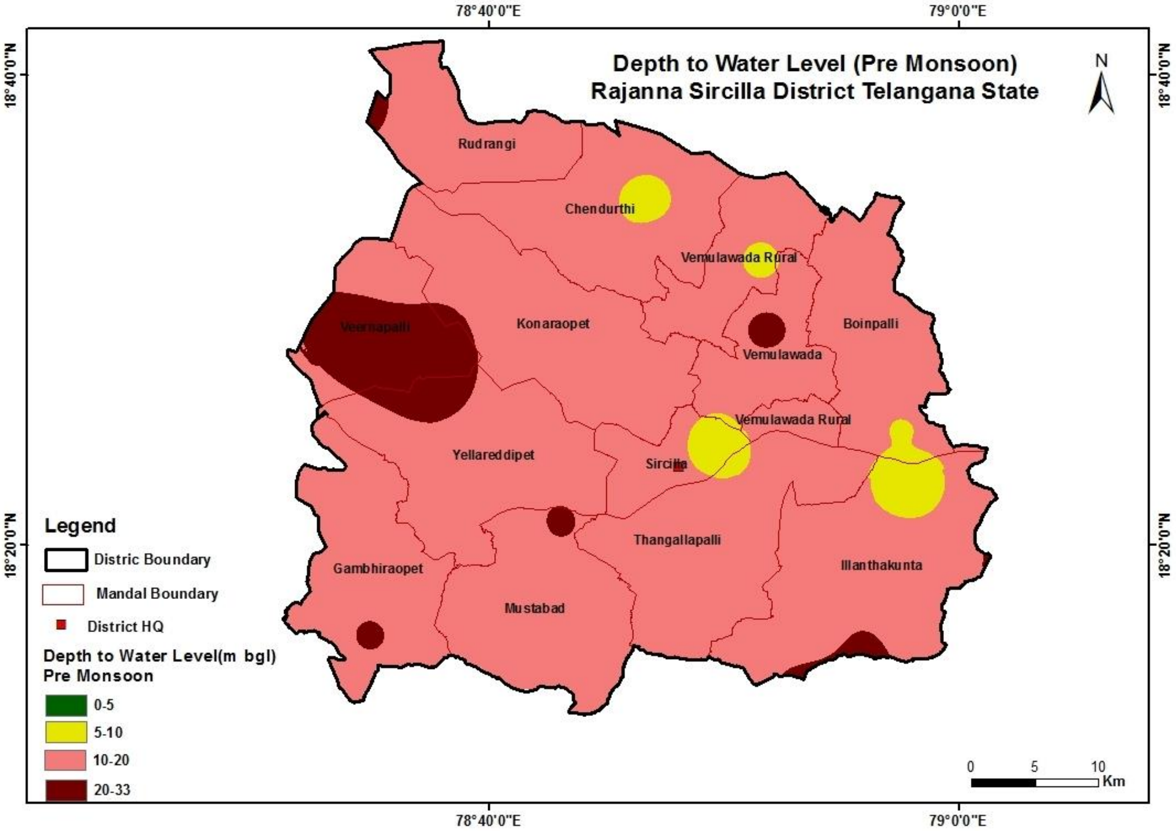


Fig 2.4: Depth to water levels Pre-monsoon (avg. of 10 years: 2011 to 2020).

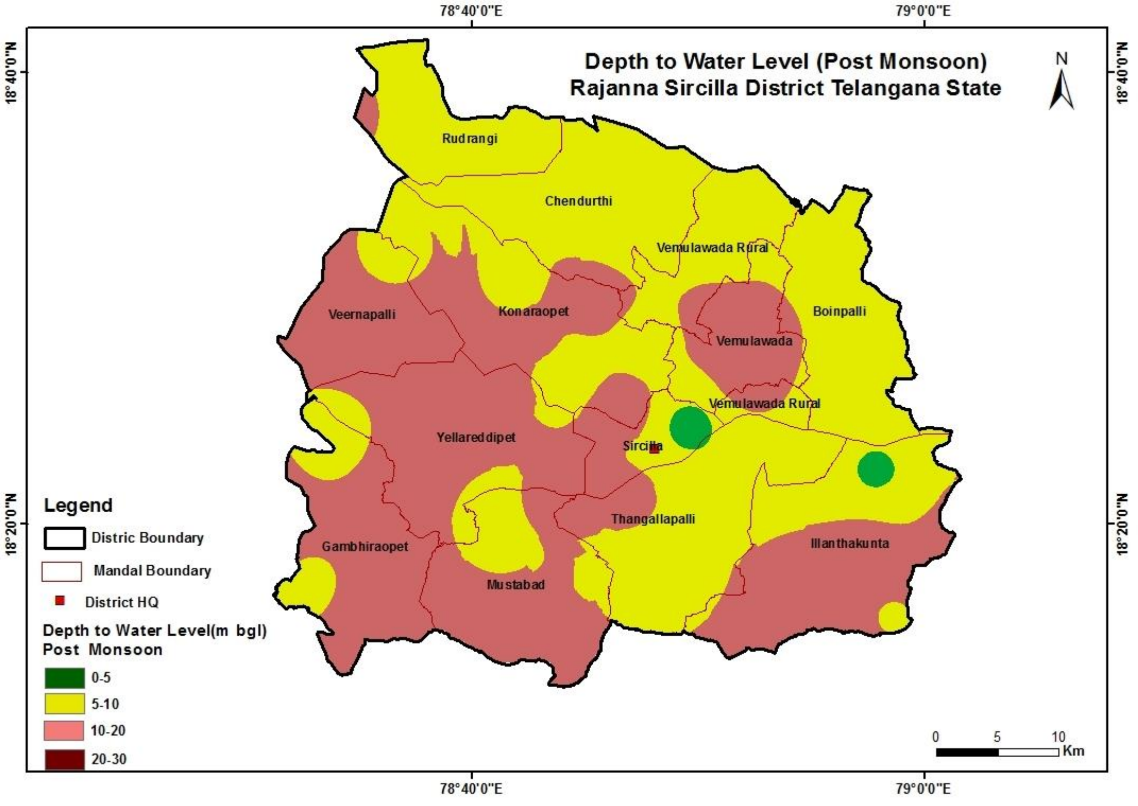


Fig.2.5: Depth to water levels Post-monsoon (avg. of 10 years: 2011 to 2020).

2.2.4 Water Level Fluctuations (November vs. May)

Almost all wells show rise in water levels in the range of 1.74 to 18.78 m (Fig. 2.5). With respect to the rising in water levels, most of the wells (50% of the wells) shows water level rise from 2 to 5 m located in Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Rudrangi, Sircilla, Thangallapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals, followed by 5 to 10 m in 41% of the wells located in Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Rudrangi, Sircilla, Thangallapalli, Veernapalli, and Yellareddipet mandals. The water level rise between 10 to 20 m (03% of thea wells) is noticed in Konaraopet,Veernapalli and Yellareddipet mandal. In Boinpalli and Illanthakunta, mandals, the water level rise of <2 m is noticed in 3% of the wells (Fig. 2.6).

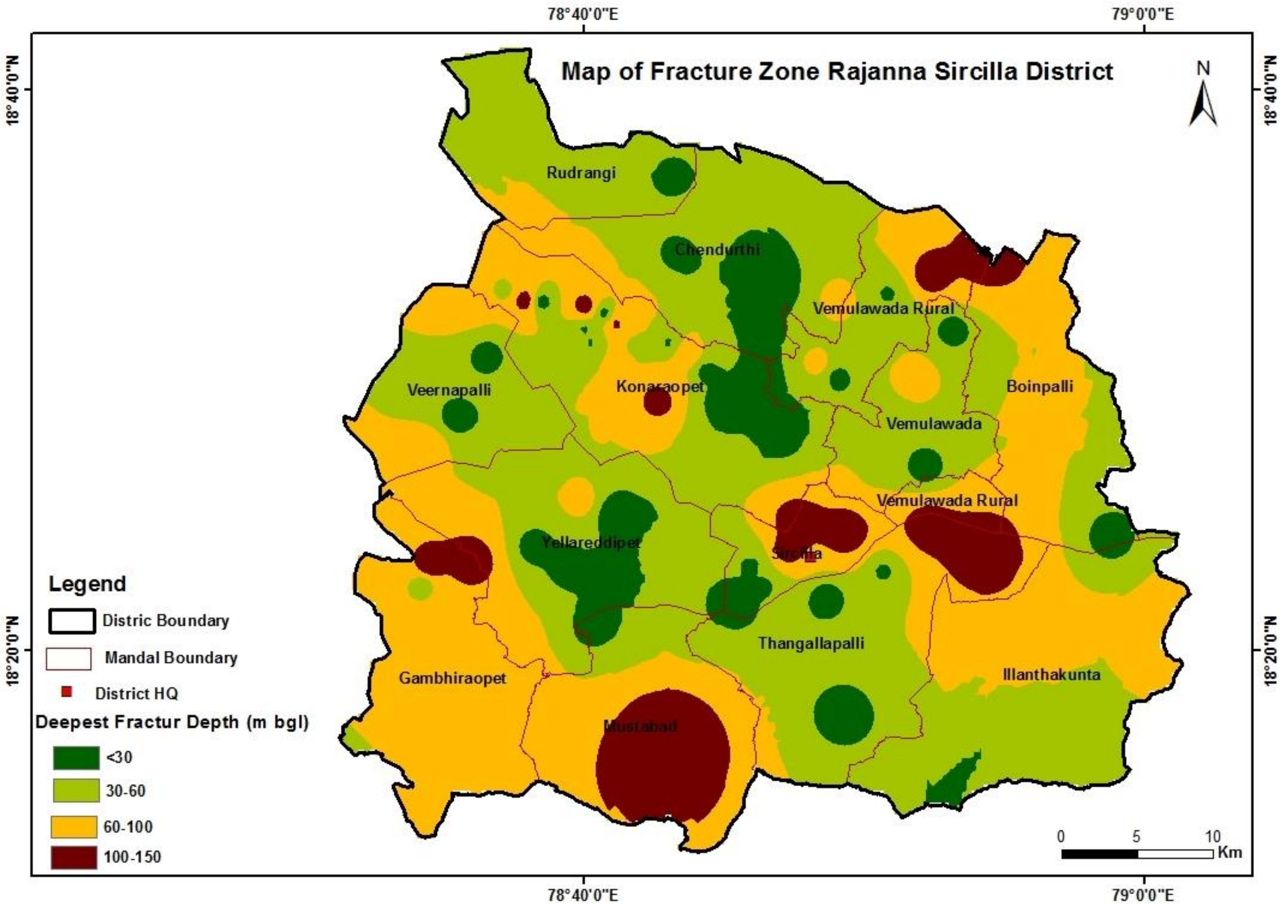


Fig. 2.6: Water Level Fluctuations (m) (Nov vs. May).

2.2.5 Long term water level trends (2011-2020)

The trend analysis for last 10 years (2010-2019) is studied from the different hydrograph stations of CGWB and SGWD. During pre-monsoon season, 55% of the wells shows rising trends ranging from 0.05 to 2.24 m/yr (Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Rudrangi, Sircilla, Thangallapalli, Veernapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals) and in remaining 45% of the wells shows falling trend in the range of -0.093 to -1.17 m/yr (Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Sircilla, Thangallapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals) (Fig. 2.7). Whereas, during post-monsoon season, 100% of the wells are showing rising trend ranging from 0.016 to 2.82m/yr which is noticed in all mandals Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Rudrangi, Sircilla, Thangallapalli, Veernapalli, Vemulawada, Vemulawada Rural and Yellareddipet(Fig. 2.8).

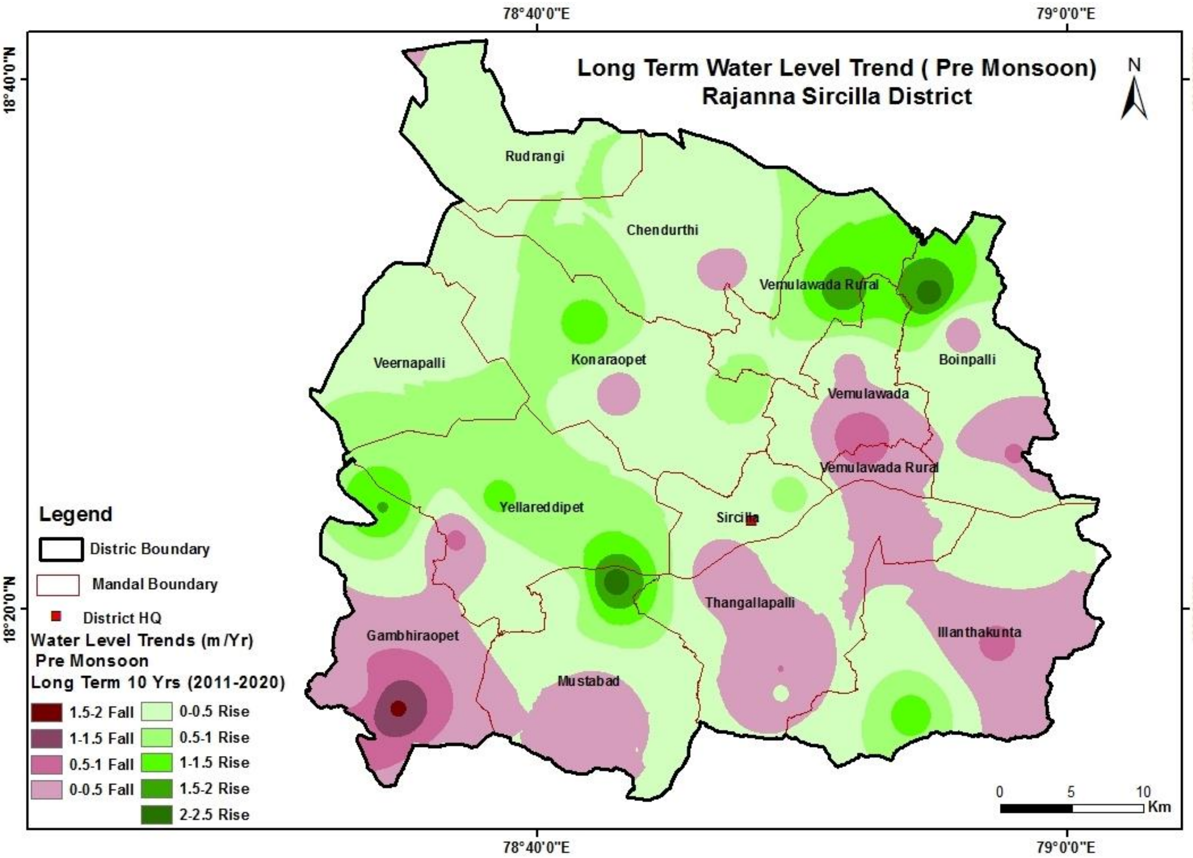


Fig. 2.7: Long-term water level trends (Pre-monsoon 2011-20).

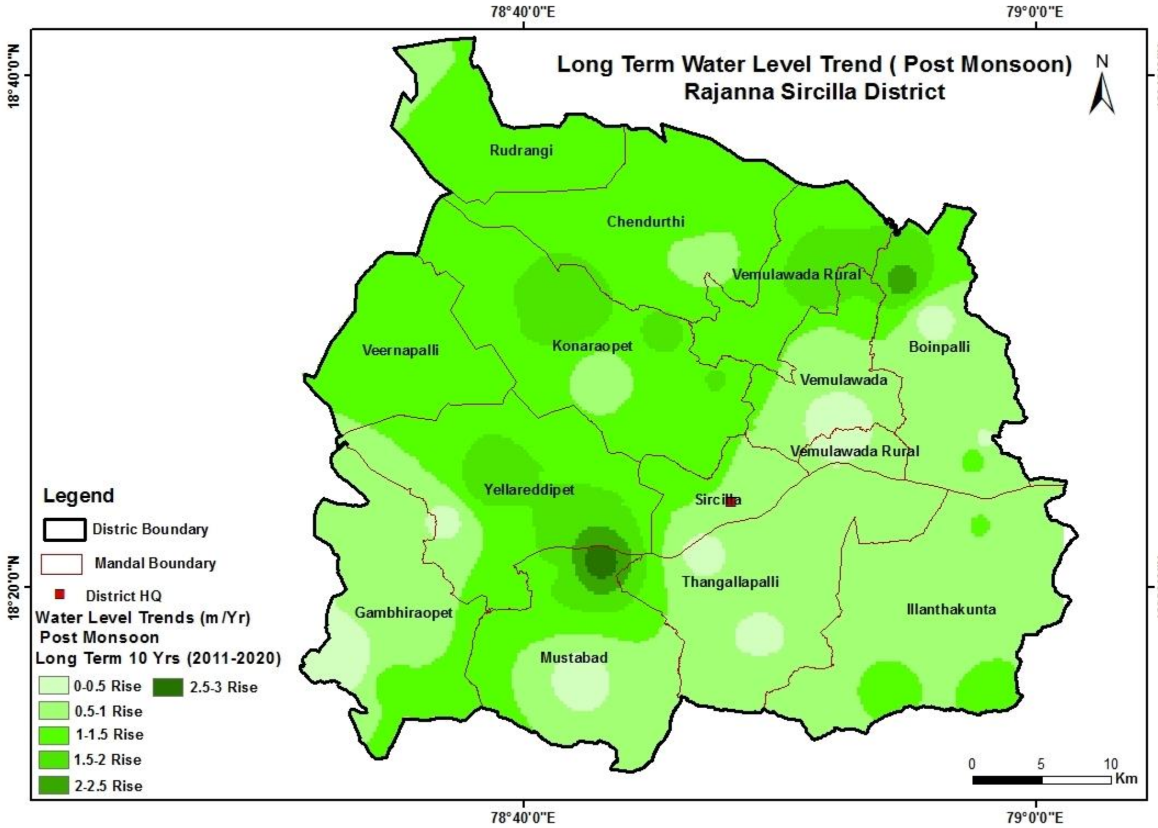


Fig. 2.8: Long-term water level trends (Post-monsoon 2011-20).

2.3 Geophysical Studies

From the analysis of VES data reveal that the resistivity is < 90 Ohm (Ω) m for the weathered granite, 90-180 Ω m for underlying semi weathered granite, between 180-350 Ω m fractured granite and > 350 Ω m for massive granite.

2.4 Hydro-chemical Studies

To understand chemical quality of groundwater, water samples in the year 2021 collected from CGWB and SGWD were utilized. Various chemical parameters namely pH, EC (in µS/cm at 25 ° C), TH, Ca, Mg, Na, K, CO_3, HCO_3, Cl, SO_4, NO_3 and F were analyzed. Out of which, five parameters namely pH, EC, TDS, NO_3 and F were interpreted for suitability for drinking purposes and is assessed as per BIS standards (2012) and irrigation suitability as per electrical conductivity.

2.4.1 Pre-monsoon 2021 (Total Samples: 457 SGWD)

Groundwater from the area is mildly alkaline in nature with pH in the range of 7.10 to 8.90 (avg. 7.70). The electrical conductivity varies from 402 to 4700 µ Siemens/cm (avg. 1126 µ Siemens/cm). In about 82% of the samples from Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Rudrangi, Sircilla, Thangallapalli, Veernapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals, the EC is within 1500 µ Siemens/cm, while in 17% of the samples from Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Sircilla, Thangallapalli, Vemulawada, Vemulawada Rural, mandals it is in the range of 1500-3000 µ Siemens/cm. In about 1% of the samples located in Mustabad, Illanthakunta, Thangallapalli, Vemulawada mandal, the EC of >3000 µ Siemens/cm is observed (Fig. 2.9). The concentration of TDS varies from 257 to 3008 mg/l (avg. 720 mg/l) and found that in 99% of samples, it falls within maximum permissible limits of BIS (<2000 mg/l) whereas in the remaining 1% of the samples, it is exceeding the permissible limit (>2000 mg/l) in Illanthakunta, Thangallapalli and Vemulawada mandals. The NO_3 concentration ranges from 0.20 to 467 mg/l and noticed that in about 54% of the samples are falling within the permissible limits of <45 mg/l and in about 46% of the samples quality is not suitable for drinking water purpose (>45 mg/l) (Fig. 2.10). The Fluoride concentration varies from 0.09 to 4.4 mg/l (avg. 1.21 mg/l) and in 76% of the samples, it is within the permissible limit of <1.5 mg/l (Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Rudrangi, Sircilla, Thangallapalli, Veernapalli, Vemulawada, Vemulawada Rural, Yellareddipetmandals) and in remaining 24% of the samples, it is beyond permissible limit of >1.5 mg/l (Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Rudrangi, Sircilla, Thangallapalli, Veernapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals) and not suitable for drinking water purpose (Fig. 2.11).

2.4.2 Post-monsoon 2021 (Total Samples: 464 SGWD)

Groundwater from the area is mildly alkaline in nature with pH in the range of 7.06 to 9.1 (avg. 7.72). The electrical conductivity varies from 310 to 2624 µ Siemens/cm (avg. 1059 µ Siemens/cm). In 85% of the samples from all mandals, the EC is within 1500 µ Siemens/cm while in 15% of the samples from Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Sircilla, Thangallapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals, it is in the range of 1500-3000 µ Siemens/cm. In none of the samples, the EC >3000 µ Siemens/cm is observed (Fig. 2.11). The concentration of TDS varies from 198 to 1679 mg/l (avg. 678 mg/l). In all the samples from Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Rudrangi, Sircilla, Thangallapalli, Veernapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals it is within the maximum permissible limits of BIS (<2000 mg/l). The NO3 concentration ranges from 0.40 to 298 mg/l with an average of 54.52 mg/l. It is noticed that in about 52% of the samples from Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Rudrangi, Sircilla, Thangallapalli, Veernapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals it is within the permissible limit (<45 mg/l) while in 48% of the samples from Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Rudrangi, Sircilla, Thangallapalli, Veernapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals, it is beyond the permissible limit (>45 mg/l) and not suitable for drinking water purpose (Fig. 2.13). The Fluoride concentration varies from 0.05 to 4.34 mg/l with an average of 1.10 mg/l. In about 80% of the samples, it is falling within permissible limit of <1.5 mg/l (Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Rudrangi, Sircilla, Thangallapalli, Veernapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals) while in 20% of the samples from Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Sircilla, Thangallapalli, Veernapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals are having high fluoride concentration beyond permissible limits (>1.5 mg/l) and are not suitable for drinking water purpose (Fig. 2.14).

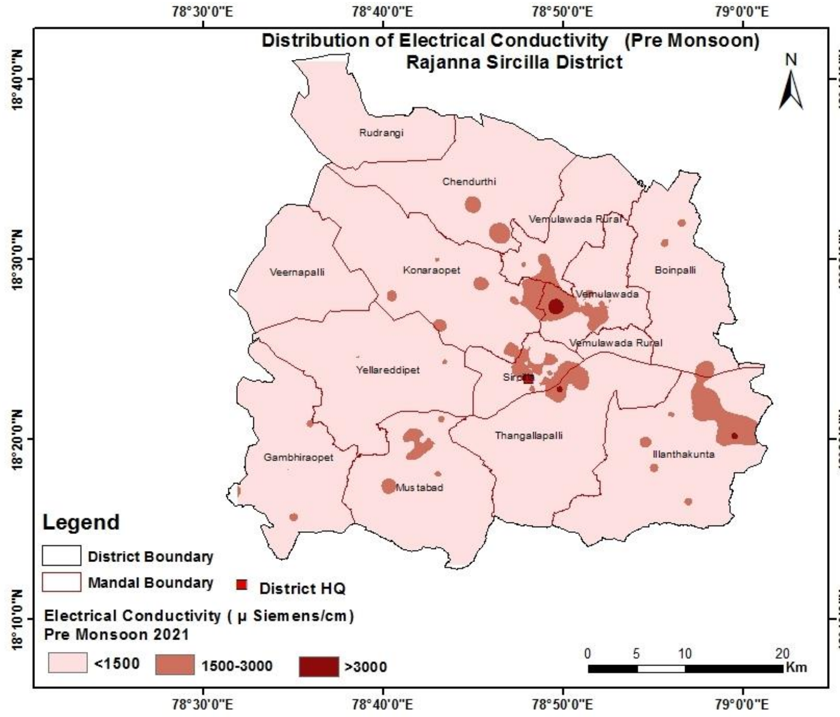


Fig.2.9: Distribution of Electrical conductivity (Pre-monsoon 2021).

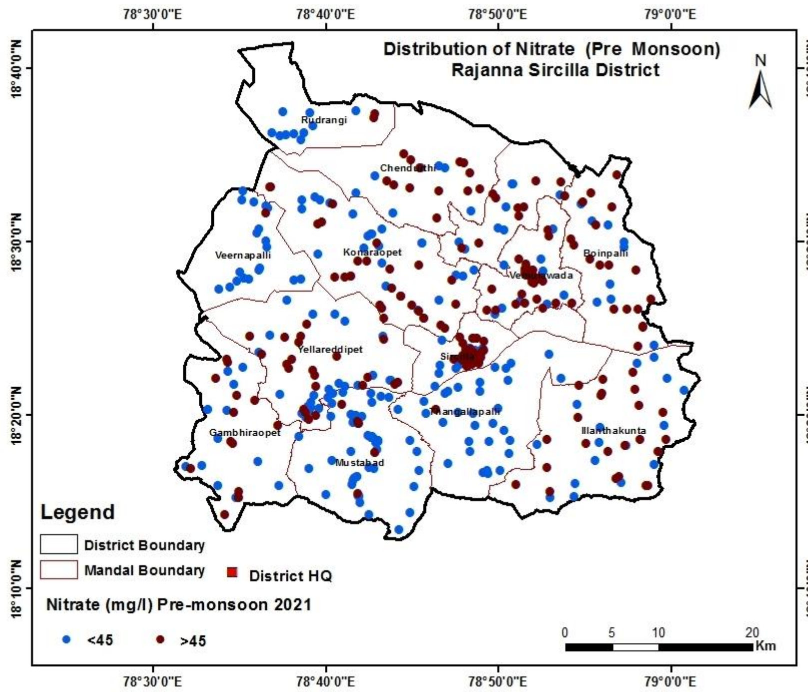


Fig. 2.10: Distribution of Nitrate (Pre-monsoon 2021).

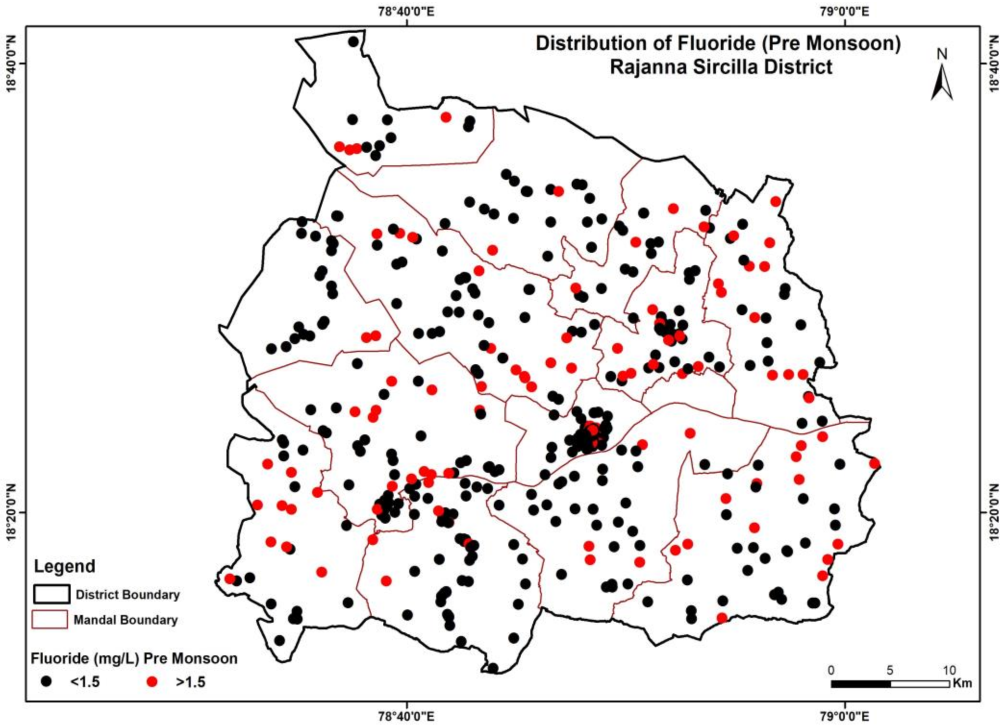


Fig. 2.11: Distribution of Fluoride (Pre-monsoon 2021).

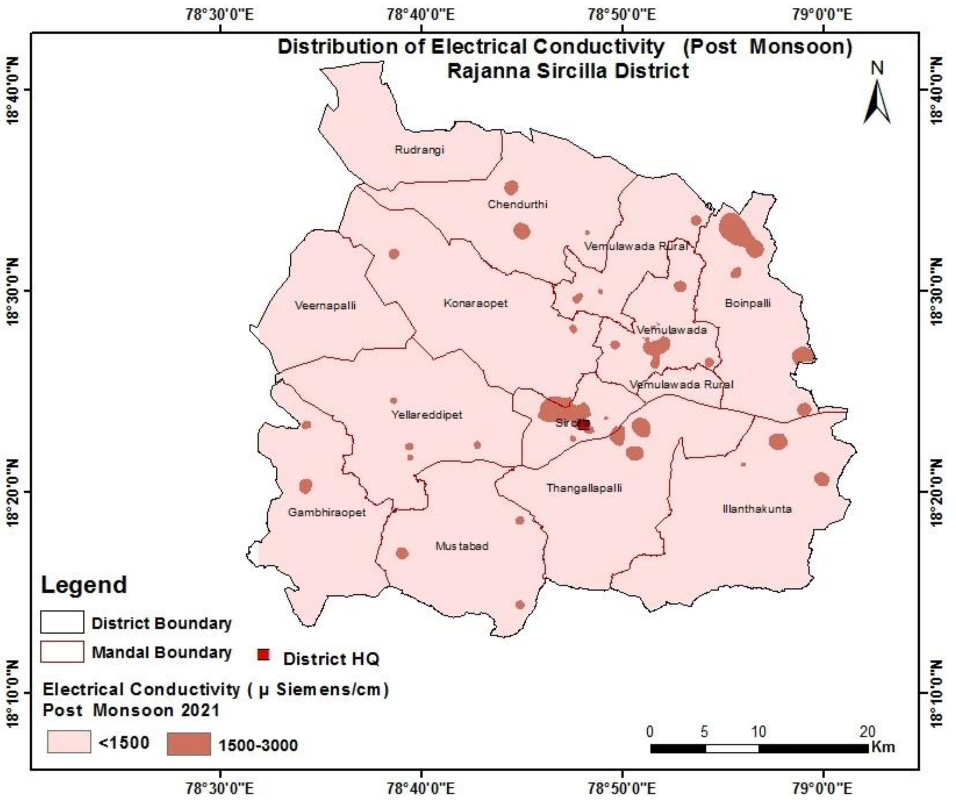


Fig.2.12: Distribution of Electrical conductivity (Post-monsoon 2021).

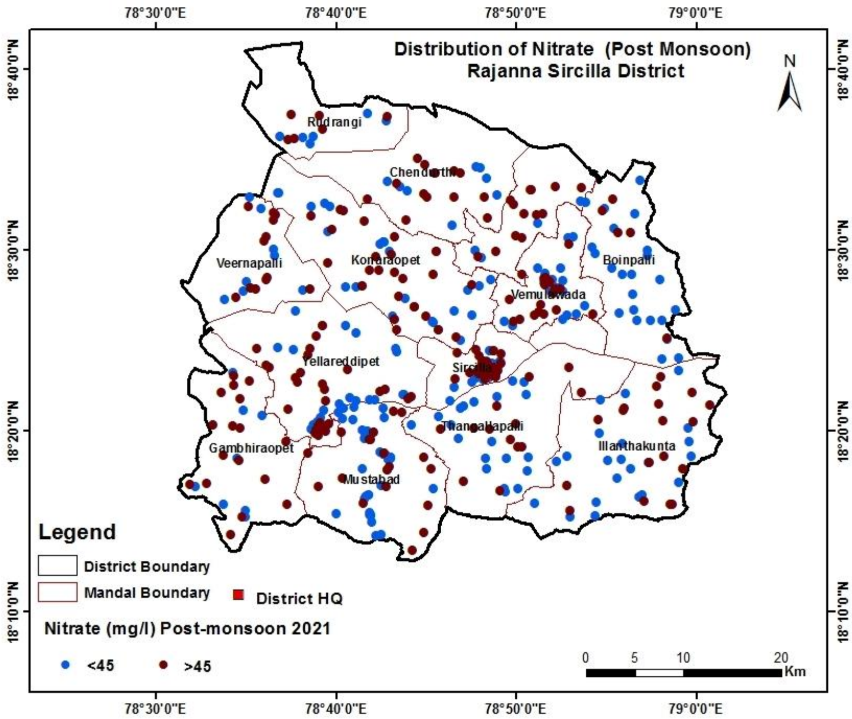


Fig.2.13: Distribution of Nitrate (Post-monsoon 2021).

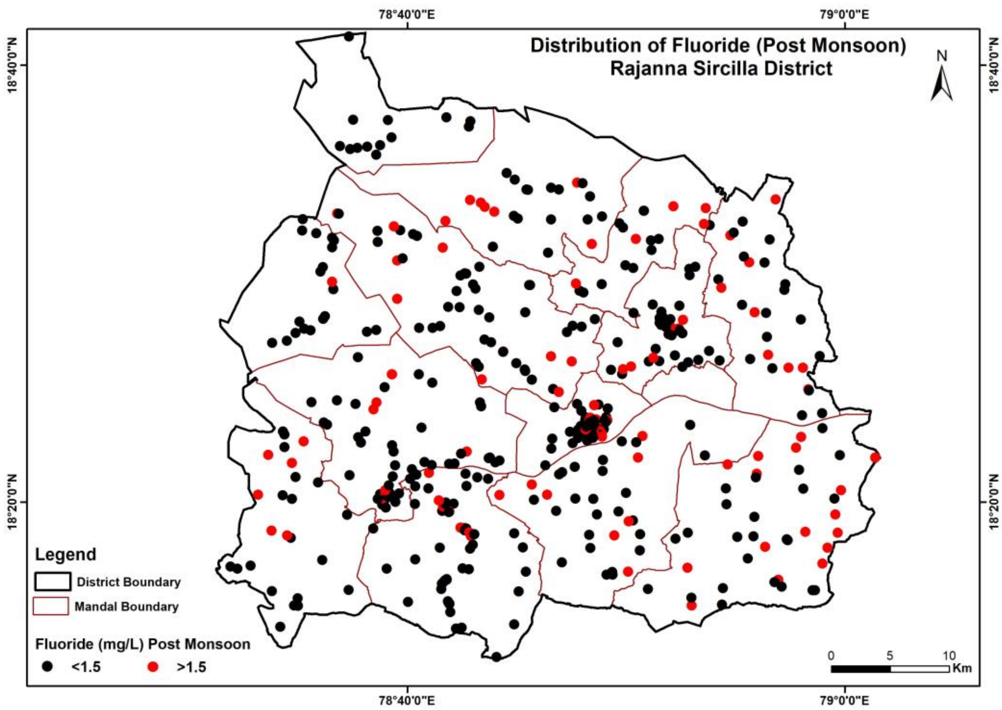


Fig. 2.14: Distribution of Fluoride (Post-monsoon 2021).

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

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

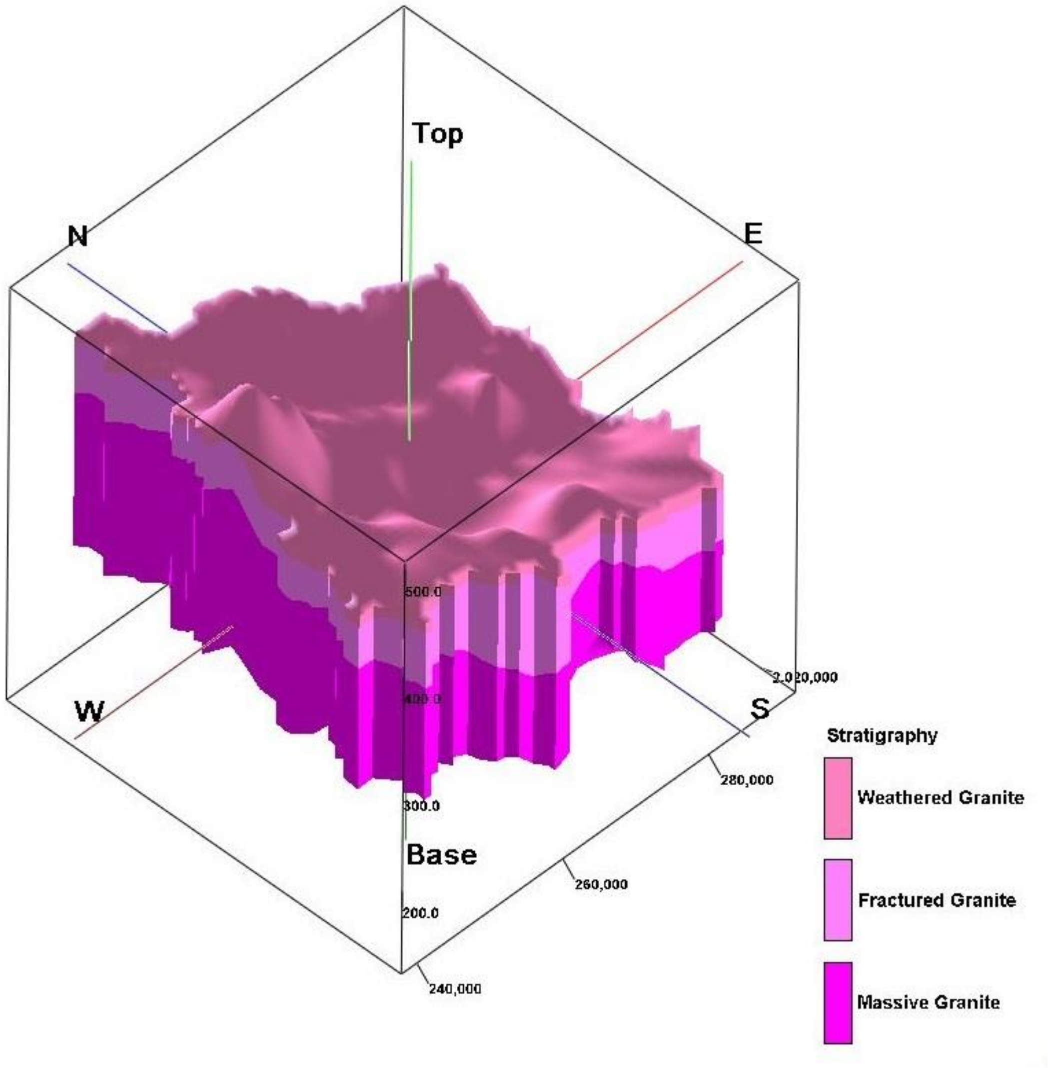


Fig. 3.1: 3D Model.

3.1 Conceptualization of aquifer system in 3D

Aquifers were characterized in terms of their potential and quality based on integrated hydrogeological data and various thematic maps. The depth of investigation carried out was up to 200 m bgl. The weathered zone ranges from 3 to 35 m bgl. The weathering >20 m bgl is observed in Chendurthi, Konaraopet, Sircilla, Vemulawada, Vemulawada Rural, mandals. The fractured zone ranges from 6 to 145 m bgl with the yield ranging from <1 to 5.4 lps with an average of 1.5 lps. About 79% of the fractures were encountered within 100 m bgl depth noticed in Boinpalli, Chendurthi, Gambhiraopet, Konaraopet, Mustabad, Sircilla, Vemulawada, Vemulawada Rural, and Yellareddipet. The deeper fractures beyond 100 m bgl (22%) are encountered in Konaraopet, Mustabad, Sircilla and Vemulawada mandals.

3.2 Hydrogeological Sections

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

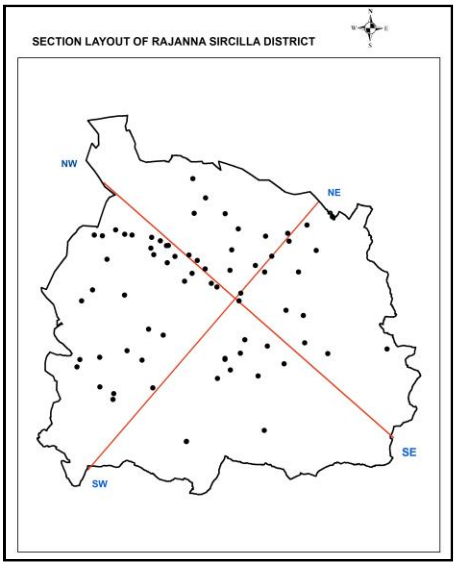


Fig: 3.2 Map showing orientataion of Hydro geological sections

3.2.1 NE-SW Section (a)

The section drawn along the NE-SW direction covering distance of ~53 kms. It depicts uniform weathered zone throughout the section. The thickness of fractured zone is more between 0-4 km,8-13 km and 38-53 kms stretch of the section (Fig. 3.3a).

3.2.2 NW-SE Section (b)

The section drawn along the NW-SE direction covered a distance of ~48 kms. It depicts a uniform weathered zone. The thick fractured zone is noticed between the distances of 26 to 34 kms stretch of the section (Fig. 3.3b).

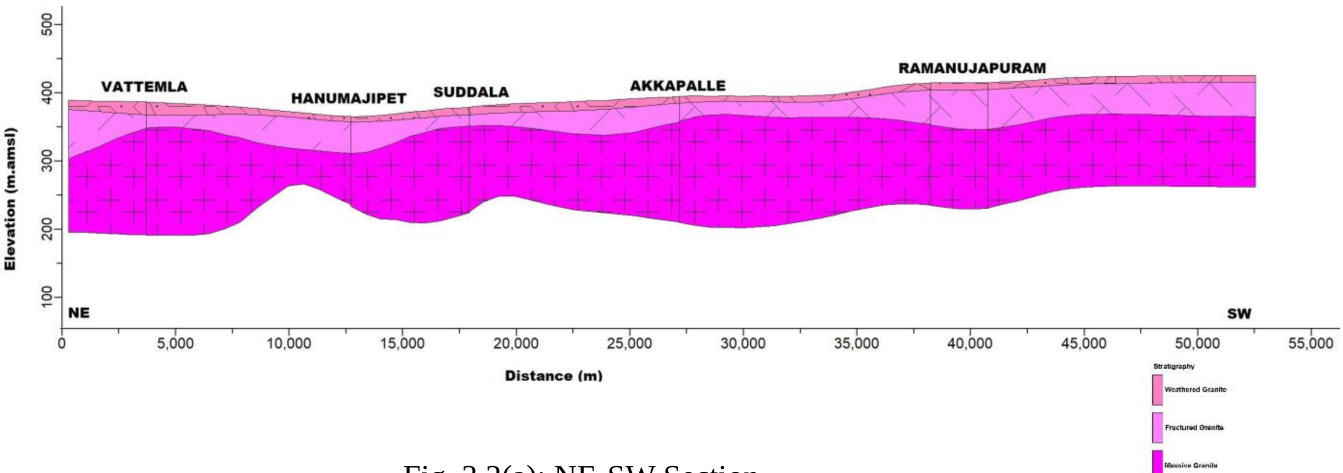


Fig. 3.2(a): NE-SW Section.

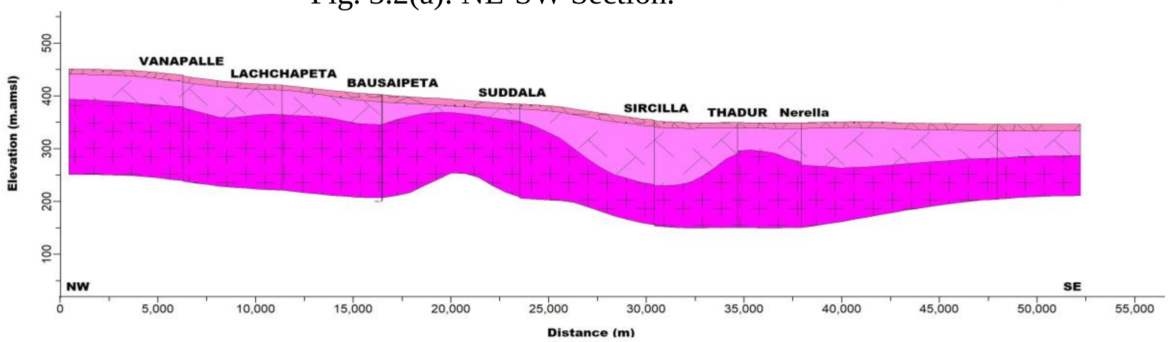


Fig. 3.2(b): NW-SE Section.

Fig.3.2 (a-b): Hydrogeological sections along different directions.

3.3 Aquifer Characterization

3.3.1 Weathered zone

The weathered zone thickness is more over the gneissic formation. The dug wells, which were in operational earlier, have gradually becoming dry and defunct due to over-exploitation particularly during pre-monsoon season. The depth of weathering ranging from 3 to 35 m bgl. In majority of the district (68% of the area), the depth of weathering is between 10 to 20 m bgl and is mostly observed in Boinpalli, Chendurthi, Illanthakunta, Konaraopet, Mustabad, Rudrangi, Sircilla, Thangallapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals, while the depth of weathering ranging from <10 m bgl (31% of the area) is observed in Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Konaraopet, Mustabad, Rudrangi, Veernapalli, Vemulawada, Vemulawada Rural, Yellareddipet mandals. The weathering depth >20 m bgl (01 of the area) is noticed in Chendurthi, Konaraopet, Sircilla, Vemulawada, Vemulawada Rural, Yellareddipet mandals (Fig.3.3 and Fig.3.4).

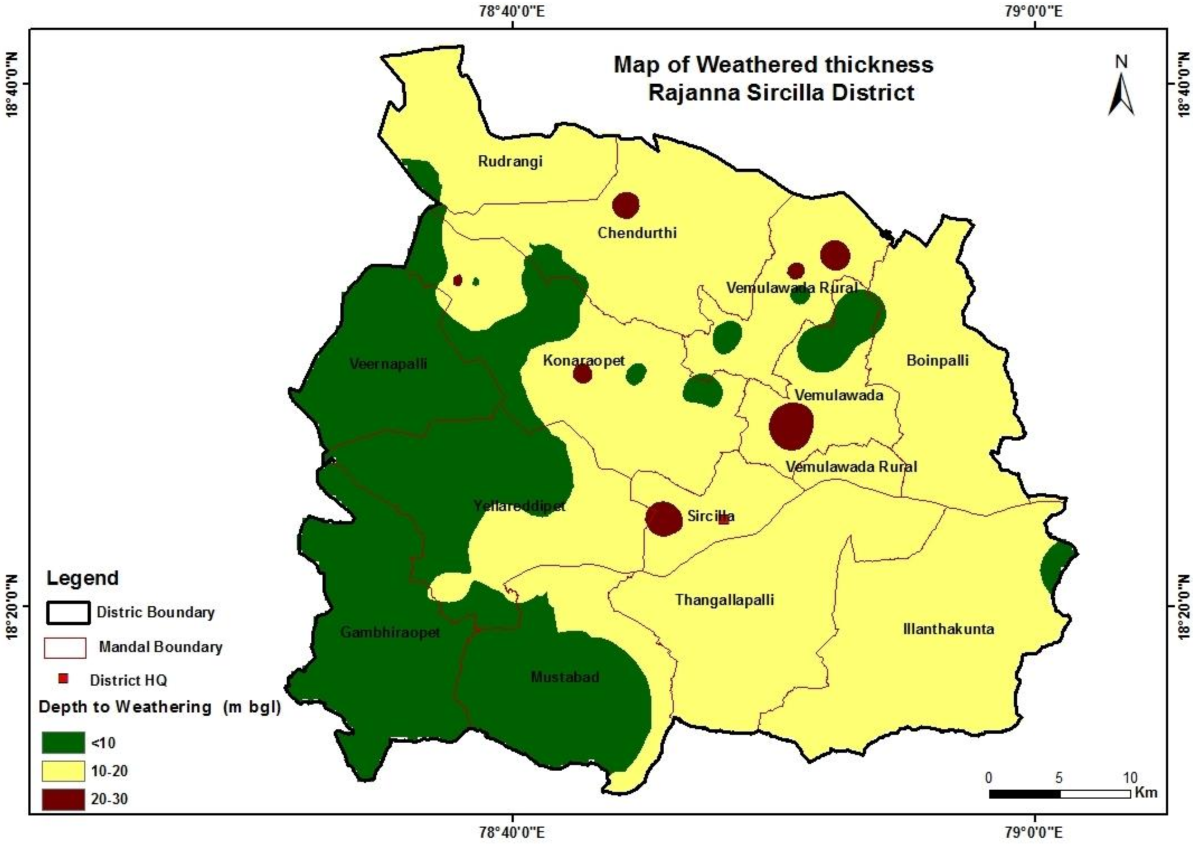


Fig.3.3: Thickness of Weathered zone.

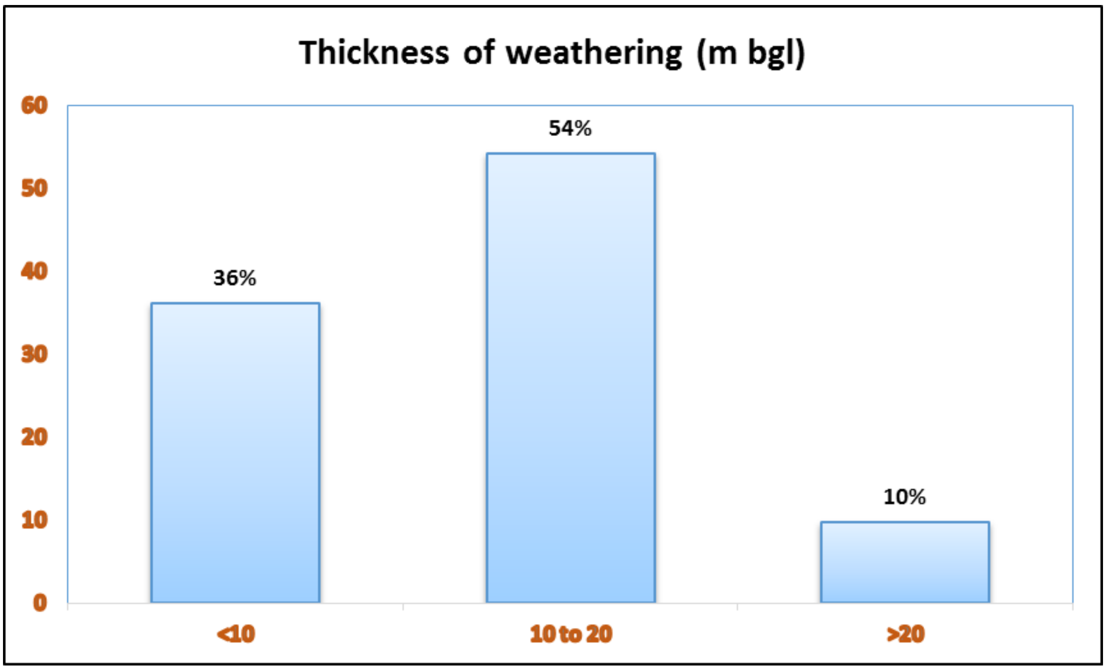


Fig.3.4: Depth wise distribution of weathering zone.

3.3.2 Fractured zone

Groundwater is extracted mainly through bore wells tapping fractured zone to the depth 200 m bgl. Based on CGWB and SGWD exploration data, it is inferred that 47% of the fractures occur within 30 m bgl with yield ranging from 0.01 to 5.0lps observed at Boinpalli, Chendurthi, Konaraopet, Mustabad, Sircilla, Vemulawada Rural and Yellareddipet mandals. About 13% of the fractures occur within depth range of 30 to 60 m bgl with yields varying from 0.01 to 5.0 lps and are observed at Chendurthi, Gambhiraopet, Konaraopet, Sircilla, Vemulawada and Yellareddipeta mandals. About 19% of the fractures occurring within the depth range of 60 to 100 m bgl with yield varying from 0.01 to 5.40 lps (Gambhiraopet, Konaraopet, Vemulawada, Vemulawada Rural and Yellareddipet mandals) (Fig. 3.6). About 21% of the fractures have occurred beyond 100 m bgl with yield varying 0.01 to 5.40 lps (Konaraopet, Sircilla, Vemulawada and Mustabad mandals). The deepest fracture tapped at the depth of 145 m bgl is observed in Mustabad mandal. Over all, the yield varies from 0.01 to 5.40 lps in the terrain with an average of 1.5 lps. The transmissivity varies from 12 to 24 m^2/day. The storativity varies up to 0.0001. From the fracture analysis, it is revealed that the area most potential fractres were noticed within 100 m bgl.

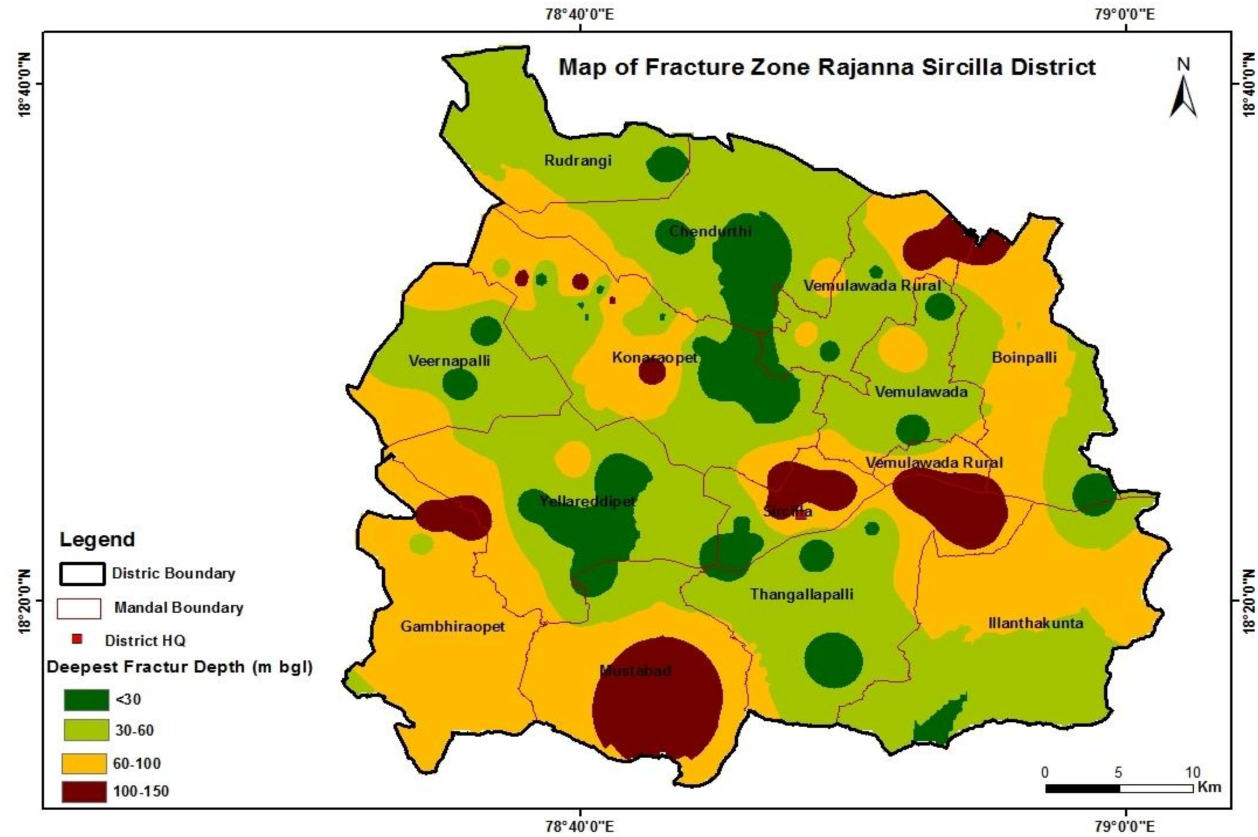


Fig.3.5: Depth of Fractured zone.

4. GROUND WATER RESOURCES (2020)

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 2015 methodology (Table 4.1).

As per GEC 2020 report, the net dynamic replenishable ground water availability for newly formed Rajanna Sircilla district is 328 MCM, gross ground water extraction for all uses 261 MCM, provision for drinking and industrial use for the year 2025 is 18 MCM and net annual ground water potential available for future irrigation needs is 57 MCM.

Out of 13 mandals, 02 mandals are falling under Safe (Boinpalli (69%), Vemulawada Rural (69%)) and 09 mandals falling under Semi-Critical (Chendurthi (73%), Illanthakunta (83%), Konaraopet (78%), Rudrangi (80%), Sircilla (73%), Thangallapalli (79%), Veernapalli (75%), Vemulawada (72%) and Yellareddipet (85%)) and the remaining remaining 2 mandals falling under Critical catetory (Gambhiraopet (91%) and Mustabad (96%)). The overall average stage of ground water extraction in the district is 79%.

Table 4.1: Computed dynamic ground water resources.

Parameters	Resources (GEC 2020) in MCM
Dynamic (Net GWR Availability)	328
• Monsoon recharge from rainfall	143
• Monsoon recharge from other sources	67
• Non-Monsoon recharge from rainfall	21
• Non-monsoon recharge from other sources	115
• Natural Discharge	17
Gross Recharge	345
Gross GW Draft	261
• Irrigation	254
• Domestic and Industrial use	07
Provision for Drinking and Industrial use for the year 2025	18
Net GW availability for future irrigation	57
Average Stage of GW extraction (%)	79
Categorization of mandals	**Safe: 02, Semi-Critical: 09 and Critical:02** **Safe:** Boinpalli (69%), Vemulawada Rural (69%) **Semi-Critical:** Chendurthi (73%), Illanthakunta (83%), Konaraopet (78%), Rudrangi (80%), Sircilla (73%), Thangallapalli (79%), Veernapalli (75%), Vemulawada (72%) and Yellareddipet (85%) **Critical:** Gambhiraopet (91%) and Mustabad (96%)

5. GROUND WATER RELATED ISSUES AND REASONS FOR ISSUES

5.1 Issues

Pollution (Geogenic and Anthropogenic)

- Few mandals are fluorosis endemic where fluoride (geogenic) in ground water is as high as 4.40 mg/l during pre-monsoon and 4.30 mg/l during post-monsoon season. The high fluoride concentration (>1.5 mg/l) occur in 24% of samples and 20% of samples during pre and post-monsoon season respectively.
- High nitrate (>45 mg/l) due to anthropogenic activities is observed in 46% of the samples and 48% of the samples during pre and post-monsoon season respectively.

Sustainability

- Low yield (<1 lps) occurs in >50% of the exploratory wells covering in Boinpalli, Chendurthi, Gambhiraopet, Illanthakunta, Mustabad, Sircilla, Vemulawada, Yellareddipet mandals. 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 critical, semi critical and other areas also and people are buying bottled water from the market for drinking purposes.

5.2 Reasons

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.

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 beyond weathered zone are very limited in extent, as the compression in the rock reduces the opening of fractures at depth and the majority of fractures normally occured within 100 m depth and further exploitation is happening beyond 100 m bgl till to the depth 200 m bgl. The 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, 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, 8896 MCM of unsaturated volume (below the depth of 5 m) is available during post-monsoon, having 178 MCM of recharge potential and 46 MCM of uncommitted runoff. 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 Kakatiya, during Phase-1 to Phase-4, out of 666 tanks, 295 tanks were desilted. This helped in strengthening of water bodies and created additional surface storage, thereby increased groundwater augmentation in the district.

- There is a need to take remaining tanks in the next phases for de-siltation. This will greatly help in stabilisation of tank ayacut and groundwater 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 the water grid with intake from Manair River at Mid Manaiar dam covering entire district to provide protected water from surface reservoirs. The scheme is to enhance the existing drinking water scheme and to provide 100, 135 and 150 lpd/person of water in rural, municipal and Municipal Corporation respectively.

- The total water requirement as per 2011 cenus is 21.43 MCM and this imported water from surface sources will reduce the present utilized 12.09 MCM of groundwater (considering 60 lpcd). This can be effectively utilized to irrigate 2015 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 5 m). Initially village wise dynamic groundwater resources of 2020 are considered. Potential surface run off is estimated by following standard procedures. Initailly, 20% run off yield is considered as non-committed yield 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.

Priority-1 (Area where groundwater development >90%)

- Based on the village wise GEC 2020 estimates an area consisting of 34 villages having 315 km^2 covered under Priority-1, where 36 MCM recharge potential and 6 MCM utilizable yield (uncommitted run-off) is available and immediate intervention is required where the stage of groundwater development is >90%. The management plan for Priority-1 area is given in Fig. 6.1 and Annexure-1.
- About 154 artificial recharge structures were constructed (PTs: 87, CDs: 67) in 32 villages with existing storage capacity of 3.72 MCM.

- About 29 artificial recharge structures (16 mini PT's with 1.5 fillings with a unit cost of Rs. 20 lakhs each and 13 CD's with recharge shafts with 6 fillings with a unit cost of Rs. 15 lakhs each) with a total cost of 5.15 Crores can be taken up.
- After effective utilization of this yield, there will be 1 MCM of groundwater recharge with 100% recharge efficacy.
- Roof top rainwater harvesting structures should be made mandatory to all Government buildings (new and existing).

Priority-2 (Area where groundwater development <90%)

- Area consisting of 134 villages having 1485 km^2 covered under Priority-2, where 142 MCM recharge potential and 41 MCM utilizable yield (uncommitted run-off) is available and immediate intervention is required. The management plan for Priority-2 area is given in Fig. 6.1 and Annexure-2.
- About 438 artificial recharge structures were constructed (PTs:213, CDs:225) in 79 villages with existing storage capacity of 12 MCM.
- Artificial recharge structures are recommended for 50% of the utilizable yield in the intermittent areas.
- About 546 artificial recharge structures (323 mini PT's with 1.5 fillings with a unit cost of Rs 20 lakhs each and 223 CD's with recharge shafts with 6 fillings with a unit cost of Rs. 15 lakhs each) with a total cost of 98.05 Crores can be taken up.
- After effective utilization of this yield, there will be 13 MCM of groundwater recharge with 100% recharge efficacy.
- Roof top rainwater harvesting structures should be made mandatory to all Government buildings.

6.1.1.4 Water Conservation Measures (Farm Ponds):

The farm ponds are the ideal water conservation structures, which are constructed in the low lying areas of the farm. The size of form ponds can be 10 x 10 x 3 m. The total 3420 farm ponds are recommended (20 in each village in 171 villages) at Rs 25,000/-each with total cost of 8.5 Crores, this can create an additional storage of 1.03 MCM.

Other Supply Side Measures

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

6.1.2 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 1733 ha. Area is brought under micro-irrigation (Sprinklers: 996 and drip: 717) saving 2.6 MCM of groundwater (considering 25% of saving to traditional practices).

6.1.2.2 Proposed Micro-irrigation (MI)

- About ~8550 ha. of additional land that can be brought under micro-irrigation (@50 ha/village in 171 villages) costing about 51 Crores (considering 1 unit/ha. @0.6 lakhs/ha.). With this, about 12.83 MCM of groundwater can be conserved over the traditional irrigation practices (considering 25% of net saving 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.
- Participatory Ground Water Management (PGWM) approach in sharing of groundwater and monitoring resources on a continuous basis along with effective implementation of the existing 'Water, Land and Trees Act' of 2002 (WALTA-2002).
- Subsidy/incentives on cost involved in sharing of 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. 163 Crores, the likely benefit would be increases in gross groundwater availability with net saving of 27.32 MCM of groundwater or net reduction of 6% in stage of groundwater extraction, i.e., from the existing 79 to 73%. The onetime cost will be 5.97 paisa/litre and the actual cost of invest will be 0.59paisa/litre if considered the life of the artificial recharge structures and micro irrigation equipment as 10 year.

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Annexure – I

Proposed interventions in Priority-1 areas (Area where ground water development >90 %).

New Mandal	Village	Existing No. of Check Dams	Existing No of Percolation Tanks	Proposed Check Dams	Proposed Percolation Tanks
Gambhiraopeta	Gajasingaram	3	2	1	1
Gambhiraopeta	Gorantial	2	3		
Gambhiraopeta	Samudralingapuram	3	2		
Gambhiraopeta	Laxmipuram	2	4		
Gambhiraopeta	Dammannapet	2	3	1	1
Gambhiraopeta	Lingampalle Khurdu	3	1		
Gambhiraopeta	Mallareddipet	2	3		
Gambhiraopeta	Mustafanagar	4	4		
Gambhiraopeta	Ramanujapuram	2	2		
Gambhiraopeta	Srinivasapuram	3	4		
Gambhiraopeta	Desaipet	4	3		
Gambhiraopeta	Gambhiraopet	2	2	1	1
Gambhiraopeta	Lingannapet	0	0	3	4
Gambhiraopeta	Narmala	3	3		
Gambhiraopeta	Kothapalle	2	5	1	1
Gambhiraopeta	Kollamaddi	3	5		
Gambhiraopeta	Mucherla	3	4		
Gambhiraopeta	Srigadha	2	3		
Mustabad	Kondapur	2	2		
Mustabad	Aunoor	2	1		
Mustabad	Padira	2	6		
Mustabad	Turkapalle	0	0	1	1
Mustabad	Gudem	0	2	1	2

New Mandal	Village	Existing No. of Check Dams	Existing No of Percolation Tanks	Proposed Check Dams	Proposed Percolation Tanks
Mustabad	Gudur	1	2		
Mustabad	Chippalapalle	0	2	1	1
Mustabad	Mustabad	4	3		
Mustabad	Namapur	3	6		
Mustabad	Pothugal	2	1	1	1
Mustabad	Terlumaddi	0	2	1	2
Mustabad	Cheekod	2	1		
Mustabad	Moraipalle	2	1		
Mustabad	Morrapur	0	2		
Mustabad	Maddikunta	1	1		
Mustabad	Bandankal	1	2	1	1

Annexure – II

Proposed interventions in Priority-2 areas (Area where ground water development <90 %).

New Mandal	Village	Existing No. of Check Dams	Existing No of Percolation Tanks	Proposed Check Dams	Proposed Percolation Tanks
Chandurthi	Chandurthi	3	4		
Chandurthi	Lingampeta	2	4		
Chandurthi	Mallial	3	2		
Chandurthi	Ananthapalle	4	3		
Chandurthi	Jogapuram	2	3		
Chandurthi	Marrigadda	4	4		
Chandurthi	Thimmapuram	3	4		
Chandurthi	Bandapalle	4	3		
Chandurthi	Moodepalle	2	2		
Chandurthi	Yangal	2	2		
Ellanthakunta	Veljipuram			6	9
Ellanthakunta	Anantharam				
Ellanthakunta	Jangamreddipalle			4	6
Ellanthakunta	Thippapuram			13	19
Ellanthakunta	Dacharam	8	3	1	2
Ellanthakunta	Sirikonda			1	1
Ellanthakunta	Repaka			2	3
Konaraopeta	Marrimadla			2	3
Konaraopeta	Vattimalla			3	4
Konaraopeta	Bausaipeta			3	4
Konaraopeta	Kondapuram	1	2	1	2
Konaraopeta	Mamidipalle	3	2	3	5

New Mandal	Village	Existing No. of Check Dams	Existing No of Percolation Tanks	Proposed Check Dams	Proposed Percolation Tanks
Konaraopeta	Nimmapalle	3	2	2	3
Konaraopeta	Venkatraopeta			1	2
Konaraopeta	Kanagarthi			1	2
Konaraopeta	Konaraopet			2	2
Konaraopeta	Malkapet			2	4
Konaraopeta	Nizamabad			2	3
Konaraopeta	Palle (Makta)			3	5
Konaraopeta	Sivangalapalle			1	1
Konaraopeta	Suddala			2	2
Konaraopeta	Nagaram	2	4	1	2
Konaraopeta	Dharmaram	2	3	1	1
Konaraopeta	Marthanpet	2	2	1	1
Konaraopeta	Ramannapet	3	1		
Konaraopeta	Kolanur	4	3	1	1
Rudrangi	Manala			5	7
Rudrangi	Rudrangi			4	6
Sirsilla	Mushtipalle	3	4		
Sirsilla	Bonala	2	2	6	8
Sirsilla	Peddur	2	3	2	4
Sirsilla	Sardapur	2	4	1	1
Thangallapalle	Chintalthana	2	1		
Thangallapalle	Cheerlavancha	2	1	4	6
Thangallapalle	Thadur	2	1	1	2
Thangallapalle	Thangallapalle	2	1	3	4
Thangallapalle	Gandilachachapet	2	1	5	7
Thangallapalle	Kasbekatkur	1	1	1	2

New Mandal	Village	Existing No. of Check Dams	Existing No of Percolation Tanks	Proposed Check Dams	Proposed Percolation Tanks
Thangallapalle	Mandepalle	2	1	5	7
Thangallapalle	Baswapur	1	1	1	2
Thangallapalle	Badnepalle	3	1	3	4
Thangallapalle	Oblapur	1	1	2	3
Thangallapalle	Sarampalle	2	1		
Thangallapalle	Venugopalpur	2	1	1	2
Thangallapalle	Nerella	2	1		
Thangallapalle	Narsimhulapalle	12	4		
Thangallapalle	Ramchandrapur	9	4		
Thangallapalle	Jillella	10	3	3	4
Veernapalle	Garjanpalle	1	2	13	19
Veernapalle	Vanapalle	2	3	0	0
Veernapalle	Adivipadira	2	3		
Veernapalle	Maddimalla			1	2
Vemulawada	Satrajupalle	2	2	3	4
Vemulawada	Jayavaram	2	4	6	8
Vemulawada	Thippapuram	3	4		
Vemulawada	Vemulawada	2	2	1	2
Vemulawada	Chandragiri	2	4	1	1
Vemulawada	Nampalle	3	5	1	2
Vemulawada	Thettakunta	2	3	3	4
Yellareddypeta	Akkapalle	2	5	1	2
Yellareddypeta	Almaspur	2	4		
Yellareddypeta	Gundaram	3	3	1	1
Yellareddypeta	Pothareddipalle	5	2		
Yellareddypeta	Rajannapet	1	5		

New Mandal	Village	Existing No. of Check Dams	Existing No of Percolation Tanks	Proposed Check Dams	Proposed Percolation Tanks
Yellareddypeta	Gollapalle	3	2		
Yellareddypeta	Boppapuram	3	3		
Yellareddypeta	Dumala	3	4		
Yellareddypeta	Timmapuram	1	4	5	7
Yellareddypeta	Yellareddipeta	3	4	5	7
Yellareddypeta	Narayanapur	4	2	3	5
Yellareddypeta	Korutlapet	2	3	4	5
Yellareddypeta	Sarvaipalle	2	2	2	2
Yellareddypeta	Singaram	2	3		
Yellareddypeta	Venkatapuram	4	2	4	6
Yellareddypeta	Bandalingampalle	3	4	0	0
Boinpalle	Ananthapalle			7	10
Boinpalle	Dundrapalle			1	1
Boinpalle	Korem			3	4
Boinpalle	Boinpalle			2	3
Boinpalle	Burgupalle			1	2
Boinpalle	Sthambhampalle	4	3	1	1
Boinpalle	Shabashpalle			1	1
Boinpalle	Vardavelli	4	3		
Boinpalle	Kodurupaka			1	1
Boinpalle	Kothapeta			1	2
Vemulawada_Rural	Nookalamarri	4	4		
Vemulawada_Rural	Chekkapalle	3	4	1	2
Vemulawada_Rural	Edurugatla	2	3	2	2
Vemulawada_Rural	Marripalle	3	2		
Vemulawada_Rural	Vattemla			1	2

New Mandal	Village	Existing No. of Check Dams	Existing No of Percolation Tanks	Proposed Check Dams	Proposed Percolation Tanks
Vemulawada_Rural	Venkatampalle	3	2	2	2
Vemulawada_Rural	Mallaram	2	4	1	1
Vemulawada_Rural	Bollaram	4	3	2	3
Vemulawada_Rural	Hanumajipet	2	2	2	3
Vemulawada_Rural	Lingampalle			2	4
Vemulawada_Rural	Rudraram	4	3	1	2
Vemulawada_Rural	Anupuram	2	2		
Vemulawada_Rural	Kodumunja	3	4	7	11