केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

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

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

SIDDIPET DISTRICT, TELANGANA

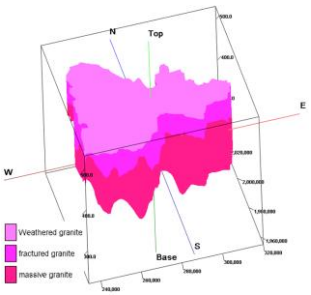
दक्षिणी क्षेत्र, हैदराबाद

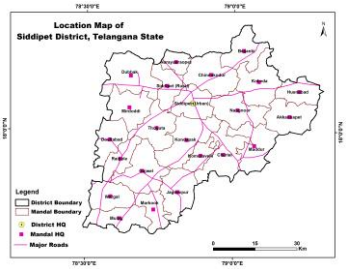
Southern Region, Hyderabad

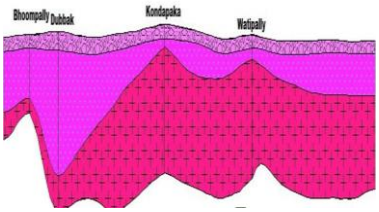
भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग
केंद्रीय भूमिजल बोर्ड

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

REPORT ON
AQUIFER MAPPING AND MANAGEMENT PLANS FOR SUSTAINABLE GROUND WATER RESOURCES IN SIDDIPET DISTRICT, TELANGANA STATE







CENTRAL GROUND WATER BOARD
SOUTHERN REGION
HYDERABAD

MARCH 2022

REPORT ON
AQUIFER MAPPING AND MANAGEMENT PLANS FOR SUSTAINABLE GROUND WATER RESOURCES IN SIDDIPET DISTRICT, TELANGANA STATE
(AAP 2021-22)

CONTRIBUTORS' PAGE

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Regional Director

CENTRAL GROUND WATER BOARD
SOUTHERN REGION
HYDERABAD

MARCH 2022

FOREWORD

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

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

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

This report has been prepared by Dr. S. S. Vittala, Scientist - B (Hydrogeology), and the efforts made by the officer in preparation of this report is greatly appreciated. Due thanks to Dr. G. Praveen Kumar, Scientist - C (Hydrogeology) and Nodal Officer (NAQUIM) who had prepared the erstwhile NAQUIM report of Medak district in the year 2018-19, from which the present report is carved out and his guidance and support in completing this report. Thanks are due to Sh. Ravi Kumar Gumma, Scientist-C for valuable suggestions in finalizing this document. Appreciation is due to Sh.Bijay Ketan Mohanta, Scientist-B for support in preparation of maps. Thanks, are also due to various organizations of the Government of Telangana for providing data required for compiling this report.

I hope this report will be of great help to District Administration and Stakeholder Departments for planning and sustainable management of groundwater resources in the district.

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

EXECUTIVE SUMMARY

The Siddipet district covering 3639 km^2 is carved from erstwhile Medak district. Administratively the area is governed by 3 revenue divisions, 23 revenue mandals and 384 revenue villages with a population of 10.12 lakhs (2011 census) (Rural: 86% and Urban: 14%) with average density of 278 persons/km^2.

The annual normal rainfall of the district varies from 602.4 mm (Thoguta Mandal) to 911 mm (Husnabad Mandal) with district normal of 742.7 mm. Average number of annual rainy days is around 56 days. Southwest monsoon contributes 78% (575.9 mm), Northeast monsoon by 14% (101.3 mm) and remaining 8% by January to May months of normal annual rainfall. Mean monthly rainfall varies from 180.7 mm in July to 4.1 mm in December. The district received large excess rainfall of 1499.7 mm (102% above normal) during the water year 2020-21.

The district is contiguous part of Mysore Plateau and characterised by erosional topography with general slope from SSE-NNW and SW-NE directions. Pediplain is the major landform followed by pediment.

The district falls under Godavari basin and Pranhita sub basins. The Kodli river is flowing in the district which flows along SSE-NNW direction and another major river Mohidemada is flowing along SW-NE direction towards eastern side of the district. The entire district is underlain by crystalline rocks of Banded Gneissic Complex of Archaean to Proterozoic age.

The soils from the district are mainly form fine montmorillonitic, clayey skeletal, loamy skeletal, fine mixed, rock land & clayey skeletal soils, etc. Majority of soils are occupied by fine montmorillonitic, clayey skeletal and loamy skeletal soils. The forest occupies about 7% of the total geographical area, barren and uncultivable land occupies 6% of area; land put to non-agricultural use is 5%, cultivable wasteland is 2%. With respect to land utilization, out of total area, 11% of the area is falling under current fallows; 12% is under other fallows. The net area sown is about 54% and area sown more than once is 12% which brings gross cropped area to 66%. During kharif season, out of total gross cropped area, the Cotton is grown in 44% of the area followed by Paddy and Maize (24% each) and other crops in 8% of the area while during rabi season, Paddy is grown in 75% of the area followed by Maize in 11% and others in 14% of the area

Groundwater exploration data down to the depth of 200 m bgl reveals that weathering thickness varies from 2.5 to 38 m bgl. The data indicated that about 9% of the wells are shallow wells that are drilled up to a depth of <30 m bgl, 34% of the wells between the depth of 30-60 m bgl, each 6% of the wells drilled between the depth range of 60 to 100 & 100 to 150 m bgl respectively, and about 46% 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 Bejjanki, Cherial, Chinnakodur, Dowlatabad, Dubbak, Gajwel, Jagadevpur, Kondapak, Maddur, Mirdoddi, Mulugu, Nanganur, Siddipet Rural, Siddipet Urban, Thoguta and Wargal mandals. Further, the study reveal that majority of fractures (72%) occur within 100 m depth. The deepest fractures >100 m bgl is noticed in Cherial, Chinnakodur, Dowlatabad, Dubbak, Gajwel, Jagadevpur, Kondapak, Maddur, Mirdoddi, Mulugu, Nanganur, Siddipet Urban, Thoguta and Wargal mandals.

Water level data indicates that during pre-monsoon season, the majority of the water levels are in the range of 10 to 20 m bgl m bgl and distributed in 49% of the area located in Akkannapet, Bejjanki, Cherial, Chinnakodur, Husnabad, Jagdevpur, Koheda, Komuravelli, Kondapak, Maddur, Mirdoddi, Nangnoor, Siddipet Rural and Siddipet Urban mandals followed water levels >20 m bgl (34% of the area) noticed from Akkannapet, Bejjanki, Chinnakodur, Doultabad, Dubbak, Gajwel, Jagdevpur, Kondapak, Markook, Mirdoddi, Mulug, Raipole, Siddipet Rural and Siddipet Urban mandals. The water levels in the range of 5 to 10 m bgl is noticed in 17% of the area falling in Bejjanki, Cherial, Doultabad, Husnabad, Komuravelli, Kondapak, Maddur and Wargal mandals. Water levels of <5 m bgl is noticed in the area during this season. During post-monsoon, the majority of the water levels are in the range of 5 to 10 m bgl and noticed in 41% of the area located in Akkannapet, Cherial, Chinnakodur, Doultabad, Husnabad, Jagdevpur, Koheda, Komuravelli, Maddur, Nangnoor, Siddipet Urban and Wargal mandals followed by water levels from 10 to 20 m bgl distributed in 31% of the area falling in Akkannapet, Bejjanki, Chinnakodur, Dubbak, Jagdevpur, Komuravelli, Kondapak, Maddur, Markook, Mirdoddi, Mulug and Siddipet Rural mandals. The deeper water levels >20 m bgl is noticed in 19% of the area in Chinnakodur, Doultabad, Dubbak, Gajwel, Kondapak, Mirdoddi, Mulug and Raipole mandals. The shallow water levels of <5 m bgl (10% of the area) is observed in Bejjanki, Cherial, Husnabad, Komuravelli, Kondapak and Maddur mandals.

The data analysed from the groundwater quality indicate that during pre-monsoon season, the Electrical conductivity varies from 310 to 2420 µ Siemens/cm (avg. 978 µ

Siemens/cm). In none of the samples, the EC of >3000 µ Siemens/cm is observed. The NO_3 concentration ranges from 2 to 350 mg/l (avg. 72 mg/l) and noticed that in about 51% of the samples from Akkannapet, Bejjanki, Cherial, Chinnakodur, Doultabad, Dubbak, Gajwel, Husnabad, Jagdevpur, Koheda, Komuravelli, Maddur, Mulug, Nangnoor, Siddipet Rural and Wargal mandals, the quality is not suitable for drinking water purpose as the samples showing above permissible limit of >45 mg/l. The Fluoride concentration varies from 0.33 to 6.62 mg/l (avg. 1.59 mg/l) and in 29% of the samples from Bejjanki, Cherial, Gajwel, Jagdevpur, Koheda, Kondapak, Maddur, Mulug, Nangnoor, Siddipet Rural and Siddipet Urban mandals it is showing behind permission of limit of 1.5 mg/l and not suitable for drinking water purpose. During post-monsoon season, the EC varies from 302 to 2428 µ Siemens/cm (avg. 911 µ Siemens/cm) and in none of the samples, the EC >3000 µ Siemens/cm is observed. The NO_3 concentration ranges from 2.74 to 273 mg/l (avg. 65 mg/l). In about 44% of the samples from Cherial, Chinnakodur, Doultabad, Dubbak, Husnabad, Jagdevpur, Mirdoddi, Nangnoor, Raipole, Siddipet Rural and Siddipet Urban mandals, it is beyond the permissible limit (>45 mg/l) and not suitable for drinking water purpose. The Fluoride concentration varies from 0.12 to 2.51 mg/l (avg. 0.91 mg/l) and noticed that in about 13% of the samples from Cherial, Chinnakodur, Mulug, Nangnoor, Siddipet Rural and Siddipet Urban mandals are having high fluoride concentration beyond permissible limits (>1.5 mg/l) and are not suitable for drinking water purpose

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

As per GEC 2020 report, the net dynamic replenishable ground water availability for newly formed Siddipet district is 518 MCM, gross ground water draft for all uses 340 MCM, provision for drinking and industrial use for the year 2025 is 36 MCM and net annual ground water potential available for future irrigation needs is 154 MCM. Out of 23 mandals, 15 mandals are falling under Safe (Gajwel (53%), Siddipet Rural (53%), Nanganur (54%), Thoguta (56%), Bejjanki (58%), Chinnakodur (59%), Doulthabad (59%), Siddipet Urban (61%), Husnabad (62%), Mulugu (62%), Jagdevpur (63%), Narayanraopet (63%), Akkannapet (64%), Cherial (64%) and Kondapak (69%)) and the remaining 8 mandals falling under Semi-Critical (Markook (70%), Raipole (74%), Maddur (75%), Wargal (76%), Koheda

(78%), Mirdoddi (81%), Dubbak (82%) and Komuravelly (83%)). The overall average stage of ground water extraction in the district is 64% falling under Safe category.

The village wise groundwater management plan is prepared and presented. As per village wise GEC 2020 estimates, the areas spread over 218 villages covering 1658 km^2 falls under Priority-1, where the state of groundwater extraction is >100% and required an immediate intervention. In this area, 159 MCM recharge potential and 45 MCM utilizable yield (uncommitted run-off) is available. Around 164 artificial recharge structures viz., 82 mini PT's and 82 CD's with recharge shafts with a total cost of 29 Crores recommended. By constructing these structures, there will be additional groundwater recharge of 4.31 MCM which will help in sustainability of the groundwater.

Area consisting of 166 villages having 1981 km^2 covered under Priority-2, where the state of groundwater extraction is <100%. In the area, 216 MCM recharge potential and 57 MCM utilizable yield is available. About 181 artificial recharge structures viz., 109 mini PT's and 72 CD's with recharge shafts with a total cost of 33 Crores are recommended. By constructing these structures, there will be additional groundwater recharge of 4 MCM which will help in sustainability of the groundwater. This will help in arresting the deterioration of groundwater levels.

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 7680 farm ponds needs to be constructed at a unit cost of Rs. 25,000/- totalling to 19 Crores. This will create an additional storage capacity of 2.3 MCM.

As per the studies, it is estimated that 8027 ha. of additional land that can be brought under micro-irrigation (where actual area irrigated though MI is less than 1,000 ha.) costing about 48 Crores. By shifting from traditional to micro irrigation practices, 12 MCM of groundwater can be conserved.

The above interventions by investing about Rs. 129 Crores, a net saving of 23 MCM of groundwater can be achieved which will help in net reduction in groundwater extraction by 2% i.e., from the existing 64% to 62%. This will help in arresting the groundwater deterioration and its sustainability. The onetime cost will be 6 paisa/litre and the actual cost of invest will be 0.6 paisa/litre if considered the life of the artificial recharge structures and micro irrigation equipment as 10 year.

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ABBREVATIONS

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

1. INTRODUCTION

Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic, hydrogeological and chemical analyses is applied to characterize the quantity, quality and sustainability of 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.

Hard rocks 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 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, information dissemination, education, 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 Siddepet district covering about 3639 km^2 lies between north latitude 17°40'07" - 18°20'44" and east longitude 78°29'31" - 79°18'17" (Fig. 1.1). The district is bounded on the north by Sircilla and Karimnagar districts, on the east by Warangal districts, on the south by Jangaon, Yadadri and Medchal districts and on the west by Medak district state. The present district is carved from erstwhile Medak district. Administratively, the district is governed by 3 revenue divisions, 23 revenue mandals and 384 revenue villages with a population of 10.12 lakhs (2011 census) (Rural: 86% & Urban: 14%) with average density of 278 persons/km^2. Of the 23 revenue mandals, 16 mandals from erstwhile Medak district viz., Chinnakodur, Doulthabad, Dubbak, Gajwel, Jagdevpur, Kondapak, Markook, Mirdoddi, Mulugu, Nanganur, Narayanraopet, Raipole, Siddipet Rural, Siddipet Urban, Thoguta and Wargal, 4 mandals from erstwhile Karimnagar distirict viz., Akkannapet, Bejjanki, Husnabad and Koheda and 3 mandals from erstwhile Warangal distict viz., Cherial, Komuravelly and Maddur have been included in the present newly formed district of Siddipet. The hilly and forest area occupying 7% of the total area located in different part of the district.

1.4 Climate and Rainfall

The district experiences tropical climate and is geographically located in semi-arid area. The district falls under Central Telangana Agro-climatic zone based on the geographical characteristics such as rainfall, temperature, nature of soils etc. The Southwest monsoon enters into the district in June and lasts until second week of October (as per IMD report) and

Northeast monsoon from October to December. Summer starts in March, and reaches peak in May with average highest temperature of 40.5°C. Winter season starts in late November and lasts until early February with lowest average temperature of 14.4°C in January. The annual normal rainfall of the district varies from 602.4 mm (Thoguta Mandal) to 911 mm (Husnabad Mandal) with district normal of 742.7 mm. Average number of annual rainy days is around 56 days. Southwest monsoon contributes 78% (575.9 mm) while Northeast monsoon contributes only 14% (101.3 mm) and remaining 8% by January to May months of normal annual rainfall. Mean monthly rainfall varies from 180.7 mm in July to 4.1 mm in December. Isohyetal map prepared using annual normal rainfall of mandals in the district collected from DES, Govt. of Telangana is shown in Fig. 1.2. The district received large excess rainfall of 1499.7 mm (102% above normal) during the water year 2020-21.

Analysis of time series annual rainfall data (January to December) for 16 years (2005-2020) collected from TSDPS, Govt. of Telangana shows increasing trend in annual rainfall of around 23 mm/yr. The district received excess rainfall (+20% to +59% departure from normal) in 4 years (2013, 2016, 2019 and 2020), deficient rainfall (-20% & below normal) in 4 years (2009, 2011, 2014 and 2018) and normal rainfall (-19% to +19%) in the remaining 8 years. The monthly rainfall trend graph for 16 years shows increasing trend in rainfall for Southwest monsoon months especially in June (7.2 mm/yr) and October (7.8 mm/yr) months.

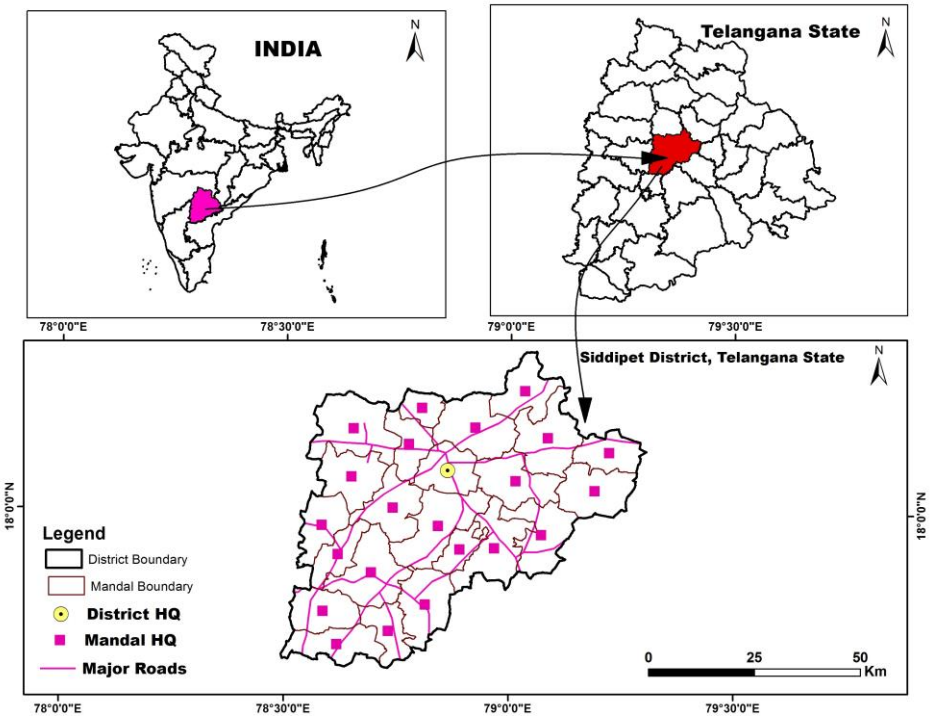

Fig. 1.1: Location map.

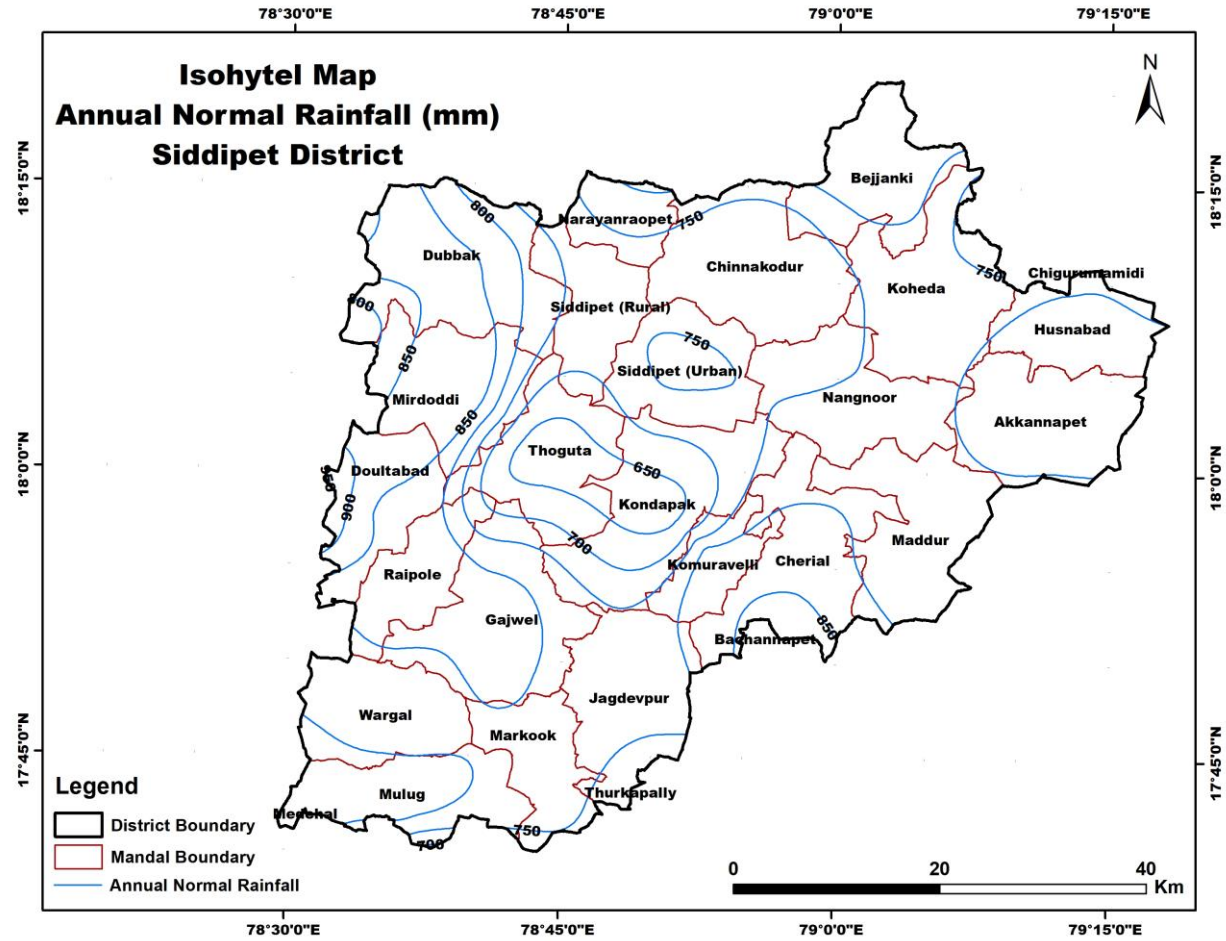

Fig. 1.2: Isohyetal map.

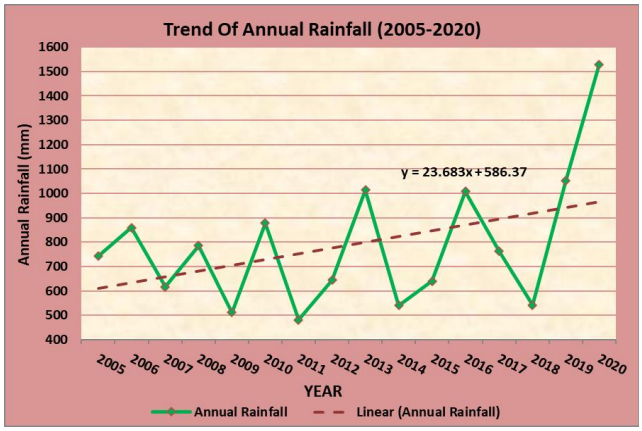

Fig. 1.3a: Annual Rainfall trend

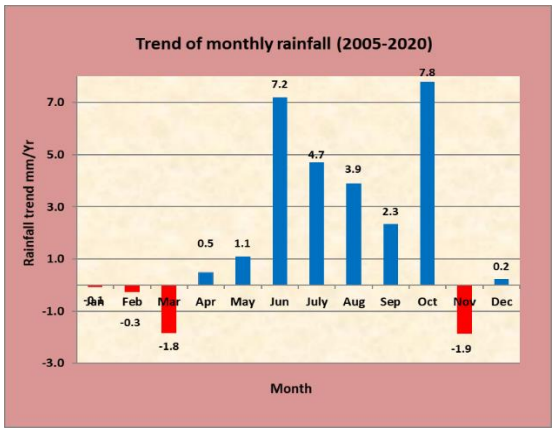

Fig. 1.3b: Monthly Rainfall trend

1.5 Geomorphological Set up

The district is contiguous part of Mysore Plateau and characterised by erosional topography with general slope is SSE-NNW and SW-NE directions. Pediplain is the major landform followed by pediment, linear ridge, residual hill, inselberg (Fig. 1.4).

1.6 Drainage

The district falls under Godavari basin and Pranhita sub basins. The Kodli river is flowing in the district which flows along SSE-NNW direction and another major river Mohidemada is flowing along SW-NE direction towards eastern side of the district. The major lineament trends falling along SSE-NNW and SW-NE directions. Map depicting drainage and water bodies is presented in Fig. 1.5.

1.7 Land use/ land cover

Based on the land use study, several classes have been delineated in the district viz., agricultural crops (kharif and rabi), double crop, forest plantation, deciduous open forest, scrub forest, fallow land, waste land and waterbodies. Out of the total area, majority of the area (>50%) falling under kharif category followed by deciduous open forest. Some of the double cropped area also noticed on either side of the river courses with in the district. The land use / land cover map is given in Fig. 1.6.

1.8 Soils

The soils from the district are mainly form fine montmorillonitic, clayey skeletal, loamy skeletal, fine mixed, rock land and clayey skeletal soils. Majority of soils are occupied by fine montmorillonitic, clayey skeletal and loamy skeletal soils. They are grouped into many classes (NBS & LUP) based on geomorphology and landscapes and further sub-divided based on physiography, relief and drainage (Fig. 1.7).

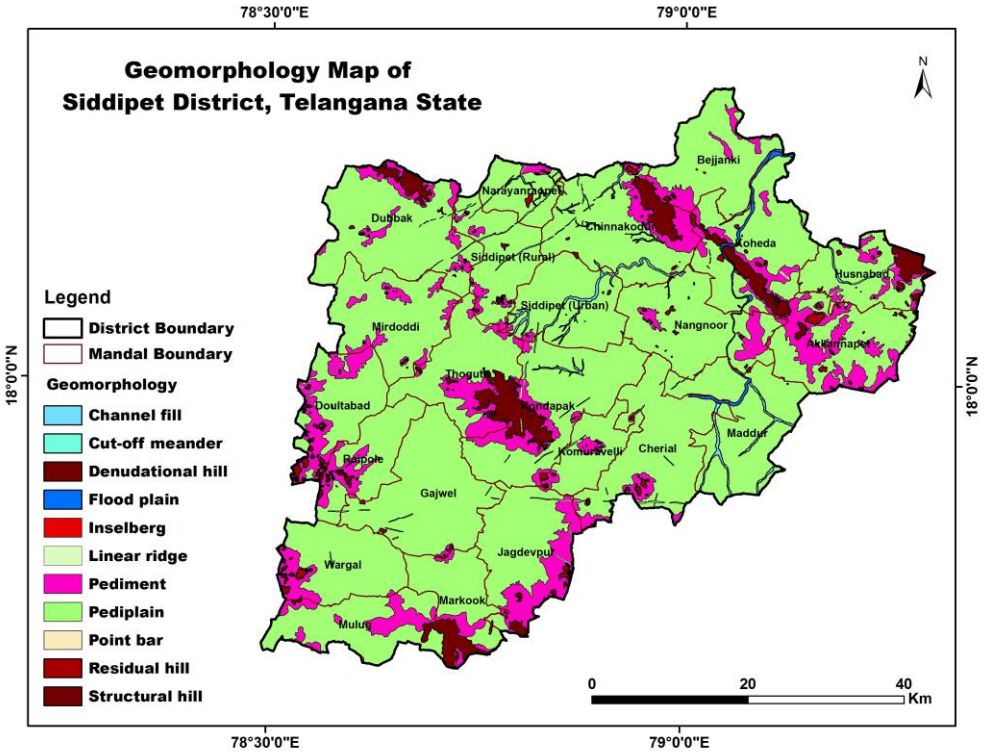

Fig. 1.4: Geomorphology map.

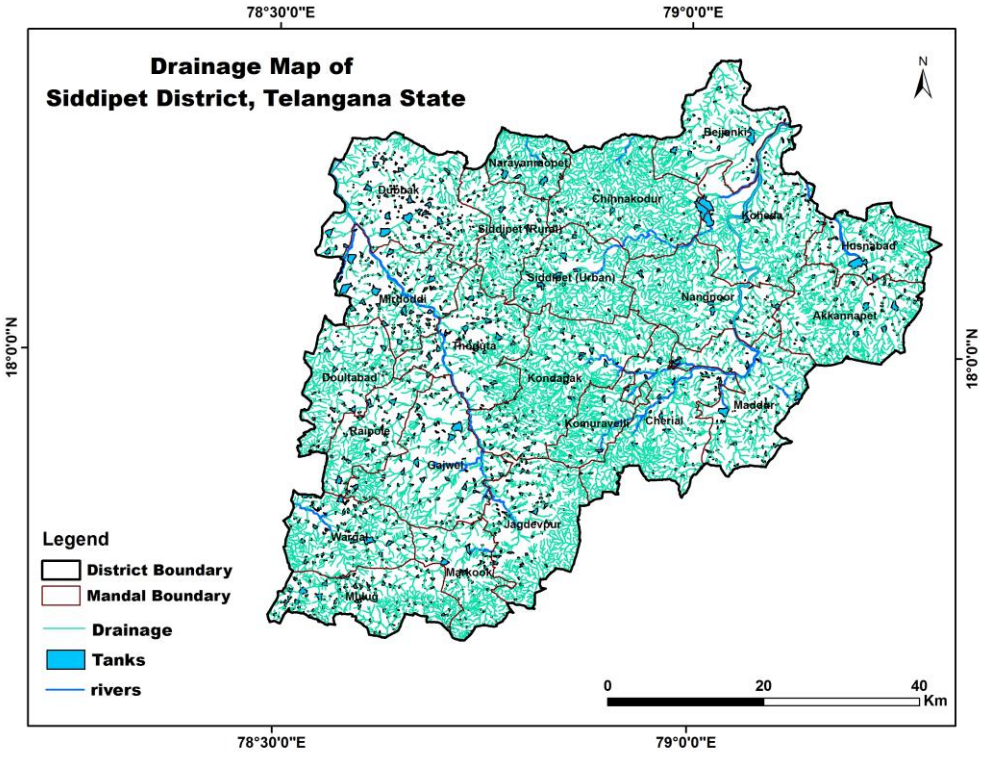

Fig 1.5: Drainage and water bodies map.

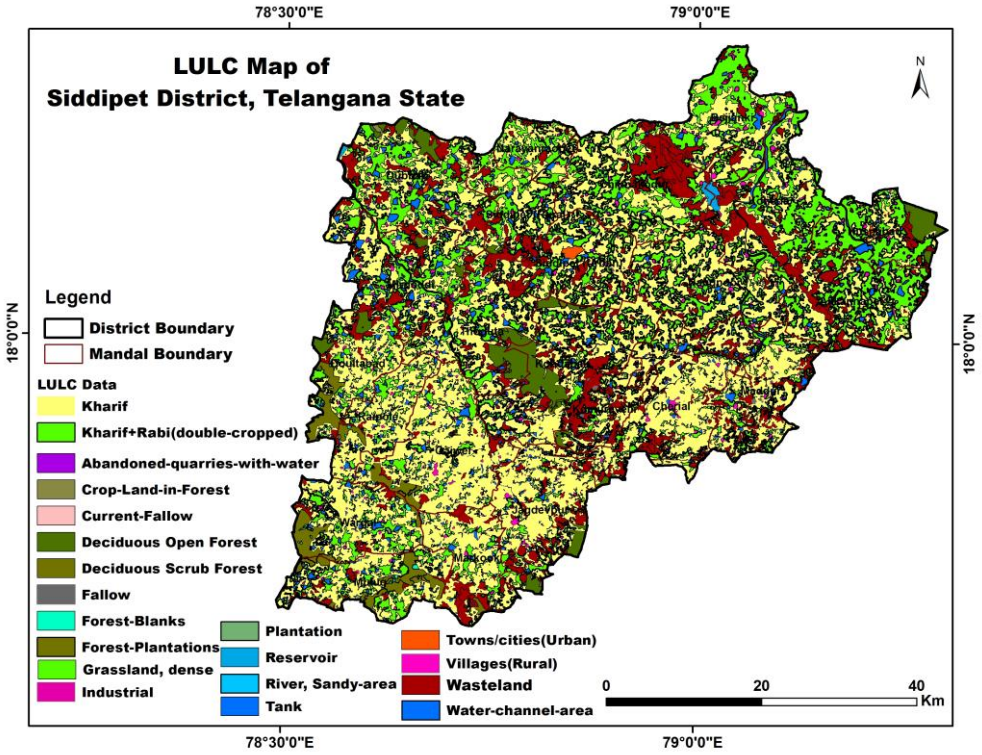

Fig. 1.6: Land use / land cover map

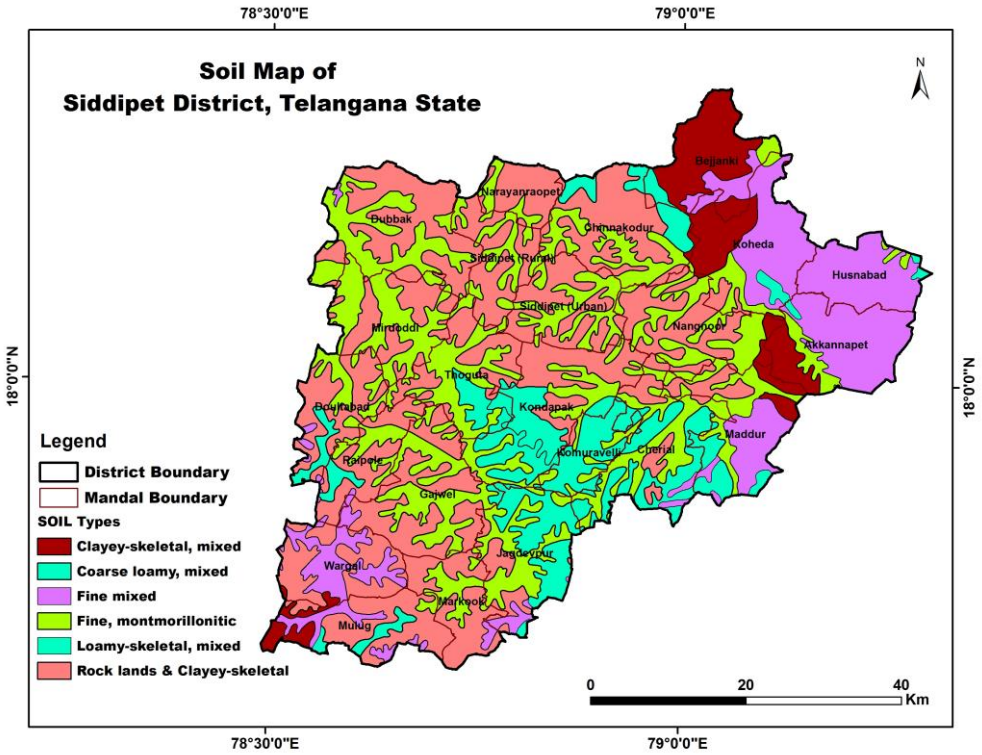

Fig. 1.7: Soil map.

1.9 Cropping Pattern (2019-20 in ha.)

The forest occupies about 7% of the total geographical area, barren and uncultivable land occupies 6% of area; land put to non-agricultural use is 5%, cultivable wasteland is 2%. With respect to land utilization, out of total area, 11% of the area is falling under current fallows; 12% is under other fallows. The net area sown is about 54% and area sown more than once is 12% which brings gross cropped area to 66%. During kharif season, out of total gross cropped area, the Cotton is grown in 44% of the area followed by Paddy and Maize (24% each) and other crops in 8% of the area while during rabi season, Paddy is grown in 75% of the area followed by Maize in 11% and others in 14% of the area (Fig. 1.8).

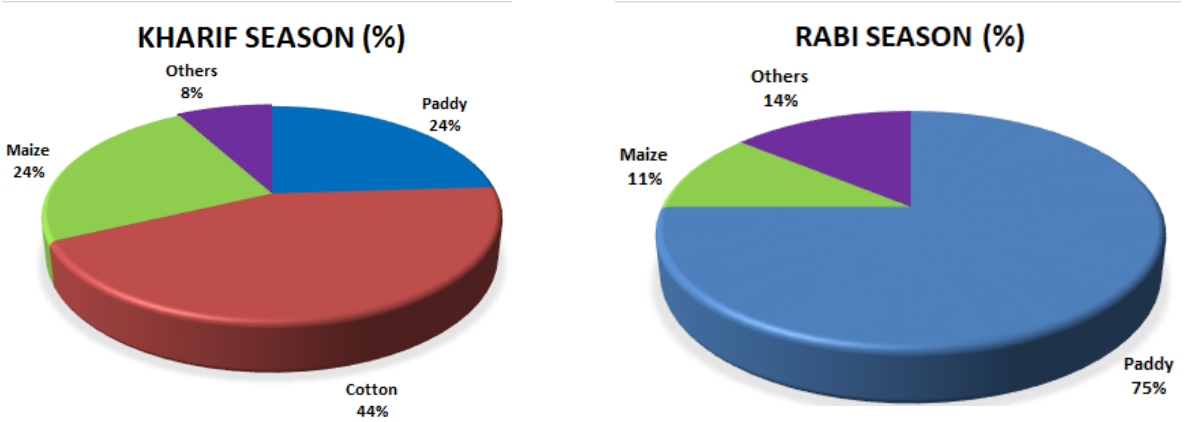

Fig. 1.8: Cropping pattern.

1.10 Irrigation

In the district, there are 3 contemplated/completed Irrigation Potential (IP) projects viz., Indiramma Flood Flow Canal from SRSP (17992 ha.), JCR Godavari Lift Irrigaiton Scheme (32652 ha.) and Shanigaram Project (2064 ha.). The Indiramma Flood Flow canal envisages diversion of flood water from Sri Ram Sagar reservoir through the flood flow canal which would be stored in two reservoirs viz., Mid Manair Reservoir and Gouravelly Reservoir to provide irrigation facilities in the district. JCR Devadula LIS is envisaged to lift the water from Godavari River near Gangaram village of Warangal district to irrigate in upland drought prone areas of Siddipet district. Shanigaram Project is an existing Medium Irrigation Project constructed across Siddipet vagu a tributary of Mohidummedvagu in Manair sub basin of Godavari basin near Shanigaram village of Koheda mandal. In the district, about 2635 number of minor irrigation tanks which is covering 59877 ha. of ayacut. As per the latest GEC 2020 report, there are about more than 72000 numbers of bore wells (irrigation, domestic and industrial) and more than 17500 dug wells are existing in the district.

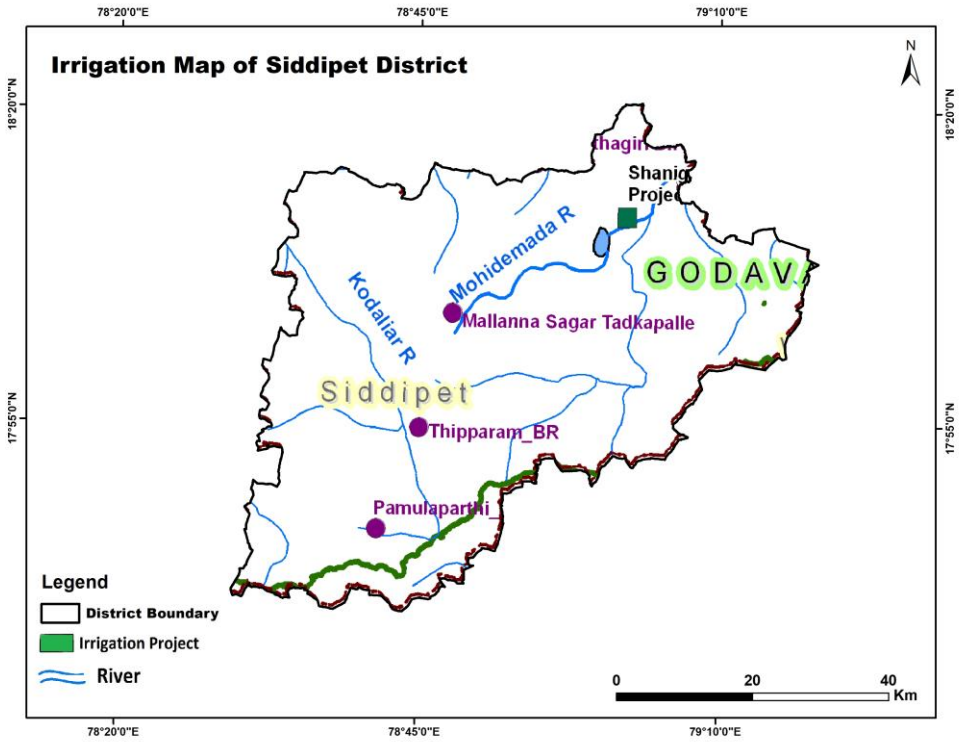

Fig. 1.9: Irrigation Projects in the district.

1.11 Cropping Pattern trend

To understand the long term cropping pattern changes, it is observed from the cropping area trend that the cropping areas of Paddy, Maize and Cotton is increasing and cropping areas of millets and oil seeds are decreasing. Over all the cropping area of the district is increasing.

The observations made from the analysis are given below:

- There is a gradual change in cropping pattern in the past several years.
- The extent of paddy, cotton and pulses in gross cropped area is increasing whereas the extent of millets and oil seeds are decreasing during the same period.
- Average gross cropped area is also increased during last 10 years (2009-19).

1.12 Prevailing Water Conservation/Recharge Practices

In the district, there are 1897 artificial recharge structures (PT's: 1035 and CD's: 862) are existing with combine storage capacity of 47 MCM. Under Mission Kakatiya (Phase-1 to 4), out of 3635 minor irrigation tanks, 1564 tanks are desilted.

1.13 Geology

The entire district is underlain by crystalline rocks of Banded Gneissic Complex of Archaean to Proterozoic age. This hard rock formation is essentially massive and lacks primary porosity and secondary porosity is developed due to weathering and fracturing and thus forms the productive aquifers in the district. The major lineaments in the area trend is along SSE-NNW and SW-NE directions (Fig. 1.10).

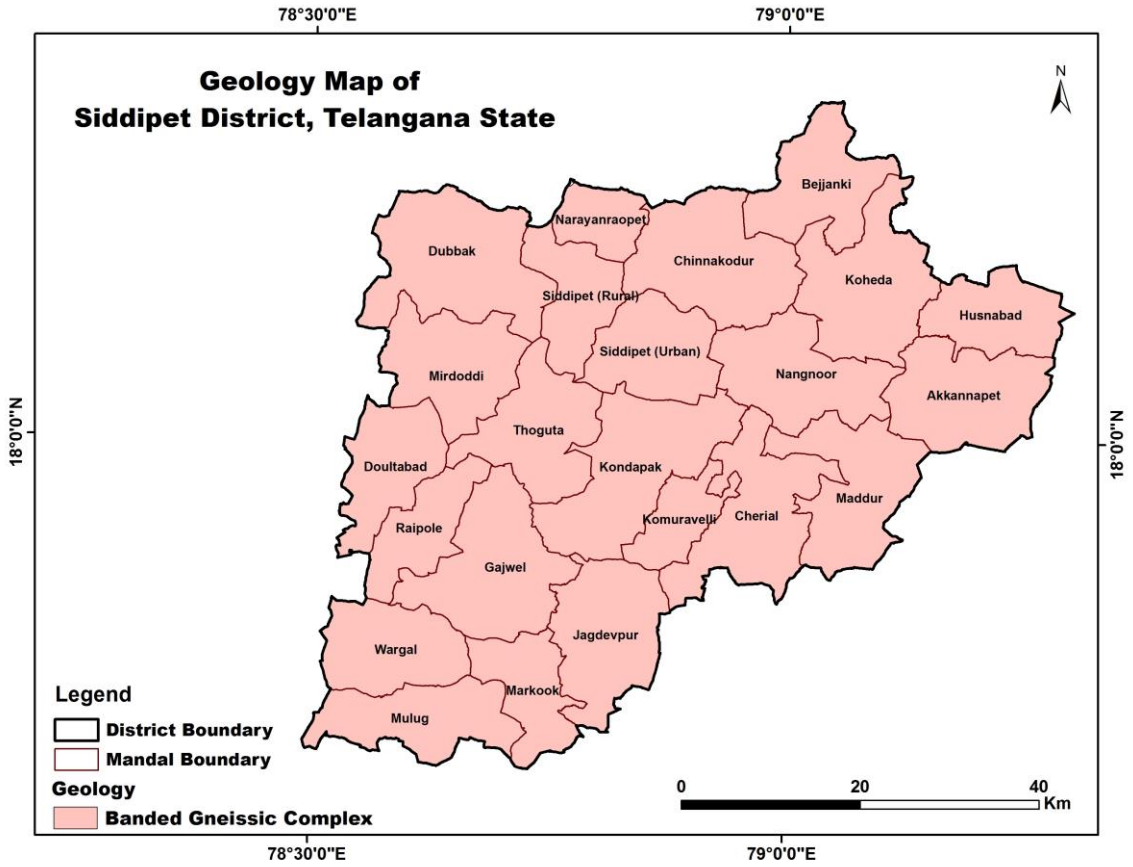

Fig. 1.10: Geology map.

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 (Table2.1).

Table 2.1: Brief activities showing data compilation and generations.

S. No.	Activity	Sub-activity	Task
1	Compilation of existing data/ Identification of Principal Aquifer Units and Data Gap	Compilation of Existing data on 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 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).

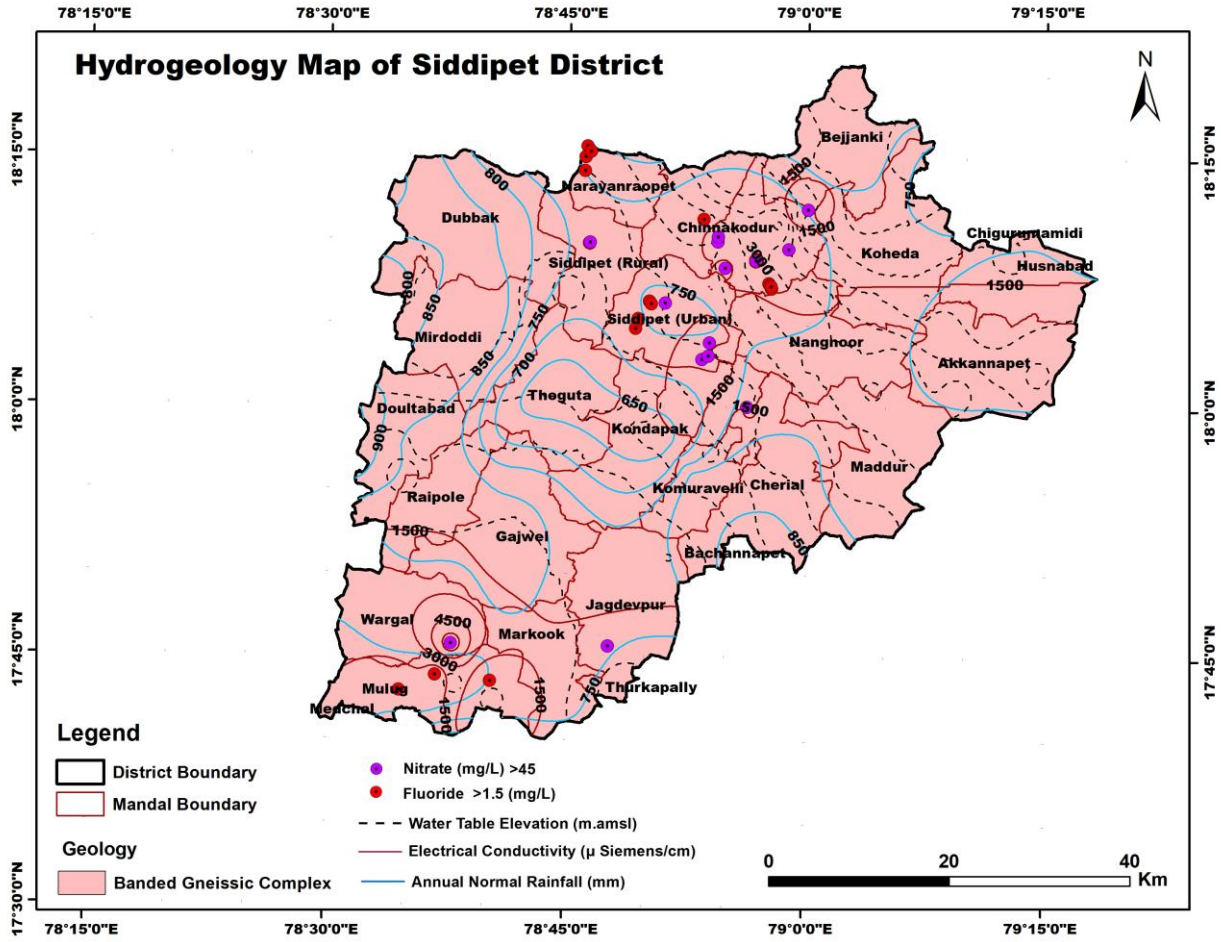

Fig. 2.1: Hydrogeology map.

2.1.1 Ground water occurrences and movement

Ground water occurs under unconfined and semi-confined conditions and flows downward from the weathered zone into the fracture zone. The main aquifers constitute the weathered

zone at the top, followed by a discrete anisotropic fractured/fissured zone at the bottom, generally extending down to the depth of 200 m bgl. The storage in 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 as well as interconnected fractures.

2.1.2 Exploratory Drilling

Groundwater exploration started in the district in the year in four phases (1971-75, 1989-92, 1999-2004 and 2014-16). As on 31/03/2020, CGWB drilled 89 bore wells (exploratory, observation, piezometers and outsourcing) and SGWD drilled 25 wells (piezometers) in the district. The depth drilled varies from 20 to 200 m bgl and weathering thickness varies from 2.5 to 38 m bgl. The data analysed from the exploratory wells indicates that 9% of the wells are shallow wells that are drilled up to a depth of <30 m bgl, 34% of the wells between the depth of 30-60 m bgl, each 6% of the wells drilled between the depth range of 60 to 100 & 100 to 150 m bgl respectively, and about 46% 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 Bejjanki, Cherial, Chinnakodur, Dowlatabad, Dubbak, Gajwel, Jagadevpur, Kondapak, Maddur, Mirdoddi, Mulugu, Nanganur, Siddipet Rural, Siddipet Urban, Thoguta and Wargal mandals. Further, the study reveal that majority of fractures (72%) occur within 100 m depth. The deepest fractures >100 m bgl is noticed in Cherial, Chinnakodur, Dowlatabad, Dubbak, Gajwel, Jagadevpur, Kondapak, Maddur, Mirdoddi, Mulugu, Nanganur, Siddipet Urban, Thoguta and Wargal mandals.

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

To study the behaviour of ground water regime in time and space, 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 7.22 to 43 m bgl (average: 17 m bgl) and 3.13 to 35 m bgl (average: 11.73 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 286 to 567 and 291 to 570 m amsl respectively. The general ground water flow is towards NW-SE and ultimately joins River Manjeera (Fig. 2.2 and 2.3).

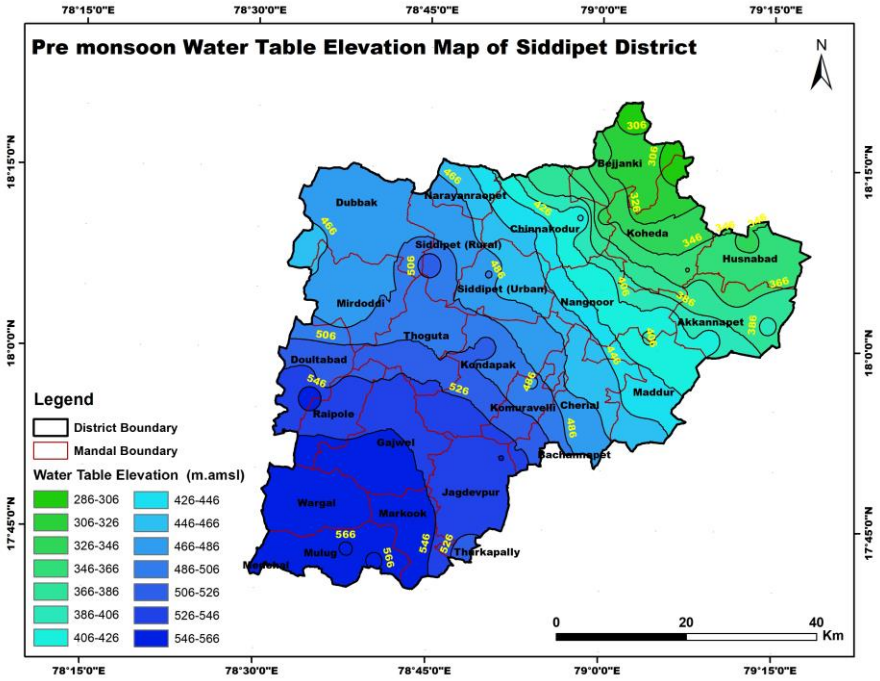

Fig. 2.2: Water table elevation (m amsl) map of pre-monsoon.

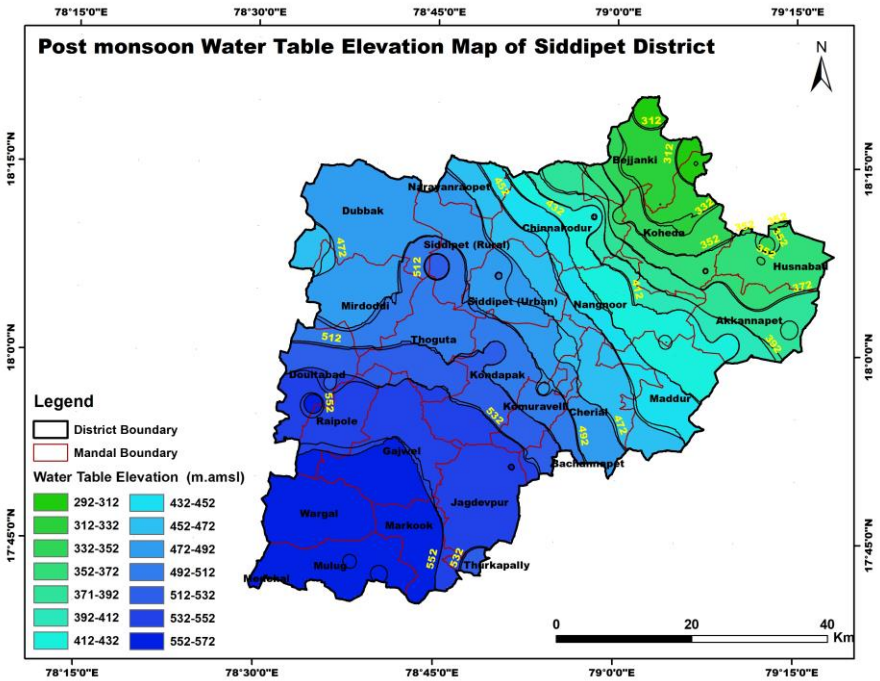

Fig. 2.3: Water table elevation (m amsl) map of post-monsoon.

2.2.2 Pre-monsoon Season

During this season, majority of the wells show water levels in the range of 10 to 20 m bgl m bgl and distributed in 49% of the area located in Akkannapet, Bejjanki, Cherial, Chinnakodur, Husnabad, Jagdevpur, Koheda, Komuravelli, Kondapak, Maddur, Mirdoddi, Nangnoor, Siddipet Rural and Siddipet Urban mandals followed water levels >20 m bgl (34% of the area) noticed from Akkannapet, Bejjanki, Chinnakodur, Doultabad, Dubbak, Gajwel, Jagdevpur, Kondapak, Markook, Mirdoddi, Mulug, Raipole, Siddipet Rural and Siddipet Urban mandals. The shallow water level of 5 to 10 m bgl is noticed in 17% of the area falling in Bejjanki, Cherial, Doultabad, Husnabad, Komuravelli, Kondapak, Maddur and Wargal mandals. There are no water levels of <5 m bgl is noticed in the area during this season (Fig. 2.4).

2.2.3 Post-monsoon Season

During post-monsoon, the majority of the water levels are in the range of 5 to 10 m bgl and noticed in 41% of the area located in Akkannapet, Cherial, Chinnakodur, Doultabad, Husnabad, Jagdevpur, Koheda, Komuravelli, Maddur, Nangnoor, Siddipet Urban and Wargal mandals followed by water levels from 10 to 20 m bgl distributed in 31% of the area falling in Akkannapet, Bejjanki, Chinnakodur, Dubbak, Jagdevpur, Komuravelli, Kondapak, Maddur, Markook, Mirdoddi, Mulug and Siddipet Rural mandals. The deeper water levels >20 m bgl is noticed in 19% of the area in Chinnakodur, Doultabad, Dubbak, Gajwel, Kondapak, Mirdoddi, Mulug and Raipole mandals. The shallow water levels of <5 m bgl (10% of the area) is observed in Bejjanki, Cherial, Husnabad, Komuravelli, Kondapak and Maddur mandals (Fig. 2.5).

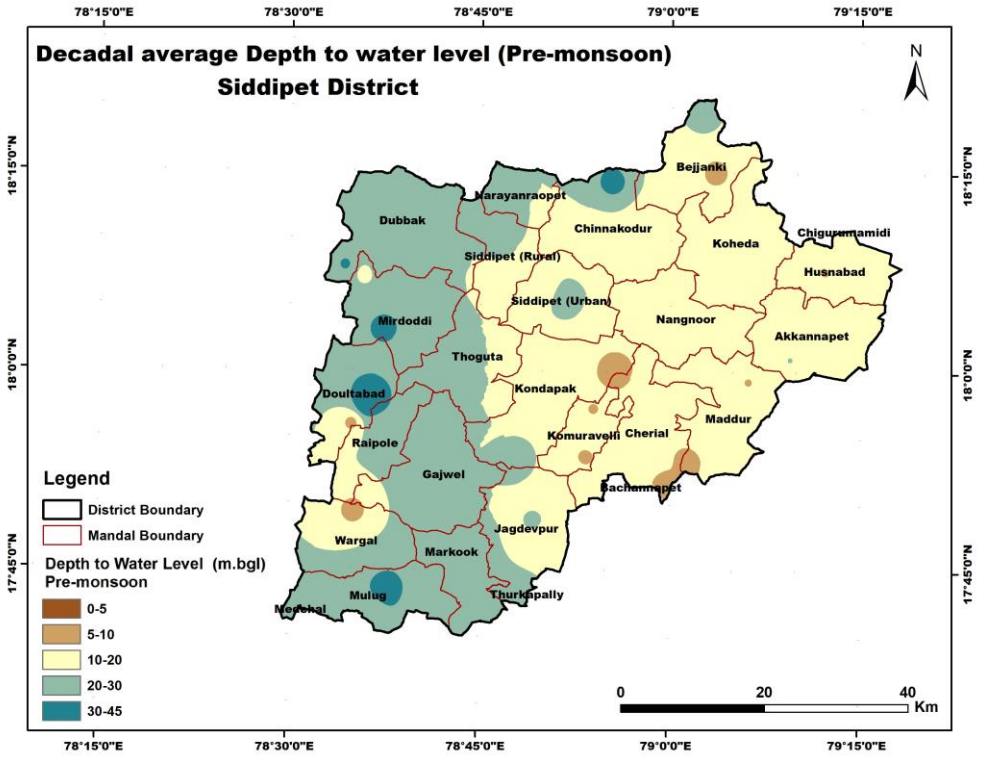

Fig. 2.4: Depth to water levels Pre-monsoon (avg. of 10 years: 2010 to 2019).

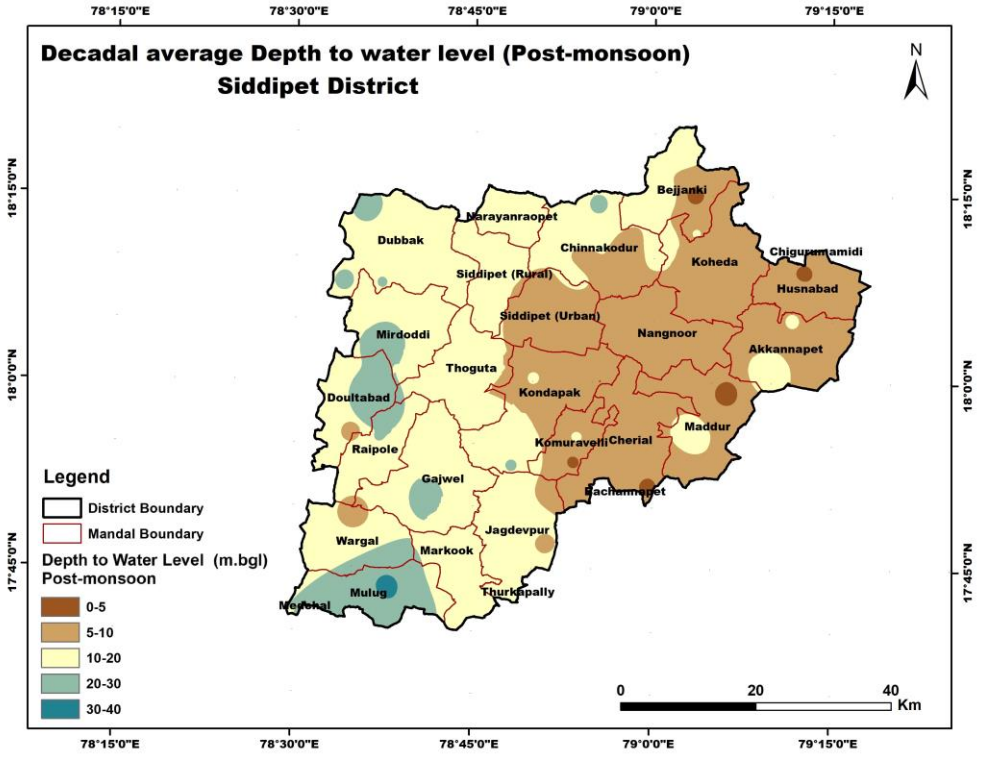

Fig. 2.5: Depth to water levels Post-monsoon (avg. of 10 years: 2010 to 2019).

2.2.4 Water Level Fluctuations (November vs. May)

Almost all wells show Rise in water levels in the range of 0.92 to 13.78 m (in one of the wells in Siddipet (Urban), it is showing rise upto 20.21 m. With respect to the rising in water levels, most of the wells (46% of the area) shows water level rise from 5 to 10 m located in Akkannapet, Bejjanki, Cherial, Chinnakodur, Dubbak, Husnabad, Jagdevpur, Koheda, Komuravelli, Kondapak, Maddur, Markook, Mirdoddi, Nangnoor, Siddipet Rural and Siddipet Urban mandals, followed by 2 to 5 m in 41% of the area located in Akkannapet, Bejjanki, Cherial, Chinnakodur, Dubbak, Gajwel, Husnabad, Jagdevpur, Koheda, Komuravelli, Kondapak, Maddur, Mirdoddi, Mulug, Nangnoor and Raipole mandals. The water level rise between 0 to 2 m (8% of thea area) is noticed in Chinnakodur, Doultabad, Jagdevpur, Mulug and Wargal mandal. In Chinnakodur, Doultabad and Siddipet Urban mandals, the water level rise of 10 to 20 m is noticed in 5% of the area (Fig. 2.6).

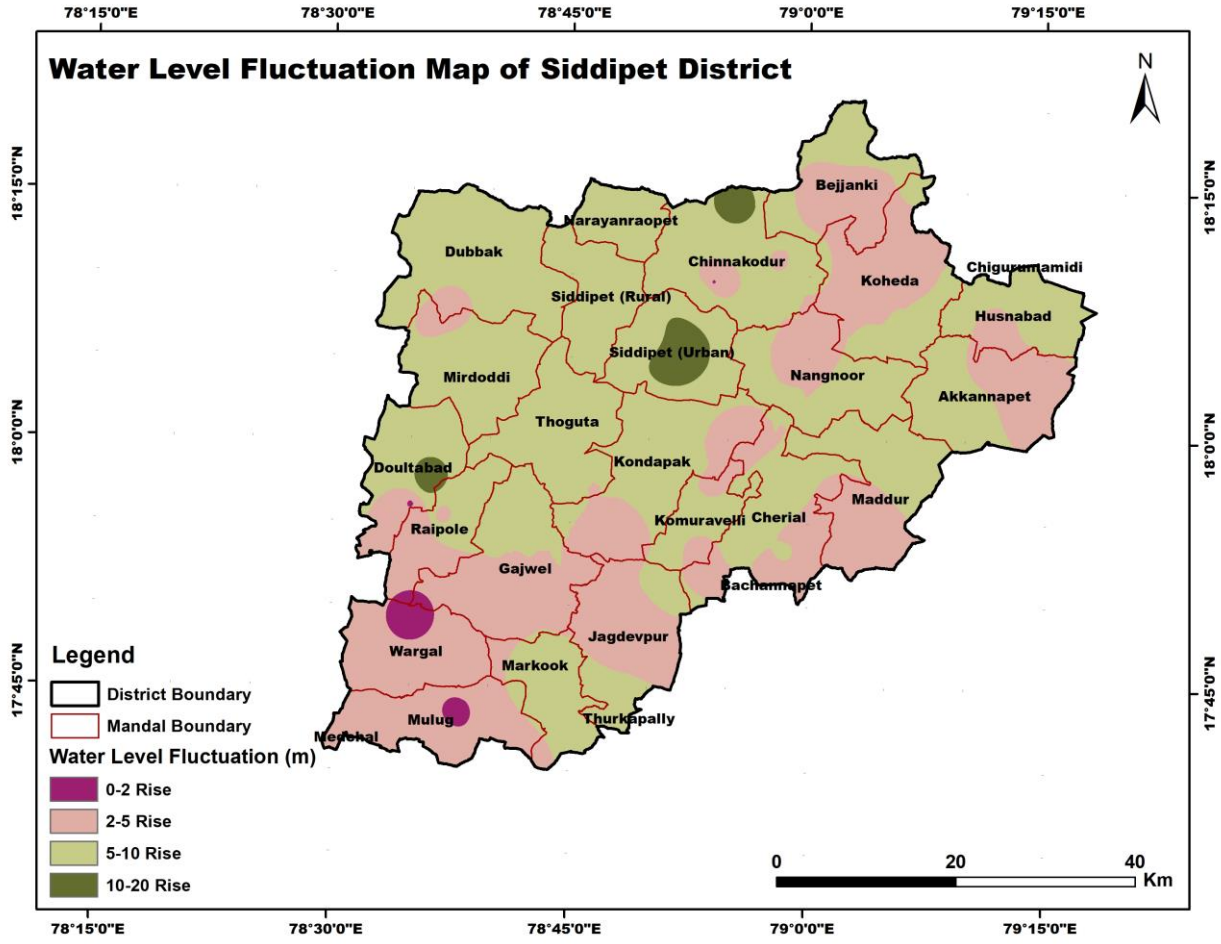

Fig. 2.6: Water Level Fluctuations (m) (Nov vs. May2019).

2.2.5 Long term water level trends (2010-2019)

The trend analysis for last 10 years (2010-2019) is studied from the different hydrograph stations of CGWB and SGWD. During pre-monsoon season, 61% of the area shows rising trend ranging from 0.02 to 2.17 m/yr (Akkannapet, Bejjanki, Chinnakodur, Doultabad, Dubbak, Gajwel, Husnabad, Jagdevpur, Koheda, Komuravelli, Mirdoddi, Mulug, Nangnoor, Siddipet Rural, Siddipet Urban and Wargal mandals) and in remaining 39% of the area show falling trend in the range of -0.02 to -2.11 m/yr (Akkannapet, Bejjanki, Chinnakodur, Dubbak, Husnabad, Jagdevpur, Koheda, Kondapak, Maddur, Mirdoddi, Mulug, Nangnoor, Raipole and Siddipet Rural mandals) (Fig. 2.7). Whereas, during post-monsoon season, 98% of the area is showing rising trend ranging from 0.07 to 3.61 m/yr which is noticed in Akkannapet, Bejjanki, Chinnakodur, Doultabad, Dubbak, Gajwel, Husnabad, Jagdevpur, Koheda, Komuravelli, Kondapak, Maddur, Mirdoddi, Mulug, Nangnoor, Raipole, Siddipet Rural, Siddipet Urban and Wargal mandals and in remaining 2% of the area, it is showing the falling trend (-0.79 m/yr) observed in Mulug mandal (Fig. 2.8).

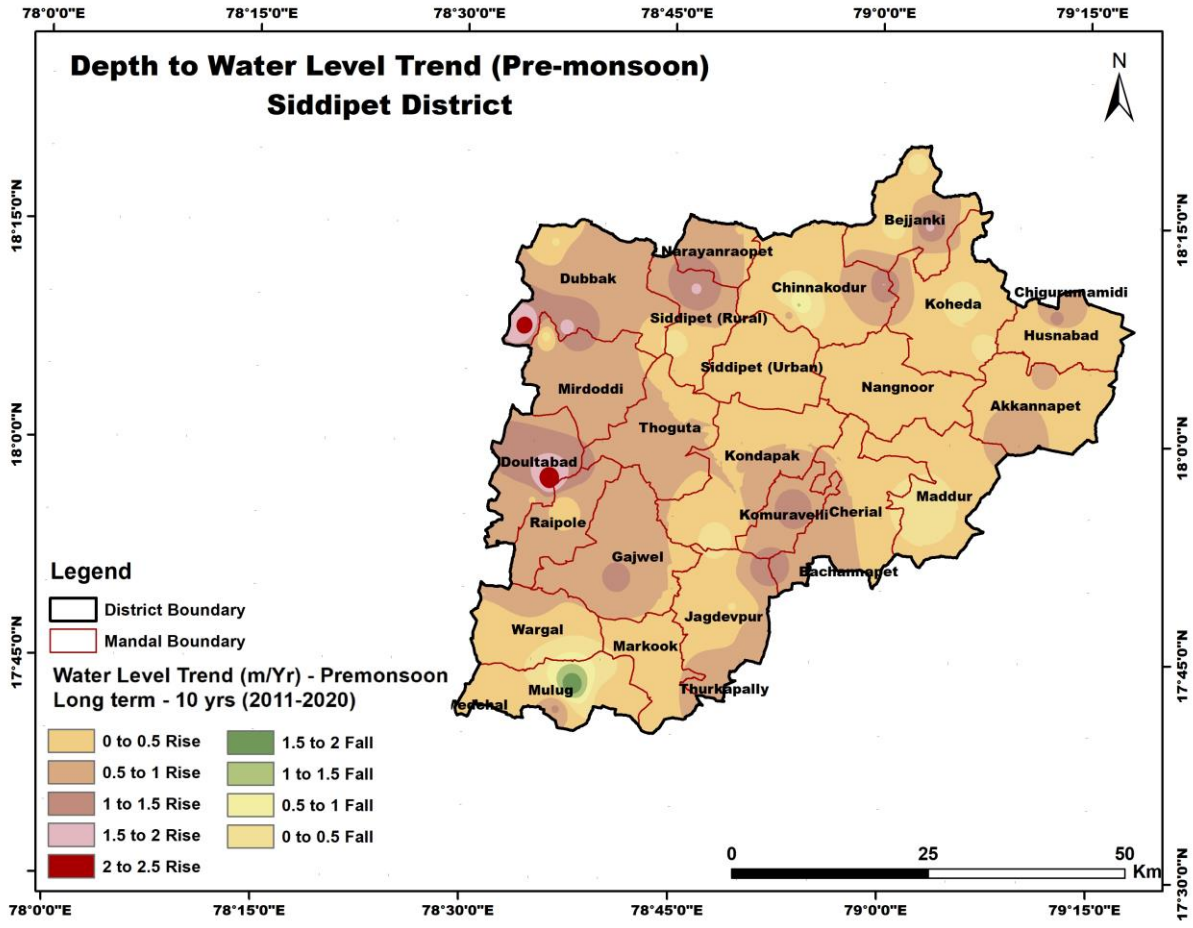

Fig. 2.7: Long-term water level trends (Pre-monsoon 2010-19).

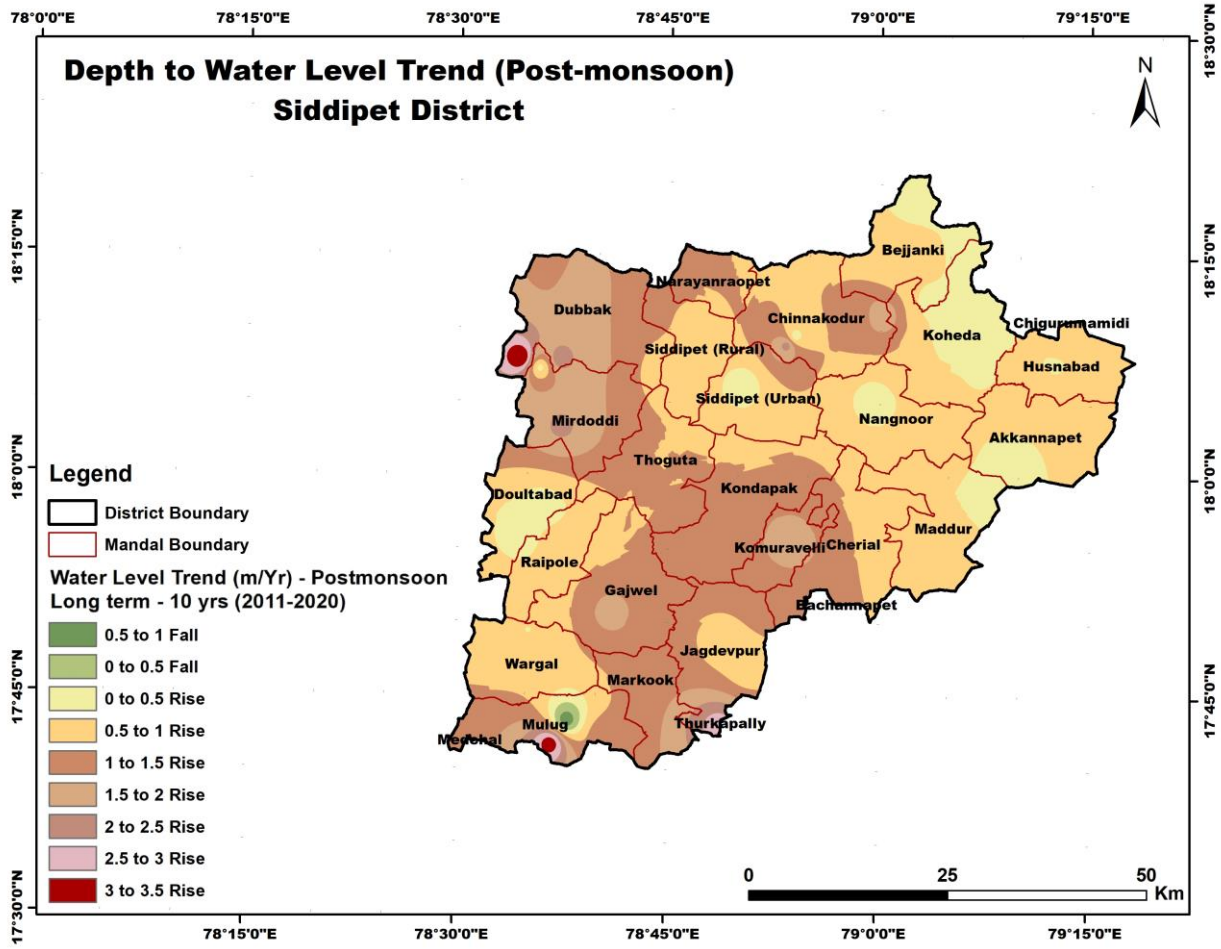

Fig. 2.8: Long-term water level trends (Post-monsoon2010-19).

2.3 Geophysical Studies

The analysis of VES data reveal that the resistivity is <30 Ohm (Ω) m for highly weathered, 30-60 Ωm for underlying semi weathered, between 60 to 375 Ωm for fractured and >350 Ωm for massive formations.

2.4 Hydro-chemical Studies

To understand chemical quality of groundwater, water samples in the year 2019 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

Groundwater from the area is mildly alkaline in nature with pH in the range of 7.41 to 9.25 (avg. 8.41). The Electrical conductivity varies from 310 to 2420 µ Siemens/cm (avg. 978 µ Siemens/cm). In about 86% of the samples from Akkannapet, Bejjanki, Cherial, Chinnakodur, Doultabad, Dubbak, Gajwel, Husnabad, Jagdevpur, Koheda, Komuravelli, Kondapak, Maddur, Mirdoddi, Mulug, Nangnoor, Raipole, Siddipet Rural, Siddipet Urban and Wargal mandals the EC is within 1500 µ Siemens/cm, while in 14% of the samples from Akkannapet, Bejjanki, Cherial, Chinnakodur, Husnabad and Koheda mandals it is in the range of 1500-3000 µ Siemens/cm. In none of the samples, the EC of >3000 µ Siemens/cm is observed (Fig. 2.9). The concentration of TDS varies from 198 to 1549 mg/l (avg. 622 mg/l) and found that in all the samples, it falls within maximum permissible limits of BIS (<2000 mg/l) (Akkannapet, Bejjanki, Cherial, Chinnakodur, Doultabad, Dubbak, Gajwel, Husnabad, Jagdevpur, Koheda, Komuravelli, Kondapak, Maddur, Mirdoddi, Mulug, Nangnoor, Raipole, Siddipet Rural, Siddipet Urban and Wargal mandals). The NO_3 concentration ranges from 2 to 350 mg/l (avg. 72 mg/l) and noticed that in about 49% of the samples from Akkannapet, Bejjanki, Chinnakodur, Doultabad, Dubbak, Jagdevpur, Koheda, Komuravelli, Kondapak, Maddur, Mirdoddi, Mulug, Nangnoor, Raipole, Siddipet Rural and Siddipet Urban mandals is falling within the permissible limits of <45 mg/l and in about 51% of the samples from Akkannapet, Bejjanki, Cherial, Chinnakodur, Doultabad, Dubbak, Gajwel, Husnabad, Jagdevpur, Koheda, Komuravelli, Maddur, Mulug, Nangnoor, Siddipet Rural and Wargal mandals, the quality is not suitable for drinking water purpose (>45 mg/l) (Fig. 2.10). The Fluoride concentration varies from 0.33 to 6.62 mg/l (avg. 1.59 mg/l) and in 71% of the samples, it is within the permissible limit of <1.5 mg/l (Akkannapet, Bejjanki, Cherial, Chinnakodur, Doultabad, Dubbak, Husnabad, Jagdevpur, Komuravelli, Kondapak, Maddur, Mirdoddi, Nangnoor, Raipole, Siddipet Rural and Wargal mandals) and in remaining 29% of the samples, it is beyond permissible limit of >1.5 mg/l (Bejjanki, Cherial, Gajwel, Jagdevpur, Koheda, Kondapak, Maddur, Mulug, Nangnoor, Siddipet Rural and Siddipet Urban mandals) and not suitable for drinking water purpose (Fig. 2.11).

2.4.2 Post-monsoon

Groundwater from the area is mildly alkaline in nature with pH in the range of 6.4 to 8.71 (avg. 7.82 mg/l). The Electrical conductivity varies from 302 to 2428 µ Siemens/cm (avg. 911 µ Siemens/cm). In 87% of the samples from Cherial, Chinnakodur, Doultabad, Dubbak, Husnabad, Jagdevpur, Komuravelli, Kondapak, Maddur, Mirdoddi, Mulug, Nangnoor, Raipole, Siddipet Rural, Siddipet Urban and Wargal mandals, the EC is within 1500 µ

Siemens/cm while in 13% of the samples from Dubbak, Husnabad, Komuravelli, Mirdoddi and Nangnoor 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. 2.12). The concentration of TDS varies from 193 to 1554 mg/l (avg. 589 mg/l). In all the samples from Cherial, Chinnakodur, Doultabad, Dubbak, Husnabad, Jagdevpur, Komuravelli, Kondapak, Maddur, Mirdoddi, Mulug, Nangnoor, Raipole, Siddipet Rural, Siddipet Urban and Wargal mandals it is within the maximum permissible limits of BIS (<2000 mg/l). The NO_3 concentration ranges from 2.74 to 273 mg/l (avg. 65 mg/l). It is noticed that in about 56% of the samples from Cherial, Chinnakodur, Dubbak, Husnabad, Jagdevpur, Komuravelli, Kondapak, Maddur, Mirdoddi, Mulug, Nangnoor, Siddipet Rural and Wargal mandals it is within the permissible limit (<45 mg/l) while in 44% of the samples from Cherial, Chinnakodur, Doultabad, Dubbak, Husnabad, Jagdevpur, Mirdoddi, Nangnoor, Raipole, Siddipet Rural and Siddipet Urban 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 0.12 to 2.51 mg/l (avg. 0.91 mg/l). In about 87% of the samples, it is falling within permissible limit of <1.5 mg/l (Cherial, Chinnakodur, Doultabad, Dubbak, Husnabad, Jagdevpur, Komuravelli, Kondapak, Maddur, Mirdoddi, Mulug, Nangnoor, Raipole, Siddipet Rural and Wargal mandals) while in 13% of the samples from Cherial, Chinnakodur, Mulug, Nangnoor, Siddipet Rural and Siddipet Urban mandals are having high fluoride concentration beyond permissible limits (>1.5 mg/l) and are not suitable for drinking water purpose (Fig. 2.14).

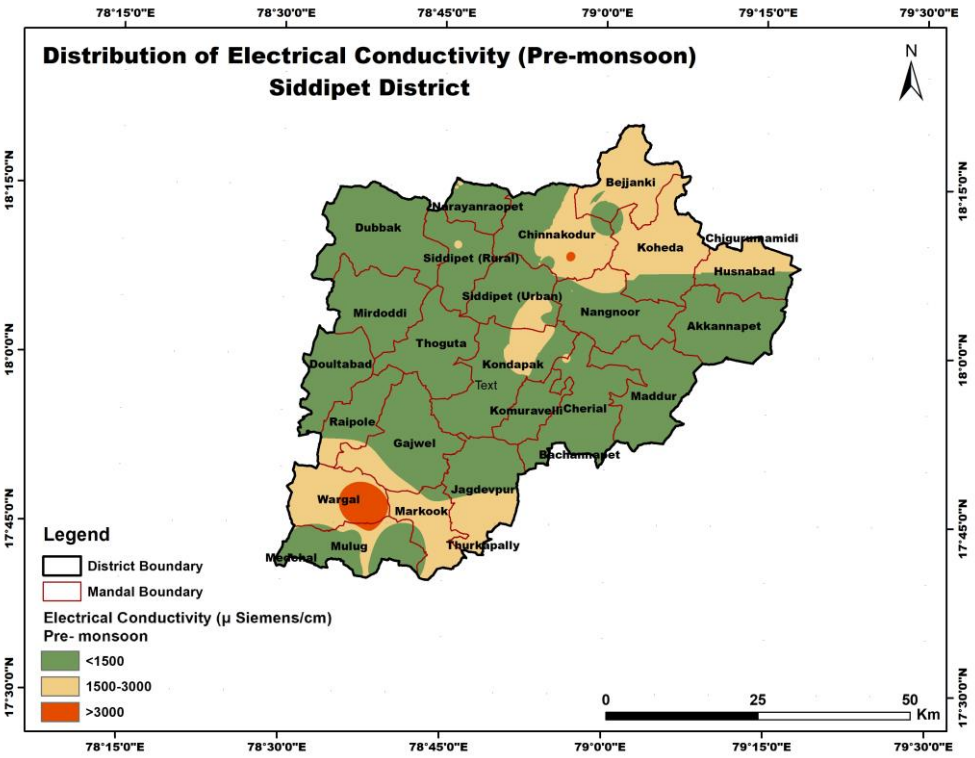

Fig. 2.9: Distribution of Electrical conductivity (Pre-monsoon 2019).

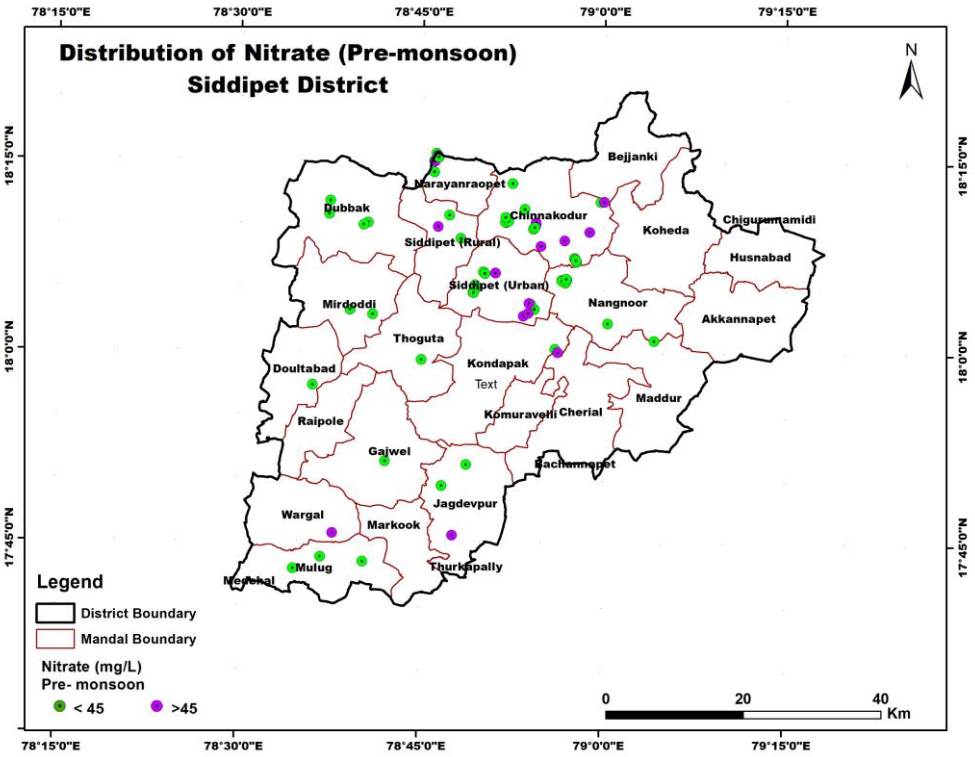

Fig. 2.10: Distribution of Nitrate (Pre-monsoon 2019).

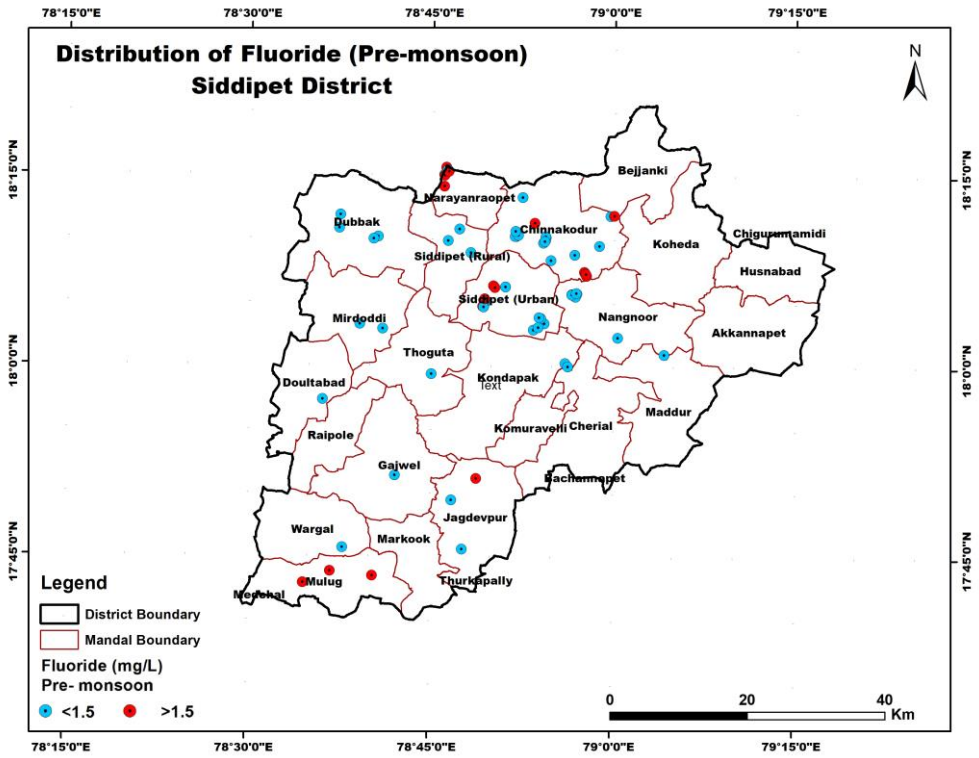

Fig. 2.11: Distribution of Fluoride (Pre-monsoon 2019).

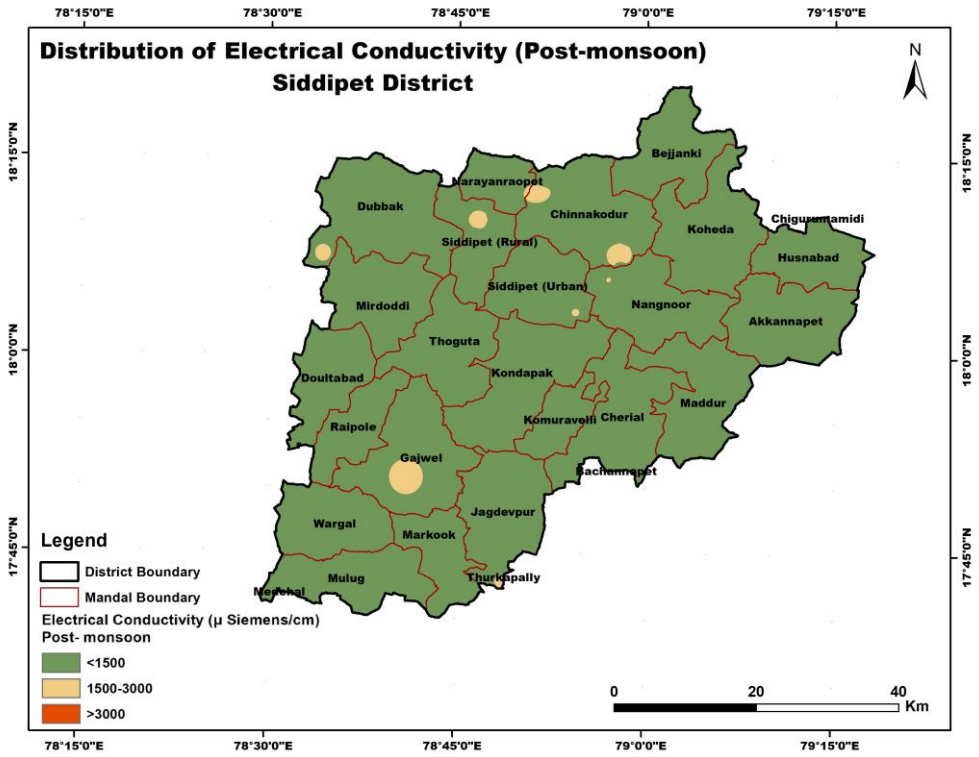

Fig. 2.12: Distribution of Electrical conductivity (Post-monsoon 2019).

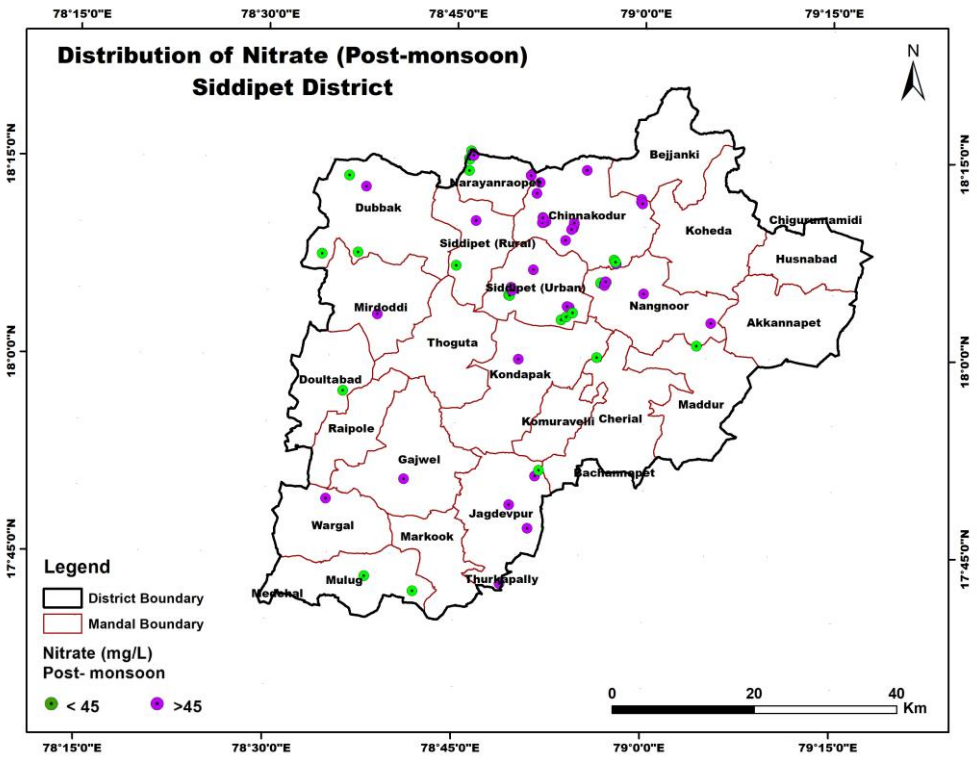

Fig. 2.13: Distribution of Nitrate (Post-monsoon 2019).

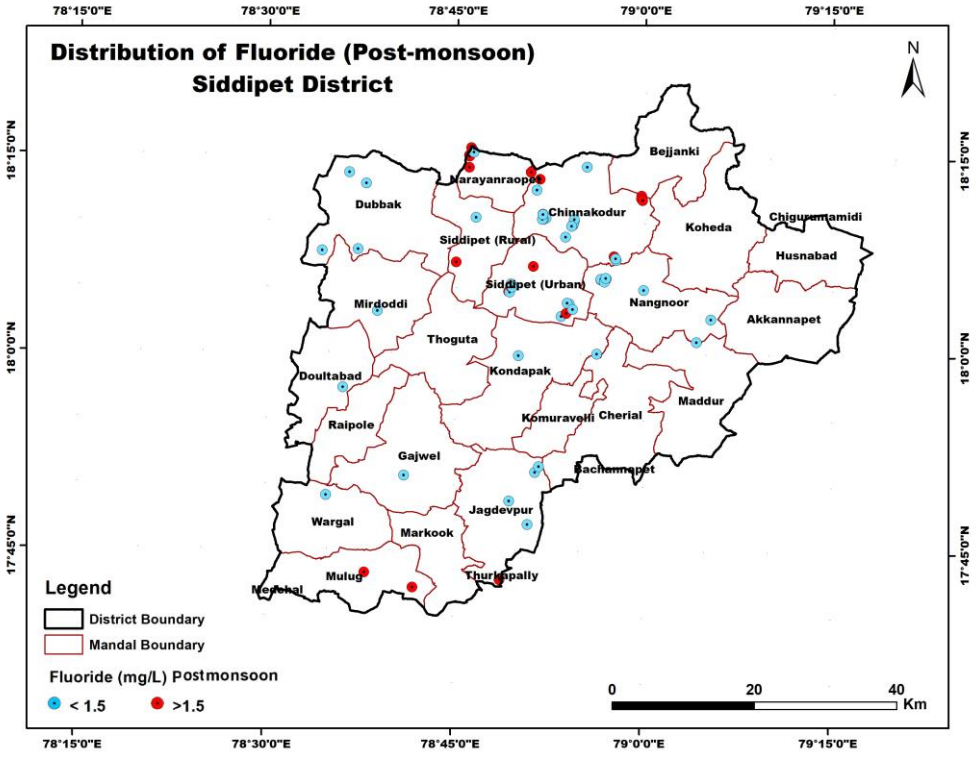

Fig. 2.14: Distribution of Fluoride (Post-monsoon 2019).

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

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

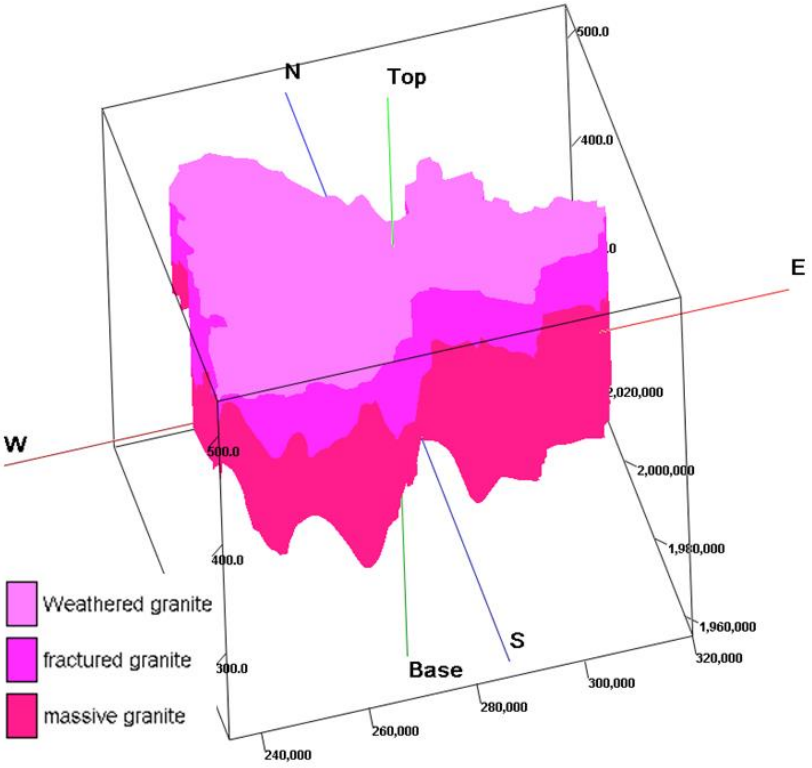

Fig. 3.1: 3D Model.

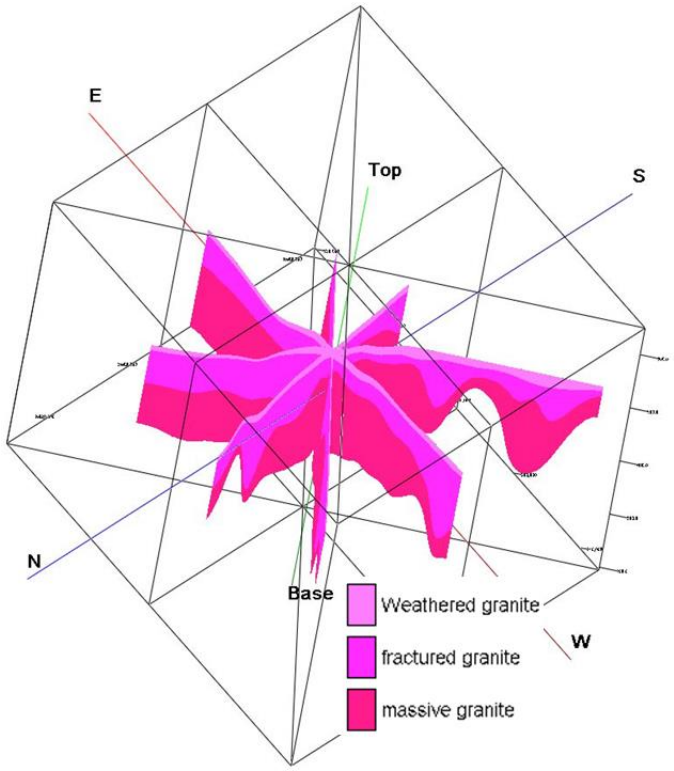

Fig. 3.2: Panel Diagram.

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 is rangs from 2 to 38 m bgl. The weathering thickness >20 m bgl is observed in Akkannapet, Bejjanki, Cherial, Dowlatabad, Dubbak, Gajwel, Husnabad, Jagadevpur, Koheda, Kondapak, Markook, Mirdoddi, Mulugu, Siddipet Urban, Thoguta and Wargal mandals. The fractured zone is ranging from 2.67 to 198 m bgl with the yield rangs from <1 to 18.55 lps with an average of 2 lps. About 72% of the fractures were encountered within 100 m bgl depth noticed in Bejjanki, Cherial, Chinnakodur, Dowlatabad, Dubbak, Gajwel, Jagadevpur, Koheda, Kondapak, Maddur, Mirdoddi, Mulugu, Nanganur, Siddipet Rural, Siddipet Urban, Thoguta and Wargal mandals. The deeper fractures beyond 100 m bgl (28%) are encountered in Cherial, Chinnakodur, Dowlatabad, Dubbak, Gajwel, Jagadevpur, Kondapak, Maddur, Mirdoddi, Mulugu, Nanganur, Siddipet Urban, Thoguta and Wargal mandals.

3.2 Hydrogeological Sections

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

3.2.1 NE-SW Section (a)

The section drawn along the NE-SW direction covering distance of ~85 kms. It depicts uniform weathered zone throughout the section. The thickness of fractured zone is more between 0 and 45 km and 58 to 85 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 ~60 kms. It depicts a uniform weathered zone. The thick fractured zone is noticed between the distance of 0 to 25 kms and 45 to 60 kms (Fig. 3.3b).

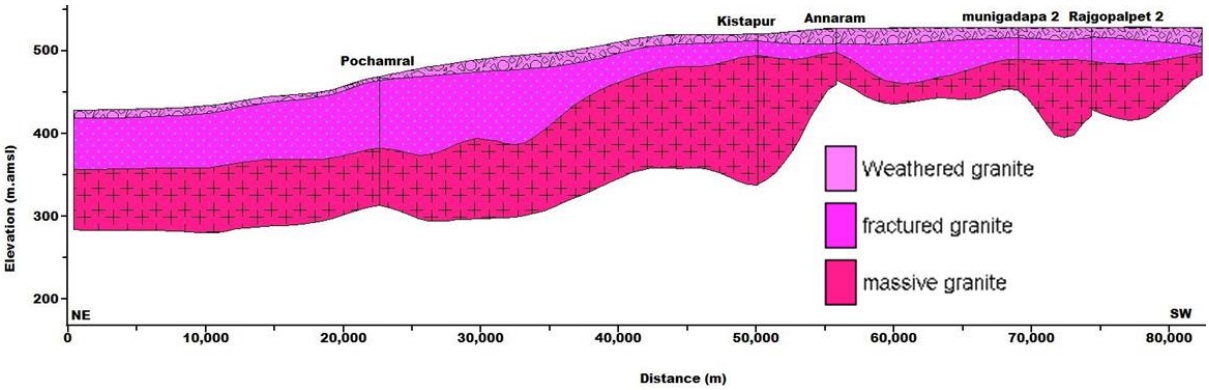

Fig. 3.3(a): E-W Section.

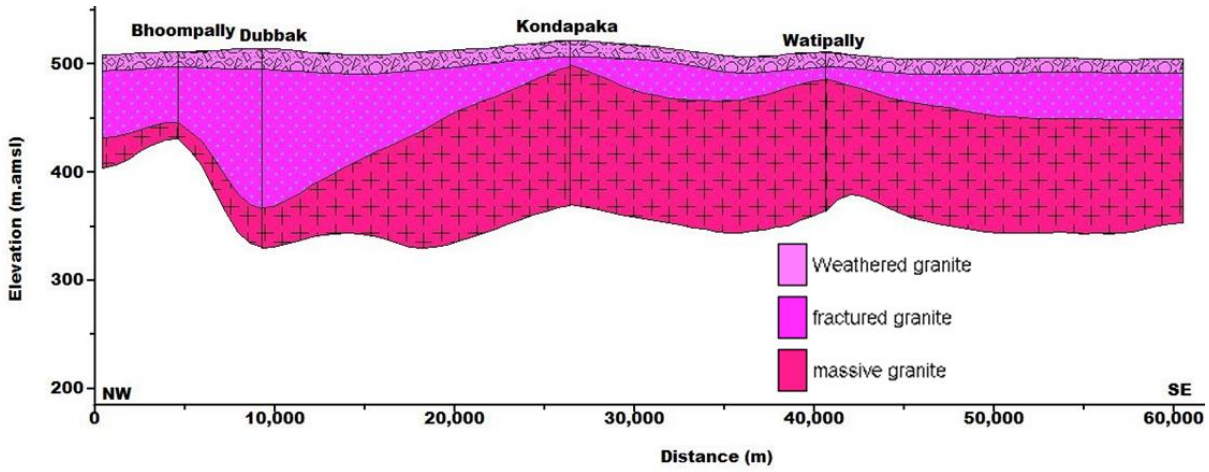

Fig. 3.3(b): N-S Section.

Fig.3.3: Hydrogeological sections along different directions.

3.3 Aquifer Characterization

3.3.1 Weathered zone

The 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 2 to 38 m bgl. In majority of the district (51% of the area), the depth of weathering is between 10 to 20 m bgl and is mostly observed in Akkannapet, Bejjanki, Cherial, Chinnakodur, Dowlatabad, Dubbak, Gajwel, Husnabad, Jagadevpur, Koheda, Kondapak, Maddur, Mirdoddi, Mulugu, Nanganur, Siddipet Rural, Siddipet Urban, Thoguta and Wargal mandals, while the depth of weathering ranging <10 m bgl (29% of the area) is observed in Akkannapet, Bejjanki, Cherial, Chinnakodur, Dowlatabad, Dubbak, Gajwel, Husnabad, Koheda, Kondapak, Mulugu, Nanganur, Siddipet Urban, Thoguta and Wargal mandals. The weathering depth >20 m bgl (20% of the area) is noticed in Akkannapet, Bejjanki, Cherial, Dowlatabad, Dubbak, Gajwel, Husnabad, Jagadevpur, Koheda, Kondapak, Markook, Mirdoddi, Mulugu, Siddipet Urban, Thoguta and Wargal mandals (Fig. 3.4 and Fig. 3.5). The transmissivity varies from 1 to 30 m^2/day with average of 7 m^2/day. The specific yield varies from 1 to 3 with average of 2.

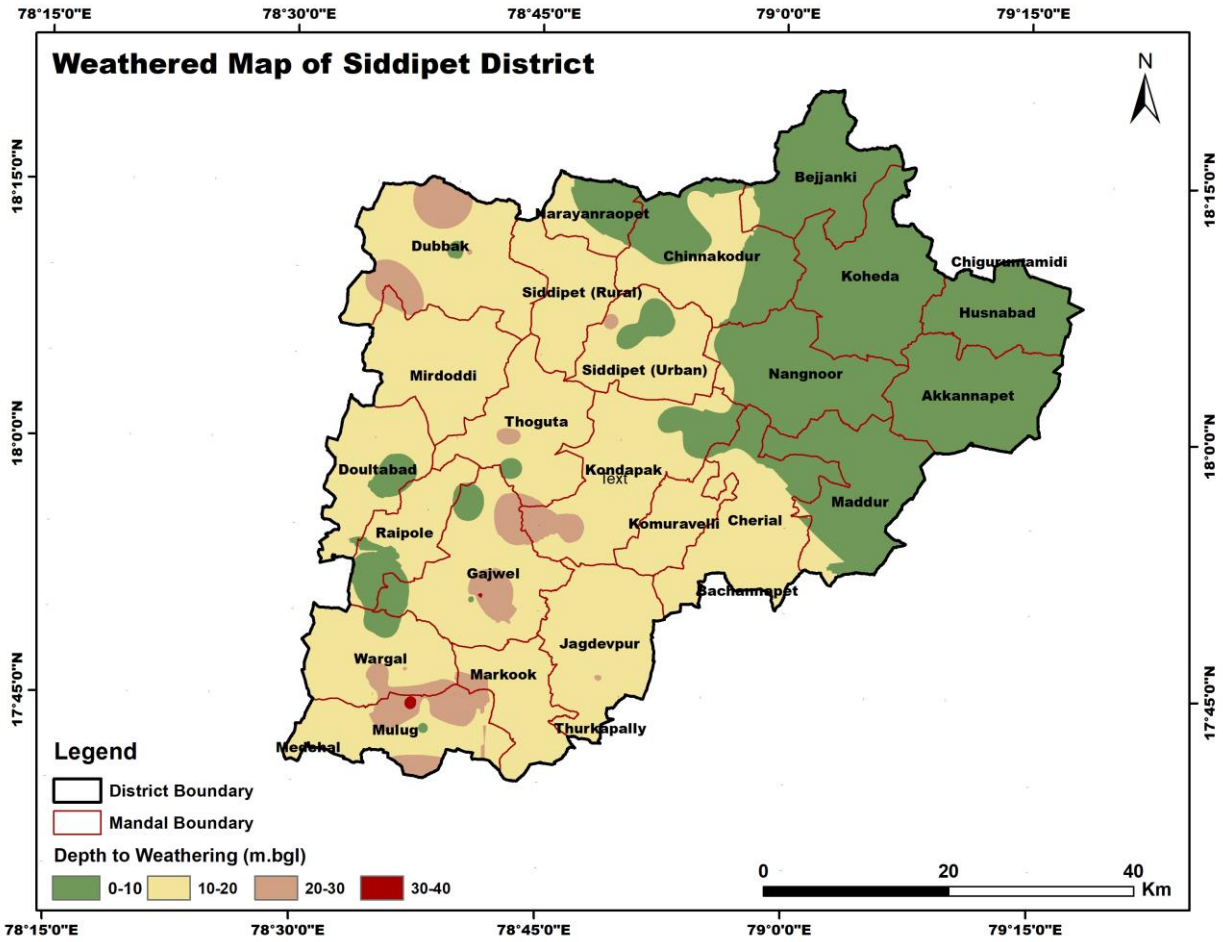

Fig. 3.4: Thickness of Weathered zone.

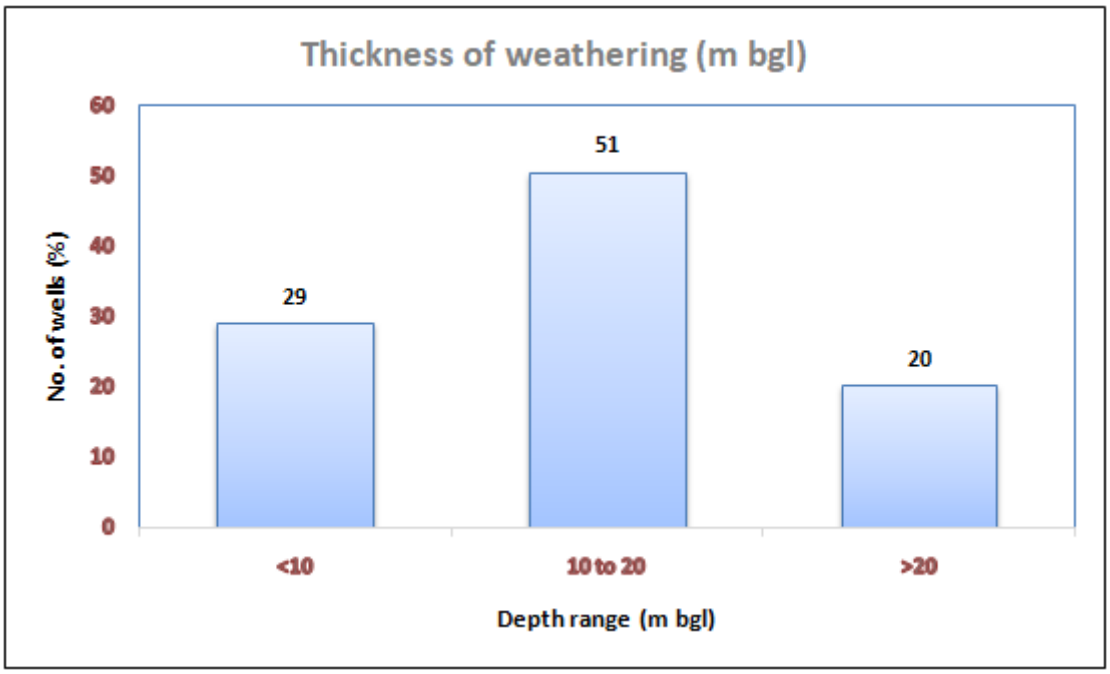

Fig. 3.5: Depth wise distribution of weathering zone.

3.3.2 Fractured zone

Groundwater is extracted mainly through bore wells tapping fractured zone till to the depth 200 m bgl. Based on CGWB and SGWD exploration data, it is inferred that 40% of the fractures occur within 30 m bgl with yield ranging from 0.08 to 7 lps observed at Bejjanki, Cherial, Chinnakodur, Dowlatabad, Gajwel, Kondapak, Maddur, Mulugu, Nanganur, Siddipet Rural, Siddipet Urban, Thoguta and Wargal mandals. About 26% of the fractures occur within depth range of 30 to 60 m bgl with yields varying from 0.07 to 10 lps and are observed at Bejjanki, Cherial, Chinnakodur, Dubbak, Gajwel, Jagadevpur, Koheda, Kondapak, Maddur, Mirdoddi, Nanganur, Siddipet Urban and Wargal mandals. About 6% of the fractures occurring within the depth range of 60 to 100 m bgl with yield varying from 0.7 to 18.5 lps (Cherial, Dowlatabad, Dubbak, Nanganur and Thoguta mandals). About 28% of the fractures have occurred beyond 100 m bgl with yield varying 0.08 to 18.55 lps (Cherial, Chinnakodur, Dowlatabad, Dubbak, Gajwel, Jagadevpur, Kondapak, Maddur, Mirdoddi, Mulugu, Nanganur, Siddipet Urban, Thoguta and Wargal mandals) (Fig. 3.6). The deepest fracture tapped at the depth of 198 m bgl is observed in Chinnakodur mandal. Over all, the yield varies from 0.078 to 18.55 lps in the terrain with an average of 2 lps. The Transmissivity varies up to 68 m^2/day. The Storativity varies up to 0.0812. From the fracture analysis, it is revealed that the most potential fractres were notied within 100 m bgl and it is also noticed that further exploitation also continued beyond 100 m bgl.

The yield wise data analysis shows that in about 57% of the wells, the yield is <1 lps (Bejjanki, Cherial, Chinnakodur, Dowlatabad, Dubbak, Gajwel, Jagadevpur, Kondapak, Maddur, Mirdoddi, Mulugu, Nanganur, Siddipet Rural, Siddipet Urban, Thoguta and Wargal mandals) while in 10% each of the wells, the yield is ranges from 1 to 2 lps (Bejjanki, Gajwel, Mirdoddi and Nanganur mandals). In about 18% of the wells, the yield is ranges from 2 to 3 lps (Bejjanki, Cherial, Dowlatabad, Jagadevpur, Koheda, Mulugu, Nanganur and Siddipet Urban mandal) and in 15% of the wells, the yield is >3 lps (up to 18.55 lps) noticed in Bejjanki, Cherial, Dubbak, Maddur and Nanganur mandals (Fig. 3.7).

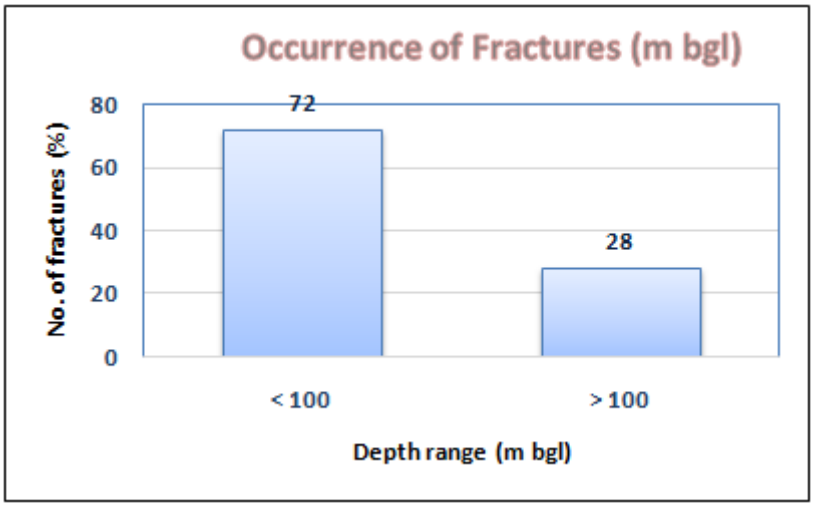

Fig. 3.6: Depth of Fractured zone.

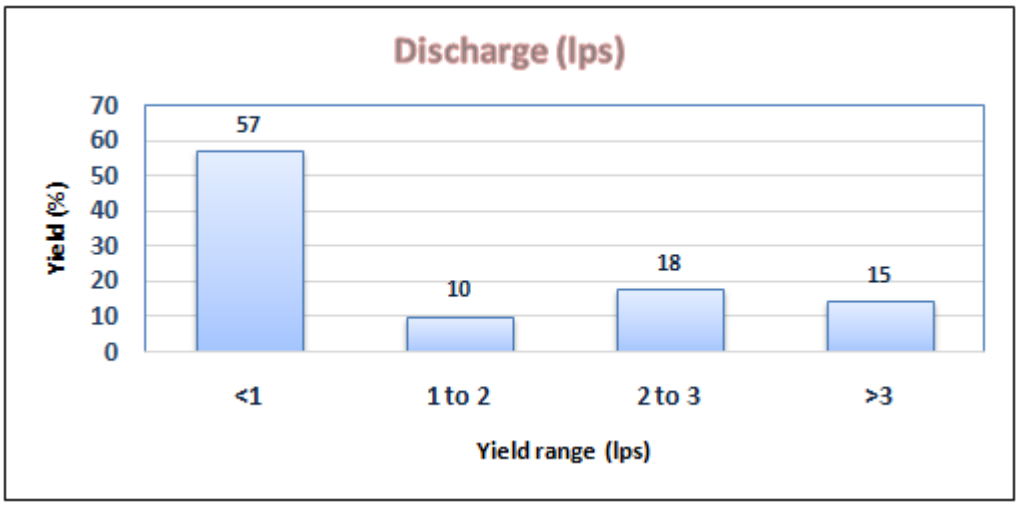

Fig. 3.7: Yield wise data analysis.

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 methodology (Table 4.1).

As per GEC 2020 report, the net dynamic replenishable ground water availability for newly formed Siddipet district is 518 MCM, gross ground water draft for all uses 340 MCM, provision for drinking and industrial use for the year 2025 is 36 MCM and net annual ground water potential available for future irrigation needs is 154 MCM.

Out of 23 mandals, 15 mandals are falling under **Safe** (Gajwel (53%), Siddipet Rural (53%), Nanganur (54%), Thoguta (56%), Bejjanki (58%), Chinnakodur (59%), Doulthabad (59%), Siddipet Urban (61%), Husnabad (62%), Mulugu (62%), Jagdevpur (63%), Narayanraopet (63%), Akkannapet (64%), Cherial (64%) and Kondapak (69%)) and the remaining 8 mandals falling under **Semi-Critical** (Markook (70%), Raipole (74%), Maddur (75%), Wargal (76%), Koheda (78%), Mirdoddi (81%), Dubbak (82%) and Komuravelly (83%)) (Fig. 4.1). The overall average stage of ground water extraction in the district is 64% falling under Safe category.

Table 4.1: Computed dynamic ground water resources.

Parameters	Resources (GEC 2020) in MCM
Dynamic (Net GWR Availability)	518
• Monsoon recharge from rainfall	237
• Monsoon recharge from other sources	104
• Non-Monsoon recharge from rainfall	43
• Non-monsoon recharge from other sources	162
• Natural Discharge	27
Gross Recharge	546
Gross GW Draft	
• Irrigation	329
• Domestic and Industrial use	11
Provision for Drinking and Industrial use for the year 2025	36
Net GW availability for future irrigation	154
Average Stage of GW extraction (%)	64 (Safe)
Categorization of mandals	**Safe: 15 and Semi-Critical: 8** **Safe:** Gajwel (53%), Siddipet Rural (53%), Nanganur (54%), Thoguta (56%), Bejjanki (58%), Chinnakodur (59%), Doulthabad (59%), Siddipet Urban (61%), Husnabad (62%), Mulugu (62%), Jagdevpur (63%), Narayanraopet (63%), Akkannapet (64%), Cherial (64%) and Kondapak (69%) **Semi-Critical:** (Markook (70%), Raipole (74%), Maddur (75%), Wargal (76%), Koheda (78%), Mirdoddi (81%), Dubbak (82%) and Komuravelly (83%)

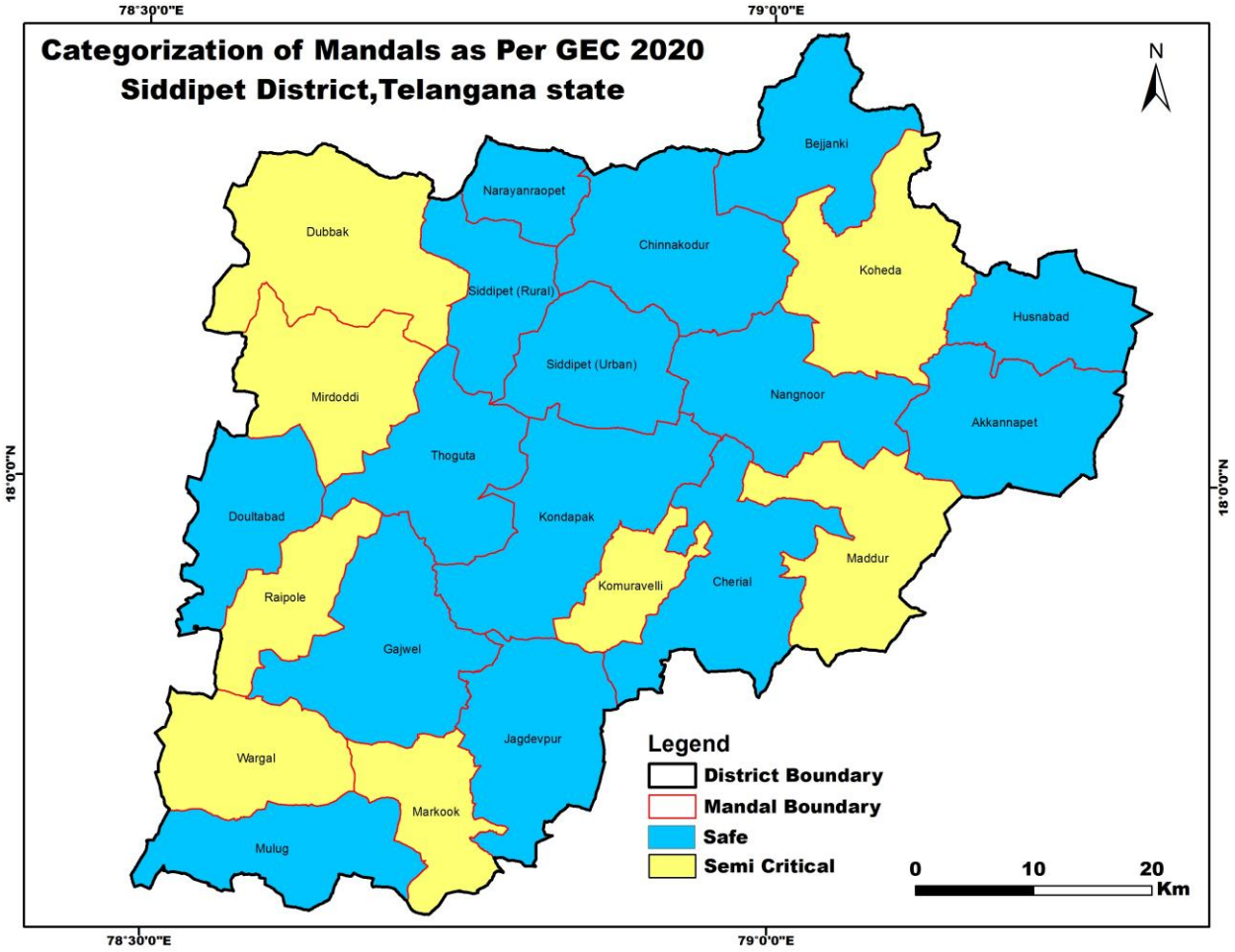

Fig. 4.1: Categorization of mandals based on GEC 2020.

5. GROUND WATER RELATED ISSUES AND REASONS FOR ISSUES

5.1 Issues

Over-exploitation

- 1658 km^2 area (46% of area) covering 218 villages are categorized as over-exploited where ground water balance for future irrigation is negligible or nil.

Pollution (Geogenic and Anthropogenic)

- Few mandals are fluorosis endemic where fluoride (geogenic) in ground water is as high as 6.62 mg/l during pre-monsoon and 2.51 mg/l during post-monsoon season. The high fluoride concentration (>1.5 mg/l) occur in 29% of samples and 13% of samples respectively during pre and post-monsoon season of the year 2019.
- High nitrate (>45 mg/l) due to anthropogenic activities is observed in 51% of the samples and 44% of the samples during pre and post-monsoon season respectively.

Deep water levels

- Deep water levels (>20 m bgl) are observed during pre-monsoon season in 34% of the area and it 19% during post-monsoon season.

Sustainability

- Low yield (<1 lps) occurs in 57% of the exploratory wells covering in Bejjanki, Cherial, Chinnakodur, Dowlatabad, Dubbak, Gajwel, Jagadevpur, Kondapak, Maddur, Mirdoddi, Mulugu, Nanganur, Siddipet Rural, Siddipet Urban, Thoguta and Wargal mandals 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.
- Change in land use from agricultural land to residential purposes and cropping pattern from traditional crops to cash crops (cotton and paddy) is observed.
- In non-command area, the paddy crop grown during rabi season is completely dependent on ground water which leads to heavy withdrawal of ground water during non-monsoon period.

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.

Deep water levels

- Over-extraction for paddy cultivation during rabi season leads to more ground water extraction in proportion to recharge, limited artificial measures and low rainfall etc., are the causes of deeper water levels in the area.

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, 18712 MCM of unsaturated volume (below the depth of 5 m) is available during post-monsoon, having 374 MCM of recharge potential and 72 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 3635 minor irrigation tanks, 1564 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 Manjira River at Singur (Segment-8, 9 and 10A) 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 import will be 38 MCM (drinking and industrial needs) and this imported water from surface sources will reduce the present utilized 22 MCM of groundwater (considering 60 lpcd). This can be effectively utilized to irrigate 3694 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 2017 are considered. Potential surface run off is estimated by following standard procedures. On conservative side 25% 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.

The pre-monsoon groundwater quality is considered for categorising contaminated area (F >1.5 mg/l & EC >3,000 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 followed by Priority-2. A detailed hydrogeological characteristic along with its category is prepared for the state. Based on this, the district is falling under 7 categories (category-1, category-2, category-3, category-4, category-5, category-7 and category-8) (Table 6.1).

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.

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

- Based on the village wise GEC 2020 estimates an area consisting of 218 villages having 1658 km^2 covered under Priority-1, where 159 MCM recharge potential and 45 MCM utilizable yield (uncommitted run-off) is available and immediate intervention is required where in some of the villages, the stage of groundwater development is >100%. The area identified under Priority-1 on the basis of prioritization based on quality criteria is given in Fig. 6.1 and Annexure-1.
- About 1027 artificial recharge structures were constructed (PTs: 588, CDs: 439) in 167 villages with existing storage capacity of 25 MCM.
- About 164 artificial recharge structures are proposed (82 mini PT's with 1.5 fillings with a unit cost of Rs. 20 lakhs each and 82 CD's with recharge shafts with 6 fillings with a unit cost of Rs. 15 lakhs each) with a total cost of 29 Crores can be taken up.
- After effective utilization of this yield, there will be 4.31 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 <100%)

- Area consisting of 166 villages having 1981 km^2 covered under Priority-2, where 216 MCM recharge potential and 57 MCM utilizable yield (uncommitted run-off) is available and immediate intervention is required. The area identified under Priority-2 on the basis of prioritization based on quality criteria is given in Fig. 6.1 and Annexure-2.
- About 870 artificial recharge structures were constructed (PTs: 447, CDs: 423) in 129 villages with existing storage capacity of 22 MCM.
- Artificial recharge structures are recommended for 50% of the utilizable yield in the intermittent areas.
- About 181 artificial recharge structures are proposed (109 mini PT's with 1.5 fillings with a unit cost of Rs 20 lakhs each and 72 CD's with recharge shafts with 6 fillings with a unit cost of Rs. 15 lakhs each) with a total cost of 32.6 Crores can be taken up.
- After effective utilization of this yield, there will be 4.17 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 7680 farm ponds are recommended (20 in each village in 600 villages) at Rs 25,000/- each with total cost of 19 Crores, this can create an additional storage of 2.3 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.

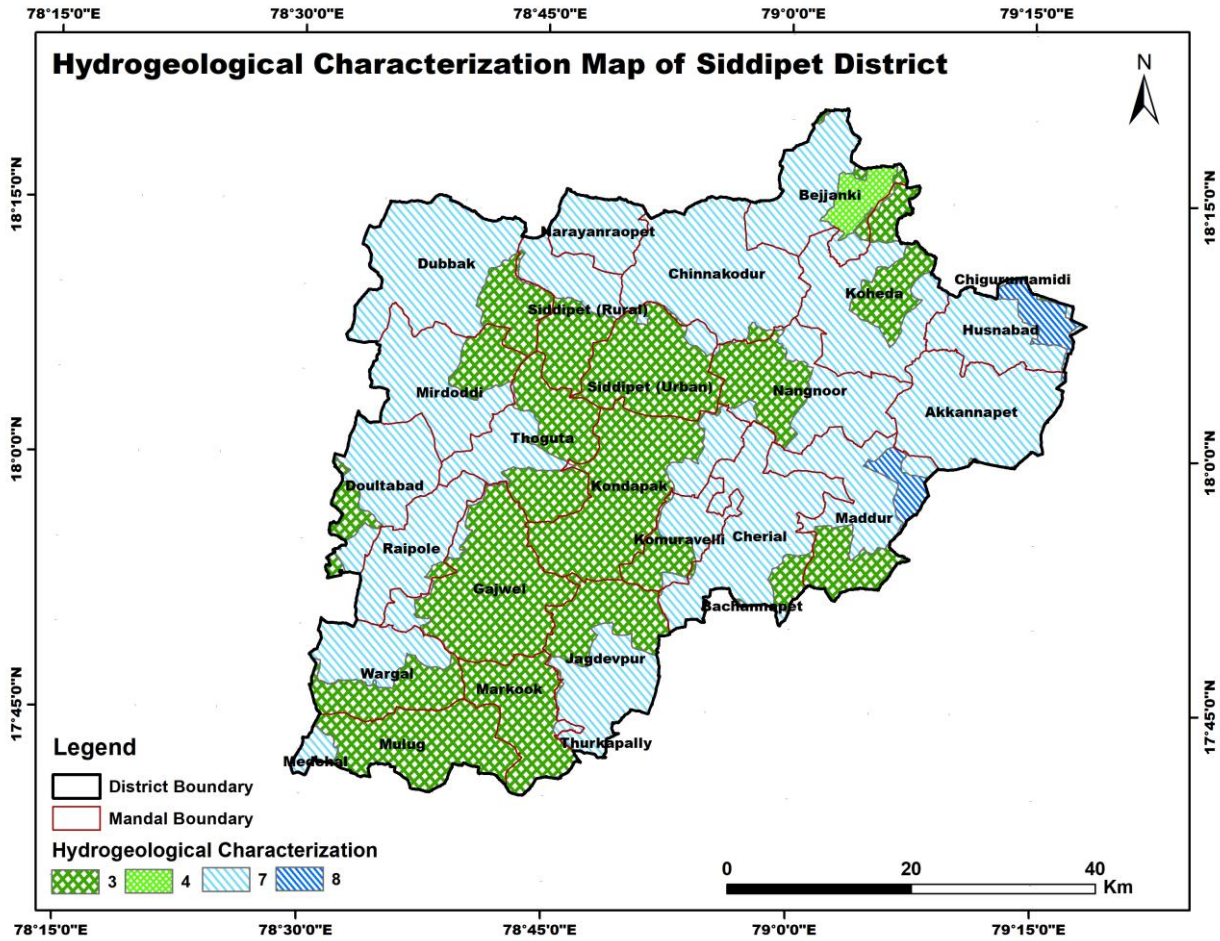

Fig. 6.1: Priority area for sustainable management plan based on ground water resources and quality.

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 18665 ha. area is brought under micro-irrigation (Sprinklers: 7308 nos. and drip: 11646 nos.) saving 28 MCM of groundwater (considering 25% of saving to traditional practices).

6.1.2.2 Proposed Micro-irrigation (MI)

- About 8027 ha. of additional land that can be brought under micro-irrigation (where actual area irrigated though MI is less than 1,000 ha.) costing about 48 Crores (considering 1 unit/ha. @0.6 lakhs/ha.). With this, about 12 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. 129 Crores, the likely benefit would be increases in gross groundwater availability with net saving of 23 MCM of groundwater or net reduction of 2% in stage of groundwater extraction, i.e., from the existing 64 to 62%. The onetime cost will be 6 paisa/litre and the actual cost of invest will be 0.6 paisa/litre if considered the life of the artificial recharge structures and micro irrigation equipment as 10 year.

Acknowledgments

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Annexure – I

Proposed interventions in Priority-1 areas (Area where ground water development >100 %), Siddipet district.

Mandal	Village	Existing No. of Check Dams	Existing No. of Percolation Tanks	Proposed Check Dams for intermittent areas	Proposed Percolation Tanks for intermittent areas
Anthakkapeta	Akkannapeta		11	5	
Anthakkapeta	Anthakkapeta		3	2	
Anthakkapeta	Choutapalle		4	1	
Anthakkapeta	Dongala Dharmaram		2	1	
Anthakkapeta	Gandipalle		4	4	
Anthakkapeta	Gouravelli	4	12		
Anthakkapeta	Jangaon	5	12		
Anthakkapeta	Katkur			5	5
Anthakkapeta	Kesavapur		5	2	
Anthakkapeta	Mallampalle		3	2	
Anthakkapeta	Nandaram		2	2	
Anthakkapeta	Potharam (J)		2	1	
Bejjanki	Devakkapalle	2	3		
Bejjanki	Gagillapur	1	3		
Bejjanki	Gundaram (P.S.)		5	4	
Bejjanki	Kallepalle			4	4
Bejjanki	Potharam	2	7		
Bejjanki	Potharam			3	3
Bejjanki	Regulapalle	1	8	1	
Bejjanki	Veerapur	2	5		
Cherial	Chunchukota				
Cherial	Nagapuri			1	1
Cherial	Peddarajupeta		2		
Chinnakodur	Ch.A Pally	4	5		
Chinnakodur	Chandlapur	3	9		
Chinnakodur	Chinnakodur	8	9		
Chinnakodur	Gangapur	2	2		1
Chinnakodur	Kasthurpally	5	6		
Chinnakodur	Machapur	8	6		
Chinnakodur	Medipally	4	3		
Chinnakodur	Oblapur	8	8		
Chinnakodur	Pedda Kodur	5	6		
Chinnakodur	Ramancha	4	7		
Chinnakodur	Ramunipatla	5	5		
Chinnakodur	Sivampally	5	3		
Doultabad	Deepayampally	2	5		
Dubbak	Akaram	5	2		

Mandal	Village	Existing No. of Check Dams	Existing No. of Percolation Tanks	Proposed Check Dams for intermittent areas	Proposed Percolation Tanks for intermittent areas
Dubbak	Appanapally	6	3		
Dubbak	Arepally	3	3		
Dubbak	Cheekode	2	2	2	2
Dubbak	Chillapur	5	3		
Dubbak	Chittapur	2	2		
Dubbak	Choudarpally	2	4		
Dubbak	Dharmajpet	3	1		
Dubbak	Enagurthy	4	5		
Dubbak	Habisipur	1	2	1	
Dubbak	Hasan Mirapur	4	2		1
Dubbak	Lachapet	2	2		
Dubbak	Potharam	2	2		
Dubbak	Pothareddypet	2	5	2	
Dubbak	Rajakkapet	2	2		1
Dubbak	Ramakapet	3	4		
Dubbak	Shivarampur	6	5		
Dubbak	Timmapur	2	3		
Dubbak	Timmapur	2	5		
Gajwel	Burugupally	2	4		
Gajwel	Dilalpur	2	2		
Gajwel	Hawaigude	2	3		
Gajwel	Kolgur	2	2		
Husnabad	Husnabad	3	11		
Husnabad	Kuchanpalle		3	2	
Husnabad	Madudha			1	1
Husnabad	Mirzapur			3	3
Husnabad	Mohammadapur			1	1
Husnabad	Pandilla	1	9	2	
Husnabad	Potharam (S)		6	2	
Husnabad	Potlapalle		4	2	
Jagadevpur	Ananthsagar	3	3		
Jagadevpur	Baswapur	2	2		
Jagadevpur	Dharmaram	3	3		
Jagadevpur	Gopalpur	3	5		
Jagadevpur	Kondapur				1
Jagadevpur	Kondapur	2	3		
Jagadevpur	Ramchandrapur	2	1		
Jagadevpur	Rayavaram	2	2		1
Jagadevpur	Tegulnarsapur	6	8		
Jagadevpur	Thimmapur	2	4		
Jagadevpur	Wattipally				3

Mandal	Village	Existing No. of Check Dams	Existing No. of Percolation Tanks	Proposed Check Dams for intermittent areas	Proposed Percolation Tanks for intermittent areas
Jagadevpur	Yellaiguda	2	2		
Koheda	Baswapur	1	1	1	1
Koheda	Kurella	4	2		
Koheda	Sriramulapalle			1	1
Koheda	Thangallapalle	1	3		
Koheda	Vinjapalle	2	2		
Komaravelli	Komaravelli			1	1
Komaravelli	Ramsagar				
Komaravelli	Tapaspalli				
Kondapak	Ankireddypally	2	3		
Kondapak	Duddeda	3	3		
Kondapak	Erravally	1	1		
Kondapak	Giraipally	2	2		
Kondapak	Konaipally	3	1		
Kondapak	Kuknoorpally	6	2		
Kondapak	Mangole	2	2		1
Kondapak	Marpadga	2	2		2
Kondapak	Mathpalle	3	1		1
Kondapak	Mathpally	2	2		
Kondapak	Muddapur	3	1		
Kondapak	Singaram	5	1		1
Kondapak	Sirsangandla	2	2		
Kondapak	Thimmareddypally	3	3		
Kondapak	Velikatta	3	3		
Kondapak	Vishwanathaplly	2	3		
Kondapak	Zaptinacharam	2	3		
Maddur	Arjunapatla		2		
Maddur	Bairanpalli		1		
Maddur	Bekkal				
Maddur	Dharmaram				
Maddur	Dhulmitta				
Maddur	Gagillapur	1	4		
Maddur	Jalepalli				
Maddur	Kamalaipalli		1		
Maddur	Kondapur				
Maddur	Kutigal				
Maddur	Ladnur			1	1
Maddur	Lakkapalli				
Maddur	Lingapur				
Maddur	Madduru				
Maddur	Marmamula				

Mandal	Village	Existing No. of Check Dams	Existing No. of Percolation Tanks	Proposed Check Dams for intermittent areas	Proposed Percolation Tanks for intermittent areas
Maddur	Narsaipalli				
Maddur	Rebarthi		1		
Maddur	Salakpur		4		
Maddur	Thornala		4		
Maddur	Vallampatla	2	4		
Maddur	Vangapalli				
Markook	Angadi Kistapur	2	1		1
Markook	Pamulaparthi	2	2	1	
Markook	Sivaru Venkatapur	2	3		
Markook	Vardarajpur	2	2		1
Mirdoddi	Alwal	2	2		
Mirdoddi	Andey	2	3		
Mirdoddi	Bhoompally	4	6		
Mirdoddi	Chepial	5	2		2
Mirdoddi	Dharmaram	3	2		
Mirdoddi	Jangapally	2	5		
Mirdoddi	Khazipur	5	4		
Mirdoddi	Kondapur	2	3		
Mirdoddi	Kudavelly	3	4		
Mirdoddi	Lingupally		2		
Mirdoddi	Veerareddypet	5	2		
Mulug	Achaipally				2
Mulug	Adivimasjid	2			
Mulug	Bahilampur	3	2		1
Mulug	Bandamailaram			1	
Mulug	Cheelasagar	2			3
Mulug	Chinna Thimmapur				2
Mulug	Gangadharpally	2			
Mulug	Kothur				3
Mulug	Kotyarla	2			
Mulug	Laxmakkapally				2
Mulug	Mustafguda	1			
Mulug	Narsapur				1
Mulug	Singannaguda				2
Mulug	Srirampur				1
Nanganur	Ankeshapur	4	3		
Nanganur	Khanapur	3	6		
Nanganur	Konaipally	4	6		
Nanganur	Kondamrajpally	5	5		
Nanganur	Maqdumpoor	5	5		
Nanganur	Mundrai	4	5		

Mandal	Village	Existing No. of Check Dams	Existing No. of Percolation Tanks	Proposed Check Dams for intermittent areas	Proposed Percolation Tanks for intermittent areas
Nanganur	Nagarajpally	5	4		
Nanganur	Palamukula	1	8	1	
Nanganur	Rajgopalpet	5	6		
Nanganur	Rampoor	3	6		
Nanganur	Thimmaipally	6	4		
Nanganur	Venkatapur	4	5		
Rayapole	Ankireddypaly	2	3		
Rayapole	Arepally (S.J)	2	2		1
Rayapole	Chandampally	4	3		
Rayapole	Chinna Masanpally				2
Rayapole	Kothapally	5	2		
Rayapole	Raipole	3	4		
Rayapole	Ramaram	6	6		
Siddipet Rural	Bussapur	2	3		
Siddipet Rural	Chinnagundavelli	4	2		
Siddipet Rural	Chinthamadka	2	5		
Siddipet Rural	Gurralagondi	3	2		
Siddipet Rural	Ibrahimpur	3	4		
Siddipet Rural	Irkode	3	2		
Siddipet Rural	Jakkapur	1	2	1	2
Siddipet Rural	Narayanraopet	2	2	1	1
Siddipet Rural	Raorukkal	2	2		
Siddipet Rural	Sitharampally	3	3		
Siddipet Rural	Venkatapur	2	3		
Siddipet Urban	Burugupally	5	2		
Siddipet Urban	Ensanpalli	1	6		
Siddipet Urban	Imambad	3	5		
Siddipet Urban	Mandapally	8	9		
Siddipet Urban	Nacharpalli	1	2		
Siddipet Urban	Tadkapally	1	3		
Siddipet Urban	Velkatoor	5	2		
Thoguta	Bandarpally	1	6		
Thoguta	Chandapur	2	3		
Thoguta	Etigaddakistapur	2	1		
Thoguta	Ghanpur	3	2		
Thoguta	Kangal	3	5		
Thoguta	Lingampet	5	2		
Thoguta	Lingapur		2	1	
Thoguta	Thoguta	3	3		
Thoguta	Tukkapur	2	2		
Thoguta	Venkatraopet	2	4		

Mandal	Village	Existing No. of Check Dams	Existing No. of Percolation Tanks	Proposed Check Dams for intermittent areas	Proposed Percolation Tanks for intermittent areas
Thoguta	Yellareddypet	5	4		
Thoguta	Zapthilingareddipally	2	2		1
Wargal	Amberpet				1
Wargal	Ananthagiripalle			1	
Wargal	Chandapur				2
Wargal	Girmapur				1
Wargal	Gouraram			1	1
Wargal	Jabbapur				2
Wargal	Majidpally			1	
Wargal	Nemtoor			2	1
Wargal	Ramachandrapur				1
Wargal	Shakaram				2
Wargal	Singaipalli				1
Wargal	Sitarampalle				1
Wargal	Tunkimakta				
Wargal	Veluru			2	
Wargal	Wargal			4	1

Annexure – II

Proposed interventions in Priority-2 areas (Area where ground water development <100 %), Siddipet district.

Mandal	Village	Existing No. of Check Dams	Existing No. of Percolation Tanks	Proposed Check Dams for intermittent areas	Proposed Percolation Tanks for intermittent areas
Anthakkapeta	Ramavaram	3	8		
Anthakkapeta	Regonda	2	8		
Bejjanki	Bejjanki	3	9	2	
Bejjanki	Cheelapur	1	6		
Bejjanki	Dacharam	3	8		
Bejjanki	Dacharam	8	3		
Bejjanki	Guggilla	2	5		
Bejjanki	Muthannapet		5		
Bejjanki	Potharam			5	5
Bejjanki	Potharam			3	3
Bejjanki	Potharam			2	2
Bejjanki	Thotapalle		6		
Bejjanki	Vadlur-Begumpet				
Bejjanki	Veerapur				
Cherial	Akunuru			1	1
Cherial	Cheriyal			2	2
Cherial	Chityal				
Cherial	Danampalli				
Cherial	Dommatta			1	1
Cherial	Kadaverugu			1	1
Cherial	Mutyala			1	1
Cherial	Tadur				
Cherial	Vechrani (Yasareni)				
Chinnakodur	Alipur	6	5		
Chinnakodur	Ananthsagar	10			
Chinnakodur	Chowadaram	7	15		
Chinnakodur	Gonepally	2	10		
Chinnakodur	Ibrahimpur	3	6		
Chinnakodur	Mallaram	2	6		
Chinnakodur	Sikindlapur	7	6		
Chinnakodur	Vittalapur	5	8		
Doultabad	Dommat	7	2		
Doultabad	Doulthabad	2	2		
Doultabad	Godugupally	1			3
Doultabad	Govindapur	4	6		
Doultabad	Indupriyal	2	2		1
Doultabad	Konapur	2	2		1

Mandal	Village	Existing No. of Check Dams	Existing No. of Percolation Tanks	Proposed Check Dams for intermittent areas	Proposed Percolation Tanks for intermittent areas
Doultabad	Lingaaarajupally	2	2		1
Doultabad	Mohammadshapur	2	5		
Doultabad	Mubaraspur	5	2		1
Doultabad	Narsampally(P.D)	2			3
Doultabad	Seetharampally	2	5		
Doultabad	Seripally Bandaram	3	3		
Doultabad	Sitharampally				
Doultabad	Surampally	2	3		
Doultabad	Thirmalpur	2	2		
Doultabad	Upparpally	3	2		
Dubbak	Boppapur	4	3		
Dubbak	Dubbak	4	2	1	
Dubbak	Dumpalapally	5	5		
Dubbak	Ghambeerpur	8	6		
Dubbak	Mallaipally	3	3		
Dubbak	Paddagundavally	6	2		
Dubbak	Yallapur	3	4		
Gajwel	Ahmedipur	4	3		
Gajwel	Akkaram	3	3		
Gajwel	Arepally(SB)	2	3		
Gajwel	Bangal Venkatapur			1	2
Gajwel	Bayyaram	2	2		
Gajwel	Bejagoan	2	2		
Gajwel	Dacharam	4	5		
Gajwel	Datherpally	3	3		
Gajwel	Dharamareddypally	5	2		1
Gajwel	Gajwel	5	3		
Gajwel	Jaligoan	4	2		
Gajwel	Kodakandla	2	3		
Gajwel	Komatibanda	4	2		
Gajwel	Kyasaram	2	2		1
Gajwel	M.Masanpally				2
Gajwel	Mutrajpally	4	3		
Gajwel	Pidched	4	2		
Gajwel	Pregnapur	3	3		
Gajwel	Rimangude	2	3		
Gajwel	Sangapur	5	1		2
Gajwel	Seripally	5	2		1
Gajwel	Singatam	6	3		
Gajwel	Srigiripally	2	1		

Mandal	Village	Existing No. of Check Dams	Existing No. of Percolation Tanks	Proposed Check Dams for intermittent areas	Proposed Percolation Tanks for intermittent areas
Husnabad	Pandilla			4	4
Husnabad	Thotapalle (S)		2	2	
Husnabad	Ummapur			6	6
Jagadevpur	Alirajpet	2	2		
Jagadevpur	Chattapally	5	9		
Jagadevpur	Doulapur	3	2		
Jagadevpur	Gollapally			1	
Jagadevpur	Itikyal	2	3		
Jagadevpur	Jagadevpur	3	2		
Jagadevpur	Munigadapa			2	2
Jagadevpur	Peerlapally	2	3		
Jagadevpur	Theegul	3	1	2	
Jagadevpur	Venkatapur (PT)	5	1		
Jagadevpur	Venkatapur(BG)	2	1		
Koheda	Baswapur	2	2		
Koheda	Gottalamitta		4	1	
Koheda	Gundareddipalle	1	5		
Koheda	Koheda	3	3		
Koheda	Nakkira Kommula		2	1	
Koheda	Narayanapur		3	1	
Koheda	Narayanapur	4	2		
Koheda	Pariveda		3	1	
Koheda	Ramachandrapur		3		
Koheda	Samudrala	3	12		
Koheda	Sriramulapalle		3	1	
Koheda	Thangallapalle	2	1		1
Koheda	Varikolu	2	10		
Komaravelli	Ainapur			1	1
Komaravelli	Goiraipalli				
Komaravelli	Guruvannapeta				
Komaravelli	Kistampeta			1	1
Komaravelli	Marrimuchala				
Komaravelli	Posanpalli				
Kondapak	Bandaram	2	3		
Kondapak	Kondapak	2	3		1
Kondapak	Lakadaram	2	3		
Kondapak	Tipparam	4	1		2
Markook	Chebarthy	2	1		
Markook	Damarakunta	2	2		2
Markook	Erravalli	2	1		2

Mandal	Village	Existing No. of Check Dams	Existing No. of Percolation Tanks	Proposed Check Dams for intermittent areas	Proposed Percolation Tanks for intermittent areas
Markook	Karkapartla	1		1	
Markook	Markook	4	2		
Mirdoddi	Almaspur	3	2		
Mirdoddi	Kasulabad	5	5		
Mirdoddi	Mallupally	2	4		
Mirdoddi	Mirdoddi	2	3	4	1
Mirdoddi	Mothey	3	2		1
Mirdoddi	Rudraram	2	2		2
Mulug	Banda Thimmapur				2
Mulug	Baswapur				2
Mulug	Dasarapally				
Mulug	Kokkkonda			2	
Mulug	Mamidiyal	5	2		
Mulug	Mulugu			3	2
Mulug	Narsampally	2			3
Mulug	Tanedarpally	2	2		1
Mulug	Tunki Bollaram			2	
Mulug	Zapthi Singaipally	2			3
Nanganur	Akkanapally	5	5		
Nanganur	Beddipadga	9	9		
Nanganur	Gatlamalyal	6	6		
Nanganur	Ghanpur	5	6		
Nanganur	Khata	6	5		
Nanganur	Nangnoor	6	5		
Nanganur	Narmeta	5	2		
Rayapole	Anajpur	5	3		
Rayapole	Appajipally			4	2
Rayapole	Begumpet			1	1
Rayapole	Chinna Masanpally	4			
Rayapole	Lingareddypally	2	2		1
Rayapole	Manthoor	6	2		
Rayapole	Ramsagar	3	3		
Rayapole	Rangumpet				3
Rayapole	Waddepally			2	4
Rayapole	Yelkal				3
Siddipet Rural	Ankampet	3	4		
Siddipet Rural	Machapur	1	3		
Siddipet Rural	Malyala	4	2		
Siddipet Rural	Pullur	3	3		1
Siddipet Rural	Raghavapur	2	2		1

Mandal	Village	Existing No. of Check Dams	Existing No. of Percolation Tanks	Proposed Check Dams for intermittent areas	Proposed Percolation Tanks for intermittent areas
Siddipet Rural	Tornal	3	2		
Siddipet Urban	Bakrichepiyal	1	4		
Siddipet Urban	Mitpally	6	6		
Siddipet Urban	Narsapur	3	4		
Siddipet Urban	Ponnal	8	9		
Siddipet Urban	Siddipet	9	6		
Thoguta	Gudikandula	5	2		
Thoguta	Masanpally	3	3		
Thoguta	Palepahad	3	1		2
Thoguta	Vemulghat	3	1	1	
Wargal	Govindapur				2
Wargal	Kondaipally				1
Wargal	Madharam				3
Wargal	Mailaram			1	2
Wargal	Meenjipeta			1	3
Wargal	Nacharam			1	
Wargal	Tunkikhalasa			2	3

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