केंद्रीय भूमि जल बोर्ड

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विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

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

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

WANAPARTHY DISTRICT, TELANGANA

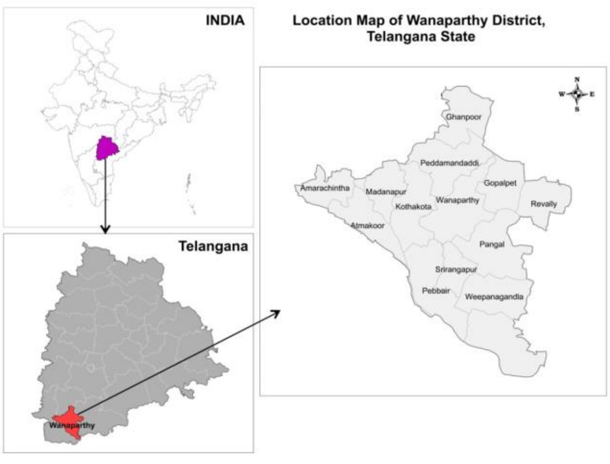
दक्षिणी क्षेत्र, हैदराबाद

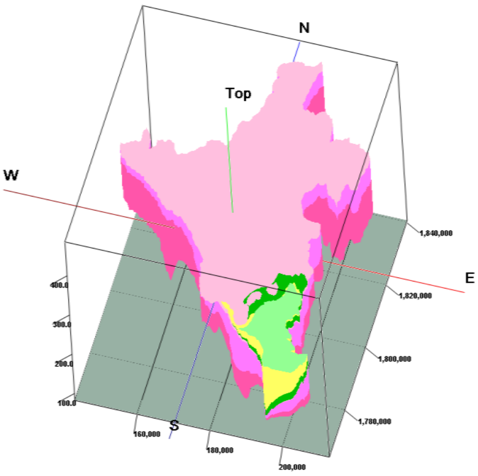
Southern Region, Hyderabad

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 FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN WANAPARTHY DISTRICT, TELANGANA STATE





CENTRAL GROUND WATER BOARD
SOUTHERN REGION
HYDERABAD

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REPORT ON
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CONTRIBUTORS' PAGE

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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 for Sustainable Ground Water Resources in Wanaparthy 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. G. Praveen Kumar, Scientist – C (Hydrogeology) & Dr. S. S. Vittala, Scientist - B (Hydrogeology) and the efforts made by the officers 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 Mahabubnagar district in the year 2017-18, 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. 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
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REPORT ON
AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN WANAPARTHY DISTRICT, TELANGANA STATE

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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 Wanaparthy district covering 2170 km^2 is carved from erstwhile Mahabubnagar district. Administratively the area is governed by 2 revenue divisions, 14 revenue mandals and 223 revenue villages with a population of 5.78 lakhs (2011 census) (urban: 16 %, rural: 84 %) with average density of 266 persons/km^2.

The normal annual rainfall varies between 376 mm (Pangal) and 635 mm (Wanaparthy) with average of 434 mm in the district. The SW monsoon contributes 75 % and 19 % is contributed by retreating monsoon (NE) season and rest by winter and summer rainfall. Rainfall increases from south-west to north and south-east direction. The area received annual rainfall of 1349 mm (133% more than the normal rainfall) during the year 2020-21.

The district is contiguous part of Mysore Plateau and characterised by erosional topography with general slope is towards south and south west. The total mappable area is 2170 km^2 with forest and hills occupy 109 km^2 (5%). The pediplain is the major landform followed by pediment and dissected plateau, etc. The district is falling under Krishna basin, the major tributary of Krishna river 'Uppuchetti Vagu' drains the district and joins to river Krishna near Kotturu village.

The soils are mainly fine mixed and loamy soils. Majority of the area is occupied by fine mixed soils followed by loamy soils. The forest occupies 5 % of the total geographical area, barren and uncultivable land occupies 8% of area; land put to non-agricultural use is 7%, cultivable waste land is 1%. With respect to land utilization, out of total area, about 16% of the area is falling under current fallows; 17% is under other fallows. The net area sown is about 44% and area sown more than once is 16% which brings gross cropped area to 60%.

Groundwater exploration carried out in four phases (1971-75, 1989-92, 1999-2004 and 2014-16), and as per the latest data till 31.03.2.21, CGWB drilled 18 exploratory wells and SGWD drilled 8 piezometers. Data analysed from the wells indicates 6 wells are of shallow depth (30 m), 13 nos (30-60 m), 3 nos (60-100 m), 3 nos (100-150 m) and 1 nos (150-200m) depth**.** Analysis of the borewell data reveal that 90% of the fractures occur within 100 m depth. The deepest fractures >60 m bgl are noticed at Gopalpet (Gopalpet mandal), China Mandadi (Peddamandaddi mandal), Nagapur and Revalli (Revalli mandal) and SriRangapur (Srirangapur mandal) and Chityal (Wanaparthy mandal) villages.

Water level data of 2019 varies from 2.58 to 28.84 meter below ground level (m bgl) (average: 10.12 m bgl) during pre-monsoon (May) and 0.97 to 14.22 m bgl (average: 6.10 m bgl) during post-monsoon (November). Majority of the water levels during pre-monsoon season are in the range of 10-20 m bgl covering 48 % of the area followed by 10-20 m bgl in 26% of the area. The deeper water level of >20 m bgl occupies about 9 % of the area. The shallow water levels of <5 m bgl occupy about 17 % of area. During post-monsoon season, majority of the water levels during this season are in the range of <5 m bgl 43% of the area, 5-10 m bgl in 43% of the area and water levels in the ranges of 10-20 m bgl occupy about 14% of the area.

The data analysed from the groundwater quality indicate that during pre-monsoon season, the EC >3000 µ Siemens/cm is observed in 9% of the samples. The NO_3 concentration ranges from 2.86 to 486 mg/l and noticed that in about 39% of the samples is beyond drinking water limits. The Fluoride concentration varies from 0.35-2.54 mg/l and found that high fluoride concentration is observed only in 1 sample (2.54 mg/l) collected in Peddamandaddi mandal. During post-monsoon season, the EC varies from 509-5456 µ Siemens/cm and exceeds >3000 µ Siemens/cm in only 1 samples form Ghanpoor mandal. The NO_3 concentration ranges from 2.26 to 394 mg/l. In 36% of the samples, it is exceeding permissible limits. The Fluoride concentration varies from 0.49-2.24 mg/l. In 14% of the samples, fluoride concentration is beyond permissible limit.

Conceptualization of 3-D hydrogeological model was carried out by interpreting and integrating representative 220 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 3-D map for the district along with panel diagram and hydrogeological sections.

As per 2020 GEC report, the net dynamic replenishable groundwater availability for Wanaparthy district is 320.02 MCM, gross groundwater draft for all uses 148 MCM. The provision for drinking and industrial use for the year 2025 is 19.4 MCM and net annual groundwater potential available for future irrigation needs is 165.21 MCM. Out of 14 mandals, 1 falls under Over-exploited, 2 under Semi Critical category and 11 under Safe category. Mandal wise stage of groundwater development varies from 17% (Chinnambavi) to 105% (Gopalpet) with an average of 46 %.

Areas spread over 31 villages covering 163 km^2 falls under Priority-1, where the state of groundwater extraction is >100% and immediate intervention is required. In this area, 16 MCM recharge potential and 1.4 MCM utilizable yield (uncommitted run-off) is available. Around 24 artificial recharge structures viz., 9 check dams (CDs) with recharge shafts at unit cost of Rs. 15 lakhs each and 19 mini percolation tanks (PTs) at unit cost of Rs. 20 lakhs each with a total cost of 4.35 crores recommended. By constructing these structured, there will be additional groundwater recharge of 0.54 MCM which will help in sustainability of the groundwater.

Area consisting of 192 villages having 2007 km^2 covered under Priority-2, where the state of groundwater extraction is <100%. In the area, 122 MCM recharge potential and 15 MCM utilizable yield is available. About 194 artificial recharge structures viz., 80 CDs with recharge shafts at unit cost of Rs. 15 lakhs each and 114 mini PTs at unit cost of Rs. 20 lakhs each with a total cost of 35 crores recommended. By constructing these structured, there will be additional groundwater recharge of 4.56 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 4460 farm ponds need to be constructed at a unit cost of Rs. 25,000/- totalling to 11.15 crores. This will create an additional storage capacity of 1.34 MCM at field level.

As per the studies, it is estimated that 4258 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 25.55 crores. By shifting from traditional to micro irrigation practices, 6.4 MCM of groundwater can be conserved.

The above interventions by investing about Rs. 65 crores, a net saving of 11.50 MCM of groundwater can be achieved which will help in net reduction in groundwater extraction by 1 % i.e., from the existing 46 % to 45%. This will help in arresting the groundwater deterioration and its sustainability. The onetime cost will be ~4.15 paisa/litre and the actual cost of invest will be 0.41 paisa/ltr if considered the life of the artificial recharge structures and micro irrigation equipment as 10 year.

A detailed groundwater management plan for both Priority-1 and Priority-2 villages is also prepared for Ravelly, Amarachintha and Gopalpet mandals as they are falling under Semi Critical and Over Exploited category.

In Ravelly mandal, the state of groundwater extraction is 77%. In both Priority-1 and Priority-2 villages, 18 artificial recharge structures viz., 9 mini percolation tanks and 9 check dams are recommended for artificial recharge. A total of 200 farm ponds at 20 structures in each village are recommended. With respect to micro-irrigation, about 1,000 ha. of additional land can be considered. After effective implementation of above interventions by investing about Rs. 10 Crores, there may be reduction of stress on ground water to the tune of 1.97 MCM, which will perhaps bring down the stage of development from existing 77% to 67% with a net change of 10%.

In Amarachintha mandal, the state of groundwater extraction is 86%. In both Priority-1 and Priority-2 villages, 18 artificial recharge structures viz., 3 mini percolation tanks and 15 check dams are recommended for artificial recharge. A total of 280 farm ponds at 20 structures in each village are recommended. With respect to micro-irrigation, about 1,400 ha. of additional land can be considered. After effective implementation of above interventions by investing about Rs. 12 Crores, there may be reduction of stress on ground water to the tune of 2.74 MCM, which will perhaps bring down the stage of development from existing 86% to 68% with a net change of 18%.

In Gopalpet mandal, the state of groundwater extraction is 105%. In both Priority-1 and Priority-2 villages, 14 artificial recharge structures viz., 8 mini percolation tanks and 6 check dams are recommended for artificial recharge. A total of 240 farm ponds at 20 structures in each village are recommended. With respect to micro-irrigation, about 1,200 ha. of additional land can be considered. After effective implementation of above interventions by investing about Rs. 10 Crores, there may be reduction of stress on ground water to the tune of 2.17 MCM, which will perhaps bring down the stage of development from existing 105% to 96% with a net change of 9%.

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 population growth, irrigation, urbanization and changing life style. Therefore, in order to have an accurate and comprehensive micro-level picture of groundwater in India, aquifer mapping in different hydrogeological settings at the appropriate scale is devised and implemented, to enable robust groundwater management plans. This will help in achieving drinking water security, improved irrigation facility and sustainability in water resources development in large parts of rural and many parts of urban India. The aquifer mapping program is important for planning suitable adaptation strategies to meet climate change also. Thus, the crux of National Aquifer Mapping (NAQUIM) is not merely mapping, but reaching the goal-that of 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 Wanaparthy district covering 2170 km^2 lies between north latitude 15°56'37" - 16°37'43" and east longitude 77°39´18" - 78°18'50 (Fig. 1.1). The district is bounded on the north by Mahabubnagar, on the east by Nagarkurnol, on the south and west by Jogulamba district and part by Narayanpet district. The present district is carved out of erstwhile Mahabubnagar. Administratively, it is divided into 2 revenue divisions, 14 revenue mandals and 223 revenue villages with a population of 5.78 lakhs (2011 census) (Rural: 84% and Urban: 16%) with average population density of 266 persons/km^2. The hilly and forest area occupying 5% of the total area located in central and northern part of the district.

1.4 Climate and Rainfall

The district experiences tropical climate and is geographically located in a semi-arid area. The district falls under Southern Telangana agro-climatic zone. The Southwest monsoon enters into the district in June and lasts until September and Northeast monsoon from October to December. Summer starts in March, and reaches peak in May with average maximum temperature of 40.3°C. Winter season starts in late November and lasts until early February with lowest average minimum temperature of 16.5°C in January. The annual normal rainfall of the district varies from 542.5 mm (Pangal mandal) to 691.1 mm (Wanaparthy mandal) with district normal of 603.9 mm. Average number of annual rainy days is around 49 days. Southwest monsoon contributes 75% (452.2 mm), Northeast monsoon by 17 % (104.8 mm) and rest 8 % by January to May months of normal annual rainfall. Mean monthly rainfall varies from 133.1 mm in July to 1.7 mm in January. Isohyetal map prepared using annual normal rainfall of mandals in the district is shown in Fig.1.2. The district received large excess rainfall of 1349.4 mm (133% above normal) during the water year 2020-21.

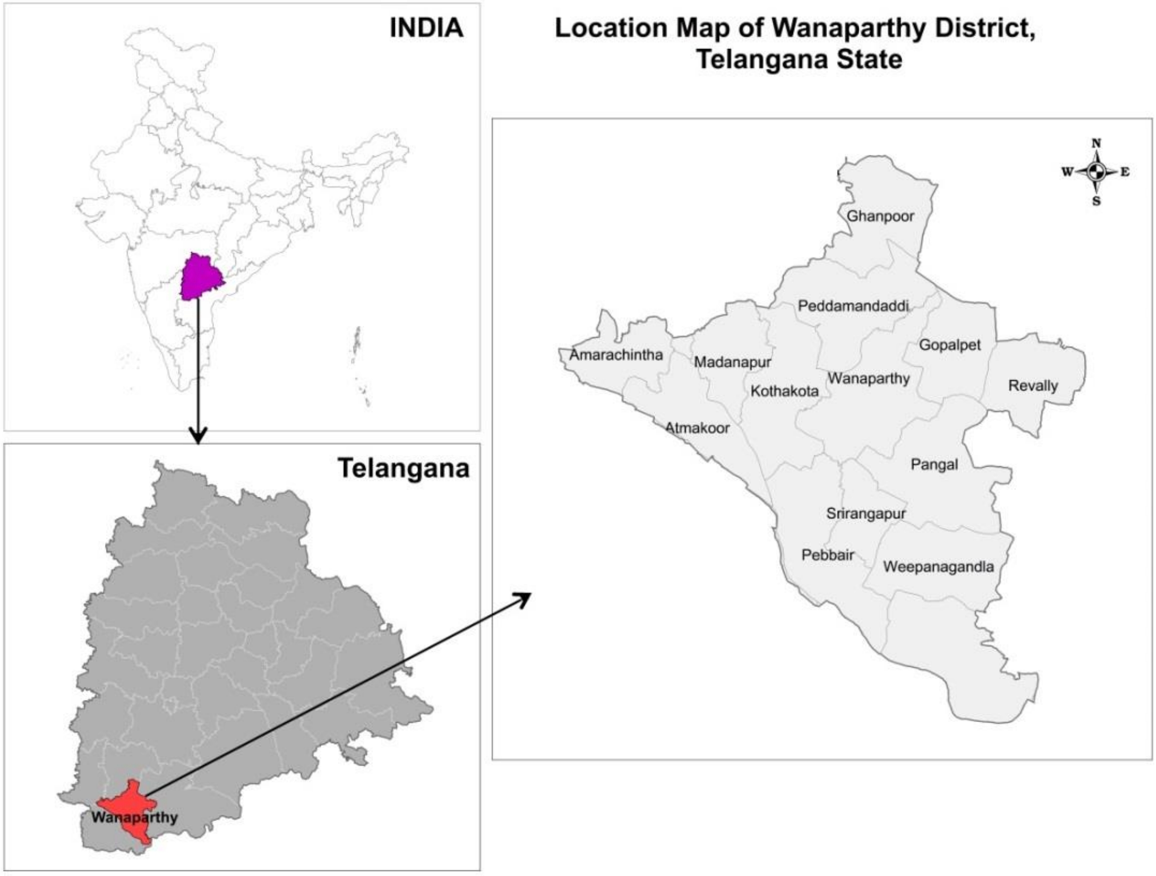


Fig. 1.1: Location map.

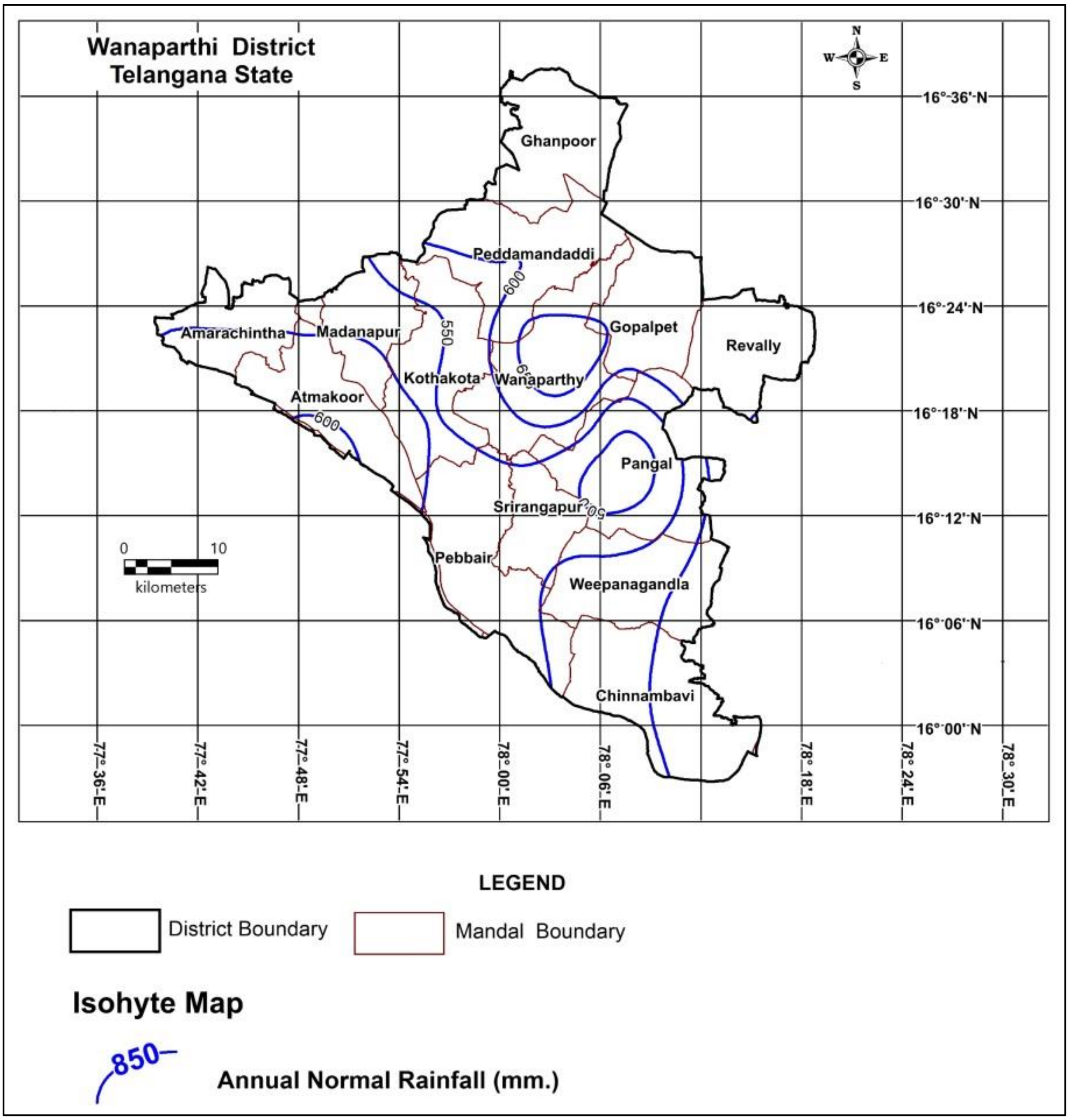
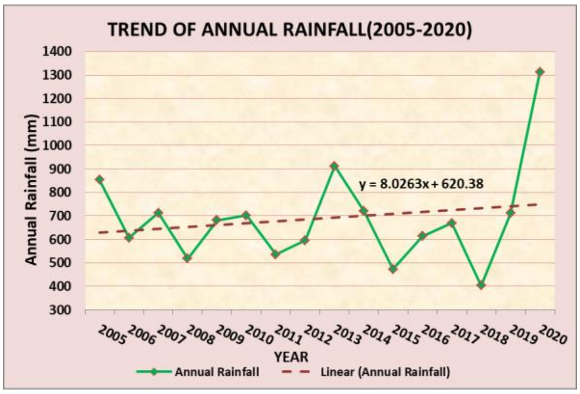


Fig. 1.2: Isohyetal map.

Analysis of time series annual rainfall data for 16 years (2005-2020) collected from TSDPS, Govt. of Telangana shows increasing trend in annual rainfall of 8 mm/yr (Fig.1.3a). The district received large excess rainfall (departure of +60% & above normal) in 2020, excess rainfall (+20% to +59%) in 2005 & 2013, deficient rainfall (-20% & below normal) in 2015 & 2018 and remaining 10 years received normal rainfall (-19% to +19%). The monthly rainfall trend graph for 16 years shows increasing trend in rainfall for July (4.3 mm/yr), August (3.4 mm/yr) and September (3.6 mm/yr) months. (Fig.1.3b).



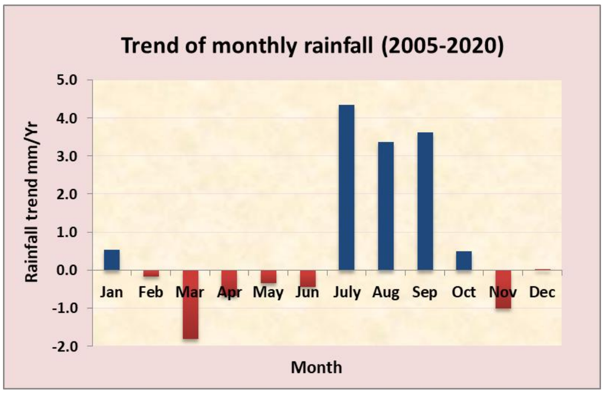


Fig. 1.3a: Annual Rainfall trend. Fig. 1.3b: Monthly Rainfall trend.

Source: *TSDPS, Govt of Telangana.*

1.5 Geomorphological Set up

The district is contiguous part of Mysore Plateau and characterised by erosional topography with general slope is towards south and south west. The total mappable area is 2170 km^2 with forest and hills occupy 109 km^2 (5%). The pediplain is the major landform followed by pediment and dissected plateau, etc. (Fig. 1.4).

1.6 Drainage

The drainage is mainly dendritic to sub-dendritic in nature and it is part of the River Krishna basin and Krishna Middle Sub-basin. The major tributary 'Uppuchetti Vagu' drains in the district and joins to river Krishna near Kotturu village about 6 kms west from Pebbair. The map depicting drainage and water bodies is presented in Fig. 1.5.

1.7 Land use/ land cover

Based on the land use study, many classes have been delineated in the district viz., kharif, double crop, plantations, deciduous forest and land with scrub and wastelands & hills. Out of the total area, majority of the area (>40%) falling under kharif category followed by double crop located along the tributaries and major streams. The deciduous forest exposures were located in central and northern part of the district. The land use / land cover map is given in Fig. 1.6.

1.8 Soils

The soils are mainly form of fine mixed and loamy soils. Majority of soils are occupied by fine mixed soils followed by loamy-skeletal, rock lands & loamy mixed soils. They are grouped into 8 classes (NBS & LUP) based on geomorphology and landscapes and further sub-divided based on physiography, relief and drainage (Fig. 1.7).

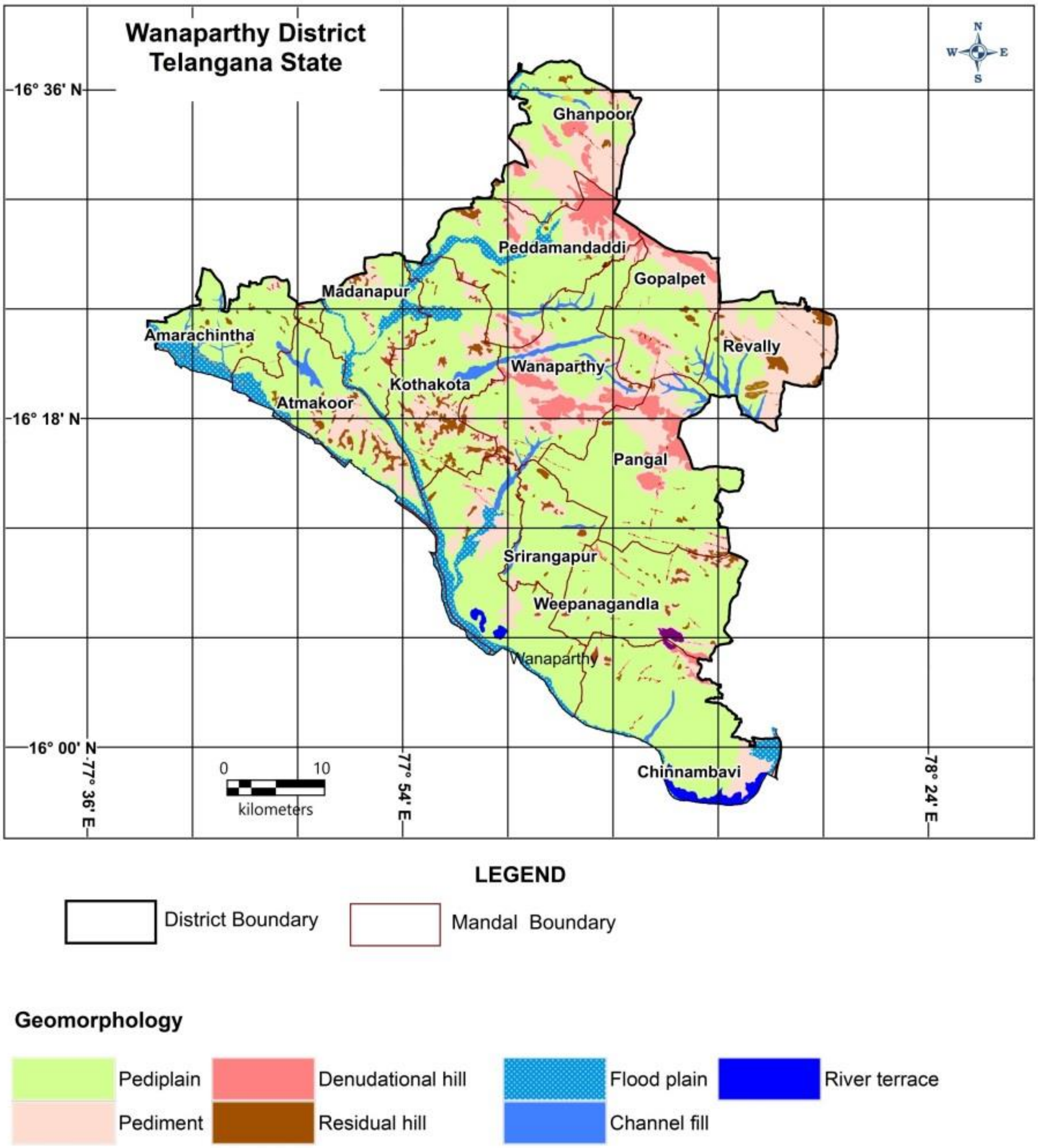


Fig. 1.4: Geomorphology map.

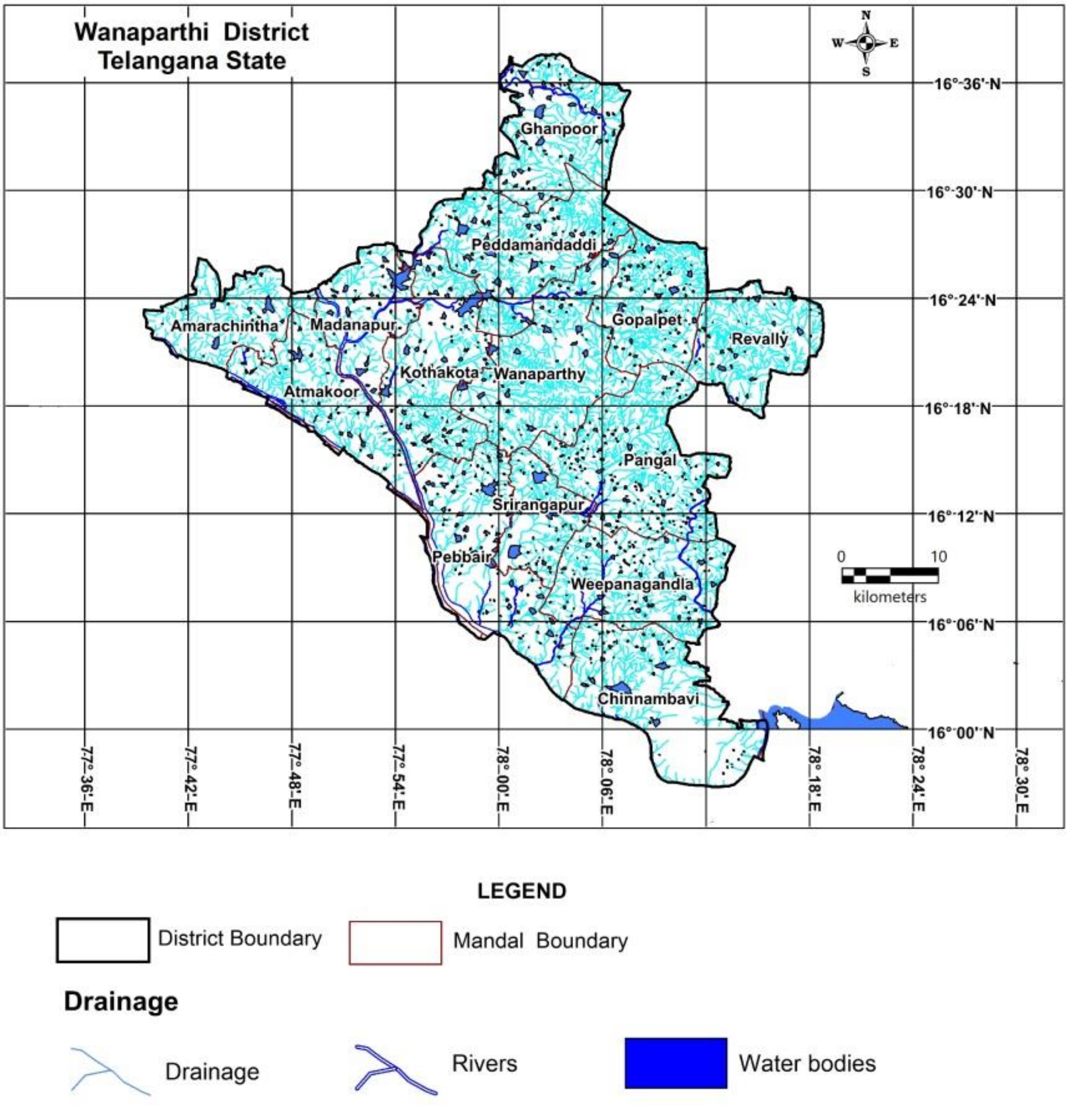


Fig. 1.5: Drainage and water bodies map.

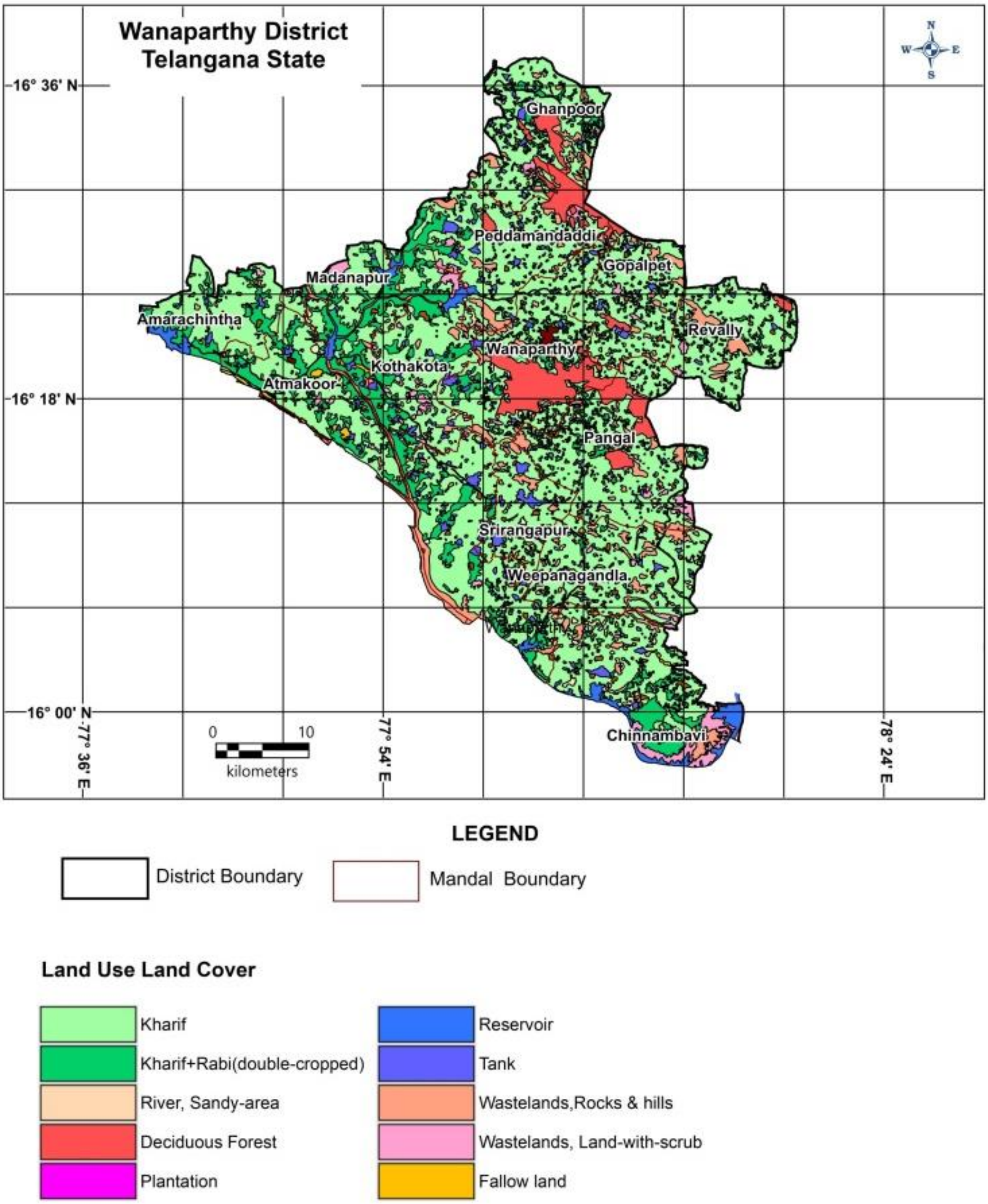


Fig. 1.6: Land use / land cover map.

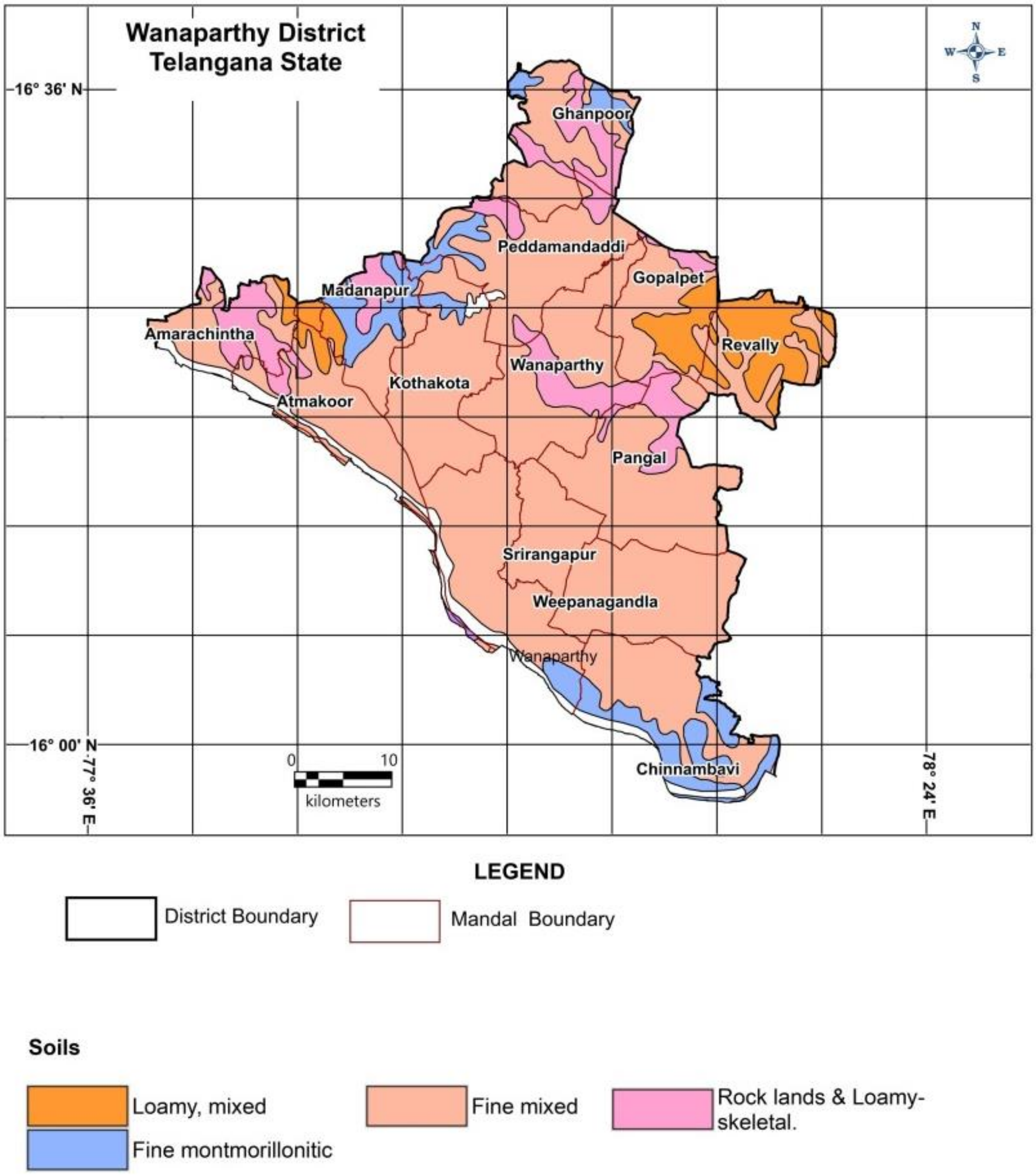


Fig. 1.7: Soil map.

1.9 Cropping Pattern (2019-20 in ha.)

The forest occupies 5 % of the total geographical area, barren and uncultivable land occupies 8% of area; land put to non-agricultural use is 7%, cultivable waste land is 1%. With respect to land utilization, out of total area, 16% of the area is falling under current fallows; 17% is under other fallows. The net area sown is about 44% and area sown more than once is 16% which brings gross cropped area to 60%.

Out of gross area sown, Paddy in 62%, Oil seeds in 15%, pulses in 10%, Cereals and millets in 6% and cotton in 2 % area is grown in the area (Fig. 1.8).

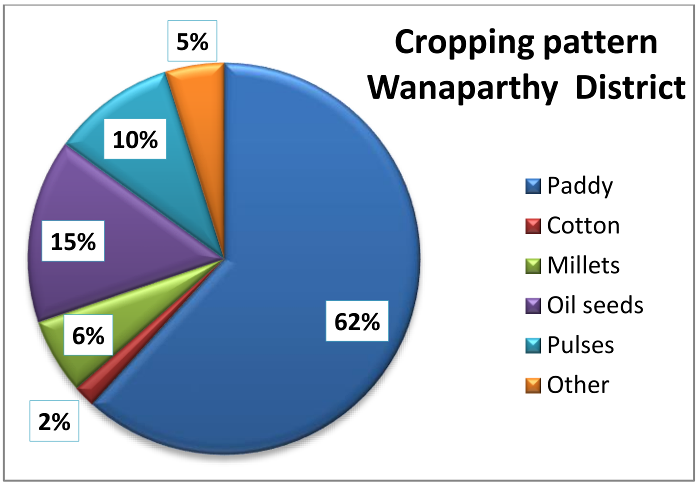


Fig. 1.8: Cropping pattern.

1.10 Irrigation

In the district, there are 4 contemplated Irrigation Potential (IP) projects viz., Mahatma Gandhi Kalwakurthy LIS (4192 ha.), Priyadarshini Jurala Project (25656 ha.), Rajiv Bheema LIS (41107 ha.) and Saralsagar Project (1694 ha.). Under Mahatma Gandhi Kalwakurthy Lift Irrigation scheme, there is proposal to lift 25 TMC of water from foreshore of Srisailam Reservoir (Fig. 1.9). In the district, about 1456 number of minor irrigation tanks covering 43426 acres of Ayacut. As per the latest MI census, there are 18700 numbers of bore wells and 5100 dug wells are existing in the district.

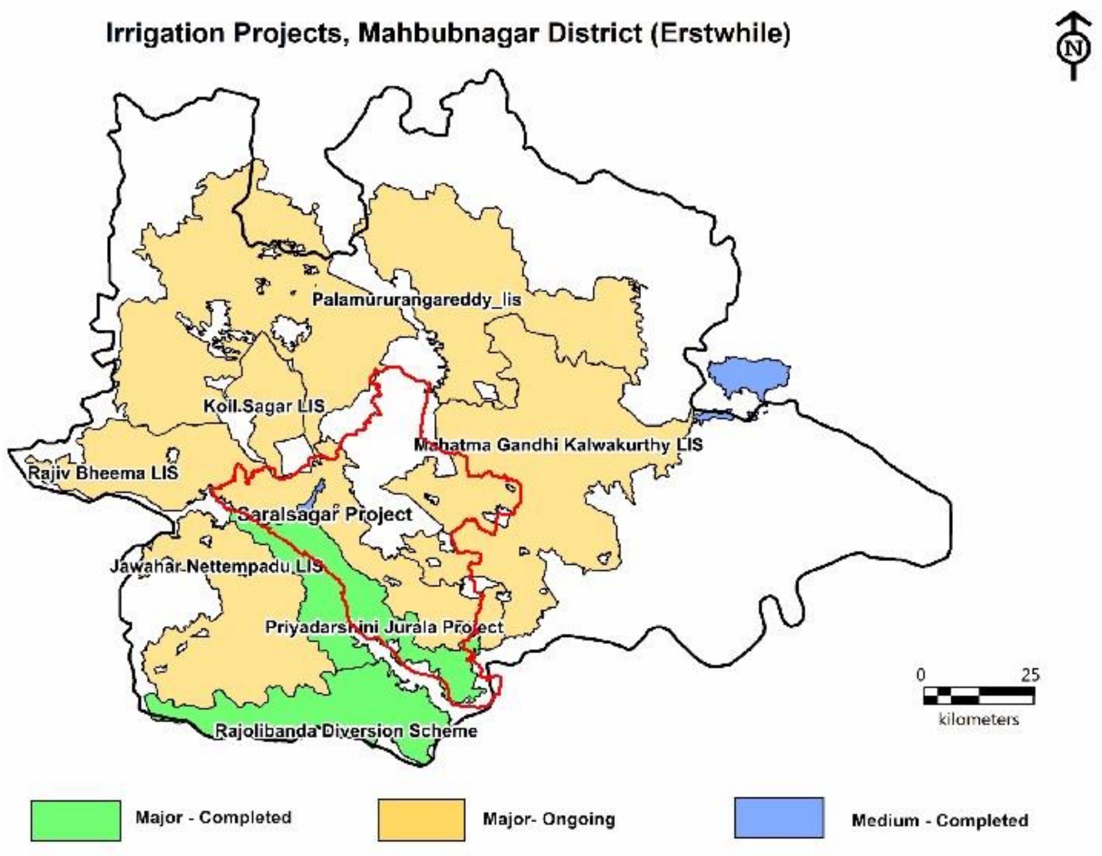


Fig. 1.9: Irrigation Projects, Mahbubnagar District (Erstwhile).

1.11 Cropping Pattern trend

To understand the long term cropping pattern changes, 4 years data of cropping pattern is analysed from 2016-17 to 2019-20. It is observed from the cropping area trend that the cropping areas of paddy and cotton are increasing while oil seeds, pulses and millets are showing decreasing trend. Overall, the cropping area in the district is increasing at a rate of 47525 ha./yr. The plots for cropping area trends is given in Fig. 1.10.

Table1.1: Cropping area trend.

Crop	Trend ha./yr		
	Kharif	Rabi	Total
Paddy	7713	9497	17209
Cotton	230		230
Oil seeds	-446	-1245	-1691
Pulses	-1129	-270	-1399
Millets	-5833	-74	-5910
Total cropped area	198	7949	8148
Source:https://aps.dac.gov.in			

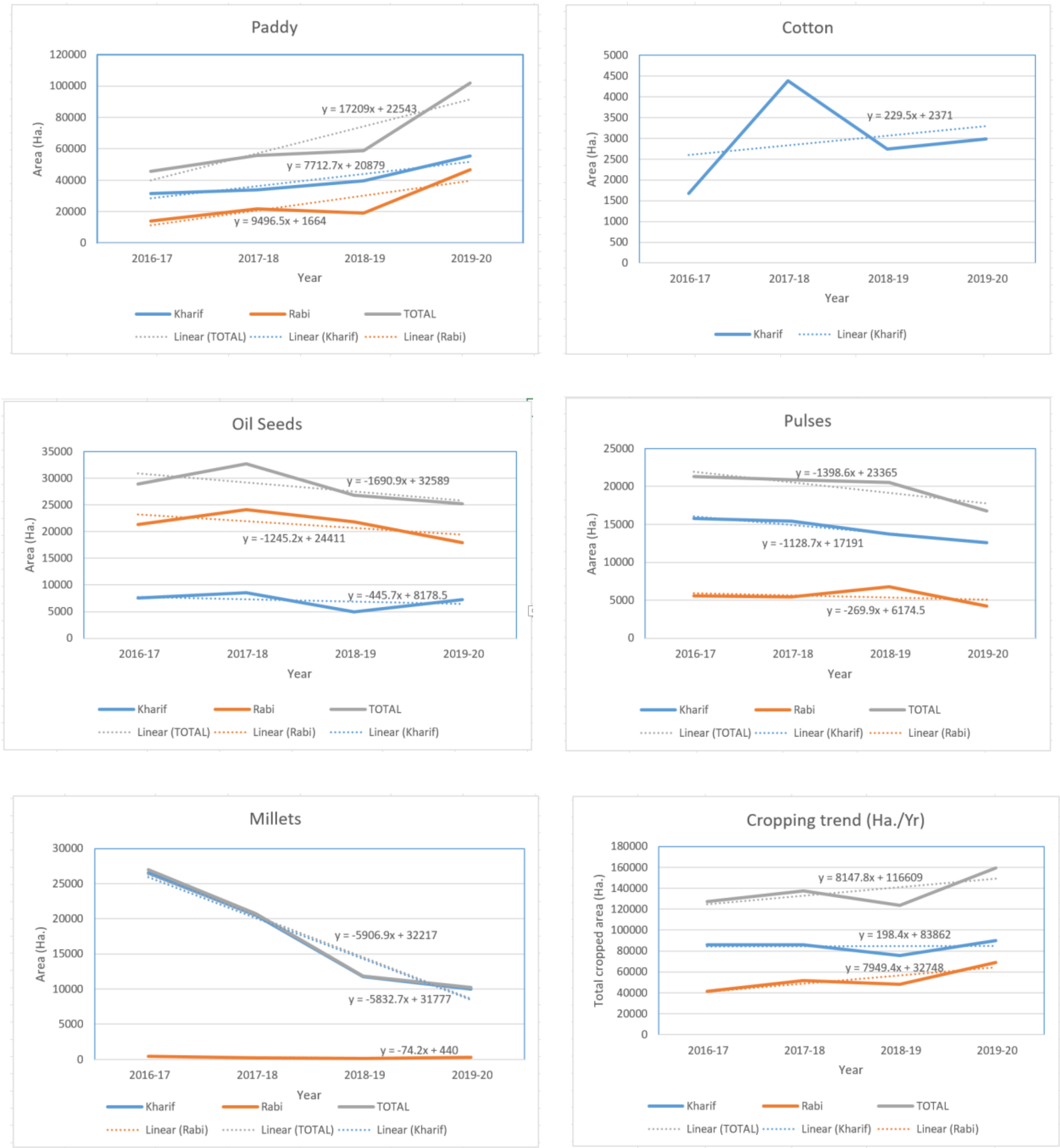


Fig. 1.10: Cropping area trend plots.

The observations made from the analysis are given below:

- There is a gradual change in cropping pattern since 2016.
- The extent of Paddy and Cotton in gross cropped area is increasing whereas the extent of Oil seeds, Pulses and Millets are decreasing during the same period.
- Average gross cropped area is also increased.

1.12 Prevailing Water Conservation/Recharge Practices: In the area there are 982 artificial recharge structures (PT: 653 and CD: 329) and 3 farm ponds with combine storage capacity of 18 MCM. Under Mission Kakatiya (Phase- 1 to 4), out of 1456 minor irrigation tanks, 579 tanks desilted.

1.13 Geology

Geologically, major part of the district is underlain by Archaean rocks namely peninsular gneissic complex (PGC) (granites) intruded by pegmatite veins/reefs and dolerite dykes at places running SE-NW direction. The major lineaments in the area trend in SE-NW direction. The migmatite formation is also noticed trending NW-SE direction. The Cuddapah group of rocks comprising quartzites and limestones occurs along the southern boundary of the district. Recent alluvium occurs along the major river namely the Krishna and Uppuchetti Vagu tributary which is a minor stream joining Krishna river (Fig. 1.11).

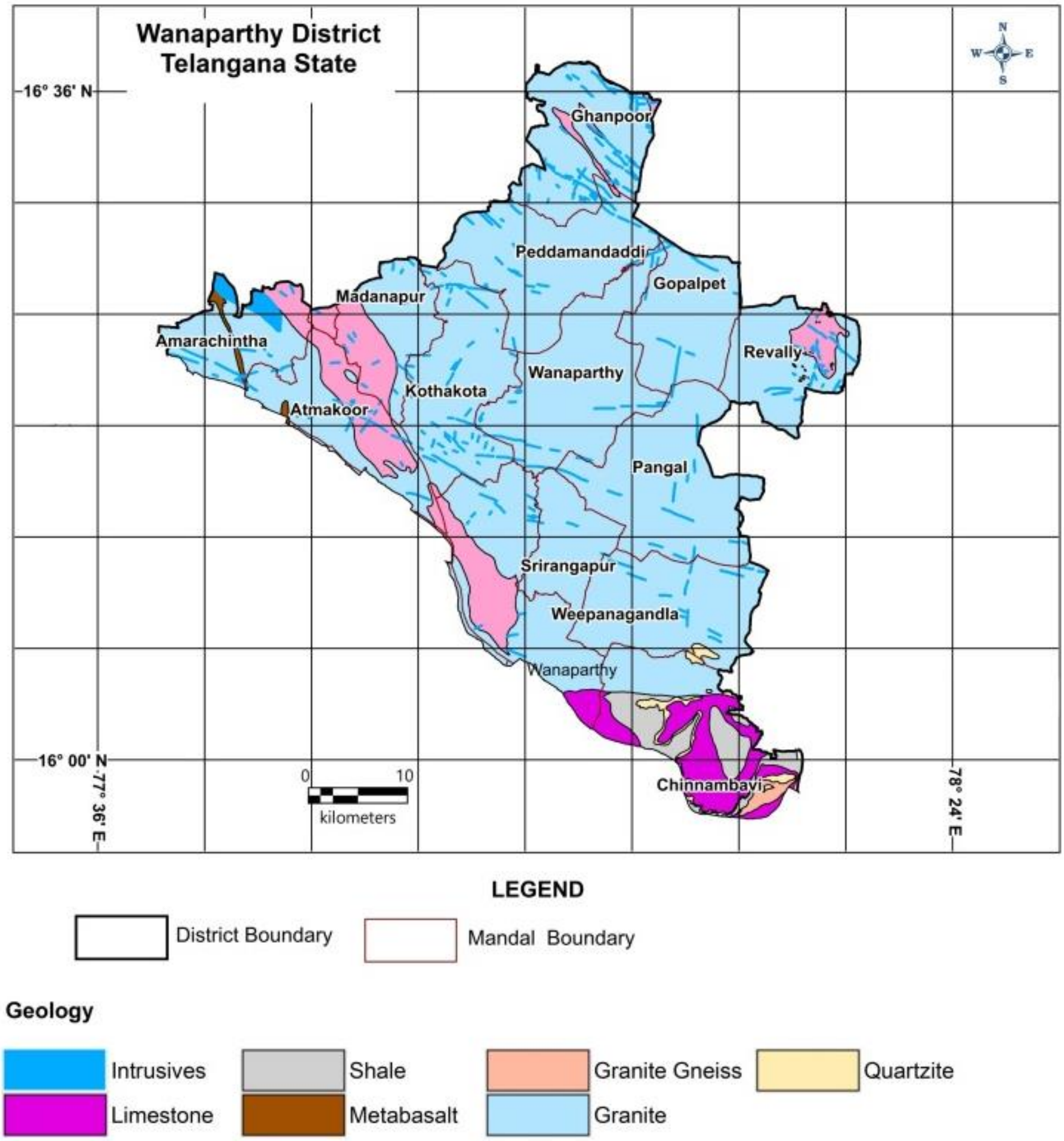


Fig. 1.11: Geology map.

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 granites 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 50 hydrogeological data points (Exploration: 26 (CGWB: 18 and SGWD: 8), Outsourcing: 13 (CGWB), VES: 9 (CGWB) and APIDC& RWS: 2) and other relevant data, the hydrogeological map is prepared (Fig. 2.1).

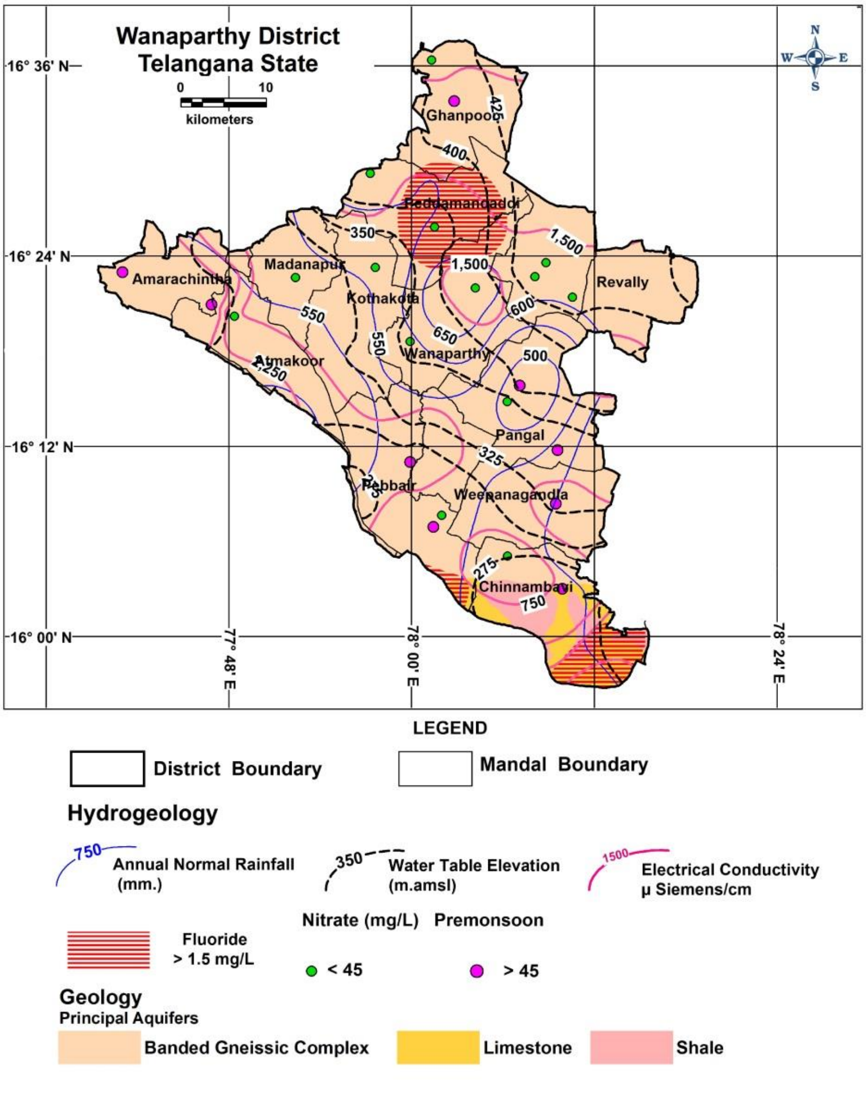


Fig. 2.1: Hydrogeology map.

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 150 m bgl. The storage in granite rocks is primarily confined to the weathered zone and it's over exploitation has resulted in desaturation at many places and reduced recharge to the underlying fractures. Presently, the extraction of groundwater is mainly through borewells up to 100 m bgl. The sustainability of the borewells is dependent on the water availability in the weathered zone.

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 18 bore wells (exploratory and piezometers) and SGWD drilled 8 wells (piezometers) in the district. Data analysed from the wells indicates 6 wells are of shallow depth (30 m), 13 nos (30-60 m), 3 nos (60-100 m), 3 nos (100-150 m) and 1 nos (150-200m) depth**.** Studies reveal that majority of fractures 90% occur within 100 m depth. The deepest fractures >60 m bgl is noticed in Gopalpet (Gopalpet mandal), China Mandadi (Peddamandaddi mandal), Nagapur and Revalli (Revalli mandal) and SriRangapur (Srirangapur mandal) and Chityal village (Wanaparthy mandal) villages.

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

Water level data from 23 wells (CGWB: 9, SGWD: 14) were utilised. The DTW varies from 2.58 to 28.84 meter below ground level (m bgl) (average: 10.12 m bgl) during pre-monsoon (May) and 0.97 to 14.22 m bgl (average: 6.10 m bgl) during post-monsoon (November) season.

2.2.1 Water Table Elevations (m amsl)

During pre and post-monsoon season, water-table elevation ranges from 260.16 – 432.98 and 278.64 – 434.55 meter above mean sea level (m amsl) respectively. The general ground water flow is towards the river Krishna from NE-SW and NNW-SSE (Fig. 2.2).

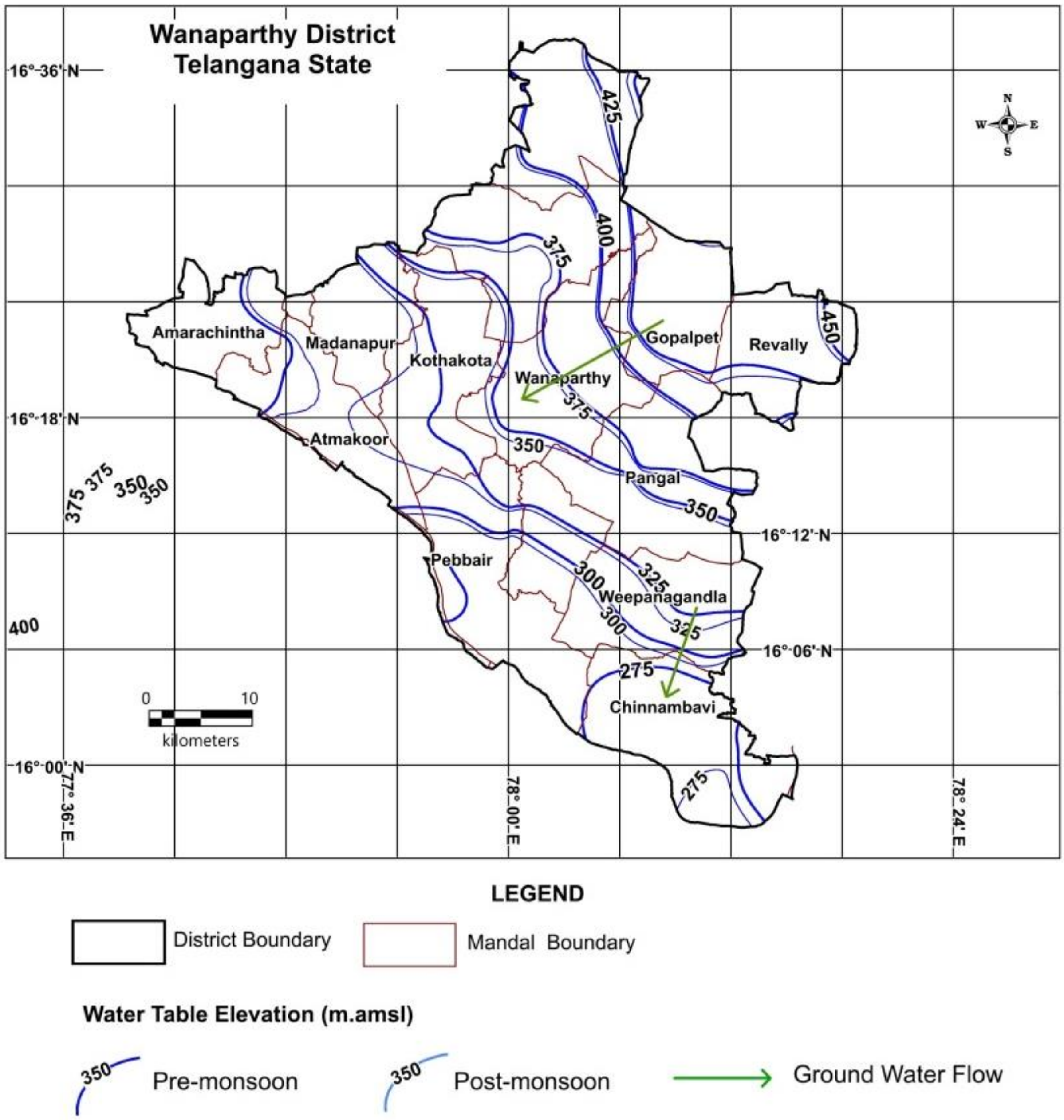


Fig. 2.2: Water table elevation (m amsl) map.

2.2.2 Pre-monsoon Season

Majority of the water levels during this season are in the range of 10-20 m bgl covering 48 % of the area (Atmakoor, Ghanpoor, Gopalpet, Madanapur, Pangal, Pebbair, Peddamandaddi, Wanaparthy and Weepanagandla mandals), followed by 10-20 m bgl (26% of the area) located in Kothakota, Pangal, Pebbair, Peddamandaddi and Wanaparthy mandals. The deeper water level of >20 m bgl occupies about 9 % of the area located in Kothakota and Chinnambavi mandals. The shallow water levels of <5 m bgl) occupy about 17 % of area located in Amarachintha, Ghanpoor, Amarachintha and Pebbair mandals (Fig. 2.3).

2.2.3 Post-monsoon Season

Majority of the water levels during this season are in the range of <5 m bgl (43%) noticed in Amarachintha, Ghanpoor, Madanapur, Pangal, Pebbair, Peddamandaddi, Wanaparthy and Weepanagandla mandals and 5-10 m bgl (43%) noticed in Atmakoor, Chinnambavi, Ghanpoor, Gopalpet, Kothakota, Pangal, Pebbair, Peddamandaddi mandals. The water levels in the ranges of 10-20 m bgl occupy about 13 % of the area located in Pangal, Wanaparthy and Kothakota mandals. Water levels above 20 m bgl are not noticed in the district during this season (Fig. 2.4).

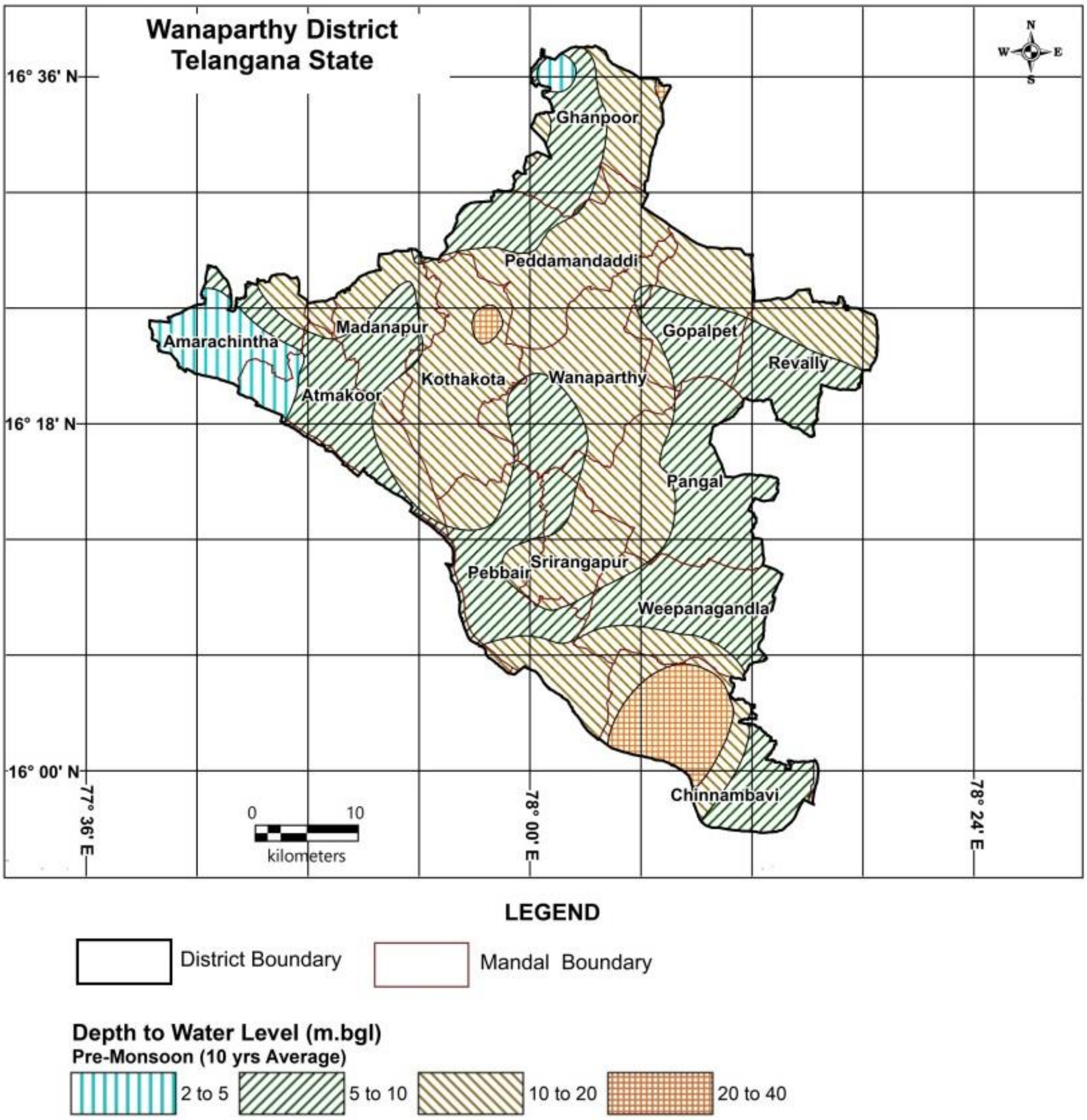


Fig. 2.3: Depth to water levels Pre-monsoon (avg. of 10 years: 2010 to 2019).

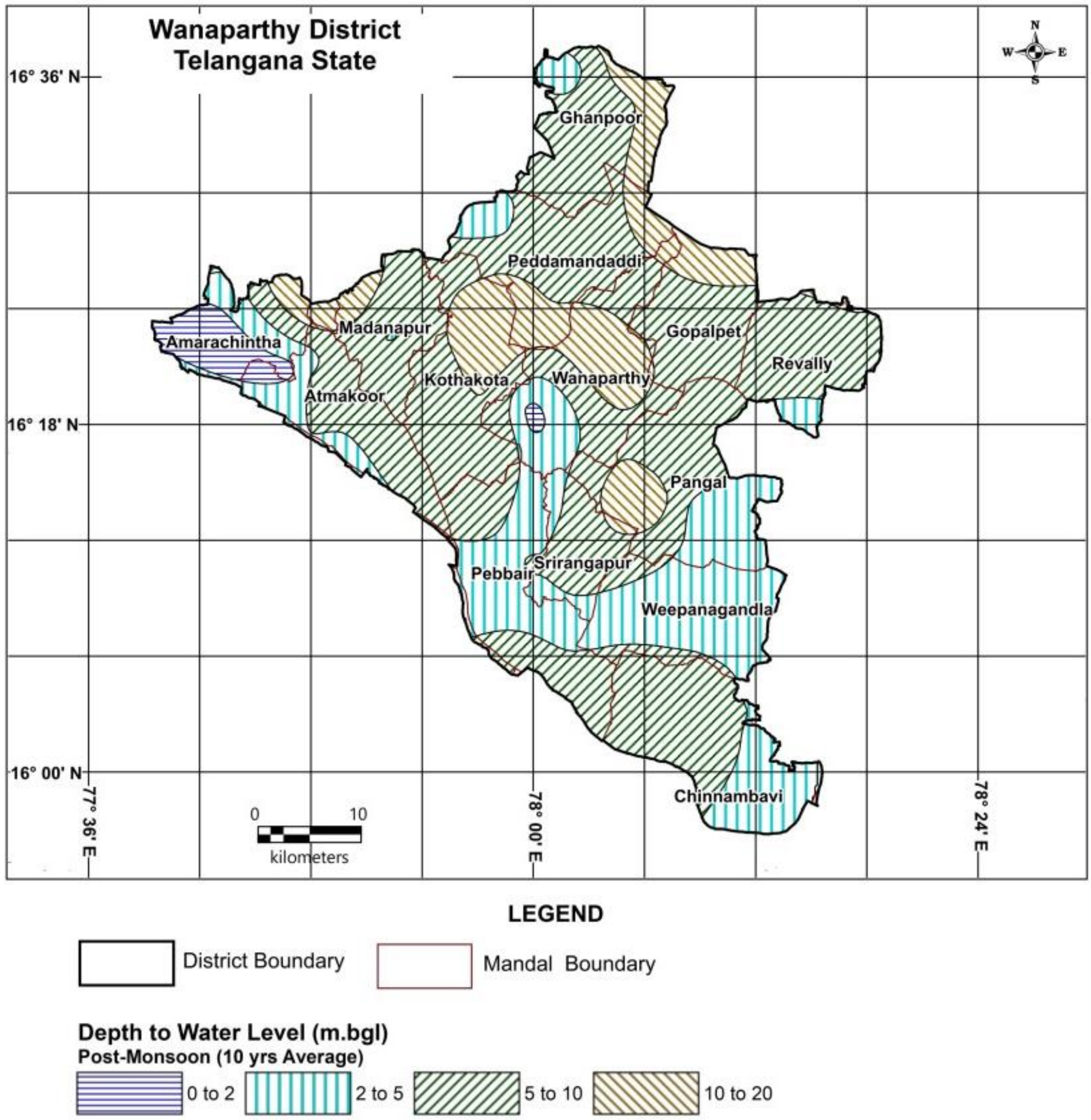


Fig. 2.4: Depth to water levels Post-monsoon (avg. of 10 years: 2010 to 2019).

2.2.4 Water Level Fluctuations (November vs. May)

Out of 23 wells, 22 wells show rise in water levels in the range of 0.35 to 19.12 m bgl (average: 4.02 m) (Fig. 2.5) while in 1 well shows fall in water levels 0.35 m. The maximum of about 55 % of the area has shown water level rise in the range of 2-5 m located in Atmakoor, Gopalpet, Madanapur, Pangal, Pebbair, Peddamandaddi, Wanaparthy and Weepanagandla mandals followed by 0-2 m (23%) located in Amarachintha, Ghanpoor, Gopalpet and Pebbair mandals. In Kothakota and Pebbair mandals the water level rise of 5-10 m noticed (17% of the area). The water level of 10-20 m is noticed in Chinnambavi mandal (5% of the area). The water fall of 0.35 m is noticed in Ghanpoor mandal (Fig. 2.5).

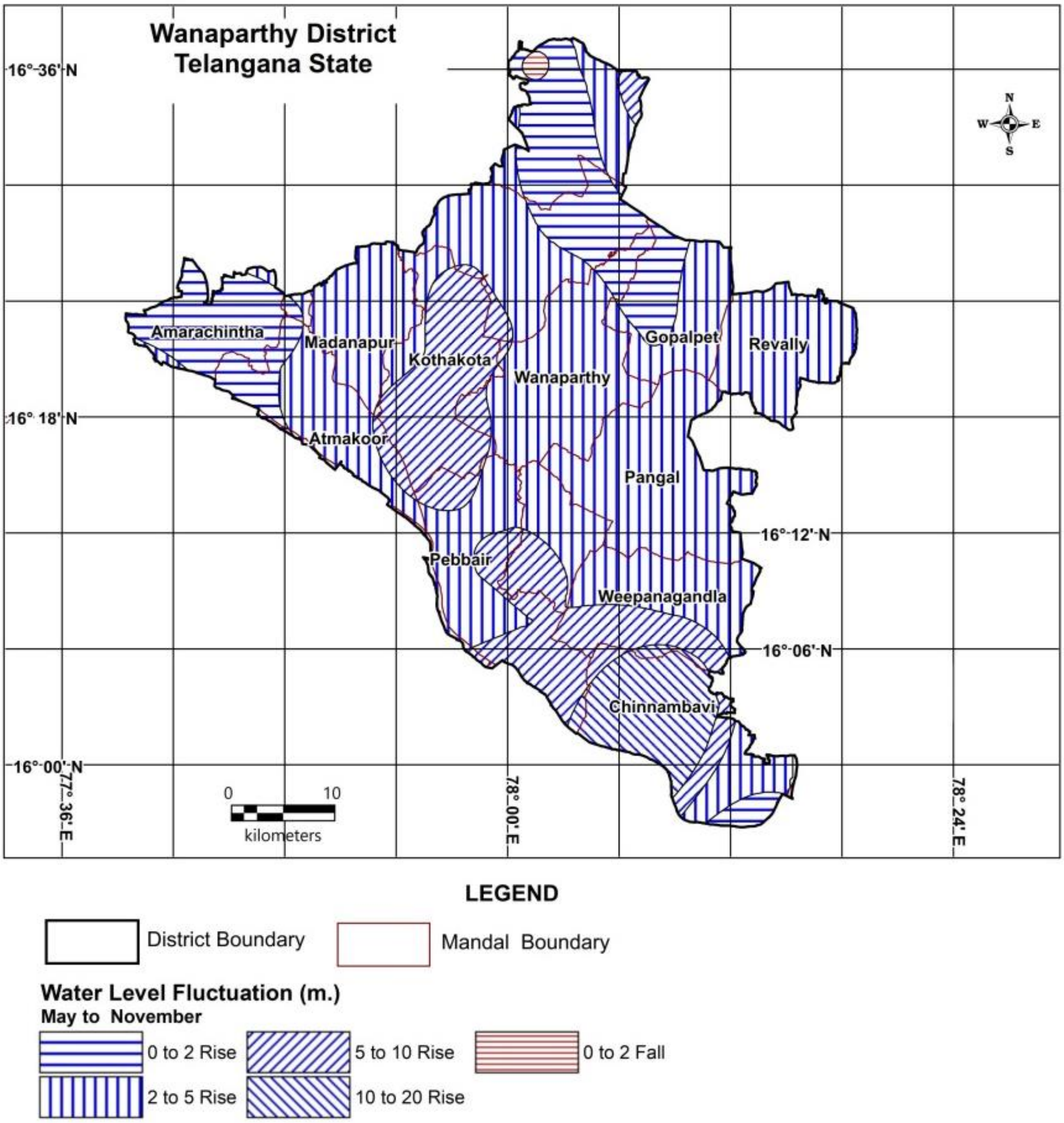


Fig. 2.5: Water Level Fluctuations (m) (Nov vs. May 2019).

2.2.5 Long term water level trends (2010-2019)

Trend analysis for the last 10 years (2010-2019) is studied from 16 hydrograph stations of CGWB (3 nos) and SGWD (13 nos). During pre-monsoon season, 6 wells show falling trends -0.078 to -0.75 m/yr (Amarachintha, Atmakoor, Pebbair, Peddamandaddi and Wanaparthy mandals) and 10 wells shows rising trend in the range of 0.25 to 1.95 m/yr (Ghanpoor, Gopalpet, Kothakota, Madanapur, Pangal, Pebbair, Peddamandaddi and Weepanagandla mandals) (Fig. 2.6). Whereas, in post-monsoon season, 2 well showing falling trend (-0.011) noticed in Amarachintha and Pabbair mandals and in remaining 14 wells, it is showing rising trend ranging from 0.095 to 1.79 m/yr in Amarachintha, Atmakoor, Ghanpoor, Gopalpet, Kothakota, Madanapur, Pangal, Pebbair, Peddamandaddi, Wanaparthy and Weepanagandla mandals (Fig. 2.7).

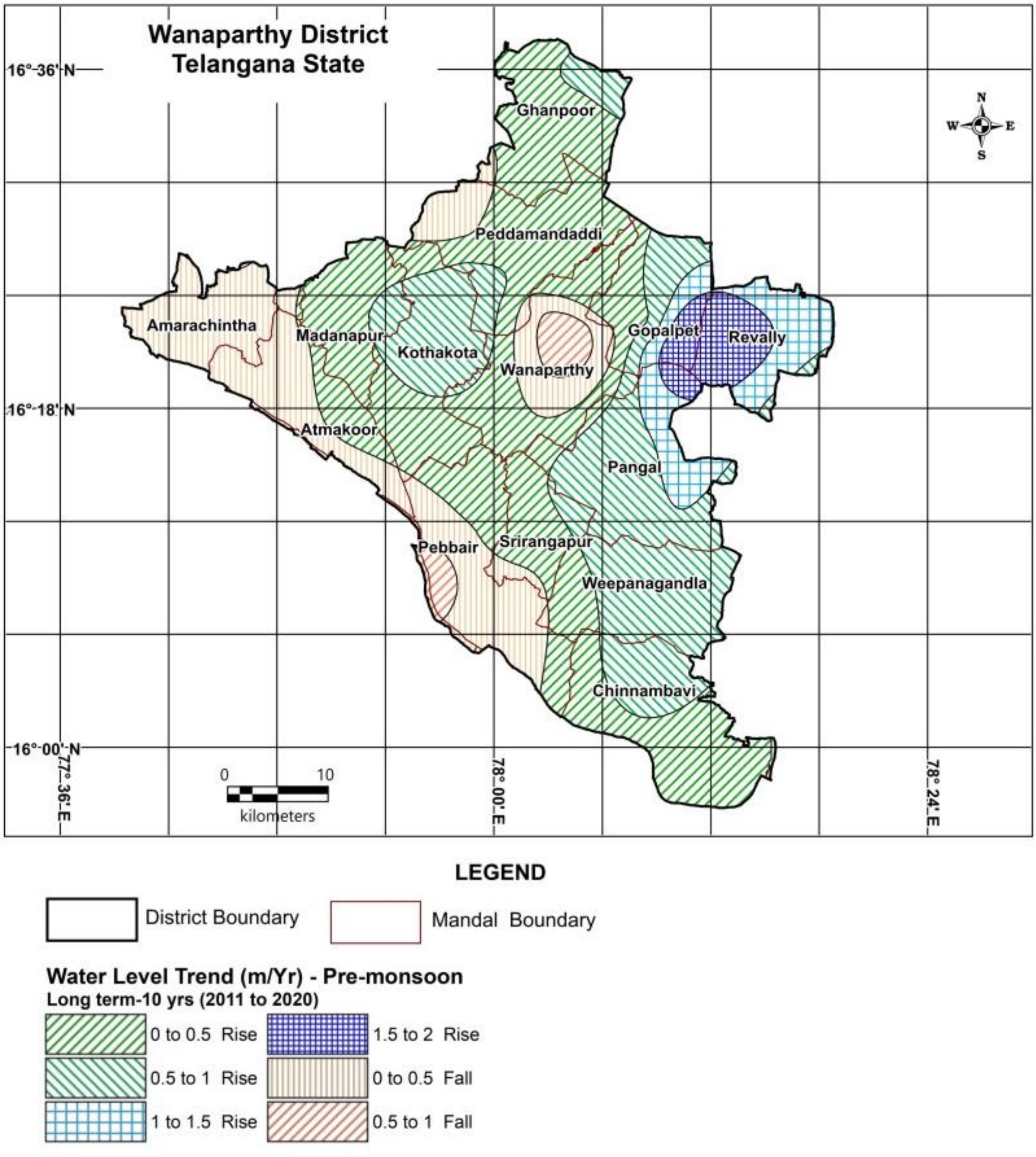


Fig. 2.6: Long-term water level trends (Pre-monsoon 2010-19).

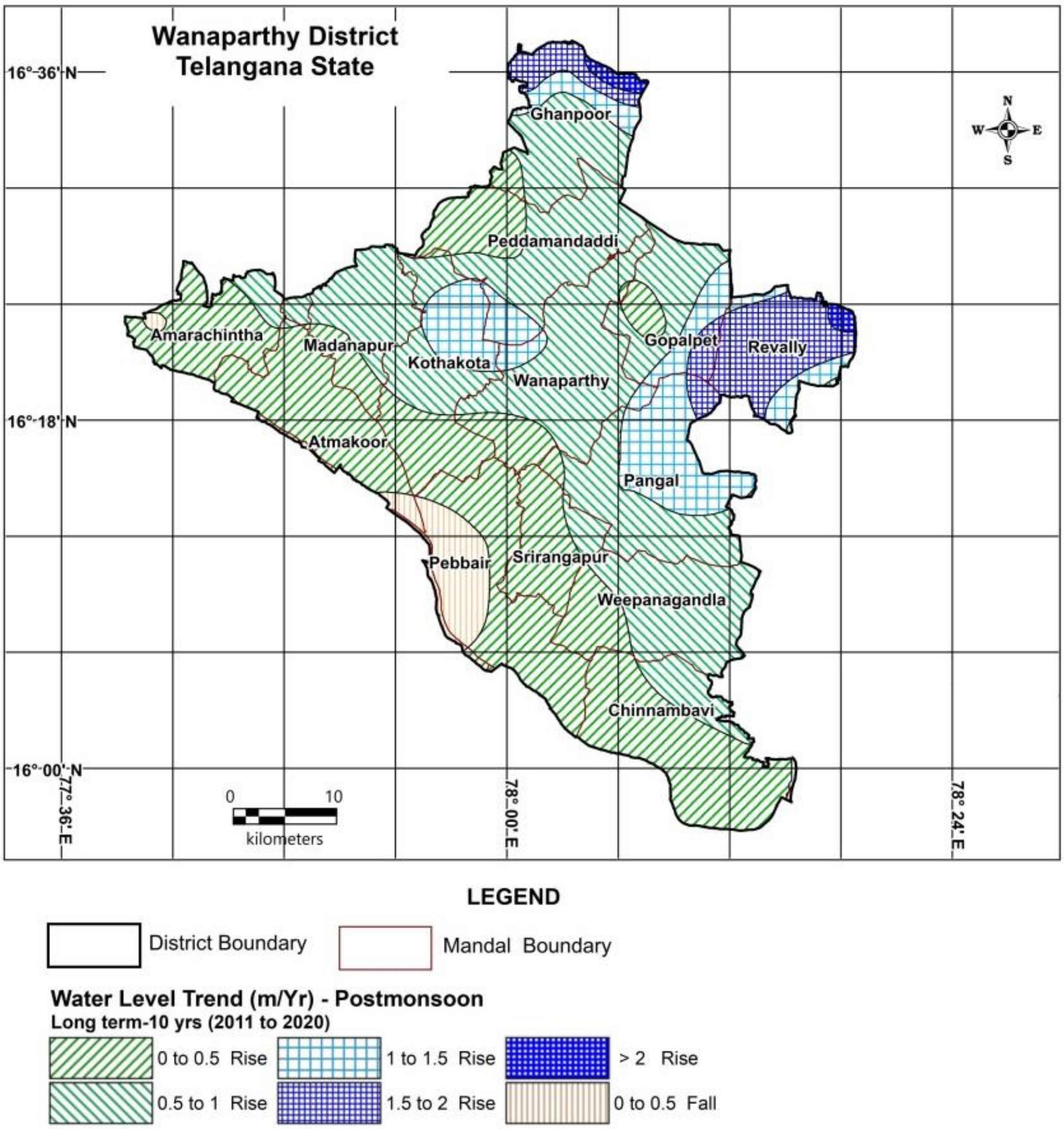


Fig. 2.7: Long-term water level trends (Post-monsoon 2010-19).

2.3 Geophysical Studies

A total of 9 VES data of CGWB is interpreted, which revealed that the resistivity is <30 Ohm (Ω) m for highly weathered granite, 30-60 Ωm for underlying semi weathered granite, between 60-375 Ωm fractured granite and >350 Ωm for massive granite.

2.4 Hydro-chemical Studies

To understand chemical quality of groundwater, a total of 23 wells data is utilized from CGWB (Pre-monsoon: 9 nos.) and SGWD (Pre: 14 & Post: 14) wells during the year 2019.

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 (Total samples 23: CGWB - 9, SGWD - 14)

Groundwater from the area is mildly alkaline in nature with pH in the range of 6.5-8.72 (avg. 7.64). Electrical conductivity varies from 447-4066 µ Siemens/cm (avg. 1455 µ Siemens/cm). In 15 number of samples (65%), the EC is within 1500 µ Siemens/cm and noticed in Chinnambavi, Ghanpoor, Gopalpet, Kothakota, Madanapur, Pangal, Pebbair, Peddamandaddi and Wanaparthy mandals while 6 samples (26%), it is in the range of 1500-3000 µ Siemens/cm noticed in Atmakoor, Ghanpoor, Pebbair, Peddamandaddi, Wanaparthy and Weepanagandla mandals. The EC >3000 µ Siemens/cm is observed in 2 samples (9%) noticed Amarachintha mandal (Fig. 2.8). The concentration of TDS varies from 300 to 2339 mg/l (avg. 908 mg/l) and found that in 21 samples (91 %) it falls within maximum permissible limits of BIS (<2000 mg/l) whereas in remaining 2 samples (9%), it is exceeding the permissible limit (Amarachintha mandal). The NO_3 concentration ranges from 2.85 to 486 mg/l. It is noticed that in about 39% of the samples (9 samples) from Amarachintha, Chinnambavi, Ghanpoor, Pangal, Pebbair and Weepanagandla mandals, the quality is not suitable for drinking water purpose (>45 mg/l) (Fig. 2.9). The Fluoride concentration varies from 0.35-2.54 mg/l and in 22 samples (96 %) it is within permissible limit of <1.5 mg/l. The high fluoride concentration (>1.5 mg/l) is observed in only one samples (2.54 mg/l) located in Peddamandaddi mandal (Fig. 2.10).

2.4.2 Post-monsoon (Total samples 14: SGWD - 14)

Groundwater from the area is mildly alkaline in nature with pH in the range of 7.3-8.47 (avg. 8.13). The Electrical conductivity varies from 509-5456 µ Siemens/cm (avg. 1510 µ Siemens/cm). In 10 samples (71%) from Amarachintha, Atmakoor, Ghanpoor, Gopalpet, Madanapur, Pangal, Pebbair, Peddamandaddi and Wanaparthy mandals, the EC is within 1500 µ Siemens/cm while in 3 sample (22%) from in Peddamandaddi, Kothakota and Weepanagandla mandals, it is in the range of 1500-3000 µ Siemens/cm. The EC >3000 µ Siemens/cm is observed in only one samples (7%) from Ghanpoor mandal (Fig. 2.11). The concentration of TDS varies from 326 to 3492 mg/l (avg. 967 mg/l) and found that in 13 samples (93%) it falls within maximum permissible limits of BIS (<2000 mg/l) whereas in remaining only 1 sample (7%) it is exceeding the permissible limit (Ghanpoor mandal). The NO_3 concentration ranges from 2.25 to 394 mg/l. It is noticed that in about 9 samples (64%) from Ghanpoor, Gopalpet, Kothakota and Wanaparthy mandals it is falling under permissible limit (<45 mg/l) while in 5 samples (36%) it is exceeding permissible limit (>45 mg/l) and not suitable for drinking water purpose (Ghanpoor, Gopalpet, Kothakota and Wanaparthy mandals) (Fig. 2.12). The Fluoride concentration varies from 0.49-2.24 mg/l and found that 12 samples (84%), it is falling under permissible limit of <1.5 mg/l. While in 2 samples (14%) from Madanapur and Amarachintha mandals are having high fluoride concentration (>1.5 mg/l) (Fig. 2.13).

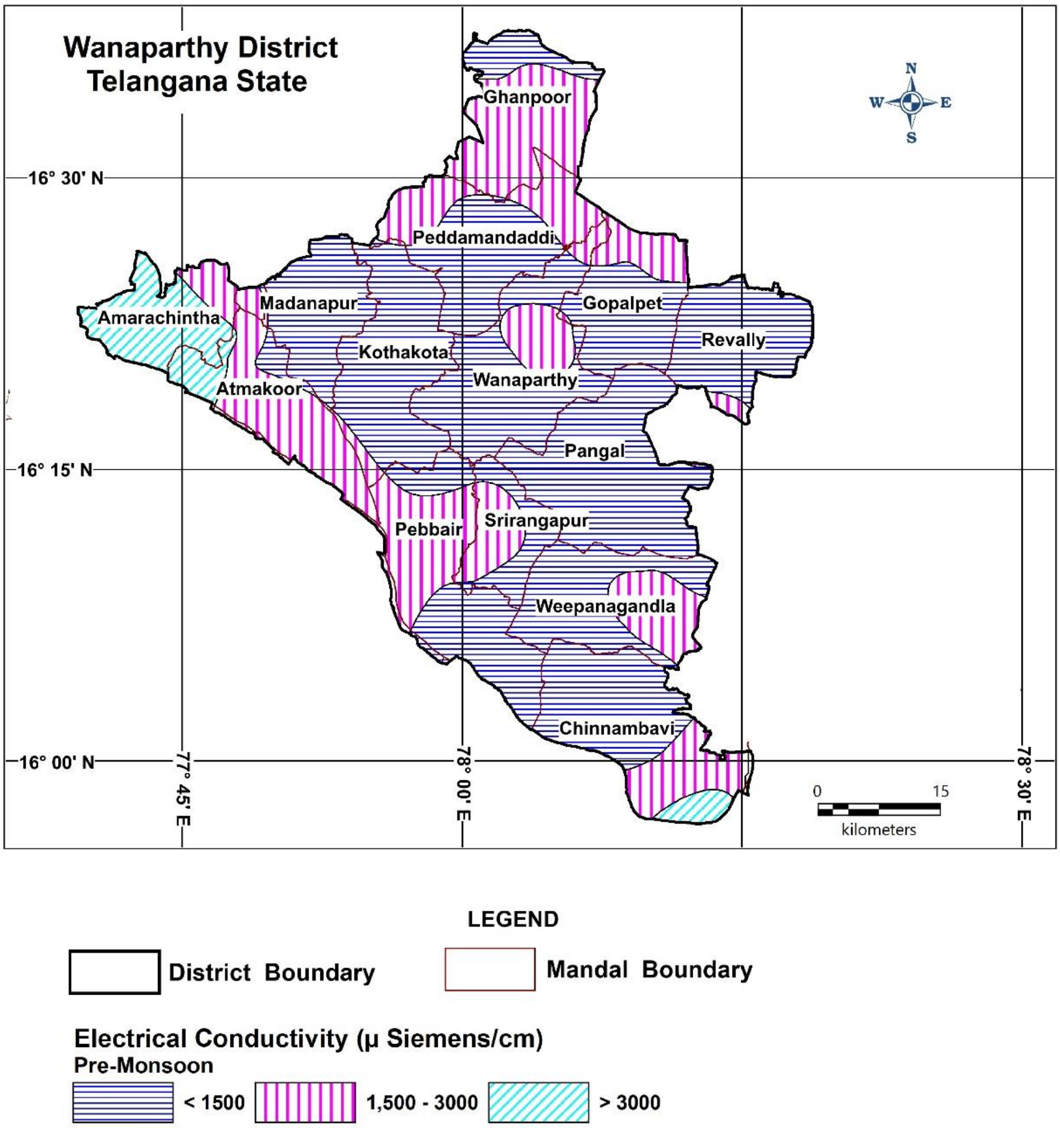


Fig. 2.8: Distribution of Electrical conductivity (Pre-monsoon 2019).

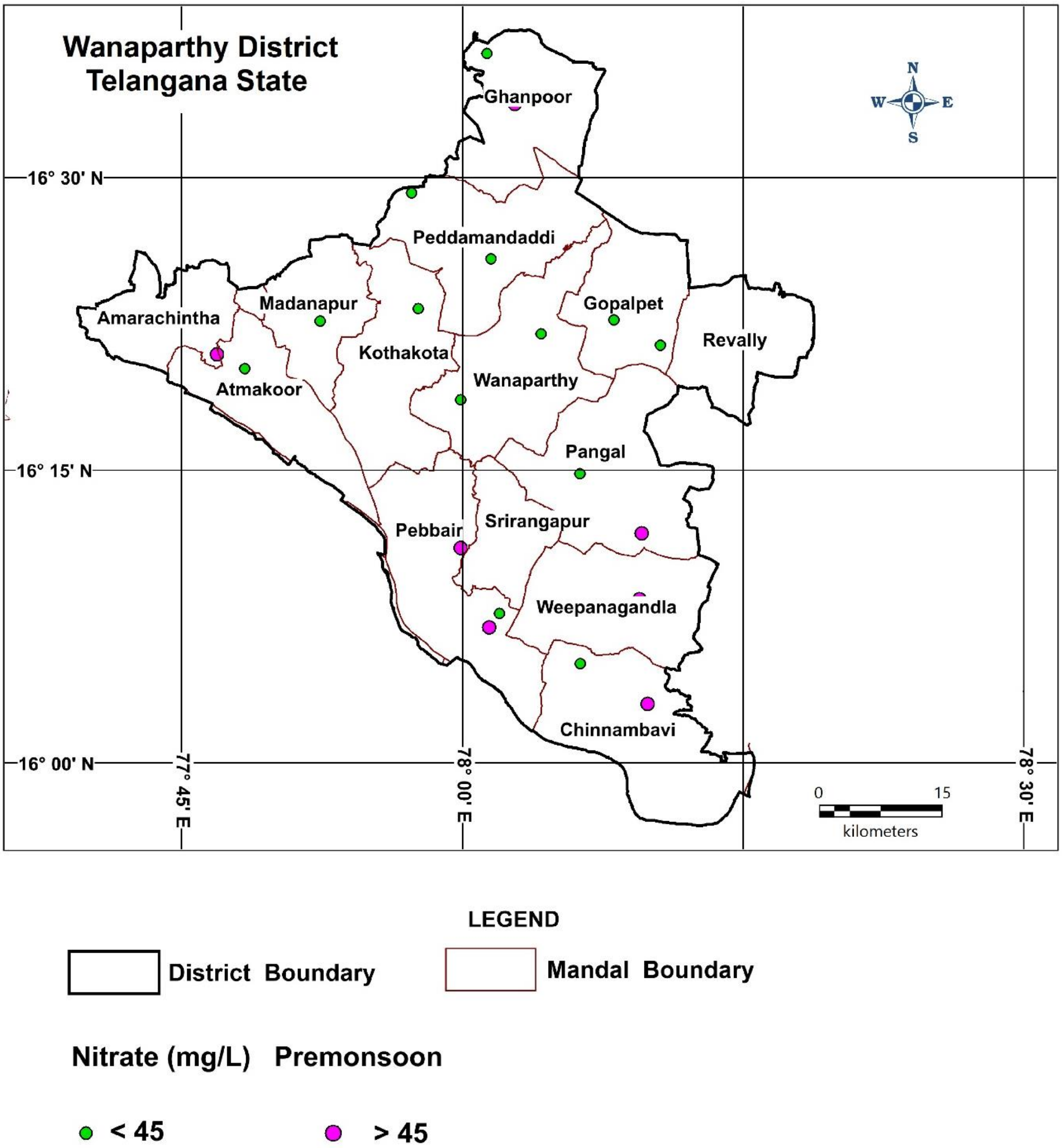


Fig. 2.9: Distribution of Nitrate (Pre-monsoon 2019).

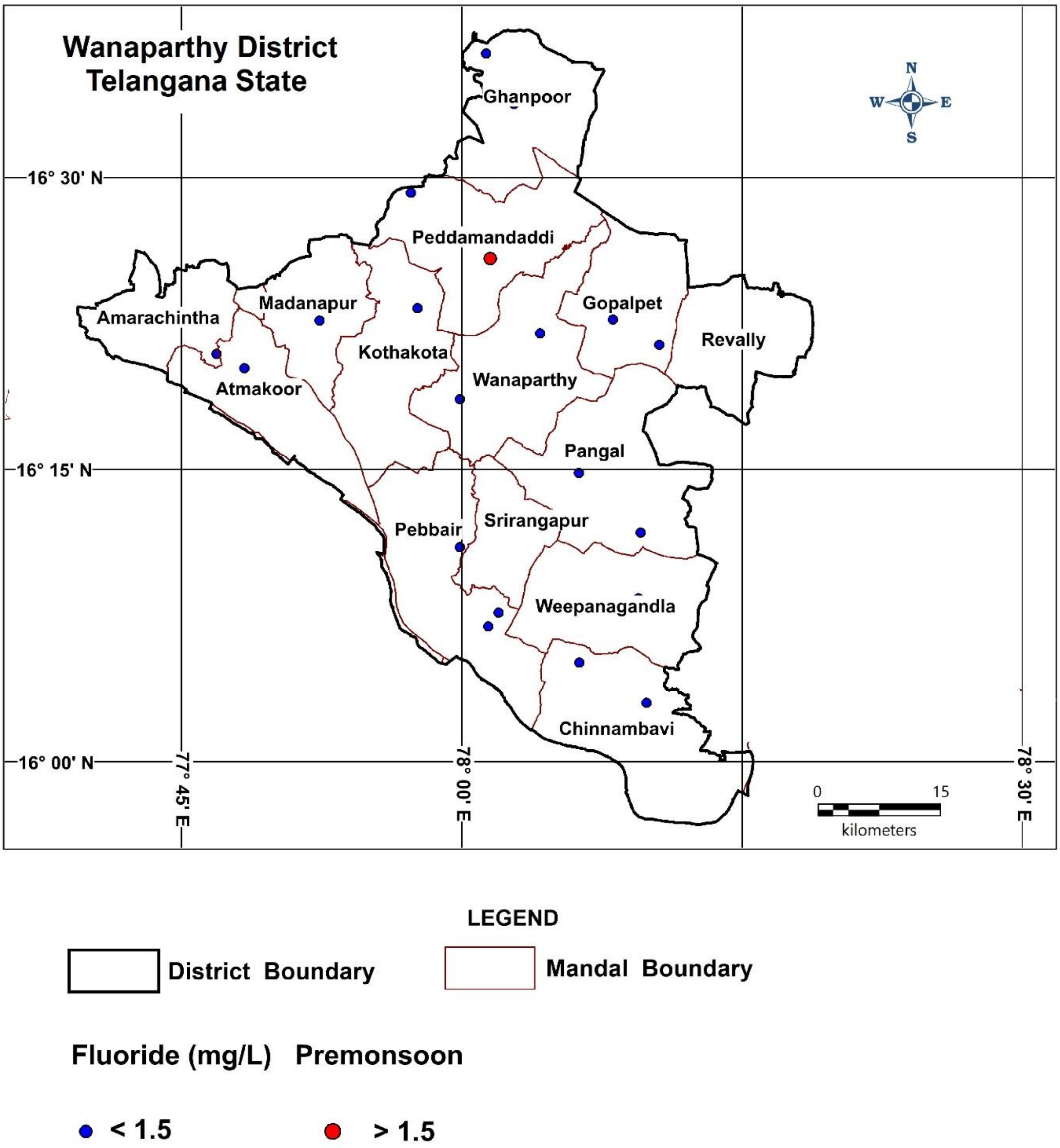


Fig. 2.10: Distribution of Fluoride (Pre-monsoon 2019).

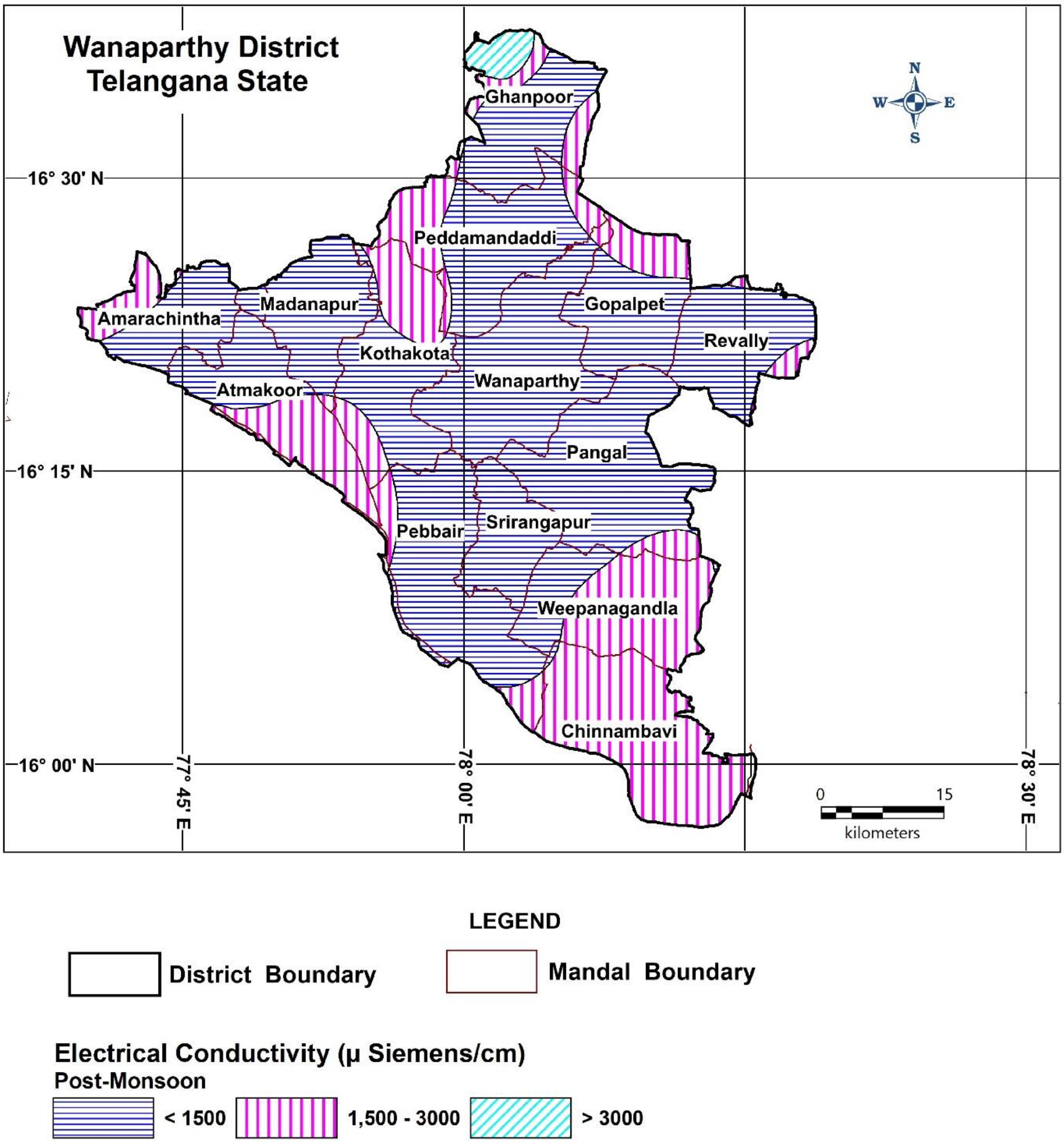


Fig. 2.11: Distribution of Electrical conductivity (Post-monsoon 2019).

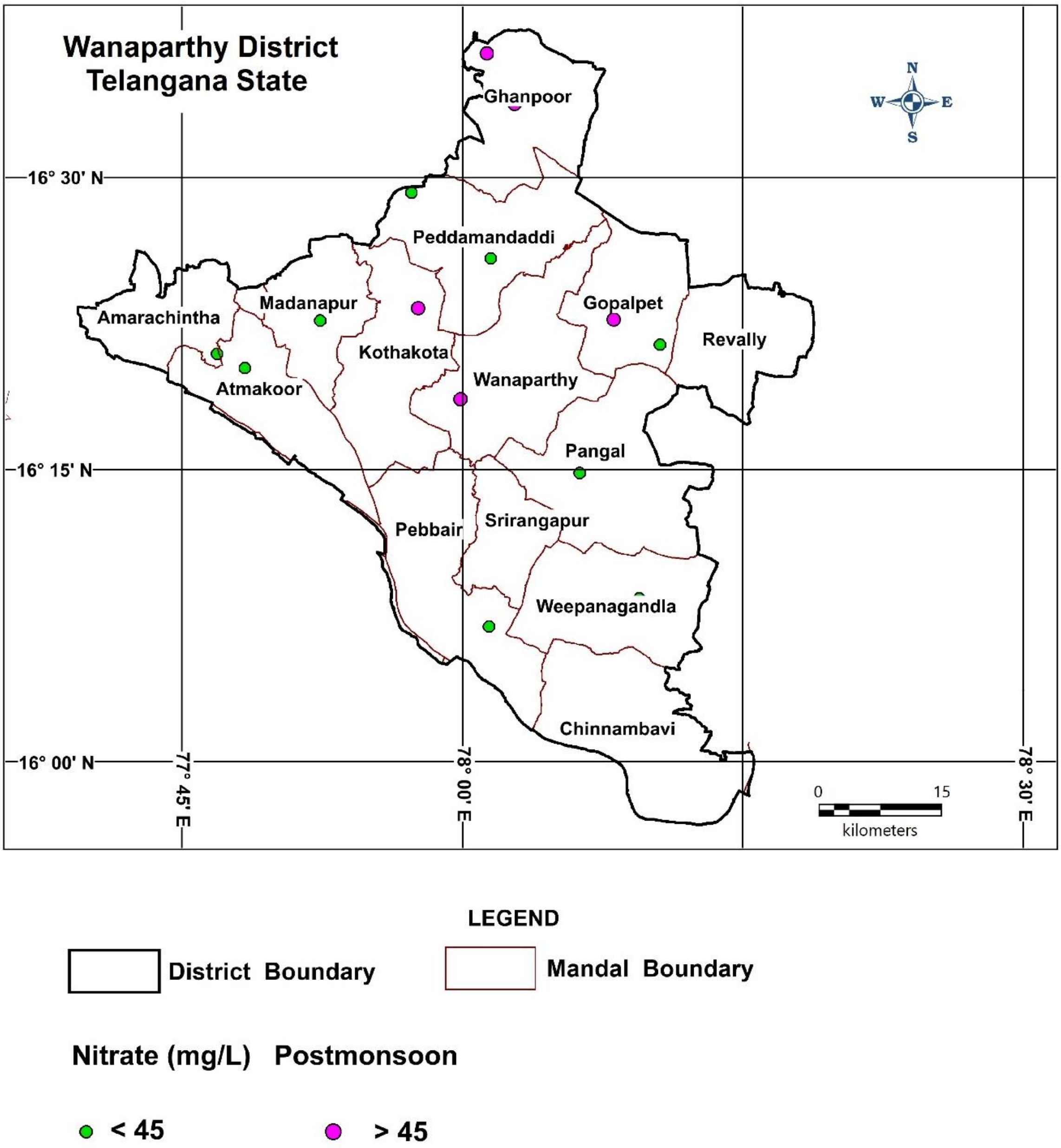


Fig. 2.12: Distribution of Nitrate (Post-monsoon 2019).

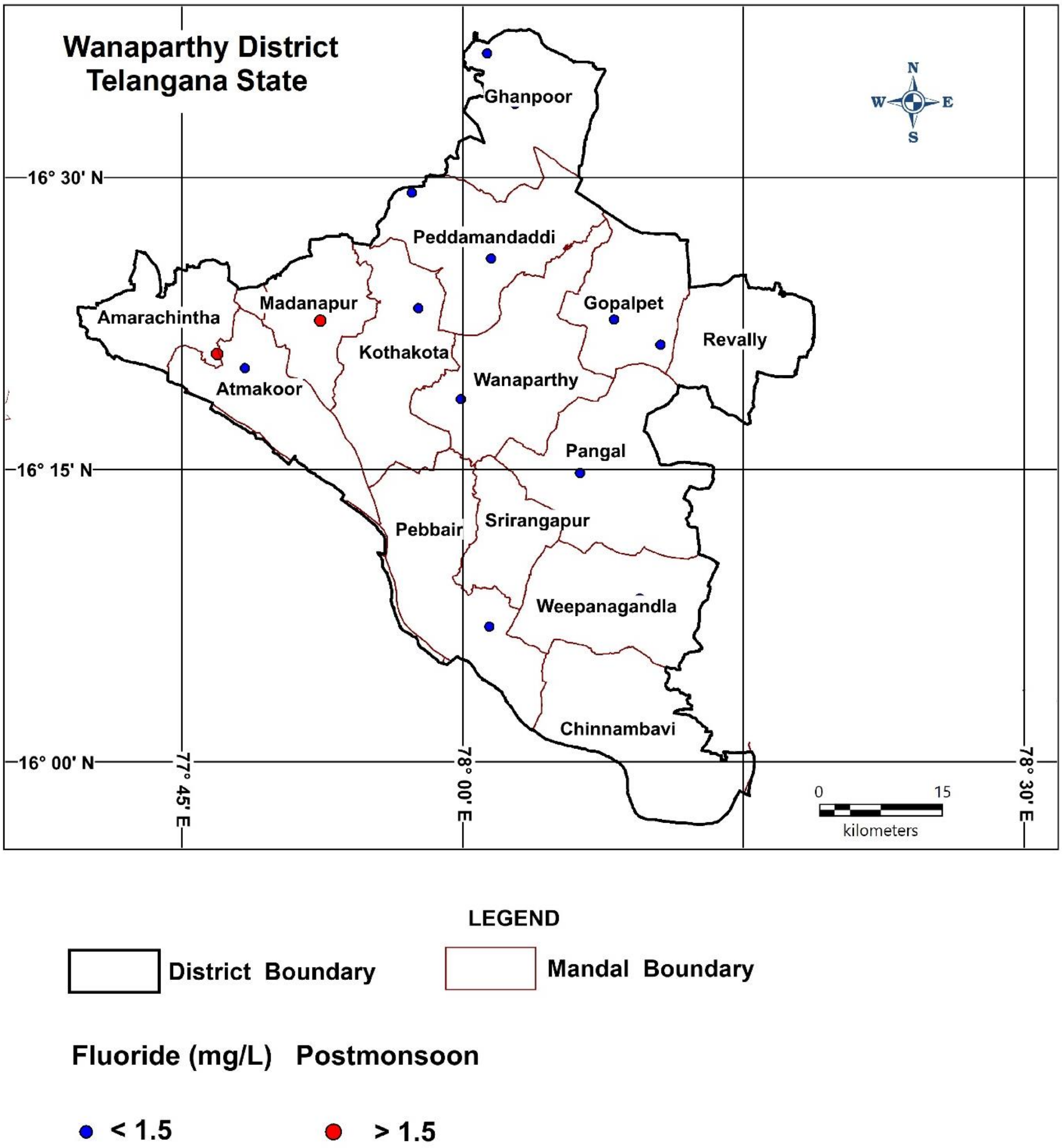


Fig. 2.13: Distribution of Fluoride (Post-monsoon 2019).

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

Conceptualization of 3-D hydrogeological model was carried out by interpreting and integrating data from various departments dealing in groundwater. A representative hydrogeological data from 593 locations (Exploration: 50 (CGWB: 18 and SGWD: 8), VES: 9 (CGWB), APIDC & RWS: 2) down to 250 m were utilized for preparation of 3-D map, panel diagram and hydrogeological sections. The data is calibrated for elevations with Shuttle Radar Topography Mission (SRTM) data. The lithological information was generated by using the RockWorks-16 software and generated 3-D map for district (Fig. 3.1) along with panel diagram (Fig. 3.2) and hydrogeological sections.

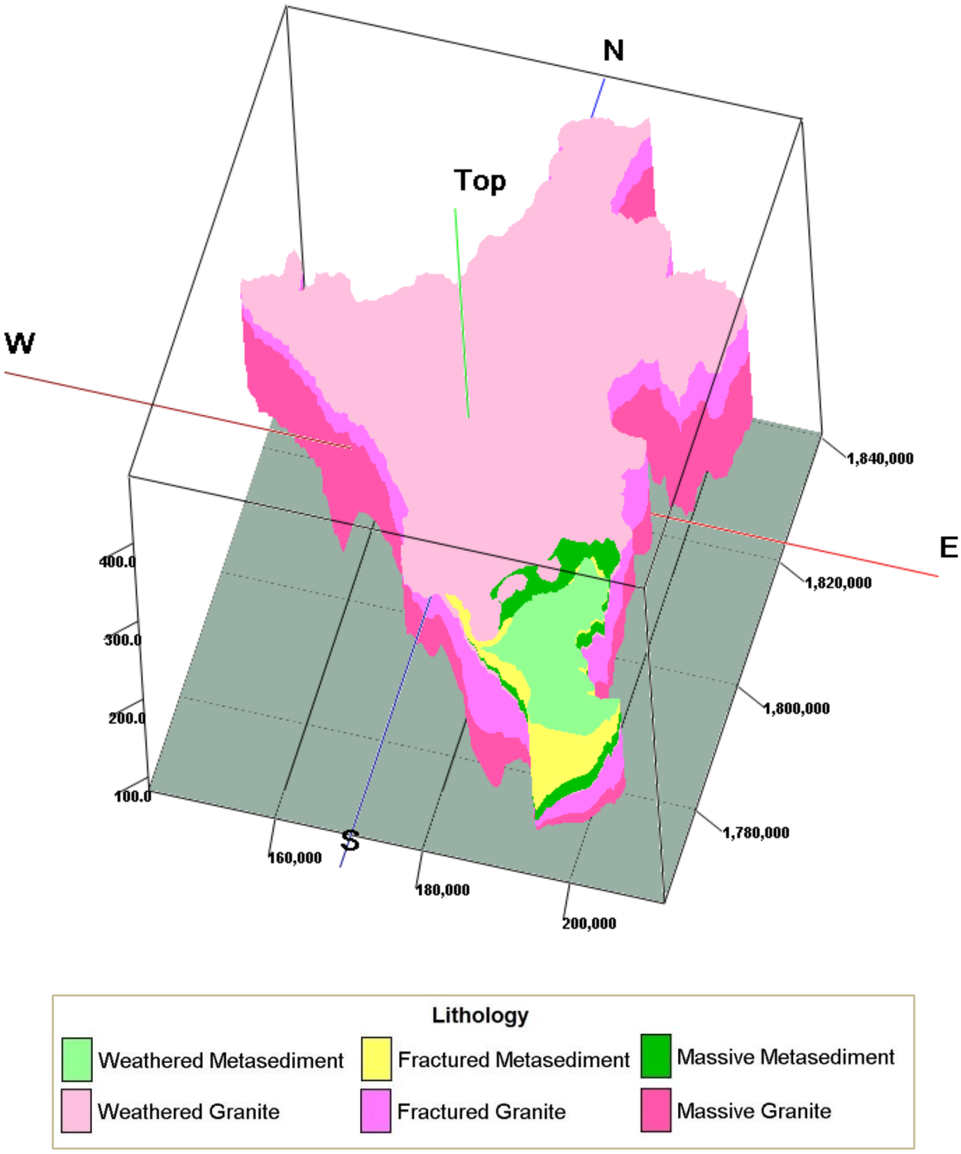


Fig. 3.1:3D Model.

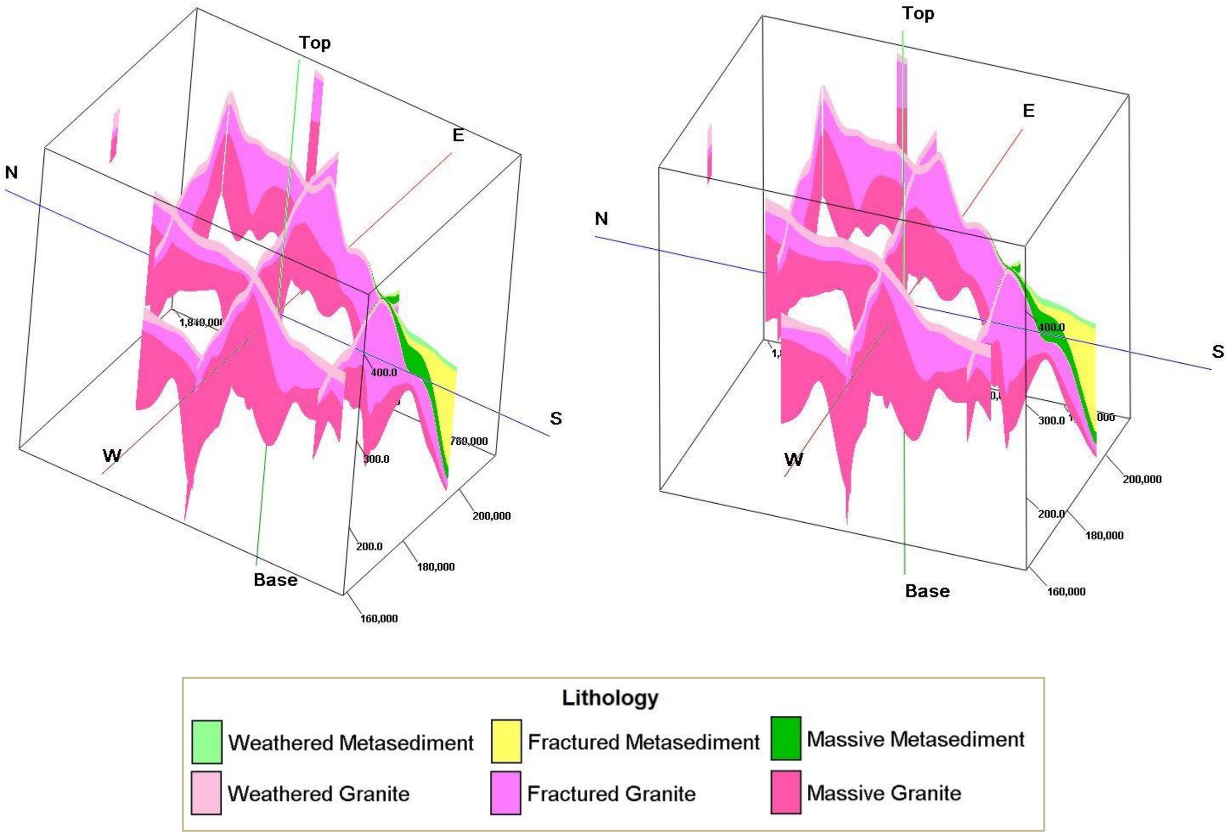


Fig. 3.2: Panel Diagram.

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 250 m bgl. The weathered zone is ranging from 2 to 28 m bgl with an average of 11 m bgl. The weathering >20 m bgl is noticed in Revally, Peddamandaddi and Ghanpoor mandals. The fractured zone is ranging from 5.6 to 153 m bgl with the yield ranging from 0.001 to 12.2 lps. About 88% of the fractures were encountered below 100 m depth. The deeper fractures beyond 100 m bgl (12%) are encountered in Chinnambavi, Pangal, Pebbair, Peddamandaddi and Weepanagandla mandals.

3.2 Hydrogeological Sections

Two hydrogeological sections are prepared along NE-SW (a) and NW-SE (b) directions and are given in Fig. 3.3 (a&b).

3.2.1 NE-SW Section (a)

The section drawn along NE-SW direction covering distance of 60 kms (Fig. 3.3a). It depicts uniform weathered zone throughout the section. Thick fractured zone occurs from a distance of 0 to 25 kms and 45 to 60 km.

3.2.2 NW-SE Section (b)

The section drawn along the NW-SE direction covering distance of 55 kms depicts a uniform weathered zone throughout the section. Thick fractured zone occurs from a distance of 25 to 55 km (Fig. 3.3b).

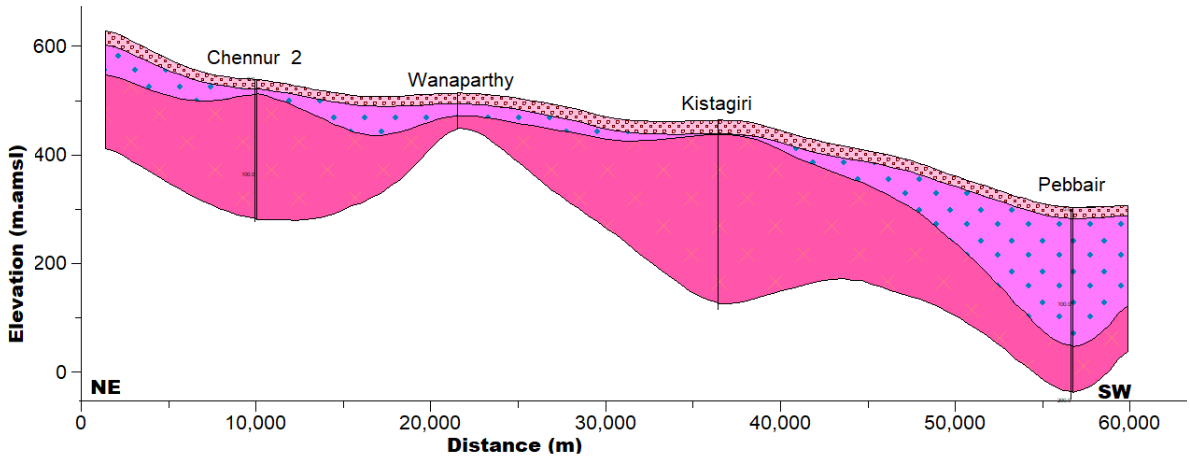


Fig. 3.3 (a): NE-SW Section.

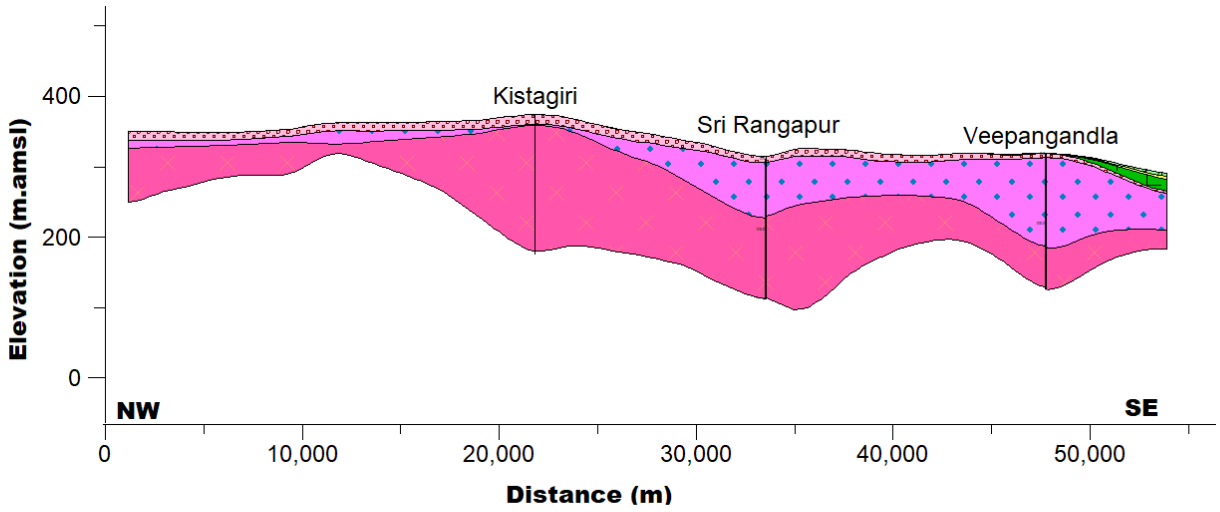


Fig. 3.3 (b): NW-SE Section.

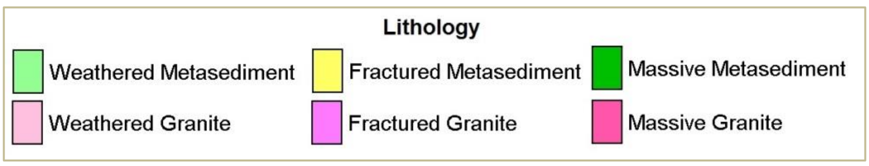


Fig. 3.3: Hydrogeological sections along different directions.

3.3 Aquifer Characterization

3.3.1 Weathered zone

The weathered zone is dominantly consisting of granites. Many of the area have gone dry during pre-monsoon season. Further, the dug wells, which were in operations earlier, have gone dry and become defunct due to over-exploitation. In most of the area, the depth of weathering ranges from 10 to 20 m bgl (44 %) observed in Ghanpoor, Gopalpet, Kothakota, Pangal, Pebbair, Peddamandaddi, Revally, Srirangapur and Wanaparthy mandals while the depth of weathering ranging from 0 to 10 m bgl is distributed in 40% of the area and noticed in Atmakoor, Chinnambavi, Ghanpoor, Gopalpet, Kothakota, Madanapur, Pangal, Pebbair, Peddamandaddi, Revally, Srirangapur, Wanaparthy and Weepanagandla mandals. The weathering depth >20 m bgl is distributed in 6% of the area falls in Revally, Peddamandaddi and Ghanpoor mandals (Fig. 3.4 and Fig. 3.5). Generally, the yield of weathered zone varies from <1 to 4 lps with average of 1 lps. 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.

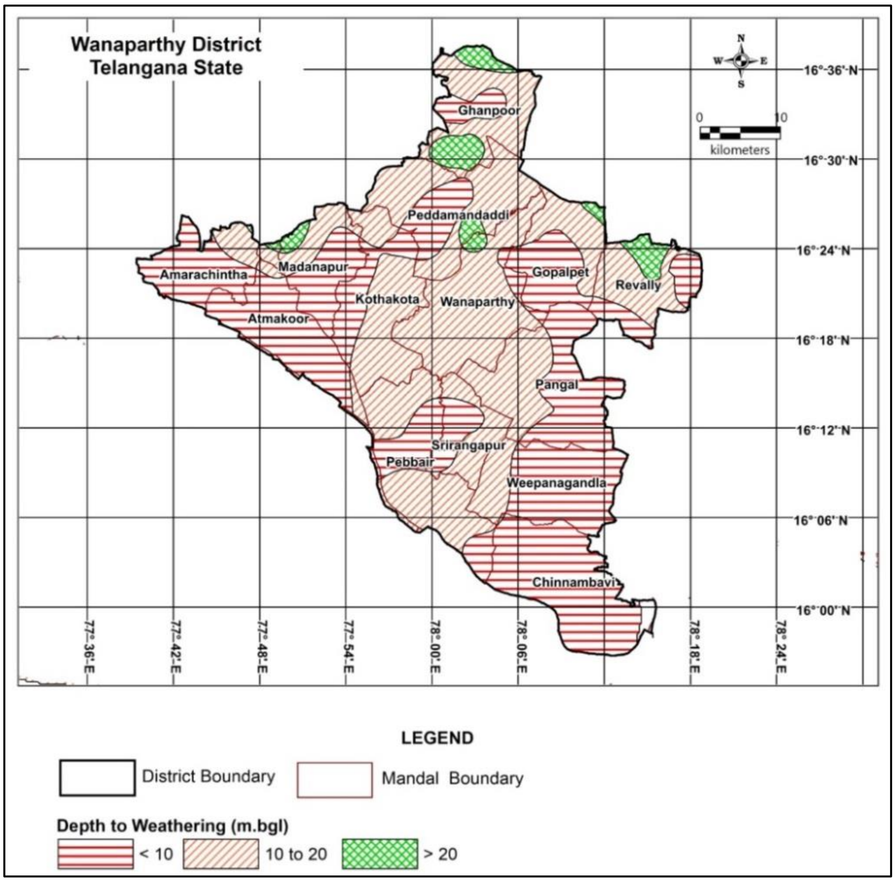


Fig. 3.4: Thickness of Weathered zone.

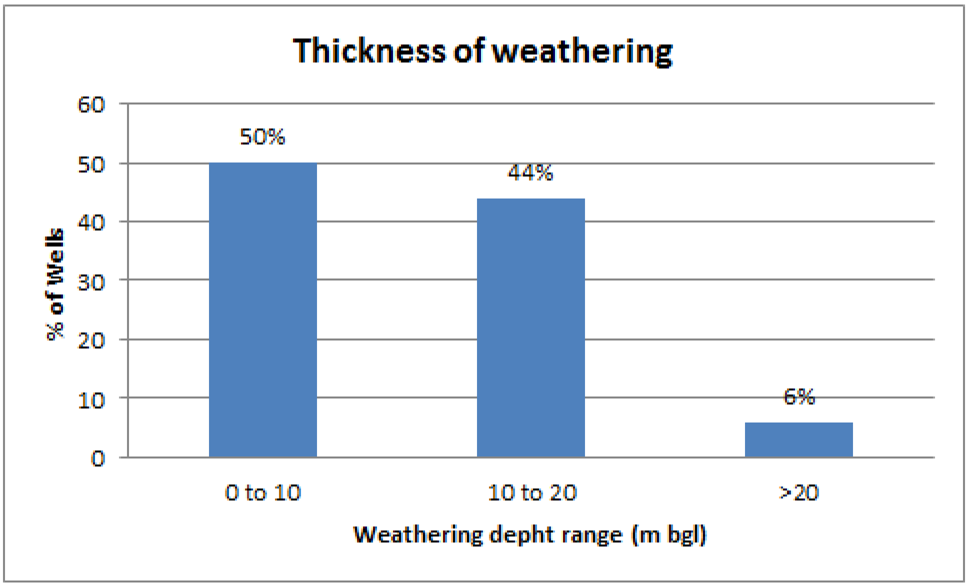


Fig. 3.5: Depth wise distribution of weathering zone.

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 (18 wells) and SGWD (8 wells) exploration data, it is inferred that 54% of the fractures occur within 30 m bgl observed at Atmakoor, Chinnambavi, Kothakota, Madanapur, Pangal, Pebbair, Peddamandaddi and Wanaparthy mandals. The fractures ranging from 30 to 60 m bgl are in 23% of the fractures observed at Ghanpoor, Gopalpet, Kothakota, Pangal and Pebbair mandals. In 19% of well, the fractures in the depth range of 60 to 100 m bgl are noticed in Gopalpet, Revally, Srirangapur and Wanaparthy mandals (Fig. 3.6). The deepest fracture tapped at the depth of 109.3 m bgl is observed Peddamandaddi mandal. The yield varies from <1 to 3 lps in the terrain with an average of 1lps. The Transmissivity varies up to 50 m^2/day. The Storativity varies up to 0.001.

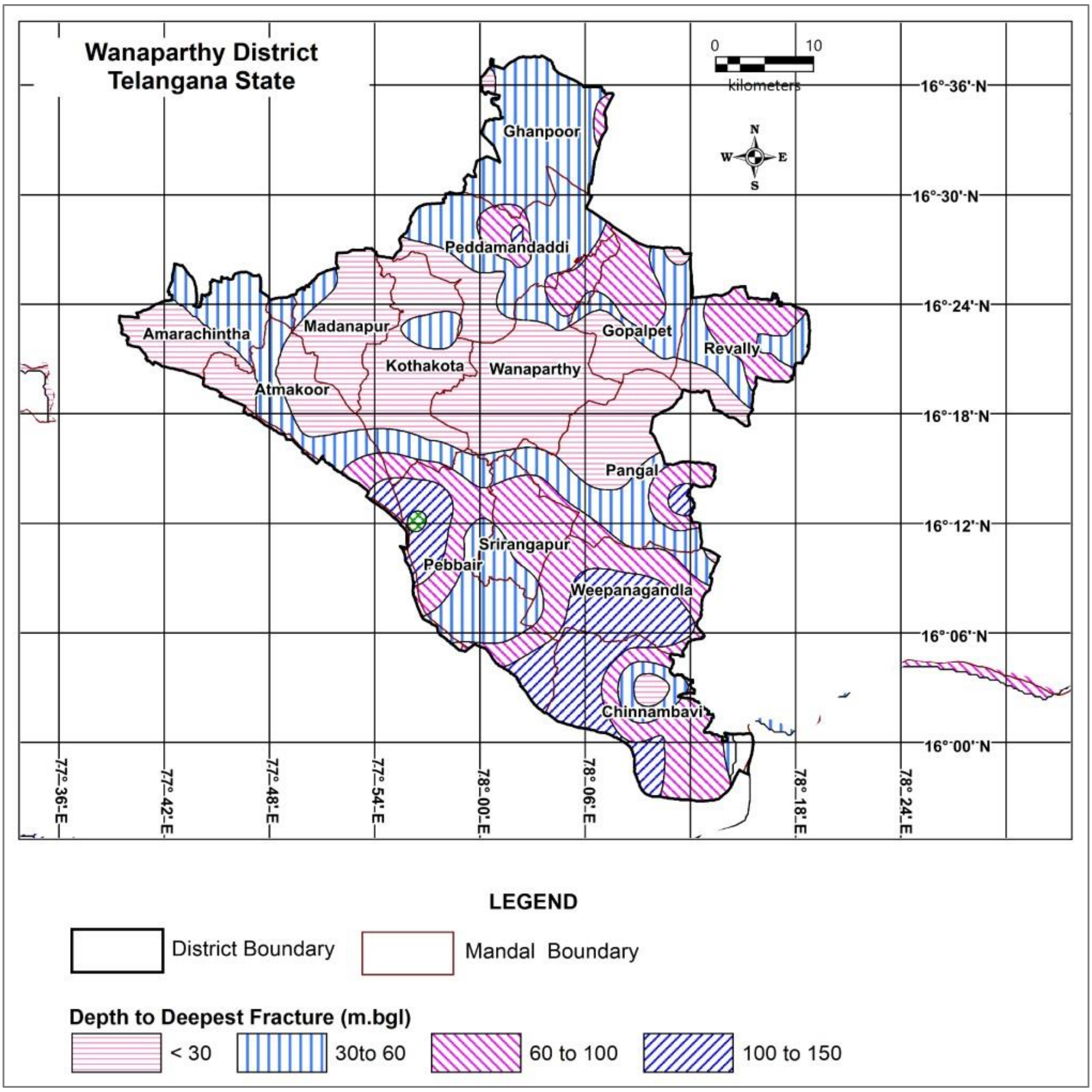


Fig. 3.6: Depth of Fractured zone.

4. GROUND WATER RESOURCES (2020)

Practically, in hard rock areas, computation of zone wise (aquifer wise) groundwater resources is very difficult 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 challenging 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 groundwater resources are computed as per the guidelines laid down in GEC methodology. Summarized computed dynamic groundwater resources is given in Table 4.1

As per 2020 GEC report, the net dynamic replenishable groundwater availability for newly formed Wanaparthy district is 320.02 MCM, gross groundwater draft for all uses 148 MCM, provision for drinking and industrial use for the year 2025 is 19.4 MCM and net annual groundwater potential available for future irrigation needs is 165.21 MCM. Out of 14 mandals, 1 falls under Over-exploited, 2 under Semi Critical category and 11 under Safe category. Mandal wise stage of groundwater development varies from 17% (Chinnambavi) to 105% (Gopalpet) with an average of 46 %.

Table 4.1: Computed Dynamic ground water resources (2020).

Parameters	Resources (GEC 2020) in MCM
Dynamic (Net GWR Availability)	320
• Monsoon recharge from rainfall	107
• Monsoon recharge from other sources	49
• Non-Monsoon recharge from rainfall	109
• Non-monsoon recharge from other sources	90
• Natural Discharge	36
Gross Recharge	356
Gross GW Draft	148
• Irrigation	135
• Domestic and Industrial use	13
Provision for Drinking and Industrial use for the year 2025	19
Net GW availability for future irrigation	165
Average Stage of GW extraction (%)	46
Categorization of mandals	**Safe:11, Semi Critical:2 & OE:1** **Safe:** Chinnambavi (17%), Atmakur (23%), Pebbair (24%), Sri Rangapur (28%), Weepangandla (32%), Kothakota (40%), Madanapur (49%), Wanaparthy (50%), Peddamandadi (52%), Pangal (54%) and Ghanpur (54%) **Semi Critical:** Revally (77%), Amarachintha (86%) **Over Exploited:** Gopalpet (105%)

5. GROUND WATER RELATED ISSUES AND REASONS FOR ISSUES

5.1 Issues

Over-exploitation

- 163 km^2 area (8 % of area) covering 31 villages are categorized as over-exploited where ground water balance for future irrigation is nil.

Pollution (Geogenic and Anthropogenic)

- Few mandals are fluorosis endemic where fluoride (geogenic) as high as 2.54 mg/l during pre-monsoon and 2.24 mg/l during post-monsoon season is found in groundwater. The high fluoride concentration (>1.5 mg/l) occur in 4 % (1 samples) and 14% (2 samples) respectively during pre and post-monsoon season of 2019.
- High nitrate (>45 mg/l) due to anthropogenic activities is observed in 9 samples (39%) and 5 samples (36%) during pre and post-monsoon season respectively.

Deep water levels

- Deep water levels (>20 m bgl) are observed during pre -monsoon season in 9% of the samples.

Declining water level trends

- Out of 16 wells analyzed, 6 wells shown falling trend in pre-monsoon and 1 well during post-monsoon season (-0.75 to -0.078 m/yr and -0.011 m/yr) respectively.

Sustainability

- Low yield (<1 lps) occurs in 65 % of the exploratory wells covering Atmakoor, Chinnambavi, Gopalpet, Kothakota, Madanapur, Pangal, Pebbair, Srirangapur and Wanaparthy 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 semi critical and other areas 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 spices) is observed.
- Paddy crop based on ground water is grown during Rabi season in non-command area also leading 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.

Over-exploitation and Deep water levels

- Over-extraction, paddy cultivation during rabi season more ground water extraction in proportion to recharge, limited artificial measures and low rainfall etc.

6. MANAGEMENT STRATEGIES

High dependence on groundwater coupled with absence of augmentation measures has led to a steady fall in water levels and desaturation of weathered zone in some parts, raising questions on sustainability of existing groundwater structures, food and drinking water security. The occurrence of fractures 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 occur within 100 m depth. 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 (granite rock), high weathering, longer residence time and alkaline nature of groundwater.

6.1 Management plan

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

6.1.1 Supply side measures

In the district, 6884 MCM of unsaturated volume (below the depth of 3 m) is available during post-monsoon, having 138 MCM of recharge potential. 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, under Phase-1 to Phase-4, out of 1456 minor irrigation tanks, 579 tanks desilted. This helped in strengthen 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 scheme, all the villages and towns are proposed to be covered from the water grid with intake from Yellore reservoir, Kalvakurthy lift irrigation. This scheme is to enhance the existing drinking water schemes and to provide 100, 135 and 150 lpcd of water in rural, municipal and Municipal Corporation respectively.

- The total water import will be 22.11 MCM (drinking and industrial needs) and this imported water from surface sources will reduce the present utilized 12.65 MCM of groundwater (considering 60 lpcd). This can be effectively utilized to irrigate 2108 ha. of additional land under ID crops.

6.1.1.3 Artificial Recharge Structures

While formulating the village wise groundwater management plan, the unsaturated volume of aquifer is estimated by multiplying the area with specific yield and unsaturated thickness (post-monsoon water levels below 3 m bgl). Initially, village wise dynamic groundwater resources of 2020 are considered. Potential surface run off is estimated by following standard procedures. Initially, 20% run off yield is considered as non-committed yield and for recommending artificial recharge structures in intermittent 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 %)

Area consisting of 31 villages having 163 km^2 covered under Priority-1, where 16 MCM recharge potential and 1.4 MCM utilizable yield (uncommitted run-off) is available and immediate intervention is required where the stage of groundwater development is >100 % (Annexure-1). The management plan for Priority-1 area is given in Fig. 6.1.

About 174 artificial recharge structures were constructed (CDs: 60, PTs: 114) in 11 villages with existing storage capacity of 3.3 MCM.

- About 24 artificial recharge structures (9 CD’s with recharge shafts with 5 fillings with a unit cost of Rs. 15 lakhs each and 15 mini PT’s with 1.5 fillings with a unit cost of Rs 20 lakhs each) with a total cost of 4.35 crores can be taken up.
- After effective utilization of this yield, there will be 0.47 MCM of groundwater recharge.
- Roof top rainwater harvesting structures should be made mandatory to all Government buildings (new and existing).

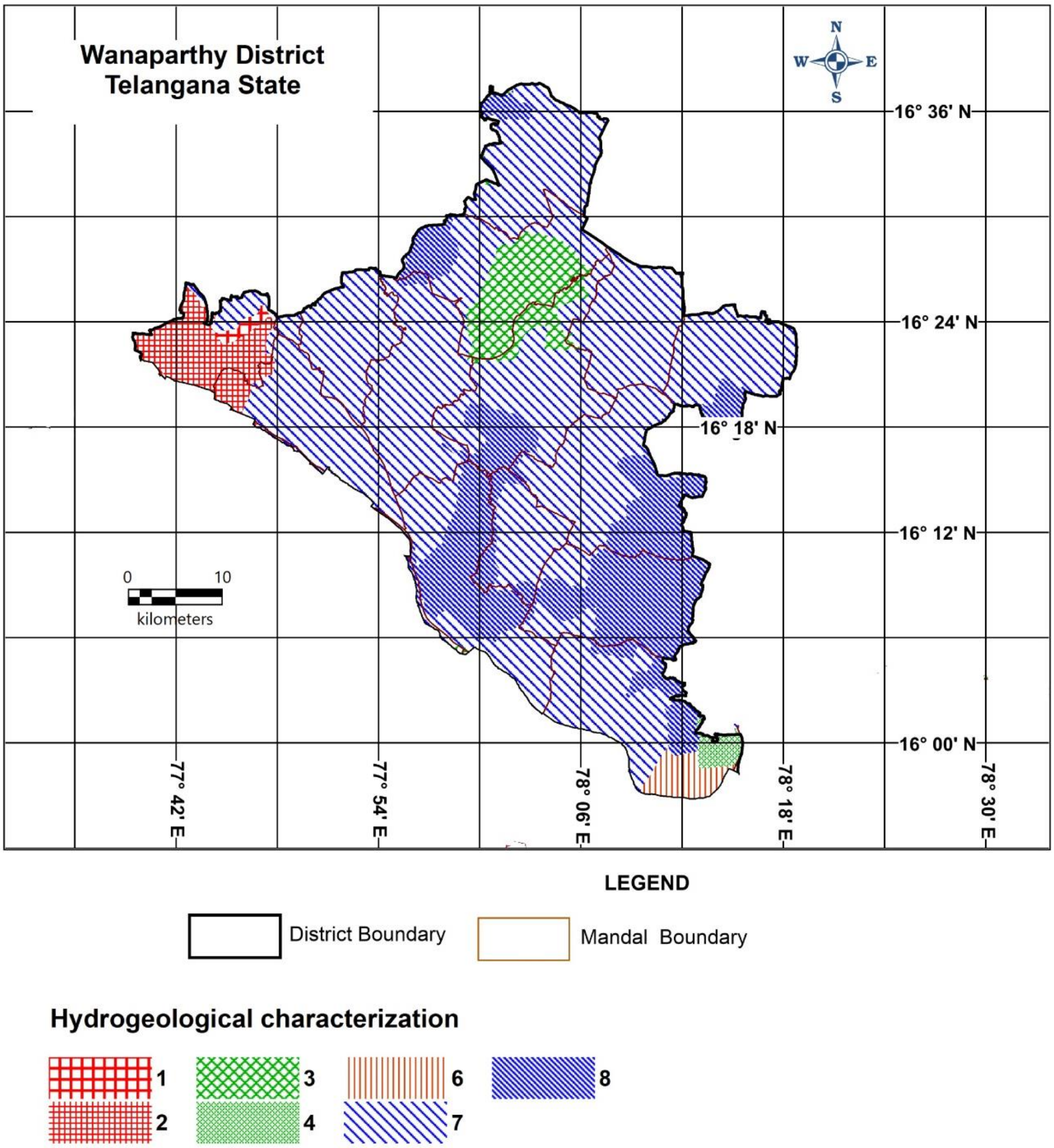


Fig. 6.1: Priority-1 area for sustainable management plan of ground water resources.

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

- Area consisting of 192 villages having 2007 km^2 covered under Priority-2, where 122 MCM recharge potential and 15 MCM utilizable yield (uncommitted run-off) is available and immediate intervention is required (Annexure-2). The management plan for Priority-2 area is given in Fig. 6.1.
- About 808 artificial recharge structures were constructed (CDs: 269, PTs: 539) in 58 villages with existing storage capacity of 15 MCM.

- Artificial recharge structures are recommended for 50% of the utilizable yield in the intermittent areas.
- About 194 artificial recharge structures (80 CD’s with recharge shafts with 5 fillings with a unit cost of Rs. 15 lakhs each and 114 mini PT’s with 1.5 fillings with a unit cost of Rs 20 lakhs each) with a total cost of 35 crores can be taken up.
- After effective utilization of this yield, there will be 4 MCM of groundwater recharge.
- 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 4460 farm ponds are recommended (20 in each village in 223 villages) at Rs 25,000/-each with total cost of 11.15 crores, this can create an additional storage of 1.34 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 5253 ha. area is brought under micro-irrigation (Sprinklers: 2035 and drip: 3000) saving 7.9 MCM of groundwater (considering 25 % of saving to traditional practices).

6.1.2.2 Proposed Micro-irrigation

- 4258 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 25.55 crores (considering 1 unit/ha. @0.6 lakhs/ha.). With this 6.4 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 constant 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 76 crores, the likely benefit would be increases in gross groundwater availability with net saving of 12.19 MCM of groundwater or net reduction of 1% in stage of groundwater extraction, i.e., from the existing 46 % to 45%. The onetime cost will be 6 paisa/litre and the actual cost of invest will be 0.6 paisa/ltr if considered the life of the artificial recharge structures and micro irrigation equipment as 10 year.

A detailed groundwater management plan for both Priority-1 and Priority-2 villages is also prepared for Critical and Semi Critical mandals of district.

6.3 Management plan for Revally mandal

Revally mandal falling under semi-critical category with a stage of groundwater extraction of 77% as per GEC 2020. As the available uncommitted runoff is negligible in the mandal, demand side measures are given more importance than supply side measures for sustainable development of ground water resources in the mandal. The management plan area is given in Fig. 6.1 and Annexure-3.

- Area consisting of 10 villages having 121 km^2 covered under both Priority-1 and Priority-2, where 9 MCM recharge potential (in both weathered and fractured) and 1.06 MCM utilizable yield (uncommitted run-off) is available and immediate intervention is required as the stage of groundwater development is 77%.
- About 53 artificial recharge structures (PTs: 26, CDs: 27) are existing in 3 villages with an existing storage capacity of 1.22 MCM in both Priority-1 and Priority-2 villages.
- In both Priority-1 and Priority-2 villages, about 18 artificial recharge structures (9 mini PT's with 1.5 fillings with a unit cost of Rs. 20 Lakhs each and 9 CD's with recharge shafts with 5 fillings with a unit cost of Rs. 15 Lakhs each) with a total cost of 3 Crores can be taken up.
- After effective utilization of this yield, there will be 0.41 MCM of groundwater recharge with 100% recharge efficacy.
- 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 200 farm ponds are recommended (20 farm ponds each in 10 villages) at Rs 25,000/-each with total cost of 0.5 Crores and this can create an additional storage of 0.06 MCM.
- About 1,000 ha. of additional land that can be brought under micro-irrigation (100 ha. per village in 10 villages) costing about 6 Crores (considering 1 unit/ha. @0.6 lakhs/ha.). With this, about 1.5 MCM of groundwater can be conserved over the traditional irrigation practices (considering 25% of net saving for ID crops).
- With the above interventions costing Rs. 10 Crores, the likely benefit would be increases in gross groundwater availability with net saving of 1.97 MCM of groundwater which perhaps bring down the stage of groundwater extraction from 77% to 67% with net change of 10%.

6.4 Management plan for Amarachintha mandal

Amarachintha mandal falling under semi-critical category with a stage of groundwater extraction of 86% as per GEC 2020. As the available uncommitted runoff is negligible in the mandal, demand side measures are given more importance than supply side measures for sustainable development of ground water resources in the mandal. The management plan area is given in Fig. 6.1 and Annexure-4.

- Area consisting of 14 villages having 103.46 km^2 covered under both Priority-1 and Priority-2, where 2.51 MCM recharge potential (in both weathered and fractured) and 0.74 MCM utilizable yield (uncommitted run-off) is available and immediate intervention is required as the stage of groundwater development is 86%.
- About 115 artificial recharge structures (PTs: 80, CDs: 35) are existing in 7 villages with an existing storage capacity of 2.06 MCM in both Priority-1 and Priority-2 villages.
- In both Priority-1 and Priority-2 villages, about 18 artificial recharge structures (3 mini PT's with 1.5 fillings with a unit cost of Rs. 20 Lakhs each and 15 CD's with recharge shafts with 5 fillings with a unit cost of Rs. 15 Lakhs each) with a total cost of 3 Crores can be taken up.
- After effective utilization of this yield, there will be 0.56 MCM of groundwater recharge with 100% recharge efficacy.
- 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 280 farm ponds are recommended (20 farm ponds each in 14 villages) at Rs 25,000/-each with total cost of 0.7 Crores and this can create an additional storage of 0.08 MCM.
- About 1,400 ha. of additional land that can be brought under micro-irrigation (100 ha. per village in 14 villages) costing about 8.4 Crores (considering 1 unit/ha. @0.6 lakhs/ha.). With this, about 2.1 MCM of groundwater can be conserved over the traditional irrigation practices (considering 25% of net saving for ID crops).
- With the above interventions costing Rs. 12 Crores, the likely benefit would be increases in gross groundwater availability with net saving of 2.74 MCM of groundwater which perhaps bring down the stage of groundwater extraction from 86% to 68% with net change of 18%.

6.5 Management plan for Gopalpet mandal

Gopalpet mandal falling under Over Exploited category with a stage of groundwater extraction of 105% as per GEC 2020. As the available uncommitted runoff is negligible in the mandal, demand side measures are given more importance than supply side measures for sustainable development of ground water resources in the mandal. The management plan area is given in Fig. 6.1 and Annexure-5.

- Area consisting of 12 villages having 127.67 km^2 covered under both Priority-1 and Priority-2, where 13.19 MCM recharge potential (in both weathered and fractured) and 1.14 MCM utilizable yield (uncommitted run-off) is available and immediate intervention is required as the stage of groundwater development is 105%.
- About 91 artificial recharge structures (PTs: 44, CDs: 47) are existing in 4 villages with an existing storage capacity of 2.1 MCM in both Priority-1 and Priority-2 villages.
- In both Priority-1 and Priority-2 villages, about 14 artificial recharge structures (8 mini PT's with 1.5 fillings with a unit cost of Rs. 20 Lakhs each and 6 CD's with recharge shafts with 5 fillings with a unit cost of Rs. 15 Lakhs each) with a total cost of 3 Crores can be taken up.
- After effective utilization of this yield, there will be 0.3 MCM of groundwater recharge with 100% recharge efficacy.
- 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 240 farm ponds are recommended (20 farm ponds each in 12 villages) at Rs 25,000/-each with total cost of 0.6 Crores and this can create an additional storage of 0.07 MCM.
- About 1,200 ha. of additional land that can be brought under micro-irrigation (100 ha. per village in 12 villages) costing about 7.2 Crores (considering 1 unit/ha. @0.6 lakhs/ha.). With this, about 1.8 MCM of groundwater can be conserved over the traditional irrigation practices (considering 25% of net saving for ID crops).
- With the above interventions costing Rs. 10 Crores, the likely benefit would be increases in gross groundwater availability with net saving of 2.17 MCM of groundwater which perhaps bring down the stage of groundwater extraction from 105% to 96% with net change of 9%.

Annexure – I

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

New Mandal	Village	Existing No. of Percolation Tanks	Existing No of Check Dams	Proposed Check Dams	Proposed Percolation Tanks
Amarachintha	Nagalkadmoor				1
Amarachintha	Kistampally	28	5		
Ghanpoor	Appareddypally				1
Ghanpoor	Almaipally				1
Ghanpoor	Agavaram	28	3		
Ghanpoor	Venkatampally	10	3		
Ghanpoor	Antayapally	10	2		
Gopalpet	Appaipally			1	
Gopalpet	Dharmapur				1
Kothakota	Sathyahally				1
Kothakota	Ramanthapur		12		
Madanapur	Dwarakanagar				1
Madanapur	Govindahally				1
Madanapur	Balakistapur	10			
Pangal	Bandapally	10	5		
Peddamandaddi	Balisepalli	1	12		
Peddamandaddi	Veeraipally	5	2		
Peddamandaddi	Chinnamandadi		3		
Revally	Shanaipaly	12	13		
Wanaparthy	Wanaparthy			2	2
Wanaparthy	Chityala			2	2
Wanaparthy	Chimanguntapally			1	1
Wanaparthy	Ankur			1	1
Wanaparthy	Kasimnagar			1	1
Wanaparthy	Rajanagar			1	
Wanaparthy	Venkatapur				1

Annexure – II

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

New Mandal	Village	Existing No. of Percolation Tanks	Existing No of Check Dams	Proposed Check Dams	Proposed Percolation Tanks
Amarachintha	Amarchinta	4		1	1
Amarachintha	Rangapur				1
Amarachintha	Chandraghad	8	13		
Amarachintha	Irladinne	9	7		
Amarachintha	Mastipur	21	1		
Amarachintha	Konkanvaripally	4	6		
Amarachintha	Pomredyaplly	4	3		
Amarachintha	Singampet	2			
Atmakoor	Jural			1	1
Atmakoor	Motlampally			1	1
Atmakoor	Arepally			1	1
Atmakoor	Rechintal			1	1
Atmakoor	Kothapally			1	
Atmakoor	Guntapelly				1
Atmakoor	Tippadampally				1
Atmakoor	Toompally				1
Atmakoor	Medipally	2			1
Atmakoor	Devarpally				1
Atmakoor	Somasagar				1
Atmakoor	Khanapur	25	7		
Atmakoor	Pinnamcherla	4	7		
Atmakoor	Atmakur	16	1		
Atmakoor	Veeraraghavapur	2			
Chinna Chinta Kunta	Alipur	1			1
Chinnambavi	Bekkam			3	3
Chinnambavi	Dagada Pally			3	3
Chinnambavi	Koppunur	3		2	2
Chinnambavi	Peddamarur			2	2
Chinnambavi	Pedda Dagada			1	1
Chinnambavi	Veltoor			1	1
Chinnambavi	Velgonda	3		1	1
Chinnambavi	Chinnamarur			1	1
Chinnambavi	Miyapuram			1	1
Chinnambavi	Chellapad			1	1
Chinnambavi	Kallor			1	1
Chinnambavi	Ammaipally			1	1
Chinnambavi	Yeparla			1	1

New Mandal	Village	Existing No. of Percolation Tanks	Existing No of Check Dams	Proposed Check Dams	Proposed Percolation Tanks
Chinnambavi	Lingasanipally				1
Chinnambavi	Gaddabhaswapuram				1
Chinnambavi	Solipuram	3			
Chinnambavi	Chinnamarur	28	1		
Ghanpoor	Ghanapuram			2	2
Ghanpoor	Solipuram			1	1
Ghanpoor	Shapur			1	1
Ghanpoor	Upparipally			1	1
Ghanpoor	Parvatapur			1	1
Ghanpoor	Kammluddinpur			1	1
Ghanpoor	Suraipalli			1	1
Ghanpoor	Malkimanpalli				1
Ghanpoor	Anpad				1
Ghanpoor	Garkasa				1
Ghanpoor	Manajipet	23	16		
Ghanpoor	Solipur	26	12		
Ghanpoor	Malkapuram	19	4		
Ghanpoor	Thirmalampalli	10	3		
Ghanpoor	Salkalapuram	7	2		
Ghanpoor	Mamidimada	3	3		
Gopalpet	Buddaram			2	2
Gopalpet	Tadparthy			1	1
Gopalpet	Mannanur			1	1
Gopalpet	Chakalpally			1	1
Gopalpet	Jaintirmalapur				1
Gopalpet	Jakkampally				1
Gopalpet	Polkepad	25	28		
Gopalpet	Gopalpet	8	15		
Gopalpet	yedutla	6	3		
Gopalpet	Chennur	5	1		
Kothakota	Miraspally			1	1
Kothakota	Kanaipally			1	1
Kothakota	Kothakota			1	1
Kothakota	Apparla			1	1
Kothakota	Sankireddypally			1	1
Kothakota	Amdabakula			1	1
Kothakota	Rainpet				1
Kothakota	Ramakrishnapur				1
Kothakota	Nirvenu				1
Kothakota	Cherlapally				1

New Mandal	Village	Existing No. of Percolation Tanks	Existing No of Check Dams	Proposed Check Dams	Proposed Percolation Tanks
Kothakota	Natavelly				1
Kothakota	Boothpur				1
Kothakota	Pullareddykunta				1
Kothakota	Pathajangamaipally				1
Kothakota	Kanimetla	6	9		
Kothakota	Palem	16	1		
Kothakota	Waddewat	1	6		
Kothakota	Pamapur	6	3		
Madanapur	Ajjakol			1	1
Madanapur	Konnur			1	1
Madanapur	Dupally			1	1
Madanapur	Tirumalapally				1
Madanapur	Nelvide				1
Madanapur	Shankerampet				1
Madanapur	Narsingapur				1
Madanapur	Dantanur				1
Madanapur	Ramanpahad				1
Madanapur	Karvena	1			1
Madanapur	Kothapally				1
Madanapur	Gopanpet	21	3		
Pangal	Sakapuram			1	1
Pangal	Pangal	20	2		
Pangal	Vengalaipally	16	3		
Pangal	Madhavaraopally	12	5		
Pangal	kadirepadu	20	1		
Pangal	Dondaipally	2	3		
Pangal	Remaddula	10	4		
Pangal	Annaram	2			
Pebbair	Rangapur			2	2
Pebbair	Pebbair			1	1
Pebbair	Gummedam			1	1
Pebbair	Shakapur			1	1
Pebbair	Bochuveerapur			1	1
Pebbair	Ramapur				1
Pebbair	Toomulapally				1
Pebbair	Rammapet				1
Pebbair	Tippaipally	27			
Pebbair	Kanchiraopally	13	1		
Peddamandaddi	Peddamandadi		2	2	2
Peddamandaddi	Veltur			2	2

New Mandal	Village	Existing No. of Percolation Tanks	Existing No of Check Dams	Proposed Check Dams	Proposed Percolation Tanks
Peddamandaddi	Alwal	8			1
Peddamandaddi	Maddigatla	1	3		
Peddamandaddi	Jagathpally	4	38		
Peddamandaddi	Gatlakhanpur		10		
Peddamandaddi	Mangilla	13	6		
Peddamandaddi	Pomreddypalli	5	7		
Peddamandaddi	Mojarla	15	2		
Peddamandaddi	Jangampally	5	6		
Revally	Yedula			2	2
Revally	Revally			2	2
Revally	Talpanur	2		1	1
Revally	Nagapur			1	1
Revally	Keshampet			1	1
Revally	Raipakula			1	1
Revally	Cheerkapally			1	1
Revally	Chennaram	4	10		
Revally	Konkalapally	8	4		
Srirangapur	Nagasanpally	6	2		
Wanaparthy	Rajapet			2	2
Wanaparthy	Savaigudem			1	1
Wanaparthy	Kadukuntla			1	1
Wanaparthy	Nagaram			1	1
Wanaparthy	Srinivaspur			1	1
Wanaparthy	Mentapalli			1	
Wanaparthy	Achutapur			1	
Wanaparthy	Mamullapally				1
Wanaparthy	Nancharammapet				1
Wanaparthy	Dattaipally	4	4		
Weepanagandla	Weepangandla			3	3
Weepanagandla	Goverdangiri			1	1
Weepanagandla	Gopaldinne			1	1
Weepanagandla	Kalvarala	17			
Weepanagandla	Sampatraopally	3	1		

Annexure – 3

Proposed interventions in Ravelly Mandal (Semi Critical area)

Village	Existing No. of Percolation Tanks	Existing No. of Check Dams	Proposed Check Dams	Proposed Percolation Tanks	Priority
Shanaipaly	12	13			1
Yedula			2	2	2
Revally			2	2	2
Talpanur	2		1	1	2
Nagapur			1	1	2
Keshampet			1	1	2
Raipakula			1	1	2
Cheerkapally			1	1	2
Chennaram	4	10			2
Konkalapally	8	4			2

Annexure – 4

Proposed interventions in Amarachintha Mandal (Semi Critical area)

Village	Existing No. of Percolation Tanks	Existing No. of Check Dams	Proposed Check Dams	Proposed Percolation Tanks	Priority
Nagalkadmoor				1	1
Kistampally	28	5			1
Amarchinta	4		1	1	2
Rangapur				1	2
Chandraghad	8	13			2
Irladinne	9	7			2
Mastipur	21	1			2
Konkanvaripally	4	6			2
Pomredyaplly	4	3			2
Singampet	2				2
Nandimalla					2
Mittanandimalla					2
Dharmapur					2
chintareddypally					2

Annexure – 5

Proposed interventions in Gopalpet Mandal (Over Exploited area)

Village	Existing No. of Percolation Tanks	Existing No. of Check Dams	Proposed Check Dams	Proposed Percolation Tanks	Priority
Appaipally			1		1
Dharmapur				1	1
Buddaram			2	2	2
Tadparthy			1	1	2
Mannanur			1	1	2
Chakalpally			1	1	2
Jaintirmalapur				1	2
Jakkampally				1	2

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